

**INVENTORY OF LEPIDOPTERA OF THE ALBEMARLE-PAMLICO
PENINSULAR REGION OF NORTH CAROLINA, INCLUDING
PETTIGREW, GOOSE CREEK, AND JOCKEY'S RIDGE STATE PARKS AND
NAG'S HEAD WOODS ECOLOGICAL PRESERVE**

by Stephen P. Hall
March 1999
(edited June 2017)



North Carolina Natural Heritage Program
Division of Parks and Recreation
P.O. Box 27687
Raleigh, NC 27611-7687

Funded by a grant from
North Carolina Natural Heritage Trust Fund

Acknowledgments

I wish to thank several people and organizations that contributed to this report. The Board of the Natural Heritage Trust Fund provided the funding for this project. Barb Blonder and Jeff DeBlieu of the Nag's Head Woods Ecological Preserve were involved in its initiation, due to their concerns about the effects on the preserve of the gypsy moth or efforts to control this forest pest. Superintendents, past and present, at the three state parks who gave their support included Sid Shearin, Pettigrew State Park; Lauris Joyner and Martha Woods, Goose Creek State Park; and George Barnes, Jockey's Ridge State Park.

Collection and specimen preparation at Nag's Head Woods was aided by the assistance of several volunteers (organized by Barb Blonder). These included Chris Carroll, David Leake, Dick Wood, Anne Wood, Joyce Hannan, Bob Hannan, Con Weltman, Paris Trail, Janet Owen, Frank Tromba, Steve Thomas, T.P. McBride, Michael Donahue, Ed Zakrajsek, and Jan DeBlieu. My wife, Dee Stuckey accompanied me on a number of sampling trips and helped with equipment and sampling. Our niece, Alicia Trigeiro, also accompanied us on one occasion.

Staff at the Natural Heritage Program who contributed information on habitats, species, or specific natural areas included Mike Schafale, Harry LeGrand, and Benson Kirkman. John Finnegan helped prepare the maps. Lepidopterists who provided information included Dale Schweitzer with the Nature Conservancy; J.Bolling Sullivan, retired from Duke University; Jamie Cromartie with Stockton State College; and Eric Quinter with the American Museum of Natural History.

TABLE OF CONTENTS

SUMMARY.....	1
INTRODUCTION.....	2
General Conservation Issues Involving Insects and Other Invertebrates.....	2
Ecological Significance of Insects and Other Invertebrates.....	2
Role of State Parks and Nature Preserves in the Conservation of Insects and other Invertebrates.	3
Role of the Larger Landscape in the Conservation of Insects and Other Invertebrates.....	4
Implications for Management of Insects and Other Invertebrates within State Parks and Nature Preserves.	5
Albemarle-Pamlico Lepidoptera Survey.	7
Reasons for the Focus on Lepidoptera.....	7
Study Objectives.	8
METHODS.	10
Survey Targets.	10
Sampling Methods.....	10
Nocturnal Sampling.....	10
Diurnal Sampling.....	11
Survey Schedule.....	11
Trap Site Selection.....	12
GENERAL RESULTS.....	13
Taxonomic Summary.....	13
New Species to North Carolina.	13
Other Significant Range Extensions.	14
Species of Conservation Concern.	14
Landscape/Habitat Indicator Guilds.....	18
Acidic Shrubland.....	18
Canebrake.	19
Cypress Swamp.	19
Bottomland Hardwood.....	20
Riparian Forest.....	20
Maritime Forest and Shrubland.....	20
Dry Woodland.	21
Open Dune.....	21
Marsh and Wet Swale.	21
Deciduous Forest.....	22
General Management Issues.	22

Gypsy Moth Control	22
Slow-the-spread Program.....	22
Recommendations for Gypsy Moth Control in State Parks and Nature Preserves.	23
Mosquito Control.....	24
Fire Management.....	24
Outdoor Lighting.....	25
 PETTIGREW STATE PARK.....	 28
Habitat Features	28
Trap Site I: Phelps Woods Natural Area	28
Trap Site II. Pocosin Natural Area.....	29
Rare or Poorly Known Lepidoptera.....	29
Habitat Indicator Guilds.....	30
Peatland Species.....	30
Canebrake Species.....	31
Lakeshore and Wet Forest Species.....	31
Management Concerns.....	32
Gypsy Moths.....	32
Prescribed Burning.....	33
Information Needs.....	33
 GOOSE CREEK STATE PARK.....	 36
Habitat Features	36
Trap Site I. Goose Creek Trail.....	36
Trap Site II. Live Oak Trail.....	36
Ragged Point Trail.....	37
Rare or Poorly Known Lepidoptera.....	37
Habitat Indicator Guilds.....	38
Lowland Forests.....	38
Canebrake.....	39
Dry Woodlands.....	39
Estuarine Fringe Evergreen Forest.....	39
Marsh.....	39
Acidic Shrubland.....	40
Management Concerns.....	40
Fire Management.....	40
Gypsy Moths.....	40
Information Needs.....	41
 JOCKEY'S RIDGE STATE PARK.....	 43
Habitat Features	43
Trap Site: Picnic Area Dunes.....	43

Rare or Poorly Known Lepidoptera.....	43
Habitat Indicator Guilds.....	44
Maritime Forest and Shrub.....	44
Open Dune.....	44
Dry Woodland.....	44
Marsh and Wet Swale.....	45
Acidic Shrubland.....	45
Management Concerns.....	45
Gypsy Moth.....	45
Fire Management.....	46
Light Pollution.....	46
Information Needs.....	46
 NAG'S HEAD WOODS.....	 49
Habitat Features.....	49
Trap Site I: Clear Pond.....	50
Trap Site II: Canoe Trail.....	50
Run Hill Trail.....	50
Rare or Poorly Known Lepidoptera.....	51
Habitat Indicator Guilds.....	51
Maritime Deciduous Forest.....	51
Lowland Forests and Pond Edges.....	53
Marsh.....	54
Management Concerns.....	54
Gypsy Moth.....	54
Fire Management.....	55
Information Needs.....	56
 CONCLUSIONS.....	 57
Recapitulation of Rules of Thumb.....	57
 Appendix A. Sampling Dates and Weather Conditions.....	 59
 Appendix B. Checklists.....	 62
 Appendix C. Alphabetized Checklist of Lepidoptera.....	 87
 REFERENCES.....	 91

TABLES

Table I.	Rare or Poorly Known Lepidoptera.....	16
Table II.	NHP Element and Watch List Species Recorded at Pettigrew State Park.....	30
Table III.	NHP Element and Watch List Species Recorded at Goose Creek State Park....	38
Table IV.	Significantly Rare and Watch List Species Recorded at Jockey's Ridge State Park.	44
Table V.	NHP Element and Watch List Species Recorded at Nag's Head Woods Ecological Preserve.	51

FIGURES

Figure 1.	Study Area.	9
Figure 2a.	Sampling Sites at Pettigrew State Park, Trap I.	26
Figure 2b.	Sampling Sites at Pettigrew State Park, Trap I.	27
Figure 3.	Sampling Sites at Goose Creek State Park.	35
Figure 4.	Sampling Site at Jockey’s Ridge State Park.	42
Figure 5.	Sampling Sites at Nag’s Head Woods Ecological Preserve.	48

SUMMARY

Moths and butterflies were sampled at monthly intervals over a one year-period at four sites within the Albemarle-Pamlico Peninsular region: Pettigrew State Park, Goose Creek State Park, Jockey's Ridge State Park, and Nag's Head Woods Ecological Preserve. Goals were to characterize the lepidopteran fauna for the region as well as for the individual preserves. Information on distribution, abundance, and habitat specialization was used to determine the conservation status within the state for each species, i.e., whether they should be listed as Natural Heritage Program elements or placed on the NHP Watch List. Within the individual parks and preserves, this information was used to identify management concerns of particular relevance for maintaining populations of native lepidoptera.

A total of 547 species of moths and butterflies were recorded, including one species new to science and 3 others found within North Carolina for the first time. The range limits for four additional species were extended northward by a significant amount. Nine species recorded in this survey are currently listed as Significantly Rare by the Natural Heritage Program, i.e., tracked as NHP element species. An additional 21 species are included on the NHP Watch List.

Eighty-two species were identified that are highly associated with nine habitats characteristic of the Albemarle-Pamlico Peninsular region. Groups representing each of these habitats – termed indicator guilds – were used in an analysis of conservation concerns for the individual preserves. Vulnerability of the guilds – and to the ecosystems they represent – were evaluated both within the preserves and adjoining areas.

Important management issues identified in this report include control of gypsy moths and other exotic pests, use of prescribed burning, and the proliferation of outdoor lighting. In addition to information provided by this survey, a number of rules of thumb are presented to help guide management decisions where information on invertebrates is largely unavailable.

INTRODUCTION

General Conservation Issues Involving Insects and Other Invertebrates

Conservation of insects and other invertebrates is a new, and, to some people, somewhat shocking concept. Nonetheless, preservation of native insects and other invertebrates is becoming increasingly important concern for managers of state parks and other nature preserves.

Ecosystem-oriented conservation -- where the contribution of all species in maintaining ecological processes is considered -- is coming to the forefront, replacing the previous focus on just a few conspicuous species, mostly vertebrates and plants. The public is also developing an appreciation for at least some groups of invertebrates. This is indicated, for example, in the growing number of butterfly counts conducted each year. There may be eventually as much demand for checklists of butterflies, dragonflies, tiger beetles, or other invertebrates as already exists for birds, other vertebrates, and wildflowers.

This survey is one of a series of insect inventories conducted by the Natural Heritage Program within the North Carolina Coastal Plain. One of the principal aims of these surveys is to bring our understanding of the distribution, abundance, and habitat affinities for at least a few important groups of invertebrates up to the level already achieved for vascular plants and vertebrates. This will be a long process. In the course of this work, we have become aware of several general issues regarding the management of nature preserves that can be expressed as rules of thumb even where information has not yet been collected on any species of invertebrate within a particular preserve. In this study, we provide a combination of both direct species information of use for particular management situations, as well as these more general rules of thumb.

Ecological Significance of Insects and Other Invertebrates

As E.O. Wilson and other conservation biologists have noted, insects and other invertebrates are the "little things that run the world" (Wilson, 1987). Insects are, for instance, the main herbivores in temperate forests, the organisms primarily responsible for turning plant biomass into a form usable by the rest of the food-chain. Most forest birds, bats, amphibians, and many species of reptiles and mammals rely on them for food. Insects and other invertebrates also play a major role within the decomposition section of the food web and are essential in many biological control processes, regulating their own numbers as well as those of other groups of organisms. Their role in mutualistic relationships, including pollination, is well known but the disruption of ecosystem processes by loss of a few critical pollinating species is just beginning to be understood.

Whether or not their contributions are ever fully appreciated, the "little things" are indispensable for maintaining ecosystem integrity. Even if the public (or preserve managers) never learn what species of insects or other invertebrates are present within a given preserve, or what their individual habitat preferences and life histories are, some attention must be given towards proper

management of these obscure organisms, even if only through application of general rules of thumb.

The first of these rules follows a general principle of ecosystem conservation given by Aldo Leopold (1953):

If the biota, in the course of aeons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering.

Since a large proportion of the “cogs and wheels” of any ecosystem are insects and other invertebrates, it follows that:

Rule of Thumb 1. Management actions that significantly alter some aspect of an ecosystem are likely to have major effects on insects and other invertebrates. The responses of these species to the management action may be very different than those of plants or vertebrates, the usual intended beneficiaries of the action. In the worst case, a large number of the unknown but important “cogs and wheels” of the ecosystem may be lost as a result of the action.

Keeping this idea in mind, additional rules of thumb will be described below that can help reduce the likelihood of a dire outcome.

Role of State Parks and Nature Preserves in the Conservation of Insects and other Invertebrates

Nature preserves, including most state parks, are usually established where high quality examples of native ecosystems exist, as indicated by vegetative communities or the presence of rare species of plants or vertebrates. Although few preserves have yet been created specifically with insects or other invertebrates in mind, areas of high quality native habitats usually contain significant faunas of invertebrates as well. There are, in fact, several reasons why invertebrates frequently turn out to be among the rarest species in a given preserve:

- Invertebrates often have highly specific habitat requirements, much more so than is typical for vertebrates. Many insects, for instance, feed only on a particular host plant. Habitat requirements for these species include those for its host plant as well as additional ones of their own.
- Invertebrate populations often undergo extreme fluctuations in numbers, resulting from vagaries in weather or cyclical changes in abundance of their predators or parasites. They are much more prone to local extirpation than either vertebrates or plants. As discussed below, they often survive only where there are enough well-dispersed habitat patches to support a metapopulation.

- Despite their vulnerability to local extirpation, some species can survive in long-lasting, relict populations, as long as natural ecosystem processes are continuous through time. For example, a population of the brown elfin (*Incisalia augustinus*) found on the summit of Occoneechee Mountain, a State Natural Area along the Eno River, may have existed there since the end of the Ice Age approximately 10,000 years ago, just as have several rare plants with similar montane or boreal distributions (no other populations of this species are known from fifty miles around). Their presence on this monadnock is indicative not only of the high quality of the habitats that currently exist, but on the continuity of those habitats and the ecological processes maintaining them throughout that immense span of time. This ability to maintain relict populations is shared with many rare plant species but is less typical for vertebrates.

For all of these reasons, the presence of healthy populations of rare or habitat specialist species of insects and other invertebrates is invariably an indication of a high degree of native ecosystem integrity. Conversely,

Rule of Thumb 2. Where high quality natural areas exist and have maintained their quality through time, a significant fauna of insects and other invertebrates -- containing both rare species and a high proportion of habitat specialists -- should be expected.

Role of the Larger Landscape in the Conservation of Insects and Other Invertebrates

Although some species of invertebrates, like some plants, can maintain small relict populations over large spans of time, most invertebrates require a distribution of habitats spread out over entire landscape. This is especially the case for species prone to local extirpation and that depend on a metapopulation structure for survival within a region. A metapopulation is composed of a number of sub-populations, each of which may be relatively unstable, some increasing in a given year, others declining to the point of extirpation. As long as movement is possible between the sub-populations, declining populations can be “rescued” by immigration from increasing populations elsewhere within the metapopulation. A metapopulation can therefore be much more stable than its parts, at least as so long as not all sub-populations affected by the same set of events. Metapopulations are most stable, consequently, when they are spread out over a significant area of the landscape.

Conservation biologists are just beginning to realize how important metapopulations are for animals in general (for vertebrate examples, see McCullough, 1996). Due to the greater fluctuations their sub-populations experience within a given year or season, invertebrates are often dependent on metapopulation structures. This is especially true of species associated with ecosystems maintained by frequent disturbances, such as fires, storms, or floods. Whereas vertebrates (and many plants) often have escape mechanisms for coping with unpredictable ecological disruptions, invertebrates typically do not. The only way many insect species survive in habitats maintained by frequent fire, for instance, is through recolonization of recently burned areas from unburned patches of habitat (Hall and Schweitzer, 1993).

Habitat fragmentation – replacement of natural landscapes with a mosaic of small patches of native habitats interspersed in a matrix of lands converted to human uses – affects all species by reducing the overall amount of available habitat, involving outright losses as well as more subtle reductions due to edge effects. The most severe effects, however, may be on species critically dependent on metapopulation structures.

By definition, habitat fragmentation is a process that increases the distances between suitable habitat patches and therefore increases the difficulties or outright danger to individuals dispersing from one habitat block to another. Since the very existence of a metapopulation depends on dispersal between suitable patches of habitat, any factor that reduces the chances of successful dispersal may doom the whole metapopulation to eventual extirpation, not just individual sub-populations as normally occurs within even intact landscapes. Habitat specialists, particularly those dependent on naturally rare types of habitat or on disturbance-maintained habitats, are at greatest risk.

Rule of Thumb 3. Insects and other invertebrates should be considered at particular risk from fragmentation of native habitats. Even though invertebrate populations can be particularly high within a given sub-population during a given season, this should not be taken as a sign that, as small species, they only need a limited amount of space to maintain themselves. Their long term survival within a region may depend on as much landscape as is required to support a population (or metapopulation) of black bears, red-cockaded woodpeckers, or other species of vertebrate.

Several insects species are believed, in fact, to have become critically endangered through loss of metapopulation structure, even though habitats within portions of the range of the metapopulation still appear to be high in quality. Examples in North Carolina Coastal Plain include the Arogos skipper (*Atrytone arogos*), Saint Francis's satyr (*Neonympha mitchelli francisci*), and Venus flytrap moth (*Hemipachnobia subporphyrea*)¹.

Implications for Management of Insects and Other Invertebrates within State Parks and Nature Preserves

Preserves can to some degree be regarded as islands of habitat. They are often chosen for conservation as something special in areas where the rest of the landscape has been significantly altered. All too frequently, preserves contain the only remnants of native ecosystems for miles around.

While these preserves are intended to remain “natural”, active management is often needed to accomplish this goal, although management, almost by definition, involves some form of artificial disturbance. This disturbance may replace a natural form, such as wildfires, or it may

¹ The Natural Heritage Program has conducted or is in the process of conducting status surveys for all three of these species.

be entirely new, such as spraying an entire preserve with a pesticide to control an exotic pest such as the gypsy moth.

Based on the three rules of thumb given previously, it should be clear that special precautions need to be considered in preserve management if crucial “cogs and wheels” of the ecosystem are to be retained. Given the importance of metapopulation structure to many invertebrates, particularly those most tightly associated with native habitats, preserve managers should always ask where will recolonization come from if species are lost from a given area of habitat?

Rule of Thumb 4. Wherever possible, management activities should be restricted to only a portion of a given habitat type. Other areas of the same habitat should be set aside as refuge areas (although potentially subject to treatment at a later time).

Rule of Thumb 5. In cases where a management action affects an entire preserve, as in treatment for gypsy moths, decisions about the scope, intensity, and alternative treatments should be based according to the proximity of refuge areas beyond the boundary of the preserve. Where other, untreated blocks of habitat are located close by, a wider range of management options can be considered. Even in the worst case, where species are extirpated from the preserve, recolonization from outside can still be expected. Where external refuges are located far away, however, management decisions should be based on the worst possible case: irrecoverable losses of species from the preserve.

Albemarle-Pamlico Lepidoptera Survey

This project surveyed a major group of insects, the Lepidoptera, in four protected but relatively isolated natural areas in northeastern North Carolina: Pettigrew, Goose Creek, and Jockey's Ridge State Parks and the Nature Conservancy's Nags Head Woods Ecological Preserve (Figure 1). The principal objectives were to obtain information on both a regional level, characterizing the moths and butterflies associated with distinctive habitats of the Albemarle-Pamlico Peninsular region, and on a local level, determining which species are of particular conservation concern within the particular preserves.

Reasons for the Focus on Lepidoptera

Although several groups of insects have been included in previous surveys conducted by the Natural Heritage Program, our focus has come to lie primarily on the Lepidoptera (the macro-lepidoptera in particular -- see Survey Targets below). There are several reasons why we have chosen to focus our invertebrate inventory efforts on this particular taxonomic group:

- Among all groups of animals, the Lepidoptera are second only to beetles in numbers of species. In North America alone, over 11,000 species have been described (Hodges et al. 1983). Over 5800 of these belong to the macro-lepidoptera, which include most of the larger and better known species (see Survey Targets below).
- Lepidoptera are particularly good indicators of habitat quality. Many species have highly specific habitat requirements and often respond to habitat fragmentation, fire, and other disturbances on a much finer scale than produce noticeable effects on the populations of either vertebrates or plants.
- As a group, Lepidoptera are second only to bees and wasps as pollinators. They are also crucial components of terrestrial food webs. As the most efficient and numerous group of primary consumers, insects in general and caterpillars in particular play important roles in structuring vegetative communities. A number of species are also important members of the detritivore food web, feeding on dead leaves, decaying wood, and fungi. Both caterpillars and adult moths and butterflies, in turn, serve as prey for a wide range of other species of animals, including such rare species as the red-cockaded woodpecker, Rafinesque's big-eared bat, and the Dismal Swamp southeastern shrew.
- Lepidoptera are more easily inventoried than other groups of insects. Using relatively few techniques, including an effective trapping method, an inventory of both representative and rare species can be obtained with only a small amount of effort.
- The taxonomy, distributions, and ecological relationships are better known for Lepidoptera than for other groups of insects (although they are still poorly understood compared to vertebrates or plants). Numerous checklists, field guides, and other reference manuals exist for both moths and butterflies (e.g., Howe 1975, Miller and Brown 1981, Hodges et al. 1983, Covell 1984, Opler and Krizek 1984, Scott 1986, Opler and Malikul 1992, Rings et al. 1992).

- Lepidoptera, particularly butterflies, are the most popular group of insects, both among collectors and the general public. Because of the widespread interest in this group, Lepidoptera play a flagship role in the conservation of insects and other invertebrates, groups of organisms that are otherwise often maligned or ignored.

Study Objectives

There were five specific objectives in this project:

- (1) Compile checklists for all macro-lepidoptera species, both for the region, as well as the individual preserves.
- (2) Identify species of general conservation concern, i.e., species on the NHP list of rare animals or potential candidates for that list
- (3) Identify habitat specialists, i.e., indicator species useful for monitoring habitat quality both within the preserves and in the surrounding landscape
- (4) Identify management concerns of particular importance for the groups included in the study
- (5) Identify additional information needs



Figure 1. Study Area

Figure 2. Study Area

METHODS

Survey Targets

This study focused on the so-called "macro-lepidoptera", which includes butterflies and several closely allied families of higher moths. Roughly half of all Lepidoptera identified in North America fall within this group (see checklist by Hodges, et al., 1994), including almost all the larger, more familiar species (e.g., those included within field guides to insects).

Families of "macro-lepidoptera" included in this study are the Hesperidae (Skippers), Papilionidae (Swallowtails), Pieridae (Whites and Yellows), Lycaenidae (Gossamer Wings), Riodinidae (Metalmarks), Nymphalidae (Brushfoots), Thyatiridae (Thyatirid Moths), Drepanidae (Hooktip Moths), Geometridae (Inchworm Moths), Epiplemididae (Epiplemid Moths), Mimallonidae (Sack-Bearer Moths), Apatelodidae (Apatelodid Moths), Lasiocampidae (Tent Caterpillar and Lappet Moths), Saturniidae (Giant Silkworm Moths), Sphingidae (Sphinx and Hawk Moths), Notodontidae (Prominent Moths), Arctiidae (Tiger, Lichen, and Wasp Moths), Lymantriidae (Tussock Moths), and Noctuidae (Owlet Moths).

The remaining families of Lepidoptera are considered "micro-moths". In general, they are indeed small and often require special methods for collecting and handling. There are also fewer identification guides available for these families than for the macro-lepidoptera. A few "micro" families contain large, relatively well-known species, however, including the following included in this survey: Psychidae (Bagworm Moths), Cossidae (Carpenter Moths), Megalopygidae (Flannel Moths), and Limacodidae (Slug Moths).

Sampling Methods

Nocturnal Sampling

Light-trapping. The majority of specimens were obtained through use of UV light traps. This type of trap makes use of the disruptive action of stationary, terrestrial lights on the moon- and star-based navigational systems used by almost all nocturnal insects. For general sampling of insect species diversity, no other method comes close to this method in terms of efficiency or versatility (Muirhead-Thomson 1991).

Traps were custom-built. The light source was a 15W UV fluorescent bulb powered by a 12V marine or gel-cel battery. The bulbs were mounted between four plexiglass deflectors. Moths drawn to the light are knocked down by the deflectors into a funnel set above a five gallon plastic bucket. Ethyl acetate, a fumigant lethal to most insects but relatively non-toxic to vertebrates, was used as the killing agent.

The traps were either suspended from vegetation or set up on the ground, depending on environmental circumstances. The goal was to maximize the visibility of the traps to night-flying

insects but to minimize their visibility to human passers-by. Wherever possible, trap sites were selected that were sheltered from the wind.

In order to minimize the drain on the batteries, the traps were set up as close to dusk as possible and picked up early the next day. Weather conditions were noted at the time the traps were set out, particularly wind and cloud cover. A max-min thermometer was used to record the low temperature reached during the night.

Sheet-sampling. UV lights suspended in front of a sheet hung on a clothesline were used to supplement the light trap samples. This method involves direct capture of specimens, using a killing jar. Not only can greater selectivity be used in collecting, but some species that are difficult to knock down into a bucket trap can be more easily sampled by this method. Since it requires the presence of the collector, this method is more labor intensive than light trapping, however, and could be used at only a few sites.

Baiting. At some collecting sites -- usually the same used for sheet-sampling -- a bait composed of fermenting bananas, beer, and molasses was painted on tree trunks. This method draws in some groups of moths that are less frequently drawn in by lights. As in sheet-sampling, collecting was done by hand, using a killing jar.

Diurnal Sampling

Day-flying Lepidoptera (butterflies, skippers, and a few diurnal moths) were sampled by means of direct search and use of a net. No trapping methods comparable to the light traps are available for this group (although a few species can be obtained through use of bait or pheromone traps).

Assistance in diurnal sampling was provided by volunteers at Nag's Head Woods. Checklist of butterflies for the project region was also supplemented by information obtained from Fourth-of-July Counts sponsored by the North American Butterfly Association. These counts are similar to the Christmas Bird Counts conducted by the Audubon Society and consist of sight records made by a team of observers over a single day period. Counts are centered on a particular reference point and can range as far out from the center as 15 miles. Fourth-of-July Counts have now been conducted at both Pettigrew State and Nag's Head Woods Park (LeGrand, 1996, 1997, 1998).

Survey Schedule

Sampling visits were made once a month, from May to October in 1993 and from February to April in 1994 (see Appendix A). Seven sites were normally trapped per month. Trap failures occurred on two occasions and one site was trapped twice during the same sampling trip. The total number of trap samples was 66.

During the growing season, visits were made between the last and first quarters of the moon in order to minimize the moon's interference with the light traps. During the winter and early

spring, the over-riding factor affecting collecting success was weather; visits then were selected to coincide as much as possible with warm spells (temperatures at dusk in the upper 50's or low 60's).

Trap Site Selection

Only a few habitats could be sampled in this survey due to time it took to travel between the sampling stations. Priority was given to sampling the best available examples of habitats typical of this region. These include peatlands, natural lakeshores, swamp forests, maritime forests, and beach dunes. Marsh habitats, also well-represented in this region, were sampled only peripherally.

Wherever possible, trap sites were situated between two or more community types. While this complicated interpretation of habitat affinities, enough information existed from other studies to determine the most likely habitat for most species of interest.

GENERAL RESULTS

Taxonomic Summary

547 species of lepidoptera were recorded overall, including 460 species of macro-moths and 58 species of butterflies. Twenty-nine species of micro-moths were also identified but represent only a small fraction of the numbers in this group that were actually trapped. The complete list of species is given in Appendix B, along with sample totals for the individual preserves.

New Species to North Carolina

The majority of the species recorded this survey have been previously documented in North Carolina. Exceptions include four noctuid moths, *Quandara brauneata*, *Parahyponodes quadralis*, *Hemeroplanis* n. sp., and *Homophoberia cristata*, all of which appear to have been recorded in North Carolina for the first time during this survey.

The record for *Hemeroplanis* n. sp. may represent the first time this species has been collected anywhere. This species resembles *H. obliquialis*, a poorly-known Midwestern species (D. Ferguson, US National Museum, pers. comm. to J.B. Sullivan), but was determined as a different species based on a comparison with the type specimen of *obliquialis* by Eric Quinter at the American Museum of Natural History. This moth has now been collected in North Carolina at widely separated localities, including as the Sandhills Game Land in Hoke County (Hall, pers. obs.) and Hanging Rock State Park in Stokes County (J.B. Sullivan, pers. comm.).

Quandara brauneata was previously known only from the Ohio River Valley (Forbes, 1948; Rings, et al., 1992) but has probably been often overlooked in macro-moth surveys due to its strong resemblance to some of the micro-moths (it has also been mis-classified as a Geometrid – e.g., Forbes, 1948). Subsequent to the discovery of this species in this survey, *Quandara* has been collected at the Dare County Bombing Range, also on the Albemarle-Pamlico Peninsula, and in floodplain forests along the lower Roanoke River.

Parahyponodes quadralis is another small, easily overlooked noctuid. It has been recorded from various points from Maine to Florida but is extremely poorly known throughout. The specimen collected at Nag's Head Woods during this survey is the only one known from North Carolina.

Homophoberia cristata is a larger, more conspicuous species that has also been reported from a number of areas along the Atlantic Coast, from southern Massachusetts to Florida. This species may also have been undersampled, in this case probably due to its habitat, lakes and ponds, which are infrequently sampled by collectors of macro-moths. The larvae of this species feed on yellow pond lily (*Nuphar luteum*). The specimen collected at Pettigrew State Park is the only one known from North Carolina.

Other Significant Range Extensions

In addition to recording four species new to the state, this study significantly extended the northern range limits for another four species, all of which have previously been recorded in southeastern North Carolina.

Anacamptodes cypressaria is a cypress-feeding geometrid moth that prior to 1992, when four specimens were collected in Brunswick County (Hall and Schweitzer, 1993), was known only from Florida (Rindge, 1966). Records from the current survey, along with records obtained from a survey of the Dare County Bombing Range (Fussell, et al., 1995) and the lower Roanoke River floodplain (Hall, 1999), place its current northern range limit in northeastern North Carolina. Given that cypress extends as far north as Maryland, however, there is a good chance that this species will eventually be found north of the North Carolina state line.

Heterocampa astarte, a prominent moth associated with maritime forests (probably feeding on live oak, *Quercus virginiana*), was recorded in this survey at Jockey's Ridge State Park, which appears to be its current northern limit. As in the case of *Anacamptodes cypressaria*, habitat for this moth extends further north, at least into southeastern Virginia where there is a good chance that it will eventually be collected.

Zale declarans is a noctuid moth also associated with maritime woodlands. This moth is far less common than *Heterocampa astarte*, however, and appears to be associated with shrubby maritime habitats rather than closed-canopy maritime forest. While it may extend into southeastern Virginia, it appears to be closer to its northern limit at Jockey's Ridge than *Heterocampa astarte*.

Dysgonia similis appears to be strongly associated with pocosins and other peatland habitats. Prior to its collection in southeastern North Carolina, it was apparently unknown north of Florida. As in the species mentioned above, there is a chance it will be eventually discovered in southeastern Virginia, but probably no further north.

Species of Conservation Concern

Based on information from this survey, as well as from six other insect inventories conducted by NHP in the Coastal Plain, 30 species recorded in this study appear to be either rare or at least infrequently collected.

Species that we are fairly confident are rare or declining are tracked as NHP Element Species, i.e., we keep detailed records for every occurrence known in the state. The nine species labeled Significantly Rare in Table I belong to this category. The element ranks estimate the rarity of the species following conventions developed by the Natural Heritage Program/Nature Conservancy Network. Global ranks refer to the rarity of the species rangewide and range from G1 for species known from five or fewer occurrences to G5 for widespread, secure species. State ranks are

similar but consider the species' rarity solely within North Carolina (more detailed rank descriptions are given at the end of Table I).

With the possible exception of *Metarranthis lateritiaria*, none of the species collected in this survey appear to globally rare (G1-G3) although several appear to be rare in North Carolina or are associated with declining habitats. All of these species are included in Landscape/Habitat Indicator Guilds discussed below.

Species that we are less certain about but which appear to be of some conservation concern are included on the NHP Watch List. Twenty-one species listed in Table I belong to this category. Although we do not keep as detailed occurrence records for these species as we do for element species, information is maintained on their distribution, habitat affinities, and other aspects of their ecology and life history of possible bearing on their conservation status. As with the element species, Watch List members included in Table I are all included in the Landscape/Habitat Indicator Guilds discussed below.

Table I. Rare or Poorly Known Lepidoptera

SPECIES	NHP/TNH ELEMENT RANK	
	GLOBAL RANK	STATE RANK
Significantly Rare Species		
Dukes Skipper (<i>Euphyes dukesi</i>) ²	G3G4	S2?
Giant Swallowtail (<i>Papilio cressphontes</i>)	G5	S2?
<i>Anacamptodes cypressaria</i> (Geometridae)	G?	S2S3
<i>Metarranthis lateritiaria</i> (Geometridae)	G3G4	S1S3
<i>Metarranthis</i> sp. 1 (Geometridae)	GU	S2S3
<i>Callosamia securifera</i> (Saturniidae)	G4	S2S3
<i>Zale declarans</i> (Noctuidae)	G5	S2S3
<i>Dysgonia similis</i> (Noctuidae)	G?	S2S3
<i>Euagrotis lubricans?</i> (Noctuidae)	G4	S3?
Watch List Species		
<i>Cleora projecta</i> (Geometridae)	G?	S3?
<i>Caripeta aretaria</i> (Geometridae)	G?	S3?
<i>Nemoria bifilata bifilata</i> (Geometridae)	G?	S3?
<i>Idaea productata</i> (Geometridae)	G?	S2S3
<i>Idaea micropterata</i> (Geometridae)	G?	SU
<i>Idaea violacearia</i> (Geometridae)	G4	S3?
<i>Scopula cacuminaria</i> (Geometridae)	G?	S3?
<i>Paonias astylus</i> (Sphingidae)	G?	S3S4

² Common names are used only for butterflies, for which a standardized list has been prepared (NABA, 1995). Scientific names for moths are italicized. Species are listed in taxonomic order, following the checklist by Hodges, et al. (1983). Appendix C provides an alphabetized list for all names used in the text, along with the checklist numbers used in Appendix B.

SPECIES	NHP/TNH ELEMENT RANK	
	GLOBAL RANK	STATE RANK
<i>Spilosoma dubia</i> (Arctiidae)	G?	S3S4
<i>Orgyia detrita</i> (Lymantriidae)	G4	S3?
<i>Parahyphenodes quadralis</i> (Noctuidae)	G4	S1S2
<i>Hemeroplanis</i> n. sp. (Noctuidae)	G?	SU
<i>Arugisa watsoni</i> (Noctuidae)	G?	S3?
<i>Lithacodia</i> n. sp. (Noctuidae)	GU	SU
<i>Argillophora furcilla</i> (Noctuidae)	G3G4	S2S3
<i>Papaipema</i> n. sp. 3 (Noctuidae)	G4?	S3?
<i>Acrapex relictata</i> (Noctuidae)	G?	S3?
Amphipyrinae, New Genus 2, Species 2 (Noctuidae)	G?	S3S4
<i>Pyreferra pettiti</i> (Noctuidae)	G?	S3?
<i>Faronta rubripennis</i> (Noctuidae)	G3G4	S2S3
<i>Ulolonche modesta</i> (Noctuidae)	G?	SU

Global Ranks estimate the rarity or commonness of a species rangewide, according to the following conventions:

G1 – Critically imperiled globally because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction. Number of extant populations is estimated to be within one to five.

G2 – Imperiled globally because of rarity or because of some factor(s) making it very vulnerable to extinction throughout its range. Number of extant populations estimated to be within six to twenty.

G3 – Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a single physiographic region) or vulnerable to extinction due to other factors throughout its range. Number of extant populations estimated to be within 21-100.

G4 – Uncommon to rare but apparently secure globally. Number of extant populations estimated to be within 100-1,000.

G5 – Demonstrably secure globally, although possibly rare in some parts of its range, particularly at the periphery. Number of extant populations estimated to be over 1,000.

GU – Global rank cannot be estimated based on current data.

G? – Global ranks have not yet been estimated

Ranks for subspecies or other taxonomic subdivisions are indicated by T-ranks. Within a particular ranking level, combinations are used when exact estimates cannot be made. Question marks are used when a specific rank rather than a range of ranks is used but where some uncertainty exists.

State ranks are analogous but refer to the distribution of a species within a state instead of its entire range.

Landscape/Habitat Indicator Guilds

The presence of rare species at a site is usually an indicator of either high quality or restricted types of habitat. Relict populations, in particular, are good indications that natural ecosystem processes have gone on at the site with few major interruptions through time.

Rare species are not the only ones useful as ecological indicators, however. Their very scarcity makes them difficult to use in monitoring studies. In insect surveys conducted by NHP, we have sought to identify a larger assortment of species that have close ties to particular types of natural communities, especially communities of conservation concern. We group such species by community or habitat type³, and refer to the groups as “landscape/habitat indicator guilds” (see Hall and Schafale, 1999, for a detailed discussion).

While the species included in these guilds may or may not be of particular conservation concern in themselves, they provide information on overall habitat quality relative to a particular ecosystem, both within a preserve and in the surrounding landscape. High species richness or overall abundance within a particular guild is taken to be a sign of both good habitat quality on the local level and good connections to other habitat units elsewhere in the landscape. Low species richness or abundances within these guilds, conversely, is taken as a sign of habitat or landscape deterioration with respect to the particular habitat type represented by the guild.

Nine primary indicator guilds were used in this study, corresponding to the following types of habitat: Acidic Shrubland, Canebrake, Cypress Swamp, Bottomland Hardwood, Riparian Forest, Dry Woodland, Maritime Forest and Shrubland, Open Dune, and Marsh and Wet Swale. These guilds include 82 (16%) of the Lepidoptera recorded in the study. The rest are more general in terms of habitat requirements and of less use in ecological monitoring within this region. However, some of these generalists were included in a tenth guild, Deciduous Forest, identified specifically for Nags Head Woods Ecological Preserve due to the extreme localization of this habitat type on the Outer Banks.

Acidic Shrubland

Species in this guild are believed to use various heaths, hollies, or other shrubs associated with acidic soils as larval host plants. While these Lepidoptera are among the most characteristic species of Pocosins, Pond Pine Woodlands, and other types of peatland communities, they are no more restricted to these habitats than are their host plants, which can occur in a number of other habitat types, in some cases including uplands as well as wetlands.

Nineteen species belonging to this guild were recorded in this study and are listed below. Species of conservation concern are indicated in bold face and those that appear to be particularly

³ Habitat as viewed by animal species may be broader or narrower than defined by plant community ecologists.

associated with peatland habitats are indicated with an asterisk. Not surprisingly, given the predominance of peatland and other acidic shrubland habitats within the study area, this list includes all but four of the species in this guild that have been collected in the North Carolina Coastal Plain overall.

<i>Glena cognataria</i>	<i>Argyrostrotis flavistriaria</i>
<i>Episemasia solitaria</i>	<i>Argyrostrotis sylvarum</i>
<i>Metarranthis lateritiaria</i>*	<i>Argyrostrotis erasa</i>
<i>Metarranthis</i> sp. 1*	<i>Argyrostrotis deleta</i>
<i>Callosamia securifera</i>	<i>Catocala praeclara</i>
<i>Sphinx gordius</i>	<i>Nola clethrae</i>
<i>Paonias astylus</i>	<i>Acrionicta tritona</i>
<i>Orgyia detrita</i>	<i>Epiglaea apiata</i>
<i>Spilosoma dubia</i>	<i>Anomogyna youngii</i>
<i>Dysgonia similis</i>*	

Canebrake

Species in this guild are all believed to feed exclusively on cane (*Arundinaria tecta* and *A. gigantea*) as larvae. Only 9 species were recorded during this study, out of the total of 16 cane-feeding species that have been recorded in North Carolina overall. Some of these additional species may turn up with more sampling effort, but at least a few of these species appear to have particular requirements for large stands of cane, large sized cane, or vigorous new growth, conditions that do not exist within the areas sampled.

Yehl Skipper	<i>Argillophora furcilla</i>
Lace-winged Roadside-Skipper	<i>Papaipema</i> sp. 3
Southern Pearly-eye	<i>Acrapex relictata</i>
Creole Pearly-eye	Amphipyridinae, New Genus 2, Species 2

Cypress Swamp

This group is composed of species believed to feed exclusively on cypress. They are thus among the most characteristic species of swamps within this region and were well represented in samples for this study. Only one other cypress-feeding moth, *Acrionicta perblanda*, has been recorded in the state, thus far only at a single site in Craven County.

<i>Semiothisa aequiferaria</i>	<i>Cutina albopunctella</i>
<i>Anacamptodes cypressaria</i>	<i>Cutina distincta</i>
<i>Anacamptodes pergracilis</i>	<i>Cutina aluticolor</i>
<i>Isoparce cupressi</i>	<i>Cutina arcuata</i>

Bottomland Hardwood

This guild includes species associated with bottomlands and other seasonally flooded forests, including those found in nonriverine wet flats. Larval hosts, where known, include a variety of woody trees and shrubs characteristic of these habitats. Certain species, including *Idaea micropterata* and *Nigetia formosalis*, are included in this guild based on habitats where adults have been captured; the larval hosts are not yet known.

Only five members of this guild were recorded in the study area, out of 13 found in the Coastal Plain more generally. No pure stands of bottomland hardwoods were sampled in this study, although several sites contained some representatives of this community type, particularly the lakeshore forests on the north side of Lake Phelps.

Zebra Swallowtail
American Snout
Tawny Emperor

Idaea micropterata
Nigetia formosalis

Riparian Forest

Members of this guild feed on willows, birches, cottonwoods, alders, sycamores, and other plants characteristic of river banks and levees and the shorelines of lakes and ponds. Only 8 of the 24 species included in this guild for the Coastal Plain overall were recorded in this study, reflecting the absence of riverine habitats. Most of these species were collected near pond and lake edges.

Viceroy
Semiothisa gnophosaria
Cabera variolaria
Clostera inclusa

Furcula cinerea
Colobochyla interpuncta
Catocala cara
Acrionicta connecta

Maritime Forest and Shrubland

Members of this guild are associated with the evergreen forests of the barrier islands and adjoining mainland. Most probably feed either on live oak (*Quercus virginiana*) or sand live oak (*Q. geminata*). The Giant Swallowtail (*Papilio cresphontes*) feeds on members of the citrus family generally; within the study area, the only choice of host plants in Hercules-club (*Zanthoxylum clava-hercules*), which is restricted to the calcium-rich sands of the barrier islands.

This guild is well-represented in the study samples. Only a few other primarily southern species are included in this guild for the Coastal Plain overall.

Giant Swallowtail (*Papilio cresphontes*)
Cymatophora approximaria
Heterocampa astarte

Panopoda repanda
Metria amella
Zale declarans

Dry Woodland

This guild includes species associated with dry, open woodlands, including sandhills and maritime forest. 56 species belong to this guild in the North Carolina Coastal Plain overall, of which only 13 were recorded in the project area. Several of the missing species occur in xeric longleaf pine habitats, which were virtually non-existent in the study area.

Zarucco skipper

Monoleuca semifascia

Stenaspilatodes antidiscaria

Idaea violacearia

Crambidia lithosioides

Crambidia uniformis

Cisthene subjecta

Bleptina inferior

Hemeroplanis scopulepes

Elaphria festivoides complex

Ulolonche modesta

Euoptocnemis fimbriaris

Euagrotis lubricans

Open Dune

Members of this guild are associated with the grasslands and other dry herbaceous communities found in dune habitats on the barrier islands. Ten species belong to this guild in North Carolina, of which five were found in this study. All five were well-represented at Jockey's Ridge State Park.

Faronta rubripennis

Leucania extincta

Leucania phragmitidicola

Agrotis vetusta

Euxoa detersa detersa

Marsh and Wet Swale

Species in this guild are associated with open, herb-dominated wetlands, including salt and freshwater marshes and wet, sedgy swales. 25 species are included in this guild for the Coastal Plain overall, of which 11 were recorded in this study:

Least Skipper

Broad-winged Skipper

Duke's Skipper

Leucanopsis longa

Macrochilo hypocriticalis

Ledaea perditalis

Arugisa watsoni

Doryodes spadaria

Simyra henrici

Leucania linita

Schinia saturata

Deciduous Forest

As mentioned previously, this guild includes many species that are widespread in eastern deciduous forests and are generally not of great conservation concern except on the Outer Banks. Species in this group will be discussed in more detail below under Nag's Head Woods.

General Management Issues

Gypsy Moth Control

The single most important management issue regarding Lepidoptera in the study area involves the control of the gypsy moth (*Lymantria dispar*), a forest pest species introduced into this country from Europe a century ago. Northeastern North Carolina falls within the advancing front of established gypsy moth populations, which have been gradually expanding outward from the Northeast, where the original introduction occurred. The population at Nags Head is considered by U.S. Forest Service to be one of the southernmost points reached by this front.

Although no control measures have been able to stop the spread of this pest, the use of Dimilin and certain other pesticides have had severe impacts on native insect populations, particularly on moths and butterflies. In some areas where the use of these chemicals has been indiscriminate, several rare species have been extirpated and even formerly common species, such as the luna moth, have now become quite scarce (Dale Schweitzer, Nature Conservancy, pers. comm.).

SLOW-THE-SPREAD PROGRAM

Given the inevitable spread of the gypsy moth and concerns about impacts to nontarget species, attempts to eradicate gypsy moth populations are now restricted to areas only far in advance of the front. Within the zone adjacent to the front, a Slow-the-Spread Program has been initiated instead. In North Carolina, this program is done in collaboration between the NC Division of Plant Industry⁴ (Department of Agriculture) and the U.S. Forest Service. Gypsy moth populations are closely monitored through use of pheromone traps, which attracts male moths looking for mates. When large outbreaks are detected, integrated pest management techniques are used to suppress the population, but not necessarily eradicate it.

Depending on the situation, the least environmentally damaging control agent is selected. The standard control agent now in use is an insecticidal preparation of *Bacillus thuringiensis* (*Bt*). This control agent has few if any impacts to vertebrate species or to most invertebrate species other than moths and butterflies. It affects a wide variety of Lepidoptera, however.

⁴ The Plant Protection Section of the Division has the specific responsibility for the control of insect pests.

Other control agents are more specific in their effects to gypsy moths but are limited in terms of the circumstances appropriate for their use. Low level infestations can be combated with pheromone flakes, which disrupt the male moths' ability to find females; it has no effects on other organisms. High level outbreaks can be fought with Gypchek, a control agent using a gypsy moth virus; again the impacts to other species are minimal.

Currently, the Natural Heritage Program reviews proposed gypsy moth suppression or eradication projects for possible impacts to rare species or threatened ecosystems. Where state park units or other nature preserves are concerned, we recommend the NC Division of Plant Industry use the most specific control agent possible. This is particularly important where the ecosystems contained within the parks or preserves have become isolated from other native systems. As discussed above, loss of species from "islands" can be permanent.

RECOMMENDATIONS FOR GYPSY MOTH CONTROL IN STATE PARKS AND NATURE PRESERVES

We recommend that all areas vulnerable to invasion by the gypsy moth be monitored yearly, preferably as part of the statewide monitoring program conducted by the Division of Plant Industry. Vulnerable areas particularly include stands with deciduous oaks, the principal host plant for the gypsy moth. Riparian stands with willow or sweetgum – two other preferred hosts – should also be checked.

If an infestation is detected, a decision must be made whether or not to take any active control measures. Chronic, low-level infestations are likely to become the rule over most of the project area within just a few years. It may not be possible, or necessarily desirable, to treat every low-level infestation every time one is detected.

Factors to consider within a state park or nature preserve include the possible impacts from the gypsy moth on rare natural communities, including old-growth stands, or on rare species particularly at risk from the defoliating effects of the gypsy moth. The consequences of a particular treatment type should also be considered.

Use of pheromone flakes to combat a low-level infestation is likely to have few adverse ecological impacts, if any. This method may be particularly effective in forestalling a more damaging outbreak if areas surrounding the preserve do not support chronic infestations. Introduction of a gypsy moth-killing fungus, *Entomophaga maimaiga*, should also be considered. While the effects of this control agent are still under study, it appears to have been responsible for population crashes in several areas where the gypsy moth had been long established. Impacts to other species appear to be low.

Where the presence of larger population levels call for the use of *Bt*, impacts to nontarget Lepidoptera, or to the species that depend on Lepidoptera for food, must be carefully weighed. Where a survey of Lepidoptera has been conducted, decisions can be based on the vulnerability of rare species or habitat specialists known to occur within preserve. Otherwise, the rule of

thumb that can be used is the likelihood of recolonization from surrounding areas, assuming the worst possible case within the treated areas. Sites containing isolated ecosystems will probably suffer the greatest long-term effects; sites that have connections to similar ecosystems in untreated areas have at least a chance of being recolonized.

If this assessment finds a high degree of risk due to treatment with *Bt*, two options to consider are doing nothing at all – letting nature take its course with regard to gypsy moth population cycles – or waiting until the outbreak reaches a sufficiently high level for Gypchek to be an effective control agent. Within the study area, the first option may not be so catastrophic. As gypsy moth populations spread from areas where they are already established, so do many of the parasitic insects, predators, fungi, and diseases that normally keep them in check. Particularly with the advent of *Entomophaga maimaiga*, gypsy moth outbreaks of the magnitude seen previously in the Northeast may become a thing of the past.

In any case, we recommend that decisions be made in consultation with the Division of Plant Protection.

Mosquito Control

The use of Malathion or other insecticides to suppress mosquito populations can have adverse on a wide range of nontarget insects. Where directly applied to natural areas or where significant drift can be expected, the same sort of considerations should be made as discussed above for the use of *Bt*.

Fire Management

Prescribed burning is becoming a more frequently used management tool, both to forestall catastrophic wildfires and to maintain certain types of fire-dependent natural communities. Extensive guidelines have been developed for both North Carolina state park units and Nature Conservancy preserves to ensure that burning can be conducted both safely and effectively, including consideration of potential impacts to rare species or habitat specialists.

Even though many insects and other invertebrates are among the most characteristic members of fire-maintained natural communities, they may nonetheless be extremely vulnerable to the direct effects of fire. In the original landscape, there would always have been sufficient unburned patches of habitat – fire refugia – to provide a source for recolonization of recently burned areas. With the loss of landscape connections now typical of the surroundings of many parks and nature preserves, complete burning of a particular habitat type may result in the permanent loss of many of the species – with ultimate effects on the entire ecosystem – that the preserve was intended to protect. Consequently, part of the prescription for conducting a burn within small islands of habitat is to make sure that sufficient fire refugia are maintained. Two specific rules of thumb are:

- (1) Do not burn more than a third of a particular habitat type in a given year.
- (2) Allow for sufficient time for recolonization to occur from a fire refugium before the refugium itself is burned. A three year rotation among burn units should be considered a minimum in this regard.

Adjustments to these rules of thumb can be made where there is more information on the spatial distribution and recolonizing abilities of particular species at risk within a preserve.

Outdoor Lighting

A management issue of particular importance to moths and other night-flying insects is the use of outdoor lighting. Many of these species are disoriented by artificial lights and once entering the zone of a light source may be unable to escape. Individuals “trapped” in this way eventually either succumb to dehydration or starvation, or fall victim to predators who learn that areas around artificial lights are rich feeding grounds.

High intensity lighting creates the greatest problems (Frank, 1988). Wherever feasible, low voltage, well-shielded fixtures should be used instead⁵. Lighting of any type should be avoided in the vicinity of habitats particularly likely to support rare species of nocturnal insects.

⁵ Many lighting recommendations may be found in publications of the International Dark-Sky Association (several recommendations and sources can be found at: www.darksky.org).

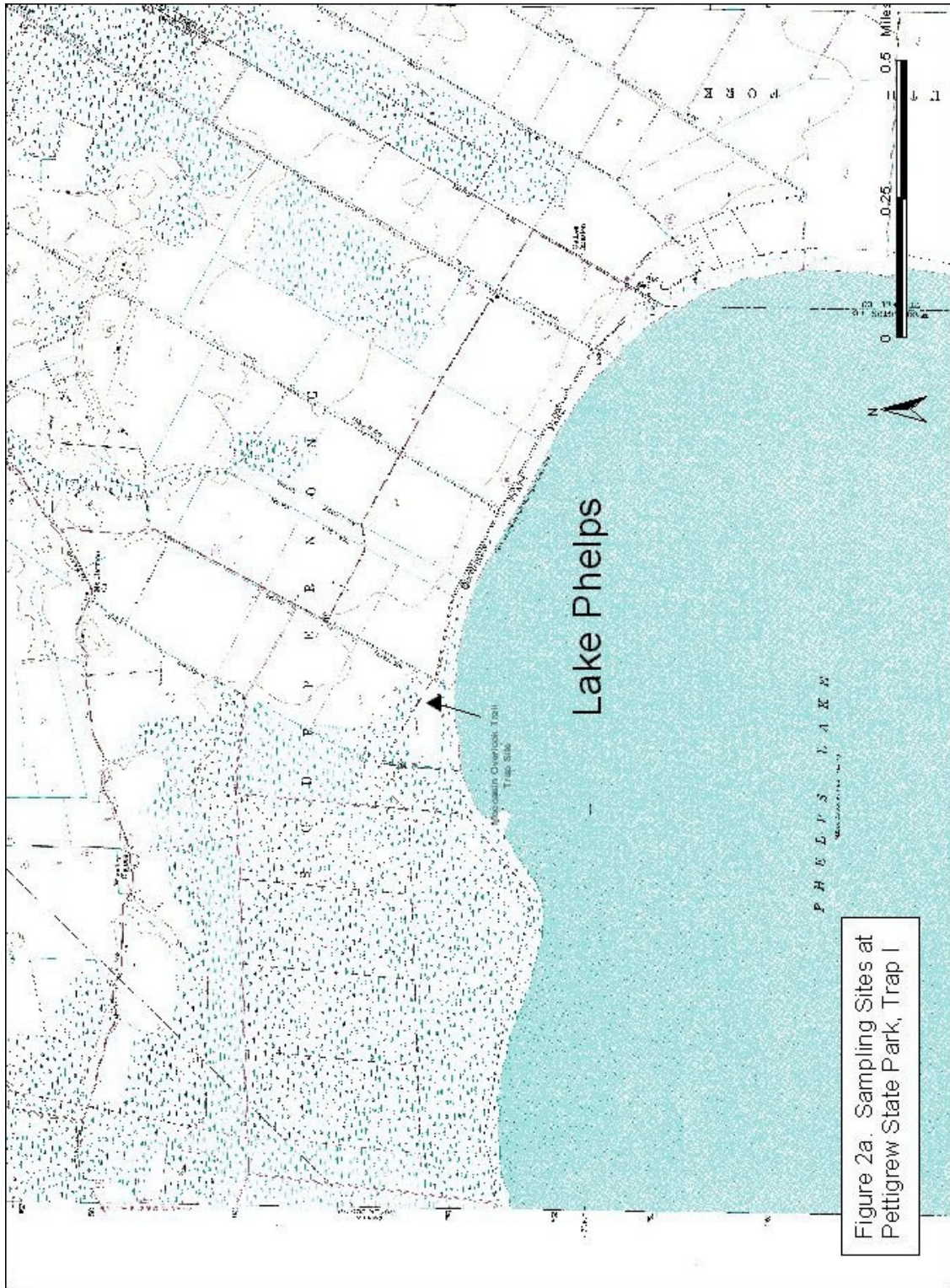


Figure 3a. Sampling Sites at Pettigrew State Park, Trap I

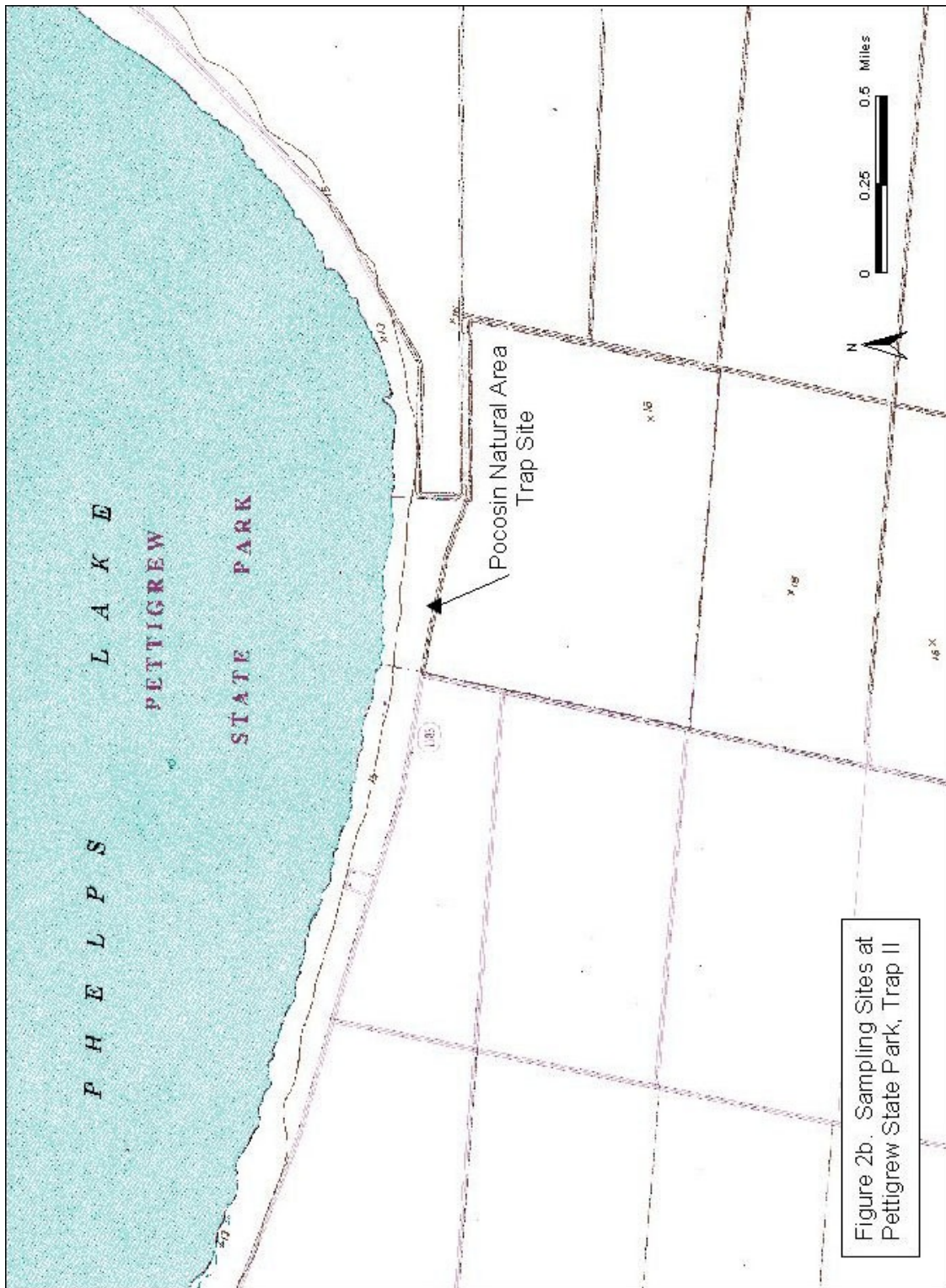


Figure 2b. Sampling Sites at Pettigrew State Park, Trap I

PETTIGREW STATE PARK

Habitat Features

The general environment of Pettigrew State Park is described in Wilson (1975), Lynch and Peacock, (1982), Biggs and Parnell (1989), and Landis (1991). Lake Phelps, the second largest natural lake in the state (16,600 acres) is the dominant natural feature of this park. Formerly, the lake was situated within vast tracts of pocosin, pond pine woodland, canebrakes, and other peatland communities. Now it is surrounded on three sides by corporate agricultural lands.

Trap Site I: Phelps Woods Natural Area

The portion of the park along the north shore of Lake Phelps contains a remnant stand of old growth forest representing primarily the Natural Lake Shoreline natural community (Schafale and Weakley, 1990). The trap site in this area was situated approximately 50' north of the Moccasin Overlook Trail, which runs through the area supporting the widest tract of this forest. The shoreline of Lake Phelps was located about 50 meters south of the trap site (Figure 2a).

This stand, which is contiguous to the registered Cypress Natural Area, is dominated by large, old bald cypress (*Taxodium distichum*), averaging 50 inches dbh and reaching as much as 14' in diameter and 120' in height (Lynch and Peacock, 1982; Landis, 1991). Swamp blackgum (*Nyssa biflora*), swamp cottonwood (*Populus heterophylla*), and willow (*Salix* sp.) also occur in the swampier ground near the lake, along with wetland shrubs such as buttonbush (*Cephalanthus occidentalis*) and Virginia sweetspire (*Itaea virginica*).

Away from the lakeshore, the stand grades into the Non-riverine Wet Hardwoods community type, particularly in the wider tract of forest located along the Moccasin Overlook Trail. Large tuliptree (*Liriodendron tulipifera*), sweetgum (*Liquidambar styraciflua*), and American elm (*Ulmus americana*) are common, forming a canopy that averages 90-100' in height. Large specimens of swamp chestnut oak (*Quercus michauxii*), red maple (*Acer rubrum*), hackberry (*Celtis laevigata*), mulberry (*Morus rubra*), and other hardwoods typical of poorly drained, mineral soils (Schafale and Weakley, 1990) also occur in this area.

The subcanopy throughout this site is dominated by abundant, tall (10-30') paw-paws (*Asimina triloba*). Switch cane (*Arundinaria tecta*) occurs in small patches, as does devil's-walkingstick (*Aralia spinosa*). Other common shrubs include American holly (*Ilex opaca*), beautyberry (*Callicarpa americana*) and spicebush (*Lindera benzoin*). The ground cover is dominated by the exotic Japanese honeysuckle (*Lonicera japonica*), although large patches of native herbs and vines also occur. Jewelweed (*Impatiens capensis*), netted chain fern (*Woodwardia areolata*), poison ivy (*Toxicodendron radicans*), Virginia creeper (*Parthenocissus quiquefolia*), cross-vine

(*Anisostichus capreolatus*), and rattan-vine (*Berchemia scandens*) are characteristic native species⁶.

Trap Site II. Pocosin Natural Area

The south side of Lake Phelps is bordered by an extensive area of peatlands, most of which was burned in a catastrophic fire in 1985 (Kirkman, 1993c). The state park includes an approximately 500 acre tract of this habitat, called the Pocosin Natural Area. The trap site in this tract was located in the middle of an unimproved road running through the center of this natural area (Figure 2b).

The dominant community type in the vicinity of the trap is Pond Pine Woodland. Much of this area was consumed in the fire and the vegetation now appears more typical of the High Pocosin community type: the site is dominated by a thick growth of evergreen shrubs with scattered pond pines only just beginning to emerge above them. Dominant species include loblolly bay (*Gordonia lasianthus*), red bay (*Persea palustris*), sweet bay (*Magnolia virginiana*), ti-ti (*Cyrilla racemiflora*), inkberry (*Ilex glabra*), gallberry (*I. coriacea*), fetter-bush (*Lyonia lucida*), zenobia (*Zenobia pulverulenta*), wax myrtle (*Myrica cerifera*), blaspheme-vine (*Smilax laurifolia*)⁷. Herbaceous species are essentially lacking in this peatland vegetation, although the road -- built on fill -- supports grasses and forbs. Black cherry (*Prunus serotina*) is another common, non-pocosin species that grows along this road.

A large freshwater marsh occurs approximately 0.2 miles north of the road along the margins of Lake Phelps. A few of the lepidoptera captured within the Pocosin Natural Area were strays from this habitat.

Rare or Poorly Known Lepidoptera

Fourteen rare or poorly known species collected in the park -- all moths -- are listed in the Table II. All except *Hemeroplanis* n. sp. have been collected during other NHP insect inventories conducted in the southern half of the North Carolina Coastal Plain.

⁶ More extensive plant lists are provided by Wilson (1975), Lynch and Peacock (1982), and Landis (1991).

⁷ See Allen and Repasky (1977) and Kirkman (1993c) for a more extensive description of the vegetation of this site.

Table II. NHP Element and Watch List Species Recorded at Pettigrew State Park

SPECIES	GRANK	SRANK	# Coll.
Significantly Rare Species			
<i>Metarranthis</i> sp. 1	GU	S2S3	11
<i>Callosamia securifera</i>	G4	S2S3	+ ⁸
<i>Dysgonia similis</i>	G?	S2S3	8
Watch List Species			
<i>Cleora projecta</i>	G?	S3?	2
<i>Caripeta aretaria</i>	G?	S3?	1
<i>Paonias astylus</i>	G?	S3S4	6
<i>Spilosoma dubia</i>	G?	S3S4	41
<i>Orgyia detrita</i>	G4	S3?	2
<i>Hemeroplanis</i> n. sp.	G?	SU	1
<i>Arugisa watsoni</i>	G?	S3?	1
<i>Lithacodia</i> n. sp.	GU	SU	3
<i>Argillophora furcilla</i>	G3G4	S2S3	2
<i>Acrapex relictta</i>	G?	S3?	1
Amphipyrinae, New Genus 2, Species 2	G?	S3S4	1

Habitat Indicator Guilds

Peatland Species

Eight of the fifteen species listed in Table II belong to the Acidic Shrubland Guild, which comes as close as any group to representing the peatland habitats of the park. These include *Metarranthis* sp. 1, *Callosamia securifera*, *Dysgonia similis*, *Cleora projecta*, *Paonias astylus*,

⁸ “+” indicate observations rather than collection data. In the case of *Callosamia securifera*, a cocoon was found in a sweetbay along the road through the Pocosin Natural Area.

Spilosoma dubia, and *Orgyia detrita*. As noted previously, *Dysgonia similis* appears to be close to the northern limit of its range in this area.

In general, this guild is well represented in the park. Other acidic shrub or peatland habitat indicators recorded from the Pocosin Natural Area include *Glena cognataria*, *Sphinx gordius*, *Argyrostroma flavistriaria*, *Argyrostroma sylvorum*, *Argyrostroma erasa*, *Argyrostroma deleta*, *Acrionicta tritona*, *Epiglaea apiata*, and *Anomogyna youngii*.

Although not a peatland species per se, the Georgia satyr (*Neonympha areolata septentrionalis*) often occurs in frequently burned, sedgy or grassy ecotones bordering pocosins. Its true habitat in this region may be low pocosin, which frequently contain sedgy openings. Its presence at the Pocosin Natural Area may be due to the openings created by the intense fire in 1985. This species appears to be rare within the state park and may be declining as the peatlands recover from the fire.

Another species possibly associated with heaths, although not necessarily with peatland habitats, is *Hemeroplanis* n. sp. This moth has been collected in the Sandhills Game Land and at Hanging Rock State Park, both areas with plenty of blueberries but little wetland habitat of any sort. Host plants for other members of this genus are unknown.

Canebrake Species

Three species listed in Table II belong to the Canebrake Guild: *Argillophora furcilla*, *Acrapex relictus*, and Amphipyridae, New Genus 2, Species 2. All were recorded from the Pocosin Natural Area, where cane is scattered throughout but mostly suppressed by the thick growth of shrubs. *Argillophora furcilla* was also collected at Trap Site I where cane was more conspicuous although still patchy. Other canebrake species include the Southern Pearly Eye (*Enodia portlandia*), which was observed at both sampling sites, and the Yehl Skipper (*Poanes yehl*) and Lace-winged Roadside-skipper (*Amblyscirtes aesculapius*), which were recorded during butterfly counts conducted in the vicinity of Lake Phelps.

Lakeshore and Wet Forest Species

Two species listed in Table II -- *Arugisa watsoni*, and *Lithacodia* n. sp. -- appear to be associated with forested wetlands, although too little is known about these moths to be certain of their habitat affinities. More clearly associated with the lakeshore forests along Lake Phelps are species belonging to the Cypress Swamp, Riparian, and Bottomland Hardwood Guilds.

Members of the Cypress Swamp Guild collected in the park include *Semiothisa aequiferaria*, *Anacamptodes pergracilis*, *Isoparce cupressi*, *Cutina albopunctella*, *Cutina aluticolor*, and *Cutina arcuata*. Riparian moths include *Semiothisa gnopharia*, *Clostera inclusa*, *Furcula cinerea*, and *Colobochyla interpuncta*. The Viceroy, a riparian butterfly, has been observed during 4th of July counts conducted around Lake Phelps (LeGrand, 1996, 1997, 1998).

Bottomland hardwood species include the zebra swallowtail (*Eurytides marcellus*), a pawpaw-feeding species whose flights – numbering in the hundreds or even thousands – are one of most spectacular natural history sights at the park. Additionally, two hackberry-feeding species have been recorded in butterfly counts in this area: American snout (*Libytheana bachmanii*) and Tawny Emperor (*Asterocampa clyton*) (LeGrand, 1996, 1997).

One additional moth species, *Homophoberia cristata*, is restricted to the lakeshore even more closely than the species listed above: as mentioned previously, its larvae feed on yellow pond lily (*Nuphar luteum*).

Management Concerns

Gypsy Moths

The gypsy moth is potentially a serious concern within this park, given the amount of oaks present in the Nonriverine Wet Hardwood community adjoining Lake Phelps. Damage caused by defoliation could be especially severe to these old-growth stands.

Based on data collected in a study of nontarget impacts of *Bt* conducted in the southeast Coastal Plain of North Carolina (Hall, et al., 1999), at least 145 species of the macro-moths recorded at Pettigrew State Park are considered to be at moderate to high risk from *Bt*, including 6 species of conservation concern and 13 additional species in the habitat indicator guilds described above.

Several of these species are associated with Pond Pine Woodlands, however, and should be at little risk. Peatlands in general do not contain oaks or other preferred host plants of the gypsy moth. They are probably safe from treatment except in extreme outbreaks, when even pocosin shrubs might become secondarily infested. This group includes all six of the species of conservation concern considered to be at risk from *Bt*: *Cleora projecta*, *Caripeta aretaria*, *Callosamia securifera*, *Spilosoma dubia*, *Orgyia detrita*, and *Dysgonia similis*. It also contains 11 of the 13 additional guild members at risk.

Subtracting the Pond Pine Woodland species leaves three members of the Cypress Swamp Guild at risk: *Semiothisa aequiferaria*, *Anacamptodes pergracilis*, and *Isoparce cupressi*; and two members of the Riparian Guild: *Clostera inclusa* and *Colobochyla interpuncta*. None of these are rare and suitable habitat exists fairly close outside the park, along the Scuppernong River. If these species become extirpated from the park due to application of *Bt*, they are likely to eventually recover.

More likely to be a significant causality of *Bt* treatment is the zebra swallowtail. Although butterflies were not included in the analysis conducted by Hall, et al. (1999), they are known to be among the most sensitive groups of species to *Bt*. Swallowtails may be especially vulnerable. In one field study, tiger swallowtails showed mortality from *Bt* even 30 days following application, long after its effects become essentially zero for other species (Johnson, et al.,

1995). Given that the first flight of the zebra swallowtail occurs in late March, larvae would definitely be present during April and May, the normal time when *Bt* is applied in northeastern North Carolina to suppress gypsy moth outbreaks. Mortality to the swallowtail might therefore be quite severe.

The next known large concentration of pawpaw is in the East Dismal Swamp, approximately six miles to the west of the park. Smaller amounts of pawpaw may be present in the Scuppernon River floodplain. In either case, large expanses of agricultural lands would have to be traversed for colonization to occur from these sources, probably hampering recovery if the species becomes extirpated from the park.

With a strong need to protect the old-growth stands but minimize the risk to vulnerable Lepidoptera, we recommend that the lakeshore forests around Lake Phelps be closely monitored for the presence of the gypsy moth and consideration be given to using pheromone flakes and *Entomophaga maimaiga* to treat low-level infestations as soon as they are discovered.

Prescribed Burning

No prescribed burning is currently conducted at Pettigrew State Park. Several communities within the park are fire-dependent, however, including canebrakes and Pond Pine Woodland. While conducting prescribed burns in peatland habitats is still in the early experimental stage, burning of woodland canebrakes has been shown to be effective in maintaining vigorous growth (Hughes, 1957).

If canebrake restoration is attempted, the rules of thumb regarding fire refugia mentioned under General Management Issues should be followed. One mitigating circumstance is that all of the cane species recorded thus far at Pettigrew State Park were recorded on both sides of the lake, in peatland habitats as well as the forests. There thus appears to be no shortage of refugia for these species, both within the park and in even larger tracts located outside (e.g., in the Pocosin Lakes National Wildlife Refuge).

Information Needs

All of the major types of habitat found in the park were included in this survey. While more species could be added with greater survey intensity, the species lists recorded for both the peatland and lowland forest communities in the park compare well with those produced by more thorough insect surveys conducted in similar habitats in southeastern North Carolina.

Several more canebrake species can be expected to occur within the park, however, and should be particularly looked for, since their discovery could help guide decisions regarding management of canebrake habitats.

Baiting was not conducted in the park and several underwing moths can be expected to be discovered by this method, as well as a number of winter noctuids. At least a few rare species in these groups, such as *Catocala marmorata* – a species that feeds on swamp cottonwood – could turn up that would have some bearing on management decisions, particularly the use of *Bt* to control the gypsy moth.

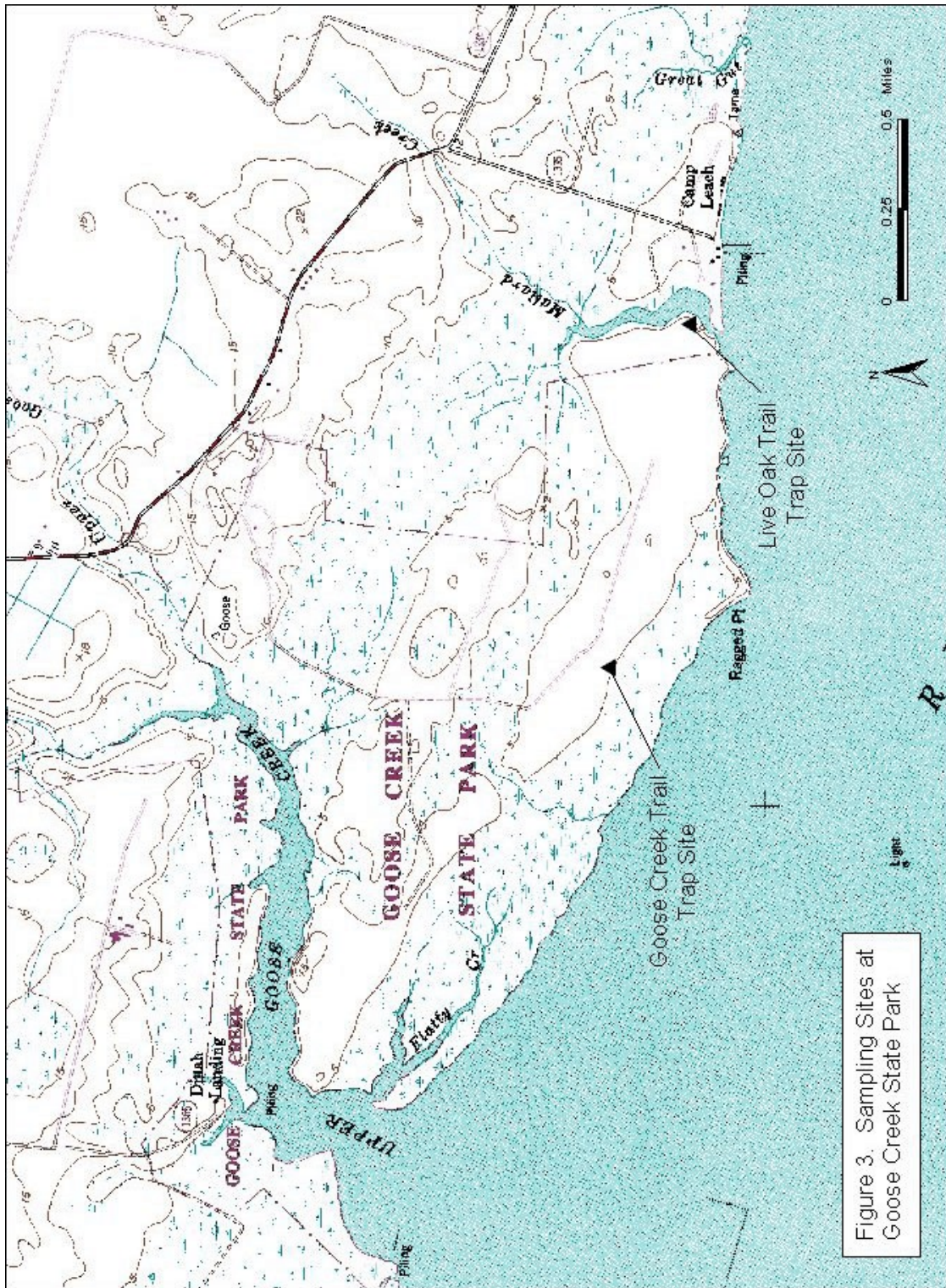


Figure 3. Sampling Sites at Goose Creek State Park

GOOSE CREEK STATE PARK

Habitat Features

Located on Pamlico Sound, Goose Creek State Park contains significant remnants of the estuarine fringe communities that once dominated the shorelines of the sounds (Biggs and Parnell, 1989). Extensive examples of these communities present in the park include Tidal Freshwater Marsh, Tidal Cypress-gum Swamp, and Estuarine Fringe Loblolly Pine Forest. Additionally, a small area of the shoreline supports a stand of Coastal Fringe Evergreen Forest, characterized by the presence of live oak (*Quercus virginiana*).

Just inland from these wetlands are a series of low sand ridges that formerly supported upland communities dominated by longleaf pine (*Pinus palustris*). Due to past logging and fire suppression, most of these ridges are now occupied by mature stands of loblolly pine forest. Scattered longleaf pines still occur in some areas, and red-cockaded woodpeckers (*Picoides borealis*) have recently been spotted in the park after a period of absence. Restoration of this habitat through use of prescribed burning is emphasized in the park's management plan.

Trap Site I. Goose Creek Trail.

The trapping station along the Goose Creek Trail was located in an ecotonal area between a stringer of Tidal Cypress-Gum Swamp Forest and the upland community dominated by loblolly pines (Figure 3). The ecotone itself was dominated by switch cane (*Arundinaria tecta*), individual stems of which reaching over 6' high and over 0.5" in diameter.

Characteristic species of the swamp include bald cypress, water tupelo (*Nyssa aquatica*), swamp red bay (*Persea palustris*), sweetgum, wax myrtle, and lyonia (*Lyonia* sp.). In addition to the dominant loblolly pines -- most individuals of which are quite large and over 100 years in age -- other tree species occurring on the upland ridge include southern red oak (*Quercus falcata*), shortleaf pine (*P. echinata*), mockernut hickory (*Carya tomentosa*), and American holly. Silky camellia (*Stewartia malacodendron*) is a distinctive member of the shrub layer in this community. Most of the trees in this area support extensive festoons of Spanish-moss (*Tillandsia usneoides*). The herb layer throughout this area is sparse.

Trap Site II. Live Oak Trail.

The second trapping station was located close to the shoreline at the eastern end of the park. The trap site itself was located within a seasonally-flooded swale separated from the sound by a narrow sandridge. Young bald cypress are the dominant trees at this site, but portions of the swale support extensive patches of cane, sawgrass (*Cladium mariscus*) and other herbaceous wetland species. Towards the east, where the swale joins Mallard Creek, dwarf palmetto (*Sabal minor*) and red cedar (*Juniperus virginiana*) occur. Tidal Freshwater Marsh occurs at the mouth of the creek.

The sandridge along the sound supports the sole tract of Coastal Fringe Evergreen Forest in the park, hence the name Live Oak Trail for the path that runs along this ridge. Only a thin fringe of live oaks occurs along the sound, however, and the vegetation is otherwise similar to the sandridges located further inland. Extensive patches of grasses occur in some areas along the trail towards the Ragged Point Picnic Area.

Ragged Point Trail.

Although the Tidal Freshwater Marsh community was not sampled intensively for moths, several daytime searches for butterflies were made along the Ragged Point Trail, whose outer portion consists of a boardwalk extending through an extensive area of this habitat (Figure 3). This community is by far the most diverse of any that occur within the state park, particularly with respect to herbaceous species. Dominant graminoids include giant cordgrass (*Spartina cynosuroides*), sawgrass, wild rice (*Zizania aquatica*), and narrow-leaf cattail (*Typha angustifolia*). Shrubs such as groundsel tree (*Baccharis halimifolia*), red cedar, wax myrtle, loblolly bay, and rose mallow (*Hibiscus moscheutos*) are scattered throughout, as are numerous wildflowers, including climbing hempweed (*Mikania scandens*), morning glory (*Ipomoea sagitta*), cardinal flower (*Lobelia cardinalis*), and joe-pye weed (*Eupatorium fistulosum*) (see Burney, 1975, for a more complete plant list).

Rare or Poorly Known Lepidoptera

Ten species on the NHP Element or Watch Lists were identified within the park. The rarest is Duke's Skipper (*Euphyes dukesi*), a butterfly associated with shaded freshwater marshes and known from only a few colonies in North Carolina. Also noteworthy is the cypress-feeding species *Anacamptodes cypressaria*, only one specimen of which was obtained during this survey (this species has subsequently been found at the Dare County Bombing Range and along the lower Roanoke River floodplain). *Euagrotis lubricans*, if the specimen collected is confirmed to belong to that species⁹, was also represented in this survey by the single specimen obtained at this park. This species is believed to be associated with wiregrass and seems out of place this far north (unless wiregrass is still hanging on somewhere in the vicinity).

⁹ Moths identified as *E. lubricans* may actually represent two or more species (Donald LaFontaine, pers comm.).

Table III. NHP Element and Watch List Species Recorded at Goose Creek State Park

SPECIES	GRANK	SRANK	# Coll.
Significantly Rare Species			
Duke's Skipper (<i>Euphyes dukesi</i>)	G3G4	S2?	+
<i>Anacamptodes cypressaria</i>	G?	S2S3	1
<i>Euagrotis lubricans?</i>	G4	S3?	2
Watch List Species			
<i>Idaea violacearia</i>	G4	S3?	3
<i>Scopula cacuminaria</i>	G?	S3?	1
<i>Orgyia detrita</i>	G4	S3?	5
<i>Lithacodia</i> n. sp.	GU	SU	3
<i>Papaipema</i> n. sp. 3	G4?	S3?	3
<i>Acrapex relictata</i>	G?	S3?	1
Amphipyrinae, New Genus 2, Species 2	G?	S3S4	3

Habitat Indicator Guilds

Lowland Forests

Guilds associated with low-lying, seasonally flooded forests were well represented in this park. Seven members of the Cypress Swamp Guild were recorded, including *Semiothisa aequiferaria*, *Anacamptodes cypressaria*, *Anacamptodes pergracilis*, *Cutina distincta*, *Cutina albopunctella*, *Cutina arcuata*, and *Isoparce cupressi*. Members of the Riparian Guild included *Furcula cinerea*, *Colobochyla interpuncta*, *Acronicta connecta*, *Clostera inclusa*, *Semiothisa gnophosaria*, and *Catocala cara*. Zebra Swallowtails and American Snout butterfly represent the Bottomland Hardwood Guild. An additional noteworthy species probably associated with wet forests is *Lithacodia* n. sp., which is on the NHP Watch List.

Canebrake

Three of the rare or poorly known species listed above belong to Canebrake Guild: *Papaipema* n. sp. 3, *Acrapex relictus*, and Amphipyridae, New Genus 2, Species 2. Additional members of this guild include Southern Pearly-eye (*Enodia portlandia*) and Creole Pearly-eye (*Enodia creola*).

Dry Woodlands

Species characteristic of the dry sandy ridges include the following members of the Dry Woodland Guild: *Monoleuca semifascia*, *Idaea violacearia*, *Stenaspilatodes antidiscaria*, *Eucoptocnemis fimbriaris*, *Crambidia lithosioides*, *Cisthene subjecta*, and *Bleptina inferior*. Only *Idaea violacearia* is considered to be of conservation interest, and is included on the NHP Watch List.

The specimen tentatively identified as *Euagrotis lubricans* can also be included in this group, if that is what it actually is. *Euagrotis lubricans* is a characteristic member of longleaf pine sandhills, although it also occurs in wetter habitats such as savannas and flatwoods. As mentioned previously, it probably feeds on wiregrass.

Estuarine Fringe Evergreen Forest

Despite the fact that only a thin line of live oaks are present in this park, four species belonging to the Maritime Forest and Shrub Guild were collected along Live Oak Trail: *Cymatophora approximaria*, *Heterocampa astarte*, *Panopoda repanda*, and *Metria amella*. It should be noted, however, that these are the most widely distributed members of this group. None are considered to be of conservation concern generally, although their populations in this park are probably separated from their nearest neighbors by a substantial distance.

Marsh

Although marsh habitat was sampled only on a limited basis in this inventory, one rare species, Duke's Skipper (*Euphyes dukesi*) was recorded in this park, along with several other species typical of this habitat. Other members of the Marsh and Wet Swale guild recorded in the park included Least Skipper, Broad-winged Skipper, *Leucanopsis longa*, *Macrochilo hypocritalis*, *Ledaea perditalis*, *Doryodes spadaria*, *Simyra henrici*, and *Leucania linita*. Additional species characteristic of the marshes in the park include species associated with southern red cedar (*Juniperus silicicola*): Juniper Hairstreak (*Mitoura gryneus*), *Patalene olynzonaria puber*, and *Glena plumosaria*.

Acidic Shrubland

Although there are no extensive peatlands present within this park, patches of heaths, hollies, and other acidic shrubs are scattered throughout, supporting a modest community of the Acidic Shrubland Guild. The eight species in this group recorded at Goose Creek include *Glena cognataria*, *Argyrostromis flavistriaria*, *Argyrostromis sylvarum*, *Argyrostromis erasa*, *Argyrostromis deleta*, *Nola clethrae*, *Acrionicta tritona*, and *Anomogyna youngii*. These are among the most widely distributed species in this guild and none are considered of conservation concern.

Management Concerns

Fire Management

Prescribed burning is currently used as a management tool at Goose Creek State Park to restore habitat on the dry sandy ridges. Prescribed burns eventually may be used to help maintain marsh vegetation, particularly to combat invasion of woody species or Phragmites.

The Canebrake Guild includes the Lepidoptera most likely to be affected by prescribed burns in this park. While cane itself benefits from occasional burning – particularly on a ten to twelve year rotation (Hughes, 1957) – none of the Lepidoptera that feed on it are likely to survive a fire. Our recommendation, therefore, is that the rules of thumb listed under General Management Issues be followed: (1) avoid burning more than a third of the cane in a given area during a single year; (2) allow enough time between burns to allow for recolonization of recently burned patches.

These same recommendations also apply to the marshes if they are ever subjected to burning. Particular attention should be given to areas supporting the highly localized Duke's Skipper.

Gypsy Moths

This park contains a sufficient number of oak, willow, and sweetgum -- preferred host plants of the gypsy moth – to support an infestation. All habitats within the park, including patches of woody species within the marshes, are potentially vulnerable to either the effects of gypsy moth defoliations or the effects of treatment with *Bt*.

Based on data collected in a study of nontarget impacts of *Bt* conducted in the southeast Coastal Plain of North Carolina (Hall, et al., 1999), at least 156 species of the macro-moths recorded at Goose Creek State Park are considered to be at moderate to high risk from *Bt*. These include two species of conservation concern, *Orgyia detrita* and *Euagrotis lubricans*, and an additional 17 species in the habitat indicator guilds described above.

Particularly at risk would be members of the Maritime Forest and Shrub guild, since little, if any of the areas surrounding the park contain this habitat. Species at risk include all four of the members of this recorded in the park: *Cymatophora approximaria*, *Heterocampa astarte*, *Panopoda repanda*, and *Metria amella*.

Euagrotis lubricans, if tied to any remnant patches of wiregrass in the park, would also be at high risk of permanent extirpation from the park. For other guild members, however, enough habitat probably exists close to the park to provide a source of recolonists (provided the surrounding areas are not also treated with *Bt*).

Butterflies were not included in the analysis conducted by Hall, et al. (1999) but are known to be among the most sensitive groups of species to *Bt*. One of the most vulnerable species in the park may therefore be Duke's Skipper, which would certainly be present as a larva during April and May, the time when *Bt* is normally applied to control the gypsy moth in northeastern North Carolina. Given the extremely high degree of localization in this species – only four colonies are currently known in the entire state – loss of the population at Goose Creek might be irrecoverable and a significant loss for the entire state.

Given these concerns, we recommend that monitoring be conducted within the park on a regular basis. Strong consideration should be given to using pheromone flakes and *Entomophaga maimaiga* to treat low-level infestations as soon as they are discovered.

Information Needs

The marshes were not directly sampled within the park and have a high potential for discovery of new species, including Natural Heritage Elements.

Canebrake habitats were sampled relatively thoroughly, although several members of the canebrake guild were not collected. More intensive inventory of cane-containing habitats may therefore yield more species, again including several Natural Heritage Elements.

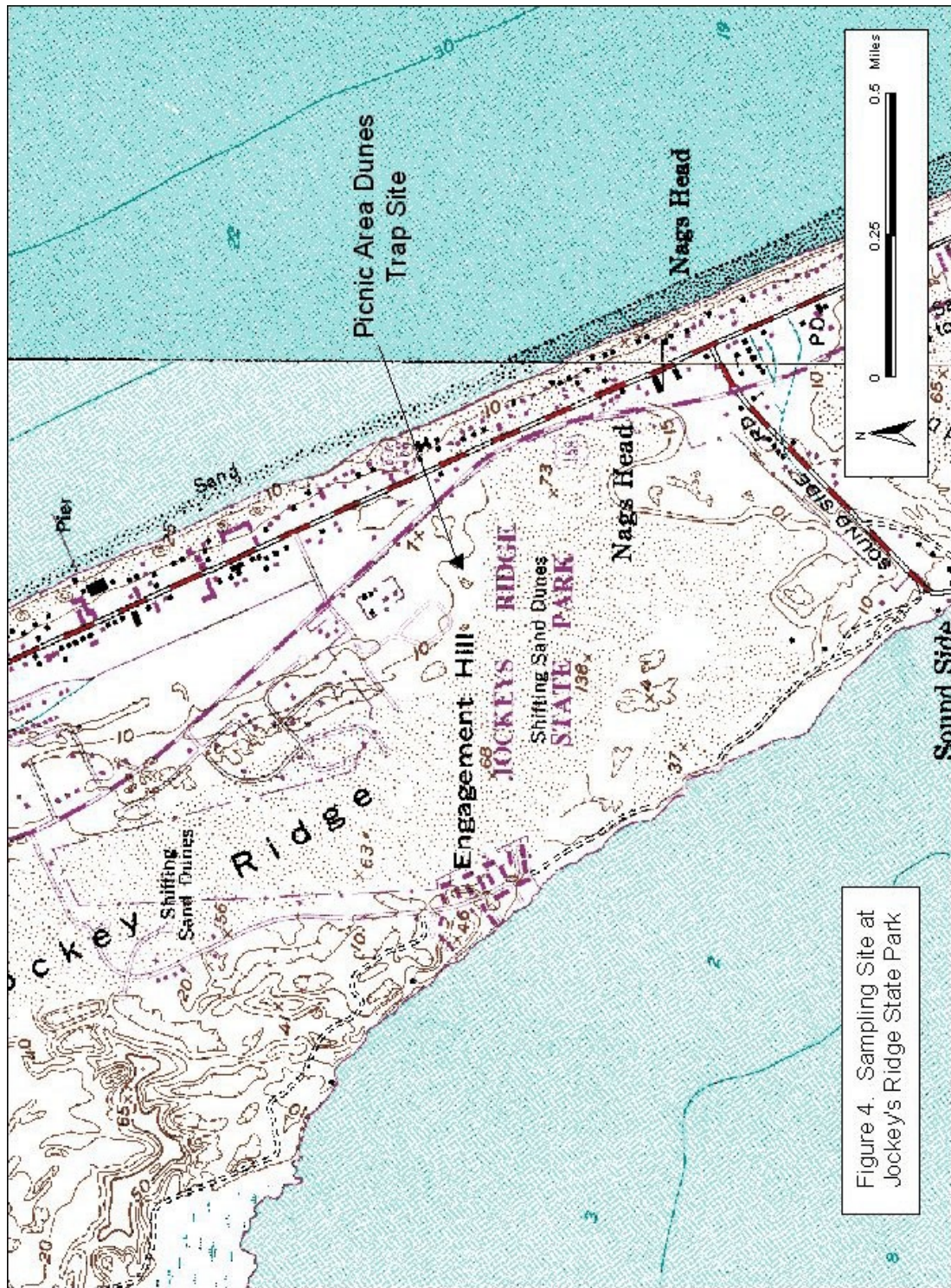


Figure 4. Sampling Site at Jockey's Ridge State Park

JOCKEY'S RIDGE STATE PARK

Habitat Features

This park is dominated by largest active sand dune in the eastern United States. While most of the dune itself is unvegetated, the park also contains examples of several maritime natural communities. Apart from a small area of Maritime Deciduous Forest located west of the main dune, most of the lower dunes and flats support maritime grassland or shrub communities, including the following: Dune Grass, Maritime Dry Grassland, Maritime Wet Grassland, Salt Marsh, and Maritime Shrub (see Kirkman, 1993b, and Biggs and Parnell, 1989 for a description of the natural features of this park).

Trap Site: Picnic Area Dunes.

Due to the heavy human usage of this site, sites where a trap could be secluded were few in number. Only one site was finally chosen for sampling, located in a fairly dry area near the south end of the picnic area and just east of the main dune (Figure 4).

The trap was placed between dense thickets of shrubs and a low sandy open area located in an interdune flat. In addition to the perennial bunch grasses and other sparse herbaceous growth characteristic of the Maritime Dry Grassland Community, the open area at this site supports a fairly extensive patch of woolly beach heather (*Hudsonia tomentosa*), a low shrub that reaches the southern limit of its range in this park. Species characteristic of the adjoining Maritime Shrub community include wax-myrtles (*Myrica cerifera* and possibly *M. pennsylvanica*), stunted live oaks (*Quercus virginiana* or perhaps *Q. geminata*), yaupon (*Ilex vomitoria*), and greenbriars (*Smilax* spp.). Also present in these thickets are black cherry (*Prunus serotina*), serviceberry (*Amelanchier* sp.), poison ivy (*Toxicodendron radicans*), and muscadine grape (*Vitis rotundifolia*). A slightly taller stand located in a wetter area within 30 ft of the site contains loblolly pines, pond pines (*Pinus serotina*), and willows (*Salix* sp.).

Rare or Poorly Known Lepidoptera

Two species listed as Significantly Rare by the Natural Heritage Program were collected, along with four species on the Watch list (Table IV). The rarest species was *Metarranthis lateritiaria*, a species probably associated with acidic shrublands; only one specimen was collected. More typical of the vegetation in this park is *Zale declarans*, which appears to be associated with maritime shrub communities. Six specimens were collected in this park but not at other sites, including Nag's Head Wood Ecological Preserve, which contains a much larger tract of Maritime Evergreen Forest.

Table IV. Significantly Rare and Watch List Species Recorded at Jockey’s Ridge State Park

SPECIES	GRANK	SRANK	# Coll.
Significantly Rare Species			
<i>Metarranthis lateritiaria</i>	G3G4	S1S3	1
<i>Zale declarans</i>	G5	S2S3	6
Watch List Species			
<i>Nemoria bifilata bifilata</i>	G?	S3?	2
<i>Orgyia detrita</i>	G4	S3?	1
<i>Faronta rubripennis</i>	G3G4	S2S3	17
<i>Ulolonche modesta</i>	G?	SU	3

Habitat Indicator Guilds

Maritime Forest and Shrub

In addition to *Zale declarans*, members of the Maritime Forest and Shrub guild recorded in the park include *Cymatophora approximaria*, *Heterocampa astarte*, and *Panopoda repanda*. *Metria amella*, recorded at both Goose Creek State Park and Nag’s Head Woods Ecological Preserve, may turn up at Jockey’s Ridge if more sampling is conducted. Giant Swallowtail (*Papilio cresphontes*), another maritime species, is less likely, given that its host plant, *Zanthoxylum clava-hercules* is more associated with closed-canopy maritime forests than the shrubbier habitats present at Jockey’s Ridge.

Open Dune

This was the only area included in the survey that contained any open dune habitat. Five members of this guild were recorded at Jockey’s Ridge, including *Faronta rubripennis*, *Leucania extincta*, *Leucania phragmitidicola*, *Agrotis vetusta*, and *Euxoa detersa detersa*. *Faronta rubripennis* is included on the NHP Watch List as perhaps should other members of this guild.

Dry Woodland

Seven members of this guild were recorded in the park, including *Stenaspilatodes antidiscaria*, *Cisthene subjecta*, *Bleptina inferior*, *Hemeroplanis scopulepes*, *Elaphria festivooides* complex, *Ulolonche modesta*, and *Eucoptocnemis fimbriaris*. Especially noteworthy are *Ulolonche modesta*, which is on the NHP Watch List, and *Bleptina inferior*, a species that appears to be

particularly abundant in xeric maritime habitats, although it also occurs in other types of dry forests.

Marsh and Wet Swale

The park contains an extensive area of marsh bordering Albemarle Sound, as well as several wet swales supporting herb-dominated communities. The trap site was located in the drier portion of the park and only following three species belonging the Marsh and Wet Swale guild were collected: *Macrochilo hypocriticalis*, *Doryodes spadaria*, and *Leucania linita*. *Semiothisa continuata*, associated with southern red cedar, another marshland plant, was also recorded at this site.

Acidic Shrubland

Only small areas of wetlands within the park support heaths, pond pines, and species characteristic of peatland habitats. Only three members of the Acidic Shrubland guild were collected in the park: *Episemasia solitaria*, *Metarranthis lateritiaria*, and *Catocala praeclara*. All three of these species probably feed on upland heaths or hollies and are not necessarily highly tied to peatland habitats.

Management Concerns

Gypsy Moth

The gypsy moth is already established in the vicinity of this park. A low level infestation has existed for several years at Nag's Head Ecological Preserve and a male gypsy moth was captured within Jockey's Ridge State Park during the survey.

Based on data collected in a study of nontarget impacts of *Bt* conducted in the southeast Coastal Plain of North Carolina (Hall, et al., 1999), at least 77 species of the macro-moths recorded in the park should be considered at moderate to high risk from *Bt*. These include both NHP element species collected in the park, *Metarranthis lateritiaria* and *Zale declarans*; two Watch List species, *Nemoria bifilata* and *Orgyia detrita*; and 11 other species in the following habitat indicator guilds: Acidic Shrubland, Dry Woodland, Maritime Forest and Shrubland, and Marsh and Wet Swale.

Most of the habitats used by these guilds are still well-distributed along the Outer Banks, although all are becoming reduced, fragmented and degraded by development. Currently, there is too little information to judge whether recolonization would be difficult for any of the species listed above if they became extirpated through use of *Bt*.

The same is true for the most distinctive guild represented in the park, Open Dune. Although the species in this guild were not considered in the analysis conducted by Hall, et al. (1999),

application of the same criteria used in that report indicates that *Leucania extincta* would be at high risk, and that *Leucania phragmitidicola*, *Agrotis vetusta*, and *Euxoa detersa* would be at moderate to high risk (Dale Schweitzer, pers. comm.). Habitat occupied by this group, however, is least likely to be treated for the gypsy moth, although drift of *Bt* or other pesticides could occur where patches of woody vegetation are located adjacent to open dunes.

Even a moderate amount of risk to these species may be sufficient argument against the use of *Bt* at this particular park. Thus far, there is no strong evidence that the gypsy moth does well in maritime evergreen habitats. The infestation at Nags Head Woods Ecological Preserve may be subsisting more on the deciduous oaks present in that preserve than on live oak. In any case, no serious defoliating outbreaks have yet taken place within this area. We recommend on the basis of this information, that no treatment be the preferred alternative at this park, even if small numbers of the gypsy moth occasionally turn up. In any area-wide treatment for large outbreaks, we recommend that Gypchek be used to treat areas within the park or that only spot applications of *Bt* be used, applied on the ground rather than aerially.

Fire Management

Prescribed burning is not currently used at this park as a management tool and none of the habitats appear to be fire-maintained. If control of *Phragmites* through use of prescribed fire is considered, we recommend that the rules of thumb given under General Management Issues be followed to minimize the impacts to Lepidoptera and other fire-sensitive species.

Light Pollution

The close proximity of Jockey's Ridge to extensive development may contribute to the isolation of its nocturnal insect populations. The rate of immigration into the park is likely to be smaller than it was before development, due both to light pollution as well as direct loss of natural communities. As mentioned in the Introduction, such isolating effects contribute to population instability and turn-over in small preserves, particularly following major disturbance events.

While there is little the park can do to prevent encroachment of development and outdoor lighting, we recommend that lighting within the park be kept to a minimum and that low voltage, well-shielded fixtures be preferred over high-intensity flood-lamps.

Information Needs

The use of only a single trap limited the amount of data collected at this park. Further limiting the effectiveness of the sampling was the frequently windy conditions that prevailed at the trap site, which often reduced the amount of ethyl acetate fumes within the trapping bucket below lethal levels, allowing many moths to escape.

More intensive and more effective sampling could lead to a significant increase in the species list. Habitats that could use more effort include the marsh, which was not sampled directly, and the open dune habitat. Even though the trap was placed in an area containing well-developed dune vegetation, several species were missed that belong to the Open Dune guild. One species that was especially targeted for this survey was *Drasteria graphica*, a maritime species whose only recorded host plant is woolly beach heather (*Hudsonia tomentosa*), a patch of which was located adjacent to the trap. Other dune species that could turn up in the park include *Ommastola linteri*, *Faronta aleada*, and *Euxoa violaris*. Discovery of any of these species, all of which are rare in North Carolina, would have a bearing on management decisions.

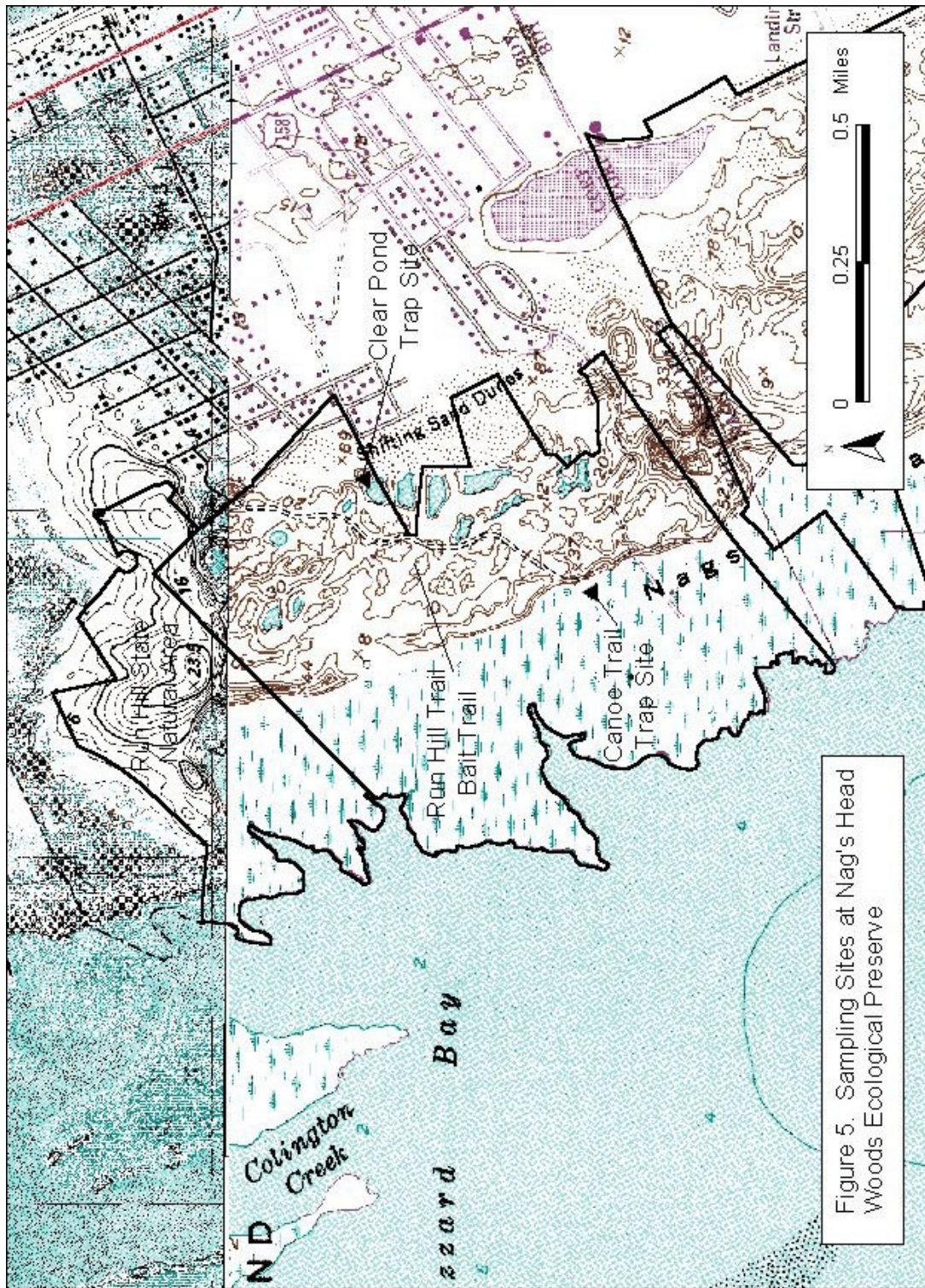


Figure 5. Sampling Sites at Nag's Head Woods Ecological Preserve

NAG'S HEAD WOODS

Habitat Features

Nag's Head Woods Ecological Preserve, owned by the Nature Conservancy, is located on the west side of Bodie Island, one of the widest of the barrier sandbanks that compose the North Carolina Outer Banks. The ecological features of the preserve have been well described in a number of reports, including Atkinson and List (1978), Otte, et al. (1984), Burney and Burney (1984), and Lopazanski et al. (1988).

Most of the preserve is covered with upland forests growing on long-stabilized aeolian dunes. In addition to such characteristic species of maritime forests as live oak (*Quercus virginiana*), sand laurel oak (*Q. hemisphaerica*), Hercules club (*Zanthoxylum clava-hercules*), and loblolly pine (*P. taeda*), a number of deciduous hardwoods are present or even dominant at this site that are widespread throughout the Eastern Deciduous Forest. Common species include southern red oak (*Q. falcata*), post oak (*Q. stellata*), beech (*Fagus americanus*), red hickory (*Carya ovalis*), mockernut hickory (*C. tomentosa*), red maple (*Acer rubrum*), American holly (*Ilex opaca*), flowering dogwood (*Cornus floridana*), ironwood (*Carpinus caroliniana*), and hop-hornbeam (*Ostrya virginiana*).

Collectively this assemblage has been identified as the Deciduous Maritime Forest natural community by Schafale and Weakley (1992). The stand at Nag's Head Woods is considered the exemplar of this community type, and according to palynological research done by Burney and Burney (1984), probably has existed on this site for at least the past 400 years and may possibly be a relict from the end of the Pleistocene. The relict status of this forest is also indicated by the overall diversity of its mainland-typical plant species (Burk, 1962).

Relict longleaf pines are also found on a few of the ridges and xeric habitats occur on the east side of the dunes and to the north, where the large, active dune known as Run Hill adjoins the preserve. This suggests that fire may have once played an important ecological role within this area, at least along the driest ridges. The presence of mesic hardwoods, on the other hand, suggests the opposite.

In addition to the upland forests, numerous interdune ponds and wetland flats are among the most distinctive ecological features of this preserve. The biology of the ponds has been extensively described in the reports mentioned above as well as in a symposium on interdunal, maritime forest ponds (Symposium, 1988). The flats and shallower examples of these ponds support stands of sweetgum (*Liquidambar styraciflua*), swamp blackgum (*Nyssa biflora*), willow oak (*Q. phellos*), red maple, and loblolly pine. Deeper ponds have expanses of open water, with emergent or floating herbaceous species around their margins (e.g., *Typha*, *Nymphaea*, and *Potamogeton*). Black willow (*Salix nigra*) is another common component of the pond-edge vegetation. No bald cypress (*Taxodium distichum*) occur within the preserve, however, although

this species is present at Kill Devil Hills Woods to the north and on Roanoke Island west across the Roanoke Sound.

On the western side of the preserve, the upland forest and interdune ponds give way to a narrow but lengthy tract of Maritime Swamp Forest, dominated by redbay (*Persea palustris*), red maple, swamp blackgum, and switch cane. The swamp forest is replaced, in turn, by a large expanse of Salt Shrub and Salt Marsh natural communities located along the sound.

Trap Site I: Clear Pond.

The Maritime Deciduous Forest community was sampled at a site located on the east side of a large interdune pond named Clear Pond (Figure 5). Southern red oak and loblolly were the dominant tree species on the slopes above the pond. Other members of the canopy included sweetgum and blackgum (*Nyssa sylvatica*), and red maples and sassafras (*Sassafras albidum*) were present as transgressives. Shrubs and vines present around the trap site included ironwood (*Carpinus caroliniana*), hop-hornbeam (*Ostrya virginiana*), flowering dogwood (*Cornus florida*), American holly, blueberry (*Vaccinium* sp.), poison ivy, greenbrier (*Smilax* sp.), and Virginia creeper (*Parthenocissus quinquefolia*). Apart from partridgeberry (*Mitchella repens*), herbs were insignificant.

The trap was situated approximately 45' from the edge of Clear Pond. Willow oak, sweetgum, red bay, swamp blackgum and southern wax myrtle (*Myrica cerifera*) were present along the margins of the pond. Spanish moss was frequent in the trees throughout the area.

Trap Site II: Canoe Trail.

A second trapping station was established in an ecotonal area between Maritime Swamp Forest and the Maritime Deciduous Forest, just off the Conservancy's Canoe Trail, which runs out to the marshes along the Roanoke Sound (Figure 5). Cane was the dominant plant at the trapping station and the trap itself was suspended from a live oak. Sweetgum, red bay, swamp blackgum, red maple and various swamp forest shrubs occurred within twenty-five feet of the trapping station to the northwest. Wax myrtle, lizardtail (*Saururus cernua*), royal fern (*Osmanthus regalis*), poison ivy, Virginia creeper, and devil's walking stick (*Aralia spinosa*) were some of the shrubby and viney species occurring near the trap.

Run Hill Trail.

This trail was routinely sampled for moths using the bait technique. The trail head begins along Nags Head Woods Road almost directly opposite from Clear Pond (Figure 5). After running over a dry sand ridge, it quickly drops down into an interdune swale, with shallow ponds on either side.

Rare or Poorly Known Lepidoptera

One Significantly Rare species, the Giant Swallowtail, is regularly observed within the preserve and is one of the most characteristic members of the Maritime Evergreen Forest community type. Additionally, 10 species of macro-moths on the NHP Watch List were recorded during this inventory, none of which are restricted to maritime habitats.

Table V. NHP Element and Watch List Species Recorded at Nag's Head Woods Ecological Preserve

SPECIES	GRANK	SRANK	# Coll.
Significantly Rare Species			
Giant Swallowtail (<i>Papilio cresphontes</i>)	G5	S2?	+
Watch List Species			
<i>Idaea productata</i>	G?	S2S3	1
<i>Idaea micropterata</i>	G?	SU	1
<i>Scopula cacuminaria</i>	G?	S3?	5
<i>Spilosoma dubia</i>	G?	S3S4	1
<i>Orgyia detrita</i>	G4	S3?	3
<i>Parahypenodes quadralis</i>	G4	S1S2	1
<i>Lithacodia</i> n. sp.	GU	SU	1
<i>Papaipema</i> n. sp. 3	G4?	S3?	2
<i>Acrapex relictata</i>	G?	S3?	37
Amphipyrinae, New Genus 2, Species 2	G?	S3S4	5
<i>Pyreferra pettiti</i>	G?	S3?	2

Habitat Indicator Guilds

Maritime Deciduous Forest

Three habitat indicator guilds make use of this community type: Maritime Forest and Shrubland, Dry Woodland, and Deciduous Forest.

In addition to the Giant Swallowtail, other members of the Maritime Forest and Shrubland guild recorded in the preserve included *Cymatophora approximaria*, *Metria amella*, and *Panopoda repanda*. *Heterocampa astarte* was unaccountably missing, since this species was collected at Jockey's Ridge State Park and appears to be associated with all maritime woodlands, both forest and shrublands. The absence of *Zale declarans*, which was also collected at Jockey's Ridge State Park, however, may reflect the lack of the Maritime Shrub community type within the preserve.

Members of the Dry Woodland guild included only two species, *Crambidia uniformis* and *Cisthene subjecta*. The relative lack of members of this guild may reflect the placement of the traps in mesic habitats. Better representation in this guild can be expected if the drier forests of the ridges are sampled.

The Deciduous Forest guild, as discussed under Habitat Indicator Guilds, is generally of little conservation significance on the mainland, where deciduous forests prevail. On the Outer Banks, however, only a few stands exist where deciduous species are prominent. The Maritime Deciduous Forest at Nag's Head Woods, as mentioned above, may be a relict from the Pleistocene. The same may be true for at least some of the moths associated with this community.

The following 86 species of general hardwood forest species were recorded in the preserve:

<i>Cossula magnifica</i>	<i>Ennomos subsignaria</i>	<i>Zanclognatha theralis</i>
<i>Prionoxystus robiniae</i>	<i>Probole amicarica</i>	<i>Renia salusalis</i>
Juvenal's Duskywing	<i>Nemoria lixaria</i>	<i>Renia nr. discoloralis</i>
Horace's Duskywing	<i>Idaea productata</i>	<i>Redectis pygmaea</i>
Tiger Swallowtail	<i>Eupithecia matheri</i>	<i>Dyspyralis nigella</i>
Spicebush Swallowtail	<i>Lacosoma chiridota</i>	<i>Parahyphenodes quadralis</i>
Red-spotted Purple	<i>Tolyte vellea</i>	<i>Abablemma brimleyana</i>
<i>Lithacodes fasciola</i>	<i>Anisota stigma</i>	<i>Panopoda rufimargo</i>
<i>Apoda y-inversum</i>	<i>Anisota pellucida</i>	<i>Panopoda carneicosta</i>
<i>Apoda biguttata</i>	<i>Antheraea polyphemus</i>	<i>Zale lunata</i>
<i>Apoda biguttata</i>	<i>Actias luna</i>	<i>Allotria elonympha</i>
<i>Natada nasoni</i>	<i>Laothe juglandis</i>	<i>Parallelia bistriaris</i>
<i>Adoneta spinuloides</i>	<i>Datana contracta</i>	<i>Catocala lacrymosa</i>
<i>Euclea delphinii</i>	<i>Datana integerrima</i>	<i>Paectes abrostoloides</i>
<i>Alsophila pomataria</i>	<i>Datana integerrima</i>	<i>Baileya ophthalmica</i>
<i>Itame pustularia</i>	<i>Nadata gibbosa</i>	<i>Raphia abrupta</i>
<i>Semiothisa aemulataria</i>	<i>Peridea angulosa</i>	<i>Acronicta americana</i>
<i>Hypomecis gnopharia</i>	<i>Macrurocampa marthesia</i>	<i>Acronicta laetifica</i>
<i>Glenoides texanaria</i>	<i>Heterocampa obliqua</i>	<i>Acronicta lobeliae</i>
<i>Anacamptodes defectaria</i>	<i>Heterocampa umbrata</i>	<i>Acronicta afflicta</i>
<i>Epimecis hortaria</i>	<i>Heterocampa biundata</i>	<i>Polygrammate hebraeicum</i>
<i>Lycia ypsilon</i>	<i>Lochmaeus manteo</i>	<i>Amphipyra pyramidoides</i>
<i>Phigalia strigataria</i>	<i>Schizura leptinoides</i>	<i>Balsa labecula</i>
<i>Lytrosis unitaria</i>	<i>Oligocentria lignicolor</i>	<i>Lithophane patefacta</i>
<i>Euchlaena amoenaria</i>	<i>Hyphantria cunea</i>	<i>Pyreferra pettiti</i>
<i>Euchlaena pectinaria</i>	<i>Halysidota tessellaris</i>	<i>Sericaglaea signata</i>

Xystocheilus rufago

Metaxaglaea viatica
Chaetoglaea tremula
Chaetoglaea sericea
Orthosia alurina

Orthosia hibisci
Egira alternans
Ulolonche culea

All but 14 of these species have been recorded on the mainland in Northeastern North Carolina, although most members of this group have been recorded elsewhere within the Coastal Plain. Two species appear to be sufficiently disjunct that they might represent Pleistocene relicts at Nag's Head Woods.

Pyrefera pettiti feeds on hop-hornbeam and has not yet been found anywhere else in the Coastal Plain (J.B. Sullivan, pers. comm.). The limited distribution of this moth in the Coastal Plain may reflect the sparse distribution of its host plant as much as past climatic patterns, however. Hop hornbeam appears to require soils that are fairly high in pH, a rare occurrence in the Coastal Plain. The relative abundance of this understory species at Nag's Head Woods is probably due to the high amount of marine shell fragments contained within the relict dunes at this site.

Juvenal's Duskywing (*Erynnis juvenalis*) feeds on a variety of deciduous oaks, including turkey oak (*Quercus laevis*) in the southern Coastal Plain. Although generally a common spring-flying species over most of the state, it appears to be largely absent from the northeastern section (LeGrand, 1994; LeGrand and Howard, 1999).

One other species in this group appears to be rare or at least poorly known in general. The single specimen of *Parahyponodes quadralis* recorded at Nag's Head Woods appears to be the only one documented for North Carolina

Lowland Forests and Pond Edges

Three members of the Riparian guild were collected at Nag's Head Woods, associated with willows and other woody shoreline vegetation of the interdune ponds: Viceroy, *Semiothisa gnopharia*, and *Catocala cara*. Only two members of the Bottomland Forest Guild were recorded: *Idaea micropterata*, and *Nigetia formosalis*. Other species associated with wetland habitats (not included in a separate guild) included *Cepphis decoloraria*, *Scopula cacuminaria*, *Lithacodia* n. sp., *Bellura obliqua*, *Bellura densa*, *Fagitana littera*, *Callopietria mollissima*, *Callopietria cordata*, and *Amolita obliqua*. Most of these species feed on wetland ferns, forbs, or graminoids. The host plants for *Cepphis decoloraria*, *Scopula cacuminaria* and *Lithacodia* n. sp. are not known and these species are listed among the wetland generalists based on habitats where adults have been captured.

Although cypress has not been recorded in the preserve, two moths believed to feed on cypress were recorded during this survey, *Semiothisa aequiferaria* and *Cutina distincta*, each represented by a single specimen collected in the Maritime Swamp Forest along the Canoe Trail. These specimens could represent strays from some other cypress-containing site, such as Kitty Hawk

Woods, or they could indicate that one or two cypresses exist somewhere within the more immediate vicinity; it is also possible that these species do not feed exclusively on cypress.

Two guilds were associated specifically with the Maritime Swamp Forest. Members of the Acidic Shrubland guild included *Orgyia detrita*, *Spilosoma dubia*, *Catocala praeclara*, and *Anomogyna youngii*. Members of the Canebrake guild included Southern pearly-eye, *Papaipema* n. sp. 3, *Acrapex relictata*, and Amphipyridinae, New Genus 2, New Species 2.

The records for the three cane-feeding species represent the first time these species have been collected on a barrier island (E. Quinter, pers. comm.). The same appears to be true for *Spilosoma dubia*, a species once believed to be confined to northern bogs and whose distribution and habitat affinities in the Southeast are still poorly known.

Marsh

Except for butterflies, the extensive marsh along Roanoke Sound was not directly sampled in this study. Marsh butterflies recorded include Least Skipper and Broad-winged Skipper. Three moths straying from the marshes into the inland trapping stations were *Leucanopsis longa*, *Doryodes spadaria*, and *Schinia saturata*. All of these species are widespread.

Management Concerns

Gypsy Moth

The gypsy moth infestation at Nag's Head Woods was first detected in 1989. Unlike other infestations in northeastern North Carolina, the one at Nag's Head Woods has remained at a fairly low level, never reaching the outbreak stage that results in significant amounts of defoliation.

A major outbreak, however, could lead to severe damage to the deciduous species that are disjunct or relict at Nag's Head Woods. Either the defoliation, or the use of *Bt* to treat the outbreak could produce major damage to the Lepidopteran community.

Based on data collected in a study of nontarget impacts of *Bt* conducted in the southeast Coastal Plain of North Carolina (Hall, et al., 1999), at least 124 species of the macro-moths recorded in the preserve should be considered at moderate to high risk from *Bt*. These include two NHP Watch List species, *Orgyia detrita* and *Spilosoma dubia*. Another Watch List species not considered in the previous analysis, *Pyreferra pettiti*, should also be included, based on the high likelihood of its larvae being present at the time *Bt* is normally applied to suppress gypsy moth populations in Northeastern North Carolina. Also included are 42 species in the habitat indicator guilds, 37 of which belong to the Deciduous Forest guild.

Although butterflies were not included in the analysis conducted by Hall, et al. (1999), they are known to be among the most sensitive groups of species to *Bt*. Swallowtails may be especially vulnerable. In one field study, tiger swallowtails showed mortality from *Bt* even 30 days following application, long after its effects become essentially zero for other species (Johnson, et al., 1995).

Butterflies at particular risk at Nag's Head Woods include the Giant Swallowtail, associated with Maritime Forests generally, and Horace's Duskywing, Juvenal's Duskywing, Tiger Swallowtail, Spicebush Swallowtail, and Red-spotted Purple, all associated with the deciduous hardwoods present at Nag's Head Woods.

The Division of Plant Protection has been monitoring the gypsy moth infestation within the Preserve for several years. So far the infestation has remained sufficiently low to not trigger any control efforts. This could change at any time, however, and there is growing concern that the presence of the infestation at Nag's Head could be leading to establishment of new populations in the vicinity. Outbreaks were recently detected at Roanoke Island to the southwest of the preserve, and at Southern Shores to the north, both requiring treatment with *Bt*.

Due to the environmental sensitivity of the preserve, no attempts have been made to treat the infestation, apart from release of a species of parasitic wasp (*Glyptapantheles porthetriae*) in 1993. If infestation levels are still low, use of pheromone flakes could be applied with virtually no impacts to other species. Introduction of the fungus, *Entomophaga maimaiga*, should also be considered, since it too is believed to be highly specific in its effects to the gypsy moth. Gypchek is another highly specific control agent, but one proven effective only against high level infestations.

In any case, the use of *Bt* should be the last resort, since it may lead to losses of species such as the Giant Swallowtail or Juvenal's Duskywing that might have a difficult time recolonizing the preserve if extirpated.

Fire Management

Prescribed burning is not currently used as a management tool at Nag's Head Woods, and most of the natural communities within the preserve are not fire-dependent. There has been some interest, however, in using fire to restore the remnant longleaf pine community that exists along one of the ridges. Fire could also be used as a management tool to combat invasion of the marshes along Roanoke Sound by *Phragmites*, an invasive reed.

These two habitats were not adequately sampled during this study. In absence of species-specific information, we would recommend that any burn plans developed for the preserve incorporate the rules of thumb outlined under General Management Issues.

Information Needs

As mentioned above, dry ridgetop forest and marsh habitats were undersampled in this survey. Given the potential management issues involving these habitats, both should be a high priority for further inventory.

CONCLUSIONS

Several rules of thumb described in the Introduction (recapitulated below) are supported by information obtained in this survey. Even though none of the State Parks in this survey or the Nag's Head Woods Ecological Preserve were established on the basis of rare insects or other invertebrates, all four preserves support species of significant conservation concern. Several of these species are, in fact, among the rarest recorded at these sites. Examples include Duke's Skipper at Goose Creek State Park, *Hemeroplanis* n. sp. at Pettigrew State Park, *Metarranthis lateritiaria* at Jockey's Ridge State Park, and *Parahyphenodes quadralis* at Nag's Head Woods Ecological Preserve.

While this study did not provide any direct data on the critical roles played by invertebrates in maintaining the ecosystems to which they belong, a substantial number of habitat specialists were identified among the principal habitats present within each of the study sites. Many of these species, moreover, were identified as being at particular risk from habitat fragmentation surrounding the preserves and potentially from management operations within the preserves themselves. The apparently disjunct and possibly relict population of *Pyrefera pettiti* at Nag's Head Woods and the isolated population of Duke's Skipper at Goose Creek State Park are particularly good examples of species that once lost from their sanctuaries might never be recovered.

This information not only served to point out potential problems but indicated possible solutions, particularly with regard to gypsy moth control and the use of prescribed burning. The key is to consider for each habitat type where possible refuge areas are located both within the preserves and outside. The scope and intensity of any management action should be decided, where possible, based on these considerations.

Following these rules of thumb should help protect other groups of invertebrates for which we still have little or no understanding. At the same time, the findings of this study strongly support the need for more inventory work directed at other groups of insects as well invertebrates more generally.

Recapitulation of Rules of Thumb

Rule of Thumb 1. Management actions that significantly alter some aspect of an ecosystem are likely to have major effects on insects and other invertebrates. The responses of these species to the management action may be very different than those of plants or vertebrates, the usual intended beneficiaries of the action. In the worst case, a large number of the unknown but important "cogs and wheels" of the ecosystem may be lost as a result of the action.

Rule of Thumb 2. Where high quality natural areas exist and have maintained their quality through time, a significant fauna of insects and other invertebrates -- containing both rare species and a high proportion of habitat specialists -- should be expected.

Rule of Thumb 3. Insects and other invertebrates should be considered at particular risk from fragmentation of native habitats. Even though invertebrate populations can be particularly high within a given sub-population during a given season, this should not be taken as a sign that, as small species, they only need a limited amount of space to maintain themselves. Their long term survival within a region may depend on as much landscape as is required to support a population (or metapopulation) of black bears, red-cockaded woodpeckers, or other species of vertebrate.

Rule of Thumb 4. Wherever possible, management activities should be restricted to only a portion of a given habitat type. Other areas of the same habitat should be set aside as refuge areas (although potentially subject to treatment at a later time).

Rule of Thumb 5. In cases where a management action affects an entire preserve, as in treatment for gypsy moths, decisions about the scope, intensity, and alternative treatments should be based according to the proximity of refuge areas beyond the boundary of the preserve. Where other, untreated blocks of habitat are located close by, a wider range of management options can be considered. Even in the worst case, where species are extirpated from the preserve, recolonization from outside can still be expected. Where external refuges are located far away, however, management decisions should be based on the worst possible case: irrecoverable losses of species from the preserve.

Appendix A. Sampling Dates and Weather Conditions

Date (YMD)	Weather	Pettigrew		Goose Creek		Jockey's Ridge	Nag's Head Woods	
		Trap 1	Trap 2	Trap 1	Trap 2	Trap 1	Trap 1	Trap 2
93/05/22	low 70's during the day; partly cloudy; low temp during the night=48°	+	+	+	+			
93/05/24	upper 70's during the day; partly cloudy; low temp during the night=66°					+	+	+
93/06/21	80's during the day; thunderstorms after dark; low temp=70°	+	+	+	+			
93/06/22	80's during the day; clear; low temp=63°				+	+	+	+
93/07/20	hot and humid; thunderstorms during the day; low temp=68°		+		+			
93/07/21	upper 80's; showers during the day; low temp=76°	+		+	+	+	+	+
93/08/17	upper 80's, overcast; thunderstorms during the day; low temp=73°	+	+	+	+			
93/08/18	80's; heavy thunderstorm during the afternoon; low temp=75°					+ ¹⁰	+	+

¹⁰ Many moths escaped when the trap was opened; windy conditions prevented fumes from accumulating

Date (YMD)	Weather	Pettigrew		Goose Creek		Jockey's Ridge	Nag's Head Woods	
		Trap 1	Trap 2	Trap 1	Trap 2	Trap 1	Trap 1	Trap 2
93/09/14	low 80's, clear; low temp=68°						+	+
93/09/16	80's with showers during the day; low temp unrecorded					+		+
93/09/20	low 70's, high clouds; rained during the night; low temp=64°	+	+	+	+			
93/10/16	low 70's, overcast; low temp=67°	+	+	+	+			
93/10/18	60's during the day, clear; low temp=54°					+	+	+
94/02/19	upper 60's during the day, partly cloudy; low temp=45°	+	+	+	+			
94/02/20	low 70's during the day; drizzled after dark; low temp=53°					+	+	+
94/03/19	low 60's during the day, clear; low temp=37° (Pett.), 46° (G. Crk.)	+	+	+	+			
94/03/20	low 60's during the day; clear at dusk; low temp=42°					+	+	+

Date (YMD)	Weather	Pettigrew		Goose Creek		Jockey's Ridge	Nag's Head Woods	
		Trap 1	Trap 2	Trap 1	Trap 2	Trap 1	Trap 1	Trap 2
94/04/21	upper 70's during the day, clear; low temp=56°	+	+	+	+			
94/04/23	60's during the day; clear and windy; low temp=36° (Jock. R.), 46° (N.H.)					+	+	+

Appendix B. Checklists

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
MICRO-MOTHS¹¹				
PSYCHIDAE				
<i>Thyridopteryx ephemeraeformis</i> (457)	2			
YPONOMEUTIDAE				
<i>Atteva punctella</i> (2401)	1	13	1	1
<i>Urodus parvula</i> (2415)	3			5
COSSIDAE				
<i>Cossula magnifica</i> (2674)		5	1	3
<i>Prionoxystus robiniae</i> (2693)				1
TORTRICIDAE				
<i>Amorbia humerosana</i> (3748)	1			
MEGALOPYGIDAE				
<i>Lagoa crispata</i> (4644)	81	5	4	13
<i>Megalopyge opercularis</i> (4647)	34	24	6	9
LIMACODIDAE				
<i>Tortricidia testacea</i> (4652)		6		
<i>Packardia geminata</i> (4659)	2			
<i>Lithacodes fasciola</i> (4665)	12	8	1	50

¹¹ This list is a highly incomplete representation of the micro-moths collected during this survey. Only for the Psychidae, Cossidae, Megalopygidae, and Limacodidae is the species list relatively complete.

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
<i>Apoda y-inversum</i> (4667)				14
<i>Apoda biguttata</i> (4669)		4		6
<i>Apoda biguttata?</i> (4669)				1
<i>Prolimacodes badia</i> (4671)	13	10	1	3
<i>Natada nasoni</i> (4679)				1
<i>Adoneta spinuloides</i> (4685)				2
<i>Monoleuca semifascia</i> (4691)	1	1		
<i>Euclea delphinii</i> (4697)	37	1		3
<i>Parasa indetermina</i> (4699)	16			
<i>Parasa sp.</i> (4699.10)	3			
<i>Sibine stimulea</i> (4700)	1	1		
PYRALIDAE				
<i>Peripasta caeculalis</i> (4951)	1			1
<i>Pyrausta bicoloralis</i> (5040)		1		
<i>Diacme elealis</i> (5142)		1		
<i>Desmia funeralis</i> (5159)			6	
<i>Diaphania nitidalis</i> (5202)	1			
<i>Clydonopteron tecomae</i> (5563)		2		3
<i>Galleria mellonella</i> (5622)	1			1
<i>Melitara prodenialis</i> (5970)			19	
<i>Euzophora ostricolorella</i> (5997)		2		
Total Number of Micro-Moth Species = 29	16	15	8	16

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
BUTTERFLIES¹²				
HESPERIIDAE				
<i>Staphylus hayhurstii</i> (3832)	+			
<i>Epargyreus clarus</i> (3870)	+	+		+
<i>Achalarus lyciades</i> (3904)				+
<i>Thorybes bathyllus</i> (3909)		+		+
<i>Erynnis juvenalis</i> (3947)				+
<i>Erynnis juvenalis?</i> (3947)	+			
<i>Erynnis horatius</i> (3952)	+		+	+
<i>Erynnis zarucco</i> (3956)	+			+
<i>Pyrgus communis</i> (3966)	+			
<i>Pholisora catullus</i> (3977)	+			
<i>Lerema accius</i> (3998)	1	+	+	+
<i>Ancyloxypha numitor</i> (4004)	+	+		+
<i>Hylephila phyleus</i> (4013)	+			
<i>Polites vibex</i> (4045)	+		+	
<i>Poanes zabulon</i> (4060)	+			
<i>Poanes yehl</i> (4063)	+			
<i>Poanes viator zizaniae</i> (4064.02)	+	+		+
<i>Euphyes dion</i> (4072)	+	+		
<i>Euphyes dukesi</i> (4074)		+		
<i>Euphyes vestris</i> (4078.02)	+		+	
<i>Amblyscirtes aesculapius</i> (4099)	+			

¹² The plus marks indicate sight records; no attempt was made to survey this group quantitatively. In addition to observations made during the inventory itself, this list includes records obtained during the Fourth of July Butterfly Counts and by volunteers at Nag's Head Woods.

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
<i>Lerodea eufala</i> (4111)	+			
<i>Oligoria maculata</i> (4114)	+			
<i>Panoquina ocola</i> (4119)	+			
PAPILIONIDAE				
<i>Papilio polyxenes asterias</i> (4159)	+			
<i>Papilio cresphontes</i> (4170)				+
<i>Papilio glaucus</i> (4176)	+	+		+
<i>Papilio troilus</i> (4181)	+	+		+
<i>Papilio palamedes</i> (4182)	+	+	+	+
<i>Eurytides marcellus</i> (4184)	+	+		
PIERIDAE				
<i>Pieris rapae</i> (4197)	+		+	+
<i>Colias eurytheme</i> (4210)	+			+
<i>Phoebis sennae eubule</i> (4228.01)	+	+		
<i>Eurema nicippe</i> (4242)	+	+		
LYCAENIDAE				
<i>Atlides halesus</i> (4270)				+
<i>Calycopis cecrops</i> (4299)	+	1		+
<i>Mitoura gryneus</i> (4318)		+		
<i>Incisalia sp.</i> (4329.10)				+
<i>Strymon melinus</i> (4336)	+	+	+	+
<i>Everes comyntas</i> (4361)	+			+
<i>Celastrina ladon complex</i> (4363)	+	+		
NYMPHALIDAE				
<i>Libytheana bachmanii</i> (4410)	+	+		
<i>Polygonia interrogationis</i> (4420)	+			

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
<i>Polygonia comma</i> (4421)	+			
<i>Vanessa virginiensis</i> (4434)	+			
<i>Vanessa cardui</i> (4435)	+			+
<i>Vanessa atalanta rubria</i> (4437)	+			+
<i>Junonia coenia</i> (4440)	+	+	+	+
<i>Euptoeita claudia</i> (4447)	+			
<i>Phyciodes tharos</i> (4481)	+	+		+
<i>Limenitis arthemis astyanax</i> (4522.02)	+			+
<i>Limenitis archippus</i> (4523)	+		+	+
<i>Asterocampa clyton</i> (4562.1)	227			
<i>Enodia portlandia</i> (4568)	+	+		+
<i>Enodia creola</i> (4568.20)		+		
<i>Enodia sp.</i> (4568.30)	+			+
<i>Cyllopsis gemma</i> (4573)		+		
<i>Hermeuptychia hermes sosybius</i> (4574.02)	+	+		
<i>Neonympha areolatus</i> (4576)	+			
<i>Cercyonis pegala</i> (4587)	+	+	+	+
<i>Danaus plexippus</i> (4614)	+		+	+
Total Number of Butterfly Species = 58	49	24	5	27

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
MACRO-MOTHS				
GEOMETRIDAE				
OENOCRROMINAE				
<i>Alsophila pometaria</i> (6258)				1
ENNOMINAE				
<i>Itame pustularia</i> (6273)	7	1		31
<i>Itame varadaria</i> (6314)	4			
<i>Semiothisa aemulataria</i> (6326)		2		1
<i>Semiothisa aequiferaria</i> (6335)	348	49		1
<i>Semiothisa transitaria</i> (6339)	10	18	6	23
<i>Semiothisa bicolorata</i> (6341)		3	1	14
<i>Semiothisa continuata</i> (6362)			2	2
<i>Semiothisa gnophosaria</i> (6405)	2	3		5
<i>Semiothisa sp.</i> (6418.10)	3			
<i>Hypomecis gnopharia</i> (6440)				2
<i>Glenoides texanaria</i> (6443)		2		12
<i>Glena cribrataria</i> (6449)	2	2		
<i>Glena cognataria</i> (6450)	3	1		
<i>Glena plumosaria</i> (6452)		1		
<i>Exelis pyrolaria</i> (6478)		1		
<i>Tornos scolopacinarius</i> (6486)	1	1		
<i>Anacamptodes cypressaria</i> (6571)		1		
<i>Anacamptodes pergracilis</i> (6580)	77	4		
<i>Anacamptodes vellivolata</i> (6582)	3	12		
<i>Anacamptodes ephyraria</i> (6583)				39
<i>Anacamptodes humaria</i> (6584)	2	1		1
<i>Anacamptodes defectaria</i> (6586)	18	6	9	4

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
<i>Anavitrinella pampinaria</i> (6590)	71	31	1	1
<i>Cleora sublunaria</i> (6594)	1			1
<i>Cleora projecta</i> (6595)	2			
<i>Ectropis crepuscularia</i> (6597)	2	4		
<i>Protoboarmia porcelaria</i> (6598)	4	10		25
<i>Epimecis hortaria</i> (6599)	30	19		8
<i>Melanolophia canadaria</i> (6620)	141	52		16
<i>Melanolophia canadaria?</i> (6620)		2		
<i>Melanolophia signataria</i> (6621)	31			1
<i>Lycia ypsilon</i> (6652)				2
<i>Hypagyrtis unipunctata</i> (6654)	5	22		12
<i>Hypagyrtis esther</i> (6655)		30		4
<i>Phigalia strigataria</i> (6660)		11		4
<i>Lomographa vestaliata</i> (6667)		1		
<i>Erastria cruentaria</i> (6705)	5	1	1	2
<i>Thysanopyga intractata</i> (6711)	4	2	1	14
<i>Episemasia solitaria</i> (6713)	1		1	
<i>Lytrosis unitaria</i> (6720)				1
<i>Euchlaena obtusaria</i> (6726)	4	1	2	
<i>Euchlaena amoenaria</i> (6733)	11	5		46
<i>Euchlaena pectinaria</i> (6735)		4		3
<i>Xanthotype urticaria</i> (6740)	1	1		2
<i>Xanthotype rufaria</i> (6742)	2			
<i>Xanthotype attenuaria</i> (6744)	2			
<i>Xanthotype</i> sp. (6744.10)	+			
<i>Cymatophora approximaria</i> (6745)		29	9	42
<i>Stenaspilatodes antidiscaria</i> (6746)	35	4	1	
<i>Pero zalissaria</i> (6752)	1	3		

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
<i>Pero hubneraria</i> (6754)	9	6		
<i>Ennomos subsignaria</i> (6798)				1
<i>Tacparia zalissaria</i> (6805)		2		
<i>Metarranthis hypocharia</i> (6826)		2		
<i>Metarranthis homuraria</i> (6828)	13	6		11
<i>Metarranthis lateritiaria</i> (6829)			1	
<i>Metarranthis n. sp. 1</i> (6829.10)	11			
<i>Metarranthis obfirmaria</i> (6832)		6		1
<i>Cepphis decoloraria</i> (6834)	5			11
<i>Probole alienaria</i> (6837)		2		
<i>Probole amicaria</i> (6838)		4		2
<i>Plagodis fervidaria</i> (6843)		10		
<i>Caripeta aretaria</i> (6869)	1			
<i>Lambdina pellucidaria</i> (6892)	9	67		
<i>Nepytia nr. semiclusaria</i> (6908.10)		41		
<i>Eusarca confusaria</i> (6941)	5	1	1	
<i>Eutralepa clemataria</i> (6966)	13	13		2
<i>Patalene olyzonaria puber</i> (6974.01)		1		3
<i>Prochoerodes transversata</i> (6982)	215	7	11	62
<i>Nematocampa resistaria</i> (7010)		20		3
GEOMETRINAE				
<i>Nemoria elfa</i> (7029)	27	11		1
<i>Nemoria lixaria</i> (7033)		2		5
<i>Nemoria saturiba</i> (7034)		4	1	
<i>Nemoria bifilata bifilata</i> (7045.01)			2	
<i>Nemoria bistriaria bistriaria</i> (7046.01)		2		
<i>Dichorda iridaria iridaria</i> (7053.01)	1	1		1
<i>Synchlora aerata aerata</i> (7058.01)		2		1

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
<i>Chloropteryx tepperaria</i> (7075)		1		4
<i>Hethemia pistasciaria pistasciaria</i> (7084.01)	6	8		
STERRHINAE				
<i>Lobocleta ossularia</i> (7094)			4	
<i>Idaea productata</i> (7112)				1
<i>Idaea demissaria</i> (7114)		1		
<i>Idaea micropterata?</i> (7119)				1
<i>Idaea violacearia</i> (7120)		3		
<i>Idaea takturata</i> (7122)	1	5		3
<i>Idaea obfusaria</i> (7123)		1		2
<i>Pleuroprucha insulsaria</i> (7132)	21	3	5	7
<i>Cyclophora packardi</i> (7136)	1	4		3
<i>Cyclophora myrtaria</i> (7137)				1
<i>Scopula cacuminaria</i> (7157)		1		5
<i>Scopula limboundata</i> (7159)	11	4		2
LARENTIINAE				
<i>Eulithis diversilineata</i> (7196)	14	6	1	28
<i>Ecliptopera atricolorata</i> (7214)	3			
<i>Xanthorhoe lacustrata</i> (7390)	32			
<i>Orthonama obstipata</i> (7414)	37	3	2	6
<i>Orthonama centrostrigaria</i> (7416)	3	2		6
<i>Disclisioprocta stellata</i> (7417)	2		1	
<i>Horisme intestinata</i> (7445)		1		
<i>Eupithecia miserulata</i> (7474)	36	1	2	8
<i>Eupithecia jejuna</i> (7486)				3
<i>Eupithecia matheri</i> (7509.10)				3
<i>Eupithecia sp.</i> (7605.10)		7		1
<i>Dyspteris abortivaria</i> (7648)	6			2

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
MIMALLONIDAE				
<i>Lacosoma chiridota</i> (7659)	1			1
APATELODIDAE				
<i>Apatelodes torrefacta</i> (7663)	16	2		
LASIOCAMPIDAE				
MACROMPHALIINAE				
<i>Tolyte velleda</i> (7670)	5	5		1
<i>Tolyte notialis</i> (7674)	1	7		
<i>Artace cribraria</i> (7683)			1	1
LASIOCAMPINAE				
<i>Malacosoma americanum</i> (7701)		1		1
SATURNIIDAE				
CITHERONIINAE				
<i>Eacles imperialis</i> (7704)	3	4		1
<i>Citheronia regalis</i> (7706)	2			
<i>Citheronia sepulchralis</i> (7708)	1			
<i>Dryocampa rubicunda</i> (7715)	13	3		
<i>Anisota stigma</i> (7716)	1	1		2
<i>Anisota pellucida</i> (7723.10)				1
HEMILEUCINAE				
<i>Automeris io</i> (7746)	6			
SATURNIINAE				
<i>Antheraea polyphemus</i> (7757)	1		1	+
<i>Actias luna</i> (7758)	1	4		2
<i>Callosamia angulifera</i> (7765)	3			
<i>Callosamia securifera</i> (7766)	+			

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
<i>Hyalophora cecropia</i> (7767)	14			
SPHINGIDAE				
SPHINGINAE				
<i>Agrius cingulata</i> (7771)	1			
<i>Manduca sexta</i> (7775)	1			
<i>Manduca quinquemaculata</i> (7776)	1			
<i>Manduca rustica</i> (7778)	1			
<i>Ceratomia undulosa</i> (7787)	1			
<i>Isoparce cupressi</i> (7791)	1	1		
<i>Sphinx gordius</i> (7810)	6			
<i>Lapara coniferarum</i> (7816)	13	14		1
<i>Paonias myops</i> (7825)	3			
<i>Paonias astylus</i> (7826)	6			
<i>Laothe juglandis</i> (7827)				2
MACROGLOSSINAE				
<i>Enyo lugubris</i> (7851)			1	
<i>Eumorpha pandora</i> (7859)	1			
<i>Deidamia inscripta</i> (7871)			1	
<i>Amphion floridensis</i> (7873)	+			
<i>Darapsa myron</i> (7885)	9	3		2
<i>Darapsa pholus</i> (7886)	1	+		
<i>Xylophanes tersa</i> (7890)	3		1	

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
NOTODONTIDAE				
<i>Clostera inclusa</i> (7896)	2	2		
<i>Datana ministra</i> (7902)	1			
<i>Datana drexelii</i> (7904)	19	2		
<i>Datana drexelii/major</i> (7904.50)	36	7		
<i>Datana major</i> (7905)	20	21		
<i>Datana contracta</i> (7906)				2
<i>Datana contracta/integerrima</i> (7906.50)				1
<i>Datana integerrima</i> (7907)		2		4
<i>Datana integerrima?</i> (7907)				1
<i>Datana perspicua</i> (7908)	9	1		
<i>Nadata gibbosa</i> (7915)		25		4
<i>Hyperaeschra georgica</i> (7917)		1		
<i>Peridea angulosa</i> (7920)		7		7
<i>Nerice bidentata</i> (7929)	1			
<i>Furcula borealis</i> (7936)		1		
<i>Furcula cinerea</i> (7937)	1	1	2	
<i>Symmerista albifrons</i> (7951)		1		
<i>Macrurocampa marthesia</i> (7975)	2		2	1
<i>Macrurocampa marthesia?</i> (7975)		1		
<i>Heterocampa astarte</i> (7977)		7	7	
<i>Heterocampa obliqua</i> (7983)	1	6		2
<i>Heterocampa umbrata</i> (7990)		11		6
<i>Heterocampa guttivitata</i> (7994)	4	5	1	8
<i>Heterocampa biundata/guttivitata</i> (7994.50)		3		2
<i>Heterocampa biundata</i> (7995)	3	10	1	17
<i>Lochmaeus manteo</i> (7998)	1	1		4

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
<i>Lochmaeus bilineata</i> (7999)	3			
<i>Schizura ipomoeae</i> (8005)	8	3	1	3
<i>Schizura unicornis</i> (8007)	5	4		2
<i>Schizura leptinoides</i> (8011)		2		12
<i>Oligocentria semirufescens</i> (8012)		2		
<i>Oligocentria lignicolor</i> (8017)		1	3	1
ARCTIIDAE				
LITHOSIINAE				
<i>Crambidia lithosoides</i> (8045)	1	3		
<i>Crambidia pallida complex</i> (8045.10)	61	85	13	53
<i>Crambidia nr. pallida (small)?</i> (8045.30)	1			
<i>Crambidia uniformis</i> (8046)				31
<i>Crambidia sp.</i> (8053.10)	70		1	73
<i>Cisthene plumbea</i> (8067)	2	10		20
<i>Cisthene subjecta</i> (8071)		11	1	14
<i>Cisthene packardii</i> (8072)	7	11	7	9
<i>Cisthene sp.</i> (8078.10)	2			
<i>Hypoprepia fucosa</i> (8090)	14	54		85
<i>Clemensia albata</i> (8098)	23	40		1
<i>Pagara simplex</i> (8099)	3			
<i>Comachara cadburyi?</i> (8104)	1			
ARCTIINAE				
<i>Haploa clymene</i> (8107)		25		3
<i>Haploa colona</i> (8108)	1			
<i>Holomelina opella</i> (8118)	13	32	1	4
<i>Holomelina aurantiaca</i> (8121)	7	5		
<i>Holomelina aurantiaca?</i> (8121)	1			

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
<i>Holomelina sp. (8125.10)</i>	1			1
<i>Pyrrharctia isabella (8129)</i>	5			
<i>Spilosoma congrua (8134)</i>	100	29		
<i>Spilosoma dubia (8136)</i>	41			1
<i>Spilosoma virginica (8137)</i>	84	9	3	5
<i>Hyphantria cunea (8140)</i>	77	7		1
<i>Ecpantheria scribonia (8146)</i>	+			
<i>Apantesis phalerata (8169)</i>	2	1	6	
<i>Apantesis vittata? (8170)</i>			1	
<i>Apantesis vittata (8170)</i>	3	7		1
<i>Apantesis nais? (8171)</i>	1			
<i>Apantesis sp. (8171.20)</i>		2	6	
<i>Grammia figurata (8188)</i>		1		
<i>Grammia parthenice intermedia (8196.10)</i>		1		
<i>Grammia arge (8199)</i>	1			
<i>Halysidota tessellaris (8203)</i>	10	13		2
<i>Leucanopsis longa (8217)</i>	21	21		6
<i>Cyenia tenera (8230)</i>	4			
CTENUCHINAE				
<i>Cisseps fulvicollis (8267)</i>	1	1	1	
LYMANTRIIDAE				
ORGYIINAE				
<i>Dasychira tephra (8292)</i>		1		
<i>Dasychira meridionalis memorata (8298.01)</i>	9	5		
<i>Dasychira manto (8307)</i>		6		
<i>Orgyia detrita (8313)</i>	2	5	1	3
<i>Orgyia definita (8314)</i>	2			

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
<i>Orgyia leucostigma</i> (8316)		1		
<i>Lymantria dispar</i> (8318)			1	2
NOCTUIDAE				
HERMINIINAE				
<i>Idia americalis</i> (8322)	8	30		25
<i>Idia aemula</i> (8323)	4	18		8
<i>Idia rotundalis</i> (8326)	27	124		67
<i>Idia forbesi</i> (8327)	1	2		
<i>Idia julia</i> (8328)	1	2		52
<i>Idia julia/rotundalis</i> (8328.05)				2
<i>Idia diminuendis</i> (8329)		12		4
<i>Idia lubricalis</i> (8334)	2	6	1	9
<i>Idia nr. lubricalis</i> (8334.10)				5
<i>Idia sp.</i> (8336.10)	1	8		
<i>Phalaenophana pyramusalis</i> (8338)	58	1		
<i>Zanclognatha lituralis</i> (8340)	2			
<i>Zanclognatha theralis</i> (8341)		5		4
<i>Zanclognatha obscuripennis</i> (8347)	14			4
<i>Zanclognatha obscuripennis?</i> (8347)	1			
<i>Zanclognatha cruralis</i> (8351)				3
<i>Zanclognatha sp.</i> (8354.20)	1	3		
<i>Chytolita morbidalis</i> (8355)	1			1
<i>Chytolita petrealis</i> (8356)	8	1		3
<i>Macrochilo hypocriticalis</i> (8357.10)	1	2	2	
<i>Macrochilo orciferalis</i> (8360)		1	1	2
<i>Phalaenostola larentioides</i> (8364)	2	1		
<i>Tetanolita mynesalis</i> (8366)	33	23	4	9

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
<i>Tetanolita floridana</i> (8368)	98	9	27	1
<i>Tetanolita sp.</i> (8369.10)		1		
<i>Bleptina caradrinalis</i> (8370)	17	89	7	7
<i>Bleptina inferior</i> (8371)		2	36	
<i>Bleptina sp.</i> (8375.10)	10		4	4
<i>Renia salusalis</i> (8378)	7	5		6
<i>Renia factiosalis</i> (8379)	3	3		
<i>Renia nr. discoloralis</i> (8381.10)	1	20	1	5
<i>Renia fraternalis</i> (8385)		1		
<i>Renia fraternalis?</i> (8385)				1
<i>Renia adspergillus</i> (8386)	43	8	8	
<i>Renia sobrialis</i> (8387)	1			
<i>Renia sp.</i> (8389.10)	2	2	1	+
<i>Lascoria ambigualis</i> (8393)	90	4		
<i>Palthis angualis</i> (8397)				1
<i>Palthis asopialis</i> (8398)	139	16	1	5
<i>Palthis asopialis?</i> (8398)				1
<i>Redectis pygmaea</i> (8400)	1			1
<i>Redectis vitrea</i> (8401)	3	1		9
RIVULINAE				
<i>Rivula propinqualis</i> (8404)		3		2
<i>Colobochyla interpuncta</i> (8411)	9	1		
HYPENODINAE				
<i>Hypenodes caducus</i> (8420)				2
<i>Hypenodes fractilinea</i> (8421)	7			
<i>Hypenodes fractilinea?</i> (8421)				6
<i>Hypenodes sp.</i> (8424.10)		14		
<i>Dyspyralis nigella</i> (8428)				2

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
<i>Parahypenodes quadralis</i> (8430)				1
<i>Schrankia macula</i> (8431)	30	36	2	36
<i>Quandara brauneata</i> (8432)		7		
<i>Abablemma brimleyana</i> (8437)				7
<i>Nigetia formosalis</i> (8440)				4
HYPENINAE				
<i>Bomolocha manalis</i> (8441)	8			
<i>Bomolocha baltimoralis</i> (8442)	1	3		
<i>Hypena humuli</i> (8461)				1
<i>Plathypena scabra</i> (8465)	98	29	1	5
<i>Hemeroplanis scopulepes</i> (8467)			1	
<i>Hemeroplanis n. sp.</i> (8477.1)	1			
<i>Phytometra rhodarialis</i> (8481)				1
CATOCALINAE				
<i>Pangrapta decoralis</i> (8490)	70	19	7	4
<i>Ledaea perditalis</i> (8491)	1	1		
<i>Isogona tenuis</i> (8493)	1			
<i>Metalectra discalis</i> (8499)	4	1		1
<i>Metalectra discalis/quadrisingnata</i> (8499.50)				+
<i>Metalectra quadrisingnata</i> (8500)	4	1		5
<i>Metalectra richardsi</i> (8505)		2		3
<i>Arugisa latiorella</i> (8509)	16	13	16	31
<i>Arugisa watsoni</i> (8510)	1			
<i>Scolecocampa liburna</i> (8514)	14	13		7
<i>Gabara subnivosella bipuncta</i> (8522.01)	2			
<i>Phyprosopus callitrichoides</i> (8525)	11	4	5	7
<i>Hypsoropha monilis</i> (8527)				2
<i>Hypsoropha hormos</i> (8528)		1	2	3

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
<i>Metallata absumens</i> (8573)		3	1	
<i>Anticarsia gemmatilis</i> (8574)	53	1	2	2
<i>Panopoda rufimargo</i> (8587)		7	1	7
<i>Panopoda carneicosta</i> (8588)	1	12		39
<i>Panopoda repanda</i> (8589)		5	56	14
<i>Phoberia atomaris</i> (8591)		2		
<i>Melipotis indomita</i> (8600)			1	
<i>Melipotis jucunda</i> (8607)			2	
<i>Lesmone detrahens</i> (8651)		1		
<i>Metria amella</i> (8666)		1		6
<i>Zale lunata</i> (8689)	6	+	2	1
<i>Zale declarans</i> (8691)			6	
<i>Zale aeruginosa</i> (8694)	21	1		
<i>Zale minerea</i> (8697)		1		
<i>Zale obliqua</i> (of Forbes) (8699)		10		1
<i>Zale squamularis</i> (8700)	2			
<i>Allotria elonympha</i> (8721)	2	5		7
<i>Dysgonia similis</i> (8725)	8			
<i>Parallelia bistriaris</i> (8727)	37	7		5
<i>Cutina albopunctella</i> (8728)	2	3		
<i>Cutina distincta</i> (8729)	4	7	1	2
<i>Cutina aluticolor</i> (8729.20)	7			
<i>Cutina arcuata</i> (8729.30)	118	11		
<i>Cutina sp.</i> (8729.40)		1		
<i>Caenurgia chloropha</i> (8733)	1	1	1	
<i>Caenurgina erechtea</i> (8739)	3			
<i>Mocis marcida</i> (8744)	2		1	
<i>Mocis texana</i> (8745)	53		6	1

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
<i>Celiptera frustulum</i> (8747)	1	1		
<i>Argyrostroma flavistriaria</i> (8759)	38	11		
<i>Argyrostroma sylvanum</i> (8760)	19	3		
<i>Argyrostroma erasa</i> (8761)	11	2		
<i>Argyrostroma deleta</i> (8763)	3	1		
<i>Argyrostroma</i> sp. (8764.10)	3			
<i>Doryodes spadaria</i> (8767)		1	1	1
<i>Catocala muliercula</i> (8774)	1	+		+
<i>Catocala lacrymosa</i> (8794)				3
<i>Catocala</i> nr. <i>ilia</i> (8801.10)			4	
<i>Catocala cara</i> (8832.01)		1		1
<i>Catocala gracilis</i> (8847)	8	1		
<i>Catocala ultronia</i> (8857)	2		2	
<i>Catocala praeclara</i> (8865)	17		2	1
<i>Catocala similis</i> (8873)			7	
<i>Catocala micronympha</i> (8876)			3	
<i>Catocala amica</i> (8878)			2	
<i>Catocala amica?</i> (8878)		+		
<i>Catocala</i> nr. <i>amica</i> (8878.20)			1	
PLUSIINAE				
<i>Pseudoplusia includens</i> (8890)	17	4	4	
<i>Allagrapha aerea</i> (8898)	1			
EUTELIINAE				
<i>Marathyssa inficita</i> (8955)	70	1	2	1
<i>Marathyssa basalis</i> (8956)		1		
<i>Paectes oculatrix</i> (8957)	9	3	4	
<i>Paectes pygmaea</i> (8959)	1	1		
<i>Paectes abrostoloides</i> (8962)	5	4	1	2

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
SARROTHRIPINAE				
<i>Baileya ophthalmica</i> (8970)		2		14
<i>Baileya dormitans</i> (8971)		1		
<i>Baileya australis</i> (8973)		1		
<i>Baileya australis?</i> (8973)				2
NOLINAE				
<i>Meganola phylla</i> (8983.10)		1		
<i>Meganola spodia</i> (8983.20)		31		
<i>Nola sorghiella</i> (8991)		1		
<i>Nola clethrae</i> (8996)	2	1		
ACONTIINAE				
<i>Hyperstrotia pervertens</i> (9037)		6		
<i>Thioptera nigrofimbria</i> (9044)	91	30		8
<i>Lithacodia bellicula</i> (9046)		1		
<i>Lithacodia muscosula</i> (9047)	19			5
<i>Lithacodia n. sp.</i> (9052.10)	3	3		1
<i>Pseudostrotia carneola</i> (9053)	9			
<i>Homophoberia cristata</i> (9056)	1			
<i>Homophoberia apicosa</i> (9057)	7	2		5
<i>Argillophora furcilla</i> (9060)	2			
<i>Eumicremma minima</i> (9076)	1	2	2	
<i>Tarachidia semiflava</i> (9085)			2	
<i>Spragueia leo</i> (9127)			1	
PANTHEINAE				
<i>Panthea furcilla</i> (9182)			1	1
<i>Raphia abrupta</i> (9192)				7
ACRONICTINAE				
<i>Acronicta americana</i> (9200)		3		1

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
<i>Acronicta tritona</i> (9211)	8	2		
<i>Acronicta connecta</i> (9219)		1		
<i>Acronicta laetifica</i> (9227)				1
<i>Acronicta hasta</i> (9229)	1	4		
<i>Acronicta lobeliae</i> (9238)	1	4		1
<i>Acronicta exilis</i> (9242)		2		
<i>Acronicta clarescens</i> (including <i>pruni</i>) (9246)	5			
<i>Acronicta inclara complex</i> (9250)		3		
<i>Acronicta retardata</i> (9251)		6		
<i>Acronicta afflictica</i> (9254)		2		1
<i>Acronicta impleta</i> (9257)		2		
<i>Acronicta longa</i> (9264)	1	1	6	
<i>Acronicta oblinita</i> (9272)	2	2		
<i>Acronicta sp.</i> (9274.30)	1			
<i>Simyra henrici</i> (9280)		5		
<i>Polygrammate hebraeicum</i> (9285)	6	181		16
<i>Harrisimemna trisignata</i> (9286)	3			
<i>Agaristinae</i>				
<i>Eudryas unio</i> (9299)	1	2		
AMPHIPYRINAE				
<i>Oligia fractilinea</i> (9406)	1	1		
<i>Meropleon cosmion</i> (9425)	1	1		
<i>Parapamea buffaloensis</i> (9463)	4	3		
<i>Papaipema duovata</i> (9465)				1
<i>Papaipema araliae</i> (9470)	1			
<i>Papaipema stenoscelis</i> (9481)	11	3		
<i>Papaipema sp. 3</i> (9509.10)		3		2
<i>Achatodes zeae</i> (9520)	1			

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
<i>Iodopepla u-album</i> (9522)		1		
<i>Bellura obliqua</i> (9525)				1
<i>Bellura densa</i> (9526)		2		1
<i>Bellura sp.</i> (9526.10)		1		
<i>Euplexia benesimilis</i> (9545)	3	1		
<i>Phlogophora periculosa</i> (9547)	22	7		
<i>Chytonix palliatricula</i> (9556)	12	8		
<i>Nedra ramosula</i> (9582)	1		3	
<i>Phosphila turbulenta</i> (9618)	1	22		3
<i>Phosphila miselioides</i> (9619)	27	8	5	57
<i>Fagitana littera</i> (9629)	6	1		1
<i>Callopietria mollissima</i> (9631)	8	3		2
<i>Callopietria granitosa</i> (9632)	9			
<i>Callopietria cordata</i> (9633)	59			1
<i>Acherdoa ferraria</i> (9636)		2	1	1
<i>Amphipyra pyramidoides</i> (9638)	6	5	1	3
<i>Proxenus miranda</i> (9647)	4			
<i>Anorthodes tarda</i> (9650)	8	26	1	
<i>Balsa labecula</i> (9664)				1
<i>Spodoptera exigua</i> (9665)	1		1	1
<i>Spodoptera frugiperda</i> (9666)	3		1	1
<i>Spodoptera ornithogalli</i> (9669)	11	+		2
<i>Elaphria versicolor</i> (9678)	2	1		1
<i>Elaphria chalcedonia</i> (9679)	8	1	2	
<i>Elaphria festivooides complex</i> (9681.10)			9	
<i>Elaphria grata</i> (9684)	41			1
<i>Galgula partita</i> (9688)	2		5	1
<i>Platysenta videns</i> (9690)	60	2		1

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
<i>Platysenta mobilis</i> (9693)	1			
<i>Platysenta vecors</i> (9696)	2	1	1	1
<i>Platysenta sutor</i> (9699)	2	2	1	
<i>Platysenta sutor?</i> (9699)		+		
<i>Condica cupentia</i> (9713)		1		
<i>Ogdoconta cinereola</i> (9720)	13	10		2
<i>Stiriodes obtusa</i> (9725)	5	6		
<i>Amolita fessa</i> (9818)		1		1
<i>Amolita obliqua</i> (9819)				1
<i>Acrapex relictus</i> (9872.10)	1	1		37
<i>Amphipyrrinae, New Genus 2, New Species 2</i> (9872.40)	1	3		5
CUCULLINAE				
<i>Lithophane patefacta</i> (9886)		+		2
<i>Pyreferra pettiti</i> (9932)				2
<i>Sericaglaea signata</i> (9941)				12
<i>Xystopeplus rufago</i> (9942)			2	1
<i>Metaxaglaea viatica</i> (9944)		1		2
<i>Metaxaglaea semitaria</i> (9945)	2			
<i>Epiglaea apiata</i> (9947)	3			
<i>Chaetaglaea tremula</i> (9949)	1			1
<i>Chaetaglaea sericea</i> (9950)	1			1
<i>Sunira bicolorago</i> (9957)	1	1		
<i>Sutyna privata</i> (9989)		1		
<i>Psaphida styracis</i> (10016)		1		
<i>Psaphida resumens</i> (10019)			2	
<i>Homohadena badistriga</i> (10059)				1
HADENINAE				
<i>Polia detracta</i> (10288)	1			1

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
<i>Lacinipolia renigera</i> (10397)	2			
<i>Lacinipolia laudabilis</i> (10411)			2	
<i>Lacinipolia implicata</i> (10414)				1
<i>Faronta diffusa</i> (10431)			1	
<i>Faronta rubripennis</i> (10434)			17	
<i>Pseudaletia unipuncta</i> (10438)	19	5	3	3
<i>Leucania extincta</i> (10439)			5	
<i>Leucania linita</i> (10440)		1	3	
<i>Leucania phragmitidicola</i> (10444)			3	
<i>Leucania phragmitidicola?</i> (10444)			2	
<i>Leucania linda</i> (10445)	2			
<i>Leucania linda?</i> (10445)	1			
<i>Leucania scirpicola</i> (10455)	31	5	2	1
<i>Leucania adjuta</i> (10456)	11	6	4	
<i>Leucania inermis</i> (10459)		1		
<i>Orthosia revicta</i> (10490)	1			
<i>Orthosia alurina</i> (10491)		1		4
<i>Orthosia hibisci</i> (10495)	6	1		1
<i>Egira alternans</i> (10517)	42	3		2
<i>Morrisonia confusa</i> (10521)		1		
<i>Ulolonche culea</i> (10567)		2		1
<i>Ulolonche modesta</i> (10569)			3	
<i>Orthodes crenulata</i> (10585)	42	6	4	2
<i>Orthodes cynica</i> (10587)	14			
<i>Tricholita signata</i> (10627)	8			2
NOCTUINAE				
<i>Agrotis vetusta</i> (10641)			5	
<i>Agrotis gladiaria</i> (10648)		1		

Species (Checklist Number used in Hodges, et al., 1983)	Pettigrew State Park	Goose Creek State Park	Jockey's Ridge State Park	Nag's Head Woods Preserve
<i>Agrotis malefida</i> (10661)			2	
<i>Agrotis ipsilon</i> (10663)	26	3	1	3
<i>Agrotis subterranea</i> (10664)	1	+	1	
<i>Feltia jaculifera</i> (10670)	1			
<i>Feltia herilis</i> (10676)	2			
<i>Eucoptocnemis fimbriaris</i> (10694)		2	6	
<i>Trichosilia geniculata</i> (10698.20)	1			
<i>Euxoa detersa detersa</i> (10838.01)			18	
<i>Ochropleura plecta</i> (10891)	29			
<i>Euagrotis lubricans</i> (10901)		2		
<i>Anicla infecta</i> (10911)	6	2	1	1
<i>Peridroma saucia</i> (10915)	1		2	
<i>Xestia dolosa</i> (10942.10)	2			
<i>Anomogyna elimata</i> (10967)	4	15		
<i>Anomogyna youngii</i> (10970)	272	35		1
<i>Cerastis tenebrifera</i> (10994)	10			1
<i>Choephora fungorum</i> (10998)	1			1
<i>Rhynchagrotis nr. cupida</i> (11043.10)			5	
HELIOTHINAE				
<i>Helicoverpa zea</i> (11068)	30	7	7	
<i>Schinia saturata</i> (11140)			15	2
<i>Schinia trifascia</i> (11149)		1		
Total Number of Macro-Moth Species= 460	284	286	126	222
Total Number of Lepidoptera Species= 547	347	326	145	266

Appendix C. Alphabetized Checklist of Lepidoptera

Butterflies

- American Lady (*Vanessa virginiensis*, 4434*)
American Snout (*Libytheana bachmanii*, 4410)
Azure (*Celastrina ladon* complex, 4363)
Black Swallowtail (*Papilio polyxenes asterias*, 4159)
Broad-winged Skipper (*Poanes viator zizaniae*, 4064.02)
Cabbage White (*Pieris rapae*, 4197)
Carolina Satyr (*Hermeuptychia hermes sosybius*, 4574.02)
Clouded Skipper (*Lerema accius*, 3998)
Cloudless Sulphur (*Phoebis sennae eubule*, 4228.01)
Common Buckeye (*Junonia coenia*, 4440)
Common Checkered-Skipper (*Pyrgus communis*, 3966)
Common Sootywing (*Pholisora catullus*, 3977)
Common Wood-Nymph (*Cercyonis pegala*, 4587)
Creole Pearly-eye (*Enodia creola*, 4568.20)
Dion Skipper (*Euphyes dion*, 4072)
Duke's Skipper (*Euphyes dukesi*, 4074)
Dun Skipper (*Euphyes vestris*, 4078.02)
Eastern Comma (*Polygonia comma*, 4421)
Eastern Tailed-Blue (*Everes comyntas*, 4361)
Eastern Tiger Swallowtail (*Papilio glaucus*, 4176)
Elfin sp. (*Incisalia* sp., 4329.10)
Eufala Skipper (*Lerodea eufala*, 4111)
Fiery Skipper (*Hylephila phyleus*, 4013)
Gemmed Satyr (*Cyllopsis gemma*, 4573)
Georgia Satyr (*Neonympha areolatus*, 4576)
Giant Swallowtail (*Papilio cresphontes*, 4170)
Gray Hairstreak (*Strymon melinus*, 4336)
Great Purple Hairstreak (*Atlides halesus*, 4270)
Hayhurst's Scallopwing (*Staphylus hayhurstii*, 3832)
Hoary Edge (*Achalarus lyciades*, 3904)
Horace's Duskywing (*Erynnis horatius*, 3952)
Juniper Hairstreak (*Mitoura gryneus*, 4318)
Juvenal's Duskywing (*Erynnis juvenalis*, 3947)
Lace-winged Roadside-Skipper (*Amblyscirtes aesculapius*, 4099)
Least Skipper (*Ancyloxypha numitor*, 4004)
Monarch (*Danaus plexippus*, 4614)
Ocola Skipper (*Panoquina ocola*, 4119)
Orange Sulphur (*Colias eurytheme*, 4210)
Painted Lady (*Vanessa cardui*, 4435)
Palamedes Swallowtail (*Papilio palamedes*, 4182)
Pearl Crescent (*Phyciodes tharos*, 4481)
Question Mark (*Polygonia interrogationis*, 4420)
Red Admiral (*Vanessa atalanta rubria*, 4437)
Red-banded Hairstreak (*Calycopis cecrops*, 4299)
Red-spotted Purple (*Limenitis arthemis astyanax*, 4522.02)
Silver-Spotted Skipper (*Epargyreus clarus*, 3870)
Sleepy Orange (*Eurema nicippe*, 4242)
Southern Cloudywing (*Thorybes bathyllus*, 3909)
Southern Pearly-eye (*Enodia portlandia*, 4568)
Spicebush Swallowtail (*Papilio troilus*, 4181)
Twin-spot Skipper (*Oligoria maculata*, 4114)
Variegated Fritillary (*Euptoeita claudia*, 4447)
Viceroy (*Limenitis archippus*, 4523)
Whirlabout (*Polites vibex*, 4045)
Yehl Skipper (*Poanes yehl*, 4063)
Zabulon Skipper (*Poanes zabulon*, 4060)
Zarucco Duskywing (*Erynnis zarucco*, 3956)
Zebra Swallowtail (*Eurytides marcellus*, 4184)

Moths

- Abablemma brimleyana (8437)
Achatodes zeae (9520)
Acherdoa ferraria (9636)
Acrapex relictata (9872.10)
Acronicta afflicta (9254)
Acronicta americana (9200)
Acronicta clarescens (9246)
Acronicta connecta (9219)
Acronicta exilis (9242)
Acronicta hasta (9229)
Acronicta impleta (9257)
Acronicta inclara complex (9250)
Acronicta laetifica (9227)
Acronicta lobeliae (9238)
Acronicta longa (9264)
Acronicta oblinita (9272)
Acronicta retardata (9251)
Acronicta sp. (9274.30)
Acronicta tritona (9211)
Actias luna (7758)
Adoneta spinuloides (4685)
Agrius cingulata (7771)
Agrotis gladiaria (10648)
Agrotis ipsilon (10663)
Agrotis malefida (10661)
Agrotis subterranea (10664)
Agrotis vetusta (10641)
Allagrapha aerea (8898)
Allotria elonympha (8721)
Alsophila pometaria (6258)
Amolita fessa (9818)
Amolita obliqua (9819)
Amorbia humerosana (3748)
Amphion floridensis (7873)
Amphipyra pyramidoides (9638)
Amphipyrae, Genus 2, Species 2 (9872.40)
Anacamptodes cypressaria (6571)
Anacamptodes defectaria (6586)
Anacamptodes ephyraria (6583)
Anacamptodes humaria (6584)
Anacamptodes pergracilis (6580)
Anacamptodes vellivolata (6582)
Anavitrinella pampinaria (6590)
Anicla infecta (10911)
Anisota pellucida (7723.10)
Anisota stigma (7716)
Anomogyna elimata (10967)
Anomogyna youngii (10970)
Anorthodes tarda (9650)
Antheraea polyphemus (7757)
Anticarsia gemmatilis (8574)
Apantesis nais (8171)

Apantesis phalerata (8169)
Apantesis sp. (8171.20)
Apantesis vittata (8170)
Apantesis vittata (8170)
Apatelodes torrefacta (7663)
Apoda biguttata (4669)
Apoda biguttata (4669)
Apoda y-inversum (4667)
Argillophora furcilla (9060)
Argyrostrotis deleta (8763)
Argyrostrotis erasa (8761)
Argyrostrotis flavistriaria (8759)
Argyrostrotis sp. (8764.10)
Argyrostrotis sylvanum (8760)
Artace cribraria (7683)
Arugisa latiorella (8509)
Arugisa watsoni (8510)
Atteva punctella (2401)
Automeris io (7746)
Baileya australis (8973)
Baileya australis (8973)
Baileya dormitans (8971)
Baileya ophthalmica (8970)
Balsalabecula (9664)
Bellura densa (9526)
Bellura obliqua (9525)
Bleptina caradrinalis (8370)
Bleptina inferior (8371)
Bomolocha baltimoralis (8442)
Bomolocha manalis (8441)
Caenurgia chloropha (8733)
Caenurgina erechtea (8739)
Callopietria cordata (9633)
Callopietria granitosa (9632)
Callopietria mollissima (9631)
Callosamia angulifera (7765)
Callosamia securifera (7766)
Caripeta aretaria (6869)
Catocala amica (8878)
Catocala amica (8878)
Catocala cara (8832)
Catocala gracilis (8847)
Catocala lacrymosa (8794)
Catocala micronympha (8876)
Catocala muliercula (8774)
Catocala nr. amica (8878.20)
Catocala nr. ilia (8801.10)
Catocala praeclara (8865)
Catocala similis (8873)
Catocala ultronis (8857)
Celiptera frustulum (8747)
Cepphis decoloraria (6834)
Cerastis tenebrifera (10994)
Ceratomia undulosa (7787)
Chaetoglaea sericea (9950)
Chaetoglaea tremula (9949)
Chloropteryx tepperaria (7075)
Choephora fungorum (10998)
Chytolita morbidalis (8355)
Chytolita petrealis (8356)
Chytonix palliatricula (9556)
Cisseps fulvicollis (8267)
Cisthene packardii (8072)
Cisthene plumbea (8067)
Cisthene subjecta (8071)
Citheronia regalis (7706)
Citheronia sepulchralis (7708)
Clemensia albata (8098)
Cleora projecta (6595)
Cleora sublunaria (6594)
Clostera inclusa (7896)
Clydonopteron tecomae (5563)
Colobochyla interpuncta (8411)
Comachara cadburyi (8104)
Condica cupentia (9713)
Cossula magnifica (2674)
Crambidia lithosioides (8045)
Crambidia nr. pallida (small) (8045.30)
Crambidia pallida complex (8045.10)
Crambidia uniformis (8046)
Cutina albopunctella (8728)
Cutina aluticolor (8729.20)
Cutina arcuata (8729.30)
Cutina distincta (8729)
Cyclophora myrtaria (7137)
Cyclophora packardii (7136)
Cyenia tenera (8230)
Cymatophora approximaria (6745)
Darapsa myron (7885)
Darapsa pholus (7886)
Dasychira manto (8307)
Dasychira meridionalis (8298.01)
Dasychira tephra (8292)
Datana contracta (7906)
Datana drexlii (7904)
Datana integerrima (7907)
Datana major (7905)
Datana ministra (7902)
Datana perspicua (7908)
Deidamia inscripta (7871)
Desmia funeralis (5159)
Diacme elealis (5142)
Diaphania nitidalis (5202)
Dichorda iridaria iridaria (7053.01)
Disclisioprocta stellata (7417)
Doryodes spadaria (8767)
Dryocampa rubicunda (7715)
Dysgonia similis (8725)
Dyspteris abortivaria (7648)
Dyspyralis nigella (8428)
Eacles imperialis (7704)
Ecliptopera atricolorata (7214)
Ecpantheria scribonia (8146)
Ectropis crepuscularia (6597)
Egira alternans (10517)
Elaphria chalcedonia (9679)
Elaphria festivoidea complex (9681.10)
Elaphria grata (9684)
Elaphria versicolor (9678)
Ennomos subsignaria (6798)
Enyo lugubris (7851)
Epiglaea apiata (9947)
Epimecis hortaria (6599)
Episemasia solitaria (6713)
Erastria cruentaria (6705)
Euagrotis lubricans (10901)
Euchlaena amoenaria (6733)
Euchlaena obtusaria (6726)
Euchlaena pectinaria (6735)
Euclea delphinii (4697)
Eucloptocnemis fimbriaris (10694)
Eudryas unio (9299)
Eulithis diversilineata (7196)
Eumicremma minima (9076)
Eumorpha pandora (7859)
Eupithecia jejuna (7486)
Eupithecia matheri (7509.10)
Eupithecia miserulata (7474)
Euplexia benesimilis (9545)
Eusarca confusaria (6941)
Eutralepa clemataria (6966)
Euxoa detersa detersa (10838.01)
Euzophora ostricolorella (5997)
Exelis pyrolaria (6478)
Fagitana littera (9629)
Faronta diffusa (10431)
Faronta rubripennis (10434)
Feltia herilis (10676)
Feltia jaculifera (10670)
Furcula borealis (7936)
Furcula cinerea (7937)
Gabara subnivoseella bipuncta (8522.01)
Galgula partita (9688)
Galleria mellonella (5622)
Glena cognataria (6450)
Glena cribrataria (6449)
Glena plumosaria (6452)
Glenoides texanaria (6443)
Grammia arge (8199)
Grammia figurata (8188)
Grammia parthenice (8196.10)
Halysidota tessellaris (8203)
Haploa clymene (8107)
Haploa colona (8108)
Harrisimemna trisignata (9286)
Helicoverpa zea (11068)
Hemeroplanis n. sp. (8477.10)
Hemeroplanis scopulepes (8467)
Heterocampa astarte (7977)
Heterocampa biundata (7995)
Heterocampa guttiventata (7994)
Heterocampa obliqua (7983)
Heterocampa umbrata (7990)
Hethemia pistasciaria (7084.01)

Holomelina aurantiaca (8121)
 Holomelina aurantiaca (8121)
 Holomelina opella (8118)
 Homohadena badistriga (10059)
 Homophoberia apicosa (9057)
 Homophoberia cristata (9056)
 Horisme intestinata (7445)
 Hyalophora cecropia (7767)
 Hypagyrtis esther (6655)
 Hypagyrtis unipunctata (6654)
 Hypena humuli (8461)
 Hypenodes caducus (8420)
 Hypenodes fractilinea (8421)
 Hyperaeschra georgica (7917)
 Hyperstrotia pervertens (9037)
 Hyphantria cunea (8140)
 Hypomecis gnopharia (6440)
 Hypoprepia fucosa (8090)
 Hypsoropha hormos (8528)
 Hypsoropha monilis (8527)
 Idaeia demissaria (7114)
 Idaeia micropterata (7119)
 Idaeia obfusaria (7123)
 Idaeia productata (7112)
 Idaeia tactorata (7122)
 Idaeia violacearia (7120)
 Idia aemula (8323)
 Idia americanalis (8322)
 Idia diminuendis (8329)
 Idia forbesi (8327)
 Idia julia (8328)
 Idia lubricalis (8334)
 Idia nr. lubricalis (8334.10)
 Idia rotundalis (8326)
 Iodopepla u-album (9522)
 Isogona tenuis (8493)
 Isoparce cupressi (7791)
 Itame pustularia (6273)
 Itame varadaria (6314)
 Lacinipolia implicata (10414)
 Lacinipolia laudabilis (10411)
 Lacinipolia renigera (10397)
 Lacosoma chiridota (7659)
 Lagoa crispata (4644)
 Lambdina pellucidaria (6892)
 Laothe juglandis (7827)
 Lapara coniferarum (7816)
 Lascoria ambigualis (8393)
 Ledaea perditalis (8491)
 Lesmone detrahens (8651)
 Leucania adjuta (10456)
 Leucania extincta (10439)
 Leucania inermis (10459)
 Leucania linda (10445)
 Leucania linita (10440)
 Leucania phragmitidicola (10444)
 Leucania scirpicola (10455)
 Leucanopsis longa (8217)
 Lithacodes fasciola (4665)
 Lithacodia bellicula (9046)
 Lithacodia muscosula (9047)
 Lithacodia n. sp. (9052.10)
 Lithophane patefacta (9886)
 Lobocleta ossularia (7094)
 Lochmaeus bilineata (7999)
 Lochmaeus manteo (7998)
 Lomographa vestaliata (6667)
 Lycia ypsilon (6652)
 Lymantria dispar (8318)
 Lytrosis unitaria (6720)
 Macrochilo hypocritalis (8357.10)
 Macrochilo orciferalis (8360)
 Macrurocampa marthesia (7975)
 Malacosoma americanum (7701)
 Manduca quinquemaculata (7776)
 Manduca rustica (7778)
 Manduca sexta (7775)
 Marathyssa basalis (8956)
 Marathyssa inficita (8955)
 Megalopyge opercularis (4647)
 Meganola phylla (8983.10)
 Meganola spodia (8983.20)
 Melanolophia canadaria (6620)
 Melanolophia signataria (6621)
 Melipotis indomita (8600)
 Melipotis jucunda (8607)
 Melitara prodenialis (5970)
 Meropleon cosmion (9425)
 Metalectra discalis (8499)
 Metalectra quadrisignata (8500)
 Metalectra richardsi (8505)
 Metallata absumens (8573)
 Metarranthis homuraria (6828)
 Metarranthis hypocharia (6826)
 Metarranthis lateritiaria (6829)
 Metarranthis obfirmaria (6832)
 Metarranthis sp. 1 (6829.10)
 Metaxaglaea semitaria (9945)
 Metaxaglaea viatica (9944)
 Metria amella (8666)
 Mocis marcida (8744)
 Mocis texana (8745)
 Monoleuca semifascia (4691)
 Morrisonia confusa (10521)
 Nadata gibbosa (7915)
 Natada nasoni (4679)
 Nedra ramosula (9582)
 Nematocampa resistaria (7010)
 Nemoria bifilata bifilata (7045.01)
 Nemoria bistriaria bistriaria (7046.01)
 Nemoria elfa (7029)
 Nemoria lixaria (7033)
 Nemoria saturiba (7034)
 Nepytia nr. semiclusaria (6908.10)
 Nerice bidentata (7929)
 Nigetia formosalis (8440)
 Nola clethrae (8996)
 Nola sorghiella (8991)
 Ochropleura plecta (10891)
 Ogdoconta cinereola (9720)
 Oligia fractilinea (9406)
 Oligocentria lignicolor (8017)
 Oligocentria semirufescens (8012)
 Orgyia definita (8314)
 Orgyia detrita (8313)
 Orgyia leucostigma (8316)
 Orthodes crenulata (10585)
 Orthodes cynica (10587)
 Orthonama centrostrigaria (7416)
 Orthonama obstipata (7414)
 Orthosia alurina (10491)
 Orthosia hibisci (10495)
 Orthosia revicta (10490)
 Packardia geminata (4659)
 Paectes abrostoloides (8962)
 Paectes oculatrix (8957)
 Paectes pygmaea (8959)
 Pagara simplex (8099)
 Palthis angulalis (8397)
 Palthis asopialis (8398)
 Pangrapta decoralis (8490)
 Panopoda carneicosta (8588)
 Panopoda repanda (8589)
 Panopoda rufimargo (8587)
 Panthea furcilla (9182)
 Paonias astylus (7826)
 Paonias myops (7825)
 Papaipema araliae (9470)
 Papaipema duovata (9465)
 Papaipema sp. 3 (9509.10)
 Papaipema stenoscelsis (9481)
 Parahypenodes quadralis (8430)
 Parallelia bistriaris (8727)
 Parapamea buffaloensis (9463)
 Parasa indeterminata (4699)
 Patalene olyzonaria puber (6974.01)
 Peridea angulosa (7920)
 Peridroma saucia (10915)
 Peripasta caeculalis (4951)
 Pero hubneraria (6754)
 Pero zalissaria (6752)
 Phalaenophana pyramusalis (8338)
 Phalaenostola larentioides (8364)
 Phigalia strigataria (6660)
 Phlogophora periculosa (9547)
 Phoberia atomaris (8591)
 Phosphila miselioides (9619)
 Phosphila turbulenta (9618)
 Phyprosopus callitrichoides (8525)
 Phytometra rhodarialis (8481)
 Plagodis fervidaria (6843)
 Plathypena scabra (8465)
 Platysenta mobilis (9693)
 Platysenta sutor (9699)

Platysenta vecors (9696)
Platysenta videns (9690)
Pleuroprucha insulsaria (7132)
Polia detracta (10288)
Polygrammate hebraicum (9285)
Prionoxystus robiniae (2693)
Probole alienaria (6837)
Probole amicaria (6838)
Prochoerodes transversata (6982)
Prolimacodes badia (4671)
Protoboarmia porcelaria (6598)
Proxenus miranda (9647)
Psaphida resumens (10019)
Psaphida styracis (10016)
Pseudaletia unipuncta (10438)
Pseudoplusia includens (8890)
Pseudostrotia carneola (9053)
Pyrausta bicoloralis (5040)
Pyreferra pettiti (9932)

Pyrrharctia isabella (8129)
Quandara brauneata (8432)
Raphia abrupta (9192)
Redectis pygmaea (8400)*Redectis vitrea* (8401)
Renia adspersgillus (8386)
Renia factiosalis (8379)
Renia fraternalis (8385)
Renia nr. discoloralis (8381.10)
Renia salusalis (8378)
Renia sobrialis (8387)
Rhynchagrotis nr. cupida (11043.10)
Rivula propinquialis (8404)
Schinia saturata (11140)
Schinia trifascia (11149)
Schizura ipomoeae (8005)
Schizura leptinoides (8011)
Schizura unicornis (8007)
Schrankia macula (8431)
Scolecocampa liburna (8514)
Scopula cacuminaria (7157)
Scopula limboundata (7159)
Semiothisa aemulataria (6326)
Semiothisa aequiferaria (6335)
Semiothisa bicolorata (6341)
Semiothisa continuata (6362)
Semiothisa gnophosaria (6405)
Semiothisa transitaris (6339)
Sericaglaea signata (9941)
Sibine stimulea (4700)
Simyra henrici (9280)
Sphinx gordius (7810)
Spilosoma congrua (8134)
Spilosoma dubia (8136)
Spilosoma virginica (8137)
Spodoptera exigua (9665)
Spodoptera frugiperda (9666)
Spodoptera ornithogalli (9669)
Spragueia leo (9127)
Stenaspilatodes antidiscaria (6746)

Stiriodes obtusa (9725)
Sunira bicolorago (9957)
Sutyna privata (9989)
Symmerista albifrons (7951)
Synchlora aerata aerata (7058.01)
Tacparia zalissaria (6805)
Tarachidia semiflava (9085)
Tetanolita floridana (8368)
Tetanolita mynesalis (8366)
Thioptera nigrofimbria (9044)
Thyridopteryx ephemeraeformis (457)
Thysanopyga intractata (6711)
Tolyte notialis (7674)
Tolyte velleda (7670)
Tornos scolopacinaris (6486)
Tortricidia testacea (4652)
Tricholita signata (10627)
Trichosilia geniculata (10698.20)
Ulolonche culea (10567)
Ulolonche modesta (10569)
Urodoxus parvula (2415)
Xanthorhoe lacustrata (7390)
Xanthotype attenuaria (6744)
Xanthotype rufaria (6742)
Xanthotype urticaria (6740)
Xestia dolosa (10942.10)
Xylophanes tersa (7890)
Xystocheilus rufago (9942)
Zale aeruginosa (8694)
Zale declarans (8691)
Zale lunata (8689)
Zale minerea (8697)
Zale obliqua (8699)
Zale squamularis (8700)
Zanclognatha cruralis (8351)
Zanclognatha lituralis (8340)
Zanclognatha obscuripennis (8347)
Zanclognatha theralis (8341)

Numbers correspond to checklist by Hodges, et al., 1983.

REFERENCES

- Allen, E.R. and Repasky, R.R. 1977. The Phelps Lake pocosin area as a possible natural area. Unpubl. Rep., NC Division of Parks and Recreation, Dept. Env. and Nat. Res.; Raleigh.
- Atkinson, T.A. and List, H.E, 1978. Basic inventory and natural diversity summary of the Nags Head Woods, Dare County, North Carolina. Rep. to the Nature Conservancy; Durham, NC. 96 p.
- Biggs, W.C. and Parnell, J.F. 1989. State Parks of North Carolina. John H. Blair; Winston-Salem.
- Burk, C.J. 1962. The North Carolina Outer Banks: a floristic interpretation. J. Elish. Mitch. Sci. Soc. 78:21-28.
- Burney, D.A. 1975. A preliminary interpretive prospectus of the Goose Creek State Park area of Beaufort County, North Carolina. Unpubl. Rep., Division of Parks and Recreation, DEHNR; Raleigh.
- Burney, D.A. and Burney, L.P. 1984. A paleoecological investigation of Nags Head Woods Ecological Preserve, Dare County, North Carolina. Unpubl. Rep. to the NC Nature Conservancy; Durham.
- Carter, J.H. III 1975. Resource management at Goose Creek State Park. Unpubl. Rep., NC Division of Parks and Recreation, DEHNR; Raleigh.
- Covell, C.V. Jr. 1984. A Field Guide to the Moths of Eastern North America. Peterson Field Guide Series. Houghton Mifflin Co.; Boston.
- Ferguson, D.C. 1978. Lymantriidae. In Dominick, R.B. et al. (eds), The Moths of America North of Mexico. Fascicle 22.2.
- Forbes, W.T.M. 1948. Lepidoptera of New York and Neighboring States. Part II. Geometridae, Sphingidae, Notodontidae, and Lymantriidae. Cornell University Agricultural Experimental Station Memoir 329. 433 p.
- Frank, K.D. 1988. Impact of outdoor lighting on moths: an assessment. Journal of the Lepidopterists' Society 42:63-93.

Fussell, J.O.; Webster, W.D.; Hall, S.P.; LeGrand, H.E.; Schafale, M.P.; and Russo, M.J. 1995. Ecosystem survey of Dare County Air Force Range, North Carolina. Rep. to N.C. Natural Heritage Program, Division of Parks and Recreation, Department of Environment and Natural Resources; Raleigh, NC.

Hall, S.P. and Schafale, M.P. 1999. Conservation assessment of the Southeast Coastal Plain of North Carolina, using site-oriented and landscape-oriented analyses. Rep. to N.C. Natural Heritage Program, Division of Parks and Recreation, Department of Environment and Natural Resources; Raleigh, NC; 247 p.

Hall, S.P. and Schweitzer, D.F. 1993. A survey of the moths, butterflies, and grasshoppers of four Nature Conservancy preserves in Southeastern North Carolina. Report to the Nature Conservancy; Durham, NC

Hall, S.P.; Sullivan, J.B.; and Schweitzer, D.F. 1999. Eradication of The Asian-strain of The Gypsy Moth from the Cape Fear Region of North Carolina: Assessment of Risk to Nontarget Macro-Lepidoptera. USDA Forest Service Technical Publication Series. In Prep.

Hodges, R.W.; Dominick, T.; Davis, D.R.; Ferguson, D.C.; Franclemont, J.G.; Munroe, E.G.; and Powell, J.A. (eds.) 1983. Check List of the Lepidoptera of America North of Mexico. E.W. Classey Ltd.; London.

Howe, W.H. 1975. The Butterflies of North America. Doubleday and Co., New York.

Hughes, R.H. 1957. Response of cane to burning in the North Carolina Coastal Plain. NC Agric. Sta. Bull. 402.

Johnson, K.S.; Scriber, M.; Nitao, J.K.; Smitley, D.R. 1995. Toxicity of *Bacillus thuringiensis* var. *kurstaki* to three nontarget lepidoptera in field studies. Environmental Entomology 24:288-297

Kimball, C.P. 1965. The Lepidoptera of Florida. Florida Department of Agriculture; Gainesville. 363 p.

Kirkman, B. 1993a. Natural Areas of North Carolina State Parks. Goose Creek State Park. Rep. to N.C. Natural Heritage Program, Division of Parks and Recreation, Department of Environment and Natural Resources; Raleigh, NC.

Kirkman, B. 1993b. Natural Areas of North Carolina State Parks. Jockey's Ridge State Park. Rep. to N.C. Natural Heritage Program, Division of Parks and Recreation, Department of Environment and Natural Resources; Raleigh, NC.

Kirkman, B. 1993c. Natural Areas of North Carolina State Parks. Pettigrew State Park. Rep. to N.C. Natural Heritage Program, Division of Parks and Recreation, Department of Environment and Natural Resources; Raleigh, NC.

Landis, T.A. 1991. A resource management plan for Pettigrew State Park, North Carolina. MS Thesis, School of Forestry and Env. Studies, Duke University; Durham.

LeGrand, H.E. Jr. (ed.) 1996. South Atlantic. NABA Fourth of July Butterfly Counts, 1996 Report. North American Butterfly Association; Morristown, NJ.

LeGrand, H.E. Jr. (ed.) 1997. South Atlantic. NABA Fourth of July Butterfly Counts, 1997 Report. North American Butterfly Association; Morristown, NJ.

LeGrand, H.E. Jr. (ed.) 1998. South Atlantic. NABA Fourth of July Butterfly Counts, 1998 Report. North American Butterfly Association; Morristown, NJ. (In prep.)

LeGrand, H.E. Jr. 1994. Biological inventory of Dismal Swamp State Natural Area, North Carolina. Unpubl. Rep. to N.C. Natural Heritage Program, Division of Parks and Recreation, Dept. Environment and Natural Resources; Raleigh, NC.

LeGrand, H.E. Jr. and Howard, T.E. Jr. 1999. Notes on the butterflies of North Carolina, Sixth Approximation. <http://www.ncsparks.net/butterfly/nbnc.html>

Leopold, A. 1953. Round River. Oxford University Press; New York.

Lopazanski, M.J.; Evans, J.P; Shaw, R.E. 1988. An assessment of maritime forest resources on the North Carolina Coast. Unpubl. Rep, NC Div. Coastal Management, NCDEHNR; Raleigh.

Lynch, J.M. and Peacock, S.L. 1982. Natural areas inventory of Washington County, North Carolina. NC Dept. Nat. Res. & Comm. Dev.; Raleigh.

McCullough, D.R. (ed.) 1996. Metapopulations and Wildlife Conservation. Island Press; Washington DC; 429 p.

Miller, L.D., and F.M. Brown. 1981. A Catalogue/Checklist of the Butterflies of America North of Mexico. The Lepidopterists' Society Memoir 2:1-280.

Muirhead-Thomson, R.C. 1991. Trap Responses of Flying Insects; the Influence of Trap Design on Capture Efficiency. Academic Press, London.

NABA, 1995. Checklist and English names for North American Butterflies. North American Butterfly Association; Morristown, NJ.

Opler, P.A., and G.O. Krizek. 1984. Butterflies East of the Great Plains. Johns Hopkins Univ. Press, Baltimore.

Opler, P.A., and V. Malikul. 1992. A Field Guide to Eastern Butterflies. Peterson Field Guide Series. Houghton Mifflin Co., Boston.

Otte, L.J.; Atkinson, D.K.S.; and Atkinson, T.A. 1984. Ecological inventory of a portion of the Nags Head Woods, Dare County, North Carolina. Unpubl Rep. to the NC Nature Conservancy; Durham.

Rindge, F.H. 1966. A revision of the moth genus *Anacamptodes* (Lepidoptera, Geometridae). Bulletin of the American Museum of Natural History 132(3):178-234.

Rings, R., E.H. Metzler, F.J. Arnold, and D.H. Harris. 1992. The Owlet Moths of Ohio. Bull. Ohio Biological Survey 9:1-219.

Schafale, M.P. and Weakley, A.S. 1990. Classification of the Natural Communities of North Carolina, Third Approximation. N.C. Natural Heritage Program, Division of Parks and Recreation, Department of Environment and Natural Resources; Raleigh, NC. 325 p.

Scott, J.A. 1986. The Butterflies of North America; a Natural History and Field Guide. Stanford Univ. Press, Stanford.

Symposium, 1988. Forum on Interdunal Ponds in Maritime Forests. ABS Bull. 35.

Wilson, E.O. 1987. The little things that run the world (the importance and conservation of invertebrates). Conservation Biology 1:344-346.

Wilson, J.E. 1974. Lake Phelps Cypress Natural Area. Unpubl. Rep., NC Div. Parks and Recreation, NCDEHNR; Raleigh.