Monitoring and Management of a Sensitive Resource: A Landscape-level Approach with Amphibians

Final Report for FY 99

Legacy Resource Management Program Contract DACA87-99-H-0001
U.S. Department of Defense

Principal Investigator:
Joseph C. Mitchell, Ph.D.
University of Richmond
Richmond, Virginia 23173

March, 2000

TABLE OF CONTENTS

Cover Illustrations

Top left: Green treefrog (*Hyla cinerea*)
Top right: Limesink pool in vegetation (study site 3), Camp Lejeune
Lower left: Limesink pool (study site 12), Camp Lejeune
Lower right: Pine woods treefrog (*Hyla femoralis*)

Photo of pine treefrog by Trip Lamb, all others by R.W. Gaul, Jr.

EXECUTIVE SUMMARY

Development of effective integrated resource management plans that are realistic and ecosystem based requires detailed information on the dynamics of populations at the landscape level. Because amphibians are sensitive indicators of environmental change, understanding their population and community dynamics in fluctuating environments provides considerable insight into how local ecosystems function. This Legacy Resource Management Program project focuses on entire amphibian communities in three military installations in eastern North Carolina: Dare County Bombing Range (US Air Force), Cherry Point Marine Corps Air Station, and Marine Corps Base Camp Lejeune. This report summarizes the results of the first of a projected three-year study.

The following objectives direct the study: (1) To develop a landscape-level methodology for assessing the dynamics of amphibian populations in federal installations in the eastern United States. This approach will provide information critical to the management of these sensitive resources from an ecosystem perspective, (2) To provide the quantitative baseline against which future assessments of amphibian populations and communities on each installation can be evaluated, (3) To provide installation personnel with the tools to monitor these sensitive organisms in the future so that population trends can be detected, and (4) To provide realistic management recommendations to each installation that will allow resource managers to reach their goals of maintaining viable populations of each species.

My field crew and I installed the following standardized techniques to assess amphibians in terrestrial habitats: 300 meter-long artificial coverboard transects (20 sheets of plywood and 10 sheets of roofing tin set 10 m apart) and 10 1.5 m long sections of PVC pipe set upright adjacent to the tin coverboard sites. A total of 6 transects was installed at Cherry Point MCAS and Camp Lejeune (180 coverboards, 60 PVC pipes each location), and 9 in Dare County Bombing Range (270 coverboards, 90 pipes). Transects were checked at least monthly to assess amphibian use of these two types of refugia. The following standardized techniques were used to assess amphibians at wetlands: weekly nighttime assessments of calling frogs and monthly minnow trap and dipnet surveys for adults, tadpoles, and salamander larvae. All protocols were run May to August 1999 until all wetlands dried up due to the drought conditions that prevailed that year. Rains from hurricanes in September filled all wetlands and allowed assessments of all wetland sites in the Fall. During 1999 we captured 594 individual amphibians at Dare County Bombing Range, 960 at Cherry Point, and 2,077 at Camp Lejeune. This report summarizes quantitative capture success for each technique in each of the three installations. Results show that each technique is effective for a portion of the amphibian community and that the use of multiple techniques is essential to any assessment of these animals. In addition, we marked 549 adult frogs for future determination of distances and patterns of movement among wetlands and between wetlands and terrestrial habitats. Information on movement between aquatic and terrestrial habitats is critical to the formulation of effective ecosystem and landscape-level management plans. The information accumulated in this start-up year and in years two and three will provide a solid baseline against which future changes in amphibian populations can be assessed. It also allows us to identify areas and issues of management concern.

The following preliminary management recommendations are provided for all three installations: (1) If the primary management goal for amphibians is to maintain the current level of species richness, then a mosaic of aquatic and terrestrial habitats is required. (2) Because no legally protected (state or federal) species were found in the first year, the amphibian fauna

should be managed as communities and not as single species. (3) Because patterns of amphibian dynamics change with habitat change and over time due to weather modifications, monitoring of this fauna should be considered a long-term effort. (4) The natural hydroperiod of the pocosin habitat on Dare County Bombing Range should be restored to the extent possible, and the wetlands on Cherry Point and Camp Lejeune should be maintained in as natural condition as possible with special attention being paid to prevention of alteration of natural hydroperiods. (6) The introduction of non-native and invasive species of plants and animals should be resisted. (7) Captive-raised or maintained amphibians should not be allowed to be released in these areas because of the potential for introduction of diseases. (8) It would be advisable to review existing management plans that affect the habitats and hydrology in each of the installations and insure that amphibians are considered in the process.

INTRODUCTION

The ability of any land manager to develop integrated management plans for the biota under his or her charge is directly proportional to the information available on the dynamics of local populations and communities. The consensus of field-oriented ecologists is that one can be much more effective in managing resources if one knows how organisms use the local landscape. The goals of today's integrated, resource management plans incorporate "ecosystem management" approaches, wherein the population and movement dynamics of all taxa are examined in light of the landscape context. Such an approach also incorporates information on aspects of land use by humans. This approach to management is a realistic way of obtaining critical ecosystem-level information on sensitive resources such as amphibians.

This report is the first to summarize the results of a multi-year landscape-level project on populations and communities of amphibians (frogs and salamanders) in three federal installations in eastern North Carolina. Amphibians were selected because they are well known to be sensitive to environmental change and perturbations (individuals exist as aquatic larvae and terrestrial adults), are declining and becoming rare in some areas (hence the need to determine status of all taxa), are well known taxonomically, and large quantitative data sets can be obtained with relatively low cost (Heyer et al., 1994). Conservation efforts on behalf of species with complex life cycles like amphibians require effective management of the full range of habitats used by all life history stages. Federal installations provide excellent opportunities to develop methodologies that incorporate a landscape approach to management of such environmentally sensitive resources.

Most amphibian populations in the East exist as metapopulations in complexes of wetlands of various sizes and configurations located throughout the landscape (Semlitsch, in press). Amphibians disperse among these wetlands at varying rates. The varying hydroperiods (length of time the pool holds water)in these wetlands create dramatic fluctuations in population sizes and reproductive success. Wetland types include Carolina bays, limesinks, and human-made surface depressions. Vernal pools include depressions in woodlands and managed grasslands, as well as road-side ditches and pools in unpaved roads created by vehicular traffic. Pools associated with roads are seldom permanent, yet support a wide diversity of amphibian species. My research on Fort A.P. Hill in Virginia (Mitchell, 1998b) and the work I have

conducted so far (1999-early 2000) on the three installations in NC indicate that seasonal wetlands allow amphibian communities to be more diverse and widespread than they would be without these bodies of water. Seasonal wetlands (e.g., limesinks, woodland pools, road ruts, miscellaneous surface depressions) provide critical habitat for reproduction, growth and development, and shelter. In addition, most species of amphibians in such habitats experience dramatic fluctuations in reproductive success (Pechmann et al., 1989; Rowe and Dunson, 1995; Semlitsch et al., 1996). Wetland dynamics within the landscape play important roles in the dynamics of the amphibian community (Hecnar and M'Closkey, 1996). Because the variety of wetlands on the three installations in eastern NC support different combinations of amphibian species and because these species exist as metapopulations on the landscape, it is imperative that we understand these dynamic systems so that we can develop management plans that work in these areas. Understanding the causes of the fluctuations is a critical precursor to creation of effective management recommendations (Semlitsch, in press).

The few prior attempts at amphibian population assessment on military or wildlife refuge lands have been species-specific or were incorporated into herpetofaunal inventories (e.g., Williamson and Moulis, 1979; Moler, 1985; Dodd and LeClaire, 1995), or they have not been conducted at all. A landscape approach within which a diversity of wetland types are evaluated is needed to better understand how amphibians use these natural resources. My project in eastern North Carolina allows us to evaluate amphibian populations in several types of permanent and temporary wetlands so that the dynamics of these sensitive species can be described in a way to allow generation of realistic management objectives. Accumulation of data and observations in the third year of this project will help ensure that all objectives will be met. This report summarizes the results of the first year's field work and are presented for each of the three military installations separately.

PROJECT OBJECTIVES

1. To develop a landscape-level methodology for assessing the dynamics of amphibian populations in federal installations in the eastern United States. This approach will provide information critical to the management of these sensitive resources from an ecosystem perspective.

2. To provide the quantitative baseline against which future assessments of amphibian populations and communities on each installation can be evaluated.

3. To provide installation personnel with the tools to monitor these sensitive organisms in the future so that population trends can be detected.

4. To provide realistic management recommendations to each installation that will allow resource managers to reach their goals of maintaining viable populations of each species.

GENERAL METHODS

Three military installations were selected for study: Cherry Point Marine Corps Air Station, Camp Lejeune (USMC), Dare County Bombing Range (USAF), all located in eastern North Carolina (**Figure 1**). Cherry Point MCAS is located in Craven County, NC, Camp Lejeune is in Onslow County, NC, and Dare County Bombing Range is in Dare County, NC. Standardized methods used to monitor amphibians on all three installations include (1) weekly nighttime assessments of vocalizing frogs during the breeding seasons, (2) monthly daytime assessments of the composition of larval communities using dipnet surveys and minnow trap surveys, (3) terrestrial transects using coverboards and refugia made of PVC pipe, and (4) visual encounter surveys conducted during transect searches. In addition, all frogs in the genera *Bufo* (toads), *Hyla* (treefrogs), *Pseudacris* (chorus frogs), and *Rana* (true, or ranid, frogs) captured are marked with a site number by clipping specific toes (see below). Recaptures of marked frogs in future years will yield allow assessment of movements between wetland and upland habitats and among wetlands on the landscape.

Site Selection: All study sites on the three military bases (Cherry Point Marine Corps Air Station, Camp Lejeune (USMC), Dare County Bombing Range (USAF)) were selected by the end of April 1999. There are a number of temporary wetland sites each on Cherry Point MCAS (11) and Camp Lejeune (18) targeted for evaluation of seasonal changes in amphibian community structure. In addition, there are six coverboard and PCV pipe transects in the surrounding forest at each of these two installations. At Dare County Bombing Range, we have selected three forest types for study: hardwood forest, mixed hardwood and pine forest, and Atlantic white cedar forest. This area has none of the small ponds and pools that characterize the other two bases; the ecosystem is entirely pocosin with a very wet substrate. Pools of water form temporarily in surface depressions in the forest and there is a matrix of roads and drainage ditches that remain wet year round. These two aquatic habitats floor allow us to assess the amphibian communities in this location.

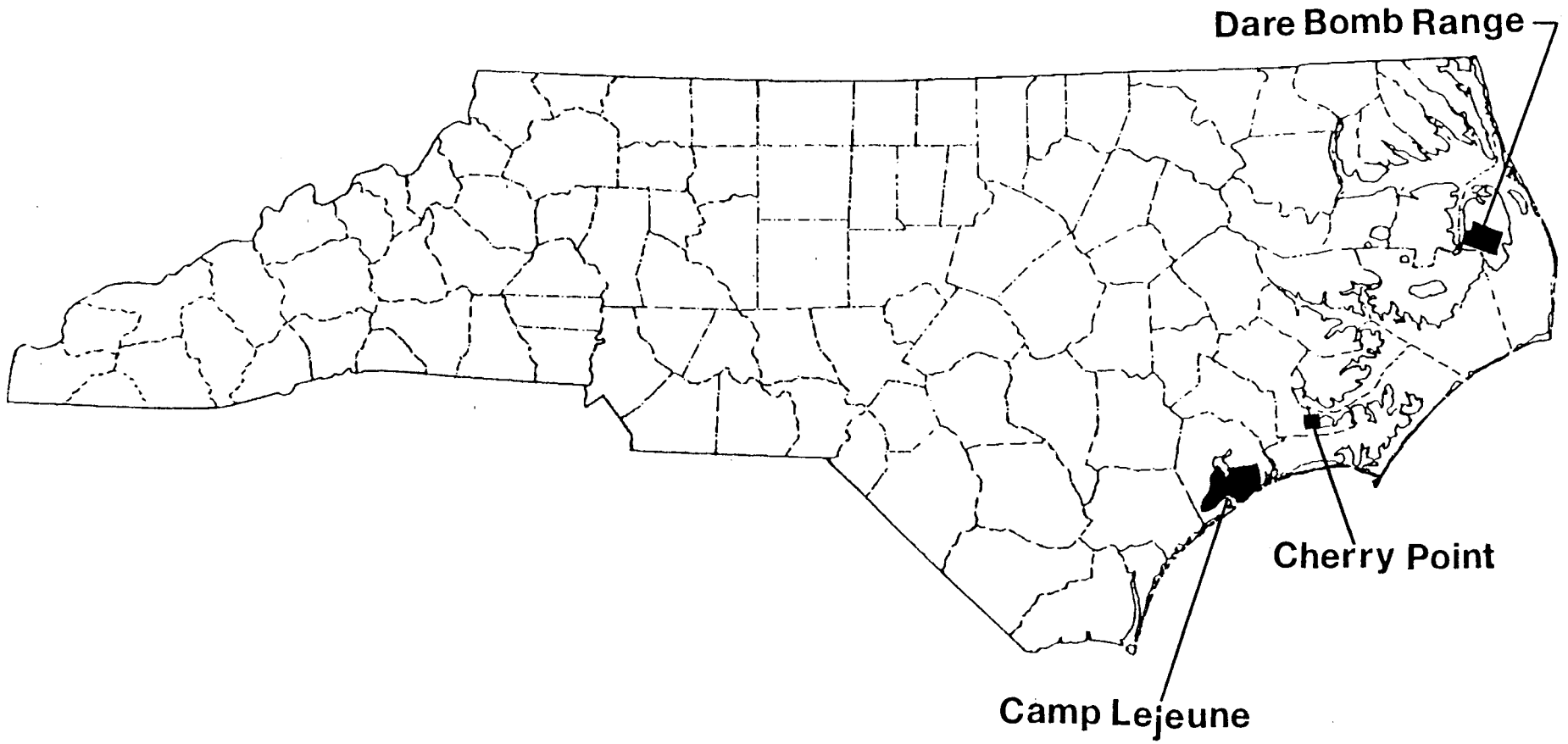

Figure 1. .Map of North Carolina illustrating the geographic locations of the federal installations whithin which this study was conducted.

Amphibian Monitoring Methods: My field crew and I have installed several standardized methodologies that provide information on the amphibians in each of the study areas.

(1) Frog calls are taped and assessed on one night each week at seven primary study sites (wetlands) during the calling season. All data are recorded on standardized field data forms (**Appendix 2**). This method was initiated in late April and continued until the end of July or into August 1999 depending on the habitat conditions on the installation. We discontinued this method by the end of July or mid-August because all of the wetland sites had dried by then and there was no frog activity. We began assessing frog vocalizations again in February 2000.

(2) The aquatic larval communities in the wetlands have been evaluated on a monthly basis since May 1999. We use two methods to quantify the numbers of tadpoles and salamanders caught, minnow traps and dipnets (see Appendix 1 for examples of the field data forms). Ten to 50 minnow traps (number depends on size of pool) are set in wetlands on one day and checked the next. All amphibians and their larvae are identified and counted. Animals caught in standard numbers of dipnet sweeps (comparable to the number of minnow traps per pool) are also identified and counted. These two methods provide quantitative comparisons between these two approaches and allow comparisons among wetland sites and across time. This assessment was temporarily discontinued after August 1999 due to pond drying. The wetlands filled with rains from Hurricanes Dennis and Floyd in September 1999 and were assessed in November to obtain a pre-winter picture of larval community structure. The aquatic sampling protocols started again in February 2000 and will be run monthly as long as there is water in the pools.

(3) Terrestrial coverboard transects were installed in all sites in May and June 1999; six each on Cherry Point and Lejeune and nine in Dare Bombing Range. Coverboards are 2x4 foot sections of plywood and sheets of roofing tin. They are positioned 10 meters apart along a 300 meter transect. There are 20 boards and 10 sheets of tin. Thus, each transect has 30 coverboards; 180 each for Cherry Point and Camp Lejeune and 270 in Dare Bombing Range. In addition, ten 1.5 meter sections of 1.5 inch PCV pile were installed upright at each of the tin sites on each transect. Thus, each 300 meter transect consists of 20 plywood coverboards, 10 sheets of tin, and

10 sections of PCV pipe. These transects have been checked monthly since May 1999. Examples of the field data sheets are in **Appendix 1**.

(4) All frogs caught at the terrestrial transects and many of them caught at the wetlands have been identified, measured, and marked with a unique site number. Marking is done by surgically removing 1-2 toes from each frog with cuticle scissors. Toes are saved by placing them in small vials with ethanol for later studies on skeletochronology (age) and genetics by colleagues. The toe numbers refer to wetland number and transect number. Upon recapture, I will be able to determine how far these animals have moved from the wetland and whether they use more than one of the local wetlands for breeding.

Terrestrial Habitat Analysis: We conducted plant ecology analyses on each of the coverboard transects in July and August 1999 to quantify the terrestrial habitats in our study areas on each of the three installations. We identified to species all trees > 4.5 m in height in each study site, subcanopy trees, and all species of forbs, herbs, and shrubs. We assessed habitat variables by a line intercept method (after Canfield, 1941). Variables were recorded adjacent to each coverboard along each terrestrial transect (total each transect = 30) and included presence or absence of downed woody debris (DWD), stumps, snags, forbs, herbs, shrubs, and a subcanopy. Percent canopy closure was estimated visually over each transect point by viewing the canopy through a cardboard tube (4.5 cm diameter, 11.5 cm length).

Field Crew: The field crew is largely based out of East Carolina University in Greenville, NC. One crew leader has his Master's Degree and another is completing his within a year. Both teach at the college level. The third crew leader has his BS degree and runs the nature program at Weyerhaeuser Company set aside area near New Bern, NC. Most support crew members (field technicians) are all undergraduates at East Carolina University. Two others are knowledgeable amateur herpetologists in eastern NC. All of the field crew personnel have conducted numerous field trips and have assisted in all phases of the work. All of them were trained in 1999 and can perform all the methodologies themselves. In general, the field crews have performed well and have ensured that the data obtained are accurate. Most of the funding for this project pays for the time these people are in the field on the three installations.

Interactions with base resource personnel: All of the Points-of-Contact at each of the military installations have been very helpful throughout the study period. They have encouraged us to continue this project for several more years. They have been instrumental in helping with site selection and continued access. Base military police and range control personnel have been very helpful in allowing us access to all our study sites when we needed to be there.

Data computerization: The data are written initially on field data sheets and have been entered into computerized Excel spreadsheets for evaluation and summary. These data are summarized below for each installation by protocol type. A copy (electronic and hard-copy printout) has been given to the Points-of-Contact at each installation.

Schedule: Field work was intensive April through August 1999. This period included establishment of contacts with appropriate base personnel and evaluation of access constraints, site selection on the three bases, installation of six to nine 300 meter coverboard transects, the execution of weekly frogcall surveys, the monthly assessment of amphibian larval communities in multiple wetland sites, and the training of all field personnel.

By August 1999 all the wetlands had dried up on Cherry Point and Camp Lejeune and there was essentially no amphibian activity. All the wetland methodologies were temporarily suspended on these two bases, although the transect work continued through the fall months. All wetlands on Cherry Point and Camp Lejeune were assessed again in November 1999. Work on Dare Bombing Range continued through the Summer and Fall 1999 because the habitat there consists of forested pocosin and channels, not ephemeral pools. Winter-breeding frogs started calling in February 2000. At that time the nighttime frog call methodology started up again and will continue through Summer 2000. Terrestrial transect surveys and aquatic dipnet and minnow trap surveys were conducted in February and will run monthly through at least September 2000.

Hurricanes Dennis and Floyd: These two tropical systems brought much needed rain to the area and filled up all the wetlands in September 1999. However, these rains also caused much flooding and damage to roads throughout eastern North Carolina. We waited several weeks for the roads to again be passable before we could access our study sites. Fortunately, frogs do not

breed much in fall months in this area, so I expected few captures of amphibians and their larvae during the late-fall assessment. The primary reason for the November 1999 assessment was to make sure that a baseline of information on each wetland was available before the winter season started.

RESULTS FOR DARE COUNTY BOMBING RANGE (USAF)

INTRODUCTION

The Dare County Bombing Range is located in Dare County, North Carolina, approximately 19 kilometers south-southwest of the town of Manns Harbor. The range is bordered on all sides by the Alligator River National Wildlife Refuge, with the exception of a small strip on its southern edge, where it borders U. S. Highway 264. Dare County Bombing Range consists of 46,600 acres of which the majority (approximately 80%) is managed for forestry, wildlife management, hunting, fishing, and other outdoor activities. This acreage is leased to the North Carolina Wildlife Resources Commission. The remaining acreage occurs in two separate parcels and is used in training Air Force and Navy pilots. Habitats on the Dare County Bombing Range consist of a diversity of wetland types including pocosin, Atlantic white cedar forest, and various wet hardwood, and mixed forest communities. Numerous roads, flanked by drainage canals, crisscross the property. These canals (ditches) served originally to lower water levels in the forest so that logging could take place. Timber management and logging operations continue on military lands, and the area is now a patchwork of forests of mixed community types. Atlantic white cedar was the dominant canopy tree but years of logging without management left patches of mixed hardwoods, pine, and cedar trees. The pocosin habitat is a wet habitat and in many places the substrate is soft and peaty with water underneath the surface. Amphibians occupy all of the terrestrial habitats, as well as all aquatic systems in the area. The extensive nature of the altered pocosin habitat and the lack of ephemeral pools and ponds in the area creates a challenge to using standardized amphibian monitoring techniques that are effective in other habitats that have pools and ponds. My field crew and I have executed most of the techniques used in Cherry Point MCAS and MCB Camp Lejeune and have been working to find other techniques that work effectively in the unique habitat at Dare County Bombing Range.

Amphibian species richness expected for Dare County Bombing Range is based on species distribution maps in Conant and Collins (1998) and include 17 species of frogs and toads and 7 species salamanders. In 1999 we encountered 14 species of frogs and 4 species of salamanders, or 75% of the expected amphibian fauna (57% of salamanders, 82% of frogs). We

used five standardized techniques to monitor the amphibians in the Dare County Bombing Range. Amphibian community monitoring was carried out primarily at five wetland study sites in an area bordered chiefly by H & B and Smith roads on the property's west side and by Beechland and Pine roads on the property's east side, supplemented by nine frog vocalization sites (**Figure 2**). This report summarizes the results from these five techniques we used in 1999.

STUDY SITE DESCRIPTIONS

Habitat

The dominant habitat type in mainland Dare County, North Carolina, is pocosin. Total wetland area in the county is 86,367 ha, whereas non-wetland area is comprised of 14,983 ha (101,350 ha total land area) (Moorehead, 1999). Pocosin habitat in the Atlantic Coastal Plain is characterized by non-alluvial hydrology (fed by rainwater or groundwater), acidic soils (peat or wet mineral), and a dense, generally evergreen, shrub layer (Weakley and Schafale, 1991; Sharitz and Gresham, 1998). Pocosins are classified by the Cowardin et al. (1979) system as palustrine wetland ecosystems. This ecosystem is typified by long hydroperiods, temporary surface water, soils of sandy, humus, peat, or muck, and periodic fires (Sharitz and Gresham, 1998). In the Dare County Bombing Range study area standing water occurred only in the human-dug channels along access roads and as puddles in the "terrestrial" habitat. The channels were deep and all were choked with vegetation that lined the side along the roads. Forest vegetation and ground cover are described below.

Precipitation Summary for 1999

Most of the eastern United States experienced drought conditions during 1998. For most months of 1999, Dare County received less than normal precipitation (**Figure 3**). Only in the months of June and August through October was there normal or greater than normal rainfall in the area. Total rainfall for June was higher than normal and it was the only month during the January – July period in which rainfall exceeded the previous 30-year normal levels. The precipitation that occurred in August – October was mostly from two hurricanes (Floyd and Dennis). Precipitation in November and December was, like earlier in the year, below normal.

Terrestrial Habitat Descriptions

Results of the plant ecology transect analyses are summarized in **Tables 1-6** for three sites within which we established coverboard and PVC pipe transects. Descriptions for each study site follow.

Site 1 (Mixed hardwoods) - This site lies to the north of Pine Road at its juncture with Beechland Road. The site consists of a wet mixed hardwood forest dominated by red maple (*Acer rubrum*), black gum (*Nyssa sylvatica*), and sweetgum (*Liquidambar styraciflua*). Understory vegetation is dominated by red maple, sweetbay (*Magnolia virginiana*), red bay (*Persia borbonia*), and cane (*Arundinaria gigantea*). Shrubs are dominated by Vaccinium sp. and dewberry (*Rubus hispidus*). Vines include yellow jessamine (*Gelsemium sempervirens*) and smilax (*Smilax rotundifolia*).

The forest floor at this site features numerous shallow depressions which fill with water during wet periods. Many of these depressions are road ruts created during past timber harvesting efforts. Others appear to be natural and are often found around the buttresses of larger trees. Virtually the entire site was inundated with water during heavy rains on 20 June 1999 and all depressions had dried up by 1 July 1999. The site was again inundated by heavy rains associated with hurricanes Dennis and Floyd in September 1999 and many of the depressions contained water during the winter of 1999-2000.

Site 2 (Mature Atlantic white cedar) - This site lies along Sycamore road approximately 1.2 km south of the junction of Navy Lead Road. The overstory is dominated by Atlantic white cedar (*Chamaecyparis thyoides*), tupelo gum (*Nyssa aquatica*), and red maple (*Acer rubrum*). The understory is dominated by red maple and red bay (*Persia borbonia*). Dominant vines include Smilax sp. and poison ivy (*Rhus radicans*). The characteristic large buttresses of Atlantic white cedar are typically covered by a thick mat of organic matter, primarily leaf litter, but also including ferns (*Woodwardia* sp.) and mosses (*Sphagnum* sp). The forb sweet pepperbush (*Mitchella repens*) also occurs on tree buttresses and higher patches of ground.

This site is the wettest of the three study areas in which artificial cover transects were established. The forest floor is characterized by many depressions which contained water throughout the sampling period. Many depressions are found directly under the buttresses of trees, and frogs encountered during the study often used these as retreats.The site was completely

inundated during heavy rains associated with hurricanes Dennis and Floyd during September, 1999 and remained so into the winter of 1999-2000.

Site 3 (Mixed pine-hardwoods) - This site lies to the west of Beechland road just north of the junction of Holly road. The dominant overstory trees are sweetgum (*Liquidambar styraciflua*) and loblolly pine (*Pinus taeda*). Understory trees are dominated by red maple (*Acer rubrum*), sweetgum, and sweetbay (*Magnolia virginiana*). The most prominent vines are Smilax sp., Virginia creeper (*Parthenocissus quinquefolia*), poison ivy (*Rhus radicans*), and yellow jessamine (*Gelsemium sempervirens*). A few small stands of cane (*Arundinaria gigantea*) occur, mostly along the northern edge of the study area. Many depressions occur on the forest floor. The majority of these are road ruts created by past logging activities, but a few appear to be natural. Many of the loblolly pines at this site are rooted on spoil piles created during formation of the road ruts.

A large number of the depressions at this site dried up during the summer of 1999 and refilled during heavy rains from hurricanes Dennis and Floyd in September 1999.

Site 4 (Atlantic white cedar control area) - This site lies along Richmond road just east of the junction of H & B road. The site features a young stand of Atlantic white cedar (*Chamaecyparis thyoides*) regenerating on a former clear-cut. The majority of these trees are from 2-3 meters in height. Some red maple (*Acer rubrum*) is present and the fringes of the site, as well as some areas within the site, support an understory of wax myrtle (*Myrica cerifera*). A thick mat of moss (Sphagnum sp.) covers the ground over much of the site.

This site remained wet throughout the sampling period. Numerous pools of water occur throughout the site but appear concentrated along Richmond road. Although water levels in some pools dropped during the summer of 1999 the thick sphagnum mats remained saturated. Sampling at this site utilized dipnetting, minnow traps, and visual encounter only;
no artificial cover transects were deployed.

Site 5 (Atlantic white cedar spray area) - This site lies at the junction of Smith and H & B roads near the western edge of the Dare Bombing Range. As with site 4, above, this site features a stand of young Atlantic white cedar of approximately the same age and height. Subcanopy and

ground vegetation characteristics are similar to those in site 4. However, this site is currently being actively managed to enhance the growth of Atlantic white cedar. Part of this management program involves the use of herbicides to control broadleaf vegetation, thus reducing competition stress for Atlantic white cedar. Herbicides (Arsenal™) were applied at this site in late November 1999.

As with site 4, above, sampling at this site included dipnetting, minnow traps, and visual encounters only. Data collected at this site and at site 4 will be used in determining the effects, if any, that the use of this herbicide may have upon amphibian communities.

METHODS SPECIFIC TO DARE COUNTY BOMBING RANGE

The pocosin habitat in mainland Dare County, North Carolina, created a special challenge for using standardized monitoring methods for amphibians. Our initial efforts to trap and dip in the ditches that parallel most of the roads in this habitat proved unsuccessful. Shallow pools in the forested pocosin could be trapped with minnow traps and we conducted numerous trapping events when there was water on the surface. The lack of ephemeral (vernal) pools and the channels meant that we could not use the dipnet survey approach and we had to devise alternative methods that worked in this unique habitat type. We used all methods in 1999 that we used in Cherry Point MCAS and Camp Lejeune except the dipnet method. In the 2000 field season we will use a form of Visual Encounter Survey called road cruising to access amphibians. This method relies on driving slowly along access roads during wet periods at night to capture frogs that are crossing the roads. Frogs can be hand-captured, their location marked on a map, and the individual marked for release and recognition upon later recapture. The results in this report summarize the captures made in 1999.

RESULTS

During 1999, we encountered 14 species of frogs and four species of salamanders in our study area in Dare County Bombing Range (**Table 7**). We captured a total of 594 individuals as larvae, juveniles, or adult males or females (**Table 8**). Tadpoles of a very common frog, *Rana clamitans* (northern green frog) comprised 77% of the captures. Single individuals of four species of frogs and one salamander represent our capture success to date. Ranid frogs in general apparently dominate the frog fauna in this area, however, additional survey effort and the use of

other techniques may reveal a different pattern. Frogs and salamanders were captured during the execution of five of the six standardized monitoring protocols (**Table 9**). Only dip net surveys were unsuccessful in capturing amphibians in the pocosin habitat. Each technique allowed us to encounter specific sets of species. The nighttime frog call survey was the only method that encountered all species.

Artificial coverboards were not very successful in capturing amphibians at Dare County Bombing Range (**Table 10**). A total of five frogs and nine salamanders were found under these coverboards. The largest number of captures was of the terrestrial plethodontid salamander (Atlantic Coast Slimy Salamander, *P. chlorobryonis*).

Frogs occasionally use the cavities provided by the upright and isolated PVC pipes for refugia (see results for Cherry Point MCAS and MCB Camp Lejeune). However, only one frog, a pinewoods treefrog (*Hyla femoralis*), was found in the 90 pipes at the Dare County Bombing Range study site in 1999 (**Table 11**).

Most amphibians encountered at Dare were observed or caught during the execution of trapping or frog calling surveys. Only five individuals of three species of frogs were observed during visual encounter surveys (**Table 12**).

Minnow trapping yielded the most captures and the highest capture success of all methods used at Dare County Bombing Range (**Table 13**). Field crews trapped in pools of six of the terrestrial transects and in shallow ditches in three other sites requested by the Point-of-Contact (Scott Smith), labeled pine, spray, and control. These sites were trapped before aerial spraying with Arsenal™ (a herbicide) to control hardwood growth in young Atlantic white cedar stands. These sites proved to be rich in amphibians and we added them to our list of sites to survey during this project. Minnow traps yielded captures of 536 individuals (adults and tadpoles) of eight species of frogs and six individuals of one species of aquatic salamander (Table 13). Frogs in the genus *Rana* were the most abundant, yielding 99% of all frog captures. Two species were represented by only one capture (narrow-mouthed toad [*G. carolinensis*], Cope's gray treefrog [*H. chrysoscelis*]). The former is a highly terrestrial species that is more often captured in pitfall traps, and the latter is an arboreal species. Tadpoles of both occur in very shallow water. Likewise, the two captures of the southern cricket frog (*A. gryllus*) and the southern toad (*B. terrestris*) were of tadpoles that prefer very shallow water. Only one

salamander, the completely aquatic amphiuma (*A. means*) was captured by the minnow trap technique.

Weekly frog call surveys were conducted from 30 May through August 5, 1999. A total of 12 species was encountered with this technique (4-11 per site) (**Table 14**). Number of species recorded per site ranged from four to eleven. Number of sites occupied by each frog species ranged from two for the little grass frog (*P. ocularis*) to all nine sites for three species (southern cricket frog [*A. gryllus*], green frog [*R. clamitans*], and carpenter frog [*R. virgatipes*]). Weekly variation in which species called during site visits and variation among sites was dramatic (**Tables 15-23**). The length of time a particular species called at a given site during the 1999 study varied from each week (8 of 9 sites for the southern cricket frog [*A. gryllus*]) the survey was conducted to only once in the entire study season (1-4 species per site). Based on calling males, the frog fauna at Dare County Bombing Range was dominated by southern cricket frogs (*Acris gryllus*), followed by green frogs (*Rana clamitans*), carpenter frogs (*Rana virgatipes*), pinewoods treefrogs (*Hyla femoralis*), green treefrogs (*Hyla cinerea*), and Cope's gray treefrog (*Hyla chrysoscelis*). The bullfrog (*Rana catesbeiana*), a predator of other frogs, was prominent at half of the sites surveyed.

We marked a total of 41 individual frogs by toe clipping at Dare County Bombing Range in 1999. The following species were marked: southern cricket frogs (*Acris gryllus*), pinewoods treefrogs (*Hyla femoralis*), bullfrogs (*Rana catesbeiana*), green frogs (*Rana clamitans*), southern leopard frogs (*Rana sphenocephala*), and carpenter frogs (*Rana virgatipes*).

DISCUSSION AND CONCLUSIONS

Capturing frogs on Dare County Bombing Range was more problematic than anticipated. This result was entirely due to the nature of the habitat type (pocosin) characteristic of the region. However, we were able to execute all but one of the protocols used in the other two installations in this project. Amphibians are relatively easy to capture in large numbers in ephemeral (vernal) pool or pond habitats (see results for Cherry Point MCAS and MCB Camp Lejeune), but not in expansive pocosin wetlands. This is due to the concentration of frogs at pond type wetlands during the breeding season. Amphibians in the pocosin habitat at Dare County Bombing Range do not congregate at specific breeding sites; they apparently breed throughout

the extensive wetlands. Thus, the relatively low numbers of marked frogs is a direct result of the fact that frogs in this area are widely dispersed. In the second year of this study we will use a modified form of the visual encounter survey (road cruising on wet nights) to aid in the capture of as many frogs as possible for marking.

I conclude from the results of the first year of study that the frog fauna will likely yield the best information on how amphibians use the landscape. Increasing the numbers of marked individuals is critical to the success of the movement portion of this study. The contiguous nature of the habitat in the area, despite the surface effects of silvicultural operations that create clearcuts, shelterwood cuts, and monocultures, probably allows dispersal of most or all species. The frogs in this area undoubtedly disperse large distances like many species do in other types of habitats (see reviews in Semlitsch, 1998; Pauley et al. 2000). Knowledge of movement distances, coupled with information on the habitats used for each life history stage, will provide important information for resource managers. Such information can be used to formulate management objectives and direct land use operations in the area.

Formulation of realistic management objectives for amphibians will require the results of all projected three years of data derived from this study. A single year's data set can only show some crude patterns. This is especially true of the first year of a large-scale study requiring considerable time for set-up, training, and testing of techniques. Thus, the following conclusions and management recommendations are preliminary and should be accepted with caution.

The following conclusions can be drawn from the first year results for Dare County Bombing Range:

1. The pocosin habitat characteristic of Dare County Bombing Range supports a rich diversity of amphibians.

2. A combination of monitoring and capture techniques is required to encounter the entire amphibian fauna. No one technique is useful to monitor all life history stages of all species.

3. The nighttime frog call survey is the best technique to assess the presence or absence of a frog species at a particular site.

4. Determination of whether a particular site is used for reproduction requires the use of at least the minnow trap technique.

5. Effective monitoring of amphibians in expansive pocosin habitats typical of the Dare County Bombing Range will require the use of creative techniques not commonly used in standardized amphibian monitoring studies. Amphibians in this habitat are not encountered in large numbers typical of pond breeding species in other areas (see below for Cherry Point MCAS and MCB Camp Lejeune).

6. The amphibian fauna at Dare County Bombing Range is dynamic and species are active on different seasonal cycles. Monitoring of all species requires multiple techniques used over the entire season, including winter, to obtain information on all species present.

PRELIMINARY MANAGEMENT RECOMMENDATIONS

1. If the primary management goal for amphibians is to maintain the current level of species richness, then a mosaic of habitats is required. This is because some species do better in full canopy forests and some do better in more open habitats (e.g., Werner and Glennemeier, 1999). Determination of which species does best in each type will require the results from the second and third years of the study, and an evaluation of the quantitative results from the capture techniques used in each habitat type.

2. Because no legally protected (state or federal) species was found in Dare County Bombing Range thus far, the amphibian fauna should be managed as communities and not as single species. Although some species appear to be rarely encountered (at least for the first year), they should not yet be considered rare and specifically managed to enhance their population. Single species management may not be the best approach with the amphibian fauna in this area.

3. Monitoring of the amphibian fauna is likely to reveal habitat distribution and population dynamic patterns that will be useful to resource managers. Because patterns change with habitat change and over time, monitoring of this fauna should be considered a long-term effort. The projected three-year baseline data set obtained in this study will provide the basis for evaluation of changes in the future. Funding should be targeted for continuation of monitoring programs after the Legacy Resource Management Program support has ended.

4. Silvicultural practices on Dare County Bombing Range occasionally use herbicides as part of the management package. Ecotoxicology studies of effects of these chemicals on amphibians have not been thorough and often use only a laboratory species not found in North America (McDiarmid and Mitchell, in press). Studies of the effects of spraying herbicides in both terrestrial and wetland habitats should continue and should target early life history stages (e.g., tadpoles). Such studies could reveal where chemical application is not harmful, where it may be harmful, and assist in developing the appropriate concentration levels to allow silvicultural use and simultaneously minimize or eliminate the effects on these sensitive species.

5. The natural hydroperiod of the pocosin habitat should be restored to the extent possible. The amphibians in the area have long been adapted to the natural hydrological fluctuations. We do not know if the amphibian community will remain the same as it is today once restoration has occurred, but long-term studies using this study as a baseline would reveal those changes, if any.

6. The introduction of non-native and invasive species of plants and animals should be resisted. This could include North American "native" species that could be harmful to amphibians.

7. Captive-raised or maintained amphibians should not be allowed to be released in this area. The potential for disease introduction is growing and every effort should be made to avoid contamination from exotics or native species from other areas. Maintenance in captivity influences development of disease and former captives should never be released in the wild.

8. It would be advisable to review existing management plans that affect the habitat and hydrology of the area with management of amphibians in mind. Such reviews may reveal conflicts that could be avoided or mediated if detected before problem arise.

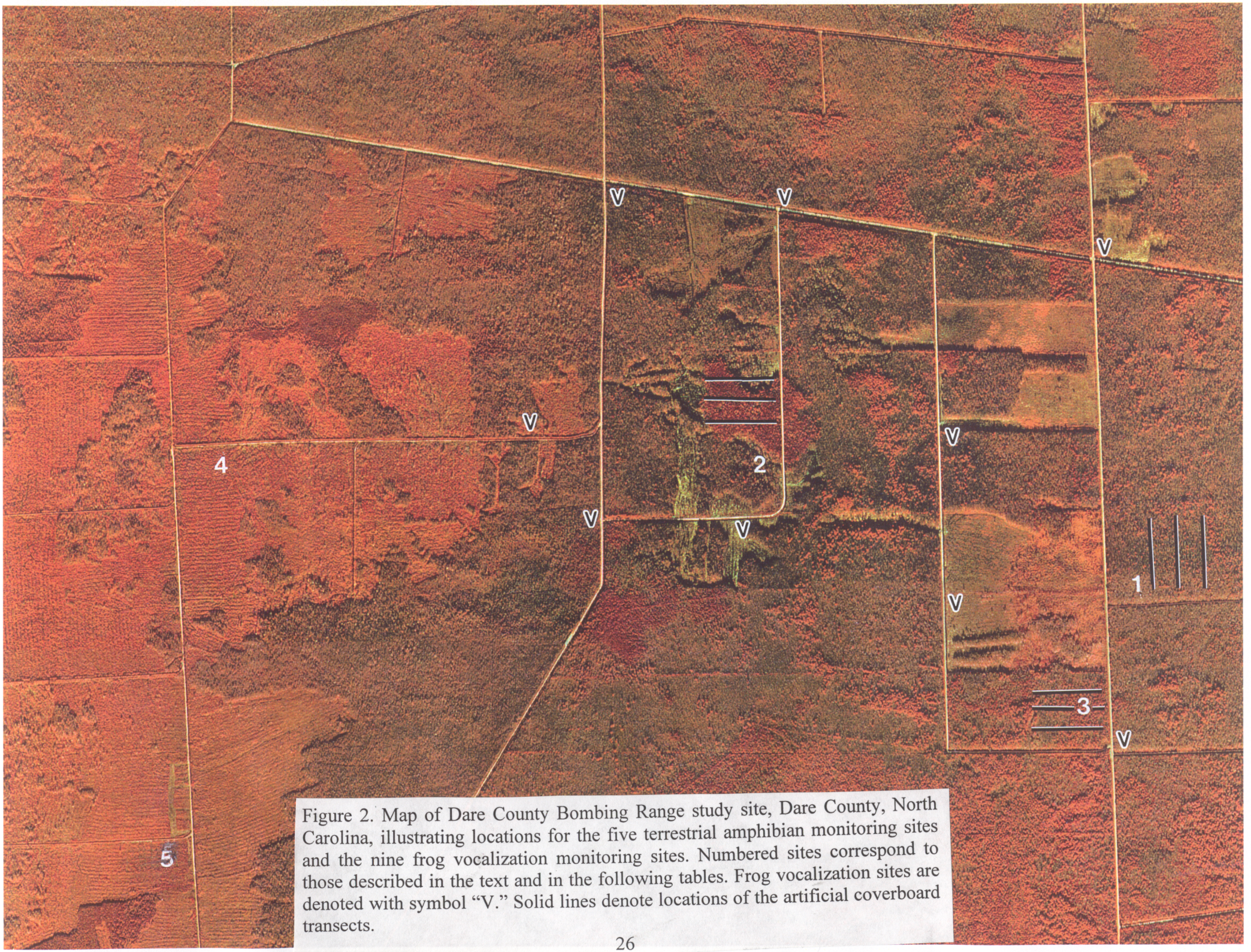

Figure 2. Map of Dare County Bombing Range study site, Dare County, North Carolina, illustrating locations for the five terrestrial amphibian monitoring sites and the nine frog vocalization monitoring sites. Numbered sites correspond to those described in the text and in the following tables. Frog vocalization sites are denoted with symbol "V." Solid lines denote locations of the artificial coverboard transects.

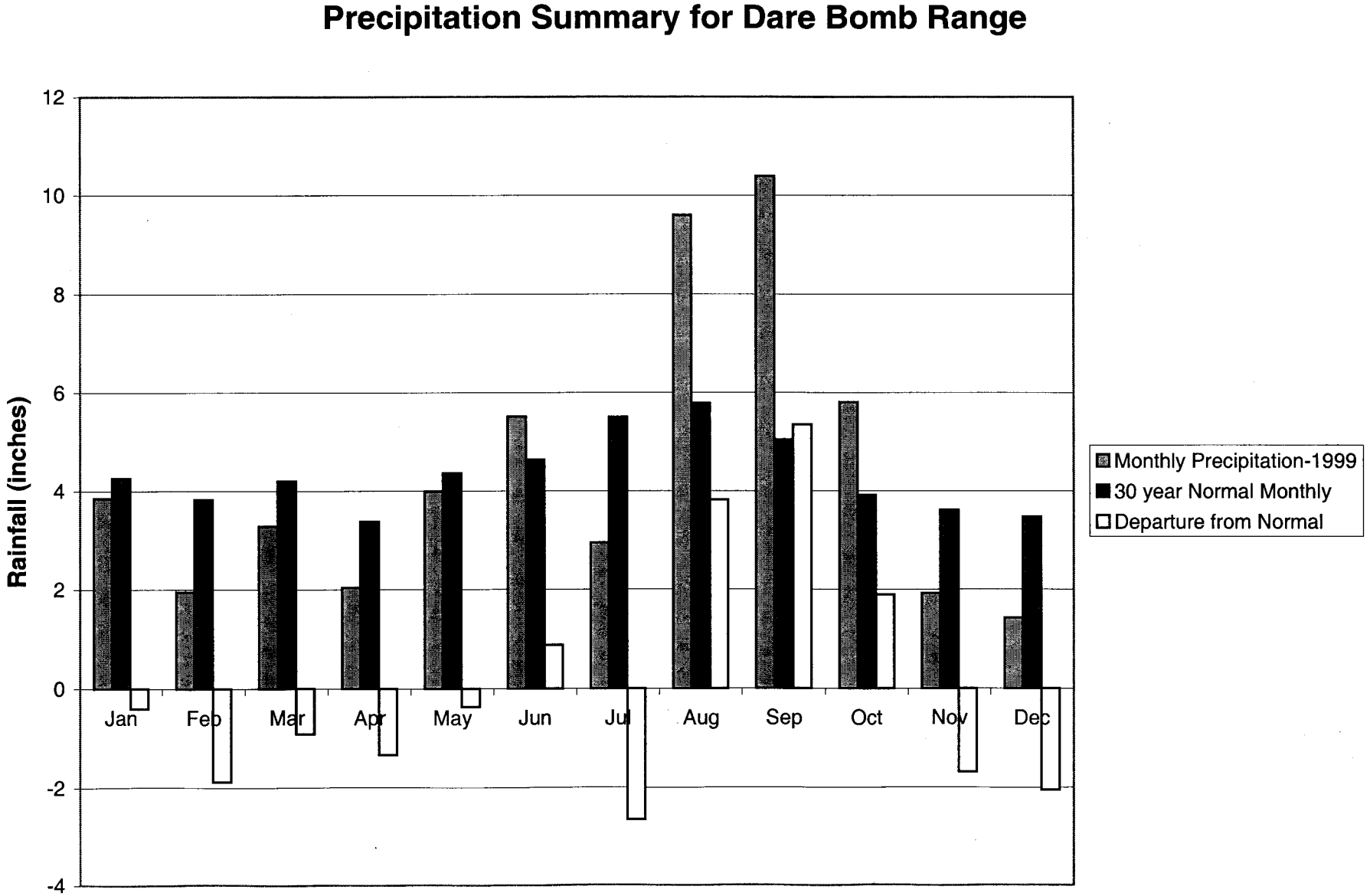

Figure 3. Monthly precipitation totals for Dare County, North Carolina, for 1999 and the average monthly totals for the previous 30 years. Monthly departure from normal in 1999 is the difference between actual precipitation and the 30 year average. Data are average values from one weather station in Manteo and one on the mainland.

Table 1. Frequencies of vegetation and other habitat variables in three transects in the Atlantic White Cedar site in Dare County Bombing Range, North Carolina. Numbers are frequency of occurrence along transects (n = 90) points.

	Site number			
Attributes/species	13	14	15	Mean Freq
Deciduous seedlings	0.60	0.57	0.57	0.58
Evergreen seedlings	0.00	0.03	0.00	0.01
Both seedlings	0.12	0.20	0.13	0.15
Grass	0.00	0.00	0.00	0.00
Canopy Closure (mean)	*79*	*81*	*81*	*80*
Subcanopy	0.60	0.67	0.63	0.63
Water	0.73	0.77	0.53	0.68
Ferns and Allies				
Woodwardia areolata	0.00	0.03	0.03	0.02
Woodwardia virginica	0.07	0.00	0.03	0.03
Osmunda regalis	0.03	0.00	0.03	0.02
Sphagnum spp.	0.23	0.27	0.17	0.22
Forbs				
Mitchella repens	0.23	0.27	0.33	0.28
Vines				
Parthenocissus quinquefolia	0.03	0.07	0.03	0.04
Rhus radicans	0.13	0.00	0.20	0.11
Smilax laurifolia	0.20	0.27	0.10	0.19
Smilax rotundifolia	0.37	0.17	0.07	0.20
Shrubs				
Clethra alnifolia	0.17	0.30	0.30	0.26
Vaccinium spp.	0.93	0.90	0.93	0.92
Fern frequency	0.10	0.03	0.10	0.08
Forb frequency	0.23	0.27	0.33	0.28
Vine frequency	0.67	0.43	0.37	0.49
Shrub frequency	0.97	0.93	0.97	0.96

Table 2. Frequency of overstory and understory trees along three terrestrial transects in the Atlantic White Cedar study site in Dare County Bombing Range, North Carolina.

	OVERSTORY				UNDERSTORY			
Trees	**13**	**14**	**15**	**Mean**	**13**	**14**	**15**	**Mean**
Acer rubrum	0.13	0.22	0.12	0.16	0.29	0.23	0.13	0.22
Chamaecyparis thyoides	0.59	0.54	0.48	0.54	0.01	0.01	0.00	0.01
Gordonia lasianthus	0.00	0.01	0.00	<0.01	0.00	0.00	0.01	<0.01
Ilex opaca	-	-	-	n/a	0.01	0.00	0.00	<0.01
Magnolia virginiana	0.00	0.00	0.02	0.01	0.03	0.00	0.00	0.01
Nyssa aquatica	0.13	0.15	0.30	0.19	0.13	0.03	0.06	0.07
Nyssa sylvatica	0.01	0.01	0.03	0.02	0.01	0.02	0.00	0.01
Persea borbonia	0.00	0.01	0.00	<0.01	0.51	0.72	0.81	0.68
Pinus taeda	0.11	0.04	0.06	0.07	-	-	-	n/a
Quercus nigra	-	-	-	n/a	0.01	0.00	0.00	<0.01
Taxodium distichum	0.03	0.03	0.00	0.02	-	-	-	n/a

Table 3. Frequencies of vegetation and other habitat variables in three transects in the mixed hardwood and pine site in Dare County Bombing Range, North Carolina. Numbers are frequency of occurrence along transects (n = 90) points.

	SITES			
Attributes/species	16	17	18	Mean Freq
Deciduous seedlings	0.79	0.63	0.53	0.65
Evergreen seedlings	0.00	0.03	0.00	0.01
Both seedlings	0.07	0.03	0.20	0.10
Grass	0.00	0.00	0.13	0.04
Canopy Closure (mean)	*86*	*83*	*84*	*84*
Subcanopy	0.97	0.67	0.70	0.78
Water	0.17	0.30	0.60	0.36
Ferns and Allies				
Thelypteris palustris	0.00	0.03	0.00	0.01
Woodwardia areolata	0.07	0.07	0.17	0.10
Woodwardia virginica	0.14	0.10	0.03	0.09
Osmunda regalis	0.07	0.00	0.00	0.02
Sphagnum spp.	0.07	0.07	0.07	0.07
Graminoids				
Arundinaria gigantea	0.00	0.00	0.10	0.03
Forbs				
Asarum canadense	0.03	0.00	0.00	0.01
Vines				
Gelsemium sempervirens	0.17	0.23	0.40	0.27
Parthenocissus quinquefolia	0.52	0.40	0.50	0.47
Rhus radicans	0.14	0.10	0.57	0.27
Smilax laurifolia	0.07	0.30	0.17	0.18
Smilax rotundifolia	0.66	0.67	0.70	0.68
Vitis spp.	0.17	0.13	0.23	0.18

Table 3 continued

Shrubs				
Clethra alnifolia	0.03	0.00	0.03	0.02
Rubus hispidus	0.52	0.30	0.63	0.48
Rubus spp.	0.03	0.00	0.00	0.01
Vaccinium spp.	0.24	0.43	0.20	0.29
Fern frequency	0.24	0.20	0.17	0.20
Forb frequency	0.03	0.00	0.00	0.01
Vine frequency	0.97	0.93	1.00	0.97
Shrub frequency	0.62	0.67	0.77	0.69

Table 4. Frequency of overstory and understory trees along three terrestrial transects on the mixed hardwood and pine study site in Dare County Bombing Range, North Carolina.

	OVERSTORY				UNDERSTORY			
Trees	**16**	**17**	**18**	**Mean**	**16**	**17**	**18**	**Mean**
Acer rubrum	0.11	0.15	0.16	0.14	0.57	0.65	0.73	0.65
Gordonia lasianthus	-	-	-	n/a	0.00	0.04	0.01	0.02
Ilex opaca	-	-	-	n/a	0.01	0.02	0.01	0.01
Juniper virginiana	-	-	-	n/a	0.01	0.00	0.00	<0.01
Liquidambar styraciflua	0.65	0.47	0.60	0.57	0.23	0.18	0.10	0.17
Magnolia virginiana	-	-	-	n/a	0.15	0.06	0.14	0.12
Nyssa sylvatica	0.00	0.09	0.00	0.03	-	-	-	n/a
Persea borbonia	-	-	-	n/a	0.00	0.05	0.01	0.02
Pinus taeda	0.22	0.29	0.24	0.25	-	-	-	n/a
Quercus nigra	0.03	0.00	0.00	0.01	0.02	0.00	0.00	0.01
Quercus phellos	-	-	-	n/a	0.00	0.01	0.00	<0.01
Rhus copallina	-	-	-	n/a	0.02	0.00	0.00	0.01

Table 5. Frequencies of vegetation and other habitat variables in three transects in the mixed hardwood and pine site in Dare County Bombing Range, North Carolina. Numbers are frequency of occurrence along transects (n = 90) points.

	SITES			
Attributes/species	19	20	21	Mean Freq
Deciduous seedlings	0.57	0.83	0.77	0.72
Evergreen seedlings	0.00	0.00	0.00	0.00
Both seedlings	0.03	0.03	0.07	0.04
Grass	0.00	0.07	0.07	0.05
Canopy Closure (mean)	*82*	*83*	*83*	*83*
Subcanopy	0.33	0.40	0.30	0.34
Water	0.03	0.03	0.13	0.06
Ferns and Allies				
Woodwardia areolata	0.03	0.17	0.20	0.13
Osmunda regalis	0.00	0.07	0.00	0.02
Sphagnum spp.	0.10	0.10	0.70	0.30
Graminoids				
Arundinaria gigantea	0.87	0.87	0.67	0.80
Vines				
Gelsemium sempervirens	0.30	0.47	0.43	0.40
Parthenocissus quinquefolia	0.00	0.03	0.00	0.01
Rhus radicans	0.17	0.17	0.47	0.27
Smilax laurifolia	0.03	0.03	0.13	0.06
Smilax rotundifolia	0.50	0.70	0.63	0.61
Vitis spp.	0.30	0.00	0.03	0.11

Table 5 continued

Shrubs				
Amelanchier spp.	0.00	0.00	0.03	0.01
Rubus hispidus	0.03	0.00	0.03	0.02
Vaccinium spp.	0.27	0.27	0.50	0.35
Fern frequency	0.03	0.17	0.20	0.13
Forb frequency	0.00	0.00	0.00	0.00
Vine frequency	0.67	0.90	0.93	0.83
Shrub frequency	0.27	0.27	0.50	0.35

Table 6. Frequency of overstory and understory trees along three terrestrial transects on the hardwood study site in Dare County Bombing Range, North Carolina. Column heading numbers are transect numbers.

	OVERSTORY				UNDERSTORY			
Trees	**19**	**20**	**21**	**Mean**	**19**	**20**	**21**	**Mean**
Acer rubrum	0.45	0.47	0.54	0.49	0.29	0.28	0.21	0.26
Gordonia lasianthus	0.00	0.02	0.00	0.01	0.00	0.00	0.01	<0.01
Ilex opaca	0.01	0.03	0.00	0.01	0.05	0.03	0.02	0.03
Liquidambar styraciflua	0.19	0.17	0.19	0.18	0.05	0.12	0.12	0.10
Magnolia virginiana	0.01	0.11	0.01	0.04	0.02	0.53	0.63	0.39
Nyssa aquatica	0.00	0.00	0.03	0.01	-	-	-	n/a
Nyssa sylvatica	0.29	0.19	0.20	0.23	0.00	0.01	0.01	0.01
Oxydendrum arboreum	-	-	-	n/a	0.01	0.00	0.00	<0.01
Persea borbonia	0.04	0.00	0.00	0.01	0.56	0.00	0.00	0.19
Pinus taeda	0.01	0.02	0.03	0.02	-	-	-	n/a
Quercus falcata	-	-	-	n/a	0.01	0.00	0.00	<0.01
Quercus nigra	0.00	0.01	0.00	0.00	0.02	0.03	0.02	0.02

Table 7. List of amphibian species encountered on Dare County Bomb Range, NC for the 1999 sampling year.

ANURA (Frogs and Toads)	
Bufonidae:	
Bufo terrestris	Southern Toad
Hylidae:	
Acris gryllus gryllus	Coastal Plain Cricket Frog
Hyla chrysoscelis	Cope's Gray Treefrog
Hyla cinereus	Green Treefrog
Hyla femoralis	Pine Woods Treefrog
Hyla squirella	Squirrel Treefrog
Pseudacris crucifer crucifer	Northern Spring Peeper
Pseudacris ocularis	Little Grass Frog
Ranidae:	
Rana catesbeiana	American Bullfrog
Rana clamitans melanota	Northern Green Frog
Rana sphenocephala utricularia	Southern Leopard Frog
Rana virgatipes	Carpenter Frog
Pelobatidae:	
Scaphiopus holbrookii	Eastern Spadefoot
Microhylidae:	
Gastrophryne carolinensis	Eastern Narrow-mouthed Toad
Caudata (Salamanders)	
Amphiumidae:	
Amphiuma means	Two-toed Amphiuma
Salamandridae:	
Notophthalmus viridescens dorsalis	Broken-Striped Newt
Plethodontidae:	
Plethodon chlorobryonis	Atlantic Coast Slimy Salamander
Stereochilus marginatus	Many-lined Salamander

Table 8. Total number of amphibians captured at Dare County Bombing Range, NC in 1999 by life history stage.

	SEX AND LIFE HISTORY STAGE				
	Male	Female	Juvenile	Larvae	Total
Frogs					
Acris gryllus	2			1	3
Bufo terrestris				1	1
Gastrophryne carolinensis				1	1
Hyla femoralis		1			1
Hyla squirella	1				1
Rana catesbeiana			15	1	16
Rana clamitans	19	12	26	402	459
Rana sphenocephala	1	2	2	73	78
Rana virgatipes	8	9	8	8	33
Salamanders					
Plethodon chlorobryonis	1				1
Total	32	24	51	487	594

Table 9. Species occurrence by sampling technique at Dare County Bombing Range in 1999.

	SAMPLING TECHNIQUE					
	Artificial Cover Transects	PVC Pipe Transects	Visual Encounter Surveys	Minnow Trapping	Dip Nets	Frog Call Surveys
Frogs						
A. gryllus			X	X		X
B. terrestris	X		X	X		X
G. carolinensis				X		X
H. chrysoscelis				X		X
H. cinerea						X
H. femoralis		X				X
H. squirella	X		X			X
P. crucifer						X
P. ocularis						X
R. catesbeiana				X		X
R. clamitans	X		X	X		X
R. sphenocephala			X	X		X
R. virgatipes	X		X	X		X
S. holbrookii			X			
Salamanders						
A. means				X		
P. chlorobryonis	X					

Table 10. Number of amphibians captured in coverboard transects at Dare County Bombing Range in 1999. Column heading numbers are coverboard transect numbers.

	SITE NUMBER					
	1600	1700	1800	2000	2100	Total
Frogs						
Hyla squirella				1		1
Plethodon chlorobryonis	3	1	4		1	9
Rana clamitans		1	2			3
Rana virgatipes	1					1
Total (3 samplings)	4	2	6	1	1	14

Table 11. Number of amphibians captured in PVC pipe transects at Dare County Bombing Range in 1999. Site number is the single transect in which this frog was captured in the pipe.

	SITE NUMBER 1800	Total
Frogs		
Hyla femoralis	1	1
Total (3 samplings)	1	1

Table 13. Number of amphibians captured in minnow traps at Dare Bomb Range in 1999. Site number refers to coverboard transect sites. Traps were set in pools along the transects.

	SITE NUMBER									
	1300	1400	1500	1600	1700	1800	Pine	Spray	Control	Total
Number of Trap days per Site:	33	18	23	38	33	36	60	136	121	498
Frogs										
Acris gryllus								1	1	2
Bufo terrestris								1	1	2
Gastrophryne carolinensis									1	1
Hyla chrysoscelis									1	1
Rana catesbeiana				2	1	1		5	6	15
Rana clamitans	4	1		10	13	19	19	31	294	391
Rana sphenocephala				5	1	2	10	3	64	85
Rana virgatipes	3	1	1	1	2	3		20	8	39
Total	7	2	1	18	17	25	29	61	376	536
Salamanders										
Amphiuma means							1	2	3	6
Total	0	0	0	0	0	0	1	2	3	6

Table 14. Amphibian species in each of nine frog call monitoring stations on Dare County Bombing Range, NC, identified by vocalizations (V). Abbreviations for each species in parentheses are for the following tables.

Species	Sites 1	2	3	4	5	6	7	8	9
Frogs:									
Acris gryllus (Agr)	V	V	V	V	V	V	V	V	V
Bufo terrestris (Bte)	V					V	V	V	V
Hyla cinerea (Hci)	V				V	V		V	V
Hyla chrysoscelis (Hch)	V	V	V		V	V	V	V	V
Hyla femoralis (Hfe)		V		V	V	V	V		V
Hyla squirella (Hsq)							V		V
Gastrop. carolinensis (Gca)	V				V		V	V	
Pseudacris brimleyi (Pcr)									
Pseudacris crucifer (Pcr)									
Pseudacris ocularis (Poc)				V					V
Rana catesbeiana (Rca)						V		V	V
Rana clamitans (Rcl)	V	V	V	V	V	V	V	V	V
Rana sphenocephala (Rsp)	V					V	V		V
Rana virgatipes (Rvg)	V	V	V	V	V	V	V	V	V

Table 15. Seasonal variation in timing of male frog vocalizations at Site 1 on the Dare County Bombing Range for 1999. Abbreviations as in Table 14.

	Species													
Week of	Agr	Bte	Hci	Hch	Hfe	Hsq	Gca	Pbr	Pcr	Poc	Rca	Rcl	Rsp	Rvg
1999														
May 30	V	V												V
June 6	V													
June 14	V													
June 23	V													
July 3	V		V				V					V		
July 13	V			V			V					V		
July 19	V		V				V					V		
July 30	V											V		
August 5	V	V										V		

Table 16. Seasonal variation in timing of male frog vocalizations at Site 2 on the Dare County Bombing Range for 1999. Abbreviations as in Table 14.

	Species													
Week of	Agr	Bte	Hci	Hch	Hfe	Hsq	Gca	Pbr	Pcr	Poc	Rca	Rcl	Rsp	Rvg
1999														
May 3	V													
June 6	V													
June 14	V													
June 23	V				V							V		V
July 3	V				V							V		
July 13	V			V										V
July 19	V				V							V		
July 30	V				V							V		
August 5														

Table 17. Seasonal variation in timing of male frog vocalizations at Site 3 on the Dare County Bombing Range for 1999. Abbreviations as in Table 14.

	Species													
Week of	Agr	Bte	Hci	Hch	Hfe	Hsq	Gca	Pbr	Pcr	Poc	Rca	Rcl	Rsp	Rvg
1999														
May 30	V													
June 6	V													
June 14	V											V		
June 23	V											V		V
July 3	V			V								V		
July 13	V			V								V		
July 19	V											V		
July 30	V			V								V		
August 5	V			V								V		

Table 18. Seasonal variation in timing of male frog vocalizations at Site 4 on the Dare County Bombing Range for 1999. Abbreviations as in Table 14.

Week of	Species													
	Agr	Bte	Hci	Hch	Hfe	Hsq	Gca	Pbr	Pcr	Poc	Rca	Rcl	Rsp	Rvg
1999														
May 30	V											V		
June 6	V									V		V		
June 14	V													
June 23	V				V							V		V
July 3	V				V							V		
July 13	V				V									V
July 19	V				V							V		V
July 30	V													V
August 5	V													

Table 19. Seasonal variation in timing of male frog vocalizations at Site 5 on the Dare County Bombing Range for 1999. Abbreviations as in Table 14.

	Species													
Week of	Agr	Bte	Hci	Hch	Hfe	Hsq	Gca	Pbr	Pcr	Poc	Rca	Rcl	Rsp	Rvg
1999														
May 30	V			V	V									V
June 6	V			V										V
June 14	V													
June 23	V											V		V
July 3	V		V	V	V									
July 13	V			V	V		V							
July 19	V		V		V									
July 30	V				V									
August 5	V													

Table 20. Seasonal variation in timing of male frog vocalizations at Site 6 on the Dare County Bombing Range for 1999. Abbreviations as in Table 14.

	Species													
Week of	Agr	Bte	Hci	Hch	Hfe	Hsq	Gca	Pbr	Pcr	Poc	Rca	Rcl	Rsp	Rvg
1999														
May 30	V	V	V	V	V						V	V	V	V
June 6	V			V										V
June 14	V	V									V			V
June 23	V		V		V							V	V	V
July 3	V		V	V	V						V	V		V
July 13	V		V	V	V									V
July 19	V		V		V						V	V		
July 30	V				V						V	V	V	
August 5	V										V	V		

Table 21. Seasonal variation in timing of male frog vocalizations at Site 7 on the Dare County Bombing Range for 1999. Abbreviations as in Table 14.

	Species													
Week of	Agr	Bte	Hci	Hch	Hfe	Hsq	Gca	Pbr	Pcr	Poc	Rca	Rcl	Rsp	Rvg
1999														
May 30	V	V										V		V
June 6	V	V												
June 14	V	V			V							V		V
June 23	V				V							V		V
July 3	V				V							V		V
July 13	V			V	V	V							V	V
July 19	V											V		V
July 30	V											V		V
August 5	V											V		V

Table 22. Seasonal variation in timing of male frog vocalizations at Site 8 on the Dare County Bombing Range for 1999. Abbreviations as in Table 14.

	Species													
Week of	Agr	Bte	Hci	Hch	Hfe	Hsq	Gca	Pbr	Pcr	Poc	Rca	Rcl	Rsp	Rvg
1999														
May 30	V													V
June 6	V	V									V			V
June 14	V	V										V		V
June 23	V													V
July 3	V		V	V								V		V
July 13	V	V		V			V							V
July 19	V		V									V		V
July 30	V		V									V		V
August 5	V											V		

Table 23. Seasonal variation in timing of male frog vocalizations at Site 9 on the Dare County Bombing Range for 1999. Abbreviations as in Table 14.

	Species													
Week of	Agr	Bte	Hci	Hch	Hfe	Hsq	Gca	Pbr	Pcr	Poc	Rca	Rcl	Rsp	Rvg
1999														
May 30	V													V
June 6	V	V									V			V
June 14	V	V										V		V
June 23	V													V
July 3	V		V	V								V		V
July 13	V			V	V	V				V			V	
July 19	V		V									V		V
July 30	V			V								V		V
August 5	V											V		

RESULTS FOR CHERRY POINT MARINE CORPS AIR STATION

INTRODUCTION

Cherry Point Marine Corps Air Station lies in Craven County, North Carolina, adjacent to the town of Havelock It is bordered by the Neuse river to the north, by Slocomb creek on the west, Hancock creek on the east, and U. S. highway 70 and N.C. highway 102 to the south. Cherry Point MCAS was established originally in 1941 as Cunningham Field but changed to Cherry Point in 1942. The installation consists of 13,320 acres, of which approximately 6,000 are used as runways, aircraft hangers, and other maintenance installations. Approximately 3,200 acres are forested and are managed for timber production, hunting and wildlife benefits. The majority of these forested areas feature a mix of wet pine flatwoods, swamp forest, and upland depression ponds.

Amphibian community monitoring was carried out primarily at a series of upland depression ponds between the northeast runway and the road that runs to the west of all runways and other aircraft installations (**Figure 4**). Artificial cover transects were established at locations in surrounding upland habitats. Habitat descriptions for study ponds and for artificial cover transects are given below.

Amphibian species richness expected for the Cherry Point MCAS region is based on species distribution maps in Conant and Collins (1998) and include 22 species of frogs and toads and 14 species salamanders. In 1999 we encountered 15 species of frogs and 4 species of salamanders, or 53% of the regional amphibian fauna (29% of salamanders, 68% of frogs). We used six standardized techniques to monitor amphibians in Cherry Point MCAS. This report summarizes the results from the six techniques used in 1999.

STUDY SITE DESCRIPTIONS

Habitat

The dominant habitat type in mainland Craven County, North Carolina, is mixed hardwood and pine forest. Of the 187,778 ha in Craven County, 63,382 are wetlands. The habitat on Cherry Point MCAS was mostly upland pine flatwoods with patches of mixed hardwoods and vegetation characteristic of riparian systems along creeks. The study area consists mostly of open

loblolly pine (*Pinus taeda*) flatwoods with an understory of red maple (*Acer rubrum*) and mixed oaks (*Quercus* spp.) and a thick ground cover of mixed grasses and blueberry (*Vaccinum* spp.). One area in which we conducted a plant ecology transect was dominated by mixed hardwoods but it was harvested for timber in January 2000 and converted to pine flatwoods. Amphibian monitoring sites in the wetlands of the area include highly ephemeral pools in open areas (created by vehicular traffic and an old telephone line right-of-way), permanent impoundments, small sinkhole ponds, and a riparian area along a small creek. The pocosin habitat characteristic of Dare County Bombing Range does not occur at Cherry Point.

Precipitation Summary for 1999

Most of the eastern United States experienced drought conditions during 1998 and 1999. For most months of 1999, Cherry Point received less than normal precipitation (**Figure 5**). Only in the months of September and October was there greater than normal rainfall in the area. Total rainfall for January through August 1999 and November through December was lower than normal. Rainfall total in September and October 1999 exceeded the previous 30-year normal levels. The large amount of precipitation that occurred in September was from two hurricanes (Floyd and Dennis).

Terrestrial Habitat Descriptions

Artificial cover transects were established in forested areas near and around study ponds to gather data on inter-pond movements of amphibians, and populations of amphibians that are largely or wholly terrestrial in habits. Results of the plant ecology transect analyses are summarized in **Tables 23-24**.Vegetation analysis revealed few significant differences between the six established transects (S. Bellows, pers. comm.), and the following descriptions apply to all of them.

The forest surrounding the study ponds is primarily wet pine flatwoods. The overstory is dominated by loblolly pine (*Pinus taeda*). Other overstory trees are sweetgum (*Liquidambar styraciflua*), red bay (*Persia borbonia*), red maple (*Acer rubrum*), and several species of oaks (*Quercus* spp.). The most abundant understory tree is sweetgum. All transects except transect "B" exhibit conspicuous stands of cane (*Arundinaria gigantea*). Forbs, especially several species of thoroughwort (*Eupatorium* spp.) are present but not abundant.

Aquatic Habitat Descriptions

Physical and vegetation characteristics of most of the ponds in our study area are generally similar. These are grouped together under the appropriate habitat descriptions given here. Those exhibiting significant habitat differences are treated separately.

Ponds 1, 3, 4 - These ponds are all small, vernal pools exhibiting moderate amounts of aquatic, emergent vegetation and moderate amounts of organic matter in the substrate. Emergent vegetation consists of water lilies and pickerel weed (*Pontaderia cordata*). The surrounding forest is dominated by loblolly pine (*Pinus taeda*). These ponds are well-shaded. Each of these ponds dried up during the summer of 1999 and refilled in September 1999 following heavy rains associated with hurricanes Dennis and Floyd.

Ponds 2, 11 - These two ponds are elongate, shallow ponds probably associated with small streams. They are heavily vegetated and well-shaded by thick surrounding forest cover (see descriptions for artificial cover transects below). Each of these ponds contained some water throughout our sampling period.

Pond 16 - This pond lies adjacent to a strip of cleared land fronting the northeast runway on the air station. It is large and deep (>1m). This pond was formed by beaver activity. Emergent vegetation is heavy, with numerous logs, sticks, and tree snags throughout. Marginal vegetation includes alder (*Alnus* sp.), sweetgum (*Liquidambar styraciflua*), and numerous forbs and grasses. A few stands of cattails (Typha sp.) are present. This pond contained water throughout the sampling period.

Pond 6- This pond is a series of wheel ruts formed in an open grassy area at the northwestern edge of our study area. There is little to no emergent vegetation and surrounding vegetation is limited to low turf-type grasses. The substrate is primarily a muddy clay. Although this is the most exposed site in our study area, several of the pools contained water, albeit small amounts, during our entire sampling period.

Ponds 5, 15 - These ponds are large, relatively deep (> 2m in some places), open, man-made ponds, created mostly for fishing and other forms of outdoor recreation. Some emergent vegetation occurs along the edges of these ponds but most is found at the outfalls of the ponds, where they flow out towards Slocomb creek. The surrounding forest is relatively open and park-like, as it is heavily used by people engaging in outdoor activities.

Ponds 10, 13, 14 - These ponds are formed in shallow, wheel ruts along the right-of-way for a power line. These are shallow (< 0.5m) clear pools with a few emergent grasses and small amounts of mosses along their margins. Each of these sites dried up in the early summer of 1999. Heavy rains from hurricanes Dennis and Floyd, refilled them and they contained water through the winter of 1999-2000.

Pond 8 - This is a shallow pond associated with a small stream that crosses a power line right-of-way. It measures approximately 20m x 4m. The substrate is thick clay with an abundance of organic matter. There is little emergent vegetation. This pond is well-shaded and receives large amounts of leaf-litter. Both the pond and its associated stream went dry during the summer of 1999.

Pond 12 - This pond lies just off the paved road leading to Hancock Creek housing area and Marina. It is extensive, approximately 60m x 20m in area, but is relatively shallow (< 1m). It is well shaded with some emergent grasses, especially along its' western shore and relatively closed canopy of trees. This pond dried out completely during the summer of 1999.

Pond 7 - This is a small, nearly circular pond lying just within the forest that borders a clear grassy area at the northwestern end of the study area. It resembles several other ponds in the study area (e.g. : ponds 1, 3 and 4), but is deeper (> 1m) and features a conspicuous raft of grasses and water lilies. This pond contained water throughout our sampling period.

RESULTS

During 1999, we encountered 15 species of frogs and four species of salamanders in our study area in Cherry Point MCAS (**Table 25**). We captured a total of 960 individuals as larvae,

juveniles, or adult males or females (**Table 26**). Three species of frogs were captured in large numbers: *Hyla cinerea* (green treefrog), *Hyla squirella* (squirrel treefrog), and *Rana sphenocephala* (southern leopard frog). Most green treefrogs captured were adults, whereas most southern leopard frogs captured were tadpoles. Total numbers for these three species accounted for 63.5% of all captures in 1999. The broken-striped newt (*Notophthalmus viridescens*) was the most abundant salamander captured. Most frogs were captured during the execution of three of the six standardized monitoring protocols at Cherry Point MCAS (**Table 9**) but all techniques yielded frogs. One species of frog (oak toad, *Bufo quercicus*) was captured only by one technique (artificial coverboards), whereas all other species were captured by two or more techniques. Two of the four species of salamanders were captured by 2-3 techniques and two (amphiuma, *Amphiuma means*; marbled salamander, *Ambystoma opacum*) were captured only by minnow trapping.

Artificial coverboard transects yielded only five individual and five species of frogs and three individuals of two species of salamanders (**Table 28**). The frogs were distributed randomly among the transect sites, whereas the salamanders were captured in two of the six transects.

PVC pipe transects proved to be a very useful monitoring technique for treefrogs at Cherry Point MCAS. A total of 257 adult individuals of four species of treefrogs was captured in 1999 (**Table 29**). Of these, 69.3% were captures of green treefrogs (*Hyla cinerea*). All PVC pipe transects yielded treefrogs, suggesting that these amphibians are distributed throughout the terrestrial habitat in the area.

A total of 199 amphibians were observed or caught during visual encounter surveys of the nine wetlands on Cherry Point MCS (**Table 30**). Three species were observed more commonly than the others, Cope's gray treefrog (*Hyla chrysoscelis*), pine woods treefrog (*Hyla femoralis*), and squirrel treefrog (*Hyla squirella*). Number of species observed with this technique varied from 2 at wetland sites 7 and 15 to 7 at site 6. No amphibians were observed at site 8.

The minnow trap technique was successful at 11 wetland sites. The total number of frogs captured was 457 and the total number of salamanders captured was 35 (**Table 31**). Numbers of captures for individual species varied from 1 (pine woods treefrog, *Hyla femoralis*) to 378 (southern leopard frog, *Rana sphenocephala*). Most of the latter were tadpoles. Broken-striped newts (*Notophthalmus viridescens*) dominated salamander captures. Number of frogs captured

among wetlands varied from 1 at site 13 to 193 at site 6. Number of salamanders captured among wetlands varied from 0 at sites 3, 6, 8, and 14 to 12 at site 1.

Dipnet surveys were conducted in nine of the wetland sites. A total of 169 individuals of seven species of frogs and eight individuals of one salamander species was captured in 1999 (**Table 32**). Captures of frogs were dominated by southern leopard frog (*Rana sphenocephala*) tadpoles (65%). Number of individuals captured among wetlands varied from 2 in site 13 to 96 in site 6. Number of species among wetlands ranged from one in site 8 to four in site 10. All broken-striped newts (*N. viridescens*) were captured in site 4. There were no captures of amphibians by dipnetting in site 1.

The weekly nighttime frog call survey yielded information on all 14 of the 15 species of frogs documented to date for Cherry Point MCAS (**Table 33**). Based on male vocalizations alone, this technique recorded 6 to 13 species present in these seven wetlands. Thirteen species called at one site (1), 9-11 called at five sites, and 6 called at one site (12). Dipnet and minnow trap results found tadpoles of several species in five of the seven sites monitored. **Tables 34-40** provide information on seasonal occurrence of the 14 species of frogs within each of the seven wetlands. There was considerable variation in when a particular species called at each wetland. For example, the southern cricket frog (*Acris gryllus*) called extensively in 1999 at four of the study sites but one to not at all at three others. Many species called for several weeks in a row, then skipped one or more weeks before calling again (e.g., barking treefrog [*H. gratiosa*], squirrel treefrog [*H. squirella*], southern leopard frog [*R. sphenocephala*]). Based on calling males, the frog fauna of Cherry Point MCAS appears to be dominated by six species: southern cricket frogs (*A. gryllus*), squirrel treefrogs (*H. squirella*), pine woods treefrogs (*H. femoralis*), Cope's gray treefrogs (*H. chrysoscelis*), spring peepers (*P. crucifer*), and southern leopard frogs (*R. sphenoceplaha*).

We marked a total of 296 individual frogs by toe clipping at Cherry Point MCAS in 1999. The following species were marked: southern toads (*Bufo terrestris*), Cope's gray treefrog (*Hyla chrysoscelis*), green treefrog (*Hyla cinerea*), pinewoods treefrogs (*Hyla femoralis*), barking treefrog (*Hyla gratiosa*), squirrel treefrogs (*Hyla squirella*), bullfrogs (*Rana catesbeiana*), southern leopard frogs (*Rana sphenocephala*), and narrow-mouthed toads (*Gastrophryne carolinensis*).

DISCUSSION AND CONCLUSIONS

The frog fauna on Cherry Point MCAS consists primarily of species that breed in shallow, ephemeral bodies of water or use beaver ponds. All these species use the surrounding forested habitat for shelter during most of the year except for mating and egg laying periods at the small wetlands characteristic of the installation. Thus, both the aquatic and terrestrial habitats are essential to the long term survival of these sensitive species on Cherry Point. Management of the remaining forest on the base by selective removal of trees may impact the size and dynamics of some of the amphibian populations through the reduction of non-breeding shelter locations. Treefrogs use arboreal refugia (trees) extensively. Reduction in number of natural shelter sites may affect survival of some individuals. A way to test this hypothesis is to add artificial shelters (e.g., PVC pipes) and determine if the population of breeding frogs increases over time. Determination of a relationship of shelter abundance to frog breeding population size may have forest management implications.

I conclude from the results of the first year of study that the frog fauna will likely yield the best information on how amphibians use the landscape. Increasing the numbers of marked individuals is critical to the success of the movement portion of this study. The mosaic of habitats in the area, despite the effects of silvicultural operations that create small clearcuts, shelterwood cuts, and pine moncultures, may be an important determining factor in local amphibian population dynamics. The frogs in this area undoubtedly disperse large distances like many species do in other types of habitats (see reviews in Semlitsch, 1998; Pauley et al. 2000). Knowledge of movement distances, coupled with information on the habitats used for each life history stage, will provide important information for resource managers. Such information can be used to formulate management objectives and direct land use operations in the area.

Formulation of realistic management objectives for amphibians will require the results of all the projected three years of data derived from this study. A single year's data set can only show some crude patterns. This is especially true of the first year of a large-scale study requiring considerable time for set-up, training, and testing of techniques. Thus, the following conclusions and management recommendations are preliminary and should be accepted with caution.

The following conclusions can be drawn from the first year results for Cherry Point MCAS:

1. The pine flatwoods and its associated ephemeral wetlands characteristic of Cherry Point MCAS support a rich diversity of amphibians.

2. A combination of monitoring and capture techniques is required to encounter the entire amphibian fauna. No one technique is useful to monitor all life history stages of all species.

3. The nighttime frog call survey is the best technique to assess the presence or absence of a frog species at a particular site.

4. Determination of whether a particular site is used for reproduction requires the use of the dip net and minnow trap techniques, as well as visual observation.

5. The amphibian fauna at Cherry Point MCAS is dynamic and species are active on different seasonal cycles. Monitoring of all species requires multiple techniques used over the entire season, including winter, to obtain information on all species present.

PRELIMINARY MANAGEMENT RECOMMENDATIONS

1. If the primary management goal for amphibians is to maintain the current level of species richness, then a mosaic of habitats is required. This is because some species do better in full canopy forests and some do better in more open habitats (e.g., Werner and Glennemeier, 1999). Determination of which species does best in each type will require the results from the second and third years of the study and an evaluation of the quantitative results from the capture techniques used in each habitat type.

2. Because no legally protected (state or federal) species have been found in Cherry Point MCAS thus far, the amphibian fauna should be managed as communities and not as single species.

Although some species appear to be rarely encountered (at least for the first year), they should not yet be considered rare and specifically managed to enhance their population size. Single species management may not be the best approach with the amphibian fauna in this area. Habitat management is the best strategy.

3. Monitoring of the amphibian fauna is likely to reveal habitat distribution and population dynamic patterns that will be useful to resource managers. Because patterns change with habitat change and over time, monitoring of this fauna should be considered a long-term effort. The projected three-year baseline data set obtained in this study will provide the basis for evaluation of changes in the future. Funding should be targeted for continuation of monitoring programs after the Legacy Resource Management Program support has ended.

4. The introduction of non-native and invasive species of plants and animals should be resisted. This could include North American "native" species that could be harmful to amphibians.

5. Captive-raised or maintained amphibians should not be allowed to be released in this area. The potential for disease introduction is growing and every effort should be made to avoid contamination from exotics or native species from other areas. Maintenance in captivity influences development of disease and former captives should never be released in the wild.

6. It would be advisable to review existing management plans that affect the habitat and hydrology of the area with management of amphibians in mind. Such reviews may reveal conflicts that could be avoided or mediated if detected before problems arise.

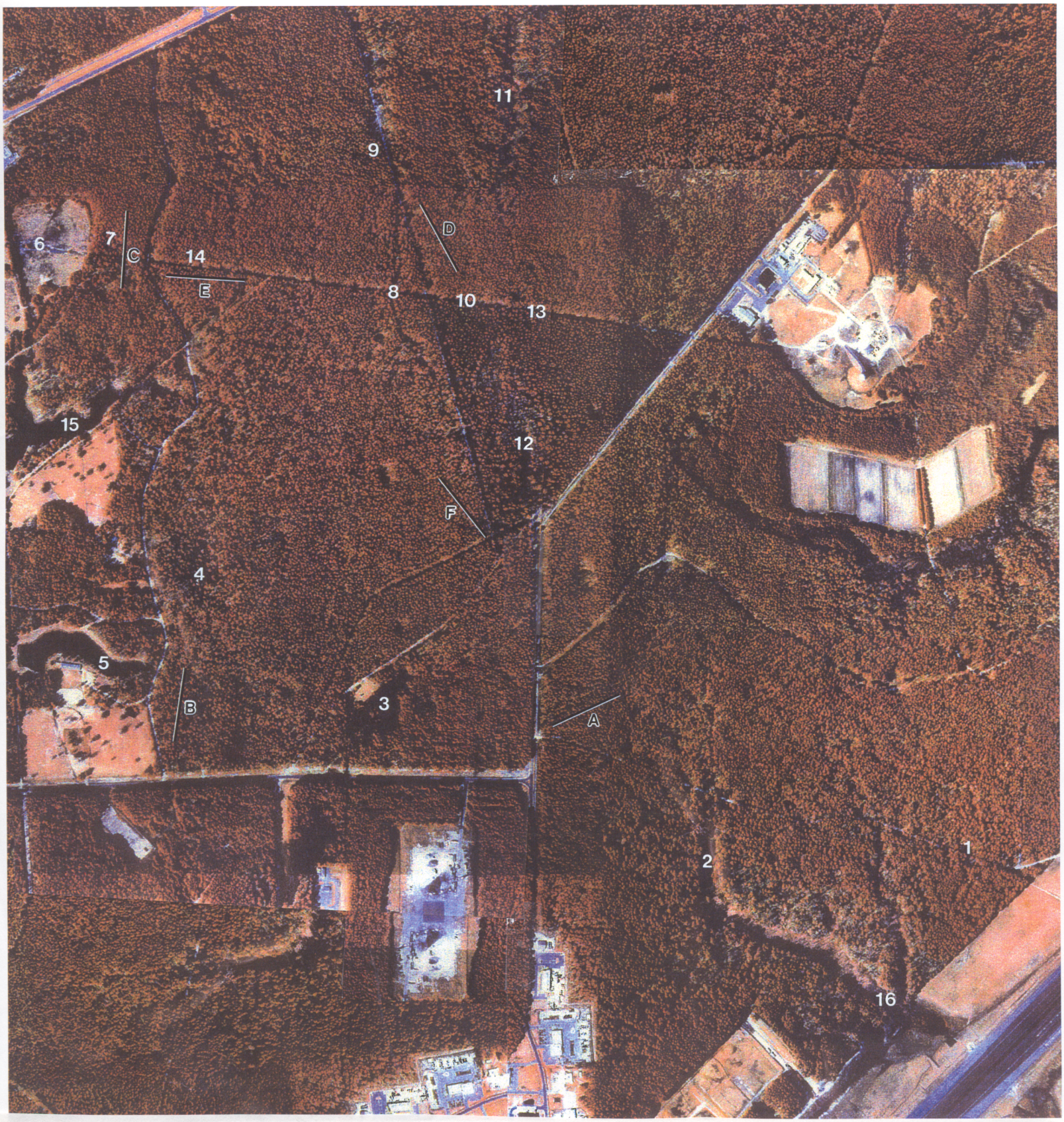

Figure 4. Map of Cherry Point MCAS, Craven County, North Carolina, illustrating locations of 16 study wetland ponds and six artificial coverboard transects. Wetland sites are denoted by numbers. Coverboard transects are denoted by letters. Each letter corresponds to transect numbers listed in the following tables (A = 700, B = 800, C = 900, D = 1000, E = 1100, F = 1200).

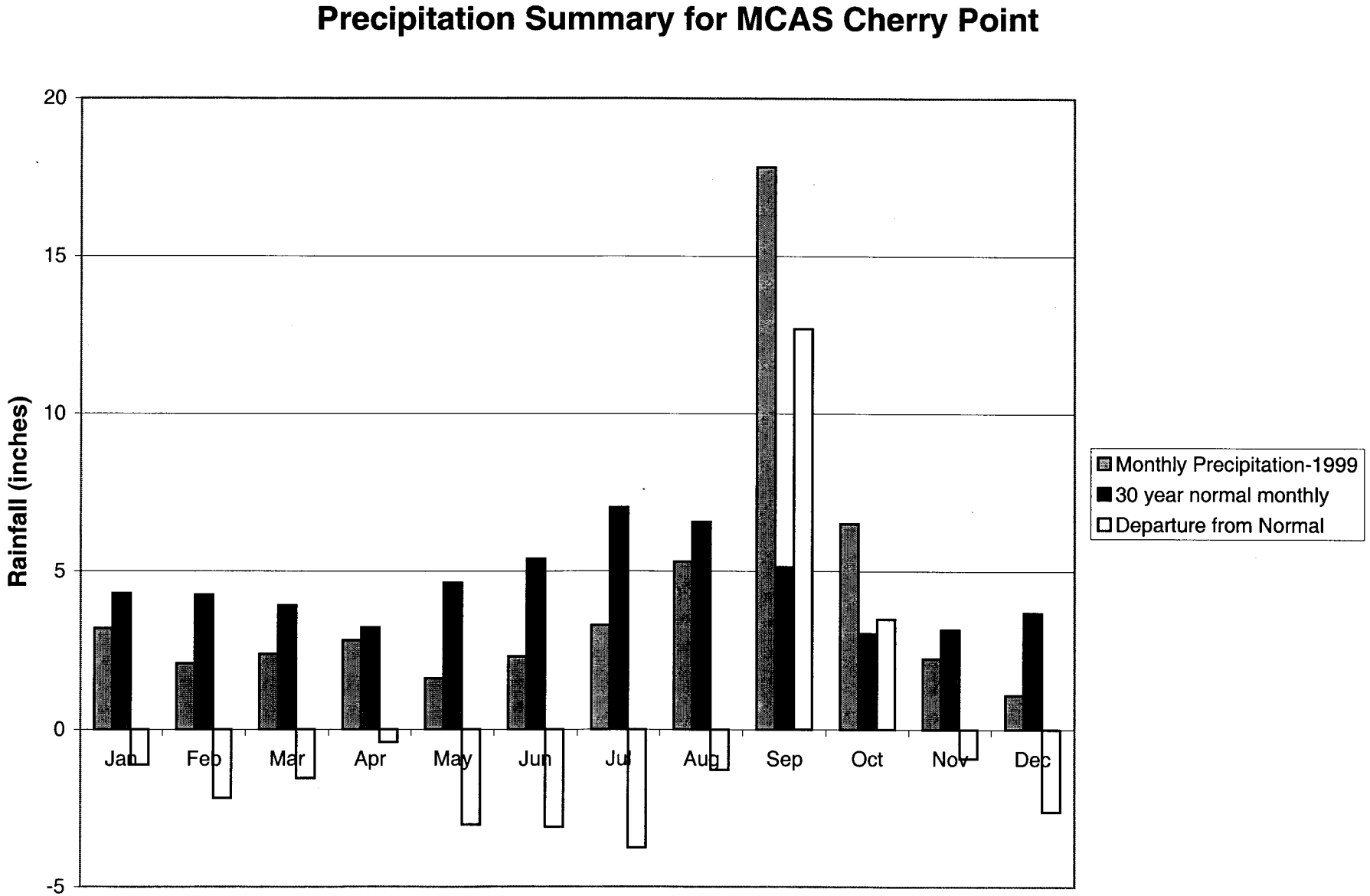

Figure 5. Monthly precipitation totals for Cherry Point MCAS and vicinity for 1999 and the average monthly totals for the previous 30 years. Monthly departure from normal in 1999 is the difference between actual precipitation and the 30 year average. Data from Cherry Point MCAS.

Table 23. Frequencies of vegetation and other habitat variables in six transects on MCAS Cherry Point, North Carolina. Numbers are frequency of occurrence along transects (n = 30 points each).

	SITE NUMBER						
Attributes/species	7	8	9	10	11	13	Mean Freq
Deciduous seedlings	0.63	0.60	0.63	0.53	0.67	0.60	0.61
Evergreen seedlings	0.03	0.00	0.00	0.03	0.03	0.03	0.02
Both seedlings	0.33	0.40	0.30	0.37	0.20	0.23	0.31
Grass	0.50	0.83	0.47	0.70	0.60	0.73	0.64
Canopy Closure (mean)	*61*	*59*	*63*	*55*	*52*	*63*	*59*
Subcanopy	0.20	0.07	0.30	0.10	0.07	0.17	0.15
Water	0.00	0.00	0.00	0.10	0.00	0.10	0.03
Ferns and Allies							
Botrychium dissectum	0.00	0.03	0.00	0.00	0.00	0.00	0.01
Thelypteris palustris	0.00	0.00	0.00	0.00	0.10	0.03	0.02
Woodwardia areolata	0.03	0.00	0.00	0.00	0.17	0.17	0.06
Woodwardia virginica	0.17	0.00	0.00	0.00	0.03	0.17	0.06
Osmunda cinnamomea	0.00	0.00	0.03	0.03	0.17	0.17	0.07
Osmunda regalis	0.00	0.00	0.00	0.03	0.00	0.00	0.01
Pteridium aquilinum	0.23	0.00	0.03	0.23	0.17	0.13	0.13
Lycopodium inundatum	0.00	0.00	0.00	0.00	0.13	0.00	0.02
Sphagnum spp.	0.00	0.00	0.00	0.00	0.13	0.00	0.02
Graminoids							
Arundinaria gigantea	0.90	0.00	0.70	0.87	0.97	0.97	0.74
Forbs							
Asarum canadense	0.00	0.00	0.03	0.03	0.00	0.00	0.01
Caltha palustris	0.00	0.00	0.00	0.00	0.03	0.00	0.01
Cassia nictitans	0.00	0.00	0.03	0.03	0.00	0.00	0.01
Desmodium rotundifolium	0.00	0.07	0.00	0.00	0.00	0.00	0.01
Desmodium spp.	0.00	0.07	0.00	0.00	0.00	0.00	0.01
Eupatorium album	0.03	0.10	0.00	0.00	0.00	0.00	0.02

Table 23, continued

Eupatorium capillifolium	0.00	0.00	0.00	0.17	0.00	0.00	0.03
Eupatorium pilosum	0.03	0.00	0.03	0.27	0.00	0.13	0.08
Eupatorium rotundifolium	0.10	0.07	0.03	0.07	0.00	0.00	0.05
Lespedeza procumbens	0.00	0.17	0.00	0.00	0.00	0.00	0.03
Mitchella repens	0.07	0.00	0.07	0.00	0.23	0.07	0.07
Polygala lutea	0.00	0.00	0.00	0.10	0.00	0.03	0.02
Polygonatum biflorum	0.03	0.00	0.00	0.00	0.00	0.00	0.01
Potentilla simplex	0.00	0.03	0.00	0.00	0.00	0.00	0.01
Vinca minor	0.03	0.00	0.00	0.00	0.00	0.00	0.01
Viola spp.	0.00	0.07	0.00	0.00	0.00	0.00	0.01
No ID (specimen spoiled)	0.00	0.00	0.03	0.00	0.00	0.00	0.01
Sabatia spp.	0.00	0.00	0.00	0.03	0.00	0.00	0.01
Eupatorium spp.	0.00	0.00	0.00	0.00	0.00	0.03	0.01
Vines							
Amphicarpa bracteata	0.07	0.17	0.00	0.00	0.00	0.00	0.04
Apios americana	0.07	0.10	0.00	0.00	0.00	0.00	0.03
Bignonia capreolata	0.00	0.00	0.03	0.00	0.00	0.00	0.01
Campsis radicans	0.03	0.03	0.00	0.00	0.00	0.00	0.01
Gelsemium sempervirens	0.30	0.53	0.33	0.23	0.30	0.40	0.35
Parthenocissus quinquefolia	0.03	0.10	0.10	0.03	0.03	0.00	0.05
Rhus radicans	0.13	0.13	0.10	0.03	0.00	0.07	0.08
Smilax bona-nox	0.00	0.00	0.10	0.00	0.03	0.00	0.02
Smilax rotundifolia	0.53	0.13	0.57	0.63	0.53	0.90	0.55
Vitis spp.	0.43	0.67	0.50	0.50	0.37	0.30	0.46
Shrubs							
Amelanchier spp.	0.00	0.00	0.03	0.03	0.03	0.07	0.03
Aralia spinosa	0.00	0.03	0.00	0.00	0.00	0.00	0.01
Clethra alnifolia	0.67	0.00	0.07	0.60	0.50	0.57	0.40
Elaeagnus commutata	0.00	0.07	0.00	0.00	0.00	0.00	0.01
Gordonia lasianthus	0.20	0.00	0.00	0.17	0.10	0.20	0.11
Hypericum spp.	0.20	0.00	0.00	0.03	0.03	0.07	0.06

Table 23, continued

Myrica cerifera	0.13	0.27	0.13	0.07	0.07	0.13	0.13
Rubus spp.	0.13	0.10	0.07	0.07	0.07	0.00	0.07
Vaccinium spp.	0.77	0.77	0.93	0.60	0.70	0.67	0.74
Fern frequency	0.43	0.03	0.07	0.30	0.43	0.50	0.29
Forb frequency	0.30	0.57	0.23	0.37	0.27	0.23	0.33
Vine frequency	0.80	0.90	0.90	0.90	0.80	0.97	0.88
Shrub frequency	0.90	0.90	0.97	0.80	0.83	0.83	0.87

Table 24. Frequency of overstory and understory trees along six transects in MCAS Cherry Point, North Carolina.

	OVERSTORY							UNDERSTORY						
Trees	**7**	**8**	**9**	**10**	**11**	**13**	**Mean**	**7**	**8**	**9**	**10**	**11**	**13**	**Mean**
Acer rubrum	0.03	0.02	0.10	0.02	0.10	0.08	0.06	0.15	0.19	0.08	0.04	0.04	0.05	0.09
Carya glabra	-	-	-	-	-	-	n/a	0.00	0.00	0.00	0.01	0.00	0.00	<0.01
Cornus florida	0.01	0.00	0.01	0.00	0.00	0.00	<0.01	0.00	0.00	0.04	0.00	0.00	0.00	0.01
Diospyros virginiana	-	-	-	-	-	-	n/a	0.00	0.01	0.00	0.00	0.00	0.00	<0.01
Fagus grandifolia	-	-	-	-	-	-	n/a	0.00	0.00	0.00	0.01	0.00	0.00	<0.01
Gordonia lasianthus	-	-	-	-	-	-	n/a	0.00	0.00	0.00	0.00	0.08	0.08	0.03
Liquidambar styraciflua	-	0.01	0.01	0.05	0.03	0.01	0.02	0.65	0.64	0.61	0.88	0.21	0.58	0.60
Liriodendron tulipifera	0.00	0.00	0.01	0.03	0.00	0.00	0.01	-	-	-	-	-	-	n/a
Nyssa sylvatica	0.03	0.00	0.03	0.03	0.02	0.00	0.02	0.03	0.00	0.03	0.00	0.00	0.00	0.01
Oxydendrum arboreum	0.00	0.00	0.02	0.00	0.00	0.00	<0.01	0.01	0.13	0.05	0.00	0.00	0.00	0.03
Persea borbonia	0.00	0.00	0.01	0.00	0.05	0.00	0.01	0.03	0.03	0.17	0.03	0.63	0.28	0.20
Pinus taeda	0.90	0.57	0.59	0.71	0.77	0.81	0.73	0.02	0.00	0.00	0.03	0.03	0.00	0.01
Pinus virginiana	0.00	0.01	0.00	0.00	0.00	0.00	<0.01	-	-	-	-	-	-	n/a
Quercus alba	0.02	0.08	0.14	0.05	0.00	0.00	0.05	0.00	0.00	0.00	0.02	0.00	0.00	<0.01
Quercus falcata	0.01	0.21	0.06	0.08	0.02	0.00	0.06	0.03	0.00	0.01	0.00	0.00	0.00	0.01
Quercus marilandica	0.00	0.01	0.00	0.00	0.00	0.00	<0.01	0.03	0.00	0.02	0.00	0.00	0.01	0.01
Quercus nigra	0.01	0.00	0.00	0.00	0.03	0.08	0.02	0.00	0.00	0.00	0.00	0.01	0.00	<0.01
Quercus phellos	0.00	0.00	0.00	0.00	0.00	0.01	<0.01	0.00	0.01	0.00	0.00	0.00	0.01	<0.01
Quercus rubra	0.00	0.10	0.02	0.03	0.00	0.01	0.03	-	-	-	-	-	-	n/a
Quercus stellata	0.00	0.01	0.01	0.02	0.00	0.02	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.01
Rhus copallina	-	-	-	-	-	-	n/a	0.03	0.00	0.00	0.00	0.00	0.00	0.01

Table 25. List of amphibian species encountered on MCAS Cherry Point, NC, for the 1999 sampling year.

Anura (frogs and toads)	
Bufonidae:	
Bufo quercicus	Oak Toad
Bufo terrestris	Southern Toad
Hylidae:	
Acris gryllus grullus	Coastal Plain Cricket Frog
Hyla chrysoscelis	Cope's Gray Treefrog
Hyla cinerea	Green Treefrog
Hyla femoralis	Pine Woods Treefrog
Hyla gratiosa	Barking Treefrog
Hyla squirella	Squirrel Treefrog
Pseudacris crucifer crucifer	Northern Spring Peeper
Pseudacris ocularis	Little Grass Frog
Microhylidae:	
Gastrophryne carolinensis	Eastern Narrow-mouthed Toad
Pelobatidae:	
Scaphiopus holbrookii	Eastern Spadefoot
Ranidae:	
Rana catesbeiana	American Bullfrog
Rana clamitans melanota	Northern Green Frog
Rana sphenocephala utricularia	Southern Leopard Frog
Caudata (salamanders)	
Ambystomatidae:	
Ambystoma opacum	Marbled Salamander
Amphiumidae:	
Amphiuma means	Two-toed Amphiuma
Plethodontidae:	
Plethodon chlorobryonis	Atlantic Coast Slimy Salamander
Salamandridae:	
Notophthalmus viridescens dorsalis	Broken-striped Newt

Table 26. Total number of amphibians captured at MCAS Cherry Point, NC in 1999 by life history stage.

	SEX/ LIFE HISTORY STAGE				
	Male	Female	Juvenile	Larvae	Total
Frogs					
Acris gryllus	1			6	7
Bufo terrestris	8	1	2	4	15
Gastrophryne carolinensis	11	4			15
Hyla chrysoscelis	38	2		22	62
Hyla cinerea	53	126	2		181
Hyla femoralis	81	14			95
Hyla gratiosa	10	1		6	17
Hyla squirella	80	17	6		103
Pseudacris crucifer				32	32
Pseudacris ocularis	1				1
Rana catesbeiana	1		13		14
Rana clamitans				46	46
Rana sphenocephala		4	5	317	326
Scaphiopus holbrookii	3				3
Salamanders					
Amphiuma means	1				1
Ambystoma opacum				5	5
Notophthalmus viridescens	17	11	1	6	35
Plethodon chlorobryonis		2			2
Total	305	182	29	444	960

Table 27. Species occurrence by sampling technique at MCAS Cherry Point in 1999.

	SAMPLING TECHNIQUE					
	Artificial Cover Transects	PVC Pipe Transects	Visual Encounter Surveys	Minnow Trapping	Dip Nets	Frog Call Surveys
Frogs						
A. gryllus			X		X	X
B. quercicus	X					
B. terrestris	X		X		X	X
G. carolinensis	X		X			X
H. chrysoscelis		X	X	X	X	X
H. cinerea		X	X	X		X
H. femoralis		X	X	X		X
H. gratiosa			X	X		X
H. squirella	X	X	X	X		X
P. crucifer				X	X	X
P. ocularis	X		X			X
R. catesbeiana			X	X	X	X
R. clamitans			X	X	X	X
R. sphenocephala			X	X	X	X
S. holbrookii			X			X
Salamanders						
A. means				X		
A. opacum				X		
N. viridescens	X			X	X	
P. chlorobryonis	X		X			

Table 28. Number of amphibians captured in artificial coverboard transects at MCAS Cherry Point in 1999. Column headings are transect numbers.

	TRANSECT NUMBER						
	700	800	900	1000	1100	1200	Total
Frogs							
B. quercicus	1						1
B. terrestris			1				1
G. carolinensis				1			1
H. squirella		1					1
P. ocularis					1		1
Total (7 samplings)	1	1	1	1	1		5
Salamanders							
N. viridescens			1				1
P. chlorobryonis			1	1			2
Total	0	0	2	1	0	0	3

Table 29. Total number of amphibians captured in PVC pipe transects at MCAS Cherry Point in 1999. Column headings are transect numbers.

	TRANSECT NUMBER						
	700	800	900	1000	1100	1200	Total
Frogs							
H. chrysoscelis		1					1
H. cinerea	10	34	11	16	74	33	178
H. femoralis	4	6	1	1	11	3	26
H. squirella	10	37	2	3			52
Total (7 samplings)	24	78	14	20	85	36	257

Table 30. Number of amphibians captured during Visual Encounter Surveys at MCAS Cherry Point in 1999.

	SITE NUMBER									
	3	4	6	7	8	10	12	14	15	Total
Frogs										
B. terrestris		8	1			1				10
G. carolinensis			11			1		1	1	14
H. chrysoscelis	16	6	9	6						37
H. cinerea	3			1						4
H. femoralis	1	45	1			2		16		65
H. gratiosa		11								11
H. squirella			30					9	8	47
P. ocularis								1		1
R. catesbeiana			1				3			4
R. clamitans							1			1
R. sphenocephala		1	3				1			5
Total	20	71	56	7	0	4	5	27	9	199
Salamanders										
P. chlorobryonis					1					1

Table 31. Number of amphibians captured in minnow traps at MCAS Cherry Point in 1999.

	SITE NUMBER											
	1	3	4	6	7	8	10	12	13	14	17	Total
Number of trap days at each site:	15	10	55	19	35	34	22	41	13	6	6	256
Frogs												
H. chrysoscelis			1				1					2
H. cinerea											2	2
H. femoralis									1			1
H. gratiosa			4									4
H. squirella	11			2								13
P. crucifer			4				2					6
R. catesbeiana			2			3	1	2				8
R. clamitans						6	36	1				43
R. sphenocephala			22	191	139	21		2		3		378
Total	11	0	33	193	139	30	40	5	1	3	2	457
Salamanders												
A. means					2				1		1	4
A. opacum								5				5
N. viridescens	12		10				4					26
Total	12	0	10	0	2	0	4	5	1	0	1	35

Table 32. Number of amphibians captured in dipnet surveys at MCAS Cherry Point in 1999.

	SITE NUMBER									
	1	4	6	7	8	10	12	13	14	Total
Number of Sweeps per site:	13	30	40	16	10	15	36	9	6	175
Frogs										
A. gryllus						5			2	7
B. terrestris			12			3				15
H. chrysoscelis		4				3				7
P. crucifer		18		8						26
R. catesbeiana			1							1
R. clamitans							3			3
R. sphenocephala			73	30	3	1		2	1	110
Total		22	96	38	3	12	3	2	3	169
Salamanders										
N. viridescens		8								8

Table 33. Amphibian species in each of seven long-term frog call monitoring sites on Cherry Point MCAS, North Carolina. Abbreviations: species identified by vocalizations (V) and by identification of frog larvae (tadpoles) collected by dipnet (L). Note abbreviations of species.

Species	Sites 1	3	4	5	6	10	12
Frogs							
Acris gryllus (Agr)	V	V	V	V	VL		
Bufo terrestris (Bte)	V	V	V	V	VL	VL	L
Hyla cinerea (Hci)	V	V	V	V			
Hyla chrysoscelis (Hch)	V	V	VL	V	V	VL	V
Hyla femoralis (Hfe)	V	V	V		V	V	V
Hyla gratiosa (Hgr)	VL		V				
Hyla squirella (Hsq)	V		V	V	V	V	V
Gastrophryne carolinensis (Gca)	V	V	V		V	V	V
Pseudacris crucifer (Pcr)	V	V	VL		V	VL	V
Pseudacris ocularis (Poc)	V	V		V	V	V	
Rana catesbeiana (Rca)	V		V			V	
Rana clamitans (Rcl)	V				L	VL	
Rana sphenocephala (Rsp)	V	V	VL	V	VL	VL	VL
Scaphiopus holbrookii (Sho)							

Table 34. Seasonal variation in timing of male frog vocalizations and presence of larvae (tadpoles) in Site 1 on Cherry Point MCAS for 1999. Abbreviations as in Table 33.

	Species														
Week of	Agr	Bte	Bqu	Hci	Hch	Hfe	Hgr	Hsq	Gca	Pcr	Poc	Rca	Rcl	Rsp	Sho
1999															
April 15								V							
April 22		V								V					
April 29										V					
May 4		V								V				V	
May 13								V		V					
May 20														V	
May 27															
June 5								V							
June 12								V							
June 17					V			V	V						
June 24								V							
July 2								V							
July 8															
July 15					V	V		V	V						
July 22															
July 29															

Table 35. Seasonal variation in timing of male frog vocalizations and presence of larvae (tadpoles) in Site 3 on Cherry Point MCAS for 1999. Abbreviations as in Table 33.

	Species														
Week of	Agr	Bte	Bqu	Hci	Hch	Hfe	Hgr	Hsq	Gca	Pcr	Poc	Rca	Rcl	Rsp	Sho
1999															
April 15										V					
April 22	V	V								V				V	
April 29										V				V	
May 4	V	V								V	V			V	
May 13	V														
May 20	V				V	V				V					
May 27	V											V	V		
June 5	V			V											
June 12	V														
June 17	V	V												V	
June 24	V			V											
July 2	V			V											
July 8															
July 15	V	V		V	V	V			V						
July 22	V														
July 29															

Table 36. Seasonal variation in timing of male frog vocalizations and presence of larvae (tadpoles) in Site 4 on Cherry Point MCAS for 1999. Abbreviations as in Table 33.

	Species														
Week of	Agr	Bte	Bqu	Hci	Hch	Hfe	Hgr	Hsq	Gca	Pcr	Poc	Rca	Rcl	Rsp	Sho
1999															
April 15		V						V		V					
April 22										V					
April 29										V					
May 4		V						V		V	V			V	
May 13	V				V	V	V			V	V				
May 20	V				V	V				V				V	
May 27	V													VL	
June 5	V			V		V	V								
June 12															
June 17	V	V			VL	V	VL			L	V			L	
June 24	V						V								
July 2	V					V					V				
July 8															
July 15	V				V	V	VL		V		V				
July 22											V				
July 29															

Table 37. Seasonal variation in timing of male frog vocalizations and presence of larvae (tadpoles) in Site 5 on Cherry Point MCAS for 1999. Abbreviations as in Table 33.

	Species													
Week of	Agr	Bte	Bqu	Hci	Hch	Hfe	Hgr	Hsq	Gca	Pcr	Poc	Rca	Rcl	Rsp	Sho
1999															
April 22		V		V										V	
April 29												V		V	
May 4		V										V		V	
May 13				V	V			V				V		V	
May 20				V								V		V	
May 27				V								V		V	
June 5		V		V				V				V			
June 12								V						V	
June 17		V										V		V	
June 24				V				V				V			
July 2	V	V		V				V				V			
July 8				V											
July 15		V										V		V	
July 22		V													
July 29		V													

Table 38. Seasonal variation in timing of male frog vocalizations and presence of larvae (tadpoles) in Site 6 on Cherry Point MCAS for 1999. Abbreviations as in Table 33.

Week of	Species														
	Agr	Bte	Bqu	Hci	Hch	Hfe	Hgr	Hsq	Gca	Pcr	Poc	Rca	Rcl	Rsp	Sho
1999															
April 15		V													
April 22	V	V								V	V				
April 29										V				V	
May 4	V	V									V			V	
May 13	V								V						
May 20	V					V									
May 27	V	L						V						L	
June 5								V							
June 12								V							
June 17		V				V		V						VL	
June 24								V						V	
July 2															
July 8				V			V	V							
July 15		V			V	V		V	V					VL	
July 22				V			V								
July 29				V											

Table 39. Seasonal variation in timing of male frog vocalizations and presence of larvae (tadpoles) in Site 10 on Cherry Point MCAS for 1999. Abbreviations as in Table 33.

	Species														
Week of	Agr	Bte	Bqu	Hci	Hch	Hfe	Hgr	Hsq	Gca	Pcr	Poc	Rca	Rcl	Rsp	Sho
1999															
April 15		V						V		V	V				
April 22	V	V						V		V				V	
April 29								V		V	V			V	
May 4	V									VL	V		L	VL	
May 13	V					V								V	
May 20	V				V										
May 27											V				
June 5						V		V			V				
June 12						V									
June 17					V	V		V	V		V				
June 24	V				V						V				
July 2	V										V				
July 8															
July 15	VL	L			VL	V		V	V		V			L	
July 22	V														
July 29															

Table 40. Seasonal variation in timing of male frog vocalizations and presence of larvae (tadpoles) in Site 12 on Cherry Point MCAS for 1999. Abbreviations as in Table 33.

Week of	Species														
	Agr	Bte	Bqu	Hci	Hch	Hfe	Hgr	Hsq	Gca	Pcr	Poc	Rca	Rcl	Rsp	Sho
1999															
April 15					V					V	V			V	
April 22		V								V				V	
April 29										V				V	
May 4		V						V		V	V		L	VL	
May 13		V			V			V			V	V			
May 20					V										
May 27													L	L	
June 5								V					V		
June 12								V							
June 17					V	V		V	V						
June 24					V								V		
July 2															
July 8															
July 15					V	V		V	V		V				
July 22															
July 29															

RESULTS FOR MCB CAMP LEJEUNE

INTRODUCTION

MCB Camp Lejeune is located in Onslow County, North Carolina (**Figure 6**), and is comprised of approximately 153,000 acres of land that is divided by the New River. The installation has 22 kilometers of marine shoreline used for training, swimming, fishing, and management of beaches used for nesting by two species of endangered sea turtles. Camp Lejeune was established in 1941 and named in honor of LtGen John A. Lejeune. It is home to the II Marine Expeditionary Force and the U.S. Marine Corps Forces Atlantic. Before 1941, the land was in private ownership and in poor condition due to over-harvesting of forests and extensive agriculture. The first natural resources management plan was prepared in 1946. Natural regrowth of vegetation and forest management since that time has established Camp Lejeune as an important center for regional biodiversity. A variety of rare or unusual natural communities occur on the installation (LeBlond et al., 1994).

Amphibian species richness expected for MCB Camp Lejeune and vicinity is based on species distribution maps in Conant and Collins (1998) and include 22 species of frogs and toads and 14 species salamanders. In 1999 we encountered 16 species of frogs and 3 species of salamanders, or 53% of the expected amphibian fauna for the region (73% of salamanders, 21% of frogs). We used six standardized techniques to monitor amphibians in MCB Camp Lejeune. This report summarizes the results from the six techniques used in 1999.

STUDY SITE DESCRIPTIONS

Habitat

The dominant habitat type in mainland Onslow County, North Carolina, is mixed hardwood and pine forest. An unknown portion of the county was originally in longleaf pine – wiregrass habitat. Total wetland area in the county is 77,701 ha, whereas non-wetland area is comprised of 118,106 ha (195,807 ha total land area). The habitat on MCB Camp Lejeune is currently mostly upland pine flatwoods with patches of mixed hardwoods and riparian systems along creeks with

characteristic vegetation. Some of the installation near the primary study area is managed specifically for longleaf pine and federally endangered red-cockaded woodpeckers.

Precipitation Summary for 1999

Most of the eastern United States experienced drought conditions during 1998-1999. For most months of 1999, Camp Lejeune received less than normal precipitation (**Figure 7**). Only in the months of June and August through October was there normal or greater than normal rainfall in the area. Total rainfall for June was higher than normal and it was the only month during the January – July period in which rainfall exceeded the previous 30-year normal levels. The precipitation that occurred in August – October was mostly from two hurricanes (Floyd and Dennis). Precipitation in November and December was, like earlier in the year, below normal.

Terrestrial Habitat Descriptions

Artificial coverboard transects were established in forested areas near and around study ponds to gather data on inter-pond movements of amphibians and on populations of amphibians that are largely or wholly terrestrial in habits. Vegetation analysis revealed few significant differences between the six established transects (S. Bellows, pers. comm.), hence the following descriptions apply to all of them. Results of the plant ecology transect analyses are summarized in **Tables 42-43.**

The overstory vegetation for all transects is dominated by loblolly pine (*Pinus taeda*) with smaller numbers of sweetgum (*Liquidambar styraciflua*) and red maple (*Acer rubrum*). Other overstory trees include red bay (*Persia borbonica*), flowering dogwood (*Cornus florida*), and several species of oaks (*Quercus* spp.). Understory vegetation shows slightly more evenness in dominance between sweetgum and red bay. A large number of forbs occur at the sites, the most abundant being several species of thoroughwort (*Eupatorium* spp.) and partridgeberry (*Mitchella repens*). Controlled burns were carried out in the forest near transects A and C during the winter of 1999-2000.

Aquatic Habitat Descriptions

With a small number of exceptions most of the ponds in our study area have generally similar physical and vegetational characteristics. Ponds with such similarities are grouped together under the appropriate descriptions given here.

Ponds 1, 2, 5, 6, 7, 8, 9, 10, 11, 12, 25, 26, 32- These ponds are all relatively small, often nearly circular in shape, and primarily occur in the southeastern corner of our study area, between the actual open TLZ Jaybird training area and the access road leading to the study area from highway 172. These ponds are all shallow (< 1m) and contain little emergent vegetation. Most have a number of logs and tree snags present. The substrate is mainly clay. The surrounding forest is a mix of loblolly pine (*Pinus taeda*) and various hardwoods (see descriptions for artificial cover transects below). All of these ponds dried up during the summer of 1999 and refilled in September 1999 due to heavy rains associated with hurricanes Dennis and Floyd.

Ponds 13, 14, 15, 16, 17, 18, 19, 30, 31 - These ponds are located in the open TLZ Jaybird training area on the southwest side of the study area. These ponds feature a somewhat variable but moderate amount of emergent vegetation. Pond 16 has a conspicuous growth of water lilies. Most of the emergent vegetation, however, consists of various grasses. The substrate in these ponds is mainly clay. The amount of organic matter in the substrate varies from moderate in Pond 16 to very little in Pond 14. Surrounding vegetation is dominated by various successional grasses, forbs, scrub oaks (*Quercus marilandica*) and young loblolly pines (*Pinus taeda*).

This group of ponds has been heavily impacted by human activities. Wheel ruts are present throughout the site, some passing through the ponds themselves. Three of the ponds (13, 18, 19) contained some water throughout 1999.

Ponds 3, 4 - These ponds are located just to the southwest of the access road the TLZ Jaybird training area. They are shallow (< 1m) with conspicuous grasses. Some emergent vegetation occurs throughout the ponds' surface. Pond 3 contained water throughout the sampling period.

Pond 23 - At approximately 210m x 160m in area, this pond is the largest in the study area. It is shallow, with only a small area being ~ 1m in depth or greater. There is much emergent vegetation consisting of grasses and water lilies. Numerous logs and tree snags occur around the pond's periphery. The substrate is highly organic in content. Vegetation around the edges of this pond includes alder (*Alnus serrulata*), wax myrtle (*Myrica cerifera*), and loblolly pine (*Pinus taeda*). This pond dried up during the summer of 1999 and refilled from heavy rains caused by hurricanes Dennis and Floyd, in September, 1999.

Pond 24 - This pond lies to the north-northeast of the access road leading to the New river. It is approximately 150m x 60m in area. This pond is similar to Pond 23 in emergent vegetation and substrate properties. It contained water throughout the 1999 sampling period.

Pond 29 - This pond lies adjacent to the access road leading from highway 172 to the study area. It is heavily vegetated, with emergent grasses and a stand of cattails (*Typha* sp.). It may have been formed as a result of construction activities along the adjacent road. It dried up during the summer of 1999.

RESULTS

During 1999, we encountered 16 species of frogs and three species of salamanders in our study area in MCB Camp Lejeune (**Table 44**). We captured a total of 2,077 individuals as larvae, juveniles, or adult males or females (**Table 45**). Five species of frogs were captured in large numbers: *Acris gryllus* (southern cricket frog), *Bufo terrestris* (southern toad), *Hyla gratiosa* (barking treefrog), *Rana catesbeiana* (American bullfrog), and *Rana sphenocephala* (southern leopard frog). Most cricket frogs were captured as adults, whereas many of the other abundant species were captured as tadpoles. Total numbers for these five species accounted for 89.7% of all amphibian captures in 1999. The broken-striped newt (*Notophthalmus viridescens*) was the most abundant salamander captured. Most of the frogs were captured during the execution of three of the six standardized monitoring protocols at MCB Camp Lejeune (**Table 46)** but all techniques yielded frogs. Southern cricket frogs and eastern spadefoots were captured only by one technique (frog call surveys and visual encounter surveys, respectively), whereas all other species were captured by two or more techniques. Broken-striped newts (*N. viridescens*) were

captured by three techniques and the Atlantic Coast slimy salamanders (*P. chlorobryonis*) were captured the artificial coverboard technique.

Artificial coverboard transects yielded a total of 12 individuals of seven species of frogs and one individual of one species of salamander (**Table 47**). The frogs were distributed randomly among the transect sites, whereas the salamanders were captured in one of the six transects.

PVC pipe transects proved to be a useful monitoring technique for treefrogs at MCB Camp Lejeune. A total of 90 adult individuals of five species of treefrogs was captured in 1999 (**Table 48**). Of these, 50% were captures of green treefrogs (*Hyla cinerea*) and 34% were captures of squirrel treefrogs (*Hyla squirella*). All PVC pipe transects yielded treefrogs, suggesting that these amphibians are distributed throughout the terrestrial habitat in the area.

A total of 255 amphibians were observed or caught during visual encounter surveys of the nine wetlands on Cherry Point MCS (**Table 49**). Five species were observed more commonly than the others, southern cricket frog (*A. gryllus*), barking treefrog (*H. gratiosa*), squirrel treefrog (*H. squirella*), bullfrogs (*R. catesbeiana*), and southern leopard frogs (*R. sphenocephala*). Number of species observed with this technique varied from one at wetland sites 4, 7, 8, 11, 14, 19, and 29 to five at sites 1, 12, and 23. No site lacked amphibians.

The minnow trap technique was successful at 178 wetland sites. The total number of frogs captured was 676 and the total number of salamanders captured was 24 (**Table 50**). Numbers of captures for individual species varied from 1 (green frog, *Rana clamitans*) to 542 (bullfrog, *Rana catesbeiana*). Most of the latter were tadpoles. The broken-striped newt (*Notophthalmus viridescens*) was the only salamander captured in minnow traps. Number of frogs captured among wetlands varied from zero at site 24 and 1 at sites 3 and 7 to 283 at site 18. Number of broken-striped newts captured among wetlands varied from 1 at sites 8 and 24 to 18 at site 23.

Dipnet surveys were conducted in 12 of the wetland sites. A total of 977 individuals of six species of frogs and 28 individuals of one salamander species was captured in 1999 (**Table 51**). Captures of frogs were dominated by southern toads (*Bufo terrestris*), barking treefrogs (*Hyla gratiosa*), and southern leopard frog (*Rana sphenocephala*) tadpoles (65%). Number of individuals captured among wetlands varied from 2 in sites 10, 16, 24, and 29 to 545 in site 1.

Number of species among wetlands ranged from one in site 29 to five in site 23. All broken-striped newts (*N. viridescens*) were captured in site 23.

The weekly nighttime frog call survey yielded information on all 13 of the 16 species of frogs documented to date for MCB Camp Lejeune (**Table 52**). Based on male vocalizations alone, this technique recorded 4 to 10 species present in these eight wetlands. Ten species called at sites 23 and 24, 7-9 called at sites 3, 12, 18, and 29, 6 called at site 1, and 4 called at site 19. Dipnet and minnow trap results found tadpoles of several species in seven of the eight sites monitored. **Tables 53-60** provide information on seasonal occurrence of the 14 species of frogs within each of the eight wetlands. There was considerable variation in when a particular species called at each wetland. For example, the southern cricket frog (*Acris gryllus*) called extensively in 1999 at five of the study sites but only two to three times at two others. Many species called for several weeks in a row, then skipped one or more weeks before calling again (e.g., green teefrog [*H. cinerea*], squirrel treefrog [*H. squirella*], spring peepers [*P. crucifer*], and southern leopard frog [*R. sphenocephala*]). Based on calling males, the frog fauna of MCB Camp Lejeune appears to be dominated by six species: southern cricket frogs (*A. gryllus*), squirrel treefrogs (*H. squirella*), barking treefrogs (*H. gratiosa*), spring peepers (*P. crucifer*), bullfrogs (*R. catesbeiana*), and southern leopard frogs (*R. sphenoceplaha*). Wetland sites 1, 3, and 29 dried before the end of June and all sites had dried by early August due to the drought.

We marked a total of 212 individual frogs by toe clipping at MCB Camp Lejeune in 1999. The following species were marked: southern toads (*Bufo terrestris*), Cope's gray treefrog (*Hyla chrysoscelis*), green treefrog (*Hyla cinerea*), pinewoods treefrogs (*Hyla femoralis*), barking treefrog (*Hyla gratiosa*), squirrel treefrogs (*Hyla squirella*), bullfrogs (*Rana catesbeiana*), southern leopard frogs (*Rana sphenocephala*), and narrow-mouthed toads (*Gastrophryne carolinensis*).

DISCUSSION AND CONCLUSIONS

The frog fauna on Camp Lejeune consists primarily of species that breed in shallow, ephemeral bodies of water or sinkhole ponds that rarely dry out. All these species use the surrounding forested habitat for shelter during most of the year except for mating and egg laying periods. Thus, both the aquatic and terrestrial habitats are essential to the long term survival of these sensitive species on Camp Lejeune. Management of the forest on the installation that

results in elimination of terrestrial refugia may impact amphibian populations. Treefrogs use arboreal refugia (trees) extensively and some frogs and salamanders use terrestrial and subterranean microhabitats exclusively. If protection and management of amphibians is an important resource management goal, then amphibian ecology and dynamics in aquatic and terrestrial habitats must be considered in development of any and all management plans involving forestry, wildlife, or landscape operations.

The results of the first year of study suggests that the frog fauna will yield the most useful information on how amphibians use the landscape. Thus, this information will be useful to resource managers when developing management plans that involve natural habitats. Increasing the numbers of marked individuals is critical to the success of the movement and landscape portion of this study. The diversity of the sinkhole pond wetlands and other ephemeral wetland habitats in the area, despite the surface effects of silvicultural operations that create clearcuts, shelterwood cuts, and moncultures and natural disturbances such as wind throw from hurricanes, supports many species. The frogs in this area undoubtedly disperse long distances like many species do in other types of habitats (see reviews in Semlitsch, 1998; Pauley et al. 2000). Knowledge of movement distances, coupled with information on the habitats used for each life history stage, will provide resource managers with the tools to more completely understand how the land is being used by amphibians. Such information can be used to formulate management objectives and direct land use operations in the area.

Formulation of realistic management objectives for amphibians will require the results of all projected three years of data derived from this study. A single year's data set can only show crude patterns. This is especially true of the first year of a large-scale study requiring considerable time for set-up, training, and testing of techniques. Thus, the following conclusions and management recommendations are preliminary and should be accepted with caution.

The following conclusions can be drawn from the first year results for MCB Camp Lejeune:

1. The mosaic of mixed hardwood and pine forest and the associated ephemeral wetlands (limesinks) characteristic of the study area on MCB Camp Lejeune supports a rich diversity of amphibians.

2. A combination of monitoring and capture techniques is required to encounter the entire amphibian fauna. No one technique is useful to monitor all life history stages of all species.

3. The nighttime frog call survey is the best technique to assess the presence or absence of a frog species at a particular site.

4. Determination of whether a particular site is used for reproduction requires the use of both the dip net and minnow trap techniques.

5. The amphibian fauna at MCB Camp Lejeune is dynamic and species are active on different seasonal cycles. Monitoring of all species requires multiple techniques used over the entire season, including winter, to obtain information on all species present.

PRELIMINARY MANAGEMENT RECOMMENDATIONS

1. If the primary management goal for amphibians is to maintain the current level of species richness, then a mosaic of habitats is required. This is because some species do better in full canopy forests and some do better in more open habitats (e.g., Werner and Glennemeier, 1999). Determination of which species does best in each type will require the results from the second and third years of the study and an evaluation of the quantitative results from the capture techniques used in each habitat type.

2. The amphibian fauna should be managed as communities and not as one species over another. Although some species appear to be rarely encountered (at least for the first year), they should not yet be considered rare and specifically managed to enhance their population. Single species management may not be the best approach with the amphibian fauna in this area. However, management of listed species, such as the gopher frog (*Rana capito*), a species we have yet to encounter, should be undertaken with the entire amphibian fauna in mind. Management of habitat for this one species should not be done in ways that negatively affect other species.

3. Monitoring of the amphibian fauna is likely to reveal habitat distribution and population dynamic patterns that will be useful to resource managers. Because patterns change with habitat change and over time, monitoring of this fauna should be considered a long-term effort. The projected three-year baseline data set obtained in this study will provide the basis for evaluation of changes in the future. Funding should be targeted for continuation of monitoring programs after the Legacy Resource Management Program support has ended.

4. The introduction of non-native and invasive species of plants and animals should be resisted. This could include North American "native" species that could be harmful to amphibians.

5. Captive-raised or maintained amphibians should not be allowed to be released in this area. The potential for disease introduction is growing and every effort should be made to avoid contamination from exotics or native species from other areas. Maintenance in captivity influences development of disease and former captives should never be released in the wild.

6. It would be advisable to review existing management plans that affect the habitat and hydrology of the area with management of amphibians in mind. Such reviews may reveal conflicts that could be avoided if detected before problem arise.

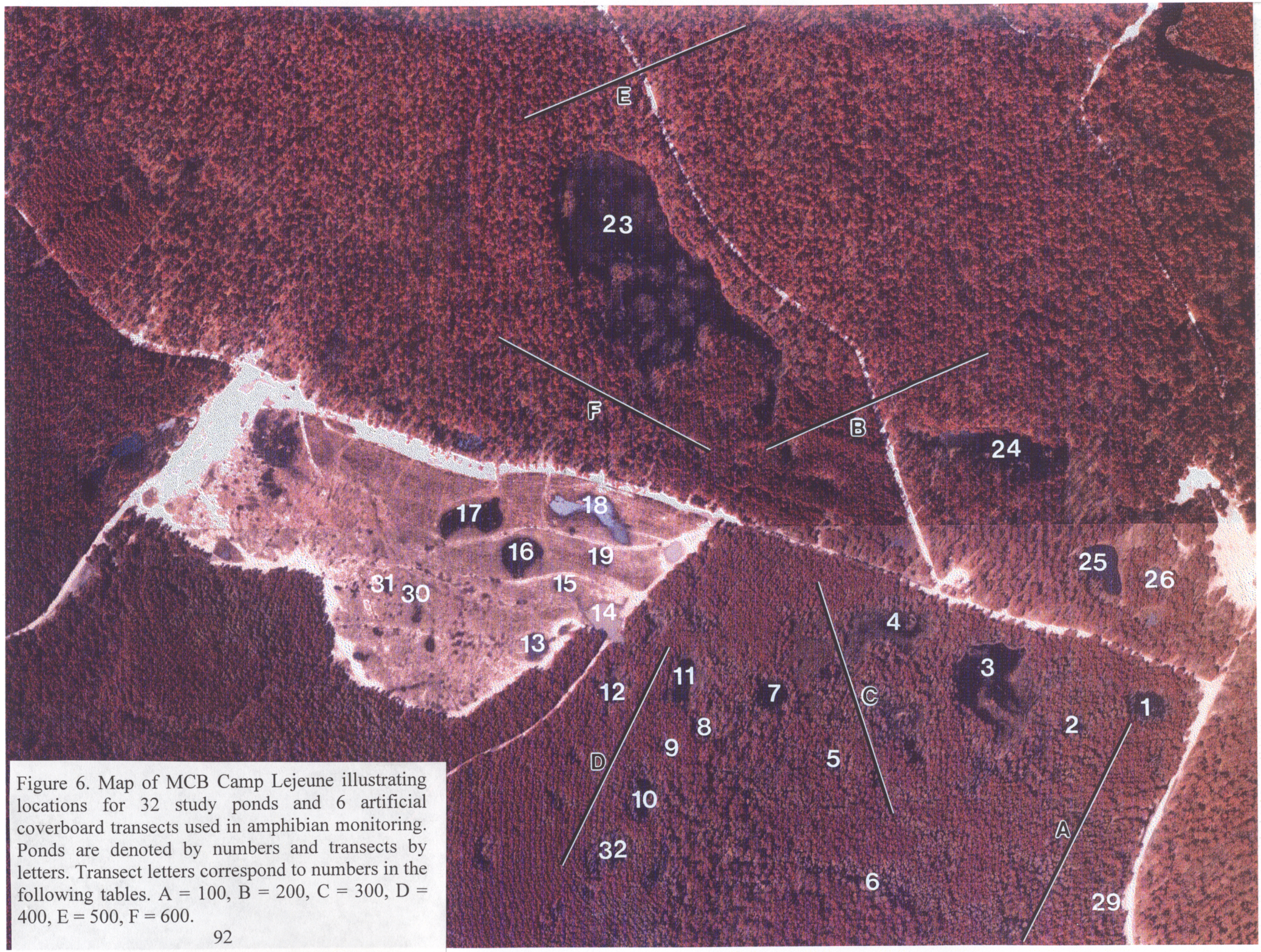

Figure 6. Map of MCB Camp Lejeune illustrating locations for 32 study ponds and 6 artificial coverboard transects used in amphibian monitoring. Ponds are denoted by numbers and transects by letters. Transect letters correspond to numbers in the following tables. A = 100, B = 200, C = 300, D = 400, E = 500, F = 600.

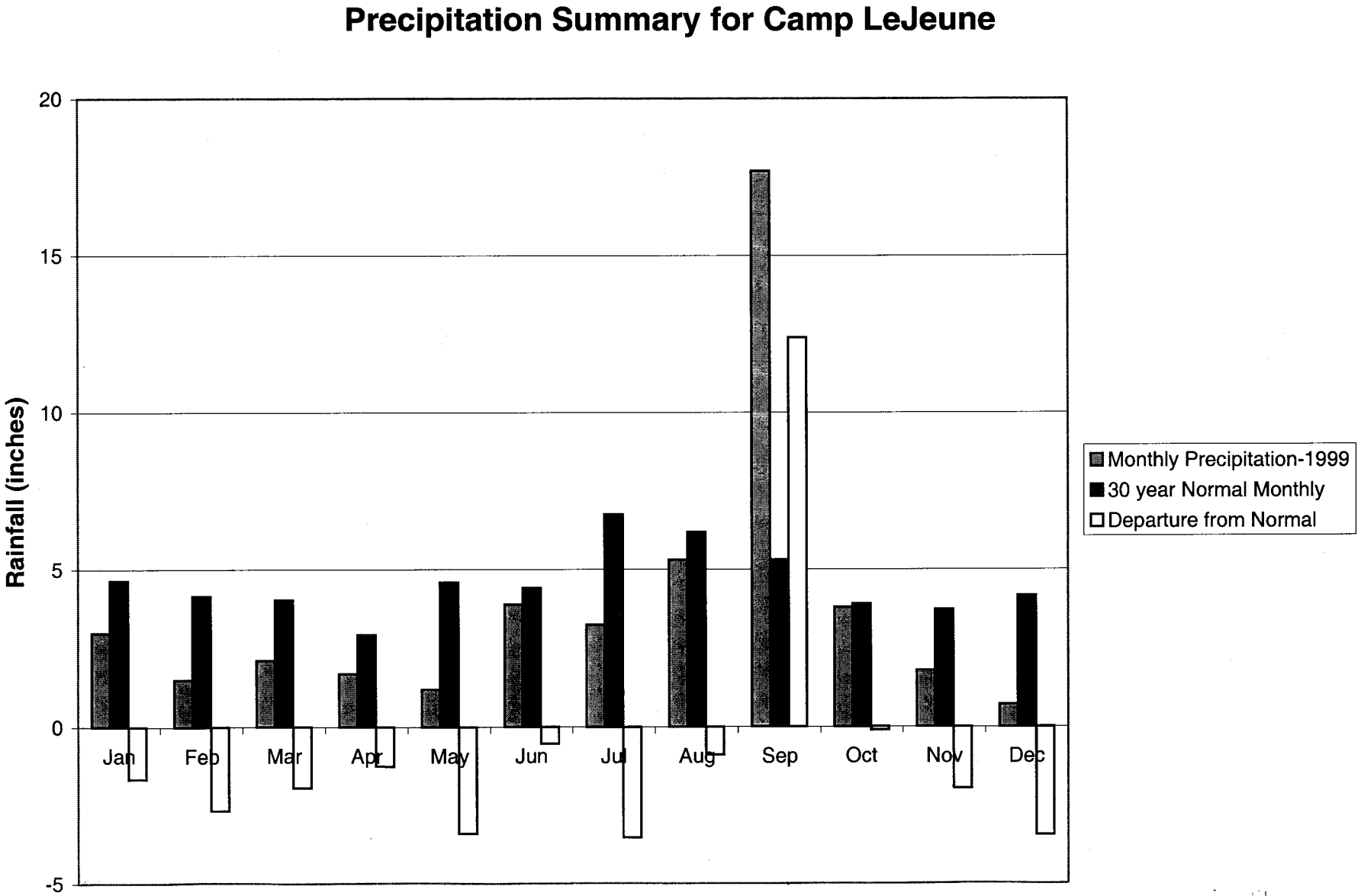

Figure 7. Monthly precipitation totals for MCB Camp Lejeune and vicinity for 1999 and the average monthly totals for the previous 30 years. Monthly departure from normal in 1999 is the difference between actual precipitation and the 30 year average. Data from Jacksonville, NC.

Table 42. Frequencies of vegetation and other habitat variables in six transects on MCB Camp Lejeune, North Carolina. Numbers are frequency of occurrences along transects (n = 30 points each).

	SITE NUMBER						
Attributes/species	1	2	3	4	5	6	Mean Freq
Deciduous seedlings	0.33	0.33	0.70	0.67	0.13	0.23	0.40
Evergreen seedlings	0.10	0.07	0.00	0.03	0.07	0.00	0.05
Both seedlings	0.43	0.47	0.20	0.10	0.77	0.77	0.46
Grass	0.97	0.93	0.87	0.57	0.93	0.97	0.87
Canopy Closure (mean)	*60*	*23*	*29*	*54*	*22*	*24*	*35*
Subcanopy	0.40	0.07	0.07	0.57	0.03	0.20	0.22
Water	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ferns and Allies							
Thelypteris novaboracensis	0.07	0.00	0.07	0.13	0.00	0.00	0.05
Woodwardia areolata	0.00	0.00	0.03	0.07	0.13	0.03	0.04
Woodwardia virginica	0.03	0.00	0.07	0.10	0.00	0.00	0.03
Osmunda cinnamomea	0.03	0.00	0.10	0.07	0.17	0.17	0.09
Osmunda regalis	0.03	0.10	0.07	0.10	0.03	0.00	0.06
Pteridium aquilinum	0.10	0.10	0.17	0.07	0.13	0.07	0.11
Lycopodium inundatum	0.00	0.00	0.03	0.00	0.00	0.03	0.01
Sphagnum spp.	0.00	0.00	0.00	0.03	0.00	0.00	0.01
Graminoids							
Arundinaria gigantea	0.07	0.00	0.00	0.00	0.33	0.00	0.07
Forbs							
Asclepias incarnata	0.00	0.03	0.03	0.00	0.00	0.07	0.02
Caltha palustris	0.07	0.00	0.03	0.00	0.00	0.13	0.04
Cassia nictitans	0.07	0.00	0.00	0.00	0.00	0.00	0.01
Desmodium spp.	0.07	0.00	0.00	0.00	0.00	0.00	0.01
Elephantopus spp.	0.00	0.00	0.00	0.00	0.00	0.03	0.01
Eupatorium album	0.00	0.03	0.00	0.00	0.00	0.00	0.01

Table 42 continued

Eupatorium capillifolium	0.10	0.13	0.00	0.03	0.20	0.40	0.14
Eupatorium rotundifolium	0.27	0.27	0.10	0.07	0.07	0.33	0.19
Fragaria virginiana	0.03	0.00	0.00	0.00	0.00	0.00	0.01
Lespedeza virginica	0.03	0.03	0.00	0.00	0.00	0.00	0.01
Lobelia nuttallii	0.03	0.07	0.13	0.03	0.00	0.07	0.06
Mitchella repens	0.07	0.00	0.00	0.17	0.27	0.10	0.10
Polygala lutea	0.00	0.00	0.10	0.07	0.07	0.00	0.04
No identification (specimen spoiled)	0.00	0.07	0.00	0.00	0.00	0.00	0.01
Viola pp.	0.00	0.03	0.00	0.00	0.00	0.00	0.01
Vines							
Campsis radicans	0.03	0.00	0.00	0.00	0.00	0.00	0.01
Gelsemium sempervirens	0.13	0.13	0.10	0.30	0.17	0.00	0.14
Lonicera japonica	0.17	0.00	0.00	0.00	0.00	0.00	0.03
Parthenocissus quinquefolia	0.00	0.00	0.00	0.00	0.00	0.07	0.01
Rhus radicans	0.03	0.00	0.00	0.00	0.03	0.13	0.03
Smilax bona-nox	0.00	0.37	0.33	0.10	0.00	0.13	0.16
Smilax rotundifolia	0.57	0.17	0.27	0.20	0.23	0.23	0.28
Vicia spp.	0.03	0.00	0.00	0.00	0.00	0.00	0.01
Vitis spp.	0.10	0.13	0.00	0.00	0.00	0.17	0.07
No identification (specimen spoiled)	0.00	0.03	0.00	0.00	0.00	0.00	0.01
Shrubs							
Amelanchier spp.	0.07	0.00	0.03	0.00	0.00	0.00	0.02
Clethra alnifolia	0.30	0.00	0.00	0.00	0.10	0.00	0.07
Hypericum spp.	0.03	0.10	0.00	0.17	0.07	0.07	0.07
Myrica cerifera	0.20	0.33	0.23	0.17	0.23	0.23	0.23
Rubus spp.	0.30	0.17	0.10	0.10	0.43	0.53	0.27
Vaccinium spp.	0.47	0.50	0.90	0.57	0.23	0.13	0.47
No identification (specimen spoiled)	0.00	0.07	0.00	0.40	0.17	0.10	0.12

Table 42 continued

Fern frequency	0.20	0.20	0.47	0.53	0.30	0.23	0.32
Forb frequency	0.53	0.47	0.33	0.37	0.53	0.77	0.50
Vine frequency	0.80	0.67	0.60	0.57	0.40	0.57	0.60
Shrub frequency	0.80	0.77	0.93	0.80	0.83	0.80	0.82

Table. 43. Frequency of overstory and understory trees along six terrestrial transects on MCB Camp Lejeune, North Carolina.

	OVERSTORY							UNDERSTORY						
Trees	**1**	**2**	**3**	**4**	**5**	**6**	**Mean**	**1**	**2**	**3**	**4**	**5**	**6**	**Mean**
Acer rubrum	0.08	0.02	0.02	0.00	0.00	0.00	0.02	0.07	0.01	0.08	0.01	0.00	0.00	0.03
Cornus florida	0.02	0.11	0.00	0.01	0.11	0.04	0.05	0.00	0.02	0.00	0.00	0.02	0.00	0.01
Diospyros virginiana	-	-	-	-	-	-	n/a	0.02	0.02	0.00	0.00	0.00	0.00	0.01
Ilex opaca	0.00	0.01	0.00	0.01	0.08	0.06	0.03	0.00	0.00	0.00	0.00	0.02	0.00	<0.01
Liquidambar styraciflua	0.05	0.17	0.05	0.06	0.36	0.36	0.18	0.48	0.62	0.40	0.37	0.50	0.83	0.53
Liriodendron tulipifera	0.00	0.00	0.00	0.00	0.03	0.00	0.01	-	-	-	-	-	-	n/a
Nyssa aquatica	-	-	-	-	-	-	n/a	0.02	0.00	0.00	0.00	0.00	0.00	<0.01
Nyssa sylvatica	0.01	0.06	0.06	0.14	0.07	0.03	0.06	0.01	0.00	0.00	0.03	0.00	0.00	0.01
Oxydendrum arboreum	0.01	0.00	0.00	0.00	0.00	0.00	<0.01	-	-	-	-	-	-	n/a
Persea borbonia	0.00	0.03	0.01	0.08	0.03	0.01	0.03	0.28	0.28	0.41	0.49	0.44	0.17	0.35
Pinus taeda	0.83	0.48	0.86	0.70	0.30	0.49	0.61	0.10	0.04	0.10	0.09	0.01	0.01	0.06
Quercus alba	0.00	0.02	0.00	0.00	0.00	0.01	0.01	-	-	-	-	-	-	n/a
Quercus falcata	0.00	0.06	0.00	0.01	0.00	0.00	0.01	-	-	-	-	-	-	n/a
Quercus marilandica	0.00	0.00	0.00	0.00	0.01	0.00	<0.01	0.01	0.01	0.00	0.00	0.00	0.00	<0.01
Quercus nigra	0.01	0.00	0.00	0.00	0.00	0.00	<0.01	0.02	0.00	0.00	0.00	0.01	0.00	0.01
Quercus stellata	0.00	0.00	0.00	0.00	0.01	0.00	<0.01	0.00	0.00	0.00	0.00	0.01	0.00	<0.01
Quercus velutina	0.00	0.04	0.00	0.00	0.00	0.00	0.01	-	-	-	-	-	-	n/a
Rhus copallina	-	-	-	-	-	-	n/a	0.01	0.02	0.00	0.00	0.00	0.00	0.01
Salix nigra	0.01	0.00	0.00	0.00	0.00	0.00	<0.01	-	-	-	-	-	-	n/a
Sassafras albidum	0.00	0.01	0.00	0.00	0.00	0.00	<0.01	-	-	-	-	-	-	n/a

Table 44. List of amphibian species encountered on MCB Camp Lejeune, NC, in 1999.

Anura (frogs and toads)

Bufonidae	
Bufo terrestris	Southern Toad
Hylidae	
Acris gryllus gryllus	Southern Cricket Frog
Hyla chrysoscelis	Cope's Gray Treefrog
Hyla cinerea	Green Treefrog
Hyla femoralis	Pine Woods Treefrog
Hyla gratiosa	Barking Treefrog
Hyla squirella	Squirrel Treefrog
Pseudacris crucifer crucifer	Northern Spring Peeper
Pseudacris nigrita nigrita	Southern Chorus Frog
Pseudacris ocularis	Little Grass Frog
Pseudacris ornata	Ornate Chorus Frog
Microhylidae	
Gastrophryne carolinensis	Eastern Narrow-mouthed Toad
Pelobatidae	
Scaphiopus holbrookii	Eastern Spadefoot
Ranidae	
Rana catesbeiana	American Bullfrog
Rana clamitans melanota	Northern Green Frog
Rana sphenocephala utricularia	Southern Leopard Frog

Caudata (salamanders)

Amphiumidae	
Amphiuma means	Two-toed Amphiuma
Plethodontidae	
Plethodon chlorobryonis	Atlantic Coast Slimy Salamander
Salamandridae	
Notophthalmus viridescens dorsalis	Broken-striped Newt

Table 45. Number of amphibians captured at MCB Camp Lejeune, NC, in 1999 by life history stage.

	SEX/LIFE HISTORY STAGE				
	Male	Female	Juvenile	Larvae	Total
Frogs					
Acris gryllus	55	9	2	41	107
Bufo terrestris	1	1	2	701	705
Gastrophryne carolinensis	12	5			17
Hyla chrysoscelis	7	2			9
Hyla cinerea	34	8	1		43
Hyla femoralis	8	2	1		11
Hyla gratiosa	66	6	2	160	234
Hyla squirella	38	13			51
Pseudacris crucifer		1			1
Pseudacris ocularis	9	3			12
Pseudacris ornata	1				1
Rana catesbeiana	8	6	83	462	559
Rana clamitans				3	3
Rana sphenocephala	10	14	9	226	259
Scaphiopus holbrookii	1				1
Salamanders					
Notophthalmus viridescens	10	12		40	62
Plethodon chlorobryonis	1				1
Total	262	82	100	1633	2077

Table 46. Species occurrence by sampling technique at Camp LeJeune in 1999.

	SAMPLING TECHNIQUE					
	Artificial Cover Transects	PVC Pipe Transects	Visual Encounter Surveys	Minnow Trapping	Dip Nets	Frog Call Surveys
ANURA (frogs and toads)						
A. crepitans			X			
A. gryllus		X	X	X	X	
B. terrestris	X				X	X
G. carolinensis	X		X			X
H. chrysoscelis		X				X
H. cinerea	X	X				X
H. femoralis	X	X	X		X	X
H. gratiosa		X	X	X	X	X
H. squirella		X	X			X
P. crucifer crucifer	X					X
P. ocularis			X			X
P. ornata						X
R. catesbeiana			X	X	X	X
R. clamitans			X	X	X	X
R. spenocephala			X	X	X	X
S. holbrookii			X			
CAUDATA (salamanders)						
N. viridescens			X	X	X	
P. chlorobryonis	X					

Table 47. Number of amphibians captured in coverboard transects at Camp LeJeune in 1999.

	TRANSECT NUMBER						
	100	200	300	400	500	600	Total
Frogs							
B. terrestris	1	1					2
G. carolinensis	1	1					2
H. cinerea					1	1	2
H. femoralis	1						1
H. gratiosa		1					1
H. squirella	1				2		3
P. crucifer					1		1
Total (6 samplings)	4	3	0	0	4	1	12
Salamanders							
P. chlorobryonis		1					1

Table 48. Number of amphibians captured in PVC pipe transects at Camp LeJeune in 1999.

	TRANSECT NUMBER						
	100	200	300	400	500	600	Total
ANURA (frogs and toads)							
H. chrysoscelis	2	1	4			2	9
H. cinerea	3	5	5	7	4	21	45
H. femoralis	4						4
H. gratiosa						1	1
H. squirella	1	5	2	12	2	9	31
Total (6 samplings)	10	11	11	19	6	33	90

Table 49. Number of amphibians captured by visual encounter surveys at Camp Lejeune in 1999.

	SITE NUMBER														
	1	4	7	8	9	10	11	12	14	18	19	21	23	29	Total
Frogs															
A. gryllus	8	1						3					46		58
B. terrestris	1														1
G. carolinensis	10							7							17
H. femoralis				1				1					4		6
H. gratiosa													59		59
H. squirella	23					1									24
P. ocularis			3					9							12
R. catesbeiana	2	1			1	2	1	1	1	1	1		41		52
R. sphenocephala										1		1	23		25
S. holbrookii														1	1
Total	44	2	3	1	1	3	1	21	1	2	1	1	173	1	255

Table 50. Number of amphibians captured in minnow traps at Camp Lejeune in 1999. Abbreviations: Agr = *Acris gryllus*, Hgr = *Hyla gratiosa*, Rca = *Rana catesbeiana*, Rcl = *Rana clamitans*, Rsp = *Rana sphenocephala*, Nvi = *Notophthalmus viridescens*.

	SITE NUMBER																	
	1	3	4	7	8	9	10	11	12	14	15	16	17	18	19	23	24	29
trap day	15	5	6	21	3	13	10	15	7	12	6	14	16	51	7	432	10	13
Frogs																		
Agr																5		
Hgr																75		
Rca	1	1	36	1		3	4	5	8	3	7	30	24	283	4	41		1
Rcl															1			
Rsp	1		10		3						1					116		12
Total	2	1	46	1	3	3	4	5	8	3	8	30	24	283	4	238		13
Salamanders																		
Nvi	4				1											18	1	

Table 51. Number of amphibians captured by dipnet at Camp Lejeune in 1999.

	SITE NUMBER												
	1	7	8	10	14	15	16	17	18	23	24	29	Total
Number of sweeps at site:	15	11	3	10	30	15	11	12	23	150	9	10	199
Frogs													
Acris gryllus										41			41
Bufo terrestris	525			1	32			143					701
Hyla gratiosa										83			83
Pseudacris crucifer			1										1
Rana catesbeiana	20					15	1	1	21	1			59
Rana sphenocephala		2	50		1	32		1		4	1	1	92
Total	545	2	51	1	33	47	1	145	21	129	1	1	977
Salamanders													
Notophthalmus viridescens										28			28

Table 52. Amphibian species in each of eight frog call monitoring sites on Camp Lejeune, NC, identified by vocalizations (V) and larvae (L). Abbreviations for each species in parentheses are for the following tables.

Species	Sites 1	3	12	18	19	23	24	29
Frogs:								
Acris gryllus (Agr)	VL	V	VL	V	V	VL	V	V
Bufo terrestris (Bte)	VL	V				V	V	
Hyla cinerea (Hci)			V	V		V		
Hyla chrysoscelis (Hch)		V						
Hyla femoralis (Hfe)	V	V	VL	V	V	V	VL	V
Hyla gratiosa (Hgr)			V		V	VL	V	
Hyla squirella (Hsq)	VL	V	V	V		V	V	
Gastrop. carolinensis (Gca)	VL		VL	V			V	V
Pseudacris crucifer (Pcr)						V	V	
Pseudacris ocularis (Poc)		V	V					V
Rana catesbeiana (Rca)	L		VL	VL	VL	VL	VL	V
Rana clamitans (Rcl)		V	L			VL	V	
Rana sphenocephala (Rsp)	VL	V	VL	VL		VL	VL	VL

Table 53. Seasonal variation in timing of male frog vocalizations and presence of larvae (tadpoles) in Site 1 on MCB Camp Lejeune, North Carolina in 1999. Abbreviations as in Table 52.

Week of:	Agr	Bte	Hci	Hch	Hfe	Hgr	Hsq	Gca	Pcr	Por	Poc	Rca	Rcl	Rsp	Shol
1999															
23Apr99												L			
2May99	V						V					L		V	
9May99	V				V		V	V				L		V	
16May99	V	V					V	V				L		V	
23May99	V	L			V		V					L		V	
6Jun99	V				V		V					L		V	
20Jun99	V				V		V								
27Jun99															
4Jul99															
17Jul99															
25Jul99															
8Aug99															
30Oct99														L	

Table 54. Seasonal variation in timing of male frog vocalizations and presence of larvae (tadpoles) in Site 3 on MCB Camp Lejeune, North Carolina in 1999. Abbreviations as in Table 52.

Week of:	Agr	Bte	Hci	Hch	Hfe	Hgr	Hsq	Gca	Pcr	Por	Poc	Rca	Rcl	Rsp	Shol
1999															
23Apr99	V									V			V		
2May99	V				V		V				V				
9May99	V			V	V		V				V		V		
16May99	V				V		V						V		
23May99	V	V			V						V		V		
6Jun99	VL											L		V	
20Jun99	L											L			
27Jun99	L											L			
4Jul99	L				L							L			
17Jul99															
25Jul99	V						V							V	
8Aug99															

Table 55. Seasonal variation in timing of male frog vocalizations and presence of larvae (tadpoles) in Site 12 on MCB Camp Lejeune, North Carolina in 1999. Abbreviations as in Table 52.

Week of:	Agr	Bte	Hci	Hch	Hfe	Hgr	Hsq	Gca	Pcr	Por	Poc	Rca	Rcl	Rsp	Shol
1999															
23Apr99															
2May99	V						V				V			V	
9May99	V						V	V			V			V	
16May99	V				V		V				V	L		VL	
23May99	VL				V	V	V	L			L	VL	L	V	
6Jun99	VL		V				V	L			L	L		V	
20Jun99	VL							VL			L	L			
27Jun99	L							L			L	L			
4Jul99	L							L			L	L			
17Jul99						V		VL		V	L	L			
25Jul99															
8Aug99	L				L			L			L	L			

Table 56. Seasonal variation in timing of male frog vocalizations and presence of larvae (tadpoles) in Site 18 on MCB Camp Lejeune, North Carolina in 1999. Abbreviations as in Table 52.

Week of:	Agr	Bte	Hci	Hch	Hfe	Hgr	Hsq	Gca	Pcr	Por	Poc	Rca	Rcl	Rsp	Shol
1999															
23Apr99															
2May99	V		V				V					VL		V	
9May99	V		V				V					VL		V	
16May99	V											VL		V	
23May99			V									VL			
6Jun99	V		V				V					VL		V	
20Jun99	V											VL		V	
27Jun99	V											VL		V	
4Jul99	V				V			V				L		V	
17Jul99												VL			
25Jul99															
8Aug99															
30Oct99												L			

Table 57. Seasonal variation in timing of male frog vocalizations and presence of larvae (tadpoles) in Site 19 on MCB Camp Lejeune, North Carolina in 1999. Abbreviations as in Table 52.

Week of:	Agr	Bte	Hci	Hch	Hfe	Hgr	Hsq	Gca	Pcr	Por	Poc	Rca	Rcl	Rsp	Shol
1999															
23Apr99															
2May99															
9May99															
16May99															
23May99												L			
6Jun99												L			
20Jun99															
27Jun99	V				V	V									
4Jul99	V				V	V						V			
17Jul99															
25Jul99	V				V	V									
8Aug99															

Table 58. Seasonal variation in timing of male frog vocalizations and presence of larvae (tadpoles) in Site 23 on MCB Camp Lejeune, North Carolina in 1999. Abbreviations as in Table 52.

Week of:	Agr	Bte	Hci	Hch	Hfe	Hgr	Hsq	Gca	Pcr	Por	Poc	Rca	Rcl	Rsp	Shol
1999															
23Apr99	V	V				V	V						V	V	
2May99	VL				VL	VL			V			L		L	
9May99	VL				V	VL			V			L		VL	
16May99	VL				V	VL			V			L		VL	
23May99	VL		V			VL						L		VL	
6Jun99	VL				V	VL			V			L		VL	
20Jun99	VL		V			VL						L	V	VL	
27Jun99	VL					VL						L		VL	
4Jul99	VL		V			VL	V					VL		VL	
17Jul99	V					VL						L		VL	
25Jul99	V				V	V						L		VL	
8Aug99															
30Oct99												L	L	L	

Table 59. Seasonal variation in timing of male frog vocalizations and presence of larvae (tadpoles) in Site 24 on MCB Camp Lejeune, North Carolina in 1999. Abbreviations as in Table 52.

Week of:	Agr	Bte	Hci	Hch	Hfe	Hgr	Hsq	Gca	Pcr	Por	Poc	Rca	Rcl	Rsp	Shol
1999															
23Apr99	V					V	V							V	
2May99	V					V			V		V	L		L	
9May99	V					V					V	L		V	
16May99	V	V			V	V			V			L			
23May99	V				V	V			V		V	L	V		
6Jun99	V					V		V	V			VL			
20Jun99	V					V						L			
27Jun99	V					V	V					VL		V	
4Jul99	V					V	V				V	L		VL	
17Jul99	V					V						VL		V	
25Jul99	V	V			V	V						L		V	
8Aug99															

Table 60. Seasonal variation in timing of male frog vocalizations and presence of larvae (tadpoles) in Site 29 on MCB Camp Lejeune, North Carolina in 1999. Abbreviations as in Table 52.

Week of:	Agr	Bte	Hci	Hch	Hfe	Hgr	Hsq	Gca	Pcr	Por	Poc	Rca	Rcl	Rsp	Shol
1999															
23Apr99															
2May99					V						V	V		VL	
9May99	V				V			V				V		VL	
16May99	V				V						V	V		VL	
23May99														L	
6Jun99															
20Jun99															
27Jun99															
4Jul99															
17Jul99															
25Jul99															
8Aug99															

ACKNOWLEDGMENTS

I thank the following resource managers at their respective installations for their help in making this project possible: Scott Smith and Robert Montgomery (Dare County Bombing Range), Bill Rogers (Cherry Point MCAS), and Carmen Lombardo, John Hammond, and John Townsend (MCB Camp Lejeune). Range Control on Camp Lejeune and the game wardens on Cherry Point also contributed to this project by providing access to study areas. Rusty Gaul, my primary field manager, and Jeff Hall and Archie Sturgill, my other field crew leaders, have helped in innumerable ways to make sure this project was completed. This includes production of most of the tables and all of the figures in this report. Field technicians that helped in various ways were S. Bellows, B. Buck, P. Foltz, T. Georgel, J. Harris, S. Johnson, C. Saunders, M. Scibetta, D. Schwidde, R. Symula, C. Wigent, D. Woods, and A. Young. A. S. Bellows spearheaded the vegetation transect data collection and conducted the data analysis. A. Braswell and S. Busack provided the collecting permit and specimen tags from the North Carolina Museum of Natural Sciences. I am indebted to the DoD Legacy Resource Management Program for inviting me to submit the proposal to work in North Carolina and for funding this project.

LITERATURE CITED

Canfield, R.H. 1941. Application of the line interception method in sampling range variation. Journal of Wildlife Management 39:388-394.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Fish & Wildlife Service, Pub. FWS/OBS-79-31. Washington, DC.

Dodd, C.K., Jr. 1996. Use of temporary habitats by amphibians in the sandhill uplands of north-central Florida. Alytes 14:42-52.

Dodd, C.K., Jr. and L.V. LeClarie. 1995. Biogeography and status of the striped newt (*Notophthalmus perstriatus*) in Georgia, USA. Herpetological Natural History 3:37-46.

Hecnar, S.J. and R. T. M'Closkey. 1996. Regional dynamics and the status of amphibians. Ecology 77:2091-2097.

Heyer, W.R., M.A. Donnelly, R.W. McDiarmid, L.C. Hayek, and M.S. Foster. 1994. Measuring and Monitoring Biological Diversity Standard Methods for Amphibians. Smithsonian Institution Press, Washington, DC. 364 pp.

LeBlond, R.J., J.O. Fussell, and A.L. Braswell. 1994. Inventory of the rare species, natural communities, and critical areas of the Camp Lejeune Marine Corps base, North Carolina. Report to the North Carolina Natural Heritage Program, Raleigh, NC.

McDiarmid, R.W., and J.C. Mitchell. In press. Distribution and diversity of amphibians and reptiles. In D. Sparling. C. Bishop, and Linder (eds.), Ecotoxicology of Amphibians and Reptiles, SEATAC Press.

Mitchell, J.C. 1998. Amphibian decline in the mid-Atlantic region: Monitoring and management of a sensitive resource. Final Report. Legacy Resource Management Program. US Department of Defense. 144 pp.

Mitchell, J.C. 1998. Vernal pools: a keystone resource for amphibians on Fort A.P. Hill. Interim Report for 1997. Unpublished report submitted to the US Army, Fort A.P. Hill, Bowling Green, VA. 14 pp. + 2 appendices.

Moler, P.E. 1985. A new species of frog (Ranidae: *Rana*) from northwestern Florida. Copeia 1985:379-383.

Moorhead, K.K. 1999. Contiguity and edge characteristics of wetlands in five coastal counties of North Carolina, USA. Wetlands 19:276-282.

Pauley, T.K., J.C. Mitchell, R.R. Buech, and J.J. Moriarty. 2000. Ecology and management of riparian habitats for amphibians and reptiles. Pp. 169-192 In E.S. Verry, J.W. Hornbeck, and C.A. Dolloff (eds.), Riparian Management in Forests of the Continental Eastern United States. Lewis Publishers, Boca Raton, FL.

Pechmann, J.H.K., D.E. Scott, J.W. Gibbons, and R.D. Semlitsch. 1989. Influence of wetland hydroperiod on diversity and abundance of metamorphosing juvenile amphibians. Wetlands Ecology and Management 1:3-11.

Peterson, C.R., and M.E. Dorcas. 1994. Automatic data acquisition. Pp. 47-57 In W.R. Heyer et al. (eds). Measuring and Monitoring Biological Diversity Standard Methods for Amphibians. Smithsonian Institution Press, Washington, DC. 364 pp.

Rowe, C.L. and W.A. Dunson. 1995. Impacts of hydroperiod on growth and survival of larval amphibians in temporary ponds of central Pennsylvania. USA. Oecologia 102:397-403.

Semlitsch, R.D. 1998. Biological delineation of terrestrial buffer zones for pond-breeding salamanders. Conservation Biology 12:1113-1119.

Semlitsch, R.D. in press. Principles for management of aquatic-breeding amphibians. Journal of Wildlife Management.

Semlitsch, R.D., D.E. Scott, J.H.K. Pechmann, and J.W. Gibbons. 1996. Structure and dynamics of an amphibian community, Evidence from a 16-year study of a natural pond. Pp. 217-248 In M.L. Cody and J.A. Smallwood (eds.), Long-term Studies of Vertebrate Communities. Academic Press, San Diego, CA.

Sharitz, R.R., and C.A. Gresham. 1998. Pocosins and Carolina Bays. Pp. 343-389 In M.G. Messina and W.H. Conner (eds.), Southern Forested Wetlands, Ecology and Management. Lewis Publishers, Boca Raton, FL.

Weakley, A.S., and M.P. Schafale. 1991. Classification of pocosins of the Carolina Coastal Plain. Wetlands 11:355-375.

Werner, E.E., and K.S. Glennemeier, 1999. Influence of forest canopy cover on the breeding pond distributions of several amphibian species. Copeia 1999:1-12.

Williamson, G.K. and R.A. Moulis. 1979. Survey of reptiles and amphibians on Fort Stewart and Hunter Army Airfield. Unpublished report submitted to the US Army, Fort Stewart, GA. 343 pp.

APPENDICES

Appendix 1 – Scientific and common names of plants found on Dare County Bombing Range, Cherry Point MCAS, and MCB Camp Lejeune.

Appendix 2 – Example field data sheets.

Appendix 1. List of scientific and common names for all plants observed on terrestrial transects on Dare County Bombing Range, Cherry Point MCAS, and MCB Camp Lejeune in 1999.

DARE COUNTY BOMBING RANGE

Ferns and Allies	
Thelypteris palustris	marsh fern
Woodwardia areolata	netted chain fern
Woodwardia virginica	Virginia chain fern
Osmunda regalis	royal fern
Sphagnum spp.	Sphagnum moss
Graminoids	
Arundinaria gigantea	switch cane
Forbs	
Asarum canadense	wild ginger
Mitchella repens	partridgeberry
Vines	
Gelsemium sempervirens	yellow jessamine
Parthenocissus quinquefolia	Virginia creeper
Rhus radicans	poison ivy
Smilax laurifolia	bullbrier greenbrier
Smilax rotundifolia	common greenbrier
Vitis spp.	grape spp.
Shrubs	
Amelanchier spp.	shadbush
Clethra alnifolia	coast pepperbush
Rubus hispidus	swamp dewberry
Rubus spp.	bramble spp.
Vaccinium spp.	blueberry spp.
Trees	
Acer rubrum	red maple
Chamaecyparis tyoides	Atlantic white cedar
Gordonia lasianthus	loblolly bay
Ilex opaca	American holly
Juniper virginiana	red cedar

Liquidambar styraciflua	sweetgum
Magnolia virginiana	sweetbay
Nyssa aquatica	water tupelo
Nyssa sylvatica	black tupelo
Oxydendrum arboreum	sourwood
Persea borbonia	redbay
Pinus taeda	loblolly pine
Quercus falcata	southern red oak
Quercus nigra	water oak
Quercus phellos	willow oak
Rhus copallina	winged sumac
Taxodium distichum	baldcypress

CHERRY POINT MCAS

Ferns and Allies	
Botrychium dissectum	cut-leaved grape fern
Thelypteris palustris	marsh fern
Woodwardia areolata	netted chain fern
Woodwardia virginica	Virginia chain fern
Osmunda cinnamomea	cinnamon fern
Osmunda regalis	royal fern
Pteridium aquilinum	bracken
Lycopodium inundatum	bog clubmoss
Sphagnum spp.	Sphagnum moss
Graminoids	
Arundinaria gigantea	switch cane
Forbs	
Asarum canadense	wild ginger
Caltha palustris	cowslip
Cassia nictitans	wild sensitive plant
Desmodium rotundifolium	prostrate tick trefoil
Desmodium spp.	trefoil spp.
Eupatorium album	white boneset
Eupatorium capillifolium	dogfennel
Eupatorium pilosum	rough boneset
Eupatorium rotundifolium	round-leaved boneset

Lespedeza procumbens	trailing bush clover
Mitchella repens	partridgeberry
Polygala lutea	yellow milkwort
Polygonatum biflorum	smooth Solomon's seal
Potentilla simplex	common cinquefoil
Vinca minor	periwinkle
Viola spp.	?
No identification (specimen spoiled)	?
Sabatia spp.	?
Eupatorium spp.	?

Vines

Amphicarpa bracteata	hog peanut
Apios americana	groundnut
Bignonia capreolata	cross vine
Campsis radicans	trumpet creeper
Gelsemium sempervirens	yellow jessamine
Parthenocissus quinquefolia	Virginia creeper
Rhus radicans	poison ivy
Smilax bona-nox	bullbrier greenbrier
Smilax rotundifolia	common greenbrier
Vitis spp.	grape spp.

Shrubs

Amelanchier spp.	shadbush
Aralia spinosa	devil's walkingstick
Clethra alnifolia	coast pepperbush
Elaeagnus commutata	American silverberry
Gordonia lasianthus	loblolly bay
Hypericum spp.	St. Johnswort spp.
Myrica cerifera	common waxmyrtle
Rubus spp.	bramble spp.
Vaccinium spp.	blueberry spp.

Trees

Acer rubrum	red maple
Carya glabra	pignut hickory
Cornus florida	flowering dogwood
Diospyros virginiana	common persimmon
Fagus grandifolia	American beech

Gordonia lasianthus	loblolly bay
Liquidambar styraciflua	sweetgum
Liriodendron tulipifera	tulip-tree
Nyssa sylvatica	black tupelo
Oxydendrum arboreum	sourwood
Persea borbonia	redbay
Pinus taeda	loblolly pine
Pinus virginiana	Virginia (scrub) pine
Quercus alba	white oak
Quercus falcata	southern red oak
Quercus marilandica	blackjack oak
Quercus nigra	water oak
Quercus phellos	willow oak
Quercus rubra	northern red oak
Quercus stellata	post oak
Rhus copallina	winged sumac

MCB CAMP LEJEUNE

Ferns and Allies	
Thelypteris novaboracensis	New York fern
Woodwardia areolata	netted chain fern
Woodwardia virginica	Virginia chain fern
Osmunda cinnamomea	cinnamon fern
Osmunda regalis	royal fern
Pteridium aquilinum	bracken
Lycopodium inundatum	bog clubmoss
Sphagnum spp.	Sphagnum moss
Graminoids	
Arundinaria gigantea	switch cane
Forbs	
Asclepias incarnata	swamp milkweed
Caltha palustris	cowslip
Cassia nictitans	wild sensitive plant
Desmodium spp.	trefoil spp.
Elephantopus spp.	
Eupatorium album	white boneset
Eupatorium capillifolium	dogfennel
Eupatorium rotundifolium	round-leaved boneset

rotundifolium	
Fragaria virginiana	wild strawberry
Lespedeza virginica	slender bush clover
Lobelia nuttallii	Nuttall's lobelia
Mitchella repens	partridgeberry
Polygala lutea	yellow milkwort
Sabatia campanulata	slender marsh pink
No identification (specimen spoiled)	?
Viola pp.	?
Vines	
Campsis radicans	trumpet creeper
Gelsemium sempervirens	yellow jessamine
Lonicera japonica	Japanese honeysuckle
Rhus radicans	poison ivy
Smilax bona-nox	bullbrier greenbrier
Smilax rotundifolia	common greenbrier
Vicia spp.	vetch spp.
Vitis spp.	grape spp.
No identification (specimen spoiled)	?
Shrubs	
Amelanchier spp.	shadbush
Clethra alnifolia	coast pepperbush
Hypericum spp.	St. Johnswort spp.
Myrica cerifera	common waxmyrtle
Rubus spp.	bramble spp.
Vaccinium spp.	blueberry spp.
No identification (specimen spoiled)	?
Trees	
Acer rubrum	red maple
Cornus florida	flowering dogwood
Diospyros virginiana	common persimmon
Ilex opaca	American holly
Liquidambar styraciflua	sweetgum
Liriodendron tulipifera	tulip-tree
Nyssa aquatica	water tupelo
Nyssa sylvatica	black tupelo
Oxydendrum arboreum	sourwood

Persea borbonia	redbay
Pinus taeda	loblolly pine
Quercus alba	white oak
Quercus falcata	southern red oak
Quercus marilandica	blackjack oak
Quercus nigra	water oak
Quercus stellata	post oak
Quercus velutina	black oak
Rhus copallina	winged sumac
Salix nigra	black willow
Sassafras albidum	sassafras

LEGACY HERP PROJECT - JOSEPH C. MITCHELL, PRINCIPLE INVESTIGATOR

TERRESTRIAL TRANSECT DATA SHEET

Collection No. _____ Date (d/mo/yr) _____ Location: Dare Cherry Pt Camp Lejeune (circle 1)

Start time _____ End time _____ Observers _____ Transect No _____ Toe clip no. ____

Habitat _____ Weather: (circle) clear cloudy pcloudy rain drizzle fog **Air Temp** _____

frogs *lizard/snake*

cover bd no	P/T	Species	sex	SVL	Tail Lth	Total Lth	Wt.	Eye dia	Tymp dia	HW	HL	Toe no.	Notes

Notes: behavior, abnormalities, coloration, gravid, # eggs palped, mental gland, recapture; **1 line per individual**
Sex: Male, Female, Juvenile, Metamorph; **Tail lgh**: original + regenerated; **EyeD**: frogs & snakes; **P/T**: pine/tin

Coverboards without herps (list numbers) _____ Pg ____ of ____

LEGACY HERP PROJECT - JOSEPH C. MITCHELL, PRINCIPLE INVESTIGATOR

PCV PIPE TRANSECT DATA SHEET

Collection No. _____ Date (d/mo/yr) _____ Location: Dare Cherry Pt Camp Lejeune (circle 1)

Start time _____ End time _____ Observers _____ Transect No _____ Toe clip no. ____

Habitat _____ Weather: (circle) clear cloudy pcloudy rain drizzle fog **Air Temp** _____

frogs *lizard/snake*

Pipe no.	Species	sex	SVL	Tail Lth	Total Lth	Wt.	Eye dia	Tymp dia	HW	HL	Toe no.	Notes

Notes: behavior, abnormalities, coloration, gravid, # eggs palped, mental gland, recapture; **1 line per individual**
Sex: Male, Female, Juvenile, Metamorph; **Tail lgh**: original + regenerated; **EyeD**: frogs & snakes

PCB pipes without herps (list numbers) _____ Pg ____ of ____

LEGACY HERP PROJECT - JOSEPH C. MITCHELL, PRINCIPLE INVESTIGATOR

DIPNET AND MINNOW TRAP DATA SHEET

Collection No. _____ Date (d/mo/yr) _____ Location: Dare Cherry Pt Camp Lejeune (circle 1)

Start time _____ End time _____ Observers _____ Dip/Trap No _____ Toe clip no. ____

Habitat _____ Weather: (circle) clear cloudy pcloudy rain drizzle fog **Air Temp** _____

frogs *lizard/snake*

trap, dip/#	Species	sex	SVL	Tail Lth	Total Lth	Wt.	Eye dia	Tymp dia	HW	HL	Toe no.	Notes (incl developmental stage)

Notes: behavior, abnormalities, coloration, gravid, # eggs palped, mental gland, recapture; **1 line per individual**

Sex: Male, Female, Juvenile, Metamorph; **Tail lgh**: original + regenerated; **EyeD**: frogs & snakes

LEGACY HERP PROJECT - JOSEPH C. MITCHELL, PRINCIPLE INVESTIGATOR

GENERAL AMPHIBIAN AND REPTILE DATA SHEET

Collection number _____ Date (d/mo/yr) _____ Base: Dare Cherry Pt Camp Lejeune (circle 1)

Observers _____ Location _____ Coordinates _____ Habitat _____

frogs *lizard/snake*

Time	Species	Sex	SVL	Tail lth.	Total lth.	Wt	Eye dia	Tymp dia	HW	HL	Toe no.	Notes

Notes: behavior, abnormalities, coloration, gravid, # eggs palped, mental gland, recapture; **1+ lines per individual**

Sex: Male, Female, Juvenile, Metamorph; **Tail lth**: original + regenerated; **EyeD**: frogs & snakes