Brookhaven National Laboratory

NATURAL RESOURCE MANAGAMENT PLAN

ANNUAL REPORT

CALENDAR YEAR 2006

1.0 Introduction

This document summarizes activities carried out under Brookhaven National Laboratory's (BNL) Natural Resource Management Plan (NRMP) during calendar year 2006. Previous year's reports may be obtained from BNL's Cultural and Natural Resource Manager. All activities carried out under the NRMP during CY2006 will be discussed and the report will facilitate development of summary information for the Site Environmental Report for 2006.

2.0 Comprehensive Natural Resource Management Plan

The Laboratory completed and issued the Comprehensive Natural Resource Management Plan in December 2003. The development of this plan was carried out over several years with the assistance of the Technical Advisory Group (TAG) that was established to provide input to the Natural Resource Program and the Upton Ecological and Research Reserve.

This report discusses work related to actions established within the NRMP and through subsequent annual reviews. Incremental changes from annual reviews will be incorporated annually with the completion of the required Annual Report. All incremental changes will be addressed during the 5-year re-write of the Plan scheduled to begin in 2008.

3.0 Progress

3.1 Transition Wildlife Management Plan Actions into NRMP

This was completed in December 2003 with the publishing of the current NRMP.

3.2 Annual Summary Report

An annual summary report for calendar year 2005, as required under the NRMP, was written as part of the Internal Self Assessment program of the Environmental & Waste Management Services Division. The annual report for calendar year 2005 was completed by the May 4, 2006, approximately one month past the deadline established in previous reports. The CY 2005 report was also submitted to the TAG for Review.

3.3 TAG Review of Annual Report

The CY2005 report on the NRMP was submitted to the TAG for review. The TAG had no comments directly on the Annual Report but the majority of the members indicated that there is no real necessity for the TAG to meet annually just to look at a document. The TAG members suggested the role of the TAG should primarily assist in the re-write of the NRMP and assist FERN in the selection of research proposals within the Pine Barrens when funding is available to support research. This annual report will be sent as informational material and comments considered if offered.

3.4 Adaptive Management Cycle

The current report is the fourth Annual Report in the Adaptive Management Cycle. It is not expected to result in a need for significant changes. As actions identified in the NRMP are implemented, monitored, and reported on in the future, the need for change will be identified.

3.5 Improve Decision making through use of Innovative Tools

The use of global positioning systems (GPS) and geographic information systems (GIS) continue to be utilized for natural resource management activities. Projects routinely capture GPS coordinates for inclusion in BNL's geodatabase. Data on remote wildlife camera locations has been added, as well as, locations for fox dens, forest health monitoring grids, prescribed fire locations, and other miscellaneous data points. GIS continues to be extensively used by student interns, Faculty and Student Teams, and teachers when completing projects at BNL.

Projects using the GIS and/or GPS include tiger salamander and marbled salamander larval and metamorph surveys, box turtle, and spotted turtle radio telemetry surveys, Odonate (dragonfly and damselfly) surveys, vernal pool water chemistry studies, fox genetic surveys, and documentation of species locations from random sightings.

3.6 Maintain and Improve Relationships with Stakeholders

BNL continues to maintain good relationships with all of its stakeholders. Through interactions with the Office of Education Program's – Open Space Stewardship initiative increased activities with stakeholders is taking place. More than 20 school districts, 4 towns, Suffolk County, and over two dozen teachers are participating. The Natural Resource Program at BNL plays a role in training teachers to carryout monitoring of open space throughout Suffolk County. This activity strengthens BNL's relationship with numerous stakeholders.

The Foundation for Ecological Research in the Northeast (FERN) in working with BNL added additional plots to the Forest Health Monitoring network. This effort required the acquisition of access permits which increased visibility of both BNL and FERN with various State, County, and Town governments. FERN and the Natural Resource Program at BNL are closely allied to ensure sound operation of the Upton Reserve and to encourage the use of the Reserve and BNL for ecological research.

3.7 Peconic River Flow Monitoring

Peconic River flow is measured at several locations including above the outfall (HE), down river at the East Firebreak (HMn), and near the boundary of the Laboratory (HQ). In addition flows from the central wetlands are monitored before they enter the Peconic River station at the East Firebreak (HMs), and flows from the STP are measured prior to discharge into the Peconic River. Flow data is presented in Figure 1. The chart shows three peaks. The February 2006 peak is likely due to snow fall. The June and December 2006 peaks are associated with rainfall. Numerous rainfall events resulted in a series of peaks throughout the summer of 2006 and in general river flows were higher throughout 2006 as compared to the past 2-3 years.

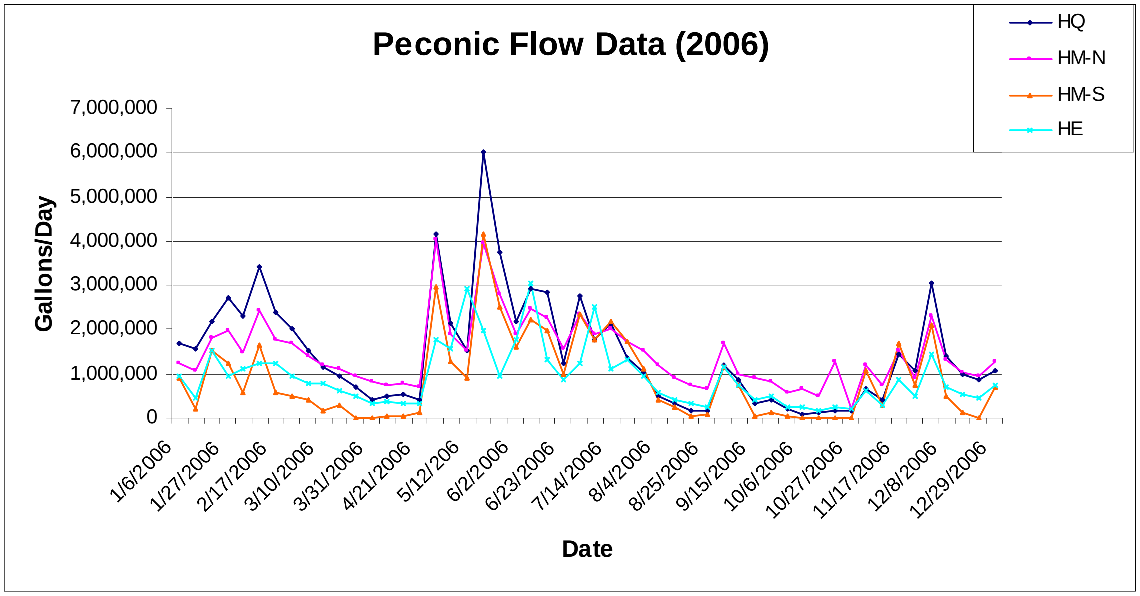

Figure 1. Peconic River flow data for 2006.

3.8 Water Quality Monitoring

Water quality is monitored as a requirement of BNL's State Pollutant Discharge and Elimination System (SPDES) permit. Water quality is measured at various outfalls including the STP discharge to the Peconic River and at several recharge basins that receive stormwater and/or once through cooling water. Results are reported to the NYSDEC on a monthly basis and summarized in the Site Environmental Report each year. The Site Environmental Report for the previous year is made available in October and may be viewed via the Internet at http://www.bnl.gov/esd/SER.asp. Sampling in 2006 did not indicate any concerns for threatened or endangered species within basins or the Peconic River.

3.9 Fish Sampling Peconic River

A population assessment of the onsite portion of the Peconic River was not completed in 2006 due to high water making seining difficult. Fish sampling in the area of the river near North Street and the Lab boundary was unsuccessful with the exception of a single brown bullhead being caught in July. At the time of sampling dissolved oxygen was measured at levels of ~ 2ppm. Low dissolved oxygen generally forces fish to move to areas of higher concentration. While water levels were higher throughout the Peconic River the presence of the filter dam at HQ continues to act as a barrier to upstream fish passage. This in concert with low flow and drought conditions reported in 2005 are the likely cause for low fish populations on site.

While fish populations have not recovered, there is a necessity to obtain fish samples from on site and downstream of BNL to document the effectiveness of the Peconic River clean up in reducing mercury concentrations in fish. Attempts to obtain fish on site will occur primarily in the area of North Street and the east boundary. However, fish samples upstream are desirable and attempts to obtain samples will take place annually.

Efforts to document the banded sunfish population in Zeke's pond were attempted in early June. However, due to cooler spring temperatures spawning did not take place until late May. When seining and dip netting was used, a few banded sunfish fry less than 7mm were found. This small size resulted in most individuals passing through the mesh of the nets without being captured; therefore further attempts to quantify the population were not made.

3.10 Deer Management

While the need for deer population management continues to be an issue for BNL, there has been no change in deer management in 2006, except for updated population estimates based on new census techniques.

Discussions on various deer management issues are provided below.

3.10.1 Issue and Decision Paper on Deer Management

No further effort was placed on this action in 2006. Effective management of deer will continue to be an issue that at some point must be addressed not only by the Laboratory but also local landowners, the state, county, and towns.

3.10.2 Environmental Assessment for Deer Management

Once an issue and decision paper is finalized and approved, the need for an EA can be re-evaluated.

3.10.3 Implement Deer Management

No additional work has been done on this action in 2006.

3.10.4 Deer Population Estimation

Deer population estimates were conducted in both spring (prior to birth of fawns) and in the fall (after birth of fawns and while bucks had antlers). Figure 2 shows the population trend over the past five years. Population levels are considered to be above the ecosystems carrying capacity and the effects of over population on the ecosystem are still evident.

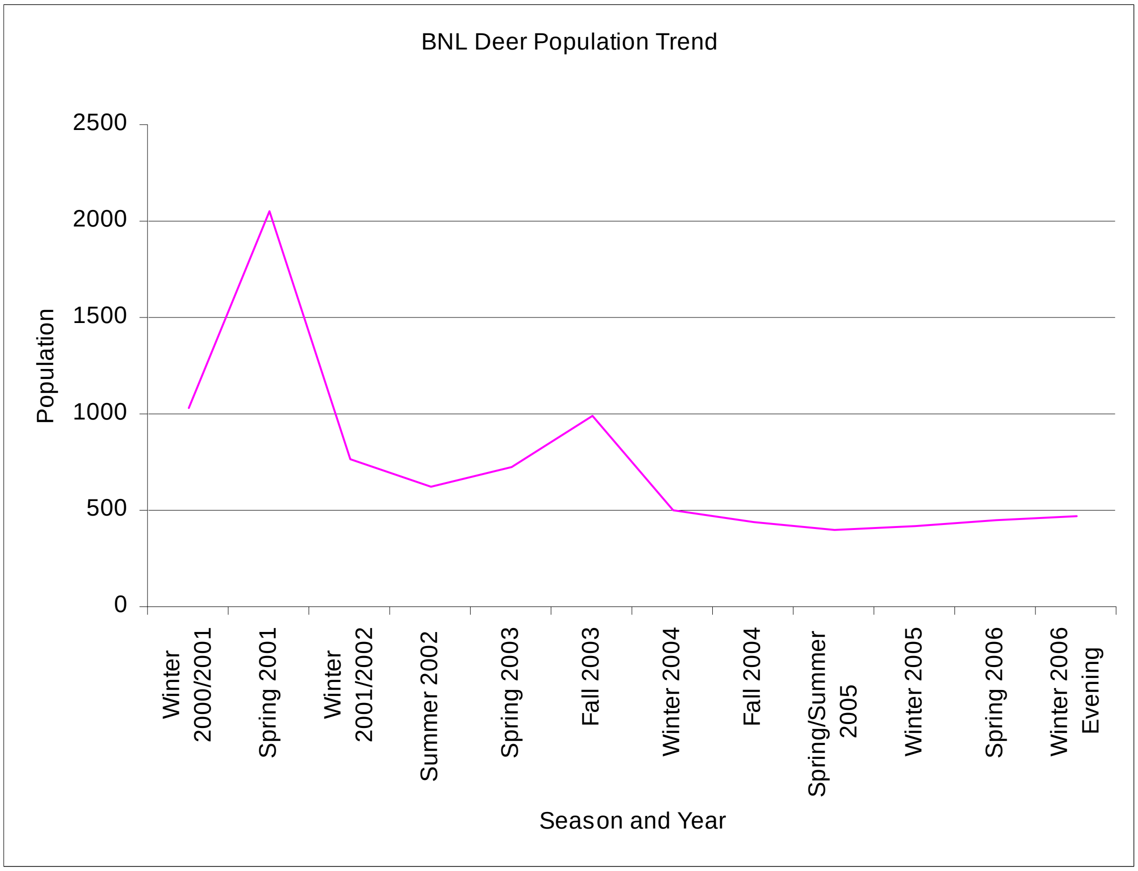

Figure 2. Trend in population estimates of white-tailed deer between 2001 and 2006. Note: Spring 2001 estimate is high due to limited data.

3.11 Special Status Species

BNL is home to a number of plants and animals that are considered special status species including the New York State endangered tiger salamander and Persius duskywing, and the state threatened banded sunfish, swamp darter, frosted elfin butterfly and northern harrier (Table 1). Endangered and threatened plants include the crested fringed orchid, stargrass, and stiff goldenrod. There is also a relatively long list of species of special concern, and rare or vulnerable plants. Under the NRMP the Lab is working to identify areas that may be suitable habitat for species on this list.

In addition to the list in Table 1, species like the wild turkey and Canada goose are also of interest due to their prominence and potential to interact with humans. Information on these species is maintained simply to be aware of potential issues that may arise.

3.11.1 Maintain Special Status Species List

Table 1 is the most recent update of the special status species list. A threatened damselfly species, the pine barrens bluet (*Ennalagman recurvatum*) was placed on the list in 2005 after it was confirmed to exist onsite. Table 1 contains all species identified onsite since the mid-1980s. The sharp-shinned hawk and osprey was added in 2006 based on repeated identifications during routine bird surveys or other observations. The sharp-shinned hawk may nest on-site and the osprey has been documented using cellular communication towers as roosts and construction of false nests. The continued presence of several "likely" occurring bird species on the list will be evaluated for removal from the list in 2007.

3.11.2 Identify Habitats of Special Status Species

When special status species are identified as being present on the BNL site, their habitats are also identified. If applicable, surveys for the correct habitat take place with surveys for the species in question and information concerning presence or absence of the species is recorded and maintained in BNL's GIS. Currently surveys for four species take place at least annually, these are the tiger salamander, banded sunfish, swamp darter, frosted elfin, and pine barrens bluet.

3.11.3 Tiger Salamander

The eastern tiger salamander, a New York endangered species, is locally abundant on the BNL site. This species has been documented using at least 22 of the 27 ponds or pond systems on site. During the development of the NRMP pond designations were modified to lessen the confusion between confirmed (TS) and unconfirmed (ts) habitat.

3.11.3.1 Tiger Salamander Annual Egg Mass Surveys

Annual egg mass surveys were conducted between the end of December and mid-April. Warm weather in December 2006 along with precipitation resulted in a egg masses being laid in at least one pond during the first week in December. This is the earliest documented reproductive event for the eastern tiger salamander in NY. Late winter – early spring egg mass surveys documented production at TS-1, TS-2, TS-5 TS-6, TS-7, TS-A7, TS-9, TS-10, TS-13a, and TS-W6b. Egg mass production is then followed up when possible with larval surveys in the late spring or early summer.

Table 1. New York State Threatened, Endangered, and Species of Special Concern.			
Common Name	Scientific Name	State Status	BNL Status
Insects			
Frosted elfin	*Callophrys iris*	T	Likely
Mottled duskywing	*Erynnis martialis*	SC	Likely
Persius duskywing	*Erynnis persius persius*	E	Likely
Pine Barrens Bluet	*Enallagma recurvatum*	T	Confirmed
Fish			
Banded sunfish	*Enniacanthus obesus*	T	Confirmed
Swamp Darter	*Etheostoma fusiforme*	T	Confirmed
Amphibians			
Eastern tiger salamander	*Ambystoma tigrinum tigrinum*	E	Confirmed
Marbled salamander	*Ambystoma opacum*	SC	Confirmed
Eastern spadefoot toad	*Scaphiopus holbrookii*	SC	Confirmed
Reptiles			
Spotted turtle	*Clemmys guttata*	SC	Confirmed
Eastern box turtle	*Terrapene carolina*	SC	Confirmed
Worm snake	*Carphophis amoenus*	SC	Confirmed
Eastern hognose snake	*Heterodon platyrhinos*	SC	Confirmed
Birds (nesting, transient, or potentially present)			
Horned lark	*Eremophila alpestris*	SC	Likely
Whip-poor-will	*Caprimulgus vociferus*	SC	Likely
Vesper sparrow	*Pooecetes gramineus*	SC	Likely
Grasshopper sparrow	*Ammodramus savannarum*	SC	Confirmed
Northern harrier	*Circus cyaneus*	T	Confirmed
Cooper's hawk	*Accipiter cooperii*	SC	Confirmed
Osprey	*Pandion haliaetus*	SC	Confirmed
Shap-shinned Hawk	*Accipiter striatus*	SC	Confirmed
Plants			
Stargrass	*Aletris farinosa*	T	Confirmed
Butterfly weed	*Asclepias tuberosa*	V	Confirmed
Spotted wintergreen	*Chimaphila maculata*	V	Confirmed
Flowering dogwood	*Cornus florida*	V	Confirmed
Pink lady's slipper	*Cypripedium acaule*	V	Confirmed
Winterberry	*Ilex verticillata*	V	Confirmed
Sheep laurel	*Kalmia angustifolia*	V	Confirmed
Narrow-leafed bush clover	*Lespedeza augustifolia*	R	Confirmed
Ground pine	*Lycopodium obscurum*	V	Confirmed
Bayberry	*Myrica pensylvanica*	V	Confirmed
Cinnamon fern	*Osmunda cinnamomera*	V	Confirmed
Clayton's fern	*Osmunda claytoniana*	V	Confirmed
Royal fern	*Osmunda regalis*	V	Confirmed
Crested fringed orchid	*Plantathera cristata*	E	Likely
Swamp azalea	*Rhododendron viscosum*	V	Confirmed
Long-beaked bald-rush	*Rhynchospora scirpoides*	R	Confirmed
Stiff goldenrod	*Solidago rigida*	T	Confirmed
New York fern	*Thelypteris novaboracensis*	V	Confirmed
Marsh fern	*Thelypteris palustris*	V	Confirmed
Virginia chain-fern	*Woodwardia virginica*	V	Confirmed

Notes: * information based on 6 NYCRR Part 182, 6 NYCRR Part 193, and BNL survey data.

No federally listed threatened or endangered species are known to occur at BNL.

E = endangered, T = threatened, SC = species of special concern, R = rare, V = exploitably vulnerable

3.11.3.2 Tiger Salamander Larval Surveys

Larval surveys are conducted at ponds that had positive egg mass identification during the spring breeding season, as well as the following summer when larvae are large enough to be sampled via seining. Of the ponds listed above in 2006, larvae were identified at TS-A7, TS-7, TS-9, and TS-A6 complex. In addition to these ponds larvae were also identified at TS-13a, TS-1, and TS-2. The absence of larvae at a pond with egg masses does not preclude them from being there. Most ponds are difficult to enter and capture larvae due to debris (sticks and branches) on the pond bottom. Many of the ponds on site dried down during 2006and metamorphs likely emerged early or not at all.

3.11.3.3 New Pond at RHIC

A new pond was constructed in the RHIC ring between August and December 2002. Native vegetation emerged during the spring and summer months in 2005 and vegetation improved in 2006. Egg masses were identified in this pond, which is part of the TS-A6 complex. No larvae were documented during the summer months. The pond will continue to be surveyed for both egg masses and larvae.

3.11.3.4 Cover Board Surveys on one TS Pond

Cover board surveys were discontinued in 2004, but several boards were left around both TS-7 and TS-10 to provide shelter for emerging metamorphs. Remaining cover boards are occasionally checked when other work is being conducted around various ponds. They are simply used as alternative habitat for various reptile and amphibian species. Drift fence surveys of TS-6, TS-7, and TS-A7 continued in 2006.

3.11.3.5 TS-A7 Restoration of Meadow Marsh

Restoration was completed in 2003. This pond is currently being monitored as part of a long-term study of tiger salamanders being conducted by the State University of New York at Binghamton to compare its use by tiger salamanders to typical use of coastal plain ponds by salamanders. Drift fencing was installed in 2004 and egg mass, larval, and metamorph surveys have been routinely conducted. Several metamorphic and adult tiger salamanders have been captured, tagged using radio transmitters and followed to determine the extent of their migration. This work continued through 2006 and will continue into the summer of 2007 to gain a better understanding of tiger salamander biology.

3.11.3.6 TS-W6b Pond Remediation ER Program

The TS-W6B Pond is located on the northwest edge of the Former Hazardous Waste Management Facility (FHWMF). The clean up and restoration of the wetland was completed in September 2005 and was conducted under a wetlands equivalency permit issued by the NYSDEC. Tiger salamander egg mass surveys were resumed in 2006 with no evidence of use. Two vegetation samples were obtained from the eastern edge of the pond to determine whether any contamination from runoff within the FHWMF had entered the pond. The results of the sampling and analysis indicated values of Cs-137 at near background levels providing an indication that the clean up was successful. The pond is now on an annual schedule for egg mass surveys.

3.11.4 Banded Sunfish

The banded sunfish (*Enneacanthus obesus*) is a New York threatened species that inhabits backwater areas of the Peconic River and Zeke's Pond. Substantial effort was expended from April through mid-November 2004 to capture as many banded sunfish as possible from the Peconic River ahead of and during the remediation effort. During the onsite portion of the remediation, a total of 147 banded sunfish were rescued and placed in Zeke's Pond until such time as the habitat in the Peconic River is suitable for returning the fish. A total of 46 additional banded sunfish were rescued from the offsite portion of the River. As mentioned above in section 3.9 surveys of Zeke's Pond during summer 2006 provided indication that the Banded Sunfish was still breeding, but fry were too small to safely continue surveys without harm. Zeke's Pond has maintained water levels sufficient for survival throughout 2006 and breeding success will be documented in 2007.

3.11.4.1 Peconic River Flow Monitoring HMn

As mentioned above in section 3.7 Peconic River flows are recorded at numerous locations including at HMn. Flow is important for the survival of the banded sunfish in the Peconic River system.

3.11.4.2 OU V Peconic River Remediation Program

The Peconic River clean up began in April 2004 and concluded in May 2005. As mentioned above, flows from the upstream portion of the river were diverted downstream past the east boundary of the Laboratory. This was done to facilitate the clean up. Short sections of the river were isolated using temporary dams and pumps to decrease the amount of water present in any given area being excavated. Besides capturing banded sunfish, staff and volunteers captured other fish, frogs, turtles, and snakes moving them either upstream or down stream out of the way of the project. Upon conclusion of clean-up operations, the river was re-contoured and native vegetation taken from the river ahead of the clean-up was replanted in the river. An evaluation of the revegetation efforts indicated that the restoration was, in most areas, better than 85% effective. The onsite area at the east boundary required replanting and several areas on and offsite had the invasive plant phragmites removed by hand. This work will took place starting in spring 2006. By the summer's end, 2006, restoration of vegetation had reached better than 90% at most locations with an overall average of 92% coverage of the entire restoration area. Invasive species composition within in restoration areas was well under 5% of the area.

3.11.5 Frosted Elfin

The frosted elfin (*Callophrys iridis*) is a small orange-brown butterfly that is dependent on wild lupine. Historically, the frosted elfin was found along the south boundary and LIRR right of way at the south east corner of the Lab. This area is typified by soil disturbance that enhances habitat for wild lupine that in turn provides habitat for the butterfly.

3.11.5.1 Confirm Presence/Absence of Frosted Elfin

Surveys of the primary area of lupine occurring on site showed little or no increase in plant production over 2005 surveys. Plants observed along the north firebreak in 2005 were absent in 2006.

3.11.5.2 Establish Monitoring Protocols for Frosted Elfin

BNL has participated with the NYSDEC and NY Heritage during their surveys, but should develop monitoring protocols for onsite use. A better understanding of the life history of this butterfly is needed in order to establish effective protocols. No additional information on this has been forthcoming. At this point only surveys of host plants appear to be effective.

3.11.5.3 Maintain and Enhance Habitat for Frosted Elfin

Wild lupine likes disturbed soil areas as is found along the south firebreak at the southeast corner of the Lab. Disturbance of the primary area of lupine has not yet resulted in additional plants establishing, and as mentioned above plants identified on the north firebreak in 2005 were absent from the area in 2006.

3.11.5.4 Habitat assessment for Lupine

Areas planted with wild lupine in 2003 and 2004 did not produce plants in 2006. Additional effort in this area is likely needed.

3.12 Habitat Enhancement other species

Several species of birds have been targeted for improvements in nesting habitat. These include the eastern blue bird, kestrel, and wood duck. As information is gained on other species of special interest, habitat improvement needs will be identified and implemented as necessary.

3.12.1 Bird nests/boxes

Nest boxes are important for many species of birds because of the lack of proper habitat. This is particularly true of birds that utilize cavities for nesting. The eastern bluebird is one of the better know birds for which nest boxes are important. BNL currently has 56 boxes distributed across the site in appropriate habitat (open fields near forested areas). House wrens, tree swallows, chickadees, and tufted titmouse also use the bluebird boxes (Table 2). The successful use of the nest boxes is evident as indicated in Figure 3. The percent use of nest boxes by bluebirds has increased to over 50%, while use by other species like house wrens and tree swallows has remained constant.

All nest boxes including bluebird, wood duck, and kestrel boxes continue to be monitored by volunteers several times each year. To date three years of monitoring suggest very limited use of wood duck boxes near the biology fields and in the RHIC ring, and apparently no use of kestrel boxes is occurring.

Table 2 Results of Bluebird Nest Box Monitoring 2001 - 2006

Summary of Nesting Success							
Year	# of Boxes	Empty/other	Bluebird	House Wren	Tree Swallow	Chickadee	Tufted Titmouse
2001	37	12	19	6	1		
2002	46	13	19	6	6	2	
2003	46	14	21	4	4		2
2004	48	12	23	6	6	1	
2005	53	9	39	6	6	1	
2006	56	8	38	9	6	1	

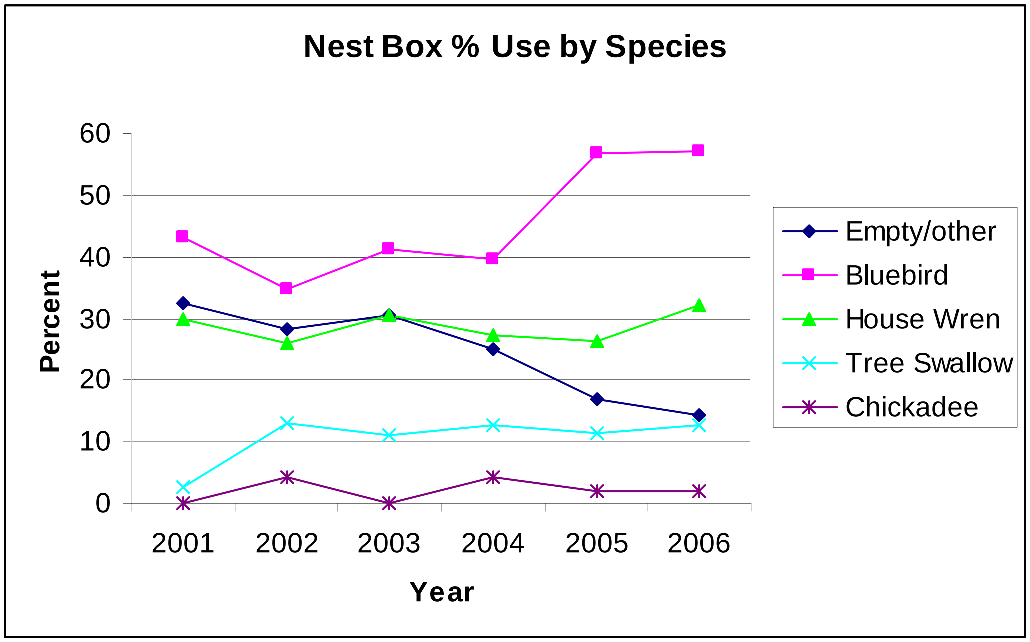

Figure 3. Bluebird nest box use based on a percentage of available boxes.

3.12.2 Surveys and Monitoring

Conducting surveys and routine monitoring allows BNL to identify, track, and trend population status for a number of species. New surveys for reptiles and amphibians, Odonata (damselflies and dragonflies), and incidental reporting of other species during routine activities results in a better understanding of which species are present. The following discussions will touch on the results of various surveys and monitoring in 2006.

3.12.3 Develop Survey Methodology to document all Biota on BNL

A full set of monitoring and survey protocols are still needed. Contracts for a research data base and forest health monitoring protocols were completed in 2005. The forest health monitoring protocols have been implemented across BNL. Additional details are discussed below. Working with FERN, development of protocols for freshwater wetlands was started in the fall of 2006.

3.12.3.1 Reptiles and Amphibians

Work on reptiles and amphibians included continuation of radio telemetry tracking of spotted turtles (*Clemmys guttata*) in the fall of 2006 in order to gain a better understanding of the habitat needs of this species. The 2006 work consisted of simply following additional introduced turtles from the time of their release in August through to their hibernation to ensure that they successfully established.

Interns began marking all eastern box turtles found by notching their carapace and releasing them. The practice started in 2003 and continued in 2006. A database of marked turtles was started. As reported in last year's annual report turtles are routinely inspected and recaptures documented.

In 2005 several box turtles were found with upper respiratory infections with three documented as having an amphibian ranavirus (iridovirus) isolated from their tissues. Based on this information, a study of the box turtles was planned for the summer 2006 field season. Several turtles were captured in the TS-7 area, radio transmitters attached and then followed. This study was primarily looking at the potential of turtles to interact through territorial intersections. Additionally the study attempted to isolate iridovirus from individuals. A poster of the results is attached. This project will continue in 2007.

3.12.3.2 Monitor Canada Goose & Wild Turkey Populations

The Canada goose population on site is currently estimated to be 120 birds. Counts are periodically conducted by driving all open lawn areas at BNL during key grazing periods, typically between 9 and 11 am. In June 2006 the NYSDEC requested permission to band Canada geese on site. A total of 21 geese were banded and a total of 70 geese have been banded through these efforts since 2003. Banding allows researchers and waterfowl biologists opportunities for information gathering. During future efforts, banded geese will be recorded which allows estimates of age to be made. If a goose is shot by hunters or found dead, the information from the band is sent to the FWS where information on banded birds is maintained. Through nationwide efforts the banding information leads to a better understanding of the larger population of geese in the Northeast.

New rules for managing non-migratory or resident Canada geese were promulgated by the U.S. Fish & Wildlife Service in 2006. The new rules ease the permitting requirements for managing the population. NYSDEC can now more readily permit the management of nests and nuisance geese. BNL will investigate the potential for nest management in early 2007 to begin the more effective reduction of the goose population over time.

3.12.3.3 Turkey Sighting Reports to NYSDEC

The NYSDEC did not request assistance in monitoring of wild turkey populations in 2006. Rough estimates of the turkey population continue to place the number around 300 birds.

A few reports during spring 2006 indicated turkeys potentially damaging paint on cars as they respond to their reflections in the paint.

3.12.3.4 Song Bird Surveys

Songbird surveys have been carried out since May 2000. Monitoring involves recording ambient weather conditions at the beginning and end of each of the six routes, and counting the number of individuals of each species heard or seen during a five minute period at each point on the route. Points are spaced approximately 300 meters (Fig. 4) apart to prevent overlap of counts from point to point. Monitoring is carried out monthly from April through September each year.

The current results of monitoring are provided in Table 5 below. In 2006, 70 species of birds were detected. Routes next to wetlands (Peconic River, Biology Fields, and Z-path routes) continue to have the highest number of species detected. This is likely due to higher biodiversity in these habitats that support a greater variety of nesting sites and foraging opportunities. Results along the Z-Path route are also beginning to indicate high number of species, likely due to the variability of habitats along this route. The Z-Path route goes through the most diverse habitats, ranging from pine forest, to wetlands, to mixed forest.

As indicated in previous reports, data acquired from surveys allows long-term monitoring of population health and comparison to Breeding Bird Surveys which have been carried out since 1966. It is important to utilize both a global perspective using all species as well as look at individual species and use a long-term analysis comparing to historic data rather than rely on a limited set of data. BNL will continue monitoring in 2007.

3.12.3.5 Odonate Surveys

Surveys of Odonata (dragonflies and damselflies) continued in 2006. A total of 37 species of dragonflies (5 new species for 2006) and 23 species of damselflies were identified from seventeen locations on site. Where possible both larval and adult forms were identified. One rare species of damselfly, the NY State threatened Pine Barrens Bluet (*Enallagma recurvatum*), is now known to exist onsite. Table 8 presents a compiled list of all species found at BNL from 2003 through 2006.

In 2006 a pilot study to determine whether Odonate populations can be estimated using mark recapture techniques was conducted. A single species the Cherry-faced Meadowhawk was used to test the idea. Individual dragonflies were captured and uniquely marked using indelible markers on their wings. They were released and monitored over a period of time in order to document capture/re-capture data. A copy of the poster produced as part of the 2006 intern work is attached to this document and the results are to be presented at a regional wildlife conference in 2007. The study will be refined and continued in 2007.

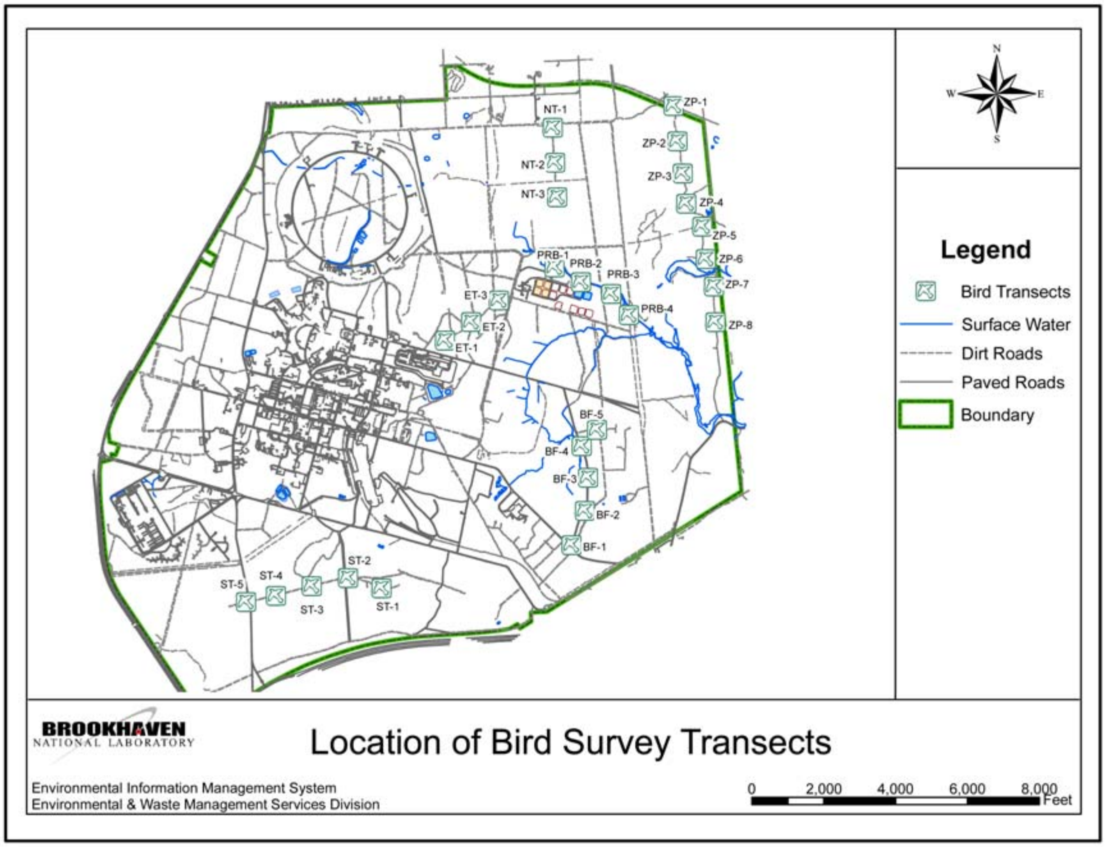

Figure 4. Songbird survey routes.

Table 3. Results of Bird Surveys

Bird Survey Results 2000 - 2006									
Year	# of Species Identified	# New Species Identified	Total # of Species	# of Species Biology Fields	# of Species East Trenches	# of Species North Transect	# of Species Peconic River	# of Species South Transect	# of Species Z-Path
2000	70		73	50	31	23	48	32	
2001	73	23	93	53	32	34	45	39	
2002	73	6	100	45	29	30	43	29	47
2003	79	4	106	49	27	31	47	33	44
2004	68	2	108	45	24	33	44	28	41
2005	67	3	126	49	26	32	43	26	43
2006	70	2	135	58	29	33	42	25	37

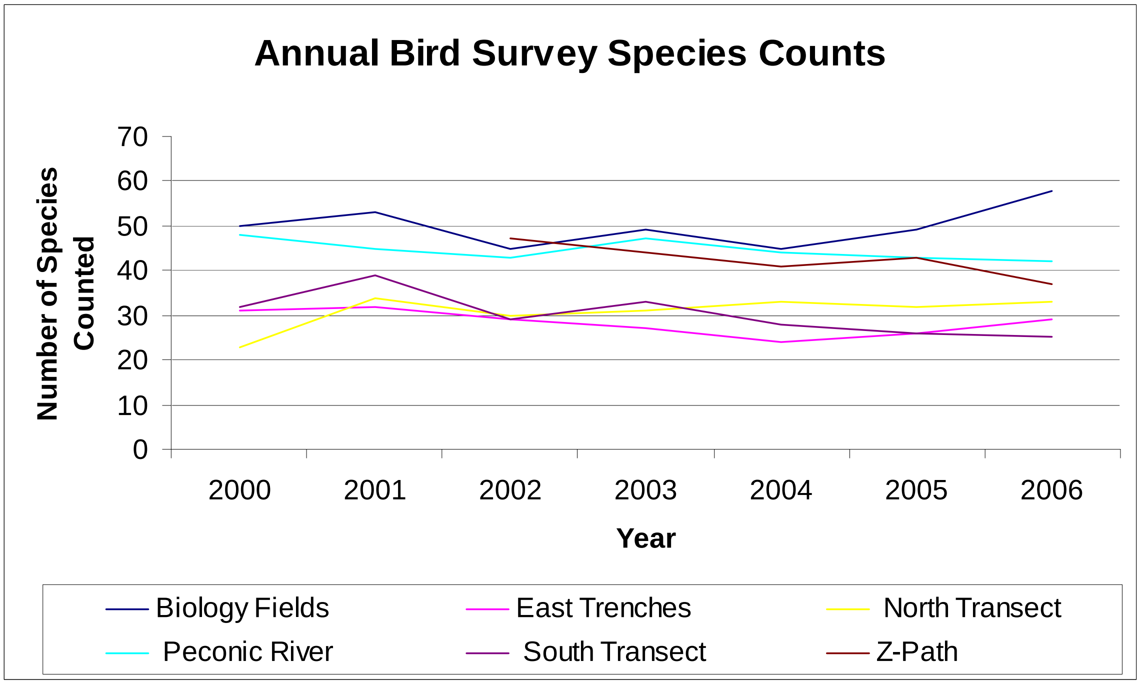

Figure 5. Trends in species counts of songbirds per transect from 2000 – 2006.

Table 4. Data concerning routinely documented bird species

		Year - Number						
Common Name	Scientific Name	2000	2001	2002	2003	2004	2005	2006
American Crow	*Corvus brachyrhynchos*	71	74	87	121	49	29	43
American Robin	*Turdus migratorius*	207	120	492	231	176	178	278
Baltimore Oriole	*Icterus galbula*	6	41	39	53	53	35	61
Black-and-White Warbler	*Mniotilta varia*	11	10	11	12	1	9	10
Black-billed Cuckoo	*Coccyzus erythropthalmus*	10	14	9	3		3	2
Black-capped Chickadee	*Poecile atricapillus*	84	114	122	111	173	135	186
Blue Jay	*Cyannocitta cristata*	123	216	319	288	253	199	230
Blue-Grey Gnatcatcher	*Polioptila caerulea*		5	6	3	3	4	2
Brown Thrasher	*Toxostoma rufum*	9	6	1	7	1		2
Brown-headed Cowbird	*Molothrus ater*	9	34	98	81	84	78	69
Canada Goose	*Branta canadensis*	28	82	46	216	103	93	85
Carolina Wren	*Thryothorus ludovicianus*	1	1	7	1	9	5	10
Cedar Waxwing	*Bombycilla cedrorum*	39	2	22	2	1	8	46
Chipping Sparrow	*Spizella passerina*	124	130	195	182	237	197	249
Common Grackle	*Quiscalus quiscula*	40	55	64	90	153	89	556
Common Yellowthroat	*Geothlypis trichas*	11	10	20	15	11	16	13
Dark-eyed Junco	*Junco hyemalis*	18	2		1	1		2
Double-crested Cormorant	*Phalacrocorax auritus*		3	70	42		15	
Downy Woodpecker	*Picoides pubescens*	7	17	30	24	35	26	30
Eastern Bluebird	*Sialia sialis*	1	2	7	3	3	3	5
Eastern Kingbird	*Tyranus tyranus*	2	1	4	8	3	3	5
Eastern Phoebe	*Sayornis phoebe*	3	10	9	2	10	3	12
Eastern Towhee	*Pipilo erythrophthalmus*	151	216	252	211	219	220	213
Eastern Wood Peewee	*Contopus virens*	68	51	67	59	70	52	56
European Starlings	*Sturnus vulgaris*	32	21		18	7		1
Field Sparrow	*Spizella pusilla*		1		8	7	4	5
Goldfinch	*Carduelis tristis*	54	35	49	70	82	47	87
Great Crested Flycatcher	*Myiarchus crinitus*						12	22
Grey Catbird	*Dumetella carolinensis*	57	65	68	62	49	47	59
Hairy Woodpecker	*Picoides villosus*		3	3	2	2	4	
Hermit Thrush	*Catharus guttatus*		5	4	1	4	10	4
Herring Gull	*Larus argentatus*	2		3	24	6	5	3
House Wren	*Troglodytes aedon*	14	4	7	11	3	3	9
Indigo Bunting	*Passerina cyanea*		5	11	15	21	8	12
Mallard Duck	*Anas platyrhyncos*	2	7	3	2	1	6	1
Mourning Dove	*Zenaida macroura*	55	41	78	39	46	27	16
Northern Cardinal	*Cardinalis cardinalis*	15	13	7	16	8	14	17
Northern Flicker	*Colaptes auratus*	31	21	38	20	27	21	42
Northern Mockingbird	*Mimus polyglottos*	6	13	13	9	6	7	8
Ovenbird	*Seiurus aurocapillus*	19	71	86	58	65	56	89
Pine Warbler	*Dendroica pinus*	5	23	54	25	81	57	91
Red-bellied Woodpecker	*Melanerpes carolinus*	12	8	4	7	15	3	4
Red-breasted Nuthatch	*Sitta canadensis*	5	19	13	11	25	43	38
Red-eyed Vireo	*Vireo olivaceus*	24	31	15	20	28	19	32
Red-tailed Hawk	*Buteo jamaicensis*	3	2	2	6	6	5	5
Red-winged Blackbird	*Agelaius phoeniceus*	8	12	45	16	34	25	18
Scarlet Tanager	*Piranga olivacea*	3	8	7	15	11	13	25
Tree Swallow	*Tachycineta bicolor*	6	3	8	9	17	3	10
Tufted Titmouse	*Baeolophus bicolor*	34	19	29	32	25	26	17
Veery	*Catharus fuscescens*	3	1	6	3	3		
White-breasted Nuthatch	*Sitta carolinensis*	5	3	3	3	3	9	8
Wild Turkey	*Meleagris gallopavo*	15	3	7	8	9	36	38
Wood duck	*Aix sponsa*			3	7	3	4	6
Wood Thrush	*Hylocichla mustelina*	43	16	10	10	12	10	20
Yellow-billed Cuckoo	*Coccyzus americanus*	13	8	20	26	5	6	18

3.12.4 Population Management

There are currently four species on site whose populations either do or may require management in the near future. These are the white-tailed deer (discussed above), Canada geese, wild turkey, and feral cats.

3.12.4.1 Manage Canada Goose Population

As mentioned above, the Canada goose population is currently estimated at 120 birds living year round on the BNL site. Numerous requests for management of the geese were received in 2006 mainly dealing with presence of goose droppings on sidewalks and walkways. In two instances geese were said to be causing safety issues due to their defensive posturing to protect their nests. Recommendations for low, retractable, fencing have been made for deployment by Grounds and Maintenance crews, but the need for repeated removal for mowing and the trip hazard associated with low fencing has resulted in this solution not being implemented. Because of the continued nuisance situation the Natural Resource Program began to evaluate obtaining permits under new U.S. Fish & Wildlife Service (FWS) regulations established late in 2006. These regulations allow nest management to occur based on registering with the FWS and reporting data back to them.

3.12.4.2 Manage Wild Turkey Population

The wild turkey population seems to be stabilizing around 300 - 350 birds. In 2006 only a few instances of nuisance situations, birds pecking at paint on cars, or blocking access to buildings, were reported. In general the turkeys have not cause significant nuisance situations, but if they do, NYSDEC is willing to issue permits for capture and transport of nuisance animals to other locations onsite. Issues with feeding turkeys and other animal seems to have diminished in most cases. When feeding is documented the issue is dealt with on a case by case basis.

3.12.4.3 Feral Animals

BNL has an estimated 30 – 50 feral cats of which approximately 35 are managed in three cat colonies by an ad hoc group of Laboratory employees, who are working to humanely reduce the population onsite. In 2006 the Natural Resource Management Program began working directly with this ad hoc group to gather information on the care of the individual colonies. The group provides monthly data on the amount of food provided to the cats, the general number of cats counted while feeding, the general health of the cats, and documents limited wildlife interactions.

Late in 2006 a pack of at least 4 feral dogs took up residence on the BNL site with a pregnant female taking over one of the cat shelters to give birth to 4 puppies. The mother and pups were captured and sent to the local animal shelter where the pups were cared for until they could be adopted. The mother could not be tamed and was euthanized once the pups were weaned. An effort to capture the other 3 dogs in the pack ensued, but was not successful by year's end.

Table 8. Dragonfly and damselfly species identified during surveys at BNL.

DRAGONFLIES			
Aeshnidae	***Scientific Name***	***Libellulidae (cont.)***	***Scientific Name***
Shadow Darner	*Aeshna umbrosa*	Slaty Skimmer	*Libellula incesta*
Common Green Darner	*Anax junius*	Widow Skimmer	*Lebellula luctuosa*
Comet Darner	*Anax longipes*	Twelve-spotted Skimmer	*Libellula pulchella*
Swamp Darner	*Epeaeschna heros*	Painted Skimmer	*Libellula semifasciata*
Harlequin Darner	*Gophaeschna furcillata*	Band-winged Meadowhawk	*Sympetrum semicinctum*
Gomphidae		Black Saddlebags	*Tramea lacerata*
Unicorn Clubtail	*Arigomphus villosipes*	Blue Dasher	*Pachydiplax longipennis*
Ashy Clubtail	*Gomphus lividus*	Carolina Saddlebags	*Tramea carolina*
Corduliidae		Cherry-faced Meadowhawk	*Sympetrum internum*
Common Baskettail	*Epitheca cynosura*	Common Whitetail	*Libellula lydia*
Williamson's Emerald	*Somatochlora williamsoni*	Eastern Amberwing	*Perithemis tenera*
Libellulidae		Great Blue Skimmer	*Libellula vibrans*
Bar Winged Skimmer	*Libellula axilena*	Black Setwing	*Dythemis nigrescens*
Calico Pennant	*Celithemis elisa*	Spot-winged Glider	*Pantala hymenaea*
Halloween Pennant	*Celithemis eponina*	Wandering Glider	*Pantala flavescens*
Martha's Pennant	*Celithemis martha*	White-faced Meadowhawk	*Sympetrum obtrusum*
Eastern Pondhawk	*Erythemis simplicicollis*	Double-ringed Pennant	*Celithemis verna*
Dot-tailed Whiteface	*Leuchorrhinia intacta*	Ruby Meadowhawk	*Sympetrum rubicundulum*
Spangled Skimmer	*Libellula cyanea*	Frosted Whiteface	*Leucorrhinia frigida*
Blue Corporal	*Libellula deplanata*	Elfin Skimmer	*Nannothemis bella*
DAMSELFLIES			
Calopterygidae	***Scientific Name***	***Coenagrionidae (cont.)***	***Scientific Name***
Ebony Jewelwing	*Calopteryx maculata*	Azure Bluet	*Enallagma aspersum*
Lestidae		Familiar Bluet	*Enallagma civile*
Spotted Spreadwing	*Lestes congener*	Northern Bluet	*Enallagma cyathigerum*
Common Spreadwing	*Lestes disjunctus*	Atlantic Bluet	*Enallagma doubledayi*
Amber-winged Spreadwing	*Lestes eurinus*	Big Bluet	*Enallagma durum*
Sweetflag Spreadwing	*Lestes forcipatus*	Skimming Bluet	*Enallagma geminatum*
Elegant Spreadwing	*Lestes inaequalis*	Pine Barrens Bluet	*Enallagma recurvatum*
Slender Spreadwing	*Lestes rectangularis*	Citrine Forktail	*Ischnura hastata*
Lyre-tipped Spreadwing	*Lestes unguiculatus*	Fragile Forktail	*Ischnura posita*
Swamp Spreadwing	*Lestes vigilax*	Rambur's Forktail	*Ischnura ramburii*
Coenagrionidae		Eastern Forktail	*Ischnura verticalis*
Marsh Bluet	*Enallagma ebrium*	Sphagnum Sprite	*Nehalennia gracilis*
Variable Dancer	*Argia fumipennis*		

3.12.4.3.1 Establish BNL Policy on feral animals

A general agreement on feral cats was established with the ad hoc cat managers. This agreement basically provides for the continued care of existing cats and does not allow any additional cats to be added to the colonies regardless of whether they are introduced or wander into a colony. This policy ensures that the colony size will be reduced over time.

3.12.4.3.2 Protocols for monitoring and managing feral cats

As mentioned above the ad hoc group caring for the feral cats now reports efforts taken to care for the cats. This assists in tracking the health and welfare aspects of the colonies and provides some indication on population levels in each colony.

3.13 Vegetation Management

BNL continues to participate in the EPA Region 2 Performance Track program with one of the commitments being the restoration of 10 acres/year to either native vegetation or to a prescribed fire regime. BNL met its commitment in 2006 through implementation of a 15 acre prescribed fire and the restoration of 1 acre of land where building demolitions took place. The prescribed fire was conducted to restore fire regime to the area with the purpose being to increase oak regeneration. The 1 acre of restored land was planted with native grasses. The three year commitment resulted in a total of 42 acres of land either restored or placed into a fire rotation.

3.13.1 Native Vegetation

As mentioned above an additional 1 acre of land was restored to native grasses after buildings were demolished.

3.13.1.1 Establish Protocol for Use of Native Vegetation

BNL now routinely uses native vegetation in its landscaping efforts. Where possible native vegetation is specified during the planning and design stages of projects

3.13.1.2 Use Native Vegetation on Restoration and new Construction Projects

This is routinely implanted.

3.13.1.3 RHIC Revegetation

Pitch pine seedlings planted in 2001 and 2005 are beginning to grow more rapidly, slowly returning the area to typical Pine Barrens habitats.

3.13.1.4 Establish Policy and procedure for cutting trees

An informal process is used in which the Assistant Laboratory Director for Facilities and Operations makes a decision based on input from Plant Engineering and the Natural Resource Manager. This informal process appears to be efficient as it has become a routine procedure and no additional formalization is deemed necessary.

3.13.2 Invasive Species

BNL continued to participate in the Long Island Weed Management Area efforts in 2006. BNL working with the Central Pine Barrens Commission and The Nature Conservancy had several wetlands onsite surveyed for the presence or absence of invasive plants. Of the six wetlands surveyed none had any invasive plants present.

3.13.2.1 Identify and Monitor Distribution of Invasive Species

In cooperation with the Central Pine Barrens Commission, several of BNL's freshwater wetlands were surveyed for invasive species and found to be "weed free" in 2006. The information on these surveys has been incorporated in the overall Pine Barrens weed mapping effort.

3.13.2.2 Establish Volunteer "Weed Watchers" group

No further action has occurred on this since determining that the group is not needed.

3.13.2.3 Removal or Control of Invasive Plants

This action must still be planned. Several areas containing infestations of highly invasive plants were identified in 2003. The plants in these areas will hopefully be removed before they spread to undeveloped forested areas. An external source of funds must be obtained to support this effort or BNL resources committed.

3.13.2.4 Identify Funding Sources

One of the major issues for invasive species management is funding. In order to protect weed free areas, weeds that can be controlled need to be removed or controlled. Control often means removal and destruction of invasive plants using mechanical or chemical means. Both mechanisms can be expensive. The Natural Resource Management program is requesting budget increases and looking for other funding mechanisms.

No funding has been found to implement reduction of invasive species since most federal funding sources prevent federal facilities from applying.

3.14 Ecosystem Monitoring & Management

BNL utilizes Forest Health Monitoring protocols established by the Foundation for Ecological Research in the Northeast and will participate in the development of Freshwater Wetland protocols in 2007.

FERN continued conducting Forest Health monitoring in 2006, and BNL utilized these protocols to document forest conditions within the area of a 15 acre prescribed fire.

3.14.1 Wetland Health Monitoring

Two Faculty and Student Teams continued work in wetlands in 2006. One team from North Carolina A&T conducted research and monitoring within wetland ponded areas while a second team from Southern University at New Orleans conducted monitoring of the Peconic River headwaters and central wetlands on BNL. Results of this work is presented in the attached posters.

3.14.1.1 Determine Functionality of BNL Central Wetlands

No activity on this item took place in 2006.

3.14.1.2 Maintain or improve wetland functions

This action cannot be undertaken until wetland health monitoring and a determination on functionality is completed. Once the previous two actions are completed then plans for management of the wetlands can be made.

3.14.2 Forest Health Monitoring

Forest health monitoring was initiated in 2002 with the establishment of several deer exclosures in the Upton Reserve. These have been visited each year with photo points established in order to track vegetation growth. These exclosures have provided no real indication of recovery as compared to the control areas outside of the exclosures.

3.14.2.1 Develop Criteria

As mentioned above the protocols were received and implemented across the entire Pine Barrens in 2005, including onsite at BNL.

3.14.2.2 Establish Forest Health Monitoring locations

Monitoring locations and the number of plots necessary was determined by the contractor who developed the various monitoring protocols for forest health. As mentioned above a total of 50 plots in three forest types were established. Additional random plots were identified and 41 additional plots were established in 2006. A final report is planned pending identification of funds to allow the completion of the effort.

3.15 Security

Several security issues were identified in the NRMP that need to be addressed. Most notably is the illegal use of ATVs and motorcycles on site, followed by other trespass issues regarding foot, bicycle, and horse traffic. While foot, bicycle, and horse traffic is illegal it generally does not result in significant damage to the ecosystem.

3.15.1 Illegal Use of ATVs

Illegal ATV use continues to be a problem. The Central Pine Barrens Protected Lands Council began planning mitigative actions to attempt to reduce ATV traffic in the Sarnoff Preserve in Riverhead. Should these actions prove affective, then BNL would determine whether they could be successfully implemented onsite.

3.15.2 Other Trespass issues

No new issues have been identified in 2006.

3.16 Pesticide Use

Plant Engineering and Biology currently manage pesticide use on site using state requirements for application. The need for an SBMS Subject Area and discussions on appropriate use for natural resource management must still be completed.

3.16.1 SBMS Subject Area

This action, if deemed necessary, must still be initiated. Current practices follow all required regulations. If a subject area is needed, its development must be placed on the SBMS master schedule.

3.16.2 Use in Natural Resource Management

In the future the use of pesticides, primarily herbicides, will be necessary for control of invasive plants. Protocols for use and approvals must be developed when determined necessary.

3.17 Wildland Fire Management

BNL approved the Wildland Fire Management Plan. No new actions are currently necessary.

3.17.1 Implement Wildland Fire Management Plan

The Wildand Fire Management Plan continues to be implemented.

3.17.2 Implement Use of Prescribed Fire

BNL's second prescribed fire took place in October 2006 when a 15 acre parcel in the northeast section of the Laboratory was burned. The current prescription for a larger 60 acre block was being prepared toward the end of 2006 for implementation in 2007. New prescribed fire plans would allow prescribed fire outside of the Annual Wildland Fire and Incident Command Academy held each October.

3.18 Integration of Cultural Resources

Cultural Resource Management issues are now routinely incorporated in natural resource planning.

3.18.1 Identify Cultural Resources and Develop GIS layers

Cultural resource map layers are routinely maintained within the GIS.

3.19 GIS and GPS

The Natural Resource Management program has integrated GIS and GPS into much of its management. GPS is routinely used to obtain location information of species, habitats and most recently the movement of species including eastern hognose snakes, spotted turtles, and box turtles. GPS information is entered into the GIS and new layers developed as necessary.

3.19.1 Develop Natural Resource data layers for GIS

The GIS has been used to map home range information for all species that are being tracked with radio telemetry equipment. In 2006 eastern box turtle, red fox, and grey fox were added to species being tracked.

3.19.2 Plan Trails and paths that limit impact

No actions were taken on this in 2006.

3.19.3 Fill data gaps concerning flora and fauna

Filling data gaps is documented throughout this annual report in earlier sections concerning endangered, threatened, and species of special concern, reptile and amphibian studies, and Odonate studies as examples.

3.20 Education Programs

In 2006, the Natural Resource Management program and the Foundation for Ecological Research in the Northeast hosted twenty-five individuals that included a 2 Faculty and Student Teams (2 Professors and 7 -students), four Lab Science Teacher Professional Development interns, eleven undergraduate research interns, and one high school intern, all working on various projects. These interns completed work on salamanders, radio telemetry work on eastern box turtles, inventory of Odonate species, genetic evaluation of chytrid fungus in frogs, island wide surveys for southern leopard frog, genetic surveys for red and gray fox, soil and water chemistry interactions of coastal plain ponds, forest health monitoring, and small mammal surveys. Additionally, FERN hired a permanent biologist and office manager to coordinate and manage work on the Forest Health Monitoring project.

Each intern was responsible for their own research as well as assisting each other in the collection of data. Results of the research were presented in a poster session sponsored by the Office of Education Programs, and the research was also presented at a poster session at the Pine Barrens Research Forum. Copies of all posters are attached to this report.

Many students and BNL staff participated in the BNL Science Museum's Summer Camp program. Each week, camp participants met on Thursday at the Weaver Rd. pond to learn about soils and water. Each intern also presented their research to the campers. These lessons introduced students in grades 4 –6 to the various research topics, and gave the student interns an opportunity to learn teaching skills.

3.21 Research

Research carried out in 2006 through funding from FERN included the Forest Health Monitoring mentioned above, microbial study of the Gamma Forest soils, and an island wide search for the southern leopard frog. FERN also developed a database for the forest health data and prepared an annual report of the efforts.

3.21.1 Identify, attract, and support ecological research to BNL

Researchers from SUNY Binghamton continued working on a tiger salamander research in 2006. As mentioned above FERN funded research looking at the microbial make-up of Gamma Forest soils. A researcher from St. John's University also began revisiting the floral composition of the Gamma Forest to look at age structure and species make-up roughly 30 years after the experiment was terminated.

The Foundation for Ecological Research in the Northeast continues to work on identifying outside sources for funding research in the Pine Barrens.

3.22 NRMP Plan Update

Since the NRMP was completed in December 2003 it will not require a complete update until 2008 (five years). Appendix C of the NRMP has been updated to reflect progress made in 2006. Appendix C is attached.

This report once completed will be provided to the TAG for their information.

APPENDIX C

NATURAL RESOURCE MANAGEMENT PLAN – ACTION ITEMS

Action Item	Site ID	Action	Planned Date	Action Taken
1	*Site-wide	Transition WMP Action into NRMP	December 2003	Complete
2	Site-wide	Annual Summary Report	Annual by March 31	Ongoing
3	Site-wide*	TAG Review of Annual Report	Annual by May	Ongoing
4	Site-wide*	Adapt Management based on new information	As Required	3nd annual report 4/30/06, ongoing
5	Site-wide*	Improve decision making through use of innovative tools	As Necessary	Implemented 2003, ongoing
6	Site-wide*	Maintain and Improve relationships with stakeholders	Continual	Ongoing
Peconic River/Basins				
7	Peconic River Station HMn	Monitoring for flow: water quality	Monthly sampling SPDES Program	Ongoing
8	Fish Sampling Peconic River	Fish sampling with NYSDEC/Cold Spring Harbor: population assessment of banded sunfish and swamp darter	Annual Spring/Summer	Ongoing
9	TS-7	Monitoring for water quality	Monthly sampling SPDES Program	Ongoing
Deer Management				
10	*Site-wide	Issue and Discussion Paper on deer management by Natural Resource Manager	Fall 2003	On hold, indefinitely
11	*Site-wide	Environmental Assessment under NEPA for deer management		On hold, indefinitely
12	*Site-wide	Implement Deer Management		On hold, indefinitely
13	Site-wide	Deer population estimation	Nov-Jan May-June	Ongoing. Routine estimates made twice a year, new protocol developed in 2004
Special Status Species				
14	*Site-wide	Maintain Special-status species list	Annual Review	Ongoing
15	*Site-wide	Identify habitats of special-status species	Continual	Ongoing
Tiger Salamander				
16	Site-wide	TS annual egg mass surveys at breeding ponds	Feb-April 2003	Ongoing
17	Site-wide	TS Larval Survey	Annual June-July	Ongoing
18	Education	Provide educational material or opportunities to BNL staff and public on environmental issues	Continual	Ongoing
19	*RHIC	New pond being added at RHIC	Summer 2004	completed
20	Tiger salamander	Set up cover boards around one breeding site (as a test case)	Summer	Summer 2001 & 2002, completed, drift fences installed
21	TS-A7	Lining of pool ER program	Aug 2003	Completed
22	TS-W6b	Pond Remediation ER program	2004-2005	Completed

APPENDIX C

NATURAL RESOURCE MANAGEMENT PLAN - ACTION ITEMS

(continued)

Action Item	Site ID	Action	Planned Date	Action Taken
Banded Sunfish				
23	OU V	Peconic River Remediation Program	Spring 2004	Completed, tracking success of restoration
Frosted Elfin				
24	*Habitat Specific	Confirm presence/absence of Frosted Elfin	May-June Annually	Ongoing
25	*Habitat Specific	Establish standard monitoring protocols for the Frosted Elfin		
26	*Species Specific	Maintain and Enhance habitat for the Frosted Elfin	Continual	Ongoing
27	*Site-wide	Habitat assessment for lupine	Spring 2004	Ongoing
Habitat Enhancement/ other species				
28	Site-wide	Bird nests/boxes	Ongoing	Routine monitoring and maintenance of bluebird, kestrel, wood duck nest boxes
29	*Site-wide	Develop survey methodology to document all biota on BNL	2004	Contract through Upton Reserve
30	Site-wide	Monitor Canada Goose and Wild Turkey populations	Ongoing	
31	Site-wide	Turkey sighting reports to NYSDEC	Ongoing	Reports sent annually in September or upon request
32	Site-wide	Song bird surveys	April – Sept.	Continuing
33	*Site-wide	Odonata Surveys	Summers	Initiated 2003, ongoing
34	*Site-wide	Reptiles and amphibian Surveys	Ongoing	Reptiles & Amphibians started 2003
Population Management				
35	*Site-wide	Manage Canada Goose population	As necessary	Not needed, yet
36	*Site-wide	Manage Wild Turkey population	As necessary	Not needed, yet
37	*Site-wide	Establish BNL policy on feral animals	General policy implemented	
38	*Site-wide	Establish monitoring and management protocols for feral animals	Fall 2003	Initiated, ad hoc group providing monitoring information
Vegetation Management				
39	*Site-wide	Establish protocol for use of native vegetation		Routinely done w/out protocol
40	*Site-wide	Use native vegetation on restorations and new construction landscaping	As necessary and applicable	Initiated 2003, ongoing
41	RHIC Revegetation	Implement Revegetation	Ongoing	Grasses planted 2002 and 2003, Completed 2005
42	*Site-wide	Establish policy and procedure for cutting trees		Informal Procedure appears adequate.
Invasive Species				
43	*Site-wide	Identify and monitor distribution of invasive species.	Ongoing	Mapping started Summer 2003, completed 2005
44	*Site-wide	Establish volunteer “Weed Watchers” group	Ongoing	Group formed May 2003, disbanded 2005

APPENDIX C

NATURAL RESOURCE MANAGEMENT PLAN - ACTION ITEMS

(continued)

Action Item	Site ID	Action	Planned Date	Action Taken
45	*Site-wide	Removal or control of invasive plants where possible.	As necessary	None taken
46	*Site-wide	Identify funding for removal or control of invasive plants where possible.	As necessary	None identified
Ecosystem Monitoring and Management				
47	*Site-wide	Develop criteria to monitor wetland health	2007	
48	*Site-wide	Determine functionality of BNL Central wetlands	2007-2009	
49	*Site-wide	Maintain or improve wetland functions		
50	*Site-wide	Develop criteria to monitor forest health	Fall 2004	Completed 2005
51	*Site-wide	Establish forest health monitoring locations	Summer 2005	Initiated 2005, continued 2006
Security				
52	*Site-wide	Coordinate with Security to reduce illegal use of ATVs	Continual	Ongoing
53	*Site-wide	Other trespass Issues	Continual	Ongoing
Pesticide Use				
54	*Site-wide	Determine need for a SBMS subject area on pesticides	As necessary	
55	*Site-wide	Pesticide use for natural resource management	As identified	
Wildland Fire Management				
56	*Site-wide	Implement Fire Management Plan	Sept. 2003	Plan Approved September 2003
57	*Site-wide	Implement use of prescribed fire and mechanical fuel reduction	March 2003	1st Fire November 2004 CY2006 Approved
Cultural Resource Management				
58	*Site-wide	Identify cultural resources and develop into GIS layers	Ongoing	LEED Area Identified 2005
GIS and GPS				
59	*Site-wide	Develop natural resource data layers of GIS	Ongoing	
60	*Site-wide	Plan trails and paths that limit impact on the environment while introducing employees to forest diversity.		
61	*Site-wide	Fill data gaps concerning all flora and fauna, including the following: terrestrial and aquatic invertebrates, Lepidoptera, wild flowers, and grasses.	Ongoing	

APPENDIX C

NATURAL RESOURCE MANAGEMENT PLAN - ACTION ITEMS

(continued)

Action Item	Site ID	Action	Planned Date	Action Taken
62	Site-wide	Education Programs	Ongoing	Utilize Office of Education Programs Interns, etc. 18 interns 2005
Research				
63	Site-wide	Cooperate with Upton Reserve, support and conduct research as needed	Ongoing	Assisting Upton Reserve in coordinating research programs, Transitioned to FERN
64	*Site-wide	Identify, attract, and support ecological research at BNL	Ongoing	Coordinating with FERN
65	Site-wide	NRMP Plan Update	Every 5 years Next update 2008	---

Notes: * New initiative

ER – Environmental Restoration
GIS – Geographical Information System
NEPA – National Environmental Policy Act
NYSDEC - New York State Department of Environmental Conservation
NRMP – Natural Resource Management Plan
OU V – Operable Unit V
RHIC - Relativistic Heavy Ion Collider
TS – Tiger Salamander

ATTACHEMENTS

STUDENT INTERN POSTERS

Spatial distribution of Iridovirus in the Eastern box turtle population at Brookhaven National Laboratory: Implications for transmittance based on home range size

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ABSTRACT

There are currently four recognized genera of the icosohedrally symmetric iridoviruses that infect both invertebrates (*Iridovirus* and *Chlorirdovirus*) and poikilothermic vertebrates (*Lymphocystivirus* and *Ranavirus*). Ranaviruses have only been documented in a relatively few number of reptiles when compared to the number of viruses that have been documented in amphibians and fish. Relatively recent detection of ranaviruses in five species of chelonians, including a virus outbreak in a population of Eastern box turtles (*Terrapene carolina carolina*) at Brookhaven National Laboratory, is especially alarming. This discovery poses a threat to box turtles in surrounding areas since the species is listed as Special Concern in the state of New York. To ascertain the current distribution of infected turtles at Brookhaven National Laboratory, cloacal and oral samples were collected and virus testing was performed using molecular genetic techniques. To further explore the potential transmission of the ranavirus within the box turtle population, determining individual home range size was necessary. Habitat quality, structure, diversity, individual preference, and population density all account for variation in size and spatial structure of box turtle home ranges. Due to this variability, it was crucial to determine home range size specific to the study area in question. Radiotransmitters were attached to 5 box turtles inhabiting the area of *Ranavirus* discovery and their daily movements and habitat preferences were recorded. Geographic Information Systems (GIS) was used to digitally map home range area in order to determine *Ranavirus* dynamics and the potential for disease spread within the box turtle population. Preliminary results indicate that the virus is likely present in the box turtle population at Brookhaven National Laboratory. Home ranges of turtles appear to be relatively small but overlapping which suggests favorable conditions for virus spread, depending on encounter rates and mode of transmission.

INTRODUCTION

Viruses of the family Iridoviridae are characterized by their icosahedral symmetry. These viruses are large and enveloped, with diameters ranging from 125 to 300 nm. They contain a linear double-stranded DNA genome which may vary from 140 to 303 kilobase pairs. Viruses are replicated within the cytoplasm at morphologically distinct viral assembly sites where they may then be released into the extracelluar space by membrane budding [1,2,3]. There are currently four genera of recognized iridoviruses that infect both invertebrates (*Iridovirus* and *Chlorirdovirus*) and poikilothermic vertebrates (*Lymphocystivirus* and *Ranavirus*) [1]. While *Lymphocystivirus* have only been found in freshwater and marine fishes, *Ranavirus* has been isolated from fish, reptiles, and amphibians.

Ranaviruses have only been documented in a relatively few number of reptiles when compared to the number of viruses that have been documented in amphibians and fish [4,5]. The majority of reptile ranaviruses have been observed in chelonians. Of important note are the multiple observations of iridovirus infections in Eastern box turtles (*Terrepene carolina carolina*). A ranavirus (TV3) may be responsible for box turtle epizootics as early as 1991. The current investigation focuses specifically on the discovery of an iridovirus infection in two wild box turtles which were found at Brookhaven National Laboratory in Suffolk County, New York (USA) on 2 August 2005. The turtles exhibited ocular discharge and swelling, aural abscesses, and yellow caseous plaques. Later histopathology, PCR, and virus isolation confirmed a ranavirus infection [6]. This finding poses a threat to box turtles in surrounding areas since the species is listed as Special Concern by the New York State Department of Conservation. According to De Voe et al. (2004), "under appropriate environmental or host circumstances, this ranavirus [TV 3] may be capable of causing considerable morbidity and mortality in eastern box turtles." [7]

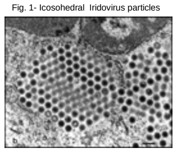
In investigating iridovirus transmission in Eastern box turtles at Brookhaven National Laboratory, the determination of home range, among other parameters, was necessary in order to evaluate the potential spread of the virus within the turtle population. Three techniques are generally used to study the movements and home ranges of box turtles: the mark-recapture method, thread-trailing, and radiotelemetry. Radiotelemetry provides a reasonably accurate assessment of both habitat use and movement patterns over a long time span [8]. Habitat quality, structure, diversity, and individual preference all account for variation in size and spatial distribution of home ranges. This explains the wide array of box turtle home range estimations that vary from 1 to 9.77 ha [8]. Due to this variability, it is necessary to determine home range size specific to the study area in question. Geographic Information Systems (GIS) can be an effective tool in investigating disease spread within populations through digitally mapping the non-infected and infected turtle distribution, home range area, and home range overlap [9]. Spatial analysis will allow inferences to be made on potential disease spread if transmittance is through animal contact.

MATERIALS AND METHODS

Iridovirus Testing

- To ascertain the current distribution of infected turtles at Brookhaven National Laboratory, cloacal and oral samples were collected from turtles encountered on the Laboratory property from chance encounter and through systematic transect searching. Intensive searching was conducted at the pond site where the infected turtles were found in 2005.
- DNA was then extracted from swabs using the Buccal Swab Spin Protocol for the DNeasy kit (Quiagen, Valencia, CA, USA). The *Ranavirus* major capsid protein was amplified using the sense primer (5'-GACTTGGCCACTTATCAC -3') and anti-sense primer (5'-GTCTCTGGAGAAGAAGAA-3') as previously described [6]. Turtle DNA was also amplified as a control.
- Using a Taq PCR Kit (New England Biolabs), mixtures containing the extracted DNA, primers, distilled water, 10x buffer, dNTP, Mg, and Taq were amplified in a thermal cycler (PTC-100, MJ Research). PCR products were resolved in 0.8% agarose gels and bands were examined.

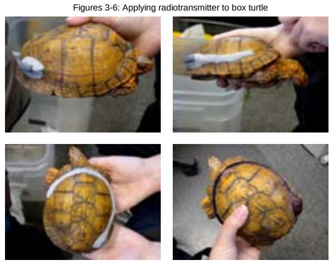
Fig. 1- Icosohedral Iridovirus particles



http://www.cdc.gov/ncidod/EID/vol5no6/daszakG4.htm

Fig. 2- Box turtle found with aural abscess

Figures 3-6: Applying radiotransmitter to box turtle



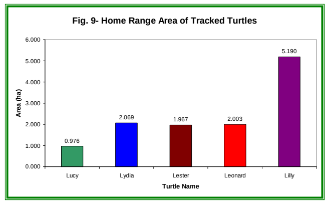
Home Range Analysis

- In order to determine box turtle home range specific to the study site, radiotransmitters were attached to 5 box turtles inhabiting the area of *Ranavirus* discovery. Transmitters were attached to the carapace and encased using Oatey epoxy putty, which was later colored black to ensure camouflage.
- Turtles were tracked daily and their location was recorded using a Global Positioning System (GPS). Weather and vegetation plot data was also collected for future analysis of habitat preferences.
- Using Geographic Information Systems (GIS) daily and total movements and minimum convex polygons were used to analyze the home range of individual turtles and to determine average home range and chance of encounter between turtles.

Fig. 7- Radiotracking turtles at study site

Fig. 8- Collecting data in the field

RESULTS



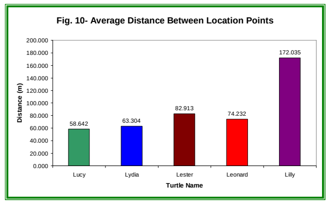


Fig. 11- Map representing encounter locations, directional movements, and home ranges of radio tracked turtles using minimum convex polygons

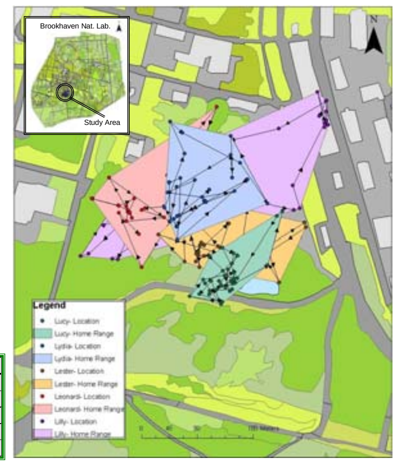


Table 1- Number of times direct paths between locations cross

	Lucy	Lydia	Lester	Leonard	Lilly
Lucy	X	0	9	0	0
Lydia	0	X	4	14	5
Lester	9	4	X	2	0
Leonard	0	14	2	X	39
Lilly	0	5	0	39	X

We were not able to successfully isolate or amplify either turtle or iridovirus DNA from the oral and cloacal swabs so the distribution of non-infected and infected turtles could not be spatially mapped and analyzed. Two turtles were found during this study (one in the study area) that exhibited viral symptoms including aural abscesses. Both were taken to a rehabilitator and one died shortly after. The abscess on the deceased turtle was tested for turtle and viral DNA but also yielded no results.

DISCUSSION AND CONCLUSION

Preliminary results suggest iridovirus is still present in the population of Eastern box turtles at Brookhaven National Laboratory because two turtles found exhibited advanced signs of infection. The technique used for DNA isolation and amplification is not successful thus far for use with oral and cloacal swabs. Swabbing may not be an adequate means of collecting DNA or the PCR product may have become contaminated. A different thermal cycling regime was followed than was previously described in iridovirus isolation which may also be the source of error.

Data from the five radio tracked turtles confirms that box turtles have well defined home ranges that often grossly overlap or are completely superimposed and, generally, individual home ranges of box turtles are stable [10]. Analysis of contact using the intersection of direct routes between encounter locations indicates that each turtle may have encountered at least one other transmitterred turtle at least once with some crossing paths almost 40 times. Individual preference appears to play a significant role in amount of movement and home range area with one turtle traveling over twice the distance and area as the others (Lilly) while the other four turtles exhibited similar movement patterns. All turtles tended to return to preferred core areas of their home range. Average distance traveled between encounter locations ranged from 58.642 m (Lucy) to 172.035 m (Lilly) with a mean distance of 90.225 m. Home range calculated using a minimum convex polygon ranged from 0.976 ha (Lucy) to 5.190 ha (Lilly) with a mean area of 2.441 ha. Results from this study are in agreement with Dodd (2001) who generalized home range of box turtles to be fairly small, varying from 1 ha to 5 ha with a diameter less than 300 m. In contrast, turtles in one Long Island population were reported to have home ranges averaging 9.77 ha while another Long Island population had home ranges averaging 6.77 ha. Both populations are assumed to reside under less than ideal habitat conditions [11] suggesting habitat at Brookhaven National Laboratory is well suited for this chelonian.

Although home range of box turtles at the study site appear to be at the smaller end of the spectrum according to the literature, the high degree of overlap of the home ranges is an important factor in the spread of iridovirus. While the virus may be contained in a relatively small area, spread to many individuals is likely. We are not able to test individuals for the virus at this time but it is presumable that, based on the overlapping home ranges of the tracked turtles, the infected turtles that were discovered likely could have spread the disease to turtles within their range. After virus testing techniques are refined, a management plan will be needed in order to evaluate and control the virus in the box turtle population at Brookhaven National Laboratory.

ACKNOWLEDGEMENTS

I would like to thank the Department of Energy and staff at Brookhaven National Laboratory's Office of Science for the opportunity to participate in the Student Undergraduate Laboratory Internship (SULI) Program. I would especially like to send thanks to my mentor, Valorie Titus, for her guidance, expertise, and patience throughout the project. Finally I would like to thank Doris Jwo in the High School Research Program for her help collecting data in the field and enduring the ticks.

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BROOKHAVEN NATIONAL LABORATORY

Office of Science U.S. DEPARTMENT OF ENERGY

The Use Of Mark-recapture to Estimate a Population of Cherry-faced Meadowhawk (*Sympetrum internum*) at a Vernal Pool on Brookhaven National Laboratory

Abstract

Dragonflies are insects of the order Odonata, suborder Anisoptera. Of the 3000 species known world wide, more than 100 species occur in the state of New York and 32 have been identified at Brookhaven National Laboratory. Odonates play a role in maintaining the delicate ecosystem of vernal pools and other bodies of water such as marshes, streams, and wetlands. Tracking and monitoring Odonates can be extremely difficult due to their relatively short lifespan, numerous populations, and extraordinary flight speed. To observe and monitor Odonates, the use of a tracking system is needed to keep accounts of specific species populations. Using a simple form of Mark-Recapture, the Odonates are caught in nets, and marks are drawn on their wings with non water-soluble markers. During a course of ten weeks, the method of Mark-Recapture was employed and perfected, considering there has been no previously documented use of it on Odonates there was a necessity to perfect the method to optimize results. Once perfected the system was used during the final four weeks, concentrating on one species, the Cherry-Faced Meadowhawk (*Sympetrum internum*) at one pond. Using the Mark-Recapture method we have found that the method can be successfully employed on Odonates with positive results. A total of 168 Cherry-faced Meadowhawks were captured with 32 individuals recaptured at least once. Using the program NOREMARK, two population estimates were generated, one estimate using the numbers of captured and recaptured Cherry-faced Meadowhawks, and one that also added a variable to account for emigration and immigration. The program estimated about 300 Cherry-faced Meadowhawks inhabit pond 7, without including emigration and immigration. Including the variable for immigration and emigration, the program estimated the population to be over 500 Cherry-faced Meadowhawks inhabiting pond 7. The method of Mark-Recapture has proven useful in the study of Odonates and may be used for future population estimates of other Odonate species. This research is part of an ongoing project that was started in 2003 to observe the Odonate populations of the Brookhaven National Laboratory and will be continued until an accurate account of species is created. Additionally, three new species of Odonates, not previously documented, were added to the list of those found at Brookhaven National Laboratory.

Cherry-faced Meadowhawk (*Sympetrum internum*)

Introduction

Odonates are predacious flying insects that inhabit bodies of water such as vernal pools, ponds, lakes, and streams. Within the order Odonata there are two sub-orders, Anisoptera (dragonflies), and Zygoptera (Damselflies). Odonates are physically characterized by a head with 2 compound eyes and three small "simple" eyes, a thorax with six bristly legs and two pairs of membranous wings, and a long brightly colored abdomen consisting of 10 segments. Since 2003 research has been conducted at Brookhaven National Laboratory (BNL) to identify the species inhabiting the ponds and Peconic River onsite. Currently there are approximately 32 identified species of dragonflies onsite at BNL. The purpose of this project is to try to identify new species, observe life span and attain an estimate of species population for at least one species. Since Odonates play a role in maintaining the delicate ecosystem of vernal pools and other bodies of water such as marshes, streams, and wetlands it is desirable to be able to estimate the health of a population within a given area. Tracking and monitoring Odonates can be extremely difficult due to their relatively short lifespan, numerous populations, and extraordinary flight speed. To observe and monitor Odonates, the use of a tracking system is needed to keep accounts of individual species populations. This study specifically looked at the development of a suitable marking system and conducted a proof-of-concept technique using off the shelf software to estimate the population of the Cherry-faced Meadowhawk (*Sympetrum* internum) at one pond on the BNL campus.

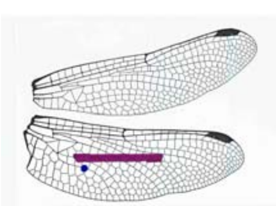

Figure 1. Wing marking pattern. Magenta line indicates pond, dot indicates specific individual (2nd captured).

Cherry-Faced Meadowhawk (*Sympetrum internum*) in Obelisking position

Materials and Methods

To collect the dragonflies, a 15-inch diameter net was used to catch the specimens while in flight or perched on vegetation. Waders were worn to wade through ponds and flooded areas around the ponds. A magnetic board was used to hold down individual dragonflies by pinning down their wings with a magnet. Non-water-soluble markers were used to mark their wings to denote the pond they were found inhabiting and distinguishing marks to note individuals of a species. Once all the data on marked individuals was recorded, the program called NOREMARK was used to calculate population estimates with and without variable's for Odonates that were marked and unmarked, and those that immigrate and emigrate.

The marks drawn on the Odonates wings distinguish one individual from another of one species, as well as denoting the pond they were found inhabiting. Each time a dragonfly is caught an additional mark is placed on the wing to note its recapture which in turn will allow us to observe a lifespan by observing the time between initial capture and final recapture, keeping in mind that the final recapture may not necessarily reflect the exact life span, but a rough estimate. The first six weeks of the ten week study was spent observing the entire dragonfly population at multiple vernal pools. Once the method of Mark-Recapture was proven to be useful in monitoring individuals of multiple species, the remaining four weeks was used to concentrate on one species at one pond in order to develop population and survival estimates.

The marking system employed involves a base color that represents the pond in which the dragonfly was found inhabiting, and an additional color to distinguish one individual from another. The color magenta was used solely for pond 7 and was placed on the right hind wing. Blue was used for the additional markings, and was utilized at every pond. In some cases, green was also used in addition to the blue marking because of the multitude of specimens and need for variation in markings. So every dragonfly caught at pond 7 would have, at minimum, one magenta line. In addition to the magenta line, each individual would have a unique magenta or blue marking which would be placed either on the right hind wing or the right forewing. Multiple series of dots and lines were used. The first individual of all species captured would get a single magenta line on their hind wing. The second would get the magenta line plus a single blue dot right next to the magenta line(See figure 1). This series of markings went up to one magenta line and six blue dots, which would make seven individuals of the same species. The eighth individual would receive two horizontal parallel magenta lines, and there after up until the eleventh another series of dots was placed ranging from one to three. For the Cherry-faced Meadowhawks, after the eleventh dragonfly was marked, vertical blue lines were placed between the two magenta lines in a series up to six. Once that series was complete, multiple combinations of horizontal blue and magenta lines were placed with additional dots of either blue or magenta(See figure 2). After 33 markings on the right hind wing, the right forewing was used for marking in addition to having at least the single magenta line on the hind wing(See figure 3). One hundred and sixty-eight Cherry-faced Meadowhawks were captured so in order to keep from repeating a marking, the English alphabet was used twice, once with all capital letters in blue below the magenta line, and once with lowercase letters above the magenta line. Additionally, eighteen characters from the Japanese alphabet, Katakana, were used in marking the Cherry-faced Meadowhawks. However, the marks could be repeated for the opposite sex, so a male and female Cherry-faced Meadowhawk could have the exact same marking, but two males or two females could not.

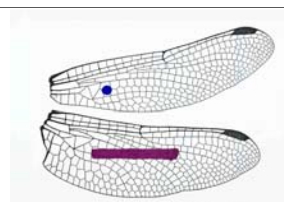

Figure 3. Wing marking pattern. Line indicates pond, as numbers captured increased dot pattern moved to forewing, spot indicates 54th captured individual.

Results

During the summer of 2006, a total of 3 ponds were visited on site at BNL. The Ponds visited were pond 7, pond 13 and the 9 o'clock pond. Over the three years of odonate research at BNL, 35 species have been found out of 56 recorded in Suffolk County, which includes the Common Baskettail (Epitheca cynosure), Martha's Pennant (Celithemis martha) and the Frosted Whiteface (Leucorrhinia intacta) which were found for the first time this year at BNL. The Frosted Whiteface being documented for the first time on Long Island. It has been established that mark-recapture can be successfully employed on Odonates with plausible results. Through the use of the program NOREMARK, population estimates have been calculated for the Cherry-faced Meadowhawks at pond 7 as being between 300 and 600 individuals.

Discussion

The purpose of the 2006 Summer Odonate research was to first test if the method of mark-recapture could be successfully employed and yield plausible results. To test the mark-recapture method three ponds were visited on a semi-regular basis and specimens of various species were captured, marked, and released. Frequent visits to the ponds yielded recaptures of some of the marked species, which proved that the method of mark-recapture could be employed with results. Once assured of the usefulness of mark-recapture, only one pond was visited, pond 7, and one species, the Cherry-faced Meadowhawk (*Sympetrum internum*), was concentrated on to calculate a population estimate. A total of one hundred and sixty-eight Cherry-faced Meadowhawks were captured with thirty-two individuals recaptured at least once. This data was entered into the NOREMARK program and two estimates of the Cherry-faced Meadowhawk population were computed. One estimate computed the population using only the numbers of marked and recaptured individuals, and the other estimate included a variable to account for individuals, marked and unmarked, which may have immigrated or emigrated. The estimates computed were approximately 350 Cherry-faced Meadowhawks inhabiting pond 7, without the variables, and over 500 with the variables for marked and unmarked immigration and emigration. Although these estimates have a difference of over 150, both appear to be accurate. The estimate of 350 Cherry-faced Meadowhawks only calculates those that were marked and those seen but unmarked. It must be taken into consideration that there were Cherry-faced Meadowhawks that were never captured or seen, and that there may, and most likely, were dragonflies on the opposite side of the pond being surveyed. The estimate which included the variables for migrating, immigrating, and unseen Cherry-faced Meadowhawks, presumably, appears to be more accurate. Three data entries were made with these variable and yielded population estimates of 516, 609, and 602. Although the gap between the two lowest estimates is 86, these estimates were calculated with 165, 166, and 173 known dragonflies alive. Averaging the three estimates would yield a population estimate of 575 Cherry-Faced Meadowhawks.

For future studies it would be recommended to either have a rough estimate of the population of specimens being researched or to project a high number to allow for the development of an easily utilized marking system. This was the first documented use of mark-recapture on odonates, so there was no information available on the type of marking system that could be used. Consideration should also be taken on whether or not it would be desirable to use gender specific markings. Gender specific markings may require physical recapture to identify the sex, where non gender specific markings would allow you the ability to visibly note a sighting of a marked individual. Also, the use of a recapture mark, may allow for easy noting of recapture where no recapture mark would require proper note taking and reliance on memory, but would allow identification by sight without the need to physically capture the animal.

Figure 2. Cherry-faced Meadowhawk(*Sympetrum internum*) with marking on right hind wing. Markings indicate the individual as the 18th captured in this study.

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I would like to take this opportunity to thank the U.S. Department of Energy for the opportunity to participate in the Pre-Service Teacher(PST) program. I would also like to thank Suffolk County Community College for introducing me to the Collegiate Science and Technology Entry Program (CSTEP) which allowed me to discover the opportunities available to me such as the internships available at Brookhaven National Laboratory. I would also like to thank my mentor Tim Green for all his time, help and support. And I would also like to thank my fellow interns, Chauncey Leahy, Wendy Finn, Sarah Snyder, and Katie Heiser, who helped me with my research and allowed me the opportunity to help with their work as well.

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Suffolk County Community College

Office of Science U.S. Department of Energy

Brookhaven National Laboratory

A Study of Variations in Soil and Water Chemistry of Selected Ponds at Brookhaven National Laboratory

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Abstract

Brookhaven National Laboratory (BNL), a 5,265 acre site, contains a variety of wetlands; included are coastal plain ponds, vernal pools, recharge basins, and streams. Wetland habitats in Pine Barrens communities serve important ecosystem functions, including providing critical habitat for the state endangered tiger salamander (*Ambystoma tigrinum*) and a number of other rare species. Survey techniques were used to gather information on soil and water chemistry of seven coastal plain ponds at BNL: four natural ponds (BP1, BP2, BP6, BP9), one man-modified pond (BP7), and two man-made ponds (BP13a, Meadow Marsh). Each pond was tracked using Global Positioning System (GPS) technology and mapped using ArcGIS. Five water samples were collected at each pond; nine soil samples were collected at five of the seven ponds. Water samples were analyzed for iron, sulfate, total chlorine, copper, aluminum, nitrate, phosphorus, tannin-lignin, suspended solids, hardness, total chromium, and molybdenum using HACH DREL/2000 and HACH CEL/890 water test kits. Soil samples were analyzed for pH, nitrate nitrogen, phosphorus, potassium, aluminum, ferric iron, magnesium, sulfate, calcium, and chloride using LaMotte soil test kits. Soil temperature, color, texture, structure, and consistency were also determined. A YSI 650 MDS meter with multi-probe was used to field-test water temperature, pH, dissolved oxygen, turbidity, and conductivity at each sample point. Water samples and soil extracts were also analyzed using an ICP-AES. The pH and temperature of the soil around the natural ponds was significantly lower than that of the anthropogenic ponds. The pH of the water from the natural ponds was significantly more acidic and the tannin-lignin content significantly higher than that of the anthropogenic ponds. We propose that these differences in the soil and water chemistry of the ponds can be explained by the nature of the surrounding vegetation. The presence of a tree canopy and dense shrub layer around the natural ponds reduces their exposure to solar radiation and increases the amount of leaf litter being added to the soil and water. The results of this study provide baseline data for monitoring pond health in the future and for assessing the suitability of ponds as breeding sites for tiger salamanders (*Ambystoma tigrinum*).

Introduction

Pine Barrens are a type of temperate coniferous forest found in southern New Jersey, Long Island, New York, and Cape Cod, Massachusetts [1]. Pine Barrens develop on soils that are nutrient poor and acidic, with a high percentage (80-96%) of well-drained sand [3]. Pine Barrens are maintained by periodic natural wildfires and without them their distinctive vegetation is replaced by hardwood forest and weedy species [1, 4]. Pitch pine (*Pinus rigida*) is the dominant tree species of the Pine Barrens. Pitch pine requires bare mineral soil for establishment from seed, is relatively shade-intolerant, and possesses adaptations to survive the fires that frequent the Pine Barrens [5]. Vernal ponds and coastal plain ponds play an important role in Pine Barrens communities: water storage, replenishment of the aquifer, nutrient retention and cycling, and they can be an important water source and refuge for resident and migrating wildlife [6, 7]. On Long Island, these ponds provide breeding habitat for frogs, toads, and salamanders, including the New York state endangered tiger salamander (*Ambystoma tigrinum*) [8, 9]. Although many studies have been carried out in the Central Pine Barrens, little is known about the soil and water chemistry of these critical breeding sites. In light of this a study was initiated to investigate several coastal plain ponds on BNL, both natural (fig. 1) and man-made or man-modified (fig. 2).

Fig 1. BP1: A natural pond

Fig 2. MM: A man-made pond

Methods and Materials

Seven ponds on Brookhaven National Laboratory were selected for sampling. They were designated BP1, BP2, BP6, BP7, BP9, BP13a, and Meadow Marsh (MM). BP1, BP2, BP6 and BP9 are natural ponds in a forested landscape; BP7, BP13a and MM are anthropogenic. A track of each pond was taken using an eTrex® Vista Cx Global Positioning System unit. These were downloaded into ArcGIS. Four water sampling points were marked on the north, south, east, and west sides of each pond; a fifth sampling point was established at the approximate center of the pond. A YSI 650 MDS meter with multi-probe was used to determine temperature, pH, dissolved oxygen, turbidity, and conductivity of the water. Water samples brought back to the laboratory were analyzed for iron, sulfate, total chlorine, copper, aluminum, nitrate, phosphorus, tannin-lignin, suspended solids, hardness, total chromium, and molybdenum using HACH DREL/2000 and HACH CEL/890 water test kits. A 100 ml subsample was preserved for ICP-AES analysis. Soil samples were collected from five of the seven ponds: BP6, BP7, BP9, BP13a and MM. Soil samples were collected on the north, south, east, and west sides of the pond 2 meters from the shoreline. Four additional sample points were placed midway between those sample points (northwest, southwest, southeast, northeast). A ninth soil sample was collected from the sediment at the center of the pond. Soil texture, color (wet and dry), structure, consistency, and moisture content were determined for each sample. Air dried samples were tested for pH, nitrate nitrogen, potassium, phosphorus, magnesium, calcium, ferric iron, sulfate, and aluminum. Five grams of soil was digested using EPA method 3050B for acid digestion of soils and the filtrate tested for molybdenum, copper, silver, chromium, iron, magnesium, aluminum, lead, cadmium, and potassium using an ICP-AES.

Results

Soil

Results of ICP-AES analysis of soil and water samples are given in fig. 3. The mean of the values of the four perimeter soil samples for each pond are given along with the values for the sediment and water samples taken at the center of each pond. In general, levels of the various elements were highest in the sediment sample, often several times that of the surrounding soil, and very low in the water samples. This is shown for the levels of aluminum, iron, magnesium, manganese, lead and potassium at PB6 in fig. 4. A two-tailed t-test revealed significant differences ($p<0.05$) between the mean values for chromium, aluminum, iron, and magnesium in the soil samples from the natural (BP6, BP9) versus the anthropogenic ponds (BP7, BP13a, MM). There are no significant differences between values for the water samples between the two types of ponds. The mean value for manganese in the sediments from the two natural ponds was significantly less than that for the anthropogenic ponds (two-tailed t-test, $p = 0.003$). Because of their limited sensitivity the results of the LaMotte soil tests were of limited value. When the anthropogenic ponds are compared to the two natural ponds, a two-tailed t-test reveals that there is a significant difference between the mean values for soil temperature (natural: 19.25°C, anthropogenic: 25.9°C; $p = 0.005$) and soil pH (natural: 5.04, anthropogenic: 5.96; $p = 0.016$) (fig. 5).

Water

Results of the field tests revealed that the mean values for temperature, pH, dissolved oxygen, and turbidity are all higher in the anthropogenic ponds (figs. 6, 7). Only the difference in pH proved to be statistically significant (two-tailed t-test, $p = 0.007$). Results of the Hach water tests for sulfate, nitrate, iron, phosphorus, total chlorine, magnesium, calcium, copper, tannin/lignin, total chromium, molybdenum, aluminum, and suspended solids are given in fig. 9. Values shown are the averages of the results for the five samples taken from each pond. When compared as groups (natural vs. anthropogenic) there are no consistent trends. The only difference between the ponds that proved statistically significant was for tannin-lignin content (natural: 4.64 ppm, anthropogenic: 1.12 ppm; $p = 0.036$) (fig. 8).

SAMPLE	Mo (ug/g)	Cu (ug/g)	Ag (ug/g)	Cr (ug/g)	Al (ug/g)	Fe (ug/g)	Mg (ug/g)	Mn (ug/g)	Pb (ug/g)	Cd (ug/g)	K (ug/g)
BP6 SOIL	3.22	25.73	7.26	12.22	4548.30	2131.70	399.92	145.71	38.58	0.51	369.40
BP6 SEDIMENT	0.00	11.21	3.21	30.97	26948.00	6788.00	1089.20	86.20	150.08	0.00	438.40
BP6 WATER	0.00	0.02	0.01	0.00	0.49	1.13	0.57	0.33	0.00	0.00	1.89
BP7 SOIL	0.00	44.33	0.00	22.23	8934.00	8924.00	892.20	104.05	73.06	0.00	126.09
BP7 SEDIMENT	5.80	195.04	0.00	87.68	22124.00	21760.00	2650.00	180.36	25.94	1.57	519.60
BP7 WATER	0.00	0.00	0.00	0.00	0.08	0.19	0.19	0.23	0.07	0.00	0.00
BP9 SOIL	5.02	6.59	1.91	4.97	2905.90	2007.90	139.55	66.11	63.59	1.29	129.81
BP9 SEDIMENT	0.00	0.00	0.00	14.71	2138.00	1119.60	85.00	62.48	111.08	0.00	86.16
BP9 WATER	0.00	0.00	0.00	0.00	0.32	1.00	0.31	0.11	0.00	0.00	0.82
BP13a SOIL	0.00	7.84	0.00	13.80	6696.00	8346.00	741.40	109.84	84.63	0.28	199.89
BP13a SEDIMENT	11.75	24.78	0.00	36.09	21116.00	20448.00	2242.00	169.60	258.04	0.00	603.20
BP13a WATER	0.00	0.00	0.00	0.01	0.96	3.66	0.68	0.26	0.20	0.00	1.04
MM SOIL	0.00	17.99	0.75	20.11	7285.33	9606.67	698.80	133.71	22.08	0.25	198.69
MM SEDIMENT	0.00	15.62	13.64	0.00	5796.00	8708.00	673.20	193.12	0.00	3.52	257.32
MM WATER	0.00	0.00	0.00	0.00	0.20	0.17	1.65	0.25	0.00	0.00	0.96
BP1 WATER	0.00	0.00	0.00	0.00	0.26	0.29	0.34	0.26	0.16	0.00	0.79
BP2 WATER	0.00	0.02	0.00	0.02	0.27	0.44	0.36	0.29	0.13	0.00	0.45

Fig 3. ICP-AES results for soil, sediment and water

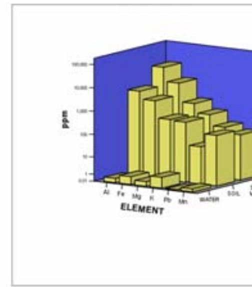

Fig 4. BP6 soil, sediment & water

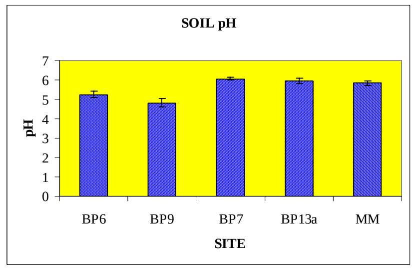

Fig 5.

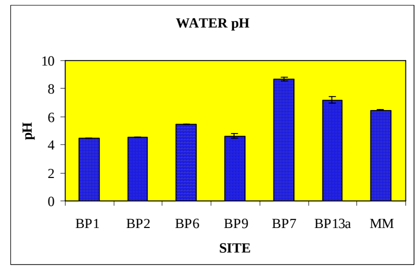

Fig 6.

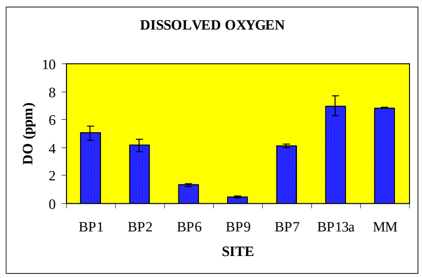

Fig. 7

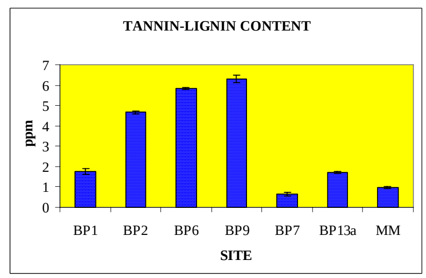

Fig. 8

SITE	Sulfate	Nitrate	Fe	P	Total Cl	Hardness: Mg	Hardness: Ca	Copper	Tannin-Lignin	Total Cr	Mo	Al	Suspended Solids
BP1	0.2	0.2	0.386	0.142	0.02	1.366	1.118	0.066	1.76	0.002	0.18	0.088	56.4
BP2	1.6	0.02	0.374	0	0.028	1.376	0.916	0.01	4.66	0.1	0	0.11	52.4
BP6	0.275	0.06	0.49	0.2	0.024	1.806	1.724	0.014	5.84	0	0	0.086	30.4
BP9	0	0.28	0.902	0.236	0.044	1.076	1.456	0.024	6.3	0	0	0.1	51.2
BP7	0.4	0.08	0.55	0.154	0.012	3.88	0.798	0.022	0.66	0.028	0.08	0	33.2
MM	1	0.04	0.248	0.222	0.032	3.446	0	0.046	0.98	0.014	0.14	0.018	22.6
BP13a	0.2	0	2.568	0.246	0.048	1.832	1.364	0.058	1.72	0.004	NA	0.52	60.2

Fig 9. Results of Hach water tests (all values are in mg/l).

Discussion

Coastal plain ponds are an important element of the natural history of Long Island. These wetlands serve important ecosystem functions and support populations of a significant number of rare species, both plant and animal [10]. Many coastal plain ponds have been altered or lost due to development [11]. Wetland restoration and creation are attempts to mitigate the effects of such losses. Within the boundaries of BNL there are a number of coastal plain ponds, both naturally occurring and anthropogenic. These ponds represent a significant portion of the known breeding habitat for tiger salamanders (*Ambystoma tigrinum*) in New York. A primary goal of wetland restoration and creation is to produce habitat that is functionally equivalent to naturally occurring elements [11]. Our study reveals that there are identifiable differences between natural and anthropogenic ponds on BNL with respect to soil and water chemistry. It is proposed that many of these differences are related to the absence of a tree canopy and woody shrubs around the anthropogenic ponds. The absence of a surrounding tree canopy exposes the anthropogenic ponds to greater levels of solar radiation, raising both soil and water temperature. The presence of trees and shrubs around the natural ponds contributes significant amounts of leaf litter to the ponds and soil, increasing tannin-lignin content and lowering the pH. Though these differences exist between natural and anthropogenic ponds, they might not have an effect on breeding site selection by tiger salamanders (*Ambystoma tigrinum*), since tiger salamanders are known to use both natural and anthropogenic coastal plain ponds on BNL [12].

Acknowledgments

This research was conducted at the Brookhaven National Laboratory. We would like to thank the Department of Energy, Office of Educational Programs for giving us the opportunity to participate in the FaST program and the chance to enjoy a new learning experience. Special thanks to our mentor, Dr. Tim Green, for his wisdom and expertise, and for supplying us with everything we needed. We would like to thank Jennifer Higbie for her patience, willingness and expertise in our dealings with ArcGIS. We would like to thank Dorra Kridis and Steve for their help with the ICP-AES.

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Environmental Health Studies on Peconic River Headwaters: Water and Sediment Chemistry

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Abstract

The purpose of this research was to collect scientific environmental health data on water and sediments from the remediated and natural sites of Peconic River (PR) headwater complex at Brookhaven National Laboratory (BNL) and to compare results with available earlier findings. The specific objectives were to: (a) analyze samples for physico-chemical factors; (b) compile and analyze data statistically; and (c) to identify the interrelationships between abiotic factors. We hypothesized that waters of PR would be acidic with excessive turbidity, nutrient poor, low dissolved oxygen (DO) levels, and free of contaminants. We have collected 54 surface water and sediment samples (<15cm deep at 150m intervals) randomly from 7 experimental sites (LH1-7). Experimental sites were plotted using eXplorist 200 Global Positioning System (GPS) and ArcInfo Geographic Information Systems (GIS). Field data were obtained on DO, temperature, pH, turbidity, and conductivity using Yellow Spring Instruments, Inc. (YSI) probe. Water samples were analyzed using Hach DR890 colorimeter. Filtered and acidified water samples (pH<2) were used to estimate metal content using Inductively Coupled Plasma Spectrometer (ICP). Sediment samples were air dried, sieved, and saved in ziploc bags. Macro and micronutrients were analyzed using LaMotte Soil Test Kits. Samples were also dried in an oven at 65^{0}C for 36-48 hr to obtain moisture. Majority of the sediments were acidic (6.00±0.00 to 6.25±0.94 at LH3 and LH5, respectively) and nutrient poor. Moisture content varied between 33.46±9.67 to 68.11±6.67% at LH1 and LH4, respectively. Water was acidic (4.61±0.10 to 5.87±0.04 at LH2 and LH5, respectively) and low in DO (1.49±0.17 to 5.67±0.70 mg/L at LH3 and LH1, respectively). Samples had traces to zero chlorides, nitrate and ammonia nitrogen (N), and sulfates. Alkalinity ranged from 10.5±5.65 mg/L at LH2 to 83.13±3.26 mg/L at LH7. Sediment ANOVA results indicated positive and negative significances (P<0.05 and P<0.01) between elements, aluminum (Al), iron (Fe), lead (Pb), and chromium (Cr). In conclusion, water and sediments of PR natural sites have higher concentrations of metals (Al, Fe, Pb) than the remediated sites. In some instances, however, current elemental contents of Al, Cd, Fe, Pb, Mg, and potassium (K) in sediments of remediated sites were greater than the earlier observations (2003 and 2005).

Introduction

Brookhaven National Laboratory (BNL), owned by the U.S. Department of Energy (DoE) and operated by associated Universities, Inc., is located on Long Island, NY, and encompasses about 5,265 acres of the native Long Island Pine Barrens ecosystem (Figure 1). Historical data of DoE at BNL indicated the presence of organic and approximately 14 inorganic contaminants (methyl mercury, copper-Cu, mercury-Hg, lead-Pb, silver-Ag, and iron-Fe) in the sediments of the PR, due to the laboratory practices during the 1940's through the 1980's [1 & 2].

Sediment in running waters is an important ecological factor and plays a critical role on biotic organisms and the water quality. Pollution loads in wastewater are established independently of the river flow of the river Arno and concluded that low flow periods or when the capacity of the river is reduced, the level of DO can fall which eventually prevents survival of aquatic species [3]. Problems such as low DO, fish extinction, and algal blooms in flowing waters were discussed [4]. Data on the total concentrations of phosphorus (P), calcium (Ca), and Fe in surface sediments were investigated on several locations of Thames catchments, River Swale in Yorkshire, and the headwaters of the Great Ouse [5]. Phosphorus plays a critical role in water quality and plant growth in fresh water bodies [6, 7,8, 9].

No peer-reviewed literature, published in scientific journals is available on the environmental health issues, such as water and sediment chemistry and its impact on biota, of PR headwaters (flowing waters). Hence, the purpose of this research was to collect scientific environmental health data on water and sediments from the remediated and natural sites of PR headwater complex at BNL and to compare results with available earlier findings. The specific objectives were to: (a) analyze samples for physico-chemical factors; (b) compile and analyze data statistically; (c) identify the interrelationships between abiotic factors; and (d) provide a knowledge base on natural sites of BNL (LH3 and LH4 – never tested) for future research.

Hypothesis

Peconic River headwater would be acidic with excessive turbidity, nutrient poor, low dissolved oxygen (DO) levels, and free of contaminants. There would be no significant difference in means (<0.05) of of physico-chemical factors between groups and within groups.

Study Area

We have investigated two major sections of PR headwaters: remediated zone (LH1, LH2, LH5, LH6, and LH7) and natural zone (LH3 and LH4) as shown in figure 1. The experimental sites are located between 18.679241 – 18.682044 E and 45.25797 – 45.28239 N (eXplorist 200 GPS coordinates). Average depth of waters was about 30-45cm in most of our experimental sites. The PR is a 25-mile coastal plain stream that begins in the Manorville drainage basin and about 12 mile of this runs through the BNL, where the upper drainage basin is located. The PR drains in an easterly direction and flows into Flanders Bay, an arm of the Peconic Bay (NorthEastern Alantic Study).

Results

Water chemistry

Water was acidic (4.61±0.10 to 5.87±0.04 at LH2 and LH5, respectively) and low in DO as shown in Figure 2 (1.49±0.17 to 5.67±0.70 mg/L at LH3 and LH1, respectively). Samples had traces to zero chlorides, nitrate and ammonia nitrogen, and sulfates. Alkalinity ranged from 10.5±5.65 mg/L at LH2 to 83.13±3.26 mg/L at LH7 (Figure 3). Metal content in water samples is summarized in Table 1. Among various physico-chemical factors analyzed using one-way ANOVA, mean differences between groups (LH1-LH7; df=6) for temperature, conductivity, DO, ammonia nitrogen, tannin, sulfate, phosphorus, suspended solids, alkalinity, and total hardness were highly significant (P<0.05). Two-tailed independent sample T-test between two zones (remediated sites and natural sites; df=52) indicated significant mean differences (P<0.05) in data for various chemical factors as summarized in Table 2. Two-tailed Pearson correlations indicated significant relationships between various physico-chemical factors at P<0.05 and P<0.01, as shown in Table 3.

Figure 2. Peconic River Headwaters: Dissolved Oxygen and Tannins (mg/L)

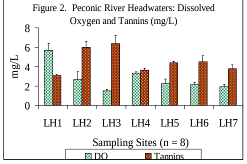


Figure 3. Peconic River Headwaters: Suspended Solids, Alkalinity, and Total Hardness (mg/L)

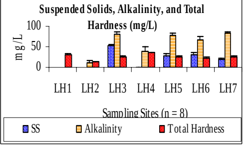
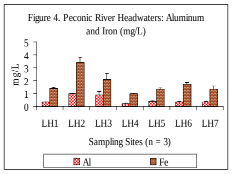


Figure 4. Peconic River Headwaters: Aluminum and Iron (mg/L)



Sediment Chemistry

The sediments were acidic (6.00±0.00 to 6.25±0.94 at LH3 and LH5, respectively) and nutrient poor. Moisture content varied between 33.46±9.67 to 68.11±6.67% at LH1 and LH4, respectively (Figure 5). One-way ANOVA results confirmed positive and negative significant (P<0.05 and P<0.01) relationships between elements, aluminum (Al), iron (Fe), lead (Pb), and chromium (Cr). Two-tailed independent sample T-test and two-tailed Pearson correlation results on data are summarized in Tables 1&2. Among all the variables studied in sediments, magnesium and potassium had highest positive significant relationship (0.996**; P<0.001). Most of the sediments have excessive amounts of Al and Fe in natural vs remediated sites 11,090±2010 vs 4469±832 µg/g Dry wt and 3078±607 vs 2780±578 µg/g Dry wt, respectively. However, these values are still in excess of the earlier data published in BNL's investigative reports, even in the remediated sites. In addition to Al and Fe, we found Pb, Cd, Mg, and K in higher concentrations than in earlier reported values in remediated sites, as shown in Figures 7&8. Our studies indicated Pb concentrations are higher in natural sites (138.5±30.62µg/g Dry wt) compared to the remediated sites (89.22±14.67µg/g Dry wt), yet, these values are much higher than the data of earlier reports (2003 & 2005 ECO data).

Figure 5. Peconic River Headwater Sediments: % Moisture

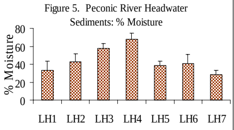


Figure 6. Peconic River Headwater Sediments: Heavy Metals

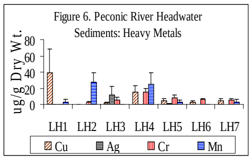


Figure 7. Peconic River Headwater Sediments: Lead Content (ug/g Dry Wt.)

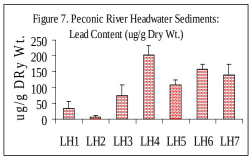


Table 1. ICP Data on Water

RemZone					NaturalZone				
ppm	**Mean**	**SE (n=15)**	**Min**	**Max**	**ppm**	**Mean**	**SE (n=6)**	**Min**	**Max**
Mo	-0.07	0.02	0	-0.16	**Mo**	-0.06	0.02	-0.01	-0.16
Ag	-0.38	0.01	-0.3	-0.41	**Ag**	-0.39	0.01	-0.36	-0.395
Al	0.5	0.07	0.03	0.46	**Al**	0.57	0.2	0.23	0.7
Mn	0.07	0.01	0.03	0.14	**Mn**	0.05	0.01	0.02	0.06
Fe	1.85	0.23	1.22	4.08	**Fe**	1.53	0.33	0.92	2.78
Cr	-0.03	0.01	0	0	**Cr**	-0.03	0.01	0	-0.07
Mg	1.44	0.12	0.51	1.92	**Mg**	2.28	0.56	1.05	4.97
Pb	-0.48	0.14	-0.07	-0.86	**Pb**	0	0.23	-0.11	-0.45
Cu	0.05	0.01	0	0.1	**Cu**	0.1	0.02	0.02	0.19
Cd	0.01	0	0	0.01	**Cd**	0.01	0	0	0.03
K	1.46	0.41	0.46	6.9	**K**	1.04	0.14	0.6	1.46

Figure 8. Comparitive Summary: 2003 & 2005 (n=4); 2006 (n=25 for Rem. Sites & n=10 for Natural Sites)

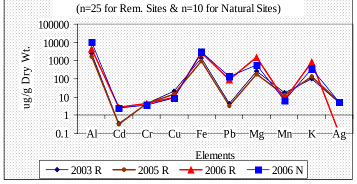
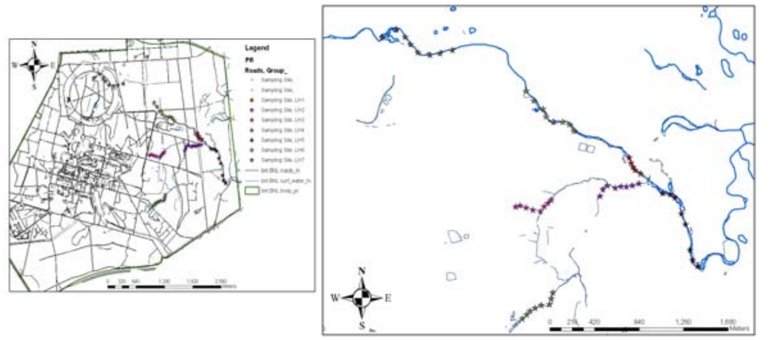


Figure 1. Experimental Sites at BNL Peconic River Headwaters



Materials and Methods

Eight surface water and sediment samples (not more than 15 cm deep) at 150 m intervals were collected, from each site of a total of seven experimental sites from the PR headwaters at BNL over a period of 10 weeks, and saved in 500 and 250 mL Nolgen bottles, respectively. The sampling sites were plotted, as shown in figure 1, using eXplorist 200 Global Positioning System (GPS) and ArcInfo Geographic Information Systems (GIS). Water samples were kept in a cooler for chemical analysis. Field data on DO, temperature, conductivity, pH and turbidity in water were obtained using the YSI (Yellow Spring Instrument Inc.) probe. Hach-DR 890 (the colorimeter) was used to test total chlorine, nitrate and ammonia N, tannin, sulfate, phosphorus, and suspended solids. The Digital Titration-16900 was used for testing total hardness and alkalinity. At the completion of water analysis for physico-chemical factors, we added 2-5 mL 1:1 nitric acid:DI water to each sample, filtered 100 mL water using Whatman 40 filter paper, and preserved the samples for trace metal analysis. Sediment samples were air-dried and sieved through 2mm sieve to remove organic matter such as roots. Air dried samples were used to measure macro and micro nutrients using LaMotte Soil Test Kits (pH, K, P, Ca, Cl, Mn, Fe, sulfate (SO_4^{-2}), Al, NH_3-N, and nitrate-nitrogen). Percentage of moisture was obtained by drying samples in an oven at 65^0 C for 36 to 48 h. Air-dried sediment samples (5g each) were digested using 100mL Kjeldahl flasks, following EPA 3050B method. Samples were digested with concentrated 10mL nitric acid (HNO_3) and 10mL hydrochloric acid (HCl) and were allowed to soak overnight. Samples were then digested on hot plates (not more than 95^{0}C) for 3-4 h and let the samples to cool overnight and filtered using Whatman 541 filter paper. Digestion extracts were diluted with deionized distilled water and made the final volume to 100 mL using volumetric flasks, labeled, and saved in 125 mL Nolgen bottles for ICP analysis. Three replicates per site for water and five replicates per site for sediments were used for ICP (Liberty 100 Emission Spectrometer) analysis to estimate Ag, Al, Pb, Cd, Mo, Cr, Cu, Mg, K, Fe, and Mn (EPA3050B method).

Statistical Analysis

Mean, variance, standard deviation, standard error, student paired T-test, Pearson two-tailed and partial correlations, and one-way ANOVA (Tukey and Duncan tests) were applied to measure significance levels between groups (remediated and natural sites) using SPSS 13.0 version.

Table 2. Two Tailed T-Test (p <0.05) (*Equal Variances Assumed)

	F	**Sig.**	**t**	**df**	**Sig**
Water					
Temp	10.47	0.002	1.79	52	0.079
Nitrate N	7.61	0.008	2.06	39.82	0.046
Mg	4.4	0.05	-2.17	19	0.043
Ammonia N	17.15	0	2.3	52	0.026
					0.001*
Sulfate	10.75	0.002	2.32	36	0.026
Hardness	0.001	0.98	-2.84	26.96	0.009
Sediment					
Phosphors	9.53	0.003	2.07	52	0.043
			3.19	38	0.003*
% Moisture	1.61	0.21	-4.25	52	0
			-4.61	34	0.000*

Table 3. Pearson Correlations (*P<0.05; **P<0.01) Sediments (n=35) and Water (n=15)

		Sediments	Water
Cr	Mo	0.462**	
Fe	Al	0.629**	**0.819****
Mn	Al	0.340*	**-0.561****
Mn	Fe	0.564**	**0.488****
Pb	Cr	0.526**	
Cd	Cr	-0.435**	
Cd	Pb	-0.530**	
K	Cr		**-0.477***
K	Fe		**0.498***
K	Mg	0.996**	

Discussion

BNL has a long history of inorganic and organic contaminants in sediments (1940s-1980s) and is listed as one of the US Environmental Protection Agency's (EPA) National Priorities List. It is necessary to quantify the extent of risks of these contaminants to BNL's environmental health and to its biota (plants, animals, microbes). In the current research project, we attempted to investigate some remediated and unexplored natural areas of PR complex to identify the quality and quantity of various contaminants in water and sediment. According to the New York State Department of Environmental Conservation, Eastern USA background (ppm) for lead vary widely (undeveloped and rural areas may range from 4-61 ppm compared to suburban areas or near highways typically range from 200-500 ppm). Suffolk County Department of Health Services (Article 12 SOP#9-95) has published (i) action levels/cleanup objective levels (ppm) of 400/100 (Pb), 500/25 (Cu), 100/10 (Cr), 100/5 (Ag), and 10/1 (Cd). Based on these standards, we conclude that lead levels in LH4-LH7 sites have exceeded the background values of rural and undeveloped areas (LH4 has 203.63±29.39 µg/g Dry Wt.).

Research results have indicated high acidic sediments along with slightly acidic waters in PR complex. Borg (1987) made similar observations that surface water in North America has become acidic due to acid compounds and metals [10]. Warnau and Pagano (1994) stated that the main sources of lead input into the marine environment are rivers and atmosphere. They reported that Sea Urchins are affected mostly by high levels of lead, mostly in Atlantic coast [11]. Ramachandran *et al* (1997) reported that aquatic life was more susceptible to the toxic effects of copper but not cadmium [12].

Sediments of PR headwaters have a maximum of 38.89±29.37µgCu/g Dry Wt. at LH1, where we have observed an increased flow of water. Neal *et al* (2000) observed that Cu, Cl, Mg, Mo, K exhibit dilution with increasing flow and increase of Al, Fe, and nitrate (NO_3^-) with increasing flow in Thames River [13]. Stow (2001) reported that symptoms of excessive eutrophication are algal blooms, low dissolved oxygen, fish kills and outbreaks of toxic microorganisms in the Neuse River, North Carolina [14]. Ramachandran *et al* (1997) reported that carbon dioxide concentrations are higher in the summer, which can lead to the cause of the water being very acidic. They have also observed that the suspended solid concentrations were higher in the summer when compared to autumn. Experimental results indicated that all our study sites have low DO without any visible fish, with a few encounters of frogs, and excessive amounts of tannins and suspended solids in acidic waters and sediments.

Conclusion

Experimental results were in partial agreement with our hypothesis (nutrient poor, low DO, and high turbidity). However, we reject null hypothesis, since our hypothesis was proven wrong regarding contaminants and mean differences among the groups of data sets. We have also observed that water and sediments of PR natural sites have higher concentrations of metals (Al, Fe, and Pb) than in the remediated sites. In some instances, however, current elemental contents of Al, Cd, Fe, Pb, Mg, and K in sediments of remediated sites were greater than the earlier observations (2003 and 2005).

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BROOKHAVEN NATIONAL LABORATORY

A Comparison of the Chemistry of Soil Surrounding Natural and Anthropogenic Ponds at Brookhaven National Laboratory

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ABSTRACT

Brookhaven National Laboratory (BNL) is located in the Long Island Pine Barrens, an area formed through decomposition and reworking of glacial materials. BNL has many wetland structures including costal plain ponds, vernal ponds, recharge basins, and streams. Some of these serve as breeding grounds for tiger salamanders (*Ambystoma tigrinum*), a species listed as endangered by the New York Natural Heritage Program. Anthropogenic habitats need to possess suitable characteristics with respect to soil and water chemistry in order to serve as successful breeding habitats for tiger salamanders. Soil is an important factor in controlling vegetation and water chemistry. In this study five ponds were selected for a study of soil chemistry: two natural (BP9, BP6) and three anthropogenic (BP7, BP13, MM). Nine soil samples were collected from each pond, eight around the perimeter and one from the pond bottom. Global Positioning System (GPS) was used to locate the sample points and ArcGIS was used to map the ponds and sample points. Soil samples were tested for pH, nitrate nitrogen, phosphorus, potassium, aluminum, ferric iron, magnesium, sulfate, calcium, and chloride using LaMotte Combination Soil and LaMotte Soil Micronutrient Kits. Soil moisture content was also determined. Soil color, texture, structure, consistency, and mottling were also observed and recorded. Five of the nine soil samples from each pond were digested using EPA method 3050B for Acid Digestion of sediment, sludge, and soil and then tested for copper, iron, molybdenum, magnesium, cadmium, aluminum, chromium, manganese, potassium and lead using an Inductively Coupled Plasma – Atomic Emission Spectroscope (ICP-AES). The natural ponds were more acidic then the anthropogenic ponds. The soil temperature is higher around the anthropogenic ponds (BP7, BP13, MM) than the natural ponds (BP9, BP6). Nutrient levels were low and consistent across pond types. Though these differences exist, both types of ponds accomplish the goal of providing suitable breeding sites for tiger salamanders (*Ambystoma tigrinum*). This information will serve as baseline data for BNL's natural resource manager and enable BNL to optimize the management of amphibian and reptile habitats.)

Introduction

The soils of the Long Island Pine Barrens (LIPB) were developed by deposition and reworking following several advances of Pleistocene glacial ice [1]. The soil is made-up of 80-96% sand and is very well-drained, nutrient poor, and acidic [2]. The vegetation types that characterize the LIPB are influenced by its soil's profile [3]. Only vegetation that is able to withstand the harsh conditions of droughty soil, low nutrient levels, and acidity is able to persist. Many of the plants present produce waxes, resins, or volatile oils that reduce both water loss and insect herbivory. This adaptation, which enables vegetation to exist in pine barren soil, also increases the potential for fires [4]. Pitch pine (*Pinus rigida*) is the dominate canopy tree of the LIPB; one or more oak species (*Quercus coccinea*, *Q. alba*, *Q. velutina*) are also normally present. The shrub layer is dominated by ericaceous plants such as huckleberry (*Gaylussacia baccata*) and blueberries (*Vaccinium* spp.) [2].

Land clearing, development, and fire suppression have destroyed much of the LIPB [1]. Brookhaven National Laboratory (BNL), an advocate for preserving the natural beauty of the LIPB, is located in the Central Pine Barrens of Long Island. BNL has many wetland structures including coastal plain ponds, vernal ponds, recharge basins, and streams. Coastal plain ponds are circular depressions that are nutrient- poor, acidic, and ground water fed. They are typified by seasonally fluctuating water levels; ponds which regularly dry out completely are called vernal ponds [4]. Some of these serve as breeding grounds for tiger salamanders (*Ambystoma tigrinum*)(fig.6.), listed as a state endangered species by the New York Natural Heritage Program. Tiger salamanders have been known to breed at sixty-one sites within the Long Island Pine Barrens. Vernal ponds and coastal plain ponds, because of their seasonally fluctuating water levels, are fish free habitat, eliminating the main source of predation of the salamander's eggs and larvae [4].

To enhance the population of tiger salamanders in the Central Pine Barrens anthropogenic habitats are being introduced. The main goal of introducing anthropogenic habitats is to reduce the loss of ecological function by providing habitats that are functionally equivalent to natural habitats [5]. To categorize an anthropogenic habitat as flourishing its ecological functions (hydrologic [e.g., soil], biochemical [e.g., water chemistry] and habitat [e.g., vegetation]) must be compared to the ecological functions of a successful natural habitat [5, 6]. Comparing the soil chemistry of natural and anthropogenic ponds on BNL will allow us to assess the suitability of the latter as alternative breeding sites for tiger salamanders. This research will provide baseline data for BNL's natural resource manager and enable BNL to optimize the management of amphibian and reptile habitats.

Fig.1. Natural Pond (BP9)

Fig. 2. Anthropogenic Pond (BP7)

MATERIALS AND METHODS

Five ponds within Brookhaven National Laboratory were selected for study: two natural (BP6, BP9) and three anthropogenic (BP7, BP13a, MM). Nine soil samples were collected from each pond, one from the center of the pond and eight from around the pond two meters from the shoreline. The center of the pond was found using Global Positioning System (GPS). The other eight samples were collected at each cardinal point (N, S, E, W) and the midpoint between each of them (NE, NW, SE, SW). Soil temperature, texture, structure, consistency, and litter depth was recorded at each sample location. At each of the eight terrestrial sampling points a circular plot representing 0.588 sq.m. was set out and five randomly selected points within the plot were marked. At each of the five points approximately 20 grams of soil was collected; these were mixed to create an approximately 100 gram sample from each plot.

To determine soil moisture content 10g from each sample was placed in a pre-weighed container and oven dried for 48 hours at 65°C. The remaining soil was air dried for 24 hours. Soil color, both wet and dry, was observed and recorded using Munsell Soil Color Charts. Each soil sample was tested for pH, nitrate nitrogen, potassium, phosphorus, magnesium, calcium, chloride, ferric iron, sulfate, and aluminum using LaMotte Combination Soil and LaMotte Soil Micronutrient Kits.

Five grams of air-dried soil from the north, south, east, west and center samples of each pond was digested using EPA method 3050B for Acid Digestion of sediment, sludge, and soil and then tested for copper, iron, molybdenum, magnesium, cadmium, aluminum, chromium, manganese,

Fig. 3 Collecting soil sample from BP9

RESULTS

- Natural ponds had lower pH values than anthropogenic ponds (fig.4)
- Soil temperatures of anthropogenic ponds were higher than the soil temperature of natural ponds (fig.5)
- The levels of various elements were greater in the sediment sample than the perimeter soil samples (Table 1)

SAMPLE	Mo (ug/g)	Cu (ug/g)	Ag (ug/g)	Cr (ug/g	Al (ug/g)	Fe (ug/g)	Mg (ug/g)	Mn (ug/g	Pb (ug/g)
BP6 SOIL	3.220	25.732	7.261	12.221	4548.300	2131.700	399.920	145.710	38.578
BP6 SEDIMENT	0.000	11.208	3.210	30.968	26948.000	6788.000	1089.200	86.200	150.080
BP7 SOIL	0.000	44.328	0.000	22.231	8934.000	8924.000	892.200	104.050	73.059
BP7 SEDIMENT	5.800	195.040	0.000	87.680	22124.000	21760.000	2650.000	180.360	25.940
BP9 SOIL	5.015	6.591	1.907	4.966	2905.900	2007.900	139.547	66.110	63.594
BP9 SEDIMENT	0.000	0.000	0.000	14.708	2138.000	1119.600	85.000	62.480	111.080
BP13a SOIL	0.000	7.841	0.000	13.801	6696.000	8346.000	741.400	109.840	84.630
3P13a SEDIMEN	11.752	24.776	0.000	36.092	21116.000	20448.000	2242.000	169.600	258.040
MM SOIL	0.000	17.985	0.750	20.115	7285.333	9606.667	698.800	133.707	22.080
MM SEDIMENT	0.000	15.620	13.644	0.000	5796.000	8708.000	673.200	193.120	0.000
CONTROL	0.000	0.657	30.340	4.988	55.160	0.000	0.000	76.680	0.000

Table1. ICP-AES for Soil and Sediment

Site	pH	Soil Temp	Litter Depth (mm)	Nitrate (lb/ac)	Phosphorus (lb/ac)	Calcium (ppm)	Chloride (ppm)	Sulfate (ppm)
BP6	5.26	18.9	14.5	3.89	15.56	77.78	144.44	0
BP7	6.07	24.9	13.4	6.67	13.89	116.67	0	0
BP9	4.82	19.6	30.9	3.89	15.56	0	0	0
BP13	5.96	27.1	1	7.22	29.44	0	2.78	0
MM	5.838	25.7	0	3.75	1	0	12.5	0

Table 2. LaMotte soil test results

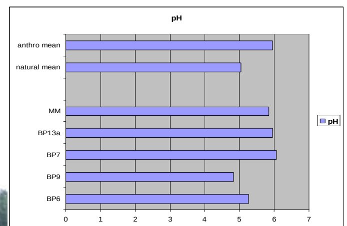

Fig.4. Soil pH

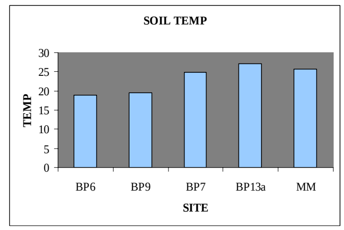

Fig. 5. Soil Temperature

DISCUSSION AND CONCLUSION

The landscapes of the three anthropogenic ponds differed from those of the two natural ponds. The anthropogenic ponds lack a canopy (fig.2), the soil mainly covered with herbaceous vegetation within the testing perimeter. The natural ponds possess a canopy consisting of a mixture of hardwoods and pitch pine (*Pinus rigida*) (fig.1). Hardwoods commonly present include red maple (*Acer rubrum*), black gum (*Nyssa sylvatica*), and oaks (*Quercus alba*, *Q. coccinea*). The shrub layer is dominated by blueberry (*Vaccinium corymbosum).* Greenbrier (*Smilax* sp.) is also common. The absence of a canopy is assumed to have an active role in some of the differences observed between the pond types. The soil temperature is higher around the anthropogenic ponds (BP7, BP13, MM) than the natural ponds (BP9, BP6). The soil sample sites around the anthropogenic ponds were in direct sunlight, increasing the soil temperature. The natural pond soil sample sites were completely shaded from the sun, causing the soil temperature to be lower. The presence of a canopy also played a role in the amount of litter around a pond. Soils of natural ponds are covered with more litter than the soils of anthropogenic ponds. The presence of decomposing organic matter at the natural ponds had an affect on soil pH, causing it to be more acidic than that of the anthropogenic ponds (fig. 4).

The presence of a canopy seems to have no effect on the presence of tiger salamanders. Tiger salamanders have been known to breed at both types of ponds on BNL. Valorie Titus, a researcher of tiger salamanders at BNL for the past few years, stated that: "Tiger salamanders are optimistic breeders; they are attracted to minimal disturbance." All of the ponds in this study have been successful breeding sites for salamanders at one time, and some continue to be. The three anthropogenic ponds presently are productive; one of the natural ponds (BP9) holds the same status. The other natural pond (BP6) is less productive. This lack of productivity is due to an alteration in hydrology.

The primary goal of an anthropogenic habitat is to function similar to or better than a natural habitat [5]. This study has revealed that the chemistry of the soil that surrounds anthropogenic and natural ponds is different at BNL. Though these differences exist, both types of ponds accomplish the goal of providing suitable breeding sites for tiger salamanders (*Ambystoma tigrinum*).

Fig.6. Tiger salamanders (*Ambystoma tigrinum*)

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BROOKHAVEN NATIONAL LABORATORY

A Comparison of Water Chemistry between Natural, Modified, and Manmade Ponds within Brookhaven National Laboratory

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Abstract

Brookhaven National Laboratory (BNL) is located in the center of the Long Island Pine Barrens. Within BNL's 5,265-acre site there are 26 wetlands. Included are coastal plain ponds, vernal ponds, recharge basins, and streams, making it an ideal ecological site to study water chemistry. We tested water samples from seven coastal plain ponds on BNL: four natural (BP1, BP2, BP6, BP9), one man-modified (BP7), and two manmade (BP13a, Meadow Marsh). Five water samples were collected from each pond. An eTrex Vista Cx Global Positioning System (GPS) was used to mark each water sample point. A YSI 659 MDS meter fitted with a multiprobe was utilized to determine temperature, pH, dissolved oxygen, conductivity, and turbidity at each sample point. Water samples were analyzed for sulfate, nitrate, iron, phosphorus, chlorine, calcium, magnesium, copper, tannin-lignin, chromium, molybdenum, aluminum, and suspended solids using Hach DREL/2000 and CEL/890 water test kits. Water samples were also analyzed for eleven different elements using an ICP-AES. The pH in the anthropogenic ponds was found to be more basic than that of natural ponds. Phosphorous, tannin-lignin, and hardness were elevated in the natural ponds when compared to manmade and modified ponds, but only the difference in tannin-lignin content proved statistically significant. The natural ponds were shaded by the canopy of the surrounding forest while the manmade and modified ponds where located directly in the sun. This had a affect on water temperature. The results of this research will give environmental scientists an insight into water chemistry and interrelationships between abiotic and biotic factors and will enable BNL to optimize the management of amphibian and reptile habitats.

Introduction

Long Island, New York embodies the essence of the Pine Barrens region, from its sandy, well drained, nutrient poor soils to its abundance of pines. The Long Island Pine Barrens support a number of distinct natural communities including dwarf pine plains, oak-pitch pine forest, and pitch pine-heath forest. Pitch pine (*Pinus rigida*) is the dominant tree species in the Pine Barrens; the shrub layer is dominated by scrub oak, black huckleberry (*Gaylussacia baccata*), and hillside blueberry (*Vaccinium pallidum*)[1]. Coastal plain ponds and vernal ponds are two types of wetland structures that are found throughout the Pine Barrens region. Vernal ponds, unlike coastal plain ponds, dry out completely in the summer. These ponds are basin depressions lacking outlets, filling with water during periods of precipitation, and offering permanent or temporary habitat to a variety of species [2]. Over recent decades an increase in population and pollution has resulted in habitat loss for species such as the tiger salamander (*Ambystoma tigrinum*), northern cricket frog (*Acris crepitans*) and mud turtle (*Kinosternon subrubrum*) causing them to be placed on New York state's endangered species list [4]. BNL contains approximately 22 of the 91 known active breeding sites for tiger salamanders on Long Island. Testing the water chemistry of different ponds at BNL, in combination with soil and vegetation data, will help environmental scientists determine what conditions are most suitable for tiger salamanders. This information will give natural resource managers better guidelines on how to maintain habitats so as to prevent extinction of this species on Long Island.

Methods and Materials

A track of each pond was collected using an eTrex Vista Cx Global Positioning System (GPS). The information from the GPS unit was then downloaded into a Geographic Information System (GIS) program, which determined the midpoint of each pond (Figure1).

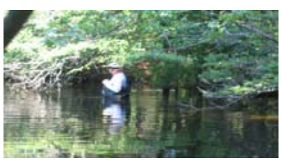

Figure 1

Stakes were used to mark sampling points on the north, south, east, and west sides of the pond three meters in from the shore. GPS was used to record the location of each sampling point. An additional stake was placed at the middle of each pond. The ponds were left to settle for twenty-four hours before sampling was carried out (Figure 2).

Figure 2

A Yellow Springs Instruments (YSI) multiprobe meter was utilized to measure pH, temperature, turbidity, conductivity, and dissolved oxygen at each point. Three successive readings were taken for each parameter at 30-60 second intervals (Figure 3).

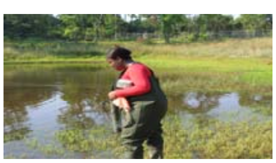

Figure 3

From each point a water sample was collected and placed on ice to minimize any chemical reaction while in the field. Each sample was analyzed for nitrate, iron, copper, chlorine, aluminum, sulfate, total chromium, molybdenum, phosphorus, tannin-lignin, suspended solids, and total hardness using Hach DREL/2000 and CEL/890 water test kits (Figure 4). A subsample was preserved with nitric acid and analyzed on an ICP-AES for eleven different elements.

Figure 4

Results

SAMPLE	Mo (ug/g)	Cu (ug/g)	Ag (ug/g)	Cr (ug/g)	Al (ug/g)	Fe (ug/g)	Mg (ug/g)	Mn (ug/g)	Pb (ug/g)	Cd (ug/g)	K (ug/g)
BP6 SOIL	3.220	25.732	7.261	12.221	4548.300	2131.700	399.920	145.710	38.578	0.506	369.400
BP6 SEDIMENT	0.000	11.208	3.210	30.968	26948.000	6788.000	1089.200	86.200	150.080	0.000	438.400
BP6 WATER	0.000	0.018	0.008	0.000	0.491	1.131	0.574	0.326	0.000	0.000	1.894
BP7 SOIL	0.000	44.328	0.000	22.231	8934.000	8924.000	892.200	104.050	73.059	0.000	126.090
BP7 SEDIMENT	5.800	195.040	0.000	87.680	22124.000	21760.000	2650.000	180.360	25.940	1.570	519.600
BP7 WATER	0.000	0.000	0.001	0.003	0.083	0.191	0.191	0.225	0.073	0.000	0.000
BP9 SOIL	5.015	6.591	1.907	4.966	2905.900	2007.900	139.547	66.110	63.594	1.288	129.811
BP9 SEDIMENT	0.000	0.000	0.000	14.708	2138.000	1119.600	85.000	62.480	111.080	0.000	86.160
BP9 WATER	0.000	0.000	0.000	0.001	0.320	1.004	0.312	0.107	0.000	0.000	0.817
BP13a SOIL	0.000	7.841	0.000	13.801	6696.000	8346.000	741.400	109.840	84.630	0.280	199.890
BP13a SEDIMENT	11.752	24.776	0.000	36.092	21116.000	20448.000	2242.000	169.600	258.040	0.000	603.200
BP13a WATER	0.000	0.000	0.001	0.009	0.963	3.659	0.683	0.265	0.198	0.000	1.042
MM SOIL	0.000	17.985	0.750	20.115	7285.333	9606.667	698.800	133.707	22.080	0.252	198.693
MM SEDIMENT	0.000	15.620	13.644	0.000	5796.000	8708.000	673.200	193.120	0.000	3.524	257.320
MM WATER	0.000	0.003	0.000	0.000	0.198	0.167	1.649	0.247	0.000	0.005	0.957
BP1 WATER	0.000	0.000	0.000	0.000	0.258	0.292	0.342	0.264	0.162	0.000	0.787
BP2 WATER	0.000	0.016	0.000	0.024	0.273	0.440	0.357	0.287	0.125	0.000	0.453

Figure 5. ICP-AES results

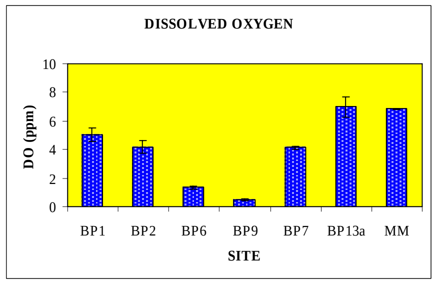

Figure 6

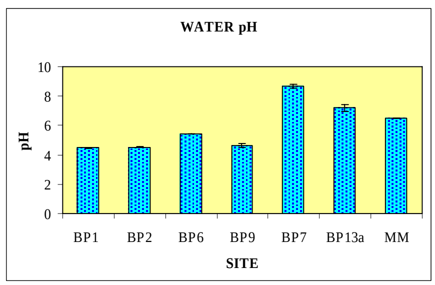

Figure 7

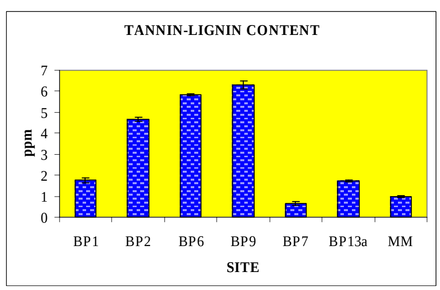

Figure 8

Location	Sulfate	Nitrate	Iron	Phosphorous	Total Chlorine	Hardness :Magnesium	Hardness:Calcium	Copper
BP7	0.4 (0.89)	0.08 (0.08)	0.55 (0.11)	0.154 (0.09)	0.012 (0.02)	3.88 (0.48)	0.798 (0.38)	0.022 (0.05)
BP6	0.275 (0.61)	0.06 (0.09)	0.49 (0.12)	0.2 (0.08)	0.024 (0.03)	1.806 (0.19)	1.724 (0.37)	0.014 (0.03)
BP9	0 (0)	0.28 (0.29)	0.902 (0.26)	0.236 (0.17)	0.044 (0.09)	1.076 (0.13)	1.456 (0.29)	0.024 (0.04)
BP2	1.6 (1.16)	0.02 (0.45)	0.374 (0.07)	0 (0)	0.028 (0.06)	1.376 (0.12)	0.916 (0.11)	0.01 (0.02)
MM	1 (0.7)	0.04 (0.05)	0.248 (0.04)	0.222 (0.15)	0.032 (0.03)	3.446 (0.65)	0 (0)	0.046 (0.05)
BP1	0.2 (0.45)	0.2 (0.17)	0.386 (0.12)	0.142 (0.10)	0.02 (0.03)	1.366 (0.11)	1.118 (0.39)	0.066 (0.06)
BP13a	0.2 (0.44)	0 (0)	2.568 (0.24)	0.246 (10)	0.048 (0.04)	1.832 (0.20)	1.364 (0.38)	0.058 (0.03)

Figure 9. Nutrient table (mg/l)

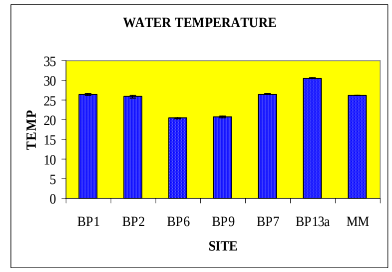

Figure 9

Discussion

The canopy that surrounds the natural ponds (BP1, BP2, BP6 BP9) provides them with shade, which was reflected in a lower water temperature when compared to the manmade and man-modified ponds. The manmade and man-modified ponds were located directly in the sun, resulting in temperatures between 25 and 26 degrees Celsius, whereas in the natural ponds the temperature ranged from 20 to 26 degrees Celsius (Figure 9). The natural ponds as a group had a pH (4.77) significantly lower than that of the man-modified and manmade ponds (7.45) (Figure 7). A lot of decaying matter such as tree branches and leaves was observed in the natural ponds. This was absent in the manmade and man-modified ponds due to the absence of surrounding trees and shrubs. This could explain why the pH levels in the natural ponds were lower than the pH levels in the manmade and man-modified ponds. Decaying oak leaves and pine needles release organic acids that result in a low pH and an increase in tannin-lignin content within a pond. Tannin-lignin was significantly higher in the natural ponds when compared to the manmade and man-modified ponds (Figure 8). Collectively, the dissolved oxygen levels in the natural ponds was lower than that of manmade and man-modified ponds, but this difference was not statistically significant (Figure 6). This difference could also be explained by the presence of decaying organic matter, possibly along with a reduced rate of photosynthesis due to shading.

Figure 10
Natural Pond (BP2)

Figure11
Man-modified
(BP7)

Figure 12
Manmade
Pond(MM)

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A Comparison of Litter Densities in Six Community Types of the Long Island Central Pine Barrens

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ABSTRACT

The condition of the Long Island Central Pine Barrens has been an area of ecological concern for the past three decades. In 2003, the Foundation for Ecological Research in the Northeast (FERN) was founded to support scientific research in the Pine Barrens. FERN's groundbreaking project is the Central Pine Barrens Monitoring Program, for which field research began during the summer of 2005 at Brookhaven National Laboratory. The purpose of this 10 year longitudinal study is to determine the current status of forest health in order to promote longevity and conservation in the Pine Barrens, as well as to learn what research should be done in the future. Litter densities from Pitch Pine, Pine-Oak, Oak-Pine, Coastal Oak, Scrub Oak, and Dwarf Pine habitats were compared in order to justify the succession of the Pine Barrens and prepare for future prescribed forest fires. Using Geographic Information System (GIS) and Global Positioning System (GPS) technology, random 16 by 25 meter plots of land were selected throughout eastern Long Island and then thoroughly surveyed. Litter and duff depth data were collected at four points along each of the ten line transects in the plot. Pitch Pine forests were found to have the most litter, with an average depth of 6.12 centimeters. Pine-Oak forests have an average litter depth of 6.03. Oak-Pine and Coastal Oak forests have comparable litter depths. Oak-Pine forests have an average litter depth of 5.01 while Coastal Oak forests have an average litter depth of 4.82. Scrub Oak lands have almost no litter with an average depth of 3.63 while Dwarf Pine Forests have an average litter depth of 2.49. A comparison of the vastly different litter densities of the six community types yields results that are consistent with the previously determined succession of the Pine Barrens and shows that litter density plays a key role in aiding forest succession. Data collected under the Central Pine Barrens Monitoring Program was used to determine a threshold for litter density, 4.82 cm. However, this trend is only from the first two years of research. In the future, a more accurate threshold can be determined in order to prescribe forest fires at appropriate times and preserve the Pine Barrens in the most effective manner.

Figure 1. A map of the Central Long Island Pine Barrens indicating the core preservation area [5]

INTRODUCTION

The Long Island Pine Barrens Society was founded in 1977 in order to bring attention to the depleting natural resources of the Pine Barrens. Initial preservation attempts to provide core or "greenbelt" areas, shown in Figure 1, during the late 1970's and early 1980's did not alleviate threats to the Pine Barrens ecosystem [1].

In 2003 the Foundation for Ecological Research in the Northeast (FERN) was founded to fund ecological and environmental research [1]. The primary project of FERN is the Central Pine Barrens Monitoring Program. The goal of this project is to track the current and future health of the Pine Barrens so that future research needs and priorities can be identified [2].

It is anticipated that the results of this research will provide data relevant to the determination of appropriate timing for prescribed forest fires. Properly timed wildfires benefit the Pine Barrens. Reduction of litter (which is composed of leaves, twigs, pine needles, and other dead vegetation) and canopy cover in the forest provides for direct sunlight on the soil and triggers new tree growth. Melting of the pine cones' resin coating enables the cone to burst open and scatter seeds directly on bare soil [3].

Baseline data for this longitudinal study was collected during the summers of 2005 and 2006. Dwarf Pine, Scrub Oak, Pitch Pine, Pine-Oak, Oak-Pine, and Coastal Oak community types were targeted at this time. Pitch Pine forests commonly have a canopy cover of nearly 100 percent pitch pine trees while Pine-Oak and Oak-Pine forests have a canopy of mixed pitch pine and oak trees. All these community types include a shrub layer consisting of huckleberry, blueberry, and scrub oak. Coastal Oak forests typically contain a canopy of various tree oaks and little to no pitch pines in addition to "a nearly continuous shrub layer of huckleberry and blueberry" [2]. Scrub Oak forests have a canopy of less than 59% that consist of primarily pitch pine trees and some oak trees. There is generally a continuous layer of scrub oak and scattered huckleberry and blueberry. Dwarf Pine forests lack canopy cover and contain Pitch Pine and Dwarf Pines that are about two meters tall. The presence of scrub oak is nearly continuous [3]. .

In order to validate the succession of the Pine Barrens and determine a threshold for litter density, litter was measured in each of the six community types.

MATERIALS AND METHODS

Plots in the Central Pine Barrens throughout eastern Long Island were randomly selected using Geographic Information System (GIS). Each plot was first located using Global Positioning System (GPS) to insure that it was in the targeted community type. Next, shrub, tree, and herbaceous cover was recorded at 20 points, each one meter apart, along each of ten transects. A densitometer was used at each point to determine an exact reading of the canopy cover. Litter and duff depths were measured to the nearest millimeter at points 3, 8, 13, and 18 along each transect [2].

Belt transects were completed following the line transects. Tapes were placed at two, four, six, and eight meters along the 16-meter edge of the plot so that seedling and sapling data could be collected for four belt transects. Next, data on trees, snags, and downed logs were collected [2].

Before leaving the plot, we estimated the percent cover and average height of each stratum including trees, shrubs, vegetation, and epiphytes. The edges and center of the plot as well as a witness tree were marked so that the plot can be located in the future [2].

A total of 91 plots were measured, however three were excluded from this study due to the vagueness of the actual community type. The breakdown of the 88 plots included for data analysis is noted in Table 1. Litter depth and seedling data for each plot (the 88 points sampled) was averaged to create a mean litter depth for each plot. This data was then sorted by community type and graphically analyzed.

Plant Community	Number of plots
Dwarf Pine	4
Scrub Oak	7
Pitch Pine	17
Pine-Oak	12
Oak-Pine	30
Coastal Oak	18

Table 1. The community type breakdown of the 88 plots used in this research.

Dana Tievsky measuring the litter depth of an Oak-Pine Forest.

RESULTS

	Dwarf Pine	Scrub Oak	Pitch Pine	Pine-Oak	Oak-Pine	Coastal Oak
Litter Depth (cm)	2.45	3.63	6.12	6.03	5.01	4.82
Standard Deviation	1.14	1.66	2.24	2.66	0.86	1
Variance	1.31	2.75	5.02	2.75	0.74	1

Table 2. The average litter depth of each community type (the mean of the average litter depth for each plot by community type). Standard deviation and variance of each mean is also displayed

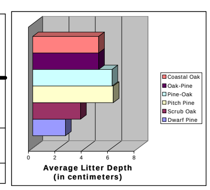

Figure 2. A comparison of average litter depth by community type.

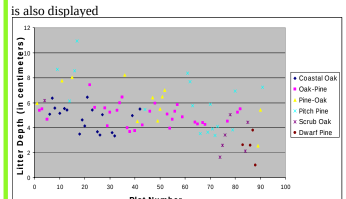

Figure 3. The average litter depth of each plot graphed to show variation in results for each community type.

Above is a picture of an undisturbed Pine-Oak forest in the Long Island Pine Barrens.

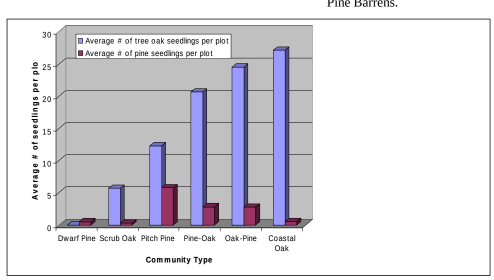

Figure 4. A comparison of the average number of tree oak seedlings to pine seedlings for each community type (in table and graph form).

Emily Efstration treks through the scrub oak to get to the plot location for the day.

DISCUSSION AND CONCLUSION

By comparing the data in Figure 2 to the forest succession, it is evident that litter depth plays an important role in the transitions of forest succession. The early stages of succession, Pitch Pine and Pine-Oak, have a high average litter depth per plot whereas the later stages of succession, Coastal Oak and Oak-Pine forests have lower litter depths. This data can be considered statistically significant since the data for each community type is within two standard deviations of its' corresponding mean.

Furthermore, community transitions because of succession occur at a very slow rate without initiation by fire. Therefore, it is sometimes necessary to prescribe forest fires and establish and maintain them safely and correctly. "Many seedlings have grown to more than six feet tall in the areas burned by the 1995 (Sunrise) fires" [4]. Pitch Pine and Scrub Oak forests are endangered community types and since these forests support uncommon species of plants and animals, it is beneficial to preserve the lands.

From the data findings of the Central Pine Barrens Monitoring Program in 2005 and 2006, a litter depth threshold of 4.82 cm. was determined. This piece of data enables prescribed fires to be properly timed for maximum conservation efforts. Resource managers of the New York State Department of Environmental Conservation can control forest fires in areas of Coastal Oak (and some Oak-Pine) forest with a litter depth of about 4.82 cm. This will jump start the forest succession and initiate more pitch pine tree growth and therefore rejuvenate the forest and help to save the endangered forest types (Pitch Pine, Scrub Oak, and Dwarf Pine)[4].

The baseline data of this research shows an abundance of Coastal Oak and Oak Pine forests as well as little regeneration in the areas of concern. Without prescribed fires it seems more than likely that the endangered community types of the Long Island Central Pine Barrens will gradually disappear.

When this project is continued in ten years, a new threshold of litter depth should be determined. Since the lands will have changed dramatically, this will help restore and manage the Pine Barrens in the most efficient way.

Prescribed forest fires should be planned and started as soon as possible so that future generations can enjoy the unique and fascinating resources that the Long Island Central Pine Barrens holds.

ACKNOWLEDGMENTS

This research was conducted in association with Brookhaven National Laboratory. I would like to thank my mentor Timothy Green, my advisors Robert Anderson and Ariana Breisch, and the FERN office manager Melanie Theisen for all of their direction and guidance during the course of the summer. Additionally, I thank the U.S. Department of Energy, Office of Science, and the SULI program for allowing me the opportunity to participate in such an exceptional and fulfilling internship program.

Special thanks also goes to the other members of the program crew: Kathryn Gutleber, Emily Efstration, Wendolie Azcona, Neal Jack, Andrew Siefert, Matthew Kull, Miranda Davis, and Chauncey Leahy.

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Foundation for Ecological Research in the Northeast

A Study of Seedling and Sapling Numbers in Relation to Canopy Cover in Six Long Island Pine Barren Community Types

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ABSTRACT

Seedlings and saplings are important to forest health because they provide insight as to how the forest will develop and survive in the years to come. The canopy cover's density has much to do with how these seedlings and saplings will develop and survive. Canopy cover, density and the amount of seedlings were studied in different forest communities to help predict the future of these forests. Using a Geographic Information System (GIS) and Global Positioning System (GPS), points were selected at random and twenty five by sixteen meter plots were analyzed. By using a densitometer, the canopy cover was determined in each plot along ten transects at randomly determined intervals. Seedlings and saplings were counted in four belt transects as well as noted in the entire plot. The different communities that were compared include Pine Oak, Oak Pine, Pitch Pine, Coastal Oak areas, Dwarf Pine and Pitch Pine-Scrub Oak Woodland/Shrubland. In the Coastal Oak community, where the cover was found to be 96% hardwood cover and no pine cover, no seedlings or saplings found. On the other hand, in a Pitch Pine plot, with 72% pine cover and 1.5% hardwood cover, approximately 86 seedlings and 85 saplings were found. When this study is redone in ten years to determine the progress of the forest, the investigators will determine if human intervention is needed to aid in forest growth. If adolescent trees were found healthy and growing, this would show the progression of the Pine Barrens and would also prove that the forest is capable of recuperating without human aid.

Emily Efstration in Scrub Oak

INTRODUCTION

The Long Island Pine Barrens, the island's largest natural area, covers 100,000 acres in Suffolk County. It is thought to have covered a quarter of a million acres at one point.

The Foundation for Ecological Research in the Northeast (FERN) was founded to fund environmental and ecological research. The Central Pine Barrens Monitoring Program is a main program of FERN. This program determines how well the Pine Barrens is doing now and how they will be in the future. By comparing the present to future data in the same areas, the overall condition of the Pine Barrens can be determined over time. Depending on the condition, human intervention may be needed to aid in restoration.

A main factor in determining the health of the forest are the seedlings and saplings that are surviving and doing well. There needs to be enough mature trees to produce seeds for germination, however there also must be enough sunlight for the seedlings to grow to maturity. A forest or community that has a lot of cover, a lot of seedlings, but not many saplings shows that the seeds are being germinated, but not enough light is reaching the ground for seedling to sapling growth. An ideal condition would be to have a large number of seedlings and saplings to show that there is growth in the community. By conducting these experiments now and again in ten years, this will show whether the Pine Barrens are growing steadily or if human intervention is needed. Studying the amount of seedlings in comparison to sunlight reaching the Pine Barren floor is very important because it determines the future of the forest.

MATERIALS AND METHODS

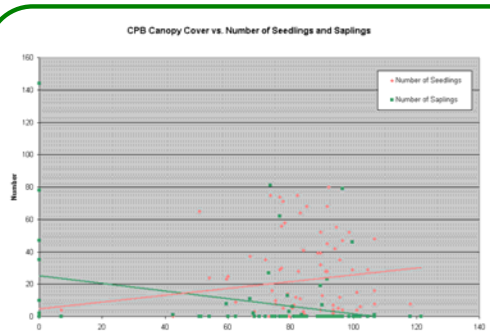
The methods were performed in accordance with the Monitoring Protocols for Central Pine Barrens Field Plots [3]. The randomly generated plots were in six different community types of the Pine Barrens Forest: Coastal Oak Forest, Oak-Pine Forest, Pine-Oak Forest, Scrub-Oak Forest, Dwarf Pine Forest and Pitch Pine Forest. The established plots are 16 by 25 meters, with the 25 meter side being parallel to the road. Ten line transects are established. The position at which the transects begin and the points where data is collected are both chosen at random. The investigator collects the data along the transects at one meter intervals for twenty meters. Once the investigator reaches each point, they record the flora observed and the density of the canopy, via a densitometer. The densitometer is an instrument used to look directly upwards. By looking through this, the observer can see exactly what kind of cover is above the point they are at in the transect. The cover will be hardwood, pine or sky.

Seedlings and saplings are recorded within the plot by forming four belt transects that are two by twenty-five meters long. Each of the four transects are sampled for seedlings and saplings of different species, hardwood and pine. Half of the plot, eight by 25 meters, is surveyed for seedlings and saplings. [3]

DISCUSSION AND CONCLUSION

All of the data collected in each of the community types (Coastal Oak, Oak-Pine, Pine-Oak, Pitch Pine, Dwarf Pine and Pitch Pine-Scrub Oak Woodland/Shrubland) supports the fact that seedlings need sunlight in order to grow into saplings. The seedlings are able to flourish under a thick canopy because the seeds are readily available for germination. By looking at the graphs, one can see that the amount of seedlings increases with the increase in canopy in all of the communities. The problem arises when the seedlings attempt to grow into saplings and the thick canopy does not allow much light to penetrate through. If the sunlight is not available, the seedlings die. This is why there are not as many saplings as seedlings under the more dense canopy.

Although the seedlings cannot grow into saplings under a dense canopy, the dense forest shows that it is thriving and doing well. It is crucial for the seedlings to develop into saplings when the forest has some sort of negative disturbance, such as a forest fire. In this case, the seedlings and saplings usually have enough sunlight to grow into adult trees and help the forest overcome the obstacle. [1,2]



RESULTS

The Figure to the left shows a direct relationship, with increasing seedling number corresponding with an increase in the density of the canopy. Saplings, on the other hand, decreased with an increased canopy cover density.

This trend was seen in all six communities (Coastal Oak, Oak-Pine, Pine-Oak, Pitch Pine, Dwarf Pine and Pitch Pine-Scrub Oak Woodland/Shrubland) studied.

Dana Tievsky looking closely for seedlings and saplings within the four belt transects, which make up 50% of the plot

ACKNOWLEDGMENTS

This research was conducted in association with Brookhaven National Laboratory. I would like to thank my mentor Timothy Green and my advisor Ariana Breisch for all of their help and guidance during the course of the summer. I also thank Melanie Theisen, our Office Manager, for her help with our research. I would also like to thank the U.S. Department of Energy, Office of Science, and the SULI program for allowing me the opportunity to participate in this excellent internship program. I would especially like to thank the other members of the program crew: Chauncy Leahy, Kathryn Gutleber, Dana Tievsky, Neal Jack and Wendolie Azcona.

Kathryn Gutleber looking at the density of the canopy cover via densitometer.

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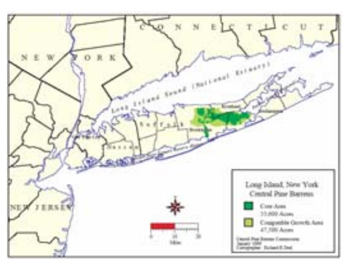

A map of the Central Long Island Pine Barrens indicating the core preservation area

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A Comparative Study of the Age Class Structures of *Quercus alba*, *Quercus coccinea*, *Quercus velutina* and *Pinus rigida* as an Indicator of Forest Health within the Long Island Pine Barrens Core Area

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ABSTRACT

Investigation of the age class structure of *Quercus* species and *Pinus rigida* within the Long Island Pine Barrens Core Area is an important aspect of monitoring the health of the Pine Barrens. The age class structures of *Quercus alba, Quercus coccinea, Quercus velutina,* and *Pinus rigida* are primary indicators of successful reproduction and the possibility of the successional change between community types. By comparing the numbers of seedlings, saplings and mature trees, the success of reproduction for these three *Quercus* species and *Pinus rigida* was analyzed. The numbers of seedlings and saplings were recorded through the use of four two-meter wide belt transects within 16 by 25 meter plots. These plots were located within the Pine Barrens subtargets of Pitch Pine, Pine-Oak, Oak-Pine, Coastal Oak, Scrub Oak and Dwarf Pine forests. This study found the success of reproduction for all the study tree species within the six community types to be varied. *Quercus alba, Quercus coccinea* and *Quercus velutina* all displayed a low number of saplings in all community types surveyed, indicating that current reproduction is not very successful. In Coastal Oak and Oak-Pine communities, *Quercus alba* was the most successful in reproduction. The reproduction of *Pinus rigida* was dominant within Pine-Oak, Pitch Pine and Pitch Pine-Scrub Oak Woodland communities. However, the low average number of *Pinus rigida* saplings found could possibly indicate the succession from pine dominated forest to oak dominated forest. There are several factors that may influence these trends in reproduction, including exposure to light, levels of litter and duff, and deer browse. Although the current levels of reproduction for *Quercus* species and *Pinus rigida* are varied and range across the different community types, they are still an important indicator of forest succession from pine to oak dominated forests within the Long Island Pine Barrens Core Area. Forest succession is an important factor in this ten-year longitudinal study of the Long Island Pine Barrens Core Area, as forest succession and species competition are primary indicators of forest health.

INTRODUCTION

The Long Island Pine Barrens, an area comprising 102,500 acres of central and eastern Long Island, is a region of ecological importance [1: 1]. In order to understand the dynamics of the Long Island Pine Barrens, the Foundation for Ecological Research in the Northeast (FERN) developed a monitoring program to collect data to measure indicators of primary ecological attributes of the region. By collecting data on the current conditions of the Pine Barrens, the monitoring program will be able to provide a baseline of forest health in order to determine the actions of further conservation efforts. When the data is collected again in ten years, the monitoring program will also serve to detect and document the degree and direction of change in forest health, and to identify the priorities of research within the Long Island Pine Barrens [2: 3].

The objective of this research is to study the age class structure of *Quercus alba, Quercus coccinea, Quercus velutina* and *Pinus rigida* so that they may be used as primary indicators of the successful reproduction patterns and the possibility of successional change from a pine to an oak dominated forest. The pattern of succession from a pine dominated forest to an oak dominated forest is from Pitch Pine forest, to Scrub-Oak Forest, to Pine-Oak forest, to Oak-Pine forest, and finally to Coastal Oak forest [3: 8]. Another objective of this research was to use the rates of reproduction of *Quercus alba, Quercus coccinea* and *Quercus velutina* to foresee the possible dominance of one particular *Quercus* species in the stages of forest succession. These findings will help to determine both the current and future ecological integrity of the Long Island Pine Barrens Core Area.

A map of the Central Pine Barrens. Courtesy of http://www.pb.state.ny.us.

METHODS

The data for this research was collected by following the Monitoring Protocols for Central Pine Barrens Field Plots. Data from 90 randomly generated plots located within six different community types was collected. The numbers of seedlings, saplings and mature trees were recorded within various randomly generated plots within the core area of the Central Pine Barrens of Long Island. These plots within the different subtargets of the Central Pine Barrens target were generated using Geographic Information System (GIS) software. The plots had dimensions of 16 by 25 meters, and were located at least 50 meters from any human disturbances (roads, houses, etc) and at least 25 meters from any ecological boundaries or differing community types. The subtargets studied were the communities of Pitch Pine forest, Pine-Oak forest, Oak-Pine forest, Coastal Oak forest, Scrub Oak forest, and Dwarf Pine Plains. To estimate the number of seedlings and saplings within each of the plots, four 2 by 25 meter transects were sampled. The entire area that was sampled for seedlings and saplings of different pine and hardwood species was 8 by 25 meters, or half of the surveyed plot.

To measure the number of mature trees within each of the plots, hardwood and pine species that had a dbh (diameter at breast height) greater than 2.5 cm and less than or equal to 10 cm, and those that had a dbh greater than 10 cm were recorded. The diameter of the trees was measured at 1.37 meters from the ground using either calipers or a dbh tape. Trees that fell in these categories were measured by dbh to the nearest millimeter and then tallied. As was the case with seedlings and saplings, if tree split below the diameter at breast height into two or more stems, the tree was still counted as being singular.

The numbers of seedlings, saplings and trees collected throughout the surveying of these plots were compiled in a Microsoft Access database. After the completion of 90 plots, the averages of the numbers of seedlings, saplings and mature trees were calculated. These averages were then used to generate graphs displaying the age class structures of *Quercus* species and *P. rigida* and relationships between *Quercus* species reproduction and *P. rigida* reproduction in the stages of forest succession.

RESULTS

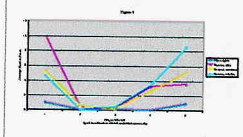


Table 1: Coastal Oak Community

	A	B	C	D	E
Pinus rigida	1	0	0.16	0.05	0.89
Quercus alba	9.8	0.32	0.11	3.11	3.47
Quercus coccinea	5.1	0.47	0.11	2.47	5.05
Quercus velutina	4.68	0.11	0.47	3.36	8.6
Average of all species	5.3	0.23	0.21	2.25	4.50
Standard deviation	3.6	0.21	0.17	1.51	3.23

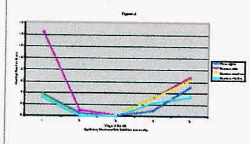


Table 2: Oak-Pine Community

	A	B	C	D	E
Pinus rigida	3.74	0.45	0	0.87	4.9
Quercus alba	14.35	0.87	0.06	3	6.55
Quercus coccinea	3.48	0.06	0.06	2.97	6.16
Quercus velutina	3.26	0	0	2.26	3.32
Average of all species	6.21	0.35	0.03	2.28	5.23
Standard deviation	5.43	0.40	0.03	1.0	1.46

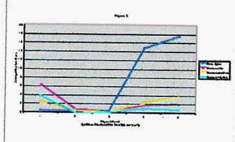


Table 3: Pine-Oak Community

	A	B	C	D	E
Pinus rigida	0.25	0.33	0.25	14.67	17.58
Quercus alba	6.08	0.58	0	1.42	1.75
Quercus coccinea	2.17	0.33	0	2	3.67
Quercus velutina	3.83	0	0	0.92	0.72
Average of all species	3.08	0.31	0.06	4.75	5.93
Standard deviation	2.48	0.24	0.13	6.63	7.86

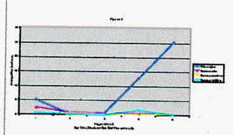


Table 4: Pitch Pine community

	A	B	C	D	E
Pinus rigida	5	0	0.44	12.67	25.17
Quercus alba	2.2	1.56	0	1.78	0.06
Quercus coccinea	0.87	0.67	0.06	1.67	1.28
Quercus velutina	0.61	0.22	0	1.78	0.33
Average of all species	2.12	0.6125	0.125	4.475	6.71
Standard deviation	2.06	0.69	0.21	5.46	12.32

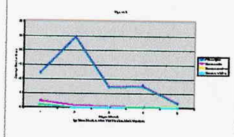


Table 5: Pitch Pine-Scrub Oak Woodland Community

	A	B	C	D	E
Pinus rigida	5	0	0.44	12.67	25.17
Quercus alba	2.2	1.56	0	1.78	0.06
Quercus coccinea	0.67	0.67	0.06	1.67	1.28
Quercus velutina	0.61	0.22	0	1.78	0.33
Average of all species	2.12	0.6125	0.125	4.475	6.71
Standard deviation	2.06	0.69	0.21	5.46	12.32

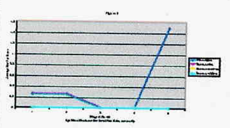
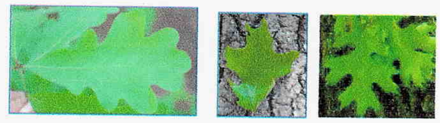


Table 6: Dwarf Pine Plains Community

	A	B	C	D	E
Pinus rigida	0.25	0.25	0	0	1.5
Quercus alba	0	0	0	0	0
Quercus coccinea	0	0	0	0	0
Quercus velutina	0	0	0	0	0
Average of all species	0.06	0.06	0	0	0.38
Standard deviation	0.13	0.13	0	0	0

In each of the figures and tables used for this research, the stages of growth are shown for each species across the six different community types. By viewing the transformation of *P. rigida* and the *Quercus* species from seedlings to saplings to mature trees, the age class structure of each species can be studied. For successful reproduction, each of the species studied will have a moderate to high number of seedlings, followed by a lower number of saplings (both between 0.5m and 2m and >2m with a dbh <2.5 cm). In healthy reproduction, the number of trees (both trees with a dbh <10cm and trees with a dbh >10cm) will increase to an average number higher than the average number of seedlings found.

For all figures and tables, the different stages of growth are represented by numbers. Seedlings are represented by A; saplings between 0.5m and 2m with B; saplings >2m and having a dbh less than 2.5cm with C; trees having a dbh less than 10cm with D; and trees with a dbh >10cm with E. The average numbers of and standard deviations for seedlings, saplings and mature trees found within the six different community types were found using the Microsoft Excel program.



Pictured above is a Quercus alba seedling. At center is a Quercus velutina leaf. At right is a Quercus coccinea leaf. Photos courtesy of www.pinebarrens.org

DISCUSSION AND CONCLUSION

The age class structures of *Quercus alba, Q. coccinea, Q. velutina* and *Pinus rigida* normally show a high number of seedlings, followed by a decrease in numbers as seedlings mature into saplings [2:33]. In order for *P. rigida* or any of the *Quercus* species to exemplify healthy patterns of reproduction, the graph representing their age class structure should display an increased average number from saplings to mature trees, following the slight decrease in average number from seedling to sapling. A high number of mature trees indicate successful reproduction patterns and overall forest health. Therefore, graphs representing the age class structure of the study species are supposed to resemble a "reverse J". Although the average number of species found per plot is supposed to decline from seedlings to saplings, the scarcity of seedlings or saplings is an indicator of the possibility of failure of tree reproduction. If the numbers of seedlings and/or saplings are very low, reproduction can be seen to be struggling [2: 33]. From this study, the range of success of reproduction between species and across the six different community types can be seen.

In studying the age class structures of the study species, it is important to look at these trends both in terms of individual species success and overall forest succession. Within the Coastal Oak and Oak-Pine communities, *Q. alba* appeared to have the most successful reproductive patterns. Factors which may influence the success of *Q. alba* over *Q. coccinea* and *Q. velutina* include include exposure to light, litter and duff depth, and the extent of deer browse [2: 34]. In order for *Quercus* species to grow, they need an adequate amount of light and fairly deep levels of litter and duff [4: 15]. If these conditions are not met, and there is deer overbrowse due to the increasing deer population in the area, the reproduction of *Q. alba, Q. coccinea* and *Q. velutina* will be unsuccessful [2: 34].

The possibility of successional change from pine dominated forest to oak dominated forest exhibited by the data from Pitch Pine and Pitch Pine-Scrub Oak Woodland communities is another aspect of reproductive patterns that are an important aspect of monitoring the Long Island Pine Barrens. Although there is some indication that these community types are undergoing succession, it is also likely that they are uneven staged forests. The reason why there are few saplings may not just be the fault of inadequate exposure to light, unsuitable levels of litter and duff, or extent of deer browse, but also may be due to different periods of growth exhibited within a surveyed community [4:14]. The number of saplings greater than two meters may be low because seedlings and saplings that are less than two meters have not had enough time to grow to further stages of maturity yet. The fact that the Pine Barrens is an uneven aged forest may also explain why there are higher average numbers of trees found within the surveyed plots while the average number of saplings was low.

Additionally, forest succession is difficult to monitor because there may not be a climax community toward which the Pine Barrens will be evolving. Rather, what the Long Island Pine Barrens appears to show us is that it is a community containing many different periods of succession. Instead of moving toward a climax community, reproductive patterns and forest succession reveal that there is an ongoing struggle between different species for light, food and nutrients contained in litter and duff. This struggle allows certain species to reproductively succeed, and others to fail in the face of varying environmental conditions [5: 70] Thus, the overall course of succession can not necessarily be predicted. By studying the individual reproductive patterns of *Quercus alba, Quercus coccinea, Quercus velutina* and *Pinus rigida* across the six different community types, the successes and failures of each species can be better understood. Future monitoring of the Long Island Pine Barrens will be needed in order to follow and preserve the natural progression of each of these species and their age class structures.

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BROOKHAVEN NATIONAL LABORATORY

Baseline pH and the Variability of pH within Plots and Community Types of the Central Pine Barrens.

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The Long Island Central Pine Barrens (CPB) is a valuable natural resource for its beauty, natural water aquifer and for being the habitat of many endangered and threatened species of plants animals and insects. The Foundation for Ecological Research in the Northeast (FERN) is an organization committed to the preservation of the Pine Barrens ecosystem by maintaining or improving the health of the forests located in the CPB. To maintain and improve the health of the forest FERN in conjunction with other organizations, funded a ten-year longitudinal study on the health of the CPB. Data collected on the pH of the soil will provide a piece of the baseline health record for this ten-year longitudinal study. To establish a baseline health record for each forest type, several 16 x 25m plots were set up, according to established protocols, within each forest community type. Using a Kelway HB-2 Soil pH meter / moisture tester the pH of the soil was taken at eight points within each plot. The average pH of the forest types were 6.3 for Coastal Oak, Pitch Pine 5.9, Pine-Oak 6.0, Oak-Pine 5.9, Pitch Pine Scrub Oak 6.1, and 6.1 for Dwarf Pine. Analyzing this data and data collected at the end of the ten-year study will be valuable in determining the long-term health of the forest as well as the effects of human intervention such as acid rain pollution.

INTRODUCTION

In 2005 the Foundation for Ecological Research in the Northeast (FERN) began research with funding provided by The Central Pine Barrens Joint Planning and Policy Commission to collect and monitor the forests in the CPB. The research was continued in 2006 to ensure enough data was collected to establish a baseline health record. In ten years the research will be repeated at the same plots that were studied in 2005 and 2006. This ten year longitudinal study is expected to provide enough data to detect small changes in the forests health.

There are several measures of forest health including, but not limited to, flora and fauna diversity, litter, canopy cover and pH of the soil. Soil pH is important because it has a role in determining what is able to survive in the soil. The pH of the soil will vary within a single plot, between different plots of the same community type and within different forest community types. Soil acidity will vary within a plot because of the flora that provide the canopy and the organic matter on the ground [1].

The purpose of this research was to establish baseline pH levels for the CPB and to determine the correlation between pH and the surrounding environment such as flora and fauna. This research will help gain insight into both the reasons for changes in forest community types as well as helping to determine a timeline for the changes.

A map of the Central Pine Barrens. Courtesy of http://www.pb.state.ny.us.

MATERIALS AND METHODS

Plots were located using Geographic Information System (GIS) software, orthophoto quad maps of Long Island and GPS units. The plot was established according to protocols [2], with ten transects bisecting the 16 x 25 meter plot.

Measurements taken included; canopy cover, ground cover, litter depth, duff depth, number of trees and saplings, size of trees, and pH of the soil. Within the plots a total of eight pH measurements were taken, four near the edges of the plot and four near the center to ensure comprehensive data (illustrated in Figure 1.)

The data used was collected from 90 plots; 18 from Pitch Pine, 18 Coastal Oak, 31 Oak-Pine, 12 Pine-Oak, 4 Dwarf Pine and 7 Pitch Pine Scrub Oak.

Using Microsoft Access and Excel, the data was analyzed to find the average pH for the community type, average pH for the plots in a community type (min/max plot avg. pH), min/max pH readings within a community type, standard deviation of average pH, variance between plots in a community type and variance between community types were all found.

Figure1 Layout of plot with red dots indicating where pH readings are taken

RESULTS

Community Type	Pine-Oak	Oak-Pine	Pitch Pine	Coastal Oak	Pitch Pine Scrub Oak	Dwarf Pine
Avg. pH	6.0	5.9	5.9	6.3	6.1	6.1
St. Dev.	0.39	0.34	0.27	0.3	0.18	0.25
Min pH	5.2	4.4	4.2	5	5.4	5.3
Max pH	6.8	6.9	6.8	7	6.8	7
Min Plot Avg. pH	5.7	5.5	4.7	5.6	5.7	5.7
Max Plot Avg. pH	6.0	6.5	6.5	6.8	6.6	6.4

Table 1 The Avg. pH, Standard Deviation, Min pH, Max pH, Min Plot Avg. pH and Max Plot Avg. pH for each community type.

Community Type	Pine-Oak	Oak-Pine	Pitch Pine
Avg. pH under Oak	5.9	5.7	-
Avg. pH under Pine	5.2	5.8	6
Edge of Tree	-	5.8	5.7
Sky	-	-	5.8

Table 2. Average soil pH in relation to canopy type for different canopy community types.

The average pH values for the different community types are shown in Table 1 with Pine-Oak 6.0, Oak-Pine 5.9, Pitch Pine 5.9, Coastal Oak 6.3, Pitch Pine Scrub Oak 6.1 and Dwarf Pine 6.1. Also in Table 1 are the minimum and maximum pH values measured in the different community types and the standard deviation of the pH. The max pH value observed was 7 and the min 4.2.

Within the three community types with canopies greater than 5 meters (Pitch Pine, Oak-Pine and Pine-Oak), the pH values are consistent with variability in plot averages.

The three remaining community types, Coastal Oak, Dwarf Pine and Pitch Pine-Scrub Oak, all have very similar pH readings. The greatest difference in readings is the max plot average pH

Below oak trees in Pine-Oak forests the soil pH was 0.2 higher than soil under oak trees in Oak-Pine forests while under pines the difference was 0.6. Also listed are the pH values of the soil in relation to the canopy cover for the point. For Pitch Pine the pH range was from 6.0 under the trees to 5.7 at the edge and 5.8 under no canopy. With Oak-Pine the pH average was 5.8 under the tree and at the edge.

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DISCUSSION AND CONCLUSIONS

The average pH values measured in this research are higher than averages measured in other forests with the same tree species present [3], [4].

Possible reasons for the differences:

- The unique location of the CPB, soil make-up and method of testing. Location could play a role in varying pH because Long Island has many different natural features not present in other Pine Barren locations such as the Atlantic Ocean, Long Island Sound, topography, geographic location, soil type, etc.
- The method of testing appears to have a large variability.

Within plots in a community type the pH was variable.

Possible reasons for the differences:

•The litter and duff depth vary within each plot [5].

•Canopy cover varies within a plot from oak to pine.

•The pH of rain falling off different parts of the tree will have different pH and cause a change in soil pH [6].

Reasons for error in pH readings:

- According to J. Peters, the Kelway HB-2 provided accurate results on soils close to pH 7.0 with an error involved using this tester of 0.2 pH [7].
- pH readings may vary due to soil texture, rainfall and manure. Litter depth, duff, mineral soil, wild animals and proximity to farms using fertilizer varied from plot to plot.
- Soil moisture varied.

Possible ways to improve accuracy.

- Other methods exist to test pH including those discussed by Cedar McKay in his article about controlled burning [8] in which samples are dried and a constant amount of water is added to the sample.
- To improve the quality of the data collected by the pH meter it may be beneficial to take the soil moisture content and compare only the data with similar moisture content.

Future Projects and Research.

- Collect samples under particular trees to determine the effect of canopy cover on soil pH.
- Consider the use of a new method of testing pH in which the testing method is more consistent and less field dependant.
- Connect research on seedling and sapling quantities to pH and other soil properties to determine if conditions can be altered to assist seedling viability.
- Repeat this study in ten years to see how soil pH has changed.

The Role of Dead Trees in a Healthy Forest: Quantifying the Abundance and Average dbh of Snags in Six of the CBP Community Types.

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Abstract

The Long Island Central Pine Barrens (CPB) has a variety of forest communities including Coastal Oak Forest, Oak-Pine Forest, Pine-Oak Forest, Scrub Oak Forest, Dwarf Pine Forest, and Pitch Pine Forest. The Foundation for Ecological Research in the Northeast (FERN) started a forest health-monitoring project in 2005 to assist land managers in preserving and protecting this natural resource. FERN evaluated Pine Barren forest health indicators including, but not limited to PH, canopy cover, sapling numbers and snags. Snags are standing dead trees, which are an important forest health indicator because they provide habitat for wildlife. The purpose of this research is to quantify the abundance of snags in six forest community types to determine in which community type they are most prevalent. Using Global Positioning System (GPS) and Geographic Information System (GIS) technology, random plots (16 x 25 meters) were selected. The quantity and average diameter at breast height (dbh) of snags in each community type were recorded for each plot. Results show that among the six community types, snags are more likely to be found in Oak-pine forest followed by Coastal oak, Pitch pine, Pine-oak, Scrub oak, and Dwarf pine Forest. Oak-pine and Coastal oak are two of the community types in which the greatest average dbh of snags exist. The research of 2005 and 2006 will be repeated in 2015 and 2016 to determine changes over time. This baseline data will also provide current information for the management of the CPB of Long Island.

Introduction

The Central Pine Barrens (CPB) is an area of Long Island that once encompassed approximately 250,000-acres in central Suffolk County but has now been reduced to 100,000 acres of relatively undeveloped land. The CPB represents one of the last strongholds of biodiversity on Long Island [2]. Many uncommon species find safe refuge to live among the sandy soils, scrublands, forests, and wetlands of the CPB. In 2005, The Foundation for Ecological Research in the Northeast (FERN) created a forest health-monitoring program in the CPB, in alliance with the Central Pine Barrens Planning and Policy Commission, Nature Conservancy, the Upton Ecological Research Reserve and Brookhaven National Laboratory, to provide forest health data.

Snags are standing dead trees, which are important forest health indicators because they provide food sources and habitat for wildlife. Moreover, the number and size of available snags affects not only the presence or absence of snag-dependent wildlife but also wildlife population levels. Commonly, the value of a snag tree increases as its size increases. To guarantee that the minimum requirements of most wildlife species are being met three snags of 12 inches dbh or greater should be available per acre [6].

The goals of this research were to 1) Quantify the abundance of snags in six of the forest community types Coastal Oak Forest, Oak-Pine Forest, Pine-Oak Forest, Scrub Oak Forest, Dwarf Pine Forest, and Pitch Pine Forest 2) Determine which community type contains a greater amount of available habitat 3) Establish the average diameter at breast height of snags in each community type.

MATERIALS AND METHODS

The data and methods of this research were collected in summers 2005 and 2006. This data came from the CPB Forest Health Monitoring Protocols by M. Batcher [1]. Plots in the Central Pine Barrens core preservation area in eastern Long Island were randomly selected using Geographic Information System (GIS). A Global Positioning System (GPS) was use to locate the plots and to insure that it was in the targeted community type located no closer than 50m to edges of human-dominated land use such as roads, and no closer than 25m to boundaries of other target community types. Field data was collected at 91 random plots (16 x 25meters). Using two 50-m tapes, chain pins, a rangefinder, and sighting compasses the corners and boundaries of the 16 x 25m plot were laid out in accordance with the protocols [1].

The entire plot was surveyed and data on trees, snags, and downed logs were collected. The diameter at breast height (dbh) was measured for all trees greater than 10 centimeters dbh, and if evident, the species was recorded. Trees 2.5 centimeters and 10 centimeters dbh were tallied by species but not measured. Trees with multiple stems were counted as one tree, but the dbh of both trunks was measured and recorded. For the downed logs, dbh's were taken at each end and in the middle of the log. The entire length of the log was also recorded.

RESULTS

In summers of 2005 and 2006, 91 plots were randomly sampled. Approximately, 210 snags were identified, and results shows that among the different communities types in the CPB Oak pine is the one that contains the greatest amount of snags with 52.3% followed by Coastal oak with 27.6%, then Pitch pine with 10.9%, Pine oak with 7.6%, Scrub oak with 1.4% and Dwarf pine plains with 0%. (See Table 1). Moreover, Average dbh show that the Scrub oak forest community contains the largest average dbh, followed by Coastal oak, Oak pine, Pine oak, Pitch pine and Dwarf pine. (See Figure 2).

In addition, results show that among the six communities types, Oak pine community contains the greatest amount of downed logs with a 31.6% followed by Coastal oak with 28.6%, Scrub oak with 22.7%, Pitch pine with 11%, Pine oak with 5.8% and finally scrub oak with 0%. Also, the Average dbh and length of downed logs was taken at each end and the middle. (See Figures 1-3).

Community Type	Plots Sampled	Average of Sags	Percentage of snags
Coastal Oak	19	58	27.6%
Pitch Pine	17	23	10.9%
Oak Pine	31	110	52.3%
Pine Oak	12	16	7.6%
Dwarf Pine	4	0	0%
Scrub Oak	7	3	1.5%
Total:	90 plots	210	99.9%

Table 1. The average number of snags in each community type and the number of plots sampled in each community type.

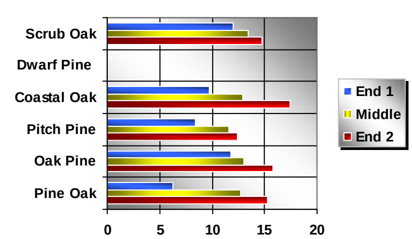

Figure 1. Average dbh of downed logs in the Six Community Types of the CBP.

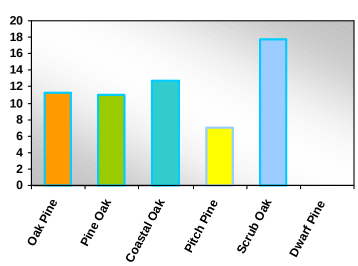

Figure 2. Average dbh of snags in of the different communities types of the CPB.

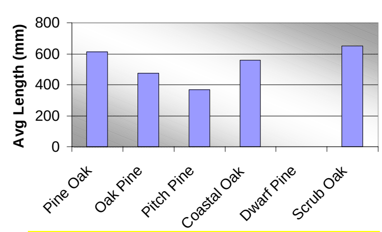

Figure 3. Average of the length of downed logs in six community types of Long Island CBP.

DISCUSSION AND CONCLUSION

When evaluating the health of a forest, it is important to consider the structural needs of wildlife. Snags are very important for a forest health because without them, there would be a decrease in the number and diversity of wildlife. Around five hundred species of birds, three hundred species of mammals, four hundred species of amphibians and reptiles and nearly all fish benefit from snags for food, nesting or shelter [6]. Therefore, it is very important to monitor and research existing snags and their effect on forest health.

Quercus alba makes the best snags, closely followed by the other *Quercus* species because they are long-lived. The Oak-Pine community has the greatest quantity of snags habitat. There were not many snags in Pine-oak or Pitch pine. A conclusion cannot be drawn on the Dwarf Pine community, as only four plots of this rare and unique community. However, none of those plots had any snags or downed trees found.

This research documents the abundance and average dbh of snags in six different communities of the CPB. When these same plots are researched again in 2015 and 2016, the changes in the quantity and average dbh of snags among the six communities will be learned. This data, in combination with other forest health data will show which areas are thriving, declining or staying the same.

Acknowledgements

I gratefully acknowledge the wisdom and assistance of the following programs, the Office of Science and Brookhaven National Laboratory for the opportunity to take part in this research. In addition, I thank the U.S. Department of Energy and the CCI program for giving me the opportunity of being part of such important research. Thanks to the following individuals, my mentor Dr. Timothy M. Green for choosing and giving me the opportunity of being in this program. Also, I would like to thank Ariana Breisch for her guidance, comprehension, and patience with us. I would also like to thank the Foundation for Ecological Research in the Northeast for creating and funding my project. Thanks to all members of the Office of Educational Programs; especially, thanks to Noel Blackburn and Kathy Gurski for their patience with me and for always being there when I needed them. I specially thank my team members Kathryn Gutleber, Neil Jack, Dana Tievsky, Emily Efstration and Chauncey Leahy without whom I would not have been able to complete the research for this report.

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CCI

Developing Techniques to Determine Associations Between Tiger Salamander and Small Mammal Burrow Use

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Abstract

The study of the terrestrial habitats of the eastern tiger salamander (*Ambystoma tigrinum tigrinum*) at Brookhaven National Laboratory is crucial in protecting further decline of the species. An important aspect of such habitats includes the presence of small mammals and the underground burrows that they create. While past studies have shown that tiger salamanders occupy abandoned burrows, they have also been observed to reside in active mammal burrows. Surveys were conducted using Sherman live-traps in order to assess the number and species of small mammals that may interact with tiger salamanders and affect their natural habitats. A comparison was done to see if there is a difference between areas where tiger salamanders have been observed and random areas with no tiger salamander observations.

Introduction

Ambystoma tigrinum tigrinum, the eastern tiger salamander, is found in New York State only in the eastern parts of Nassau County and throughout most of Suffolk County. These amphibians, endangered in New York State, have suffered a decline in population that appears to be directly linked to loss of habitat and disturbance of breeding ponds.

Tiger salamanders are fossorial and are classified as "mole salamanders" for their adult lifestyle of living underground. In early spring, these adults will travel to breeding ponds where larvae are hatched. After approximately 5 months, the larvae develop into sub-adults and leave the pond to find their own burrows.

Tiger salamanders have been largely documented to reside in small mammal burrows but have also been observed to dig shorter routes off of the main burrow. There is also evidence that tiger salamanders may occupy these underground burrows even when small mammals remain. Unfortunately, the more aggressive of these, such as the short-tailed shrew, have been known to prey on tiger salamanders. (Madison and Farrand 1998; Titus, *pers obs*)

While there are many species of small mammals found at Brookhaven National Lab, those most of concern include several species of fossorial mice, voles and shrews. Although other rodent species are also prevalent (eg. meadow vole, field mouse) we feel that they will show little to no association with tiger salamanders in this particular study because of their lack of contact with tiger salamanders.

Materials and Methods

Small mammal trapping is utilized to determine the species and population of animals living in a particular area.

Trapping was accomplished using Sherman live-traps, which are no-kill traps used to capture small mammals. Traps were baited with rolled oats in peanut butter. These particular traps are constructed into a rectangular 3" x 3.5" x 9" shape and are sprung shut when weight is placed on a lever inside the trap. Traps were laid out one meter apart in a 5 by 5 meter array. Two locations were utilized: one random woodland area and one known salamander burrow. Traps were checked early in the morning, then shut and re-opened in the late afternoon. It is advisable to check live-traps shortly after dawn in order to reduce the possibility of trap deaths due to heat stress. Furthermore, mammals with high metabolism (eg. short-tailed shrew) easily suffer from lack of food if left in the traps for too long.

We noted the species and gender of each captured specimen. Furthermore, specimens were placed in a plastic bag and weighed using precision scales. They were then released as soon as possible to reduce further stress on the mammal.

Figure 1 – White-footed mouse
http://www.abc.net.au/science/news/img/life/white_footed_mouse.jpg

Figure 2 – Eastern tiger salamander (*Ambystoma tigrinum tigrinum)*

Figure 3 – Random trapping site

Figure 4 – Salamander burrow trapping site

Figure 5 – Sherman live-trap

Figure 6 – Tiger salamander breeding pond at BNL (TS7)

Results

Over the course of 75 trap nights, 4 white-footed mice were captured at the salamander burrow site. During the same number of trap nights, 0 small mammals were captured at the random location.

Discussion/Conclusion

The small number of mammals caught at the tiger salamander burrow can be attributed to weather issues such as the extreme heat that was experienced during the survey. The lack of small mammals captured at the random location can also be linked to the weather. However, since the random site was not located near underground burrows, it is also possible that there were no mammals present.

The study of underground burrow use is essential because of the potential link between small mammal and tiger salamander populations. Moreover, any attempt by humans to control rodent populations can directly contribute to further decline of the tiger salamander species.

Further study is necessary in order to thoroughly study tiger salamander and small mammal burrow use. It is advisable in the future to conduct trapping surveys in cooler temperatures.

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Chytrid fungus and *Ranavirus* in Long Island Frog Populations

Possible leads on the disappearance of the Southern Leopard Frog from Long Island.

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Abstract:

Amphibian populations worldwide have been devastated by Chytridiomycosis, a disease caused by Chytrid fungus (*Bactrachytrium dendrobatidis*). Having likely originated in Africa, it has been found on nearly every continent and can be spread by a number of hosts. Many amphibian species do not have any tolerance to the fungus and populations can quickly disappear following its introduction to the area. However, some can survive the disease and will act as carriers to spread it. Iridovirus is also a threat to local populations and was found at the Brookhaven National Lab last year. As such, this project was conducted to investigate the potential link that these diseases may have with a recent island wide decline and possible extirpation of the southern leopard frog (*Rana sphenocephala*). In their absence, several common and related potential vector frog species were sampled from various Long Island wetlands. Frogs were swabbed and the swabs were tested for Chytrid and Iridovirus. PCR and gel electrophoresis will be used to confirm the presence or absence of the diseases. The presence of chytrid or iridovirus in local populations would serve as a possible lead in the decline of Southern Leopard Frogs on Long Island. This was a data collection study and will not include the final results.

Introduction:

Chytrid:

Chytridiomycosis, a disease caused by the fungus *Batrachochytrium dendrobatidis* has been correlated with the decline and extinction of many amphibian species worldwide. Chytrid fungus was brought to the forefront of amphibian decline research following the extinction of the Golden Toad and Harlequin Frog in Monteverde, Costa Rica (Pounds, 1994). It has been found in North and Central America, Australia and Europe (Ouellet, 2003; Pounds,1994; Obendorf,2005; Stuart, 2004). While other elements such as climate change seem to factor into the disappearance of species, Chytrid fungus has been indicated as the main cause in many cases.

The fungus is found in the keratinized skin of amphibians (Longcore, 1999). In adults this is contained to the stomach, legs and toe pads of the animal. In larvae the mouth parts are usually the only tissue affected. The fungus is not normally lethal to larval stages; however in metamorphing and adult stages, it can be fatal (Blaustein, 2004). The exact mechanism by which *B. dendrobatidis* kills is still largely unknown. The only consistent symptoms of the fungus are excessive skin cell loss and lesions in animals with heavy infections. Although *B. dendrobatidis* is lethal in some species, other populations survive with the fungus and remain relatively unharmed by it. These species may act as carriers to spread the disease to other areas and other populations. North American bullfrogs have been shown to survive with active infections (Garner, 2006). Bullfrogs and other surviving species can be tested to determine if the fungus is in an area.

Ranavirus:

Iridoviruses of the family *Iridovirdae* and genus *Ranavirus* are also a threat to amphibian populations. There are several different types of Iridoviruses which affect different groups of organisms. *Chloriridovirus,* and *Iridovirus* affect only invertebrates, while *Ranavirus* and *Lymphocystivirus* affect vertebrates (Williams, 2000). They are also responsible for the decline of some species such as the tiger salamander (*Ambystoma tigrinum diaboli)* (Bollinger, 1999). Iridovirus is also involved in the decline and disappearance of some species of turtle (De Voe, 2004; Chen, 1999). *Ranavirus* affects different species in different ways.

Both Chytrid Fungus and *Ranavirus* are possible contributors to the decline and likely extirpation of the Southern Leopard frog from Long Island. *Ranavirus* has been found in box turtles at Brookhaven National Laboratory; but it is unknown how far its range reaches. It is still uncertain whether or not Chytrid fungus has infiltrated Long Island frog populations, however it is known for its rapid spread and nearly unstoppable movement.

Discussion:

Chytrid fungus is a threat to Amphibian species and biodiversity worldwide. It has been found in many species on different continents (see Figure 1). While not all of these species are killed by the fungus, they can continue to carry it. It is unknown whether or not some species are susceptible to the fungus. Leopard Frogs are thought to be killed by the fungus and Bullfrogs and Green frogs are not. However, there is still no conclusive evidence at this time proving that Chytrid fungus has been introduced anywhere on Long Island.

Ranavirus has been shown to be lethal to other reptile and amphibian species. It may play a role in the decline of Leopard Frogs. However there is still no conclusive evidence proving whether or not it is present in frog populations. Disease is a very likely contributor to the extirpation of Southern Leopard frogs from the region. Their sudden disappearance is indicative of a catastrophic event rather than a slow change. Other possibilities include interspecific competition and invasive species introduction. An ongoing project will look into these possibilities along with the effects of chemicals and pesticides in the environment and habitat loss

Golden Toad (*Bufo periglenes*)

Bullfrog (*Rana catesbeiana*)

Wyoming toad (*Bufo baxteri*)

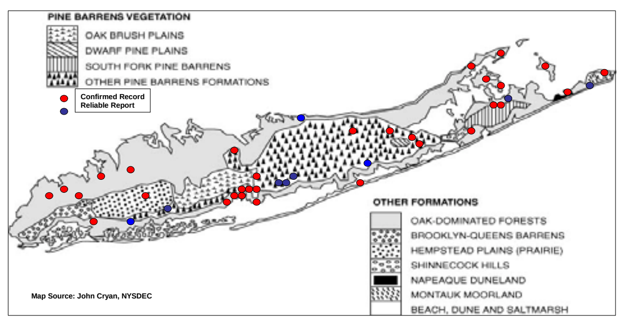
Boreal toad (*Bufo boreas*)

Spring peeper (*Pseudacris crucifer*)

Methods and Materials:

Initial data collection included surveying ponds with historic leopard frog sightings. These surveys were conducted by a minimum of two researchers at a time. At all the sites where there were green frogs, bullfrogs or pickle frogs, individuals were collected. These individuals were measured and swabbed. Swabs were collected for samples of both Chytrid fungus and *Ranavirus*. Chytrid swabs were collected from the ventral skin surfaces. The *Ranavirus* swabs were collected from the mouth and lips of the frogs. Following the collection, all swabs were kept in vials and transported to a freezer as soon as possible for long term storage.

Potential leopard frog sites on long island.



Results and Conclusion:

This study was an initial data collection for further analysis at a later time. Swabs were stored in a freezer and DNA extractions were performed. However, until PCR analysis can be done, the study will not be completed. While it is possible that chytrid fungus is present in long island populations, it will not be known until further tests are done. Since *Ranavirus* has been found on Long Island, it is likely that it is present in some populations. Its presence or absence has not been confirmed in Long Island frogs at this point.

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A Survey for the Southern Leopard Frog (*Rana sphenocephala*) on Long Island

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ABSTRACT

The southern leopard frog (*Rana sphenocephala*) was once one of the most common frog species on Long Island. However, over the last several decades, populations have declined rapidly and the southern leopard frog may be extirpated from Long Island. In order to assess the status of *R..sphenocephala* on Long Island, all wetlands on the island with suitable habitat were surveyed. A number of historic leopard frog sites and other areas considered viable within the previous range of the species were thoroughly surveyed at least once in an attempt to document any remaining populations. The southern leopard frog was not seen at any of the sites that were evaluated. However, this still does not confirm that this species no longer exists on Long Island. There may still be small, very localized populations which could only be identified during the calling season from Late March to early May, when the species is most easily found.

INTRODUCTION

The southern leopard frog (*Rana sphenocephala*) is a wide ranging species that can be found from Long Island south to Florida, and through the Midwest to Texas and Oklahoma (Conant and Collins, 1998). Southern leopard frogs will breed in a variety of habitats including ditches, wet meadows, seasonal ponds, wooded swamps and sediment basins (Conant and Collins, 1998). On Long Island, they have historically favored open, grassy habitats like farm ponds (Latham, 1971) citation. Although the primary breeding season is in March and early April, southern leopard frogs have been known to breed in every month of the year. Leopard frogs move considerable distances from water, especially in wet grasslands or damp woodlands.

The southern leopard frog was one of the most common frog species on Long Island in the early 1900's (Overton, 1914; Noble, 1927; Turrell, 1939; Latham, 1971). It remained common in many areas until recently (the past 20 – 40 years), when it declined throughout the island. This frog may now be extirpated from the entirety of Long Island. Many factors may have contributed to their decline including disease, invasive vegetation, habitat change and succession, contaminants, and overcollecting. The southern leopard frog is currently a species of special concern in New York State, however, there have not been any confirmed records on Long Island since the early 1990's.

The objective of this project was to develop an understanding of the current status of leopard frogs on Long Island, to establish theories regarding potential causes of the decline, and to locate any remaining southern leopard frog populations that may still exist. If found, they may be put into a breeding program and reintroduced to areas they were found in the past as part of a future research project.

Figure 1: Examples of southern leopard frog habitat from the New Jersey Pine Barrens.

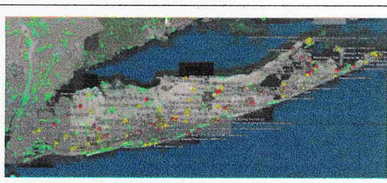

Figure 2:A map of primary, secondary, and tertiary southern leopard frog sites on Long Island. Sites with red marks are historic sites. Other potential sites are in yellow.

METHODS AND MATERIALS

Prior to the start of our project, we visited several known and currently active southern leopard frog sites in the New Jersey Pine Barrens to establish reference sites (Figure 1). These sites were visited several times during the year to provide a baseline for expected behavior and activity to apply to our research on Long Island.

Before entering the field on Long Island, wetland sites were selected using historic locality information from the literature and visits to the American Museum of Natural History and the New York State Museum. We also used anecdotal records from local naturalists. We then used the program Google Earth (Figure 2) to analyze aerial photographs and find historic sites and other wetlands with suitable habitat to create a project map (Figures 3 and 4). We classified sites into three groups: primary, secondary, and tertiary. Primary sites were historic leopard frog sites. Secondary sites were areas with appropriate habitat. Tertiary sites were wetlands that could potentially hold a remnant leopard frog population, but lacked certain characteristics of ideal leopard frog habitats.

We conducted walking pedestrian surveys at these sites and also conducted calling surveys. We inspected the perimeter of all accessible wetlands and focused on shallow, open, grassy areas. We used a tapeplayer and played the calls of southern leopard frogs in an attempt to induce the frogs to call. We also used dipnets to capture any larval amphibians in the wetlands that were surveyed.

Figure 3: An example of suitable southern leopard frog habitat from a historic leopard frog sites on Long Island.

Figure 4: Examples of poor southern leopard frog habitat from Long Island. The area on the left is a swampy, closed canopy wetland. The area on the right is being overtaken by *Phragmites*, which is the tall, stalk-like plants in the background.

Figure 5: A close relative of the southern leopard frog, the pickerel frog. This species is found near shallow water in open, grassy areas, just like the southern leopard frog. However, unlike the leopard frog, the pickerel frog is fairly common on Long Island.

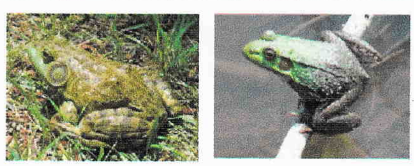

Figure 6: A bull frog (left) and a green frog (right). In places where leopard frogs were once abundant, bull frogs and green frogs are now very common. It is possible that they have outcompeted the leopard frogs.

RESULTS

After surveying 53 primary, 86 secondary, and 41 tertiary sites on the island, we did not find or confirm any surviving leopard frog populations on Long Island. However, we did receive reliable reports of southern leopard frogs from Montauk and Staten Island. We did document several other species of frogs including green frogs (*R. clamitans melanota*), bull frogs (*R. catesbeiana*), spring peepers (*Pseudacris crucifer*), gray tree frogs (*Hyla versicolor*), Fowler's toads (*Bufo fowleri*), eastern spadefoot toads (*Scaphiopus holbrookii holbrookii*), and the closest relative to the leopard frog, the pickerel frog (*R. palustris*) (Figure 5).

DISCUSSION

The two supposed remaining southern leopard frog populations in Montauk and on Staten Island must be confirmed in the near future. These populations could be located, captured, used for a captive breeding program. The frogs could then be protected, used to research the decline, and ultimately used to conduct a possible reintroduction project at other historic sites in an attempt to re-establish the species.

After surveying all of the sites we realized that many of the historic sites have changed dramatically since the early 1900's. Many farm ponds have succeeded into forested ponds. Furthermore, *Phragmites*, an aggressive invasive plant has overtaken many wetlands. Both processes may crowd out leopard frogs, as they prefer open areas.

However, we did survey several historical sites on Long Island with ideal southern leopard frog habitat, but did not see any leopard frogs at these sites. The absence of the species from these areas is alarming and may indicate a different, more subtle cause for this decline, such as disease, contamination, or competition (Figure 6). In the future, environmental samples could be taken from these sites to determine the reason for the decline of this species.

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Non-Invasive Species Confirmation of Fox Populations at Brookhaven National Laboratory or Scat Happens at BNL

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Abstract

Information regarding the present day status of Fox populations on Long Island, NY is essential for an understanding of species diversity. Historically, Red Fox (*Vulpes vulpes*) and Gray Fox (*Urocyon cinereoargenteus*) occurred sympatrically on Long Island, NY. Although current population size estimates have not been established for either species it is speculated that the Red Fox has adapted to anthropogenic disturbances better than the Gray Fox. After the discovery of a deceased Gray Fox in the Relativistic Heavy Ion Collider at Brookhaven National Laboratory (BNL) in October of 2004, questions arose concerning the presence of this species in the area. To determine if the Gray Fox is utilizing areas of BNL as a home range, this study focused on observing mitochondrial DNA markers in feaces, which enable us to distinguish between the two species. A positive scat sample and camera trap shot have confirmed the presence of gray fox at BNL.

INTRODUCTION

In October of 2004, a deceased juvenile Gray Fox *(Urocyon cinereoargenteus)* was discovered on the Relativistic Heavy Ion Collider (RHIC) road on Brookhaven National Laboratory (BNL) property. This discovery led to many questions concerning the abundance of this species at BNL. Information regarding Red Fox *(Vulpes vuples)* and Gray Fox populations on Long Island, New York is scarce and outdated with no current studies in progress on the subject. This preliminary study focuses on the method of analyzing mitochondrial DNA, which is extracted from suspected fox faeces to distinguish between the two species. This non-invasive method of species identification is very useful in field studies as it imposes no stress on the animal in question and therefore does not alter the species usual movements and habits. The samples for this type of study are easy to obtain as canids tend to follow well-traveled game trails and roads for defecation and boundary marking [1].

Past literature states that although red and gray fox occurred sympatrically on Long Island, New York, the gray fox was the predominantly abundant species [2]. The gray fox was a more aggressive competitor when in its preferred habitat of undisturbed mature pine or hardwood combined with brushy undergrowth [3]. Since the dominant habitat on BNL is mixed oak-pine with a heavy understory of blueberry and huckleberry it falls into the preferred habitat type for gray foxes. With development limiting habitat, it is speculated that the red fox has adjusted to anthropogenic impacts more successfully than the gray fox, enabling it to become the abundant species [4].

The differences between the two species are mainly in pelage coloring with the gray fox having a black tipped tail and the red fox having a white tipped tail. The pelage of the gray fox is mostly gray but does include reddish marks along its neck. The red fox has black tipped ears and black legs that also help to distinguish it from the gray fox. Both species are crepuscular and nocturnal and share the same foraging techniques in their search for prey. They both are generally opportunistic feeders subsisting mainly on small mammals, insects, carrion and whatever berries may be in season except the gray fox is more inclined to subsist on insects and vegetation than the red fox [5]. Another distinguishing is that the gray fox is the only North American canid that has the ability to climb trees enabling it to escape from most terrestrial predators.

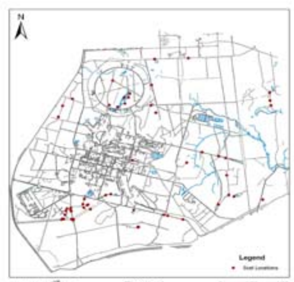


Figure 1
Location of Scat Collected at Brookhaven National Lab in 2006

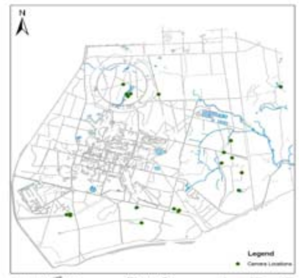
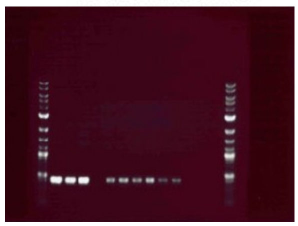
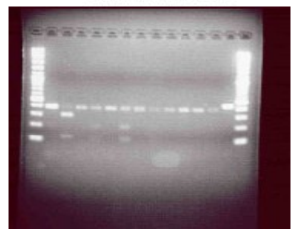


Figure 2
Camera Locations during 2006 at Brookhaven National Lab



PCR Product Results from Scat are shown as 412bp Lines on a 0.8% Agarose gel



Results of Enzyme Restriction

Gray Fox Caught on Camera Trap

Red Foxes Caught on Camera Trap

RESULTS

The camera trap provided a positive result for a gray fox identification on the east portion of the laboratory. The fox was initially caught on the time set images on 07/21/06 at 04:28 hours and 07/22//06 at 02:50 hours. On 8/2/06 canned dog food was deposited in the line of the camera trap in the hopes of gaining clearer motion set images. An individual did return on 07/29/06 and was caught on the motion images where the specific pelage distinctions between red and gray foxes could be observed. The individual did not have the black legs and ear tips normally associated with the red fox but did have a darker pelage, muzzle and the black tip tail associated with the gray fox species.

Although 90% of DNA extraction performed on stools (n = 39) yielded that DNA was present in samples, PCR proved successful in (n = 14) or 26% of scat samples. Two samples produced unexpected PCR product. PCR was successful in yielding the desired 412bp segment.

Enzyme restriction of the control sample that was run on tissue from an assumed gray fox yielded bands that matched the expected patterns of a red fox. PCR was conducted again on the tissue and results were sequenced on Sequencher software. The resulting chain of nucleotides was compared to known sequences in the genbank database and the sample was returned back as *Vulpes vulpes*.

Enzyme restriction yielded 13 positive red fox samples. A sample found on the eastern portion of the lab was positive for gray fox. Two unknown pcr products yielded no bands during enzyme restriction.

Methods

Transects were walked on a daily basis with randomly chosen locations in the search for scat collection. Transects focused on the perimeter of BNL property in the more undeveloped sections. Sample collection was relatively easy as the foxes utilized roads on many occasions. All collected samples (n=58) were recorded with a gps point location. A red fox, gray fox and domestic dog controls were established using protocols from the Qiagen DNeasy Tissue kit.

Fecal extraction for mtDNA was performed on (n = 39) samples following protocols from the Qiagen QIAmp DNA Stool Mini Kit. PCR was conducted on all resulting mtDNA samples using a Taq PCR kit following standard protocols. Following standard protocol, enzyme restriction was performed on successful pcr products using AluI and HinfI enzymes.

A Reconyx camera trap was used to locate areas of suspected fox activity. Camera locations were recorded as points with the Thales gps/gis unit (Figure Two). Once the camera confirmed presence of fox in the area transects would then be focused on that location in the search for sample collection.

DISCUSSION

With known presence of Red fox on the northern and southern Areas of BNL it was interesting to find evidence of Gray Fox on the eastern portion of the property. It is unknown if this individual is related to the individual found deceased in the RHIC in October 2004. Although initially assumed to be a transient juvenile dispersing to establish a territory, it is now speculated that this incident may be the result of a permanent gray fox sub population on lab property. The RHIC area and east fifth avenue, where the gray fox was captured on camera, are about 1 mile apart from each other, a distance that could easily be encompassed in a gray foxes home range size. It is possible these two individuals originated from the same natal range, but more information regarding the DNA sequences of each individual would be needed in order to determine their relatedness. If it was discovered that the RHIC area was encompassed within the Gray Foxes Home Range this would lead to more questions concerning Red and Gray Fox interactions due to the well-documented Red Fox den located in the center of the RHIC.

Due to heavy precipitation sample collection was limited and quality of samples was compromised. Many samples had been exposed to sun, rain and other weather occurrences for unknown lengths of time effecting sample quality for DNA extraction. DNA of unknown species may have been extracted from the samples where DNA was present in the initial gel but had no PCR success. The method of storing samples at –80° C in DET buffer may improve DNA extraction for future results [6].

Lack of PCR product from some of the scat samples can be due to lack of fox DNA present in samples. It is unknown if the origin of DNA that resulted from extraction was from fox species or from prey and vegetation consumed by the defecating individuals. It is assumed that a lack of PCR product means the original DNA did not originate from a fox species.

An interesting note in the study came from the suspected Gray Fox control that turned out to in fact be of the species *Vulpes vulpes*. When the nucleotide sequence of this individual was run through genbank database it was discovered that this individual showed some regional mutations and contained a unique nucleotide sequence that was different from other published sequences.

The future of this project will be focused on locating more evidence of gray foxes utilizing habitat on BNL. The staff of the project also hope to begin identifying individuals of fox species through DNA sequencing in order to construct home range sizes, determine survivorship and learn more about the interactions between red and gray fox species at BNL.

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Investigation of the Characteristics of Ponds and Vernal Pools used by Eastern Tiger Salamanders and their affects on Juvenile Recruitment

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ABSTRACT

The Eastern Tiger Salamander (*Ambystoma tigrinum tigrinum)* is endangered in part due to rapid over-development on Long Island. In order to properly manage this species, protocols must be developed to identify suitable habitat and habitat preservation requirements. Egg mass surveys can be used to evaluate the optimum conditions of ponds and vernal pools used by tiger salamanders for reproduction. Linking egg mass presence and abiotic factors, such as hydroperiod, weather, pH, conductivity, etc., with juvenile recruitment can assist in creating models that predict how productive a pond or vernal pool has the potential to be. This research investigated the characteristics associated with ponds and vernal pools used by tiger salamanders for breeding to determine which ponds are the most productive, as well as which ponds result in the greatest amount of surviving larva. Egg mass surveys were conducted from 2000 through 2006 at thirty-seven pond and vernal pool locations throughout the Brookhaven National Laboratory property and juvenile recruitment data was collected at four of the ponds via drift fences and several ponds were sampled via seining. Data suggest that hydroperiod and weather may be the most crucial factors influencing the survival of larvae into metamorphosis. To look further into hydroperiods affect on metamorphs, t-tests were conducted to see if there was a significant difference in the mass and snout-vent-length (SVL) of metamorphs captured at two of the focal ponds, P7 and P13. The tests resulted in significant differences which indicate the potential affect of hydroperiod.

INTRODUCTION

The Eastern Tiger Salamander (*Ambystoma tigrinum tigrinum*) species was once widely distributed across Albany and Rockland Counties of New York, as well as in Nassau and Suffolk Counties on Long Island. However, it is currently found only in a few isolated populations on Long Island Suffolk County and in the recent past, Nassau County. Populations in Nassau County are now suspected to have been extirpated. Approximately 120 sites have been defined as tiger salamander breeding sites across Nassau and Suffolk Counties, although most sites have not been re-confirmed since the early 1980's and a 1994 census effort of 51 previously documented sites resulted in just 28 confirmations [1]. The decline in tiger salamanders is mostly attributed to over development on Long Island and to protect this species from local extinction a better understanding of the characteristics of ponds and vernal pools used by tiger salamanders is needed.

Egg-mass surveys, with attention to climactic conditions, can be used to develop predictive models for determining the suitability of ponds and vernal pools as tiger salamander breeding sites [2,3]. In addition, juvenile recruitment data can be collected and used to determine the optimum conditions for larval survival [4].

This research set out to: 1) Investigate the characteristics associated with ponds and vernal pools used by tiger salamanders for breeding, 2) Determine which ponds are the most productive, and 3) Determine which ponds result in the greatest amount of surviving larva. Protocols developed from this and other studies will be applied to a management plan to ensure the survival of this endangered amphibian with recommendations for identification of suitable habitat and minimum habitat preservation requirements for habitat in areas that are being developed.

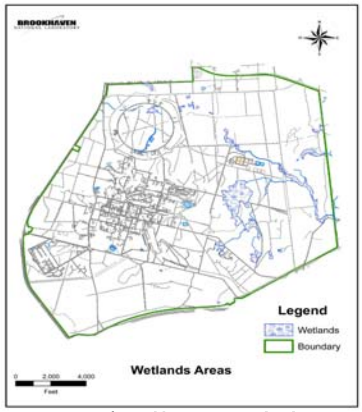

Figure 1. Map of Brookhaven National Laboratory Wetlands

Tiger Salamander Captured in Drift Fence

One of the focal ponds at Brookhaven Lab

METHODS

The data were collected in the springs of 2000 through 2006 at thirty-seven pond and vernal pool locations throughout the Brookhaven National Laboratory property (Figure 1). Pond characteristics of both known and unconfirmed tiger salamander ponds were surveyed during this study in order to create comparisons to predict potential occurrence of tiger salamanders in unstudied habitats. Numbers of egg masses per pond were recorded on an annual basis, as well as several habitat variables. These variables include vegetation cover, water depth (both average and maximum) air temperature (ºC), water temperature (ºC), turbidity, pH, conductivity, and dissolved oxygen levels. Average daily and monthly temperatures and precipitation were also documented. Presence of adult and juvenile salamanders during surveys was also noted. Surveys conducted utilized primarily daylight investigations, with some additional night surveys for confirmation of activities. Egg mass surveys are often hindered by presence of ice on ponds that may extend well into March annually.

Juvenile recruitment data were collected via drift fences at four ponds. At, three of the ponds drift fence data was collected since 2003 on all amphibians and mammals captured. The yearly drift fence and egg mass data were compared at these three ponds to further our understanding of the factors affecting recruitment.

The fourth pond's drift fence was installed this year and could not be compared to previous years. However, seining data from previous years was used to estimate juvenile recruitment for those years and those estimates were used for comparison with this year's data.

RESULTS

Figure 2 shows the average egg mass counts per year, with error bars, for ten of the ponds in this study. The average number of egg masses ranged from 2.17 to 29.33, with standard deviation ranging from ±3.13 to ±27.41.

Due to the lack of seining data, further tests were conducted. We tested the mass and SVL of P13 X P7 for years 2005 and 2006, P13 (year 2005) X P13 (year 2006), and P7(year 2005) X P7(year 2006). Table 1 shows the P-value of the t-tests.

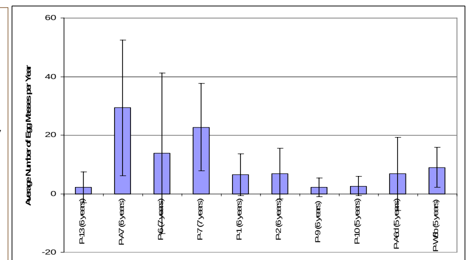

Figure 2. A graph of the average number of egg masses per year, counted at ten study ponds from 2000-2006. The error bars show the standard deviation in yearly counts and the legend notes, in parentheses, how many years each pond has been included in the study.

	P13XP7 2005	P13XP7 2006	P7(2005) X P7(2006)	P13(2005)XP13(2006)
Mass P-value	2.56365E-05	0.000258964	3.11379E-07	0.029442632
SVL P-Value	0.014130956	0.025805632	0.00430285	0.041855051

Table 1. T-test results showing significant differences in the mass and SVL of tiger salamander metamorphs captured at two focal ponds.

CONCLUSION AND DISCUSSION

Upon examination of the Figure 2, we noted that ponds with lower average counts also had lower deviation from the mean. Reasons for this possible trend are unknown at this time. However, it may be due to fluctuations in any or all pond variables discussed above. The most influential factor may be hydroperiod, which is known to play a major role in tiger salamander activity.

Because we suspected the problems with seining were also caused by changes in hydroperiod, we decided to look deeper into P13 and P7. In 2005, the water level of P13 was constant throughout the season and the water level of P7 declined rapidly in July and dried up completely before the established time of emergence. The metamorphs captured at P13 in 2005 were significantly greater than those captured at P7. In 2006, the opposite trend was observed. P13 began drying up so prematurely we had to have water added by the fire department to keep the egg masses from dying. P7 however, maintained a constant water level and metamorphs captured at P7 were significantly greater than those captured at P13. Also, the 2006 P7 metamorphs were significantly greater than the 2005 P7 metamorphs and the 2005 P13 metamorphs were significantly greater than the 2006 P13 metamorphs, which implies that the hydroperiod affects the development and potentially the survival of newly metamorphosed salamanders.

Without careful consideration of the needs of pond-breeding amphibians, such as pond hydrology or upland habitat requirements, many populations of amphibians can be affected. If development affects the hydrology of ponds and vernal pools it may ultimately affect the tiger salamanders population in a negative way. More long-term data are needed to truly understand the relationships between tiger salamanders and the ponds in which they breed.

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