Rare Lepidoptera and Shrubland Birds: Their Presence, Distribution and Habitat Preferences on the Ossipee Pine Barrens Preserve in Carroll County, New Hampshire

A 2002 field survey

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Prologue/Acknowledgements

To help The Nature Conservancy of New Hampshire better manage its Ossipee Pine Barrens Preserve in Carroll County, NH, I conducted a survey of rare Lepidoptera and declining shrubland birds native to the site. My findings are detailed in this report which is arranged in four chapters: an introduction that sets the scene, a chapter on the Lepidoptera survey, a chapter on the shrubland bird survey and a concluding chapter of combined recommendations for the management of both of these groups. This report dovetails with a companion report prepared by Dacey (2003) on the vegetation of the Ossipee Pine Barrens Preserve.

Special thanks goes to Carol Foss for guidance in the application of behavior mapping, Scott Griggs, Dr. Dale Schweitzer Ph.D. and Donald Chandler Ph.D. for their help with the Lepidoptera study; and to the staff of The Nature Conservancy, particularly Doug Bechtel and Jeffrey Lougee. The counsel of Ross T. Bell Ph.D., Allan Strong Ph.D. and Deane Wang Ph.D. of the University of Vermont was greatly appreciated. The financial support of the U.S. Fish & Wildlife Service's Partners for Fish and Wildlife Grant Program was vital to the success of this project.

Executive Summary and Summary of Recommendations

The Ossipee Pine Barrens, a globally rare natural community type occurring in east central New Hampshire, once covered an estimated 2,800 hectares (ha). Habitat conversion has reduced the barrens to approximately 800 ha and habitat fragmentation and fire suppression have significantly degraded what remains.

Despite the significant ecological degradation and the continued threat of development, the Ossipee Pine Barrens is the last viable Northern New England Pitch Pine-Scrub Oak Barrens in New Hampshire and one of the best remaining in the Northeast. Ossipee is also home to more than a dozen rare Lepidoptera and several species of shrubland birds whose populations are in steep decline.

The Nature Conservancy (TNC) owns 365 ha within the Ossipee Pine Barrens (Map 1). Their goal is to preserve the Ossipee Pine Barrens and its associated species as an exemplary pitch pine-scrub oak barrens community. To help achieve this goal, TNC has commissioned this research project to assess occurrence, distributions and habitat preferences of rare moths and butterflies (Order Lepidoptera) and declining shrubland birds native to the barrens. To accomplish this:

- Lepidoptera were collected and recorded with black lights and bait traps regularly between May and September, 2003.
- Eastern towhee and brown thrasher behavior were mapped between June and August, 2003.
- Extensive efforts were made to compile, review, and synthesize existing information on the biology and ecology of these taxa and their interactions with pitch pine-scrub oak barrens.

Results

More than 2500 Lepidoptera specimens were recorded comprising 246 species in 12 families (Appendix C), including six of the 15 rare species (tables 1 and 4, Figure 2). Of the nine rare species not collected in 2002, all but two were not active during the sample period. The six rare species recorded were:

Species	**Rarity Rank***
Glena cognataria	G4G5 S3
Itame sp. 1	G3Q S1S2
Apharetra dentata	G4 S2
Xestia elimata,	G5 S3S4
Zale obliqua	G5 S2
Zanclognatha martha	G4 S1

*See Appendix A for a discussion of New Hampshire Heritage Bureau's Rarity Ranking.

Of these six species, five were found in more than one location in the barrens. The widespread distribution of these species will allow more flexibility as managers plan restoration activities (Goldstein 1997, Thomas 2000). An additional 47 Lepidopteran species of conservation interest (Appendix E) were also collected, 22 of which were also found at more than one sample site (Appendix E).

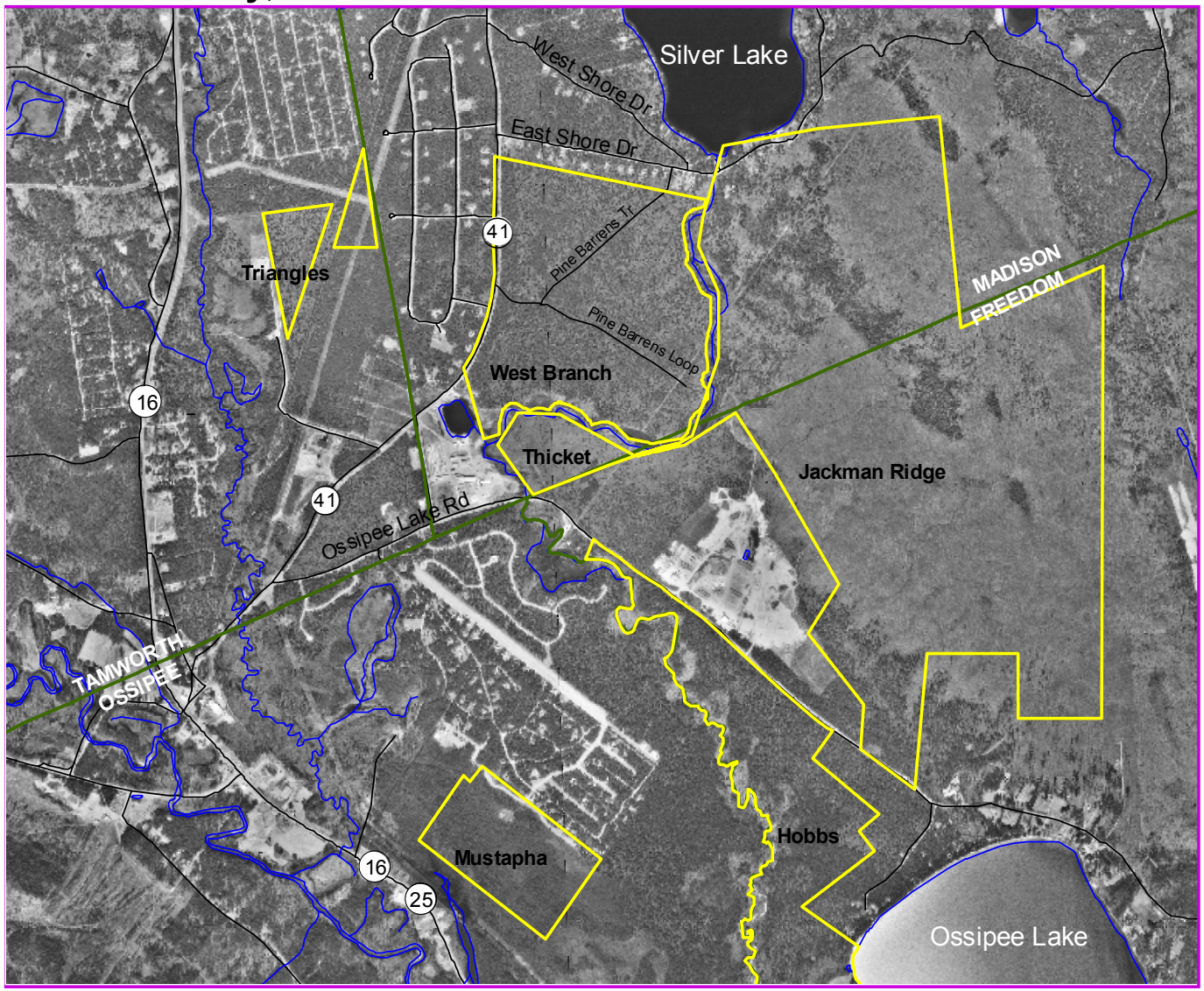
Eastern towhee, though found throughout the barrens, showed a preference for open-canopied scrub oak thicket with less than 10% forest canopy cover. No brown thrasher pairs were found in the study plots, though they were seen elsewhere in the barrens. Anecdotal observations indicate that thrasher prefer less dense ground cover than the towhee, with some access to thickets and pitch pine forest edges.

Though not part of the bird mapping study, four other bird species of conservation interest were regularly seen at Ossipee: common nighthawk (*Chordeiles minor*), whip-poor-will (*Caprimulgus vociferus*), prairie warbler (*Dendroica discolor*) and vesper sparrow (*Pooecetes gramineus*). Observations of the nighthawk population in particular indicates that it may be the most dense population in the state.

This research should help preserve managers to conserve more effectively Ossipee's rare Lepidoptera and shrubland birds as well as the ecosystem as a whole. This research dovetails with a companion study by Dacey (2003) on the vegetation of the Ossipee Pine Barrens Preserve that was also commissioned by TNC.

The Nature Conservancy's Ossipee Pine Barrens Preserve, Carroll County, NH

Map 1



400 0 400 800 Meters

400 0 400 800 Yards

Map scale 1: 30,000
March 2003

- West Branch Preserve Parcels
- Town Boundaries
- Roads & TNC Trails
- Streams

Data Sources: The Nature Conservancy: parcel boundaries. NH-GRANIT: orthophotos, roads, streams, and political boundaries.

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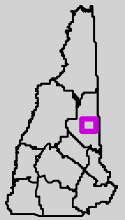
Locator Map



Ossipee Pine Barrens

Map created by Jon Kart

Summary of recommendations

While this study focused on rare birds and Lepidoptera of the Ossipee Pine Barrens Ecosystem, the site is likely home to a number of other rare species of other taxa. All deserve conservation, but devising management plans for each could unnecessarily restrict management options. A more achievable and constructive effort would be restoring and/or mimicking natural processes and functions with the goal of creating a complex mosaic of patch sizes, configurations, ages and vegetation types across the ecosystem.

With this in mind, the following recommendations for restoring and maintaining the rare Lepidoptera and shrubland birds of the Ossipee Pine Barrens—especially on the Preserve—will likely benefit much of the rest of Ossipee's flora and fauna. These recommendations fall into three categories: land acquisition, species management, and monitoring and vegetation management.

Land Acquisition

- Increase the size of the preserve through land acquisition and conservation agreements with neighboring landowners.
- Connect and consolidate parcels as much as possible to reduce undesirable boundary effects and to simplify management. Specific areas to target include: the land between the Mustapha and Hobbs parcels; the east end of Kennett tract, and the area surrounding the Triangles parcels.
- Encourage species-compatible management of the powerline right of ways bordering the TNC preserve.

Species management and monitoring

- Do not manage for individual rare species. Rather, manage for a wide range of ecosystem patterns and processes.
- Additional monitoring data should help direct future management decisions. Surveys should target spring and fall flying Lepidoptera (those missed in the 2002 survey), and some additional species (moths, beetles, birds).
- Make species monitoring a part of the vegetation management program.
- Consider enrolling the Ossipee Pine Barrens in the Audubon Society's Important Bird Area (IBA) program.
- Determine whether additional habitat for eastern towhee and vesper sparrow is desired.

Vegetation management

- Burn during the fire season, not the dormant season (except when the sole purpose of the burn is for fuel reduction).
- Base burning cycles on what current Lepidopteran populations respond to best.
- Test a variety of burn sizes/intervals/temperatures/seasons.
- Consider burning more frequently along borders to the preserve.
- Leave patches of varying sizes unburned.
- Test a variety of other vegetation management tools as well as disturbance frequencies and severity of disturbance.
- Restore the pine barrens natural community on the Thicket tract.

Introduction

Northeastern pine barrens are among the most rare and critically imperiled natural communities in the United States. More than 50 percent of the region's barrens have been destroyed, and local losses as are as high as 99 percent (Cryan 1985, Noss et al. 1995). Pine barrens are home to numerous rare invertebrate species as well as several species of shrubland birds whose populations show the steepest long-term declines of any bird species in the region (Askins 2000, Kerlinger 1981, Sauer 2001). Thirty-two species of Lepidoptera are characterized as dependent on pine barrens habitat, the largest assemblage of regionally rare Lepidoptera of any habitat in the region (Schweitzer and Rawinski 1988, Wagner et al. in press (a)).

The Ossipee Pine Barrens of Carroll County, New Hampshire is the last viable Northern New England Pitch Pine-Scrub Oak Barrens remaining in New Hampshire (Schweitzer and Rawinski 1988). This barrens once covered an estimated 2,800ha. Habitat conversion has reduced the barrens to approximately 800 ha and habitat fragmentation and decades of fire suppression have significantly degraded what remains (McCarthy 1994).

In spite of this fragmentation and destruction of habitat, the Ossipee Pine Barrens has a B2 biodiversity ranking, "very high significance," according to the New Hampshire Natural Heritage Bureau (NHNHB 2002), and The Nature Conservancy has identified Ossipee as a primary conservation objective in its Lower New England Ecoregion. Ossipee is home to a number of rare and uncommon species whose populations are declining regionally and globally (Sauer 2001, Schweitzer 2002-Appendix F). The best known taxa are Lepidoptera and birds.

Fifteen species of rare Lepidoptera have been documented at Ossipee since 1988 (Table 1) (Schweitzer and Rawinski 1988, McCarthy and VanLuven 1996, NHNHB pers. comm.). In New Hampshire, five of these species are known only at Ossipee and another four are known only from the Ossipee and the Concord Barrens. TNC has targeted these species for conservation. Given the fragmented, degraded state of

the Concord Pine Barrens, it is likely that these species are more secure in Ossipee than in Concord (McCarthy and VanLuven 1996).

Hopping (1996) found several species of shrubland birds breeding at Ossipee whose populations are in steep decline regionally, including common nighthawk (*Chordeiles minor*), whip-poor-will (*Caprimulgus vociferus*), eastern towhee (*Pipilo erythrophthalmus*) and brown thrasher (*Toxostoma rufum*), (Askins 2000, Sauer 2001). TNC has targeted these species for conservation. The towhee and thrasher populations in New Hampshire have dropped by more than 95 percent in the past 40 years. Hagen's (1993) analysis of North American Breeding Bird Survey (BBS) data indicates that towhee declines are one of the most dramatic of any non-endangered species in the United States. According to analysis of BBS data by Dunn (2003), nighthawk and whip-poor-will both qualify for World Conservation Union (IUCN) vulnerable status because their global populations have declined at least 25 percent over the past 10 years. The Ossipee Pine Barrens supports what Hopping (1996) considers the highest density of breeding nighthawks and whip-poor-wills in New Hampshire as well as several other declining species of shrubland birds.

Although pine barrens are poorly understood ecosystems (Forman 1979, Finton 1998, Motzkin et al. 1996), they are well known to be disturbance-dependent ecosystems. Fire is the dominant disturbance in pine barrens, and barrens ecology is intimately tied to fire. Historically, fires rolled through the landscape every few decades, setting back succession, releasing nutrients and affecting vegetative structures. Dominate barrens vegetation, pitch pine (*Pinus rigida*), scrub oak (*Quercus ilicifolia*) and blueberry (*Vaccinium angustifolium*), have all evolved mechanisms to help them survive fire or resprout soon after fire (Sperduto 1994). Without disturbance, particularly fire, the ecosystem could be lost through transformation into a white pine-hardwood forest system.

The Nature Conservancy wishes to preserve the Ossipee pine barrens and its associated species as an exemplary occurrence of a Pitch Pine-Scrub Oak Barrens community. The New Hampshire chapter of TNC has acquired 365 ha of

Ossipee barrens with a goal of restoring, enhancing and maintaining ecosystem processes and functions.

To reach this goal, this research project has been commissioned to:

Determine the presence and distribution of rare moths.

Determine abundance and habitat preferences for eastern towhee and brown thrasher.

Synthesize information available from literature and known experts on the biology, ecology and stresses affecting rare Lepidoptera and target shrubland bird species with data collected at the Ossipee Pine Barrens Preserve to provide TNC with a better understanding of species/community interactions.

As E.O. Wilson (1987) has noted, insects and other invertebrates are the "little things that run the world." They are the primary converters of plant matter to animal matter; they play a significant role in decomposition cycles, and they are essential in critical ecological processes such as pollination. Efforts to conserve insects and other invertebrates are few, in part due to a perceived lack of charisma and because, unfortunately, the natural history and ecology of most invertebrates is a mystery. Still, efforts to protect and conserve invertebrates are increasing.

Insects, particularly herbivorous insects such as Lepidoptera, can be extremely sensitive gauges to environmental change (Goldstein 1997). Most are specialist feeders requiring quite specific hosts. As holometabolous insects (experiencing complete metamorphosis from egg to larvae to pupae to adult), they may have specialized and quite different requirements during each life-stage. Lepidoptera can disappear long before decline in their host plants, suggesting that they have requirements in addition to nutritional needs (Goldstein 1997).

Lepidoptera were chosen as a focal taxon for this study because, relative to most other invertebrates, their taxonomy is reasonably well known, some life-history data are available for most species, and they are relatively easily sampled (Schweitzer pers. comm., Wagner et al. in press (a)). Moreover, there are many

ecological specialists within this order. Wagner (2002) considers Lepidoptera "the primary currency for judging the quality of barrens community types."

Invertebrates are important indicators of ecosystem health in fire-dependent communities. In the Midwest, where a diverse array of grassland management efforts includes fire programs, almost program monitors the effect of fire on invertebrates (Seamon 1994). Invertebrates, particularly Lepidoptera, are also becoming widely used as indicators of pine barrens habitat (Tim Simmons pers. comm.).

Shrubland birds, a comparatively well know taxa, were chosen as another focal group for this study because of the abundance of available information about the natural history and ecology of this guild (Askins 2000, Greenlaw 1996, Kerlinger, and Doremus 1981). Shrubland birds in general, and the Target Species specifically chosen for this study, have been experiencing significant decreases in their populations regionally and globally for at least the past 40 years (Sauer 2001).

Not all species can serve as surrogates for others (Caro and O'Doherty 1999). Hotspots for one taxon do not necessarily overlap hotspots for other taxa (Grand and Mello in press, Ricketts et al. 2002). The hope is that a multi-species, multi-taxa approach employed in this study will cast a broad net to provide sufficient insight into the natural history and ecology of the Ossipee Pine Barrens.

Site Description

The study site is the Ossipee Pine Barrens in Carroll County, New Hampshire (Map 1). Estimates based on surficial geology, soil maps and aerial photographs put the historic extent of this ecosystem at more than 2,800 ha (McCarthy 1996, Finton 1998). Approximately 800 ha remain.

The bulk of the barrens occur on an extremely flat plain of fluviolacustrine glacial drift (glacial-stream deposited sands and gravel) between Ossipee Lake to the south, the Ossipee Mountains to the west, the Jackman Ridge to the east and Silver Lake to the north. Deep deposits of sand and gravel (45 m deep), kettle lakes, and ponds characterize this plain.

Ossipee Pine Barrens is a fairly simple and homogenous barrens compared to others in the region. It does not grade into grassland or sandplain communities as seen in other barrens in the region such as the Albany Pine Bush. Dominant vegetation at the Ossipee Pine Barrens is similar to many other barrens in the Northeast, with pitch pine (*Pinus rigida*), scrub oak (*Quercus ilicifolia*), early lowbush blueberry (*Vaccinium angustifolium*) and late lowbush blueberry (*Vaccinium vacillins).* The Ossipee Barrens is considered a Northern New England Pitch Pine-Scrub Oak Barrens (Sperduto 1994).

The Ossipee Pine Barrens Macrosite encompasses three sections: West Branch Pine Barrens, Ossipee Pine Barrens East and White Lake. The West Branch Pine Barrens at 364 ha is in the best condition of the remaining barrens and is the largest remaining continuous area of barrens vegetation (McCarthy 1994). Ossipee Pine Barrens East contains 285 ha of barrens. White Lake contains 60 ha of pine barrens vegetation.

This study focuses on the West Branch parcels that compose TNC's West Branch Pine Barrens Preserve (Map 1) and lay in four bordering towns: Freedom, Madison, Ossipee and Tamworth. Lands bordering the preserve are, or were, primarily pine barrens, though some sections of the preserve are bordered by riparian areas or upland forest. Human development around the Preserve is predominately single family homes and commercial businesses catering to these homeowners as well as the many tourists that frequent the region. On Ossipee Lake Road, International Paper operates a logging facility, and the Kennett Corporation has a sand and gravel operation.

Presence and Distribution of Rare Lepidoptera of the Ossipee Pine Barrens

Summer 2002

Methods

Lepidoptera were collected in the late spring and summer of 2002. Data were collected from sites within and adjacent to TNC's Ossipee Pine Barrens Preserve, in the West Branch Pine Barrens, Carroll County, New Hampshire.

With the help of TNC-NH Stewardship Ecologist Jeff Lougee, night-flying macro-Lepidoptera were collected between May and September of 2002. The goal was to determine the presence and distribution of moths at Ossipee.

Target Species: Fifteen rare species were designated as Target Species (Table 1). The Target Species list contains those species previously found at Ossipee by Schweitzer (1985) and/or McCarthy (1995-1996) that have Natural Heritage Inventory rarity rankings between S1 and S4. **Species of conservation interest** (Appendix E): are Lepidopteran species collected at Ossipee in 2002 that are recommended by Schweitzer (pers comm.) for tracking during future surveys.

Table 1: Target Species for summer, 2002, Lepidoptera collection, Ossipee Pine Barrens
see Appendix A for a discussion of rarity ranks

Family	Species	Rank
Skipper	*Erynnis brizo brizo*, Sleepy Dusky-Wing	G5T5 S2
Geometriidae	*Eumacaria latiferrugata*	G4G5 S2S4
Geometriidae	*Glena cognataria*, Blueberry Grey	G4G5 S3
Geometriidae	*Itame* sp. 1, Pine Barrens itame	G3Q S1S2
Geometriidae	*Lycia rachelae* Twilight moth	No rank
Noctuidae	*Apharetra dentate* (formerly *Apharetra purpurea*)	G4 S2
Noctuidae	*Lithophane lepida lepida* Pine Pinion Moth	G4T3T4 S1S2
Noctuidae	*Lithophane thaxteri*, Thaxter's pinion moth	G4 SU
Noctuidae	*Xestia elimata*, (formerly Anomogyna elimata)	G5 S3S4
Noctuidae	*Xylena thoracica*, Pinion Moth	G4 S2
Noctuidae	*Xylotype capax*, Barrens Xylotype	G4 S2
Noctuidae	*Zale* sp. 1, Pine Barrens Zale	G3Q S1
Noctuidae	*Zale obliqua*	G5 S2
Noctuidae	*Zale submediana*	G4 S1
Noctuidae	*Zanclognatha martha*, Pine Barrens Zanclognatha	G4 S1

Rarity ranks are estimates for the species following conventions developed by the Natural Heritage Program and The Nature Conservancy. Global ranks refer to the rarity of the species rangewide 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 New Hampshire. (A review of ranking protocol and definitions can be found in Appendix A.)

Sampling was conducted strictly to determine presence/absence and distribution across the barrens, not to estimate abundance. Because Lepidopteran populations can fluctuate significantly from year to year, one season's data are insufficient for determining population size (Schweitzer and Rawinski 1988).

This study focused on macro-Lepidopteran moths. "Macros" include butterflies and several closely allied families of higher moths (Young 1997). We lacked the needed resources and expertise to identify micro-Lepidoptera, which are indeed small, and more difficult to identify. Only macros were pinned and identified. All "micros" taken during sampling have been retained and reside with TNC-NH. If in the future someone with expertise in identifying "micros" becomes available, these specimens should be examined.

Sampling locations were chosen to include a range of vegetation types characteristic of the Ossipee Pine Barrens as well as to maximize spatial coverage across the West Branch Pine Barrens subsection of the Ossipee Pine Barrens (Table 2, Map 2). Locations were selected after touring the site with TNC personnel and examining maps and ortho-photographs and reports from previous sampling and research efforts at the Ossipee Pine Barrens.

Coordinates for all sampling locations were collected using a Garmin GPS 76 GPS unit, and plotted using ESRI's ArcView 3.3 geographic information system software.

Blacklights: Sampling was conducted using blacklight and sugar bait during weeks of new, first quarter and last quarter moons at up to six sites a night. No sampling occurred during the week of a full moon. (See Appendix B for a full list dates, sites, and collection type).

Black light trapping followed guidelines from Schweitzer (1988) and Winter (2000). Standard bucket-style traps with 15-watt blacklights were placed at least 25 meters from habitat edge and set up approximately one hour before sunset. Traps were

Lepidoptera sampling locations, Summer 2002 The Nature Conservancy's Ossipee Pine Barrens Preserve, Carroll County, NH.

Map 2

400 0 400 800 Meters

400 0 400 800 Yards

Map scale 1: 30,000

March 2003

- Lepidoptera collection sites
- West Branch Preserve Parcels
- Town Boundaries
- Roads & TNC Trails
- Streams

Data Sources: The Nature Conservancy: parcel boundaries. NH-GRANIT: orthophotos, roads, streams, and political boundaries.

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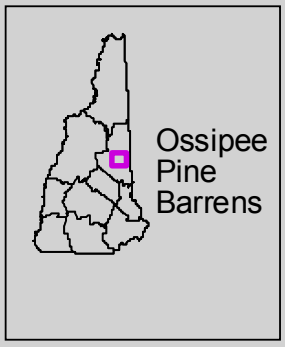
Locator Map



Map created by Jon Kart

either suspended from vegetation or set up on the ground, depending on the height and density of surrounding vegetation. The traps contained the killing agent ethyl acetate.

Table 2 Descriptions of sampling locations for summer, 2002, Lepidoptera collection, Ossipee Pine Barrens

(See Map 2 for locations and Dacey (2003) for a detailed vegetation description)

Site	Description
Hobbs Tract (106 ha) Pitch Pine-Scrub Oak Transitional Forest 25-40% canopy cover Type 2 (Dacey 2003)	**Dominant**: pitch pine (*Pinus rigida*), white pine (*Pinus strobus*), scrub oak (*Quercus ilicifolia*), blueberry (*Vaccinium angustifolium*) **Also**: red oak (*Acer rubrum)*, gray birch (*Betula populifolia*); wintergreen (*Gaultheria procumbens*), sweetfern (*Comptonia peregrina*), bracken fern (*Pteridium aquilinum*), chokeberry (*aronia* spp), Pennsylvania sedge (*Carex pennsylvanica*)
IP Heathlands (28 ha) Pitch Pine-Heath Woodland 3-8% canopy cover	**Dominant**: blueberry, pitch pine, bracken fern, wintergreen **Also**: bracken fern, wintergreen, sweetfern Scrub oak noticeably absent
Mustapha (41 ha) Pitch Pine Bog 3-8% canopy cover	**Dominant**: pitch pine, rhodora (*Rhododendron canadense)* **Also:** white pine, spruce (*Picea* spp) Sweet gale (*Myrica gale*), wintergreen
Thicket (18 ha) Scrub Oak Thicket 0-3% canopy cover Type 3 (Dacey 2003)	**Dominant**: scrub oak, blueberry **Also**: pitch pine, white pine, gray birch, wintergreen, bracken fern, sweet fern, Pennsylvania sedge
Triangles (17 ha) Pitch Pine-Scrub Oak Transitional Forest 5-20% canopy cover Type 1 (Dacey 2003)	**Dominant**: pitch pine, white pine, scrub oak, blueberry **Also**: wintergreen, bracken fern, sweetfern Triangles are bounded by powerline right-of-way dominated blueberry, Pennsylvania sedge, bracken fern
West Branch (141 ha) Open-Canopy Pitch Pine Scrub Oak Forest 15-30% canopy cover Type 2 (Dacey 2003)	**Dominant**: pitch pine, white pine, scrub oak, blueberry **Also**: gray birch; wintergreen, sweetfern, bracken fern, Pennsylvania sedge
Kennett Barrens (30 ha) Scrub Oak Thicket 0-2% canopy cover	**Dominant**: scrub oak, blueberry **Also**: pitch pine, wintergreen, bracken fern, sweet fern, Pennsylvania sedge

Traps were collected between midnight and 2 AM, or at sunrise the following morning, depending on weather conditions. On hot, highly productive nights, the traps were also emptied halfway through the night to reduce damage to specimens from other moths in the trap. Moths were transferred to collecting containers with additional killing agent.

Sheet sampling: To supplement the light trap samples, a 15-watt UV blacklight was suspended in front of a sheet suspended between two trees. Specimens were

captured directly in a killing jar. This method allowed for greater selectivity. Also, because some species are attracted to UV light but are not easily trapped in a bucket trap, the sheet method may have led to a greater species list.

Baiting: A fermented mixture of molasses, brown sugar, ripe bananas and beer was also used to collect moths. Baiting was done prior to, and well after, the blooming of red maples, as Schweitzer (1996) notes that the red maple bloom interferes with baiting success . Baitlines consisted of 15-20 trees painted with the moth bait. A bait patch approximately 6 inches by 1 foot was painted on each tree. Trees were at least 25 meters from black lights. Baitlines were walked from sundown till 2 AM during the same evenings that black light trapping occurred. Bait attracts some groups of moths that are not attracted to UV light. Moths were captured in a killing jar as in the sheet collecting method. All moths were transferred to collecting containers with additional ethyl acetate. For additional information of collecting moths with bait see Schweitzer (1996).

Identification: A rough ID/sorting of collected moths was performed using the photobook prepared by Maine TNC (2002) and Covell (1984). The goal was to sort the collection to Family, as well as to identify common species in preparation for final identification.

In the fall of 2002, moths were transported to Burlington, VT, where Scott Griggs and Dr. Dale Schweitzer and I performed final identification. In addition to using Mr. Grigg's extensive reference collection of moths, texts used to aid identification included: Ferguson (1978), Forbes (1948), Hodges et al. (1983), and Rings et al. (1992).

Rarity ranks were assigned to all species based on existing ranking by the NH Natural Heritage Inventory (1999) and by Dr. Dale Schweitzer.

Museum quality voucher specimens will be transferred in June 2003 to the University of New Hampshire's Entomology Department for storage. The Nature Conservancy also retained samples. Data on Lepidoptera will be shared with the New Hampshire Natural Heritage Inventory.

Study Limitations

This survey of Lepidoptera was conducted between May 17 and September 9, 2002. Adult Lepidoptera that are active only at other times of year, including several Target Species (Table 1, Appendix D), were, therefore, not sampled in this study.

Abundance across all sites was quite low in May according to Schweitzer (pers. comm.). This may have been low because of anomalous weather conditions. Average monthly temperature for May 2002 was 53.4°F, 2.6°F below normal. Total rainfall for the month was 4.38 inches, 1.05 inches above normal (National Weather Service 2003). Both Mello (pers comm.) in Massachusetts, and Griggs (pers comm.) in Vermont, note that their collecting in the late-spring and early summer of 2002 was below average. Abundance at Ossipee increased towards midsummer as the temperature rose and the rains departed but still were below Schweitzer's expectations.

Sampling was conducted strictly to determine presence/absence and distribution across the barrens, not to estimate abundance. Because Lepidopteran populations can fluctuate significantly from year to year, one season's data are insufficient for determining population size (Schweitzer and Rawinski 1988). Because Lepidoptera do not respond uniformly to blacklight or bait, it is not advisable to make inter-species comparisons of population size based on collection abundance.

Results Lepidoptera

More than 2500 macro-Lepidoptera were taken comprising 246 species in 12 families (Appendix C). Trapped micro-Lepidoptera were retained but not counted or identified.

Abundance and Richness

Species abundance per site was greatest in the Triangles and lowest at the IP site (Table 3, Figure 1). Abundance totaled 2524. Species richness per sites was greatest in the Triangles, and lowest at the IP site.

Not every site was visited the same number of nights (Appendix B). Species abundance and richness per trap-night was greatest at Hobbs and lowest at the IP site (Table 3, Figure 2).

Abundance and Richness of Target Species

Six of the 15 Target Species identified from collecting efforts at Ossipee in the 1980s and 1990s were collected in 2002, including: ***Glena cognataria***, ***Itame* sp. 1**, ***Apharetra dentata***, ***Xestia elimata***, ***Zale obliqua***, and ***Zanclognatha martha*** (tables 1 and 4, Figure 2). ***G. cognataria*** was taken at one location and ***Z. obliqua*** at two. ***A. dentata***, ***X. elimata***, ***Itame.* sp. 1** and ***Z. martha*** were taken at five locations each.

Nine Target Species were not found: ***Erynnis brizo brizo, Eumacaria latiferrugata, Lycia rachelae, Lithophane lepida lepida, Lithophane thaxteri,, Xylena thoracica, Xylotype capax, Zale* sp. 1** and ***Zale submediana***. Of these species, only ***E. latiferrugata*** might have been found with the sampling scheme and time frame of this study. ***E. brizoi*** is a day-flying skipper and all other Target Species are active either before sampling began (spring flyers) or after sampling ended (fall flyers). See Appendix D for specifics on the flight periods of Target Species.

Table 3: Moth Abundance and Richness by Collection Site, Ossipee Pine Barrens, for the collection period 5/17-9/9/2002

The number in parentheses in the header row is the number of times that a site was sampled. It does not account for the differences in success from night to night, i.e. one night might have been much more productive than two or three other nights combined.

*Rare species unique to a site: Target Species and additional species of conservation interest found only at one sampling location.

Family	Hobbs (6)	Mustapha (6)	IP (5)	Thicket (7)	Triangles (9)	W. Branch (8)	Kennett (1)	Northway (1)	All Sites	Total at bait	Total at light
Abundance	550	202	115	347	696	533	26	55	2524	119	2405
Species Richness	108	79	43	81	138	100	7	31	246	35	239
abundance /sampling frequency	92	34	23	50	77	67	26	55			
Species Richness/sampling frequency	18	13	9	12	15	13	7	31			
rare species unique to a site*	6	6	1	3	3	0	0	0			

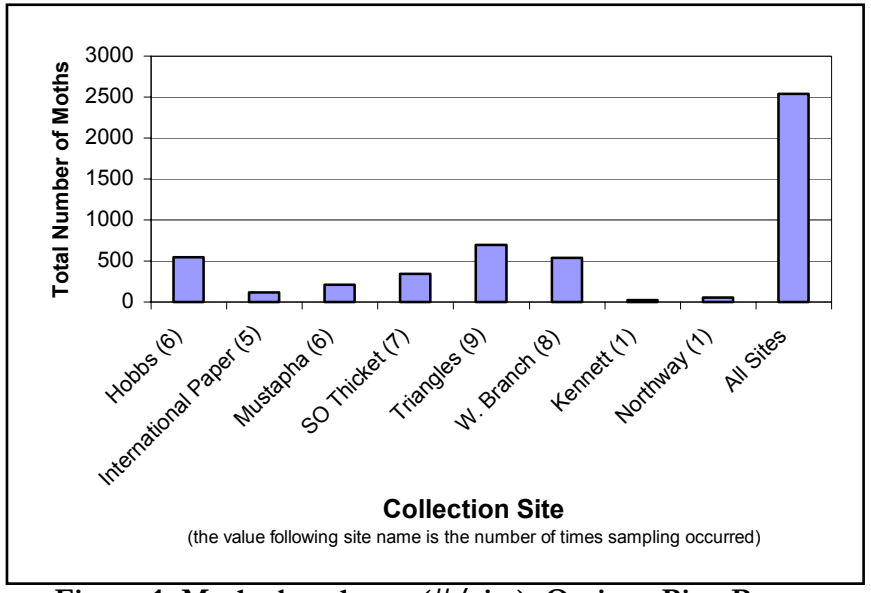


Figure 1: Moth abundance (#/site), Ossipee Pine Barrens, for the collection period 5/17-9/9/2002

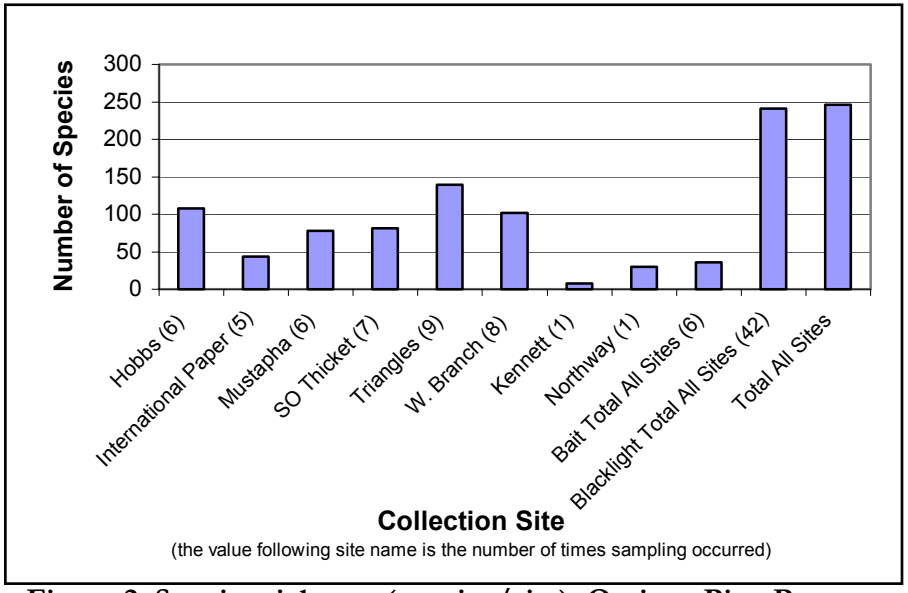


Figure 2: Species richness (species/site), Ossipee Pine Barrens the collection period 5/17-9/9/2002

Table 4: Ossipee Target Species abundance by species collection site, Ossipee Pine Barrens, for the collection period 5/17-9/9/2002.

Note that except for *G. congnitaria*, targets were found in multiple sites.

Family	Species	Rank	Hobbs	W. Branch	Triangles	SO Thicket	Mustapha	IP	Kennett	Total at bait	Total at light	Total
Geometridae	Glena cognataria	G4*			1						1	1
Geometridae	Itame Sp.#1	G3Q S1S2		6	7	1			1		15	16
Noctuidae	Apharetra dentata	G4 S2	4	7	46	22		18			97	97
Noctuidae	Xestia elimata	G5 S3S4	35	52	30	8		11		4	132	136
Noctuidae	Zale obliqua	G5 S2		1	2					1	1	3
Noctuidae	Zanclognatha martha	S4G4	8	16	10	2	3			4	35	39

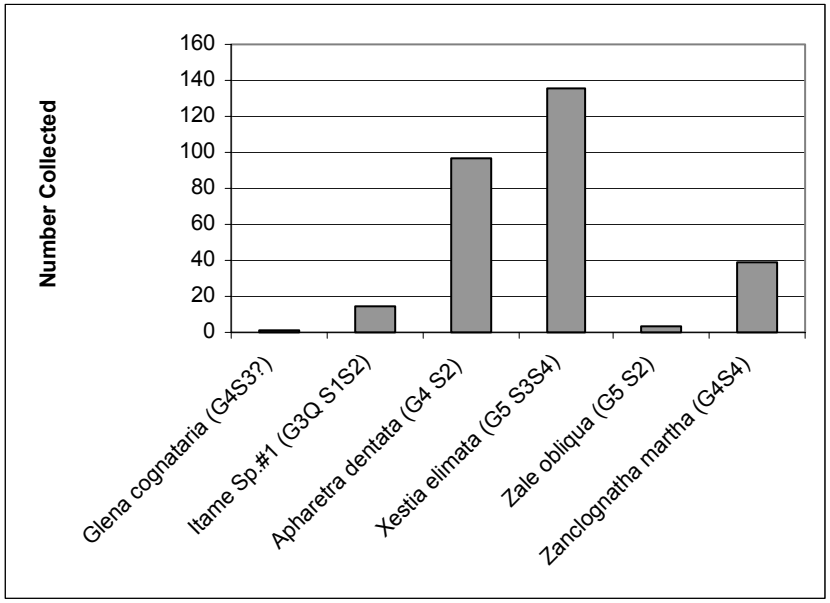


Figure 3: Ossipee Target Species abundance by species, Ossipee Pine Barrens, for the collection period 5/17-9/9/2002.

first caught	last caught	# of species	May	4	June	2	3	4	July	2	3	4	Aug	2	3	4	Sept	2
5/17/02	5/17/02	2	2															
5/17/02	8/1/02	1	1															
6/6/02	6/6/02	4			4													
6/6/02	6/18/02	1			1													
6/6/02	8/8/02	1			1													
6/18/02	6/18/02	2					2											
6/18/02	7/3/02	1					1											
6/18/02	7/12/02	1					1											
6/18/02	7/18/02	1					1											
7/3/02	7/3/02	7							7									
7/3/02	7/12/02	2							2									
7/3/02	7/18/02	3							3									
7/3/02	8/1/02	6								6								
7/12/02	7/12/02	3								3								
7/12/02	8/1/02	2								2								
7/12/02	8/8/02	3								3								
7/18/02	7/18/02	3									3							
7/18/02	9/9/02	1	# of species								1							
8/1/02	8/1/02	4		>4									4					
8/1/02	8/8/02	1		2 - 4									1					
8/1/02	9/9/02	1		1									1					
8/8/02	8/8/02	2												2				
9/9/02	9/9/02	1																1
# of species flying/week			3	1	6	3	8	5	17	**20**	**21**	14	**18**	9	3	2	2	3

Figure 4: Flight periods for Target Species and Lepidoptera of conservation interest, Ossipee Pine Barrens, for the collection period 5/17-9/9/2002

Flight Period	Species
5/17/02–5/17/02	Metarranthis duaria, Cerastis fishii
5/17/02–8/1/02	Acronicta impressa
6/6/02–6/6/02	Euchlaena marginaria, Metarranthis amyrisaria, Probole nepiasaria, Drasteria occulta
6/6/02–6/18/02	Aplectoides condita
6/6/02–8/8/02	Semiothisa granitata
6/18/02–6/18/02	Hemipachnobia monochromatea, Glena cognataria
6/18/02–7/3/02	Itame argillacearia1
6/18/02–7/12/02	Holomelina opella
6/18/02–7/18/02	Datana drexelli
7/3/02–7/3/02	Grammia virguncula, Euchlaena effecta, Euchlaena muzaria, Acronicta haesitata, Bellura obliqua, Lacinopolia lorea, Leucania inermis
7/3/02–7/12/02	Sphinx poecila, Zale obliqua
7/3/02–7/18/02	Holomelina ferruginosa, Euchlaena johnsonaria, Itame Sp.1
7/3/02–8/1/02	Grammia speciosa, Itame anataria, Semiothisa bicolorata, Semiothisa transitaria, Chortodes inquinata, Zanclognatha protumnusalis
7/12/02–7/12/02	Hyperstrotia villificans, Macrochilo hypocritalis, Paonias astylus
7/12/02–8/1/01	Eueretagrotis attenta, Euagrotis forbesi
7/12/02–8/8/02	Dasychira cinnamomea, Apharetra dentata, Zanclognatha martha
7/18/02–7/18/02	Catocala gracilis, Leucania pseudargyria, Dolba hyloeus
7/18/02–9/9/02	Abagrotis brunneipennis
8/1/02–8/1/02	Apantesis carlotta, Catocala connubialis, Hypenodes sombrus, Xestia praevia
8/1/02–9/9/02	Xestia elimata
8/1/02–8/8/02	Metarranthis Sp.#1
8/8/02–8/8/02	Catocala innubens, Hypagyrtis piniata
9/9/02–9/9/02	Xestia youngi

Additional species of conservation interest

Forty-seven additional rare or uncommon species were taken during the summer of 2002 (Appendix E). This list includes *Apantesis carlotta* not previously documented at Ossipee, *Macrochilo hypocritalis* found significantly out of its expected range, as well as rare species such as *Euagrotis forbesi* (S2S4) and *Cerastis fishii* (G4S2S4) and the little known *Hypenodes sombrus* (SU).

Ten species were collected in 2002 that are tracked by the New Hampshire Natural Heritage Inventory (Appendix E). The nine Target Species not collected in 2003 (Appendix D), but collected in previous efforts at Ossipee in the 1980s and 1990s are also tracked by the New Hampshire Natural Heritage Inventory.

The greatest number of Target Species and additional species of conservation interest were active between the first week of July through the first week in August (Figure 4). Seventeen to 21 of these species were active these weeks compared with half these numbers, or less, during the rest of the summer collection season.

Distribution

Of the six Target Species collected, only ***G. cognataria*** was taken at one site (Triangles). ***Z. obliqua*** was taken at two (Triangles and West Branch). All others were found at four to five sample sites (Table 3). Moreover, twenty-two of the 47 additional species of conservation interest were also found at more than one sample site (Appendix E).

Distribution by host plants

The Triangles had the greatest total richness and the greatest richness within each host plant grouping (Table 5) whereas Mustapha showed the least richness overall and within each host group.

Blueberry/heath feeders are the richest group (11 species). Pine feeders were found in the greatest number of sampling sites. They were most abundant at sites

with the greatest amount of pitch pine (i.e. Triangles, West Branch and Hobbs) (Table 5).

Hobbs and Mustapha had the greatest number of species unique to a sampling site. Other sites contained between zero and three unique species (Appendix E).

Distribution by Sampling Site

Hobbs and Upper Hobbs Tract (Table 2, Map 2): Species abundance at Hobbs totaled 549 specimens—the second highest total and the most specimens taken per trap-night (Table 3, Figure 1). Species richness was 108, the highest total richness of all sites and the highest per trap-night total (Table 3 Figure 2). The high richness is likely due to the proximity of two other habitat types bordering the barrens (wetlands and floodplain forest). Three of the six Target Species were taken at Hobbs: ***A. dentata***, ***X. elimata***, and ***Z. martha*** (Table 4). Eighteen of the 47 species of conservation interest were taken only at the Hobbs site including six species taken nowhere else (Appendix E):

IP (International Paper (Table 2, Map 2): Species abundance at IP totaled 116 specimens—the lowest total and the fewest specimens taken per trap-night (Table 3, Figure 1). Total species richness was 44, the lowest richness value of all sites and the lowest per trap-night total (Table 3, Figure 2). Two of the six Target Species were taken here: ***A. dentata*** and ***X. elimata*** plus nine additional species of conservation interest (Table 4, Appendix E). One of those, *Catocala connubialis*, was only taken at the IP site.

Mustapha (Table 2, Map 2): Species abundance at Mustapha totaled 208 specimens and species richness was 78 (Table 3, Figure 1). ***Z. martha*** was the sole Target Species taken here (Table 4). In addition, 16 species of conservation interest (Appendix E). Nine of these species were only taken at the Mustapha site.

Thicket (Table 2, Map 2): Species abundance at the Thicket totaled 347 specimens and species richness was 81 (Table 3, Figure 1). Four of the six Target Species were taken here (Table 4). Sixteen species of conservation

Table 5: Target Species and some other Lepidoptera of conservation interest by host plant and collection site collected 5/17-9/9/2002

1) Rows of bold text refer to total richness within a host group.
2) The numbers following individual species correspond to the number of individuals caught.
3) Not all species of conservation interest from Appendix E could be included here because their hosts could not be confirmed for the Ossipee region.
4) Shaded boxes note species found at only one site at Ossipee in 2002.
5) For a description of vegetation at each collecting site see Table 2.

Species	Larvae-host	Hobbs	IP	Mustapha	Thicket	Triangles	W. Branch	Kennett
Scrub Oak (2)		**1**	**0**	**0**	**1**	**9**	**10**	**1**
Itame sp. 1	scrub oak				1	7	9	1
Hyperstrotia villificans	scrub oak	1				2	1	
Blueberry/Heath (11)		**9**	**20**	**7**	**25**	**61**	**29**	**0**
Apharetra dentata	blueberry & other Ericaceae.	4	18		22	46	7	
Ceratsis fishii	Blueberry, probably other Ericaceae	1						
Glena cognataria	Mostly blueberry, also Prunus pumila (sand cherry), Prunus pennslyvanica					1		
Itame argillacearia	blueberry		1			6		
Abagrotis brunneipennis	blueberry	4			2	4	7	
Drasteria occulta	blueberry					1		
Eueretagrotis attenta	blueberry		1		1	2		
Grammia speciosa	bog heaths			6				
Metarranthis sp.1	heath and Myrica					1		
Xestia youngii	heaths						15	
Hemipacnobia monochromatea	early instar feed on sundews. It's believed later instars feed on heaths			1				
Pine (6)		**53**	**23**	**4**	**15**	**88**	**80**	**2**
Zanclognatha martha	Leaf litter perhaps mainly old pine needles	8		3	2	10	16	
Xestia elimata	Pitch pine, probably facultatively on white pine, perhaps even blueberry.	35	11		8	30	52	
Zale oblique	Pitch pine					2	1	
Semiothisa bicolorata	pitch pine				1	4	1	
Semiothisa Transitaria	pitch pine	9	12		4	41	9	
Semiothisa Granitata	pitch pine	1		1		1	1	2
Other (3)		**0**	**1**	**0**	**3**	**3**	**0**	**0**
Apantesis carlotta	grass, possibly					1		
Euagrotis forbesi	grass, possibly		1		1	2		
Hypenodes sombrus	Members of this subfamiliy are detritivores or fungivores. Nothing is known of the biology of this genus.				2			
	total richness per site	**11**	**9**	**7**	**13**	**20**	**14**	**5**

interest were also taken at the Thicket site, four of these were only taken at the Thicket site (Appendix E)

Triangles (Table 2, Map 2): Species abundance at the Triangles totaled 698 specimens and species richness was 139—the greatest numbers for both abundance and richness (Table 3, Figures 1 and 2). Abundance and richness at the Triangles per trap-night was the second greatest behind Hobbs tract. All six of the Target Species were taken here including the only ***G. congnitaria*** collected in 2002 (Table 4, Figure 2). Twenty-one species of conservation interest were also taken at the Triangles site and four of these species were taken only at the Triangles site (Appendix E).

West Branch Tract (Table 2, Map 2): Species abundance at the West Branch Tract totaled 540 specimens and species richness was 102 (Table 3, Figure 1). Five of the six Target Species were taken here (Table 4)—***G cognitaria*** was the only one not collected. Fifteen species of conservation interest were taken at the West Branch Tract, one of which, *Xestia youngii,* was found only here (Appendix E).

Discussion: Lepidoptera

Six of the 15 Target Species were collected in 2002 (Table 4). Of the nine Target Species not found in 2002 (Appendix D), all but ***E. latiferrugata*** and ***Zale* sp. 1** are either inactive during the study time-frame or are diurnal, explaining why they were not found. See Appendix D for specifics on the flight periods of Target Species.

Possible explanations for why ***Zale* sp. 1** was not found include insufficient sampling effort, poor weather conditions or this species' extirpation from Ossipee. Insufficient sampling effort is the most likely reason. ***Zale* sp 1** is usually taken with bait in May, but bait was used minimally during this period because of poor weather conditions and interference from the red maple bloom (Schweitzer 1996).

Possible explanations for not finding ***E. latiferrugata*** include the same hypotheses noted for ***Zale* sp 1** plus two others: lack of host plants and errors in historic records.

E. latiferrugata, a May flying species, feeds on uncommon barrens hosts—sand cherry (*Prunus pumila*), pin cherry (*Prunus pennsylvanica*), and possibly some *Aronia* species. Sand cherry was not found at Ossipee in 2002 (Dacey 2003 and personal observation). If ***E. latiferrugata*** is present at Ossipee, its population is probably quite small. It could easily have been missed, especially since the May collecting volumes were quite low.

It is also possible that ***E. latiferrugata*** may have never existed at Ossipee. According to NH Natural Heritage records, ***E. latiferrugata*** was last recorded at Ossipee in 1985. But NH Natural Heritage does not have the name of the collector and the record is suspect. Schweitzer (pers. comm.) also considers this record questionable.

Still, inferences can be made about the presence of ***Zale* sp 1** and ***E. latiferrugata***. Schweitzer (2002-Appendix F) speculates that these moths are

likely present if their host plants persist. Since ***Zale* sp 1** is a scrub oak feeder, chances of its persistence are promising. Signs are not as promising for ***E. laterferugata***. Neither sand cherry nor pin cherry was detected on the barrens in 2002 by myself or Dacey (2003). Where we did see *Prunus* we both took it to be black cherry and *Aronia* sp. was found in low numbers.

Zanclognata martha (G4S1) is the only Ossipee moth that is listed by the State of New Hampshire as a threatened species. It was found at five locations in 2002 (Table 4).

Ossipee's ***X. elimata*** may warrant additional study. Schweitzer (pers. comm.) hypothesizes that there may be a Northern and Southern race of this species. If so, he considers Ossipee the "type locality" for the northern subspecies—the definitive location to find this subspecies. Approximately 100 *X. elimata* collected at Ossipee in 2002 were sent to Schweitzer in May 2003 for further analysis.

Distribution of Target Species

Of the six Target Species collected in 2002, five were found at more than one sample site (Table 4). Only ***G. cognitaria*** was found at a single site (Triangles). Though the population dynamics of target species is not well known, finding the targets at multiple sites is an indication of either multiple subpopulations, or a single large population across the Ossipee Barrens. The more extensive a species' distribution, the more stable it is and the more amenable it will be to management actions (Goldstein 1997, Thomas 2000). Since Lepidopterans' primary means of persistence in disturbance-dependent pine barrens ecosystems is recolonization after disturbance, multiple subpopulations or a widespread population increases the probability of recolonization (Schweitzer 2002, Wagner et al. in press (a)).

Members of the local population may be better adapted to Ossipee than are long-range immigrants (Schweitzer and Rawinski 1988), as isolation of northeastern barrens over the past several millennia has likely resulted in local genetic strains adapted to particular barrens (Cryan 1985). Therefore, post-disturbance recolonization by locally adapted species could be more successful than

recolonization by immigrants from other barrens (Goldstein 1997). However, isolated populations may suffer from genetic drift (the chance loss of genes experienced by small populations) and inbreeding. Land managers should consider connectivity to other barrens in their management efforts.

Some of the populations of Target Species appear quite robust, in particular the pine feeding ***X. elimata*** and the blueberry feeding ***A. dentata***. However, because Lepidopteran populations can fluctuate greatly from year to year (Young 1997), multi-year sampling is needed to verify population integrity and size. Even population comparisons between species can be tenuous because of the small number of traps deployed and because Lepidoptera do not respond similarly to blacklight or bait. Some, in fact, do not respond at all (Winter 2000). ***Z. obliqua***, is an example of a Target Species that responds poorly to blacklights (Schweitzer 2002). Still a few conclusions can be drawn:

1. Target Species ***X. elimata*** (formerly *Anomogyna elimata*) was the second most numerous species taken (136) in 2002 after the common *Idia rotundalis* (160) (Appendix C). McCarthy and VanLuven (1996) reported a large number of ***X. elimata*** taken in 1995, including 115 specimens in one night at the Tragenza parcel (not sampled in 2002).

2. Nearly 100 ***A. dentata*** (formerly *Apharetra purpurea*) were trapped during the 2002 collecting season, a large number compared with both common and target species (Appendix C).

3. Though only a single ***G. congnitaria*** was collected (at the Triangles), this species is likely more widespread. Though very little is known about ***G. congintaria*****'s** life-history requirements, its larval host plant, blueberry is ubiquitous. According to Schweitzer (2002), Lepidoptera that feed on pitch pine, scrub oak or blueberry in the Ossipee Barrens can be assumed to be widespread, except where canopy closure exceeds 50 percent.

4. When additional species of conservation interest are included in the distribution analysis, Hobbs and Mustapha each have six species unique to a sampling site—the greatest number among all sites (Table 3, Appendix E).

These two sites have the least in common vegetatively with the other sampling sites. The Mustapha site is a bog. The Hobbs site is a transitional pitch pine forest and is within 300 meters of a fen and an extensive red maple flood plain forest. The remaining sample sites were more classically dry pitch pine-scrub oak barrens.

On a cautionary note, Ossipee Target Species live for a maximum of one year and most are univoltine species, meaning they produce only one new generation per year. None of the targets has the ability to wait out a bad year in dormancy as can the buckmoth, *Hemileuca maia*, found on other barrens. Therefore, if a population (even a robust one) has a poor reproductive year, populations can drop precipitously.

The Triangles was the only sampling site where all six Target Species were collected. The Triangles also showed the greatest overall abundance and species richness in 2002 (Table 3, Figures 1, 2). There are several possible reasons for these results. First, the Triangles was sampled more frequently than the other sites and over the broadest period of time (Appendix B).

Also, the Triangles history of logging over the past 30 years has turned it into an amalgam of habitat patches including moderately open scrubby-heath areas, dense young pitch pine stands and mixed pitch pine-white pine stands. It is possible that logging history has been beneficial to some of the Target Species. If such a benefit has occurred, it is unlikely that it will have a long-term positive effect due to logging's impact on nutrient cycling and plant composition in barrens. (See the "Management and Prescribed Fire" section for additional discussion of this issue.)

The landscape surrounding the Triangles may also boost species richness at the Triangles (Grand and Mello in press). The Triangles shares a large border with a powerline right-of-way dominated by low heath shrubs. Schweitzer (2002-Appendix F) notes that powerline right-of-ways have high potential as habitat for Lepidoptera. The Triangles was the only site to produce ***G. congnitaria,*** a blueberry feeder that perhaps relies on the right-of-way. And, though ***A. dentata***,

another blueberry feeding species, was found at four other sampling sites, its abundance at the Triangles was at least twice that at other sites (Table 4).

Though light traps and baitlines were placed at least 25 m from the edge of all parcels, the juxtaposition of habitats at the Triangles may have produced an edge effect, increasing species diversity for the area. Mello (2002) notes that significant edge effects can occur near habitat borders, and Ricketts et al. (2001) observed "halos" of relatively high species richness and abundance surrounding habitat fragments that extend about 1.0-1.4 km from an edge.

The distribution of Target Species across the Ossipee Barrens has significant and positive implications for management at Ossipee. However, finer scale analysis (within-parcel) of population size and distribution is difficult because of the small number of specimens caught at any one site and the confounding effects of adjoining patches (Mello pers. comm., Ricketts et al. 2001). However, if all six Target Species are indeed supported solely by the 17 ha Triangles plot, then managers should note that it might be possible to manage for a number of target species in a small patch—though likely only for short periods of time. In the longer run, conservation of this productive site requires the protection of adjacent habitats.

Lepidoptera composition by host plant and sample site shows only minor differences across the barrens. When Target Species and additional species of conservation interest are grouped by their respective host plants (scrub oak, heath/blueberry, pitch pine and other), species richness between sites does not differ much from overall richness between sites (Table 5).

The Triangles holds the greatest richness for each of the four host plant groups; Mustapha, the lowest. Pine feeders are found in the greatest number of sampling sites and, not surprisingly, in the greatest abundance at sites with the highest density of pitch pine—Triangles, West Branch and Hobbs (Table 5). Sample sizes are too small to identify patterns for heath/blueberry and scrub oak feeders.

Forty-seven additional Lepidopteran species of conservation interest were collected on the barrens. Most species in this group were taken in very small numbers, though 22 of the 47 were found at more than one sample site, indicating a widespread albeit small presence at Ossipee (Appendix E). A description of several of these species can be found in the 2002 Schweitzer report (Appendix F).

Schweitzer (2002) identified these 47 species as potentially useful in future monitoring efforts to give a richer picture of rare and uncommon Lepidoptera in the barrens. Expanding monitoring efforts beyond the Target Species list to include at least a portion of these species can provide a better indication of habitat quality. Monitoring at the Mustapha site would particularly benefit from additional indicator species, as the site does not fully share the same assemblage of species found at other barrens locations. Mustapha held the greatest number of unique species in the 2002 survey (Table 3, Appendix E). Potential additions to the monitoring list include:

Macrochilo hypocritalis (G4SU), a sedge-associated species that might be expanding its range northward from the Mid-Atlantic States and central US (Schweitzer 2002).

Grammia speciosa (G5SU), a bog and taiga species found more commonly well north of Ossipee in boreal regions. According to Schweitzer (2002), it is likely found in most New Hampshire bogs and perhaps fens. Its southern range is Massachusetts and Connecticut, where it is considered rare.

Paonias astylus (G4S3), a bog, barrens and acid woodland species that is new for Ossipee. Larvae feed on blueberry and probably other heaths. Two were taken at Mustapha and one at Hobbs. *P. astylus* is not considered rare in Massachusetts or Connecticut and according to Schweitzer (2002) it can be a common species. Its reputation for rarity is due to the exclusively very late night flight of the males.

A Natural History of Pine Barrens Lepidoptera

Insects appear to have requirements that are simply not well understood.
—Paul Goldstein, 1997

Thirty-two species of Lepidoptera are characterized as dependent on pine barrens habitat in the northeast US—the largest assemblage of regionally rare Lepidoptera of any habitat in the region (Schweitzer and Rawinski 1988). Clearly pitch pine-scrub oak barrens are hotspots for rare Lepidoptera (and possibly for many other invertebrates as well, including rare Heteroptera (plant bugs), Hymenoptera (particularly ants) and Coleoptera (beetles) (Schweitzer and Rawinski 1988, Sievert 2002, Wagner et al. in press (a)). Though quite little is known about the life histories of individual species within this assemblage (see Appendices D and F for life-history accounts of Ossipee's Target Species), entomologists and Lepidopterists are developing a greater understanding of the attributes that make pitch pine-scrub oak barrens so Lepidoptera friendly.

Most of the assemblages of pitch pine-scrub oak barrens Lepidoptera are not endemic to the Northeast, or to barrens. Some of these Lepidoptera also inhabit woodland, heathland, grassland or bog in the Northeast and in other regions. For example:

- Northeast pitch pine–scrub oak barrens specialists at the northern limit of their range may occur in oak and pine woodlands or even true forests to the south and west (Wagner et al. in press(a)).

- Northeast pitch pine–scrub oak barrens specialists at the southern limits of their range often occur in heath beds and boreal vegetation north and west into Canada.

- Most of the Lepidoptera with larvae specializing in pitch pine in New England and New York routinely utilize hard pines (e.g., red, jack, and Virginia) elsewhere (Wagner et al in press (a)).

Individual species in the assemblage have their own particular requirements and life histories and do not all respond to environmental gradients in the same manner. But it is only in Northeastern barrens that this varied and large assemblage comes together. The availability of host plants and other biotic and abiotic factors make this possible.

Hosts: The presence of food (larval host plant and in some cases adult nectar sources) is the primary requirement of Lepidoptera. Many Lepidopteran larvae (as well as other herbivorous invertebrates) are specialists relying on a single plant species, genus or family for food. Specialization likely evolved as a response to the extraordinary arsenal of chemical, physical, spatial and temporal defenses developed by plants to prevent assaults on their tissues (Herrera and Pellmyr 2002). Most barrens Lepidopteran larvae specialize in one of the three dominant plants in the community—scrub oak (*Quercus ilicifolia*), blueberry (*Vaccinium* spp.), and pitch pine (*Pinus rigida*).

Many Lepidoptera—including all species of Saturniidae and Lasiocampidae, and many Arctiidae and Notodontidae—do not feed as adults (Covell 1984). Feeding adults are generally not specialists (even when their larvae are) and can feed from a variety of flowering plants as well as tree sap. Because plants produce nectar to attract pollinators, nectar is generally available to many insects with few requirements (Howe and Westley 1998).

Scrub oak (*Quercus ilicifolia*) is the sole or principal regional larval host for several rare barrens Lepidoptera, including three of the 15 Ossipee Target Species in this study (Appendix D). *Vaccinium angustifolium* and *V. vacillans* are collectively known as lowbush blueberry and are the second most important regional barrens hosts. At Ossipee lowbush blueberry is the sole or primary host for five of the 15 Target Species. A few of these targets will also feed on other members of the Ericaceae family (Appendix D). Many polyphagous Lepidoptera are also believed to utilize lowbush blueberries and/or scrub oak (Wagner et al. in press (a)). Pitch pine (*Pinus rigida*) is the third most common host for barrens Lepidoptera. This includes four or five of the 15 Target Species in this study (***Zanclognatha martha,*** a leaf litter feeder, may prefer old pine needles to other litter).

The presence of host plants does not translate to presence of rare Lepidoptera (Wagner 2002). Some scrub oak and blueberry is found in habitats other than pine barrens, but many scrub oak and blueberry feeding Lepidoptera are not found in these other habitats (Schweitzer and Rawinski 1986). Furthermore, highbush blueberry, members of the *Prunus* genus, and others host a number of barrens Lepidoptera in laboratory settings but not in the field. Lepidoptera apparently have habitat requirements in addition to the presence of their hosts. The following is a review of some abiotic and biotic factors believed to affect barrens Lepidoptera habitat choice.

The importance of pine barrens to rare Lepidoptera

Wagner et al. (in press (a)) identify six characteristics of pitch pine-scrub oak barrens that are key to the persistence of barrens Lepidoptera (Table 6).

Table 6: What's so special about Pine Barrens?

Abiotic	**Biotic**
High insolation and soil temperatures	Leaf phenology—late leaf out
Dry conditions	Stressed plants
Extreme daily temperature fluctuations	Enemy-free space—Vegetation structures of the barrens many decrease the number and effectiveness of predators

Insolation: The reduced canopy cover allows high levels of solar radiation to reach the ground. The resultant high diurnal near-ground temperatures compared with cold temperatures that commonly occur in oak woodlands and even forested landscapes southward may speed up the maturation time of barrens Lepidoptera (Wagner et al. in press (a)).

Edaphic factors: Pitch pine-scrub oak barrens are among the most xeric in the Northeast. The coarse, sandy soils that typify barrens have little ability to hold water. This, combined with high daytime soil temperatures, leads to summer droughts. This leads to decreased canopy cover, low plant biomass, and low leaf litter relative to nearby oak woodlands (Wagner et al. in press (a)). The resulting open canopy and higher temperatures may benefit Lepidoptera.

Daily temperature fluctuations: Pine barrens experience broad swings in temperature, both daily and seasonally, due to extremely rapid radiational cooling associated with sandy soils and low plant biomass. Though one would expect the great fluctuations in temperature to be problematic for most Lepidoptera and most other species, Wagner et al. (in press (a)) suspect that to many caterpillars, the warm daytime temperatures more than compensate for cold nights. They've found that most nocturnal spring caterpillars are active down to about 5ºC. These caterpillars then take advantage of the daytime heat to speed digestion, assimilation, and growth.

Despite the colder night-time temperatures, nocturnality also may confer advantages to adult Lepidoptera. Significant temperature, humidity, and solar radiation gradients can develop during daylight hours. Diurnal Lepidoptera might have to employ costly energetic and behavioral responses as they move from full sunlight to shade. Nocturnal Lepidoptera can move about with less effort because ambient conditions fluctuate far less (Daily et al. 1996). Of Ossipee's 15 Target Species only one, ***Erynnis brizo brizo***, is diurnal.

Leaf phenology: The growing season in pitch pine-scrub oak barrens is short, and scrub oak does not leaf out until late May or early June. These leaves may also mature more slowly. Both attributes may make them more palatable to Lepidoptera (Mello pers. comm., Wagner et al. in press (a)) as younger oak leaves have a greater nitrogen to carbohydrate ratio and lower amounts of tannins (digestibility reducers) compared with mature leaves (Herrera and Pellmyr 2002, Young 1997).

Stressed plants: Schweitzer (pers comm.) hypothesizes that the stressful growing conditions found in barrens may limit the amount of available resources that a plant can allocate to defense (Herrera and Pellmyr 2002). This may make it easier for Lepidoptera to feed on the barrens vegetation.

Enemy free space: High insolation, low water availability, temperature fluctuations and altered leaf phenology may all combine to reduce canopy cover and simplify canopy structure. The resultant structure may discourage

caterpillars' predators, parasites and/or parasitoids because searching open ground may expose them to undesired levels of predation themselves (see the discussion of the Lepidopteran parasitoid *Compsilura* in the discussion section). Fewer members of Ossipee's avian community were seen in open patches far from dense cover during the summer of 2002. The enemy-free space theory may explain why some Lepidoptera can feed on alternate hosts in the lab, but do not do so in the field. (Wagner et al. in press (a)).

The importance of rare Lepidoptera to pine barrens

Pitch pine-scrub oak barrens are important sites for a large assemblage of rare Lepidoptera, but can the opposite be said? Are rare Lepidoptera important to the ecological functions and processes that sustain pitch pine-scrub oak barrens?

Wagner thinks not (pers. comm.). He notes that there is much ecological equivalency in barrens ecosystems so that herbivory and decomposition rates would be roughly the same with or without the rare species. Loss of rare Lepidoptera may however be problematic for parasites of rare Lepidoptera, the specialized hymenopteran and dipteran parasitoids, but beyond that Wagner does not anticipate potential cascades or repercussions.

General estimates suggest that up to five species of parasitoids exist for every insect herbivore (Hochberg 2000), but Schweitzer (per comm) doubts that many specialized parasitoids exist at Ossipee. He posits that parasitoids in the Northeast do not tend to be extreme specialists, although some do focus on a single family or group of genera. Except for ***Lycia rachelae***, all of Ossipee's Target Species have close relatives with similar phenology in the area. Schweitzer also doubts that these rare Lepidoptera are critical links except in the sense that they contribute to the total Lepidopteran biomass in the barrens, something that other species depend upon. For example Schweitzer suspects that *Xestia* spp. larvae might account for a important portion of the diet of shrews in winter.

Rare Lepidoptera may not be critical links in the food web that hold barrens together but they are unquestionably important in their own right as units of genetic and biological diversity. They may also play roles in currently unknown,

but critical ecological processes. For now, they have an important job as indicator species for pine barrens, just as aquatic invertebrates help to determine habitat quality in aquatic systems (Karr and Dudley 1981, Panzer 1988, Kremen et al. 1993, Goldstein 1997). Wagner (2002) notes that "rare Lepidoptera are the primary currency for judging the quality of barrens community types."

Management for Lepidopteran Target Species

Threats to Barrens Lepidoptera

Several intertwined mechanisms including development, fire suppression, habitat conversion, catastrophic fire, fragmentation, introduction of invasive species, predators and disease pose threats to barrens flora and fauna (Figure 5). Though some of these problems do not currently present themselves at the Ossipee Pine Barrens, land managers should be aware of them and prepared to address them if necessary.

Development: Commercial and residential development directly results in permanent loss of habitat for barrens-dependent Lepidoptera. Development continues to encroach upon the preserve. Residential and commercial lots of undeveloped land along Ossipee Lake Road and in neighboring subdivisions were on the market during 2002. The reduction of total available habitat leaves fewer opportunities for management and conservation at the landscape level to produce a complex mosaic of vegetation types and successional stages (Vickery and Dunwiddie 1997).

It is not clear how large a patch is necessary to sustain viable populations of Lepidoptera over time on the Ossipee Pine Barrens. Schweitzer and Rawinski (1988) and Cryan (1985) estimate that at least 400 ha is required; however, Ossipee is a vegetatively simple barrens, with fewer habitat variations than more complex barrens possess. For example, it does not currently include sandplain or grassland structural components, and it is presumed that these communities were never part of the complex. This relative simplicity reduces the number of habitat types that land managers need to maintain in the Ossipee habitat mosaic, but it does not obviate the fact that larger barrens generally have greater species diversity (Schweitzer and Rawinski 1988). Schweitzer reviewed the status of the Ossipee Barrens in 2002 and emphasized the importance of land acquisition as a management priority.

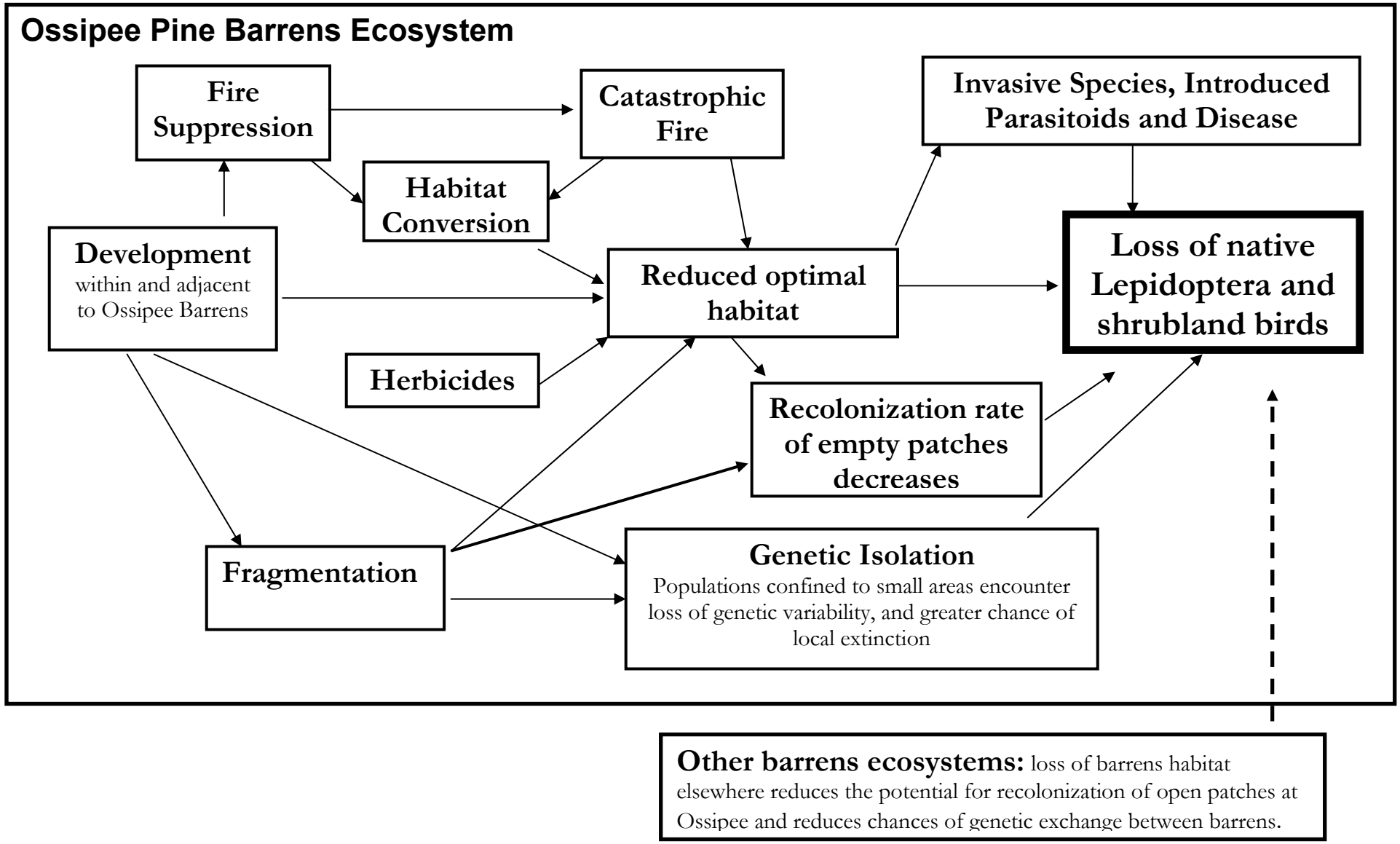


Figure 5: Threats to Ossipee Pine Barrens Lepidoptera and shrubland birds

Fire Suppression: In addition to its direct toll on total available habitat, development drives fire suppression. Due to concerns for human safety and loss of personal property, fires in the barrens have been suppressed. There has not been a significant fire in the Ossipee Barrens for at least five decades. But pine barrens ecosystems evolved with periodic fire (Forman 1979, Christensen 1985). Historic fire intervals in Ossipee are on the order of 20 to 50 years (Patterson 2001). Without fire or a viable vegetation management program that mimics fire, Ossipee's barrens ecosystem will likely shift to a more common forest type (Cryan 1985) such as a white pine-hardwood forest. Ironically, fire suppression can also precipitate catastrophic fire. Without periodic fire to thin vegetation and remove fuel from the landscape, a build-up of both can create unnaturally hot, uncontrollable fire. Fire is an inevitability and should be accommodated rather than suppressed.

Though the Thicket parcel and sections of the West Branch parcel seem quite resistant to the growth of trees, other parcels, such as the Triangles, Hobbs and the western border of the West Branch are experiencing canopy closure, the effect of prolonged fire exclusion. For additional information on Ossipee's fire history and current vegetation see Dacey (2003).

Habitat conversion: The dominant vegetation in pitch pine-scrub oak barrens require periodic fire to persist. Without fire, the forest canopy eventually closes and pitch pine and scrub oak can no longer compete with white pine, red maple and tree oaks. The Hobbs Tract, the Triangles and the Western edge of the West Branch tract show the greatest signs of conversion with substantial numbers of white pine in the canopy. None of Ossipee's five pine-feeding moths utilize white pine, and the remaining Target Species and other barrens-dependent Lepidoptera would experience reduced habitat quality. Therefore fire suppression has the net effect of reducing total available habitat for barrens Lepidoptera.

Throughout the world fire suppression and habitat conversion has lead to the reduction or loss of some Lepidoptera. For example, in the Western US, several species of greater fritillaries (*Speyeria* spp.) native to coastal shrublands and

grasslands have declined due to fire suppression (Schweitzer and Rawinski 1988). In England, heathland *Plebejus argus* populations have declined since peat digging and burning were discontinued. Conversion of heathlands and grasslands into pine plantations in England has extirpated both *Emmelia trabealis* and *Hadena irregularis* (New 1997, Young 1997 as cited in Wagner et al. in press (a)).

Catastrophic fire: Fire suppression can lead to a build-up of fuel and more dense vegetation which can result in fire that burns much hotter and larger than would naturally occur in an unsuppressed system. These hot fires can kill the dominant pitch pine and heaths that might survive a cooler fire. Whereas a cool fire might release nutrients and organic matter back into the soil, stimulating new vigorous growth, a hot fire can volatilize organic matter and sterilize soils. This can lead to prolonged periods without vegetation. The Lepidoptera would likely be killed in a hot, crown fire whereas they might survive a cool fire, either as larvae or pupae buried in the soil, or in the canopy above a ground fire. Given the small size of the overall habitat remaining in Ossipee, the threat of catastrophic fire that could wipe out entire populations of rare Lepidoptera is also of concern.

Fragmentation: Development and habitat conversion can fragment the barrens landscape. As natural patches become smaller and more isolated, their ability to maintain healthy populations of many plant and animal species is reduced (MacArthur and Wilson 1969, Harris 1984). Recolonization of isolated fragments becomes less likely as fragmentation increases. As individual species are lost from each fragment, the community changes and both species and ecosystem diversity are reduced. Fragmentation can lead to additional human neighbors bordering preserve properties. This can impede the implementation of management actions such as prescribed burning. Roads, houses and other intrusions that fragment habitat can also serve as vectors for invasive species.

Fragmentation is a concern at Ossipee as protected parcels are already disjunct and separated by roads, powerline right-of-ways, and private property. Increased development along State Highway 41 will further separate the Triangles parcels

from the West Branch Tract. Similarly development along Ossipee Lake Road and in the neighboring aviation communities will isolate the Hobbs and Thicket tracts. The Hobbs tract, being quite long and narrow, shares a significant amount of edge with non-TNC property. Land protection immediately south of the Hobbs Tract would add a significant level of buffer to the preserve and make habitat management easier.

Invasive species: Habitat destruction and fragmentation can also increase the opportunities for the introduction of invasive species to the barrens. Though invasive species are not a current threat to the Ossipee Barrens Preserve, aspens (*Populus* spp) and Japanese knotweed (*polygonum cuspidatum*) are found within the preserve. These and several species are causing problems in other barrens. This includes phragmites (*Phragmites australis*) (Martin 2001), aspens (*Populus* spp), black locust (*Robinia psuedoaccacia*) garlic mustard (*Alliaria petiolaris*), and bush honeysuckles (*Lonicera* spp) (Albany Pine Bush Preserve Commission 2002).

Because the Mustapha parcel is the only bog habitat in the Preserve, and a small one at that, it should be monitored for the arrival of invasive plants. Invasive bog and fen species can reproduce quickly and are capable of altering the bog's hydrologic regime, effectively leaving native species high and dry (McCabe pers. comm.). With volunteer help, Massachusetts TNC was able to control a *Phragmites australis* outbreak on its Kampoosa Bog site (Martin 2001).

Prevention is the best method to address exotic invasions. If prevention fails, early detection can make the difference between successful eradication and endless effort and burdensome costs (McNeely 2003).

Introduced parasitoids and diseases: A number of potentially dangerous Lepidopteran parasitoids and diseases have been intentionally and unintentionally released in the Northeast. Deliberate releases have generally been attempts to control gypsy moth (*Lymantria dispar*) and other "pest" species. A small number of gypsy moths were taken in the summer 2002 collection at Ossipee. The density of tree oaks in the Ossipee valley is modest so the threat of a gypsy moth outbreak is minimal, and fear of this species far exceeds its abilities as a

defoliator, so attempts to "control" gypsy moths in proximity to the Ossipee Barrens should be prevented. The cures for gypsy moth outbreaks can be much more damaging to the local Lepidopteron population than they are useful at controlling the gypsy moths. Three biocontrols that pose significant threats include: the tachinid fly *Compsilura concinnata,* the virus *Bacillus thuringiensis* (Bt) and the moth killing fungus *Entomophaga maimaiga*.

Compsilura concinnata*:** Of particular concern for pine barrens Lepidoptera is *Compsilura concinnata*, afast-spreading gypsy moth biocontrol. This tachinid fly is a generalist parasitoid that attacks more than 180 species of native Lepidoptera (Boettner et al. 2000) including Ossipee Target Species ***Glena cognataria, species in the genus *Datana* and many other large-bodied moths in the Saturniidae and Sphingidae families.

Large pine barrens have lost fewer species to *Compsilura* than have other habitats. Experts believe that this fly does not do well in sandy, open habitat (Schweitzer pers. comm.). Currently, Ossipee seems fairly unaffected by *Compsilura*. Though no Saturniidae were collected in 2002, several species of Sphingidae as well as *Datana drexelii* were collected in 2002—an indication that the *Compsilura* parasite is not present at Ossipee (Schweitzer 2002-Appendix F).

Unfortunately, another *Compsilura* parasitoid has more recently been introduced to the US. This one seems more capable of hunting in open areas (McCabe pers. comm.)

***Bacillus thuringiensis* (Bt):** The virus *Bacillus thuringiensis* (*Bt*) is another control agent for moth "pests" that affects a wide variety of Lepidoptera. Bt is often applied aerially and can spread in unintended directions. Land managers should be very concerned about applications of Bt near the barrens.

***Entomophaga maimaiga*:** Yet another gypsy moth killer, the fungus *Entomophaga maimaiga* appears to have been responsible for population crashes of non-target Lepidoptera as well (McCabe pers. comm.). Fungal spores enter and grow inside the body of the caterpillar. The fungus digests its way through the

exoskeleton of the caterpillar. Infected caterpillars may die within one week (Smitley 1996).

Herbicides in powerline right-of-ways: New Hampshire Public Service Company (PSC) employs herbicides in the management of powerline right-of-ways. Additional management tools in their arsenal include brush cutting and sheep grazing. Most of their right-of-ways experience vegetation control on a five-year cycle. PSC conducted brush cutting in the right-of-ways bordering the Thicket and Triangles tracts in 2000 and 2001. Scott MacGregor, PSC Arborist for the Carroll County region (pers. comm.), expects that the company will revisit these sites in two to three years to apply herbicides. Herbicides are PSC's most cost-effective control tool but are not preferred for any other reason. MacGregor has experience working with conservation managers in the Concord, NH, area to manage right-of-ways for the benefit of the federally listed endangered Karner Blue Butterfly and states that he'd be willing to work with TNC on minimizing negative effects of powerline management to Ossipee's Lepidopteran populations.

Deer: Though a survey of deer abundance on the barrens was not an objective of this study, white-tailed deer (*Odocoileus virginianus*) are an obvious presence throughout the Preserve, but in my opinion, the population is small. Augustine and Frelich (1998) found that browsing by white-tailed deer can alter woody plant abundance and that grazing can lead to the local extirpation of sensitive forbs. Browsing by deer in the Albany Pine Bush has suppressed regeneration of pitch pine (Albany Pine Bush Commission 2002).

Management and Prescribed Fire

Without fire, much of the Ossipee Pine Barrens would succeed to another forest type. Only the most xeric sites (the Thicket tract may possibly be one such site) would likely maintain barrens characteristics. These small patches would not be sufficient to maintain populations of rare barrens flora and fauna, especially since these patches will be vulnerable to stochastic events (Schweitzer and Rawinski 1988).

Prescribed fire is one of the more useful tools available (Schweitzer 2002). Mechanical methods of managing barrens vegetation (e.g. brush cutting, mowing and thinning) have been employed on barrens and other disturbance dependent landscapes with mixed success (Panzer 2002, Swengel 2001). These methods generally attempt to mimic fire or to prepare landscapes for prescribed fire. Therefore, this chapter focuses on the impact of fire on Lepidoptera. This section ends with a brief discussion of the efficacy of alternate vegetation management methods.

Refugia are key to Lepidopteran populations' persistence in fire-prone habitats. Individual Lepidoptera are not fire-resistant. Estimates of Lepidoptera mortality from fire vary but are in the range of 80-95+% within burned patches (McCabe pers. comm., Schweitzer pers. comm., Simmons pers. comm., Simmons et al. 1995). The survival of an individual within a burn depends largely on what life-stage it is in and species-specific traits associated with that stage.

Under certain circumstances, Lepidoptera can survive a fire burrowed into mineral soil or high in a tree above the heat and flames. However, the vulnerability of holometabolous insects (those that develop from egg to pupae to larvae to adult) to fire depends on the behavior of a species during each developmental stage. For example, adult female ***L. rachelae*** are flightless, so they cannot escape fire; ***L. thaxteri*** larvae do not burrow into soil where they might escape fire (as the larvae of some other species do).

There is no time of year when the majority of Target Species are safe from a fire. Using Schweitzer's (2002-Appendix F) life history information for Ossipee's Target Species, I graphed fire vulnerability by life-stage and time of year for Ossipee's 15 Target Species (Figures 6 and 7). These figures show there are time windows when individual species have better chances of surviving the immediate effects of fire but these windows are not the same for all species. Fire historically was most prevalent in late summer, so one might hypothesize that Lepidoptera have evolved strategies of late summer fire avoidance, but this does not appear to be the case. Wagner (pers comm.) succinctly addresses the management

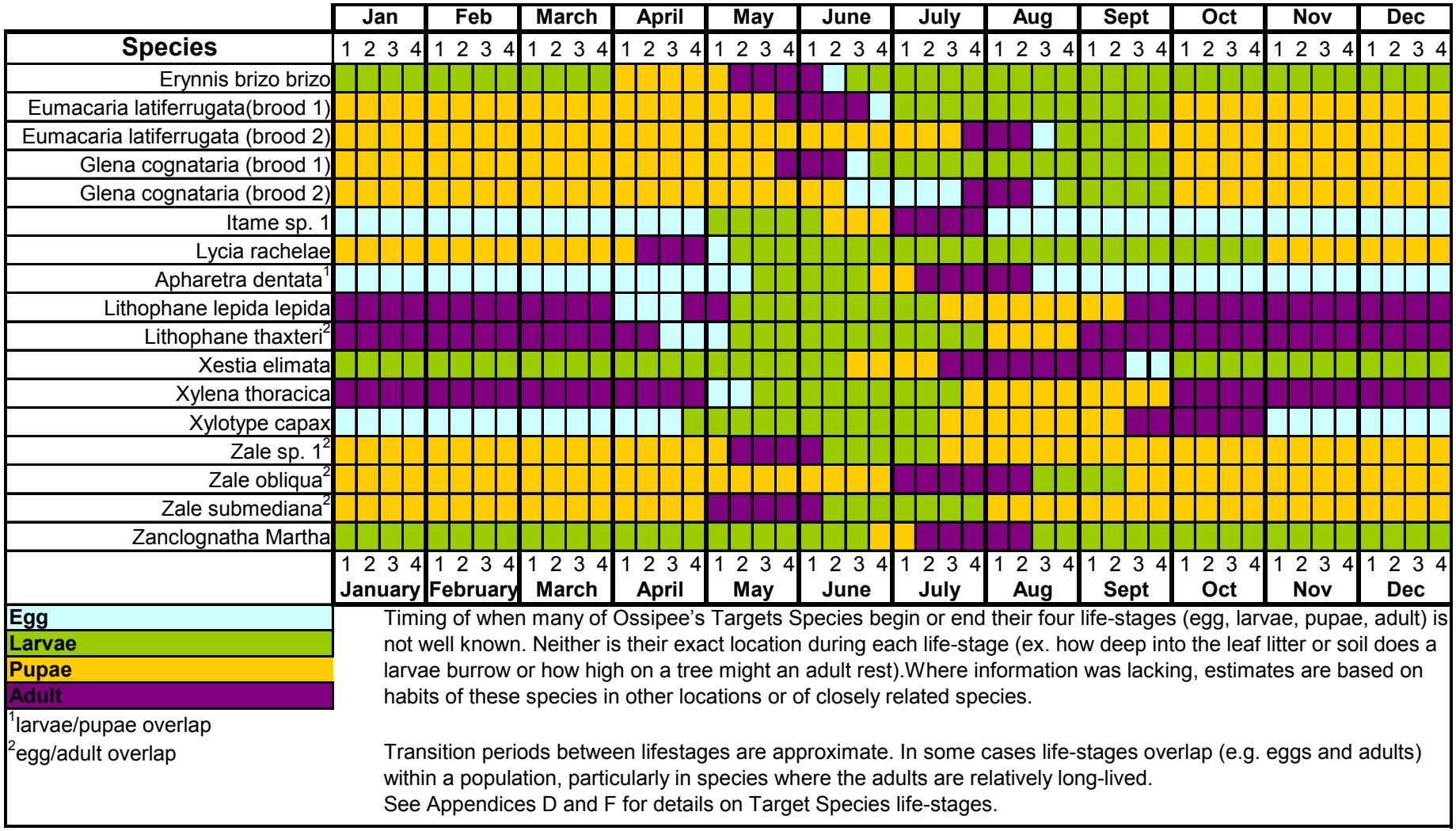


Figure 6: Approximate date ranges of Target Species life-stages, Ossipee Pine Barrens

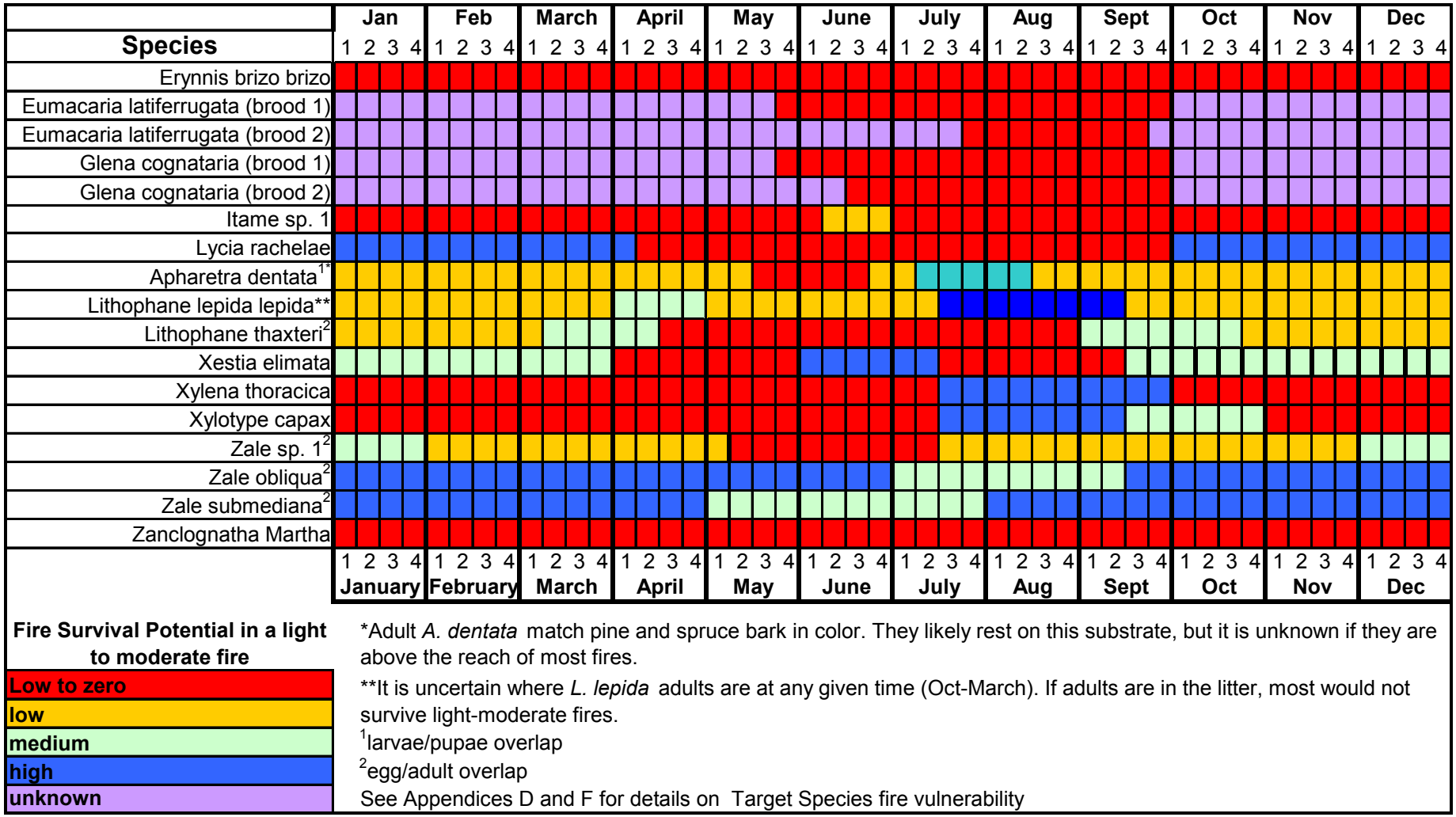


Figure 7: Fire survival potential (in light to moderate fires) for Target Species, Ossipee Pine Barrens

conundrum of the need to burn/manage barrens to prevent habitat conversion and the concern of killing many individual Lepidoptera by stating: "With burning there will be casualties…[but] without burning there will be more."

Because Ossipee's Lepidopteran Target Species do not rely on the ability of individuals to survive or escape fire, population persistence depends on recolonizing patches after fire (McCabe pers. comm., Schweitzer 2002, Thomas 1997). Burned patches within a barrens are recolonized mainly by individuals from nearby unburned refugia (Cryan 1985, Schweitzer 2002-Appendix F).

Therefore the keys to carrying Lepidoptera (and other invertebrates) through the burn window are refugia and recovery time. With the Ossipee Pine Barrens reduced to a fraction of its historic size and the preserve measuring only 365 hectares, available refugia and burning schemes will require careful planning.

Burn intervals: Fire has been used successfully to maintain Lepidoptera and the vegetation communities that support them; however, in some instances, rare Lepidoptera have been extirpated from areas in part due to fire (Schweitzer 2002). In these cases, prescribed or naturally ignited fires either came too quickly on the heels of a previous fire, or adequate refugia did not exist (Albany Pine Bush Commission 2002).

The rate of revegetation is a key variable for predicting recolonization. Research by Motzkin et al. (1996), Finton (1998) and others indicate that regeneration rates vary from barrens to barrens. Ossipee, being farther north than many barrens, may show a slower than average rate of regrowth (this may also be a reason, along with logging, that rare Lepidoptera persist on the barrens despite the lack of fire since the 1950s).

Recolonization by a full suite of Ossipee's Target Species will not be immediate and will depend on a variety of factors including the intensity and timing of the burn. Shortly after burns, niche diversity is greatly reduced and

burn area microclimate may be too harsh for barrens Lepidoptera (Swengel 2001). Although 68% of insect populations negatively affected by burning recovered within one year (Panzer 2002), others will take a period of years to reestablish populations in the post-burn habitat. Most of Ossipee's Target Species reach their greatest population densities when canopy cover is less than 50% (Mello pers. comm., Wagner et al. in press (a)). ***Z. martha***, however, is a late-successional barrens target and will likely arrive later.

In the Albany Pine Bush, McCabe (1995) found that a burn frequency of at least 12 years was best to promote rare pine barrens Lepidoptera—though not all species. McCabe (pers. comm.) finds the greatest diversity of endemic species in barrens generally occurs 15-23 years after a burn and does not recommend burning individual patches more frequently.

McCabe (pers. comm.) further recommends that preserve managers not try to recreate historic fire frequency intervals but instead focus on what current Lepidopteran populations respond to best. He reasons that historic fire frequency is difficult to determine in the wake of significant anthropogenic habitat disturbance first by Native Americans and later by European Americans.

Wagner et al. (in press (a)) recommend intervals of 10 to 25 years between burns for barrens and other shrubland communities. Schweitzer (2002) recommends intervals of 10 to 20 years with a minimum interval for a given burn unit of five years.

These researchers acknowledge that no optimal burn frequency exists for all species. They strongly advocate ongoing monitoring in order to tailor burning regimes to local Lepidoptera and vegetation assemblages.

Timing of burns: Although there is no optimal burn period when direct mortality to Ossipee's Target Species is significantly reduced, the seasonal timing of burning can be very important to the ecological function of the barrens. Factors such as temperature of burns, differences in nutrient uptake

after burns, increased insolation and evaporation will vary with the season when burning occurs (Christensen 1985).

Land managers have tended to prescribe dormant-season burns (winter and early spring) primarily because they are easier to control and to minimize the amount of smoke produced (Simmons pers comm.). Unfortunately, because there was little likelihood of ignition of dormant season burns historically, these burns may not be as ecologically beneficial to barrens Lepidoptera as growing season burns (Schweitzer pers. comm.).

Simmons (pers. comm.) concurs with Schweitzer and strongly recommends prescribed fire in the growing season. He's found that dormant season fires rarely change vegetation structure—a primary benefit of fire. This is because summer fires do a better job of heating the xylem and phloem of shrubs and trees and thereby killing them. Simmons also notes that fire ecologists have their best success in replicating naturally ignited fire when they burn in the growing season. Additionally fall may also be a good time for burning, although more research is required to determine if there is historical precedent for fall fires in Ossipee (Simmons pers. comm.).

Mechanical vegetation control

Although prescribed fire is the preferred management tool of many conservation biologists in barrens and other shrublands (Wagner et al. in press (a)), there is a role for mechanical vegetation removal, primarily for fuel reduction.

Mechanical management is employed frequently at the Albany Pine Bush to reduce fuel loads prior to and after fire. Managers there have found that fire will kill, but not remove, tall scrub oak. These standing dead shrubs persist on the landscape and during subsequent fires can become ladders that convey fire up to the pitch pine canopy, sparking uncontrollable burns (Gifford Pers. comm.).

Mechanical removal unaccompanied by prescribed burning can be sufficient for maintaining some Lepidopteran and other insect populations (Swengel 2001, Panzer 2002), but it seems to be more effective in prairie habitat than in barrens habitat (Schweitzer pers. comm.), perhaps because prairies historically supported greater populations of ungulates and other large grazing mammals.

Simmons (pers. comm.) advocates the use of mechanical methods when high-intensity fires are desired but other constraints require limits on burn size and intensity. In a review of Midwestern prairie and barrens management techniques Swengel and Swengel (2001) found that barrens butterflies responded more favorably to burning in comparison to mechanical cutting but caution preserve managers to avoid over-reliance on one management type over others.

Abundance and Habitat Preference of Declining Shrubland Birds of the Ossipee Pine Barrens

Summer 2002

Methods

All data for breeding birds were collected between June 3 and August 1, 2002. Data were collected from sites within and adjacent to TNC's Ossipee Pine Barrens Preserve, in the West Branch Pine Barrens, Carroll County, New Hampshire.

Russell Hopping's 1996 study: *Breeding Bird Species Richness, Abundance And Habitat Selection In The Ossipee Pine Barrens* provided The Nature Conservancy with a list of birds that were likely breeding at Ossipee as well as general indications of their habitat preferences. The objective of this study was to more accurately determine breeding success and habitat preferences for key pine barrens breeders.

Target Species: eastern towhee *(Pipilo erythrophthalmus)*, brown thrasher (*Toxostoma rufum)*, common nighthawk (*Chordeiles minor*) and whip-poor-will (*Caprimulgus vociferus*) were designated as Target Species (Table 7). Towhee and thrasher populations have declined in New Hampshire by more than 95% in the past 40 years and nighthawk and whip-poor-will populations are also in steep decline (Sauer 2001). Due to time constraints, nighthawks and whip-poor-wills were not part of the behavior mapping survey (as they are most active in the evening rather the morning like the towhee and thrasher), but some observations were recorded for these species.

Table 7: Avian Target Species for the Ossipee Pine Barrens and their rarity ranks

Common Name	Species	Rarity Rank
Eastern Towhee	*Pipilo erythrophthalmus*	G5/S2
Brown Thrasher	*Toxostoma rufum*	No rank
Common Nighthawk	*Chordeiles minor*	G5/S2B
Whip-poor-will	*Caprimulgus vociferus*	G5/S3B

Rarity ranks follow conventions developed by the Natural Heritage Program and The Nature Conservancy. 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 within New Hampshire only. (A review of ranking protocol and definitions can Appendix A.)

A Behavior Mapping protocol developed by Foss (Appendix G) was employed to determine what constitutes successful breeding habitat at Ossipee. Time and staffing constraints did not allow for the application of the more traditional and more labor-intensive nest search method (Murray 2000). The Behavior Mapping method allows researchers to identify 1) Birds with established home ranges, 2) Male/female pairs, 3) Nesting attempts, and 4) Successful fledgings for target species within selected plots.

Three study plots of 16 ha to 20 ha were created in the West Branch Pine Barrens subsection of the Ossipee Pine Barrens Preserve (Table 8, Map 3). Plots encompassed a range of vegetation types characteristic to the barrens from open-canopied thicket to closed canopied pitch pine forest. Plots were selected after touring the site with TNC personnel and examining maps, orthophotos and reports from earlier avian monitoring efforts at the Ossipee Pine Barrens. C.R. Foss of the NH Audubon Society was also consulted.

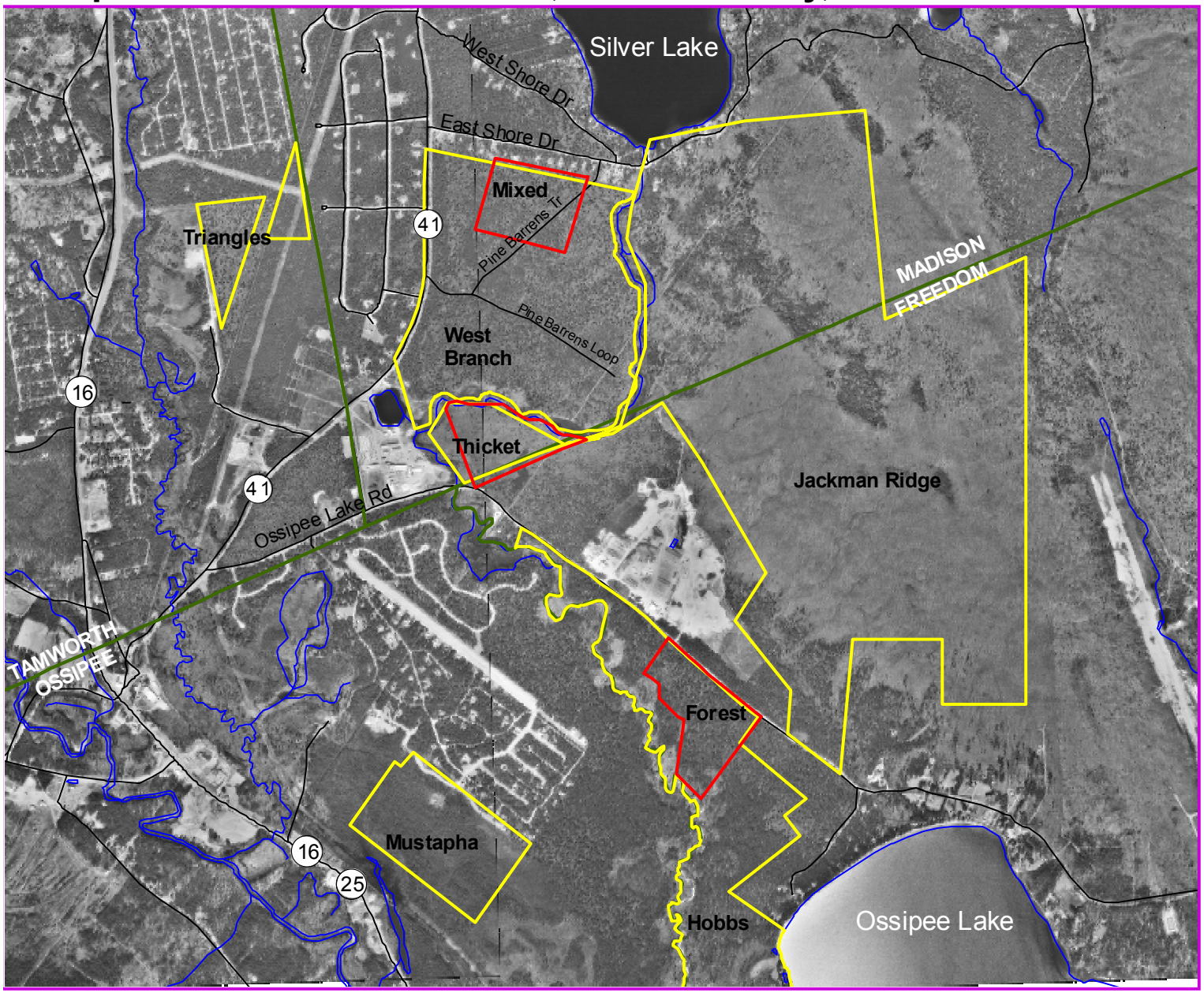
Table 8 Behavioral mapping study plots for summer 2002 bird mapping project, Ossipee Pine Barrens (see also Map 3)

Plot	Vegetation type	Plot Size (ha)
Thicket	Scrub Oak Thicket: 0-5% canopy cover. Cover type 3 (Dacey 2003)	16
Mixed	Open-Canopy Pitch Pine Scrub-Oak Forest: 5-25% canopy cover. Cover types 1, 2, 4 (Dacey 2003)	20
Forest	Pitch Pine-Scrub Oak Transitional Forest 25-40% canopy cover. Cover type 2 (Dacey 2003)	19

Each study plot was overlaid with a 50 m by 50 m grid. Paths were blazed with flagging tape and trees nearest to grid intersections were labeled with grid coordinated to help orient me. Due to the poor visibility in by scrub oak thickets, approximately 1800 m of flagging tape was used to mark transects and grid points in the three plots.

Study plots for 2002 bird survey, The Nature Conservancy's Ossipee Pine Barrens Preserve, Carroll County, NH

Map 3



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Map scale 1: 30,000

March 2003

- Bird survey study plots
- West Branch Preserve Parcels
- Town Boundaries
- Roads & TNC Trails
- Streams

Data Sources: The Nature Conservancy: parcel boundaries. NH-GRANIT: orthophotos, roads, streams, and political boundaries.

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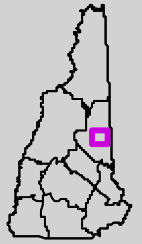
Locator Map



Ossipee Pine Barrens

Map created by Jon Kart

All four corners of the Mixed plot and the two ends of the X-axis on the Forest and Thicket plots were permanently marked with orange-blazed rebar. All grid points were captured using GPS technology and plotted on ArcView geographic information system software.

Each plot was visited on a rotating basis at least once a week from June 3rd– August 8th between sun-up and 9:30 AM. Only one plot was visited each day. Plots were surveyed only when ambient temperatures were greater than 50°F and rain was no more than light. Data recording started as soon I reached a site.

I walked every other gridline. Target birds and their behaviors were noted on daily plot maps and in a survey journal. On subsequent visits to a plot I switched direction of travel. For all Target Species both location and behaviors seen or heard were noted in the data log and on daily plot maps.

Appendix G provides a full description of the protocol. Appendix H lists the behavior and map codes used in this survey.

At the end of the breeding season, behavior maps for each of the target species were created by compiling behaviors from the daily plot maps—one map per species per plot. Territories were labeled and ranked according to the criteria in Table 9.

Table 9: Ranking protocol for behavioral mapping of avian Target Species in the Ossipee Pine Barrens, summer 2002

Name	Code	Rank	Criteria
Partial Home Range	PTHR	0	Territorial male seen 2-3 visits
Established Home Range	ESHR	1	Territorial male seen 4+ visits, or aggressive chase between 2 males
Partial Pair	PTPR	1	Territorial male seen 4+ visits and female seen 1-2 visits
Pair	PAIR	2	Territorial male seen 4+ visits and female seen 3+ visits
Nesting Attempt	NEAT	3	Found nest or distraction display by female
Successful Fledging	SUFL	4	Begging calls, fledglings seen foraging
Successful Fledging Plus 2nd attempt	SUFL	5	Successful fledging plus 2nd NEAT
Two successful Fledgings	SUFL	6	Two Successful fledgings

Study Limitations

Due to the difficulty of setting up the study plot in the thick scrub, bird surveys did not begin until June 7, 2002. The delayed start may have led to an undercount of Target Species.

Average monthly temperature for May 2002 was 53.4°F, 2.6°F below normal. Total rainfall for the month was 4.38 inches, 1.05 inches above normal (National Weather Service 2003). This colder, wet weather may have reduced nesting success of Target Species. No fledglings were seen or heard at Ossipee during the month of May and into early June—the first brood period. Carol Foss of the New Hampshire Audubon Society believes that cup nesters in Southern New Hampshire produced fewer early broods in 2002 (pers. comm.).

Diminished visibility: Behavior mapping depends on the assumption that behaviors that identify important stages in a bird's breeding cycle are observable (Vickery 1992). But visibility in scrub oak thickets was often limited to less than 10 m. Most of the detections of towhees were auditory only or began with auditory cues after which I visually identified the individual. If females or fledglings were quieter than males, it is very possible that some were missed during surveys. Males frequently perched on the taller trees in a territory to vocalize for minutes at a time. Females rarely made themselves so conspicuous, and fledglings, though gregarious, never did. Once the breeding season was underway, adult females became scarce, indicating that they may have been on nests, or they may have left the area in search of better mates or territories. Fledglings were also difficult to detect. They do have distinctive vocalizations, but fledglings will quiet down quickly while adults are not present, when an adult gives a warning signal or in presence of human beings.

Difficulties identifying territory boundaries: Adult male towhees time and again were seen leaving their territories to tour the local landscape, often

through neighboring territories. The literature indicates that these trips can be upwards of 300 m. If a substantial number of detections occurred during these extra-territory jaunts, the territory size would be exaggerated or they may have been erroneously identified as additional birds in a study plot.

Estimating brood size: Accurate counts of the number of fledglings may have been confounded by two factors: brood splitting and low natal site fidelity. Towhees practice brood splitting, meaning that adults will each take half a brood and raise them independently (Greenlaw 1996). In three of the four instances where fledglings were seen, only a single adult was detected with them. If the other adult was with additional fledglings, then actual recruitment would likely be greater.

Towhees exhibit low natal-site fidelity, reducing the chance of detection of young and adults. Shortly after fledging, towhee young will travel with an adult 100 m or more from a nest site (Greenlaw 1996). Wells (pers. comm.) observed instances of adults taking broods out of "classic shrubland habitat" into thick forest cover shortly after fledging.

Brown Thrashers also have clear distinctive calls, but males and especially females quieted down considerably once the breeding season was in full swing. Furthermore no thrasher fledglings were identified, either by sight or sound.

Results: Birds

Eastern towhee (*Pipilo erythrophthalmus*): I documented a total of four broods fledged in the summer of 2002. Three established home ranges, six pairs and one nesting attempt were also identified across the three bird plots (Table 10, Map 4).

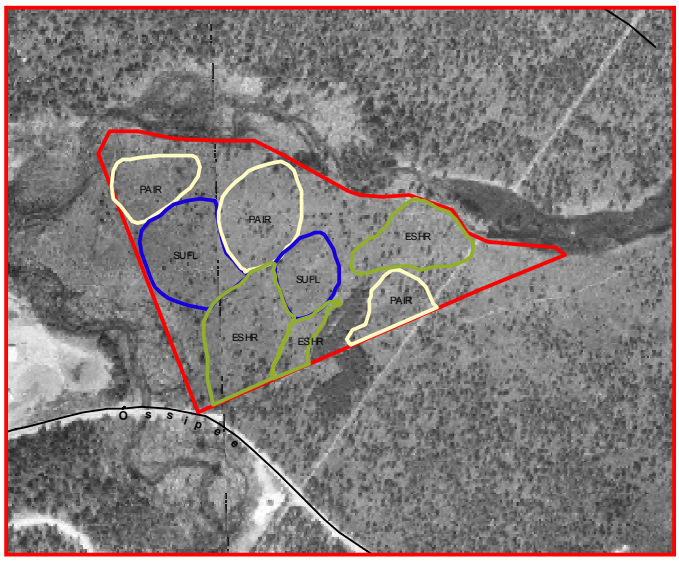
The greatest number of towhee territories were found on the Thicket plot (8), including two successful broods of fledglings, three male-female pairs and three established home ranges (Table 10, Map 5). The Mixed plot held four territories including one successful fledging, one nesting attempt and two male-female pair. Three partial territories including two partial pairs and one partial home range were also identified (Table 10, Map 6). The Forest plot produced the fewest territories—a total of two, consisting of one successful fledging and one pair (Table 10, Map 7).

Table 10: Eastern towhee (*Pipilo erythrophthalmus*) territories, on three study plots, Ossipee Pine Barrens, 2002

	Forest	Mixed	Thicket	Territory Rank	Forest	Mixed	Thicket
Plot Size (ha)	19	20	16		19	20	16
Successful Fledging (SUFL)	1	1	2	4	4	4	8
total number of fledglings detected	2	3	5				
Nesting Attempt (NEAT)	0	1	0	3	0	3	0
Pair (PAIR)	1	2	3	2	2	4	6
Partial Pair (PTPR)	0	2	0	1	0	2	0
Established Home Range (ESHR)	0	0	3	1	0	0	3
Partial Home Range (PTHR)	0	1	0	0.5	0	0.5	0
cumulative rank points					6	13.5	17
reproductive index points/ha					**0.316**	**0.675**	**1.063**
total adults per site	4	11	13				
Adults/ha	0.21	0.55	0.81				
successfully fledged broods/ha	0.05	0.05	0.13				
successfully fledged broods/adults pe	0.25	0.09	0.15				
Nesting Attempt/ha	0.00	0.05	0.00				
Pair/ha	0.05	0.10	0.19				

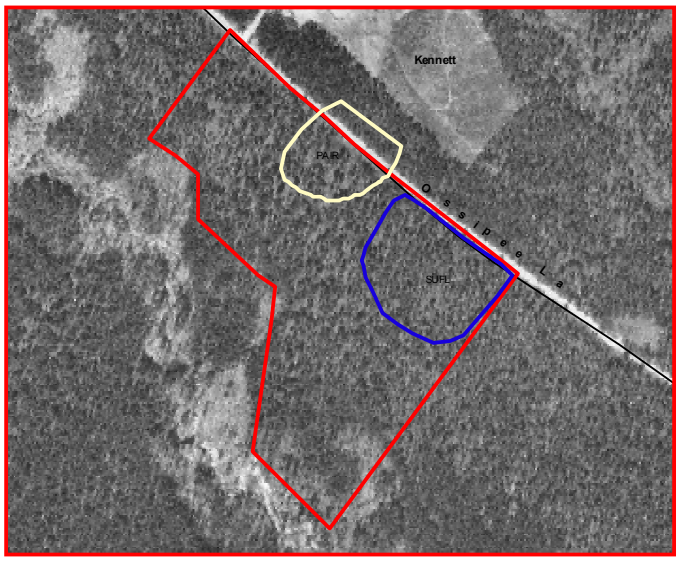
Rank	Territory Type	Behavior Observed
4	Successful fledging	begging calls, fledglings seen on nest or foraging.
3	Nesting Attempt	found nest, distraction display by female
2	Pair	three or more detections of a pair in same area, or a courtship chase between male and female of same species.
1-	Partial Pair	1-2 observations of pair in same area plus 1 or more sightings of the male in the same area
1-	Established Home Range	4 or more detections of male w/in same area or aggressive chase between 2 males (same or different species).
0.5-	Partial Home Range	2-3 observations of a male within the same area

Behavior map of eastern towhee (Piplo erythrophthalmus)
All Plots: Ossipee Pine Barrens Preserve, Summer 2002



Thicket Plot
16 hectares

Mixed Plot
20 hectares



Forest Plot
19 hectares

Map 4

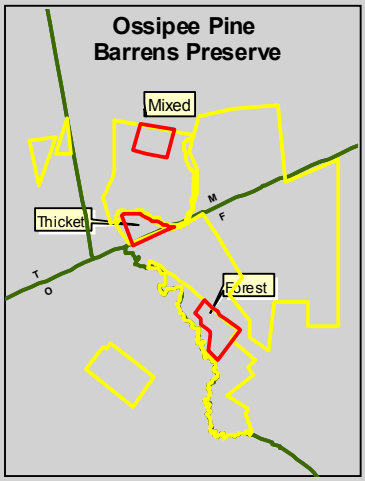
100 0 100 Meters
100 0 100 Yards

Map scale 1: 3,500
March 2003

- Successful Fledging (SUFL)
- Nesting Attempt (NEAT)
- Pair (PAIR)
- Partial Pair (PTPR)
- Established Home Range (ESHR)
- Partial Home Range (PTHR)
- Bird survey study plots
- Roads & Trails

Data Sources: The Nature Conservancy: parcel boundaries. NH-GRANIT: orthophotos, roads, streams, and political boundaries.

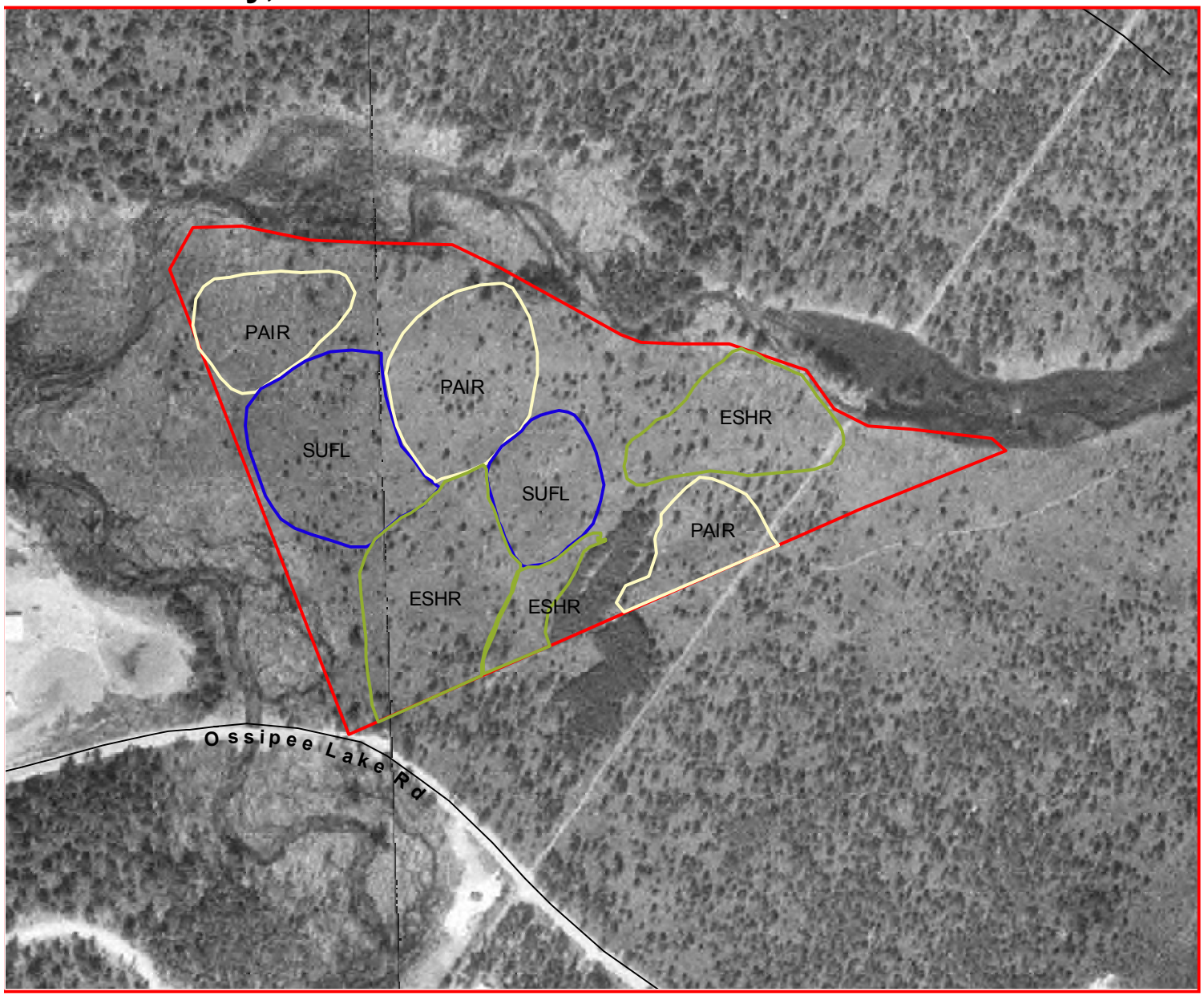
N



Map created by Jon Kart

Behavior map of eastern towhee (Piplo erythrophthalmus)
Thicket Plot: The Nature Conservancy's Ossipee Pine Barrens Preserve, Carroll County, NH. Summer 2002

Map 5



100 0 100 Meters

100 0 100 Yards

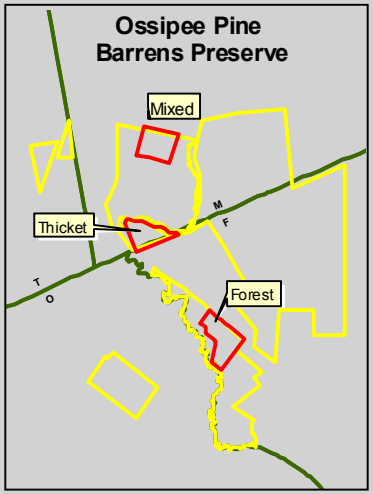
Map scale 1: 3,500

March 2003

- Successful Fledging (SUFL)
- Pair (PAIR)
- Established Home Range (ESHR)
- Bird survey study plots
- Roads & Trails

Data Sources: The Nature Conservancy: parcel boundaries. NH-GRANIT: orthophotos, roads, streams, and political boundaries.

N



Map created by Jon Kart

Behavior map of eastern towhee (Piplo erythrophthalmus)
Mixed Plot: The Nature Conservancy's Ossipee Pine Barrens Preserve, Carroll County, NH. Summer 2002

Map 6

100 0 100 Meters

100 0 100 Yards

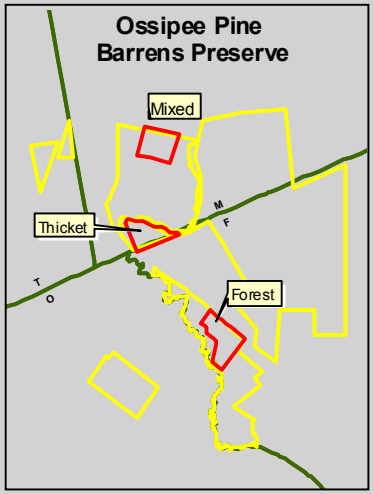
Map scale 1: 3,500

March 2003

- Successful Fledging (SUFL)
- Nesting Attempt (NEAT)
- Pair (PAIR)
- Partial Pair (PTPR)
- Partial Home Range (PTHR)
- Bird survey study plots
- Roads & Trails

Data Sources: The Nature Conservancy: parcel boundaries. NH-GRANIT: orthophotos, roads, streams, and political boundaries.

N



Map created by Jon Kart

Behavior map of eastern towhee (Piplo erythrophthalmus)
Forest Plot: The Nature Conservancy's Ossipee Pine Barrens Preserve, Carroll County, NH. Summer 2002

Map 7

100 0 100 Meters

100 0 100 Yards

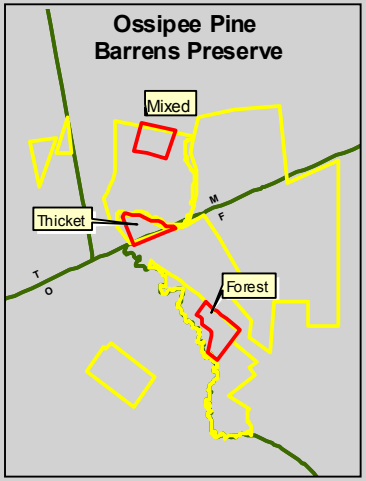
Map scale 1: 3,500

March 2003

- Successful Fledging (SUFL)
- Pair (PAIR)
- Bird survey study plots
- Roads & Trails

Data Sources: The Nature Conservancy: parcel boundaries. NH-GRANIT: orthophotos, roads, streams, and political boundaries.

N



Map created by Jon Kart

The thicket plot contained the greatest number of fledged broods, the greatest number of pairs and the greatest number of towhee territories despite being 16% smaller than the Mixed plot and 20% smaller than the Forest plot.

The average territory size for the four successfully fledged broods was 2.16ha. This includes a brood fledged on the Forest plot whose territory was almost twice the size of the other three. If the forest plot is excluded, the average territory size for towhees that successfully fledged young on the Thicket and Mixed plots was 1.61ha. This was slightly larger than the average territory size (with and without successful fledgings) on either plot (Table 11).

An assessment of breeding status within and among study plots using the reproductive index of Vickery et al (1992b) was not possible because of an insufficient quantity of data to support a statistically valid comparison. But when study plots were ranked by reproductive index points (Table 10), the Thicket plot had the highest rank (greatest level of reproductive activity) per hectare at 1.06, while the Mixed plot scored 0.73 and the Forest plot 0.32.

The first observed towhee nesting attempt—a distraction display by a female towhee—was on June 26th. The first observation of fledglings on the Thicket and Mixed plots were July 5th and on the Forest plot, July 10th. No nesting attempts, nestlings or fledglings were observed in May.

Table 11: Average territory size* for eastern towhee (*Pipilo erythrophthalmus*) on three study plots, Ossipee Pine Barrens, 2002.

	Size (Ha)
All territories all plots (n=15)	1.70
Forest plot (n=2)	2.99
Mixed plot (n-5)	1.44
Thicket plot (n=8)	1.32
Successful fledglings: all plots (n=4)	2.16
Successful fledglings: Thicket and Mixed plots only (n=3)	1.61
Nesting attempt (n=1)	0.75
Pair (n=6)	1.65
Established home range (n=3)	1.32
Partial pair (n=1)	0.52

*Partial territories are not included in these calculations as their full extent is not known.

Brown thrasher (*Toxostoma rufum*): No brown thrasher breeding territories were identified on the three study plots. Several individual thrashers, predominately males, were detected in or adjacent to the study plots during this study. A thrasher was seen twice along the southern border of the Thicket plot. Six observations of brown thrashers were made at the northeast corner of the Mixed plot and a single thrasher was twice heard singing at the northwest border of the Forest plot. Brown thrashers, including at least two pair, were regularly seen on the eastern end of the adjoining Kennett parcel (Map 3).

A possible confounding factor reducing thrasher observations was the late-May starting date of the behavioral mapping survey. After a somewhat showy and very vocal courtship period, thrashers become quiet and secretive and remain low in thick scrub (Cavitt and Haas 2000).

Additional species of conservation interest

Whip-poor-will (*Caprimulgus vociferus*), common nighthawk (*Chordeiles minor*), vesper sparrow (*Pooecetes gramineus*) and prairie warbler (*Dendroica discolor*) are also found in disturbance-dependent habitat and have populations that have declined significantly for at least the past 40 years (Sauer 2001). Though these species were not part of the behavior mapping survey, below are my observations on their whereabouts and activities. In addition, the brood parasite brown-headed cowbird (*Molothrus ater*) and nest predator blue jay (*Cyanocitta cristata*) are of interest to preserve managers, so observations of these species are also included.

Whip-poor-will (*Caprimulgus vociferus*): A whip-poor-will pair produced at least three young in the Thicket plot (Map 5) in 2002. This was the only family I saw during weekly mapping expeditions on the survey plots. I did hear "whips" regularly along the Ossipee Lake Road near Camp Calumet, and in the Carved-In-Bark subdivision West of Route 41 but never more than three in an evening. Hopping reports hearing as many as 18 singing males during one roadside survey in 1996 (Hopping 1996).

Common Nighthawk (*Chordeiles minor*): Nighthawks were regularly seen and heard across the barrens. The greatest numbers were seen high over the West Branch tract followed by the area just north of The Triangles. Three to four nighthawks were occasionally seen flying low over the eastern end of the Kennett parcel (Map 3). Hunt (pers comm.) believes that Ossipee may have the most dense nighthawk population in the state.

Prairie Warbler (*Dendroica discolor*): Regularly seen along powerline right-of-ways bordering the Thicket, Triangles and West Branch tracts of the Ossipee Pine Barrens preserve, prairie warblers appeared most abundant along the extra-wide right-of-ways adjunct to The Triangles tract.

Vesper Sparrow (*Pooecetes gramineus*): A grassland and low shrub species, three to four vesper sparrows were commonly seen in the Thicket plot. Two were seen in the eastern end of the adjoining Kennett parcel.

Brown-headed cowbird (*Molothrus ater*): Though cowbirds were seen frequently between early and mid-May, before record keeping began while I blazed the grid system of the study plots, observations of cowbirds dropped by the end of May. Five cowbirds were mapped in the Thicket plot between mid-June and mid-July, eight in the Forest plot between mid-June and mid-July and seven in the Mixed plot between late-June and mid-July.

No cowbirds were seen actively parasitizing nests of Target Species, or any others birds, and cowbird fledglings or juveniles were not detected during the course of the study.

Blue Jay (*Cyanocitta cristata*): Blue jays were abundant and conspicuous in the Mixed plot except in the most open patch in the northeastern corner. Blue jays were uncommon in the Forest plot and rare in the Thicket plot.

Discussion: Birds

Commonly found along the interface between forested and open canopied areas, towhees are considered edge generalists (Morrimoto and Wasserman 1991, Hagen 1993). They were observed at Ossipee utilizing a broad range of vegetation presentations from open canopied thicket (<1% canopy cover) to pitch pine-white pine forest (>30% canopy cover). Towhees successfully fledged young in habitat that spans this spectrum.

Abundance of individuals, breeding pairs, and successfully fledged broods, however, was not spread evenly across all study plots (Table 10) but statistical analysis of towhee territories and vegetation parameters was thwarted by an insufficient number of data points. Still, an appraisal at the plot level of the spatial arrangement of towhee territories and a ranking of these territories by breeding success indicates that towhees preferred the vegetation type of the Thicket followed by the Mixed plot with the Forest plot coming in a distant third (Table 10).

Towhees were found most frequently in sites where the tree canopy cover was less than 10%, the scrub oak mid-story was dense but not continuous, the short shrub layer (primarily blueberry and other heaths) was approximately 30% and the herb layer was 4% or greater. This mix of vegetation likely provides the best balance of protection from predators, concealment for nests and access to food resources.

Towhees feed mainly on the ground, so access to the litter layer is important. Towhees hop backward while dragging their feet to clear away litter in order to expose invertebrates, seeds and fruits. This behavior was observed in scrub oak thickets, but it is likely that when the scrub oak density gets too great, movement is impeded by the tangle of branches. Moreover, as scrub oak density and height increases the coverage of herbs and short shrubs decreases to almost zero. This may cause a decrease in herbivorous invertebrate density in the litter because their food resources decrease.

Towhees seem to prefer sparse canopy cover. They were not seen in dense, young stands of pole-sized trees. This is reflected in the results of other studies as well (Bell and Whitmore 1997). Also, white pine was noticeably lacking in most of the towhee territories, although data are insufficient to draw conclusions as to why. Towhees do, however, make use of some trees in their territories. Indeed, Towhee males regularly vocalize from these tall trees.

Territory size: The towhee is an area-independent species (Greenlaw 1996), meaning that space is not the primary determinant of territory size. Territories at Ossipee ranged from 0.48 ha to 3.8 ha (Table 11), with those in the Thicket plot generally smaller than those on either the Mixed or Forest study plots. Territories with fledglings ranged from 1 ha at the Thicket plot to 3.8 ha in the Forest plot. This implies that some factor at the Thicket either allows it to support more towhees per hectare than the other plots, or that intraspecies competition for space at the Thicket is greater than at other plots.

One hypothesis is that food availability is greater at the Thicket plot than other plots, allowing towhees to find sufficient food resources within smaller territories. Franzblau and Collins (1980), however, found that supplementing towhees with additional food did not lead to a contraction of towhee territory size.

Intraspecies competition for space may be greater at the Thicket plot. An indication of this is that towhee territories at the Thicket border at least one additional territory, and most border multiple territories (Map 5). Space competition could be for optimum nesting habitat found at the Thicket but further research is needed before a determination can be made.

Territory size at Ossipee is in line with the 1.6 ha territory average in a New Jersey mesic oak forest (Greenlaw 1969 as cited in Greenlaw 1996) but significantly larger than the 0.26 ha territories found in a coastal Massachusetts pine barrens (Morimoto and Wasserman 1991). The

difference in densities between the Ossipee Pine Barrens and the Massachusetts pine barrens is likely due to the more amenable climate in southeastern Massachusetts, and, most importantly, to a more recent occurrence of fire.

All of the Massachusetts study plots burned five to 30 years prior to the study (Morimoto and Wasserman 1991), whereas the Thicket plot hasn't burned for at least 50 years. The more recent fires may make the Massachusetts site more productive in comparison to Ossipee and therefore allow a greater density of towhee territories.

How the Thicket has maintained its open-canopied structure without fire remains a mystery (Dacey 2003). This site may be limited by nutrients, water or some other resource. Though these limitations help maintain the structure that towhees prefer, they may not support the food resources needed to host a towhee population similar to that of the Massachusetts barrens. One measure of availability of food resources is the abundance of Lepidoptera, a primary prey of towhees. The Thicket ranked fourth in abundance producing 36% fewer moths than did the most abundant site at Ossipee in 2002 (Figure 1). Management that simulates Thicket vegetation structure on a relatively richer Ossipee site may lead to even greater density of towhees.

It is possible that local towhee recruitment does not make up for adult and juvenile mortality. See Appendix I for a population viability analysis of Ossipee's eastern towhee using 2002 data.

Management for Avian Target Species

Why manage for shrubland birds?

The regional and continental decline of eastern towhee, brown thrasher, common nighthawk and whip-poor-will is due, in part, to the timeframe used to measure this decline. Though the North American Breeding Bird Survey of the past 40 years is considered the most reliable source on population trends for the majority of North American birds (O'Connor et al. 2000), it reflects a view through a narrow window of time. It does not account for the skyrocketing populations of shrubland birds in the early part of this century. The New England landscape (and attendant bird population) has ridden a roller coaster of successional change in the past two centuries (Cronon 1983). This ride took New England's landscape from forest in the 1700s to abandoned farmlands in the mid-1800s to shrubland and regenerating forest in the 1930s to it's current conditions (Askins 1993, DeGraaf and Miller 1996). The proportion of land in New Hampshire covered by forests was 47% in 1880 and 87% in 1980 (Litvaitis 1993). Among the avian species that experienced population increases and range expansions during the early regeneration were the prairie warbler, eastern towhee, brown thrasher, nighthawk and whip-poor-will (Foss 1994). The decline of these species may simply represent a return to population levels reflecting trends over the past several hundred years rather than the past 40.

Despite questions about the historic abundance of shrubland birds in the region, there is good reason to support conservation of these species at Ossipee. Over a timeframe an order of magnitude greater than that noted above, disturbance-dependent pine barrens habitat likely remained fairly constant for shrub nesters, at least relative to other forestlands in the rest of the region. Barrens, including the Ossipee Pine Barrens, may even have provided refugia for shrub nesting birds during the height of forest dominance in the Northeast.

A number of government and non-governmental agencies have identified shrubland birds as species of conservation concern in New Hampshire. For example, New Hampshire's Partners in Flight Working Group identified common nighthawk, whip-poor-will, brown thrasher, eastern towhee and vespers sparrow as High Priority Species in their master plan for conservation of native birds (Kanter and Foss 1995) and the common nighthawk is listed as threatened in the state (NHNHI 2002).

The Audubon Society's Important Bird Areas program is another attempt to protect key habitat for declining bird populations. Audubon has prioritized disturbance dependent ecosystems including shrub-scrub and pine barrens in the Northeast. Their efforts target brown thrasher, eastern towhee, and whip-poor-will (Liner pers. comm.). The Audubon Society of New Hampshire is interested in enrolling the Ossipee Pine Barrens in its Important Bird Area program. NH Audubon is currently developing a monitoring protocol for whip-poor-wills utilizing a tape-recorded call. Audubon plans to employ this survey tool this summer in southeast New Hampshire (Hunt pers comm.).

Threats to Avian Target Species

Though loss of viable habitat through development, fire suppression, habitat conversion, catastrophic fire, and habitat fragmentation is clearly the dominant factor in the decline of shrubland and grassland birds in eastern North America (see the threats section in the Lepidopteran portion of this report for a discussion of these threats), nest predation and brood parasitism are also contributing factors (Askins 1993). Parasitism by brown-headed cowbirds is a particular problem when managing for shrubland species along habitat edges.

Niemuth and Boyce (1997) demonstrated the relationship of risk of predation by blue jays and brood parasitism by brown-headed cowbirds to distance from a habitat edge on a pine barrens in Wisconsin. They found that within 50 m of an edge, predation and parasitism was as high has 32%, while

at 400-600 m from an edge predation and parasitism dropped to as low as 4%. Where barrens patches exceeded 10ha, predation on nests in a patch center dropped 50% relative to nests near a patch edge.

Both blue jays and brown-headed cowbirds were found throughout the Ossipee's Mixed plot, where the scrub oak-heath vegetation was pocketed with discontinuous stands of pitch pine and white pine. Blue jays were rarely seen in the Thicket plot, probably because of the very open canopy. Blue jays were also uncommon on the Forest plot where the continuous canopy was too closed. Cowbirds were observed most frequently prior to beginning of the study period and less so during the course of the study.

Though cowbirds were not seen actively parasitizing broods of Target Species at Ossipee, a review of the literature rates predation ranging from 4.9% to 54.2% for towhees (Morrimoto and Wasserman 1991, Greenlaw 1996) and 7.8% to 12% for thrashers (Cavitt and Haas 2000).

Common house cats frequent the Mixed study plot, but were not seen elsewhere in the preserve. Several of the cats I saw wore pet collars, indicating that they were not feral. Ground nesting birds (including the towhee, nighthawks and whip-poor-wills) are particularly vulnerable to cat predation.

Barrens Management for Avian Target Species

Avian Target Species are likely to respond well to barrens restoration and prescribed fire. A number of studies indicate that Ossipee's avian Target Species would benefit from management to restore and enhance the pitch pine-scrub oak character of the barrens, especially the character of barrens at early-mid-successional stage. In a study of three Northeastern pine barrens, Kerlinger and Doremus (1981) found that the abundance of eastern towhees, brown thrashers, and prairie warblers decreased with increased anthropogenic disturbance (habitat loss, fire suppression and habitat

conversion) and that brown-headed cowbird abundance increased from the same disturbance.

Towhees benefited from controlled burning in a Florida scrubland (Engstrom et al. 1984). Brown thrashers were 600% more abundant in a frequently burned NJ Pine Barrens than a fire suppressed section of the barrens (Kerlinger and Doremus 1981). Conservation recommendations for common nighthawks include burning areas to reduce vegetation (Poulin et al. 1996). Recommendations for management of whip-poor-will in the intermountain West includes burning to open up the understory for whip-poor-will breeding. The prairie warbler, a shrub species that has been noted to respond well to fire, may serve as a potential indicator species for fire management and barrens habitat quality in Northeastern pine barrens (Simmons, pers. comm.).

Prescribed fire is used extensively to manage birds in the Eastern United States. In New York, several Audubon Society designated Important Bird Areas currently use fire to manage shrub habitat. These include the Montezuma National Wildlife Refuge, Finger Lakes National Forest, and the Long Island Pine Barrens (Liner pers. comm.). Target species at the Long Island Pine Barrens include brown thrasher, eastern towhee, and whip-poor-will. The Albany Pine Bush also uses prescribed fire to the benefit of its avian community (Gifford pers. comm.)

In a survey of more than 60 federal, state and non-governmental organizations in 29 Eastern states on the use of prescribed fire for bird species management, Brownlie and Engstrom (2001) reported that 72% burned property specifically to provide habitat for birds. Ninety-one percent of these respondents report using prescribed fire in habitats where herbaceous and/or shrub species dominated understory vegetation, and overstory trees were scattered or absent. Eastern towhee, nighthawk, whip-poor-will, vesper sparrow and prairie warbler were identified by survey

respondents as benefiting from habitat management using fire. Brown thrasher was not listed.

Burn intervals: The effect of fire frequency on shrubland birds has not received much study, but some estimates can be made and they are in line with recommendations made for barrens Lepidoptera.

The highest density of towhees in a Florida scrub and pineland habitat occurred four years after a fire and density remained high through year seven but dropped to zero by year 16 (Engstrom et al. 1984). Since Ossipee's growing season is considerably shorter than Florida's, and since the historic fire frequency in Florida is a fraction of that found in Ossipee, the most beneficial fire frequency for eastern towhee would be considerably longer.

Whip-poor-wills in ponderosa pine forest are believed to benefit most from fire frequency of 12-15 years (Rustay pers. comm. cited in The Nature Conservancy 1999).

Timing of burns: Since Ossipee's avian Target Species all migrate south at summer's end, the best season to burn is fall. Winter burns will also be beneficial, at least in the short run, because these fires don't usually consume all the scrub oak branches. This leaves the structural complexity desired by many species.

Mechanical means of vegetation control: Though prescribed fire is a frequently used management tool for a variety of ecological reasons elaborated upon in the Management and Prescribed Fire section of the Lepidoptera survey, there may be sections of the preserve where managers will not want to use fire.

Fitzgerald and Tanner (1992) compared the effects of prescribed fire and mechanical removal of woody vegetation on bird communities in a southwestern Florida dry prairie. They found that mechanical vegetation removal decreased vertical complexity, reducing overall avian richness but increasing the number of grassland birds. Managers may wish to treat some

areas within the Ossipee Barrens Preserve solely with mechanical vegetation removal to encourage grassland/shrub species such as vesper sparrow (Vickery et al. 1997).

Managers should conduct limited tests of mechanical vegetation removal without fire, but results should be carefully scrutinized. Long-term differences in response by avian communities to changes in nutrient cycling are not known for shrubland birds. Considering the nutrient limitations found in pitch pine-scrub oak barrens and the role fire plays in the nutrient cycle, further elimination of fire from the landscape could lead to significant changes in food and other key resources.

Landscape management: The size and configuration of burned and managed patches will affect various avian Target Species differently. Managers are encouraged to create and test a number of patch sizes, types, and configurations to determine what works best for Ossipee's bird community.

Though towhees and thrashers are considered area-independent species (Greenlaw 1996) it is not known whether they respond predictably to landscape level habitat variations. Patches on the order of 5-15 hectares containing a mosaic of scrub oak, heath shrubs and herbaceous plants, including dense thickets for nesting cover, and scattered pitch pine will be sufficient for towhee. The prescription for brown thrasher is quite similar but includes a slightly greater percentage of herbaceous vegetation.

Other barrens targets, such as prairie warbler and vesper sparrow, are area-dependent and are usually found in more open patches. Prairie warbler can persist in powerline right-of-ways (Wells 2003), and a number of them were seen in the wide powerline right-of-way near The Triangles. Ideally managers will create open patches of herb and low heaths of 5 to 10ha. Open herb-rich barrens five to 10 ha are probably utilized by vesper sparrows as secondary breeding sites, though sites 50 ha and larger are more productive (Vickery et al. 1997).

Combined Recommendations

Integrating Management for Birds, Moths, and Other Taxa

The Ossipee Pine Barrens Ecosystem hosts a varied array of rare Lepidoptera and declining shrubland birds. It appears, however, that within the barrens these birds and moths do not occupy the same microsites. A similar lack of overlap between rare moth and bird hotspots was seen in a Massachusetts pine barrens (Grand et al. in press). This was the only investigation of correlations between moth and bird diversity in the literature, but several studies indicate a similar lack of concurrence between bird and butterflies (Pearson and Carroll 1999, Swengel and Swengel 1999, Ricketts et al. 2002). Managing for the conservation of these two taxa, then, is somewhat complex.

While this study focused solely on rare birds and Lepidoptera, rare species of other taxa can likely also be found at Ossipee, including rare Heteroptera (plant bugs) (Wheeler 1991), Hymenoptera (particularly ants) and Coleoptera (beetles) (Wagner et al. in press (b)). All are worthy of conservation, but devising management plans for each taxon will leave little time for their application. A more achievable and constructive effort would be restoring and/or mimicking natural processes and functions to the barrens with the goal of creating a complex mosaic of patch sizes, configurations, ages and vegetation types across the ecosystem.

Regional and national experts crafted a list of guidelines for conservation of pine barrens invertebrates (Sievert 2002). These guidelines are generally applicable to taxa beyond invertebrates and should be useful to Ossipee Pine Barrens land managers.

1. Protect pine barrens land that is currently unprotected.
2. Work to enhance biodiversity rather than managing for individual species.
3. Species associated with pine barrens are disturbance-dependent. Large habitat cores are needed to allow disturbances to act fully. Small patches

experience less frequent disturbance but potentially at a more catastrophic intensity that can extirpate local populations.

4. Lepidoptera are everywhere, but pine barrens are the richest sites of imperiled Lepidoptera.

5. Inventories and risk assessments of rare species populations should be completed before other management actions occur.

6. Maintain a public safety context: assume that an entire barrens will burn at some point in the future.

7. The clock is ticking, and species are disappearing.

Recommendations

Recommendations for restoring and maintaining the rare Lepidoptera and shrubland birds of the Ossipee Pine Barrens—especially on the Preserve—fall into three categories: land acquisition, species monitoring and vegetation management.

Land Acquisition

1. Increase the size of the preserve through land acquisition and agreements with neighboring landowners. Adding land to the preserve will increase the odds of Lepidoptera population persistence not only by increasing the amount of protected habitat available, but also by providing a buffer against other threats stemming from encroaching development.

2. Connect and consolidate parcels as much as possible to reduce undesirable boundary effects and to simplify management. Edge-related problems include entry points for invasive species and human neighbors' objections to management efforts. Land acquisition strategies should target lands that are adjacent to the preserve and that connect the isolated portions of the preserve. Specific areas to target include:

    - Connecting the Mustapha parcel to the south side of the Hobbs parcel. This would provide a substantial buffer to two existing preserve parcels and protect a significant stretch of riparian corridor.

- The east end of Kennett tract. A number of brown thrashers and nighthawks were observed here as well as a few rare Lepidoptera.

- Available land in the Triangles area. (See also next recommendation). Despite its small size, the Triangles had the greatest species richness of all sites in the 2002 Lepidoptera survey. It is likely that the surrounding landscape is important in supporting this assemblage.

3. Encourage species-compatible management of the powerline right-of-ways bordering the TNC preserve. This will effectively add beneficial land to the preserve. Wells (2003) found powerline right-of-ways to be viable habitat for some shrubland birds. Powerline right-of-ways at Ossipee contained the greatest abundance of prairie warblers and are likely hotspots for Lepidoptera. Work with Scott MacGregor (603-634-2109), the Carroll County Arborist for Public Service Company New Hampshire, to reduce herbicide spraying and manage for target species. He has experience working with conservation managers in the Concord, NH, area to mange right-of-ways for the benefit of the federally listed endangered Karner Blue Butterfly. He has stated that he'd be willing to work with TNC.

Species management and monitoring

4. Do not manage for individual rare species. Rather, manage for a wide range of ecosystem patterns and processes.

5. Sample for spring and fall flying Lepidoptera. Target spring flyers (early April through mid-May) including the previously documented: ***L. rachelae, L. thaxteri, L. lepida*** and ***X. thoracica***. Target fall flyers (September 20 to October 10) including the previously documented ***X. capax*** as well as previously undocumented *Nepytia pellucidaria, Chaetaglaea cerata, Psectraglaea carnosa* and *Fishia enthea*.

6. To determine the presence of ***E. latiferrugata*** (not found in the summer 2002 Lep survey), Schweitzer (2002-Appendix F) recommends searching for its host plants—primarily *Prunus pumila* var *cuneatus* and *P. pennsylvanica*,

and possibly related taxa such as *Aronia*. If one or both of the primary hosts are found, he feels you can assume that the species is present.

7. A whip-poor-will census can be conducted easily with a tape-recorded call protocol currently in development by the New Hampshire Audubon Society. They plan to employ this survey tool in spring/summer 2003 in southeast New Hampshire. Contact Pam Hunt at the NH Audubon for details.

8. Consider adding additional taxa to the monitoring program for a richer picture of barrens health.

    - Two additional rare birds to target are the prairie warbler and the vesper sparrow (Foss pers. comm.), both of which have slightly different habitat requirements than the current Target Species. Simmons (pers. comm.) recommends prairie warbler as an indicator in fire-dependent communities.

    - Ground beetles (Coleoptera: Carabidae) are a particularly well-documented family that includes a number of rare species and habitat specialists (Bell pers. comm.). Adding this family to the monitoring list would give a more complete picture of the Ossipee community.

    - Ongoing monitoring at the Mustapha bog site would particularly benefit from additional indicator species, as it does not fully share the assemblage of species found at other Ossipee locations. *Grammia speciosa, Paonias astylus* and *Macrochilo hypocritalis* would make good additions (Schweitzer 2002-Appendix F). *G. speciosa* and *P. astylus* are also fairly easy to identify.

9. There is little need to sample for additional summer flying Lepidoptera (June and early September) as they have been sampled sufficiently.

10. Make species monitoring a part of the vegetation management program. Be prepared to track changes in species abundance and richness from the pre-management phase through an entire cycle.

11. Consider enrolling the Ossipee Pine Barrens in the Audubon Society's Important Bird Area (IBA) program. Pam Hunt, New Hampshire Audubon's IBA coordinator is interested in enrolling the Ossipee.

Vegetation management

12. Burn primarily during the fire season, not the dormant season (except when the sole purpose of the burn is for fuel reduction). The ecological effects of fire season burning are important.

13. Base burning cycles on what current Lepidopteran populations respond to best. Determining historic burn frequencies it is too difficult in the wake of fire started by Native Americans and European Americans (McCabe pers. comm.).

14. Test a variety of burn sizes/intervals/temperatures/seasons. Recommended burn intervals range from 12 to 30 years and center around 20 years (Schweitzer 2002, McCabe pers. comm., Wagner et al. in press (a)).

15. Consider burning more frequently along borders to the preserve. Doing so will reduce fuel loads and the potential for wildfire. These border areas can be a good place to test effects of shorter fire rotations (Whelan 2002).

16. Leave patches of varying sizes unburned (just cut over in some way).

17. Test a variety of other vegetation management tools as well as disturbance frequencies and severity of disturbance.

18. If additional habitat for eastern towhee and vesper sparrow is desired, create open-canopied patches (<5% tree-canopy cover) 10 ha or greater (similar to the Thicket site).

19. If the white pine plantation on the Thicket tract is to be managed for timber, then it should be thinned soon. If the area is to be managed for biodiversity purposes, restore the pine barrens natural community.

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Appendix A: Explanation of Global and State Rank Codes

Ranks describe rarity both throughout a species' range (globally, or "G" rank) and within New Hampshire (statewide, or "S" rank). The rarity of sub-species and varieties is indicated with a taxon ("T") rank. For example, a G5T1 rank shows that the species is globally secure (G5) but the sub-species is critically imperiled (T1).

Code	Example	Description
1	G1 S1	Critically imperiled because extreme rarity (generally one to five occurrences) or some factor of its biology makes it particularly vulnerable to extinction.
2	G2 S2	Imperiled because rarity (generally six to 20 occurrences) or other factors demonstrably make it very vulnerable to extinction.
3	G3 S3	Either very rare and local throughout its range (generally 21 to 100 occurrences), or found locally (even abundantly at some of its locations) in a restricted range, or vulnerable to extinction because of other factors.
4	G4 S4	Widespread and apparently secure, although the species may be quite rare in parts of its range, especially at the periphery.
5	G5 S5	Demonstrably widespread and secure, although the species may be quite rare in parts of its range, particularly at the periphery.
U	GU SU	Status uncertain, but possibly in peril. More information needed.
H	GH SH	Known only from historical records, but may be rediscovered. A G5 SH species is widespread throughout its range (G5), but considered historical in New Hampshire (SH).
X	GX SX	Believed to be extinct. May be rediscovered, but evidence indicates that this is less likely than for historical species. A G5 SX species is widespread throughout its range (G5), but extirpated from New Hampshire (SX).
E	SE	An exotic that is established in the state, but may be native in nearby regions. The following modifiers indicate that there is some question about a species' rank.
Q	G5Q GHQ	Questions or problems may exist with the species' or sub-species' taxonomy, so more information is needed.
?	G3? S3?	The rank is uncertain due to insufficient information at the state or global level, so more inventories are needed. When no rank has been proposed the rank may be "G5T?" or "S?"

When ranks are somewhat uncertain or the species' status appears to fall between two ranks, the ranks may be combined. For example:

G4G5	The species may be globally secure (G5), but appears to be at some risk (G4).
G5T2T3	The species is globally secure (G5), but the sub-species is somewhat imperiled (T2T3).
G4?Q	A species appears to be relatively secure (G4), but more information is needed to confirm this (?). Further, there are questions or problems with the species' taxonomy (Q).
G3G4Q S1S2	The species is globally uncommon (G3G4), and there are questions about its taxonomy (Q). In New Hampshire, the species is very imperiled (S1S2).

From: New Hampshire Natural Heritage Inventory. *Animal Tracking List, Including species listed as threatened or endangered under the NH Endangered Species Conservation Act of 1979*. February 2001.

Appendix B-1 Collection sites, sample dates, methods for 2002 Ossipee Lepidoptera collection

Date	Site	Collection Method	Notes/weather/moon
5/17/02	Hobbs Tract	Blacklight	Temp: high 64, low 46. Winds light,
5/17/02	Mustapha	Blacklight	Sky: scattered clouds
5/17/02	SO Thicket	Blacklight	Moon: 5 days past new
5/17/02	Triangles	Blacklight	
5/17/02	West Branch	Blacklight	
6/6/02	Hobbs Tract	Blacklight	Temp: high 70, low 39 Winds light,
6/6/02	IP Heathlands	Blacklight	Sky: clear
6/6/02	Mustapha	Blacklight	Moon: 4 days before new
6/6/02	SO Thicket	Blacklight	
6/6/02	Triangles	Blacklight	
6/6/02	West Branch	Blacklight	
6/18/02	IP Heathland	Blacklight	*ran out of e. acetate
6/18/02	Triangles	Blacklight	Temp: high 74, low 42. Winds light Sky: scattered clouds. Moon: 8 days past new
7/3/02	Mustapha	Blacklight	Temp: high 91, low 76. Winds none
7/3/02	Northway Apts	Blacklight	Sky: scattered clouds
7/3/02	SO Thicket	Blacklight	Moon: 7 days before new
7/3/02	Triangles	Blacklight	
7/3/02	West Branch	Blacklight	
7/12/02	Hobbs Tract	Blacklight	Temp: high 78, low 49. Winds none
7/12/02	IP Heathland	Blacklight	Sky: clear
7/12/02	Mustapha	Blacklight	Moon: 2 days after new
7/12/02	SO Thicket	Blacklight	
7/12/02	Triangles	Blacklight	
7/12/02	West Branch	Blacklight	
7/12/02	West Branch	Sugar Bait	
7/16/02	Kennett Barrens	Blacklight	Temp: high 79, low 49. Winds light Sky: scattered clouds. Moon: 6 days past new
7/16/02	Upper Hobbs	Blacklight	Specimens collected at Upper Hobbs are included in the Hobbs column of appendix C

Date	Site	Collection Method	Notes/weather/moon
7/18/02	Hobbs Tract	Blacklight	Temp: high 73, low 65. Winds none
7/18/02	Mustapha	Blacklight	Sky: overcast
7/18/02	SO Thicket	Blacklight	Moon: 8 days after new
7/18/02	Triangles	Blacklight	
7/18/02	West Branch	Blacklight	
8/1/02	Hobbs Tract	Blacklight	Temp: high 88, low 70. Winds light
8/1/02	IP Heathland	Blacklight	Sky: mostly cloudy
8/1/02	Mustapha	Blacklight	Moon: 7 days before new
8/1/02	SO Thicket	Blacklight	
8/1/02	Triangles	Blacklight	
8/1/02	West Branch	Blacklight	
8/1/02	SO Thicket	Sugar Bait	
8/1/02	West Branch	Sugar Bait	
8/8/02	Hobbs Tract	Blacklight	Temp: high 78, low 48. Winds none
8/8/02	Triangles	Blacklight	Sky: scattered clouds
8/8/02	West Branch	Blacklight	Moon: new
8/8/02	SO Thicket	Blacklight	all Malacosoma disstria/americanum
8/8/02	West Branch	Sugar Bait	None collected-all very common
8/8/02	IP Heathland	Blacklight	None collected-trap knocked over
9/09/02	West Branch	Blacklight	Temp high 90 low 63, winds light, sky clear
9/09/02	West Branch	Sugar Bait	Moon 2 days past new

Appendix B-2 GPS Coordinates 2002 Ossipee Lepidoptera collection

Site	latitude	longitude
IP	43.83765827	-71.19276429
Mustapha	43.81816649	-71.18510113
West Branch	43.84197453	-71.18174217
Triangles	43.84710786	-71.19544683
Thicket	43.83367217	-71.18053308
Hobbs	43.81519762	-71.16473378
Upper Hobbs	43.82194597	-71.16444628
Kennett Barrens	43.82496488	-71.16520107
Northway	43.84002842	-71.20931787

Appendix B-3 Collection calendar 2002 Ossipee Lepidoptera collection
Collection dates, sites and methods for Ossipee Pine Barrens moth survey 5/17-9/9/2002

Site/Date	5/17/02	6/6/02	6/18/02*	7/3/02	7/12/02	7/16/02	7/18/02	8/1/02	8/8/02	9/9/02	total # samples/site
Blacklight											
Hobbs Tract							**				5
Mustapha											6
IP Heathlands											5
SO Thicket											7
Triangles											9
West Branch											8
Kennett Barrens											1
Upper Hobbs											1
Northway Apts											1
total # of light samples/night	5	6	2	5	6	2***	4	6	5	1	43

Sugar Bait					W Branch			W Branch	W Branch	W Branch
								SO Thicket	SO Thicket	
								Triangles		

* 6/18/02 Ran out of ethyl acetate and could not deploy all traps.
** This night's sample lost to mold
***Specimens collected at Upper Hobbs are included in the "Hobbs" column

Appendix D: Summary of Information on Lepidopteran Target Species at the Ossipee Pine Barrens

For details on phenology and fire vulnerability see appendix F

See figures 6 and 7 for summarized information on life-stages and fire vulnerability.

Data for this Table comes predominately from Schweitzer (2002-Appendix F and pers. comm.).

Additional data from McCabe, Mello and Simmons (pers. comm.) and Natureserve.

Species	Rank	collected	Flight Period	Larvae-active	Larvae-host	Fire Vulnerability	Additional notes	Range (most ranges incomplete)
Butterflies and skippers								
Erynnis brizo brizo Sleepy Dusky-Wing	G5T5 S2	5/23/1985	May 10-June 15	Approximately late May until leaf fall. Larvae live in a rolled leaf nest that falls to the ground in autumn	Probably only scrub oak in New England	Survival of all stages would be low or zero in most fires.		Manitoba, Gaspe Penn south to FL, Gulf Coast and Central TX
Moths, GEOMETRIDAE								
Eumacaria latiferrugata	G4G5 S2S4	5/23/1985* *This may be an erroneous record (Schweitzter pers. comm.)	Probably late May-June and late July-mid August	Two broods are expected. If so, active June-September	Varies regionally. At Ossipee probably least Prunus pumila var. cuneatus and P. pensylvanica; perhaps related taxa like *Aronia*	Not known if pupae are deep enough in soil to survive hot fires. Survival of other stages very unlikely	larvae blackish w/ 5 pair of lateral grayish stripes. Likely this spp if found on a Rosaceae.	Quebec to FL, west to SD & TX
Glena cognataria Blueberry Grey	G4G5 S3	5/23/1985 6/18/2002	late-May to June and late-July to Aug in New England	Two broods that probably follow adults closely (June and Sept)	Mostly blueberry, also Prunus pennslyvanica, Prunus pumila	Not known if pupae are deep enough in soil to survive hot fires. Survival of other stages very unlikely	very local but numerous. Two broods with moths in late May-June, Late July-Aug	Coastal Nova Scotia to FL, west to LA, uncommon north.
Itame sp. 1 Pine Barrens itame	G3Q S1S2	07/17/1985 07/06/1995	Most of July	Spring, probably late May to mid June.	scrub oak	Highly vulnerable to fire any season. Pupae possibly deep enough into soil to be insulated	eggs the overwintering stage	Very Scattered on sandplains of New England, NY, PA and southern NJ
Lycia rachelae Twilignt Moth		April 15 1986 L Crabo took 50 specimens this nightt. Probably the most ever collected in eastern North America	Mid to late April	Not known. Certainly starts in May, possibly all summer	West Canadian populations eat many woody genera. No host records w/in 2000 km of Ossipee. Scrub oak, heaths, apsen or gray birch likely.	Eggs & larvae extremely vulnerable early spring to as late as October. Pupae deep in soil—low mortality late October through March	The twilight name is a misnomer. Adults active closer to 9pm. Females are flightless	NH south to PA. Western Canada

Species	Rank	collected	Flight Period	Larvae-active	Larvae-host	Fire Vulnerability	Additional notes	Range (most ranges incomplete)
NOCTUIDAE								
Apharetra dentata (formerly Apharetra purpurea)	G4 S2	07/17/1985 many 07/12-08/08/2002	Much of July	Approximately mid May to late June	blueberry and other Ericaceae.	Not really known for any stage.	Large numbers taken at Ossipee	Quebec to Wisconsin, south to PA
Lithophane lepida lepida Pine Pinion Moth	G4T3T4 S1S2	4/15/1985, possibly 4/15/86[4]	Presumed late Sept-Oct, April-early May	May into July.	pine foliage, mainly new growth	Aestivating larvae & pupae should have some to very high survival in most natural summer/ early autumn fires. Survival at other seasons is harder to assess.	Females oviposit in spring. Come to blacklight and sugar bait. Look for unusually plain gray Lithophane on bait.	Maine to Michigan Spotty Nova Scotia to Saskatchewan and north to Manitoba.
Lithophane thaxteri Thaxter's pinion moth	G4 SU	mid April 1985-1988[4],	Approximately late September-October; April into May	May and June	Comptonia, Myrica spp. larch and Leatherleaf verified, blueberry strongly suspected.	All stages are fire sensitive. Larvae don't burrow like other Lithophane do. Adults active fall & spring and might survive light fires.	Comes to sugar bait.	Quebec to WI, South to NJ and PA.
Xestia elimata (formerly Anomogyna elimata)	G5 S3S4	08/01/1995 many 08/01-09/09/2002	At this latitude very early: apparently mid July to September	Details unavailable for cold winter climate areas, probably August to June	Pitch pine, probably facultatively on white pine, perhaps even blueberry.	Mature larvae & pupae should survive in most June-July fires. Survival minimal in fall crown fires. Adults (in litter) likely to perish in any late summer fires	Possibly a northern and southern race. If so, Ossipee's population could be the Northern paratype	NH south to MD and VA, west to PA
Xylena thoracica Pinion Moth	G4 S2	04/15/1985 04/21/1986 04/25/1996	Oct, April to early-May	Roughly mid May to mid July	General on shrubs. almost certainly mostly blueberry here	Aestivating larvae & pupae should have some to very high survival in most natural summer/ early autumn fires. Survival of all other stages (Oct-July) generally very low. Later instar larvae spend the day and molt periods in the leaf litter or possibly upper humus.	Found in bogs in NY. Comes readily to bait, sometimes to blacklight.	Quebec west to WI south to NY, NH and ME.
Xylotype capax Barrens Xylotype	G4 S2	10/5/1985	About mid-September into October	Spring: probably late April into June	Probably mainly blueberry, feeds facultatively on other woody plants like oaks, Prunus	Pupae are well underground so mortality from natural summer fires low or none. Egg & early instar survival in prescribed burns unlikely. Some late instar larvae might survive in leaf litter	Forewings resemble scaly PP bark. May be the same as X. acadica. Comes to sugar bait.	Very spotty, widely scattered colonies in eastern US except Cape Cod & southern NJ where common.
Zale sp. 1 Pine Barrens Zale	G3Q S1	05/23/1985 06/01/1995	May-early June	end May to early July	scrub oak leaves. may also eat oak catkins	Pupation probably deep enough into humus that some would survive light fires. All other stages vulnerable to all fires.		Scattered sites in NH, ME, MA, NY, NJ pinelands, PA, FL

[1] See Appendix G 2 for a full description of each species

[4] Lar Crabo possibly collected X. thoracica and L. thaxteri when he collected L. rachelae in the mid-1980s.

[3] June 1st is unusually early for Z. obliqua.

Species	Rank	collected	Flight Period	Larvae-active	Larvae-host	Fire Vulnerability	Additional notes	Range (most ranges incomplete)
Zale obliqua	G5 S2	08/02/1985 06/01/1995[3] 07/06/1995 7/12/2002	Mostly July-early August	Follows adults probably persists to September	Pitch pine, any Canadian reports such as jack or red pine are misidentifications	Pupation is probably deep enough into the humus that some would survive light fires. All other stages vulnerable to crown fire.		NY to Fl, west to MN and TX
Zale submediana	G4 S1	5/23/1985 Possibly April 2002	early May to mid-June	May, early June, possible in April in hot springs	New pine needles for early instars. Last instars also eat old needles of pitch, jack and other hard pines	Pupation is probably deep enough into humus that some would survive light fires. All other stages vulnerable to crown fire	Abundant where it occurs. Comes to bait in pine woods approx May 20. Scarce at blacklight.	
Zanclognatha martha Pine Barrens Zanclognatha	G4 S1	07/17/1985 08/01/1995 08/14/1985 many 07/12-08/08/2002	Early July-mid August	Most of the year	Leaf litter perhaps mainly old pine needles	Survival of all stages would be low or zero in most fires		NH, MA, ME, NY, PA.

Appendix E: Six Lepidopteran Target Species and 47 additional species of conservation interest collected at the Ossipee Pine Barrens 5/17-9/9/2002

Numbers in bold note the only Ossipee site where a species was found in 2002

Family	Species Name	Total	Hobbs	IP	Mustapha	Thicket	Triangles	W. Branch	Kennett	Hodges #
Geometridae	Glena cognataria[3]	1					**1**			6450
Geometridae	Itame Sp. 1[3]	18				1	7	9	1	
Noctuidae	Apharetra dentata[3]	97	4	18		22	46	7		10055
Noctuidae	Xestia elimata[2 3]	136	35	11		8	30	52		10967
Noctuidae	Zale obliqua[3]	3					2	1		8699
Noctuidae	Zanclognatha martha[3 4]	39	8		3	2	10	16		8350
Arctiidae	Apantesis carlotta[3]	1					1			XX
Arctiidae	Grammia speciosa[3]	6			6					8175a
Arctiidae	Grammia virguncula[2]	1			1					8175
Arctiidae	Holomelina ferruginosa[2]	13		1	3	3	5	1		8123
Arctiidae	Holomelina opella[2]	10		1			6	1	2	8118
Geometridae	Euchlaena effecta[2]	3			2		1			6728
Geometridae	Euchlaena johnsonaria[2]	9			3	2	1	3		6729
Geometridae	Euchlaena marginaria[2]	5	**5**							6734
Geometridae	Euchlaena muzaria[2]	1			**1**					6725
Geometridae	Hypagyrtis piniata[2]	25	5		2		11	7		6656
Geometridae	Itame anataria[2]	2				1		1		6287
Geometridae	Itame argillacearia	7		1			6			6282
Geometridae	Metarranthis amyrisaria[2]	5				1	1	3		6824
Geometridae	Metarranthis Sp.#1	1					**1**			
Geometridae	Metarranthis duaria[2]	2	**2**							6822
Geometridae	Probole nepiasaria[2]	1	**1**							6839
Geometridae	Semiothisa bicolorata	6				1	4	1		6341
Geometridae	Semiothisa granitata	75	9	12		4	41	9		6352
Geometridae	Semiothisa transitaria	6	1		1		1	1	2	6369
Lymantriidae	Dasychira cinnamomea[2]	10	1	1	8					8300
Noctuidae	Abagrotis brunneipennis	17	4			2	4	7		11044
Noctuidae	Acronicta haesitata[2]	1					1			9245
Noctuidae	Acronicta impressa[2]	8	6				2			9261
Noctuidae	Aplectoides condita	5		1			1	3		10999
Noctuidae	Bellura obliqua[2]	1			**1**					9525

Family	Species Name	Total	Hobbs	IP	Mustapha	Thicket	Triangles	W. Branch	Kennett	Hodges #
Noctuidae	Catocala gracilis[2]	2	**2**							8847
Noctuidae	Catocala connubialis	1		**1**						8877
Noctuidae	Catocala innubens	1	**1**							8770
Noctuidae	Cerastis fishii	1	**1**							10997
Noctuidae	Chortodes inquinata[2]	9			**9**					9437
Noctuidae	Drasteria occulta	1					1			8619
Noctuidae	Euagrotis forbesi	4		1		1	2			10902
Noctuidae	Eueretagrotis attenta	16	7	1		4	2	2		11009
Noctuidae	Hemipachnobia monochromatea	1			**1**					10993
Noctuidae	Hypenodes sombrus	2				**2**				8423
Noctuidae	Hyperstrotia villificans[2]	4	1				2	1		9038
Noctuidae	Lacinopolia lorea[2]	2			**2**					10405
Noctuidae	Leucania inermis[2]	1				**1**				10459
Noctuidae	Leucania pseudargyria[2]	1				**1**				10462
Noctuidae	Macrochilo hypocritalis	2			**2**					8357.1
Noctuidae	Xestia praevia[2]	4	2			1		1		10968a
Noctuidae	Xestia youngii[2]	15						**15**		10970
Noctuidae	Zanclognatha protumnusalis[2]	3	1		2					8349
Notodontidae	Datana drexelli[2]	15	3			5	7			7904
Sphingidae	Dolba hyloeus[2]	1				1				7784
Sphingidae	Paonias astylus	3	1		2					7826
Sphingidae	Sphinx poecila[2]	3				3				7810.1
	abundance	607	100	49	49	66	197	141	5	
	richness	53	21	11	17	20	27	20	3	
	species unique to a site		6	1	6	3	3	0	0	

Numbers in bold note the only Ossipee site where a species was found in 2002

[2] Voucher specimen(s) stored at University of Connecticut, University of New Hampshire, or The Nature Conservancy-New Hampshire Chapter

[3] Species included in New Hampshire's Natural Heritage Inventory's *Animal Tracking List Including species listed as Threatened or Endangered under the NH Endangered Species Conservation Act of 1979* (February 2002)

[4] Listed as a Threatened Species under the NH Endangered Species Act

Appendix F: Summary of the 2002 Lepidoptera sampling at The Ossipee, Carroll Co., New Hampshire Pine Barrens by Dale F. Schweitzer, Ph.D.

A Summary of the 2002 Lepidoptera sampling at The Ossipee, Carroll Co., New Hampshire Pine Barrens

by
Dale F. Schweitzer, Ph.D.
November 5, 2002

Prepared for
Douglas Bechtel, Scott Griggs, Jeff Lougee, Jonathan Kart
The Nature Conservancy
New Hampshire Field Office

emailed November 8, 2002

Introduction

Previous collecting efforts by myself (then working with TNC) and Lars Crabo (an avocational Lepidopterist) and on at least one night by Thomas Rawinski (then TNC) from about 1984 to 1988 had identified numerous regional or at least state level rare moths and one skipper at Ossipee Pine Barrens a large boreal variant pitch pine-scrub oak barren in Carroll County, New Hampshire. This collecting in the 1980s was the original basis for nearly all "rare" Lepidoptera records for these barrens. Also in the late 1980s I assigned global and state ranks for selected species and these, with additional input by me, were most of the significant input in listing some of them as State Threatened or Endangered. I am unsure now whether such listing actually confers any protection or not[1]. I probably overlooked some species worthy of being ranked as state-rare (S1, S2, S3). For example with 20:20 hindsight I probably should have ranked all species of *Datana* as historic or state rare in all states north and east of New Jersey at that time (see discussion).

The "element list" supplied to me contains errors and omissions which I address here. My understanding is that the list was derived in early 2002 from the NH Natural Heritage Database. I have corrected these omissions at least once for TNC and/or Heritage in the 1990s. I note a complete lack of April records from Lars Crabo who collected on a single night sometime between 1985 and 1988, probably near 15 April 1987. This presumably means these records are still inexplicably not in the Heritage Program database, although I provided them at the time. The most important omission was a massive number of the regionally very rare *Lycia rachelae* which came to a Mercury Vapor light-over 50 as I recall, probably most specimens ever collected in eastern North America. Given the miniscule sampling effort involved, the species must have been enormously abundant that spring. Unfortunately I do not have any duplicate specimens and I am not going through my 15+ year old files and notes yet again. Therefore unless TNC or Heritage has these records from my original submission or a later one *Lycia rachelae* will now have to be accepted on my say so. Or TN or heritage could contact Dr. Lars Crabo, M.D. directly. he lives near Seattle. Details as best as I can now recall them are about 50 at MV light, mid April 1985 to 1988. I am pretty sure the exact site (not really important) was the same as mine from March 1987, May and July 1985. The records were definitely supplied at the time and at least once since. I am certain Dr. Crabo did collect these and I did see some of them. Lars Crabo also collected *Lithophane lepida* the same night (probably at bait) and therefore probably *L. thaxteri* and *X. thoracica*, although I cannot now vouch for the last two. The late Dr. David Winter and myself attempted unsuccessfully to rear *L. lepida* from eggs provided by Dr. Crabo. *L. lepida* and *L. rachelae* are not dubious records in any way. I do not have an Ossipee specimen of *Lithophane thaxteri.* It is possible I deposited one elsewhere. At this point one would probably have to check my original 1980s documents supplied to Heritage. This species surely occurs there but at this time I do not know the source of the record except I can guess Lars Carbo collected it. Otherwise, the "element list" provided seems correct, except that *Apharetra purpurea* was sunk to *A. dentata* in the mid 1990s, as all Heritage Programs that tracked that

[1] For the moths discussed in this report restrictions on collecting specimens are in no way meaningful protection; since they address no conceivable threat they can be regarded only as meaningless or possibly even negative (inventory impeding) factors in terms of conserving these species. Only habitat protection can actually be considered real protection for any of these. I do not know if the State Act provides for this or not.

name were notified in a 1996 memo and subsequently in data exchanges with NatureServe. They are the same taxon.

Subsequent sampling by New Hampshire Natural Heritage, The Nature Conservancy (TNC) and possibly others reverified some of these 19980s, 1990s records but added no new rarities in the 1990s. I also looked for but did not find the buckmoth, *Hemileuca maia*, in the 1980s and verified that there was insufficient lupine to support either Karner Blue or *Erynnis persius persius* and apparently no *Ceanothus.* During the spring and summer of 2002 additional efforts were made to relocate some of the rare species and to look for others by Jonathan Kart and others for The Nature Conservancy.

Methods

Details of the methods were not supplied to me in particular the exact model of the light traps. Light traps used 15 Watt BioQuip® blacklights which are more or less standard for such surveys nowadays. Other types of lights may have been used with sheets. Baiting was attempted on some nights. The sugar bait recipe was roughly a can of cheap beer, 10 oz or so of sugar some molasses, rotting bananas or other fruit. A list of nights, sites, and techniques is appended to this report.

A complete list of all moths taken is appended to this report. Except for all of the April specimens, nearly all specimens, whether pinned or not, were examined by Dale Schweitzer and Scott Griggs, most of them by both Lepidopterists simultaneously. Mr. Griggs' reference collection was used for comparison for some northern species of Geometridae and others such as *Dasychira, Acronicta.* As of the completion of this report vouchering has not been completed. Vouchers will likely be mostly in the collections of the University of New Hampshire and Scott Griggs. Schweitzer retained only one worn *Acronicta* which proved to be *"haesitata"* and one of the *Hypenodes sombrus* from the 2002 efforts.

Results of 2002 samples

The April sample was conducted during the extreme heat wave when temperatures were exceeding 30 C during the day. Baiting was unproductive and blacklight samples unexpectedly meager. I did not see the moths but did see a tentative species list at the time. Several specimens identified incorrectly as *Zale squamularis* (not anywhere in New England or Canada) and *Z. metatoides* (much too early) were reported which probably included *Z. submediana*. It is possible but not likely that the *Xykena curvimacula* was really *X. thoracica*. In fact with few exceptions without expert examination the april specimens must be considered as identified only to genus. Clearly *Lycia rachelae* was not found but it is unknown whether it could have been under those conditions. There were very late March and early to mid April collections of it in barrens of northeastern MA and northeast PA in 2002. It is possible the flight season was over or not quite started at Ossipee by April 17. It was not present in Pennsylvania during the heat wave but was numerous a week earlier (Steve Johnson). I am inclined to conclude that *Lithophane lepida, L. thaxteri* and probably *Xylena thoracica* were effectively not looked for given that Xylenini were almost lacking in the sample and that these moths are taken overwhelmingly at bait before red maples bloom and that they cannot maintain activity much above about 17˚C.

The May samples were also spectacularly unproductive. While I cannot speculate why the May effort failed, there were almost no moths on bait so *Zale sp.*1 could not be looked for. Although some of the five blacklights operated were in suitable habitats and adults should have been present one could not expect any to have been collected by that level of effort and it would be unjustified to conclude it was looked for and not found. Summer samples went much better but still overall numbers of moths were very low. Samples during June through September 9 yielded relatively few moths per effort but were sufficient that summer species could be legitimately be scored as not found rather than not looked for if they were not encountered.

I regard the following previously documented species as not having been effectively looked for in 2002: *Erynnis brizo, Lycia rachelae, Zale sp.1, Zale submediana, Lithophane lepida, L. thaxteri, X. thoracica, Xylotype capax*. Of the remaining Heritage Program "elements", *Glena cognataria, Itame Sp 1, Zanclognatha martha, Zale obliqua, Xestia elimata, Apharetra dentata* were all found, except for the *Glena* several to many specimens at more than one site. *Eumacaria latiferrugata* was the only "element" for which there was appropriate effort that was in fact not found. It is not especially numerous in part because its foodplants are not and so it could have been overlooked. In fact there appears to have been only one prior record for these barrens. So of the 13 previously documented moth "elements" seven were not effectively, if at all, looked for and five of the six that were sampled for were found. All of these seven not looked for are spring or fall flying species. The single skipper *Erynnis brizo* was not looked for so far as known.

None of the four actual or potential autumn flying elements were looked for in 2002. At least the three Xylenini should have been present as adults on October 5, 1985 when Lars Crabo collected *X. capax* so there is one valid negative effort for them. It is quite possible there has not been a legitimate sampling effort for *Nepytia pellucidaria* since many specimens were taken in the area (North Conway, NH) before 1930. I have examined some of these at USNM.

I am not making any effort to compare this list with previous raw trap samples lists from the 1980s and 1990s supplied by me. All significant species from those samples are accounted for in the "element list". So I cannot say how many species taken in 2002 were not taken previously, probably more than 20. Also there may well be more that were taken in the 1980s or 1990s but not in 2002. However two species new in 2002 do seem important. *Macrochilo hypocritalis* is almost certainly new for NH. Two were taken at Mustopha site July 11. In New England I have seen it only from calcareous fens in Berkshire County, MA and western CT in July. However it occurs in other habitats in NY and NJ. This sedge-associated species might very well be expanding its range. It does not seem especially rare now but it was not even named until 1983. *Paonias astylus* is also new for the sites again with two at Mustapha on July 12. This bog, barrens and acid woodland species was quite expected since I collected one at Fryeburg barrens Maine in the 1980s. It is not considered rare in MA or CT. This can actually be a common moth in extensive acid soil regions with a reputation for rarity due to the exclusively very late night flight of the males. Collectors who quit by 2 AM will virtually never encounter it even where it is common. Its larva feeds on blueberry and probably other heaths in July-Sept. *Apantesis carlotta* may also be a state record, if so clearly an SU. It is common not too far to the south.

Additional sampling needs

Given the substantial number of rare species that occur as adults only in spring or fall or both, there is a clear need for effective sampling during the period September 20 to October 10. Although *Nepytia pellucidaria* was identified by me as the number one target species for 2002, followed by several three previously undocumented, but plausible to likely autumn flying Xylenini, namely *Chaetaglaea cerata, Psectraglaea carnosa, Fishia enthea*, there were no autumn samples. The first two of these are globally uncommon to rare. While a few *N. pellucidaria* might have started flying by September 9, this species should be considered as not looked for rather than not found since the date is clearly before the expected peak season. There seems no chance the other three could have been encountered that early. In addition there was far from sufficient effort in 2002 to address *Lycia rachelae, Lithophane thaxteri, L. lepida, Xylena thoracica.* The one April night may have been too hot and bait was ineffective regardless of the reason. Less important would be an adequate effort to document *Zale* sp. 1 which was last collected in 1995. This would require baiting in late May or early June preferably when a large scale freeze kill of scrub oak foliage did not occur the previous May or June. Fall and early spring sampling must include baiting. A Mercury Vapor light off a generator would also be worth considering, especially in the fall. To date there has been only one effective fall sample by Lars Crabo on October 5, 1985. I made one unsuccessful attempt in the 1980s.

There are not a lot of species of interest flying in summer and most were found in good numbers in 2002. Nor are there obvious missing summer species that would be considered regionally rare. There is not a serious need for more sampling in June through early September. I would go on the assumption that *Eumacaria latiferrugata* is still present if its Prunus foodplants are and I do not recommend more effort to document summer species.

Discussion

Given that the summer flying fauna seems more or less intact and not obviously much different from what it was in the 1980s, and that the habitats supporting that fauna are little changed, it seems unlikely that there would have been a major decline in the fall and spring active species. Most or all of them feed on common plants like pine, scrub oak and blueberry in spring. *Apharetra dentata* larvae occur in spring and it remains abundant and there is no apparent reason why other spring feeders would have declined.

The data when viewed in the context of previous collecting as well suggest that with more effort most or all of the species of concern would prove to occur widely within the barrens. Among barrens species that were found, even from the 2002 samples alone only *Glena cognataria, Drasteria occulta, Cerastis fishii* were taken at single sites. *C. fishii* was nearly missed entirely based on the sample dates. There probably are 1980s records of this one elsewhere, as there are for the *Glena*. *Zale obliqua* is not well sampled by blacklights but is documented from efforts in other years to occur widely in the system. Given the life span, flight capability, and numbers of adults, it would be nearly impossible for them not to fully occupy all suitable habitat within a few years of first reaching such a barren. In general once they are documented as present, moths whose larvae feed on pitch pine, scrub oak and blueberry should be assumed to be widespread within the barrens community except where there is excessive

canopy closure. While the data are inadequate to prove it, they certainly do not refute the assumption that all these barrens moths occur widely in the system which is the case for those with better data. *Eumacaria latiferrugata* could be more localized due to its less abundant foodplants, and that species has not been found in these barrens since 1985.

The data cannot be used to suggest any loss of barrens specialists since the mid 1980s. Five of six such species actually looked for were found in 2002. Still there has been at least one loss. Ossipee barrens almost certainly permanently has lost obligate pine feeder, the pine devil moth *Citheronia sepulcralis*. This species was known fairly widely from NH and southern Maine (Farquhar, 1934; Brower 1974; also various collection records and other literature). New Hampshire records known to me include two remarkably recent (Concord, 1937 and North Rochester, 1939) specimens from the old Montshire Museum collection (now at Yale) and older ones from Webster and Manchester. The species was collected before 1900 at Norway Maine, well to the north of Ossipee. It is almost inconceivable that this moth would not have occurred at Ossipee. By the end of the 1950s it was extirpated from New England and NY and northern PA. While it was only a facultative pine barrens species, the related imperial moth (*Eacles imperialis imperialis*) was also completely eradicated from the New England mainland and adjacent areas (all or parts of nine states). It probably also occurred at Ossipee barrens (same sources). There is now no reasonable doubt that an out of control gypsy moth biocontrol (*Compsilura concinnata*: Dipera, Tachinidae) eradicated the genus *Citheronia* and nearly *Eacles* from the Northeast.

It is by now well known that many of the larger moths (especially *Citheronia, Eacles,* other Saturniidae, *Sphinx, Datana*) have been drastically reduced or extirpated from large areas northeast of central New Jersey into northern New England (see Boettner et al., 2000). While multi-million acre DDT applications in the late 1950s played a role, probably a large one, the fly has obviously beeen even more important. This fly has at least prevented recoveries and in some areas probably wiped out survivors in unsprayed patches of woods, and was perhaps the major cause of initial reductions in some places. Reductions in native Saturniidae were first reported around Boston soon after 1900. However the drastic, pervasive crashes of Saturniidae, and many other moths with late summer larvae, came around 1957-1961 in most places. It is quite possible these barrens were never extensively sprayed.

It is also worth noting that the disappearance of *Nepytia pellucidaria* from the Northeast from about the 1940s through 1999 looks suspiciously like a *Compsilura* impact but there is much room for doubt. In fact given its rediscovery in Fryeburg barrens in 2000, it is very possible this species which was until recently regarded as globally historic would have been found in quantity at Ossipee had it been looked for in 2002. The many early 20th century specimens from North Conway and elsewhere are adequate documentation that this species occurred in the Carroll County pine barrens.

In general large pine barrens lost fewer species to *Compsilura* than other habitats and it has long been conventional wisdom that this fly does not do well in sandy areas. Besides most Saturniidae and some Sphingidae, *Datana* were even more severely impacted and are still absent or nearly so from a lot of NY and New England. During my residence in New England (1975 through 1988 seasons) I encountered but a single individual of this genus--a *D. drexelii* in the massive barrens at Plymouth, MA. *Datana* was well represented in the 2002 Ossipee samples.

The genus *Sphinx* was also widely eradicated or reduced in and near new England. However, the only one really expected in these barrens would be *S. poecila,* which was collected in 2002. I do note that there were virtually no Saturniidae in the Ossipee samples, but this is insufficient evidence to document a *Compsilura* effect in the barrens. A number of the species (*Anisota, Eacles, and Automeris*) may not reach that far north or are naturally rare (perhaps *Antheraea polyphemus*) and some others do not come very well to lights (e.g. *Hyalophora, Callosamia*). I find only the lack of luna and polyphemus moths a bit perplexing.

In summary there is not now an obvious *Compsilura* impact persisting in the Ossipee fauna other than the presumed absence of *C. sepulcralis* and *E. imperialis.* As was the case in York County, Maine where I collected extensively from 1980-1982 the fauna around Ossipee seems to have largely recovered from any *Compsilura* effects. This is generally not so in southern New England, although some of the once common large moths are at least no longer absent there as they were in the 1960s, 1970s and much of the 1980s.

Another event worth mentioning in the context of missing species was the massive wildfire of October 1946 (or 1947) which burned much of Ossipee, Fryebrug and Shapleigh-Waterboro barrens. It is not out of the realm of possibility that this event explains the absence of several species that really do seem missing at Shapleigh but have not been adequately looked for elsewhere--e.g. *Chaetaglaea cerata* and *Psectraglaea carnosa* which would have been exposed to complete mortality as adults or eggs in the dry leaf litter. Both have been taken in the general region (e.g. Brower, 1974). Lars Crabo and myself failed to find them at Ossipee in minimally productive efforts in the 1980s though. This fire could not have seriously impacted *Citheronia* or *Eacles* pupae in the soil and undoubtedly by the following summer some pitch and white pine foliage would have been available.

Management Implications

Any manger with some knowledge of Lepidoptera and other fauna and some common sense should know to be cautious with fire, although occasionally some have not shown much consideration for invertebrates. Extirpations of rare skippers and butterflies and probably moths have been caused by overzealous burning. An apparent recent example was the 2000-2002 eradication of several (most?) Canadian occurrences of the globally rare Dakota skipper (Reggie Webster, pers. comm., 2002). However, these and other known or likely examples of Lepidoptera being eradicated by prescribed burns generally involve prairies or other grasslands or savannas and usually at completely unnatural seasons. My understanding is that the eradication of arogos skipper in Ocala National Forest, Florida involved two fires in the same season which together killed the entire population. While I have not researched the subject in detail, my impression is that pine barrens fauna are much more likely to be pre-adapted to prescribed burning than prairie fauna, but no season is anywhere near safe for all fauna and so burning must be done cautiously if maintaining a community, not merely a garden, is the goal.

Fire can be used to maintain Lepidoptera and communities that support them. For the most part even species unlikely to survive within a burn unit (such as most butterflies) can be well managed with moderate partial burning. The best data are those of Panzer (1998) but it needs to be noted that other than *Papaipema* moths which recolonized and recover within about

three years, his study sites had already lost most reputedly highly fire sensitive prairie specialists like regal fritillary, all prairie skippers, and even some *Papaipema*. It is possible that his findings would have been somewhat different for some of these missing species had he been able to work in larger more intact prairie remnants. Key points are refugia and adequate recovery time. I suggest the works of Ann and Scott Swengel and others (see my Papaipema and Regal Fritillary EMGs = ESAs soon to be available on HDMS). I am aware that the Swengels' work was not well received by some TNC and other managers, although it was by most Lepidopterists involved with fire issues. I was not among the detractors and I point out that their findings generally document the expected. Furthermore their findings should be under-stating, not exaggerating, any impacts of frequent fires on butterflies because one would expect site and fire heterogeneity (which they could not control) to obfuscate, not produce, significant results.

In a large relatively simple and homogeneous community like Ossipee barrens, a common sense approach to burning can be derived without much data other than just basic Lepidoptera biology. The conclusion that the pine barren community is simple and fairly homogeneous at the species level is reasonably supported by the limited data, particularly if one considers 1980s and 1990s collections and not just those from 2002. It is also consistent with observations in nearly all comparable communities (see for example NatureServe EOSPECS for Pine Barrens moths).

Expensive complicated burn unit lay out is not justified. Roads, streams, right of ways and other convenient features should be used where possible to delineate convenient burn units. It would be preferable to document the pre-fire and post fire fauna in each unit somewhat, but in a large infrequently burned community this does not seem critical. Assuming we accept that the community itself would disappear without some fire the need for fire would be obvious, and with a bit of caution, extirpations of Lepidoptera would be very unlikely. Ideally I would recommend something like burn 25-30% in year one, skip three seasons, burn another similar unit in year four and continue every three years as needed to finish the job. One could skip only one year if units were not adjacent and there were more than about four of them. Even schemes with some burning every year could be quite reasonable.

Certain special habitats within the barrens may need more careful consideration such as making sure at least half does not burn in any given fire or allocation among multiple burn units. I suggest being careful that certain plants are not excessively concentrated in one burn unit and that well under 50% of their microhabitat burn in any three year period. The most obvious such plants are sand cherry and lupine. Grassy openings, whether natural or not (e.g. in powerlines), should also be well distributed among burn units. Since the Mustopha site has a number of bog species not found more widely in the barrens it probably needs to be unburned or only partially burned. *Hypenodes sombrus* at "thicket" may raise a caution flag also.

Some specific suggestions for future prescribed burning follow.

- There must be at least three, and should be more, burn units.
- All microhabitats need to be represented in at least three units burned on different schedules, or be excluded from fires.

- The minimum interval between fires for a given unit should be five years. This should allow adequate recovery time (e.g. Panzer, 1998).
- A between fire interval of 10-30 years per patch is recommended. This is based in part on recommendations we (Givnish et al., 1988) made for the much more complex barrens at Albany, NY (before recent misapplied fires and devastation by deer) and from work by Andrew Windisch in NJ.
- Regardless of number of burn units (as long as at least 3) the fire schedule should be such that the entire barren does not burn in a twenty year period (this allows for the short, cold growing season and would be less in most places).
- If the community is large enough it is strongly recommended that an attempt be made to maintain at least two 50-100 hectare examples of all post fire age classes from one to fifteen years (see Givnish et al. 1988 for the rationale).

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Appendix 1. Life history accounts of selected highly ranked Lepidoptera.

Accounts of the phenology, larval foodplant and fire exposure are given below for selected species considered rare in NH and in many cases also in much of New England. Since neither BCD nor HDMS is now operational, these accounts are prepared here in Word. The sections could later be pasted into HDMS fields.

Erynnis brizo brizo

Larval foodplant. Oaks, generally scrub oak north of about southern PA, but very commonly other oaks in southern NJ, southern PA and south, even where scrub oak is present (and utilized).

Phenology. Based on wild larvae in Cumberland County, NJ (Dale Schweitzer, Robert Barber) larvae occur from May well into October on oak leaves. They reach the last instar in late June. They may be inactive at times during summer but basically they feed almost until leaf fall. The larvae live in a rolled leaf nest which falls to the ground in autumn. In late February or March the larvae become active again but do not feed. They wander and spin another cocoon in which they pupate with the adults eclosing mostly in April. Circumstantial evidence suggests some larvae awaken any time starting in late January when air temperatures reach 20 degrees C. Farther north larvae appear later, presumably do not feed as late into fall and obviously do not pupate until after the snow cover melts. Adults are flying by the end of May in Maine and NH.

Fire exposure. Survival of all stages would be low or zero in most fires.

***Itame* sp. 1 (=*Itame inceptaria* of Forbes, 1948)**

Larval foodplant: scrub oak (Tim McCabe from wild collections in NY)

Phenology. The adult flight season is about mid June in Virginia and in Salem County, NJ; usually sometime in July in rest of range except occasionally end of June in NJ Pine Barrens. Adults were numerous in Carroll Co., NH on 3 July 2002. All *Itame* except the far southern *I. varadaria* (really an Itame??) are univoltine with the eggs the overwintering stage. The life history of *Itame ribearia* is well depicted by Holland (1903). The pupal stage is presumed to be three weeks which would mean pupation about mid or late June in New Hampshire. Larvae would be in May and June. Adults fly for much of July and eggs are present from July to May.

Fire exposure. It is possible pupation is in the soil deep enough to provide insulation from fire, but all other stages would incur high to total mortality in fires. This species is best considered vulnerable to any fire at any season. Note that survival of eggs is probably moot in fall, winter or spring fires since it is unlikely scrub oak refoliation would be early enough for hatchlings to find food.

Eumacaria latiferrugata

Larval foodplant. Foodplants are species of *Prunus, Malus* and closely related genera. They vary regionally, and *Prunus serotina* is not a foodplant. In NH *Prunus pumila var cuneatus* is

documented and *P. pensylvanica* and *Aronia melancocarpa* may also be used. Along the coast of New England to NJ beach plum is an important foodplant.

Phenology. Two broods in much of the range, mostly late May-mid June and mid July to early august in New Jersey, three or four broods south of there. Not well documented in NH. Probably two broods in late May-June and late July-early August. The only Ossipee date is May 23, 1985. June and late July in Nova Scotia (Ferguson, 1955). The pupae overwinter in the humus or soil (Schweitzer). Larvae are present at least in June and July and probably again in late summer.

Fire exposure. It is not known if pupae would be deep enough to have good survival in hot fires. Survival of other stages would be very unlikely since eggs and larvae are on mostly low shrubs and adults apparently in the leaf litter.

Glena cognataria.

Larval foodplants. Blueberries are obviously the primary foodplants but Dale Schweitzer has also collected larvae and reared them through on *Prunus pumila var. cuneatus* and *P. pensylvanica* in New England.

Phenology. Generally two broods with adults in May-June and July-August in much of the range, June to August in Nova Scotia (Ferguson, 1955), three or perhaps more broods from NC southward. In New England larvae June-July and August-September. Pupae hibernate in the soil or humus.

Fire exposure. It is not known if pupae would be deep enough to have good survival in hot fires. Survival of other stages would be very unlikely since eggs and larvae are on mostly low shrubs. Adults look as though they rest on conifer trunks but if they do, they probably are not very high and if not would have severe fire mortality.

Lycia rachelae.

Larval Foodplant. The larvae are polyphagous on shrubs and trees (McGuffin, 1977) including birches, alders, poplars and several Rosaceae, but probably no host records are from within 2000 km of Ossipee and few are within the range of any oak. Based on the abundance of the males at times in the 1980s, it seems likely community dominants like scrub oak and/or blueberry must be major foodplants at Ossipee although gray birch and aspen would obviously be used.

Phenology. In New England and Pennsylvania recorded only from 29 March to 30 April over more than 100 years, but apparently only about a week or two in any given spring. Larvae obviously hatch in late April or May as the foodplants leaf out. It is very unclear how long the larval stage might last in New Hampshire but McGuffin (1977) indicates late April to October for Canada (Manitoba to British Columbia). Statements that adults fly at twilight do not appear to be true for New England where most come to lights closer to 9PM--but not all at once.

Fire exposure. Apparently eggs and larvae would be extremely vulnerable from early spring to possibly as late as October. Pupation is deep in the soil so mortality from late October through March should be trivial or less. However it is very possible larvae would fail to find food following fall, winter, or early spring fires since appearance of new growth would be delayed. Since females are flightless they cannot leave temporarily unsuitable habitat.

Zanclognatha martha

Larval foodplants. The larva has been reared by Tim McCabe and others and seems to feed on dead leaves like most Herminiinae. Although the moths are never found away from pitch or related pines and seldom outside of pine barrens, the larva may or may not feed primarily on pine needles. Since no collections of larvae have been made in nature and caterpillars often eat things in the lab that they do not encounter or normally use in nature, the actual food remains unknown.

Phenology. Adults occur in June or July in all parts of the range. with stragglers into early August especially northward. Larvae occur from late June or July until the following June, hibernating in one of the mid instars like most related species.

Fire exposure. Survival of all stages would be low or zero in most fires.

Zale submediana

Larval foodplants: pitch, pond pines (mainly rearings by Schweitzer), published records of other pines probably partly correct since the species ranges well north of pitch pine. In New Hampshire pitch, probably jack and red pines. The larvae feed on the new growth for at least their first four and probably five instars but last instars often eat old needles as well.

Phenology. Very well documented in NJ (Schweitzer). In southern NJ adults early April to mid or late May, individuals rather long lived. Flight season about 6 weeks in a given year. Egg stage varies with temperature but is about a week. Larval stage varies with temperature but is roughly a month to six weeks with pupation mostly by late June. All pupae overwinter, and eclose in the next spring. In New Hampshire the phenology is pushed back about a month later but is very similar otherwise.

Fire exposure. Captive larvae burrow into soil (peat) if given the opportunity and natural pupation is probably deep enough into the humus that some would survive at least light fires. However all other stages would be fully exposed to crown fires. No stage would likely have high mortality in light ground fires.

Zale obliqua

Foodplants. Throughout its range this species feeds on a number of the southern pines. North of NJ it feeds overwhelmingly on pitch pine but probably also on planted red pine. Its range probably does not overlap jack pine and barely does for native red pine. Literature records are unreliable due to misidentifications. In general larvae do not have access to new growth but they often do feed on first year needles as well as older ones.

Phenology. In northern New England adults occur mostly in July and early August. A date of June 1, 1995 for the Ossipee barrens, NH seems suspiciously early although I have taken it nearly that early in Massachusetts. Eggs hatch within ten days so larvae within two weeks of the first adults. In NJ the larval stage lasts about five weeks, probably longer in NH. So larvae probably occur in ME and NH as late as mid September.

Fire exposure. Captive larvae burrow into soil (peat) if given the opportunity and natural pupation is probably deep enough into the humus that some would survive at least light fires. However all other stages would be fully exposed to crown fires. No stage would likely have high mortality in light ground fires.

***Zale* sp. 1.** (illustrated as *Z. lunifera* by Covell, 1984)

Larval foodplants: has not been verified in nature but captive larvae strongly prefer young oak leaves. It is not known if they also eat catkins. They also feed on species of *Prunus* but mortality of resulting pupae was very high. Pine is unacceptable and blueberry clearly not preferred if accepted at all. Based on consistent habitat, new growth of scrub oak is obviously the primary to exclusive foodplant in population north of New Jersey.

Phenology. There is only one brood everywhere, with adults from about mid May into June in and north of the Poconos, starting by the end of April in New Jersey. Adults that appear to be this species occur in northern Florida in late March. Adults are fresh and numerous for about two weeks. This species had the second most synchronized eclosion (6 days) from overwintered pupae of over 85 Lepidoptera recorded by D. Schweitzer. The egg stage is about a week and larvae grow rapidly on soft young scrub oak leaves and mature about when these leaves harden in June. All pupae overwinter and hatch the next spring.

Fire exposure. Captive larvae sometimes burrow into soil (peat) if given the opportunity and natural pupation is probably deep enough into the humus that some would survive at least light fires. However all other stages would be fully exposed to virtually all fires.

Lithophane thaxteri

Foodplants. There are a few literature reports of foodplants (e.g. Brower, 1974; Prentice, 1962; McCabe, 1991) and a few reared adults in collections. Based on these and observations of Adirondack bog larvae reared by D. Schweitzer apparently most Ericaceae and Myricaceae are utilized as well as larch. *Myrica gale* and *Comptonia* are possibly preferred. Leatherleaf is definitely used. Presumably in boreal pine barrens lowbush blueberries are on the menu.

Phenology. Well known based on Schweitzer's observations supplemented by published reports. Adults overwinter and in New England are generally active in October and late March or April into May. Mating and oviposition begin in April and egg hatch is in May. Larvae mature in five to eight weeks depending on temperature, and require new growth. In late June or July they spin their cocoons and aestivate there until about the end of August when they pupate.

Fire exposure. All stages are fire sensitive. Unlike most *Lithophane* most captive larvae made no attempt to burrow into soil. This may be an adaptation to typical wet taiga and bog habitats. Apparently aestivation and pupation are in the leaf litter. It is assumed, but not known, that adults hibernate in the litter. Adults almost certainly rest on conifer bark on which they are very cryptic. Active adults in fall and spring might therefore have some survival in light to moderate fires.

Lithophane lepida lepida

Foodplants. Various species of pine including pitch, red and jack but probably not white.

Phenology. In New Hampshire adults probably eclose in late September or early October based on 19th century records for Albany NY area. Recent Ossipee and Clinton Co. NY records are in April and very early May. Adults are active for a few weeks in autumn at least in some years and then overwinter (apparently under pine bark) reappearing in about April when they mate and begin laying eggs. Reared larvae of subspecies *adipel* in New Jersey mature in about six weeks outdoors. In New Hampshire most larvae probably mature in late June or early July. They then enter the humus or soil and spend the rest of the summer as a pre-pupal larva in a cocoon. Pupation is probably in late August and is usually in the same cocoon.

Fire exposure. Aestivating larvae and pupae should have some to very high survival in most of the natural summer fire season or in early autumn. Survival at other seasons is harder to assess. Eggs and larvae in the pines would have good survival in light ground or brush fires but minimal survival in crown fires. The same is probably true for adults but it is less certain where they are at any given time. If they in fact are in the litter most would not survive fires.

Xylena thoracica

Foodplants. Larvae accept most of the woody plants typical of barrens except for the pines. Species of this genus tend to feed on shrubs or even herbs and grasses. It is likely lowbush blueberries are the preferred foodplant in northern New England and captive larvae seemed to prefer these and wild cherry. Young scrub oak foliage is also probably used. These observations are by Dale Schweitzer. Willows are used elsewhere but would not be important in New England. The fact that this moth also occurs in bogs in new York (McCabe) further suggests Ericaeae as the major regional foodplants.

Phenology. Adults eclose in the fall, probably in late September and October. They are apparently not very active in autumn. They overwinter in the litter and mate and begin laying eggs in April and live into May. Larvae are probably mature mainly in early July.

Fire exposure. Aestivating larvae and pupae should have some to very high survival in most of the natural summer fire season or in early autumn. Survival of all other stages in the shrubs or litter (October into July) would generally be very low. Later instar larvae spend the day and molt periods in the leaf litter or possibly upper humus.

***Apharetra dentata* (=*A. purpurea*).**

Larval Foodplant: Blueberry and *Kalmia polifolia* (McCabe, 1991). Details not well documented. Presumably barrens populations use mainly blueberry.

Phenology: Not fully documented. Adults fly in July or early August nearly rangewide (Canada to s. NJ), apparently being latest in New Jersey. Larvae occur in spring and so the egg is almost certainly the overwintering stage. At Ossipee larvae must mature in June or early July, implying that egg hatch is about mid May.

Fire exposure. Not really known for any stage. There have been reports in NJ of adults in places burned the previous spring implying survival of eggs, but perhaps the moths flew in from elsewhere. Based on female morphology it seems likely eggs are laid several mm to possibly half a cm deep in the sand. If so some would likely survive light fires. Survival of larvae in May and June would be unlikely. Pupae are probably below ground in late June into July and would not likely perish in fires. Adults match pine and spruce bark in color and almost certainly rest on this substrate, but it is unknown how high.

***Xylotype capax*.**

Larval foodplants. While it is generally assumed that blueberries are the main foodplants, the only field collections of larvae have been two accidentals in rearing sleeves on *Prunus serotina* in Cumberland County, NJ. Newly hatched larvae would seem to generally have access to few possible food sources other than blueberry buds, which they readily eat. Larvae obviously start on something that leafs out or flowers very early but probably are less fussy later. The mid and later instars will readily eat new growth of species of blueberry, oaks, cherries, crabapples, but not pines.

Phenology. Adults as early as late September in New England, progressively later southward, but mostly October in most of the range. Persisting to late November in southern NJ and commonly collected in November in the mountains from southwestern Virginia to north Georgia. Based on observations by Dale Schweitzer eggs hatch very early, mostly in March in NJ, and often a month before oak and most tree buds open, but about when highbush blueberry buds swell. Larvae are mature in mid or late May in NJ and probably by late June in New England. Fully fed larvae dig several cm into the soil and pupate there, with development and eclosion in autumn.

Fire exposure. Since they are well underground mortality to pupae in the natural summer fire season would be low or none. Survival of eggs or early instar larvae during prescribed burns would be unlikely. Some late instar larvae might survive in leaf litter (where they spend the day) if it were moist enough, but they would probably starve before new foliage appeared. Some adults might survive light fall fires as they often rest several meters up on pine trunks or branches, at least in NJ. They would probably then leave to find suitable places to oviposit.

Xestia elimata

Foodplants: hard pines, apparently exclusively pitch pine north of New Jersey. All stages eat mature pine needles. Spring larvae do not use new growth even if it is present. Last instars will occasionally feed on Ericaceous buds at least in New Jersey. Ascending larvae in the evening often stop to feed on sugar baits.

Phenology: Well documented (Schweitzer) for southern New Jersey and somewhat so in the Cape Cod area, but could be different in the very cold Ossipee region. In New Jersey adults appear at the end of August and commonly persist into mid October. Eggs hatch in early fall and the larvae feed on pine needles. Older larvae (at least last two instars) leave the trees and spend the day in the litter, ascending the trunks again at dusk. In New Jersey growth and feeding continue as weather permits and in warm falls many larvae mature by early December. Presumably farther south nearly all larvae mature in winter, although adults occur progressively later. If they do not mature in late fall, New Jersey larvae apparently spend the winter in the litter and they are occasionally found ascending pine trunks on warm nights in February and March. Most years many larvae are still present in spring and mature by the end of April, rarely later. Regardless of time of year, mature larvae dig several cm into the soil where they make a cocoon which they normally do not leave until they eclose as a moth. In about May they change to an obviously prepupal state but do not pupate until about the end of July. Based on this and the much earlier flight season for adults in New Hampshire larvae obviously appear by late August and feed in the fall. Probably few or none mature before winter. A best guess would be most mature in mid May as at Plymouth Massachusetts. A further complication may be that Chris Maier reports that some northern larvae remain green with white stripes in all instars instead of turning into typical dark brown climbing cutworms. This green form is common in the related *X. badicollis* and *X. praevia.* It is unknown whether the green forms stay up in the foliage like early instar larvae or go to ground after feeding. If they remain in the foliage they may well feed day and night and therefore commonly mature in fall.

Fire exposure. Mature larvae and pupae in their underground cocoons should survive well in almost any fire during June and most of July. Survival is surely minimal in fall crown fires and adults (in the litter) would mostly perish in any late summer fires. Eggs and larvae in late summer and fall should have good survival in ground or brush fires. In spring survival might be good at night when larvae are in the trees feeding (assuming the bright flames do not trigger a drop and hide response) but could be quite high for larvae resting in dry litter in the daytime.

Appendix 2. Other selected species for additional comments with a suggested NH SRANK

Arctiidae

Apantesis carlotta. SU for now. This species was unnamed when I lived in new England and the unnamed *Apantesis* I did know at that time is apparently not carlotta and remains unnamed. The single specimen seems quite typical. This is a widespread species partial to a variety of grasslands such as hayfields, prairies even rough lawns. It is not a wetland species nor especially a barrens species. I have no idea what its actual status in new England is except that I have a few specimens from ordinary places in CT and MA. I probably saw many others but did not collect them.

Grammia speciosa. S2S4. Bog species. While there has been no careful revision documenting that this is a separate species from *G. virguncula*, there is also no question whatsoever that it is. *G. speciosa* in the USA other than Alaska is a bog species, perhaps also fens. In NH it probably is in nearly every bog. I even collected it in the 1980s at a tiny bog (<1 ha) near Hudson. It is rare in MA and CT where it reaches its apparent southern limit. While I have often seen both species from the same county, Mustopha on July 11 is the first sample I have ever known of to contain both species. There was of course nothing intermediate about any of them. Larvae have been reared (usually on dandelion as usual for the group) but little is known about the ecology. Larvae mid summer to late spring.

Geometridae

Itame argillacearia. S3S4. This is found with low bush blueberries. Typical habitats include barrens and right of ways and other heath opening. The status of this species in NH needs investigation but I suspect it is fairly common. Life history is known. Eggs overwinter probably loose in the litter under the blueberries but maybe on them. Larvae occur in spring and with adults in mid June in ME and NH pupation must be about June 1. Unless perhaps pupae no stage is below the soil surface.

Metarranthis sp.1 Unranked. A coastal mainly bog species from Nova Scotia to the New Jersey Pine barrens occurring inland to Vermont in the north. This is most of *Metarranthis lateritiaria* of Forbes (1948) and most prior authors. Little is known about its foodplants but undoubtedly include Ericaceae and Myrica. All *Metarranthis* overwinter as pupae in the litter or soil. Larvae are slow growing, probably mature in September. The August 1 collection date here is probably the latest for the species anywhere in its range. June or early July is more normal.

Semiothisa bicolorata, transitaria, granitata. In most of New England these three are basically pitch pine feeders, although only *S. granitata* obligately so. They seldom or never use white pine or other conifers. All are probably in virtually every decent stand of pitch pine in the region but could arguably be reduced to S3 status by massive habitat obliteration in NH, although they should survive well in wooded residential lots. Life histories are well known to the south and for two in Canada. There are one or two broods locally more or less from June to August. Pupae overwinter in the soil, probably occasionally twice. The egg stage is brief so larvae appear well before the end of the adult season. Larva probably persist into October.

Noctuidae

Abagrotis brunneipennis. S4? While many of us have known for decades this was a good species and Grote properly named it as one in the 1800s, for most of the 20th century the species this was erroneuously lumped with *A. cupida*. I have reared *A. brunneipennis* from ME and NJ and collected wild larvae in NJ. I agree with LaFontaine (1998) that lowbush blueberry is the primary foodplant. Adults occur July-September in most places. Eggs are laid in September and hatch in fall. Larvae feed on newly fallen leaves, in NJ throughout the winter when it is not cold. In spring they switch to new growth and buds and in NH are probably mature in late May or June. Except for the pupal stage which is in the soil for about a month, all stages are in the litter.

Cerastis (Metalepsis) fishii S2S4. Should be in most larger blueberry stands and in some bogs and pine barrens remnants. Larvae on lowbush blueberry and perhaps other heaths. Adults in April-early May with adults probably mature sometime in June. Most of year probably spent as pupae in the soil.

Drasteria occulta. SU. I really do not know what the status of this is in NH. I used to be a minor pest in Maine blueberry barrens. It is generally found in barrens, but I have collected it in a powerline corridor north of Boston. Pupae overwinter in the litter. Adults mainly in June, larvae soon after.

Euagrotis forbesi. S2S4. A poorly known genus biologically and nearly unknown species. I suspect but do not know that the larvae are grass feeders. Adults everywhere with one brood in June and July. Larva probably July to June. a species of dry sandy northern places, occasionally on acid rocky openings.

Eueretagrotis attenta. S3S4. Largely a species of northern barrens and some bogs but also occurs in other open heath habitats. David Wagner has determined that blueberry is the usual hostplant. This is somewhat a guess but probably larvae start on summer blueberry leaves, probably using fallen leaves in fall and then switch to buds or new growth in spring. It is unlikely the larvae feed exclusively on blueberry. Adults here in July suggest larvae August to June.

Hypenodes sombrus. SU. An uncommon boreal presumably wetland species. Nothing is known of the biology of the genus and members of this subfamiliy often are detritivores or fungivores.

Hemipacnobia monochromatea. S3S4. A bog species in a very loose sense. Likely anyplace with a lot of Drosera and Ericaceae, including virtually all bogs. Early instar larvae feed on sundews in summer but can eat Ericaceae. It is believed older larvae increasingly utilize these bog heaths. It is possible cranberries are preferred. Larvae summer to about end of May.

Hyperstrotia villificans. S3S4. All identifiable specimens of this genus are this one. I assume all others are too. In NJ I find the larvae often on post, scrub, and other oaks. In NH there is probably only one brood in July. That would imply larvae through August. Pupae overwinter in the soil or humus.

Xestia youngii. S3S5. At this latitude this species is all but inseparable from *X. dilucida* if indeed both occur. *X. youngii* is basically a bog and shrub swamp species north of New Jersey, but in northern New England it apparently also occurs in pine barrens. Adults in September mostly, larvae September to June starting on freshly fallen leaves or probably also still living leaves of bog heaths. In spring switches to new growth and buds. Spends summer as prepupa and pupae underground.

Appendix 3 Tentative Identifications of moths collected April 17, 2002 at Ossipee Pine Barrens

These are the tentative identifications supplied by TNC to me at the time for the 17 April 2002 samples. The fate of the specimens is unknown to me. I am not certain who wrote this (Doug Bechtel?).

These are my best guesses so far:

1. Mustard Sallow Pyreferra hesperidago
2. Dot and Dashed Swordgrass Moth Xylena Curvimacula
3. Gray Quaker Orthosia alurina(x2)
4. Zale squamularis Gray-banded Zale (x3)
5. Jocose Sallow Feralia jocosa (x2)
6. Zale metatoides Washed-out Zale (x2)
7. Cladara limitaria Mottled Gray Carpet (x3)
8. unk. inchworm moth A probably semiothisa sp.
9. unk. inchworm moth B probably sicya macularia, but ruffed up sample and too early.
10. 7 unk. micros

My response was as follows:

To: dbechtel@tnc.org; Dale Schweitzer
Cc: Parker Schuerman; Jeff Lougee; Kristen A. Puryear;
tsimmons@greennet.net; maroberts@acadia.net
Subject: Ossippee West's moths: 17 April 02

First do not bother with common names for moths. they are of no communication value. I do not know them and the author of the Field guide also admits he does not. Pyreferra hesperidago, Xylena Curvimacula, Cladara, all would be expected. X. thoracica is smaller and mottled gray too rare to make the FG. Feralia jocosa very unlikely in habitat you probably got uncommon green form of F. major. Zale squamularis does not occur in New England you got Zale duplicata, Z. submediana or both. Zale metatoides way too early (even down here). Orthosia would be more likely hibisci. I am not sure if alurina is in NH or not.

I was expecting Lycia rachelae and am surprised you did not get it. Perhaps it was too hot. Doubt it--seems odd. Was taken in MA and PA about the same time….. Dale

Appendix 4, Summary of information selected rarer Lepidoptera (including S1 to S3 species) from the Ossipee pine barrens[1].

See appendix D of the main report

Appendix 5. List of collection sites, sample dates, methods etc.

See appendix C of the main report

Appendix 6. Final list of collection data for all species collected May-September 2002 in the Ossipee Pine Barrens, NH.

See appendix C of the main report

Appendix G: Behavioral mapping protocol for 2002 Ossipee bird mapping project: Pine Barrens Bird Study Brown Thrashers and Eastern Towhees Protocol for the 2002 Field Season

Pine Barrens Bird Study

Brown Thrashers and Eastern Towhees

Protocol For 2002Field Season

Carol R. Foss

Audubon Society of New Hampshire

22 May 2002

CHECKLIST OF FIELD EQUIPMENT

binoculars
metal clipboard with
    field notebook
    site maps
    instruction packet
pencils
watch
compass
thermometer
whistle
black marker

water bottle
snacks
rain gear
extra clothes
sunscreen
insect repellent
moleskin
Swiss Army knife or Leatherman tool
headnet
bandanas
First aid kit

INSTRUCTIONS FOR BEHAVIOR MAPPING

PRE-SURVEY PREPARATION

Before leaving for a survey, make sure you have a map for the site you will be surveying. Write the date and your initials in the margin.

FIELD IMPLEMENTATION

Cover each site once a week. To minimize time bias, alternate the direction in which sites are run and transects covered on successive visits. (I.e., on the first survey, cover the "50 lines," starting at the 50 end and going up, and on the second survey cover the "100 lines," starting at the 400 end and working down.

Traverse forest patches on flagged lines, using a compass to navigate between marked points. Move quietly with moderate speed, as conditions allow. A minimum of 45 minutes per 400m is recommended for thorough coverage. Confirm your location at each 50m grid point. Pause there briefly (1-2 minutes) to listen for new detections, especially if it has been impossible to move quietly between points. Another advantage to mapping from these points is that you know precisely where you are. However, you should record new detection between points immediately, as the bird may stop singing or move by the time you reach the next grid point.

Use an "X" for detections at known locations (i.e., within a given 50m cell) and a "." for those of uncertain location. You may be able to map an uncertain location more precisely when you get closer to the bird.

Pay special attention to simultaneous detections of a given species, particularly singing males. Even if the location of one or both individuals is a bit vague, such records document that two birds are present, and the general areas in which they occur. This information is crucial for accurate map analysis. Watch especially for females in the vicinity of singing males, adults carrying food, agitated adults, family groups, and lone fledglings.

Carefully record movements of individuals within their home ranges, particularly movements between grid cells. This information is crucial for delineating home ranges during map analysis.

Closely observe interactions between individuals to determine their sex. An aggressive chase (between 2 males of the same or different species) qualifies only as an established territory, while a courtship chase documents the presence of a pair.

While you are not making a special effort to look for nests, you are likely to discover some serendipitously. Avoid disturbance to nesting birds and leave the area quietly. Note location, height above ground, and any other distinguishing features.

When you detect begging calls: record the time and pinpoint the location. Move quickly and quietly towards the sound, then stop and sit quietly when you think you are reasonably close. At least initially, you should make visual contact with all fledglings and family groups to verify your identification and gain experience with their behavior. If fledglings stop vocalizing as you approach, sit or stand quietly when you think you are nearby and wait for vocalizing to begin again, scrutinizing the area carefully for adults and fledglings.

Some adults may call frequently while foraging to feed fledglings, and a male may sing while the female and fledglings forage nearby. Once the fledging season starts, it is important to look beyond what would have been a simple "sing" or "call" record earlier in the season. (Unfortunately, I don't have experience with post-fledging behavior of these species, so I can't offer any hints. I think Diane had towhees, so she could provide some useful insights.)

Any observations you make regarding fledgling behavior or vocalizations, or other clues to their detection and identification (e.g., behavior of adults accompanying fledglings) will be a tremendous help to others using this technique in the future. Please take time to jot notes for later incorporation into the fledgling manual.

As you gain experience, visual contact with fledglings or families may not be essential. These two species are likely to be quite distinctive and distinguishable from others on your sites after a little practice.

When begging calls are detected from several directions at once, it can be difficult to decide which to follow up on, and any decision you make runs the risk of failure to make visual contact with your first choice and subsequent silence of the other(s). [This likely will be less of an issue for you, since you are focusing on two species.]

To help in making decisions, bear the following factors in mind:

> A home range for which fledglings are not yet documented should take priority over a home range with previously documented fledglings.
>
> The closer a fledgling is, the better chance you have of making a visual detection, although the terrain and vegetation between you and the bird can change the odds!

RECORDING BEHAVIOR-MAPPING DATA IN THE FIELD

General guidelines

Use the alpha codes provided for species (in capital letters) to record all observations (e.g., BRTH, EATO).

Number all observations consecutively (e.g. 1BRTH, 2EATO, 3BRTH) on a given survey.

Recording data on maps:

Use an "x" to mark observations of known location (i.e., known to be in a given 50m cell).

Use a "." to mark observations of uncertain location. This symbol should be used when you know the general vicinity of the individual but not the specific 50m cell. [We use these a lot for things like pileated woodpeckers calling from "somewhere on the other end of the site" and the like. I expect that you will be able to "x" most of your detections, although the "." may come in handy for simultaneous singers.

NOTE: Especially at the beginning of the season when your distance estimation is still rusty, you will find yourself needing to change mapped locations when you get more accurate fixes on a bird. Don't let this bother you - this is one of the reasons we map in pencil! Some songs carry for surprising distances.

Use an encircled x to mark nest locations.

Record movement of an individual with a solid line between beginning and ending points or from beginning point with arrow in direction of movement when the end point is unknown.

Record simultaneous observations of multiple individuals in the notebook with a "does not equal" sign. When creating species maps, connect the simultaneous detections with a dashed line.

Record observation of members of the same pair with a wavy line connecting the two individuals.

Record family groups in a concentrated area with a dotted circle or oval indicating the area within which they are foraging. If the group moves off, indicate the direction with an arrow, and any new locations of the group with additional circles or ovals connected by arrows.

Record observations of scattered multiple fledglings with a dotted line.

Recording data in the notebook:

Record site, date, start time, weather at start (see below), end time, weather at end.

Record each 50m point and your time of arrival as you pass at the point.

Birds
For all bird observations, record the following:

- time of observation
- species code and observation number
- sex (m, f, p, b, u) and age (ad, fl, mx, un) of individual
  - (see age categories for fledglings)
- behavior code(s) (see below)
- whether Seen, Heard, or Both (it's easiest to assume Heard unless otherwise noted)
- any pertinent comments

Nests
Record location, including approximate height above ground, fork or side branch, tree/shrub species, tree condition (dead or alive), etc.

Fledglings
To the extent practical, record number of fledglings in group, sex of accompanying adult, unique plumage features, any notes on behavior.

Native Mammals
[You may or may not wish to include this]
For chipmunks and red and gray squirrels, record time of observation, species code, observation number, and number of individuals.

Weather data

Temperature
Wind (none, light, moderate, strong)
Sky (clear, partly cloudy, mostly cloudy, overcast, fog)
Precipitation (none, mist, showers, light rain, moderate rain, sleet, flurries)

Sex categories
f female
m male
p pair
b both (family groups)
u unknown

Age categories
ad adult
fl fledgling (or, if possible, use
rf recent fledgling (down present, barely flying)
or older fledgling (no down, flies well)
mx mixed (family groups)
un unknown

Fledgling characteristics
[you may or may not want to get into this level of detail, but the info could be really helpful in for figuring out how synchronized pairs are, if pairs are double brooding, etc.]

bp begging posture
cl clumsy landing
dp down present
eg expanded gape
fw flying well
nf not capable of sustained flight
st stubby tailed

Behavior codes

agch	aggressive chase (interspecific or intraspecific)
agit	agitated
atfl	attending fledgling
cafe	carrying fecal sac(s)
cafo	carrying food
call	calling
canm	carrying nesting material
coch	courtship chase
cofe	courtship feeding
copu	copulation
cshp	(other) courtship activity
dist	distraction display
famg	family group
fefl	feeding fledgling
fled	unaccompanied fledgling
fora	foraging
movi	moving (in or below canopy)
nebu	nest building
neeg	nest with eggs
neyg	nest with young
onne	on nest
pequ	perched quietly
secr	secretive female
sing	singing
soli	soliciting (female)
unch	unknown chase
vins	visiting nest site (cavity or other hidden site)
vofl	(characteristic) fledgling vocalizations

POST-SURVEY DATA MANAGEMENT

Generating species maps from field maps

Create separate map sheets for each focus species at each site.

When transferring data from the field map to the species map, include both the observation number and the date, and replace the species code with the behavior code. Be sure to transfer locations accurately.

As on the field maps, use "x" for known locations, "." for uncertain locations, and circled x for nest sites; indicate simultaneous observations with broken lines, movement of individuals with solid lines, members of a pair with a wavy line, scattered fledglings with dotted lines, and family groups with ovals.

SPECIES CODES

ABDU	American Black Duck
AMCR	American Crow
AMGO	American Goldfinch
AMRE	American Redstart
AMRO	American Robin
AMWO	American Woodcock
BAOR	Baltimore Oriole
BANS	Bank Swallow
BAOW	Barred Owl
BEKI	Belted Kingfisher
BAWW	Black-and-White Warbler
BBCU	Black-billed Cuckoo
BCCH	Black-capped Chickadee
BTBW	Black-throated Blue Warbler
BTNW	Black-throated Green Warbler
BGGN	Blue-gray Gnatcatcher
BLJA	Blue Jay
BRCR	Brown Creeper
BHCO	Brown-headed Cowbird
BRTH	Brown Thrasher
BWHA	Broad-winged Hawk
CAWA	Canada Warbler
CEDW	Cedar Waxwing
CSWA	Chestnut-sided Warbler
CHSW	Chimney Swift
CHSP	Chipping Sparrow
COGR	Common Grackle
COME	Common Merganser
CORA	Common Raven
COYE	Common Yellowthroat
COHA	Cooper's Hawk
DOWO	Downy Woodpecker
ESOW	Eastern Screech Owl
EAKI	Eastern Kingbird
EAPH	Eastern Phoebe
EAWP	Eastern Wood-Pewee
EUST	European Starling
FICR	Fish Crow
GRCA	Gray Catbird
GBHE	Great Blue Heron
GCFL	Great Crested Flycatcher
GHOW	Great Horned Owl

GRHE	Green Heron
HAWO	Hairy Woodpecker
HETH	Hermit Thrush
HOFI	House Finch
HOME	Hooded Merganser
HOSP	House Sparrow
HOWR	House Wren
LEFL	Least Flycatcher
LOWA	Louisiana Waterthrush
MALL	Mallard
MODO	Mourning Dove
MOWA	Mourning Warbler
NAWA	Nashville Warbler
NOCA	Northern Cardinal
NOFL	Northern Flicker
NOGO	Northern Goshawk
NOMO	Northern Mockingbird
NOPA	Northern Parula
NSWO	Northern Saw-whet Owl
NRSW	N. Rough-winged Swallow
NOWA	Northern Waterthrush
OVEN	Ovenbird
PIWA	Pine Warbler
PIWO	Pileated Woodpecker
RBNU	Red-breasted Nuthatch
RBWO	Red-bellied Woodpecker
REVI	Red-eyed Vireo
RHWO	Red-headed Woodpecker
RODO	Rock Dove
RSHA	Red-shouldered Hawk
RTHA	Red-tailed Hawk
RWBL	Red-winged Blackbird
RBGR	Rose-breasted Grosbeak
RTHU	Ruby-throated Hummingbird
RUGR	Ruffed Grouse
SCTA	Scarlet Tanager
SOVI	Solitary Vireo
SOSP	Song Sparrow
SPSA	Spotted Sandpiper
SSHA	Sharp-shinned Hawk

TRES	Tree Swallow
TUTI	Tufted Titmouse
VEER	Veery
WAVI	Warbling Vireo
WBNU	White-breasted Nuthatch
WTSP	White-throated Sparrow
WIWR	Winter Wren
WITU	Wild Turkey
WODU	Wood Duck
WOTH	Wood Thrush
YBCU	Yellow-bellied Cuckoo
YBSA	Yellow-bellied Sapsucker
YTVI	Yellow-throated Vireo
YWAR	Yellow Warbler

MAMMAL CODES

GRSQ	Gray squirrel
RESQ	Red squirrel
CHIP	Eastern chipmunk

Appendix H Codes for 2002 Ossipee Bird Behavioral Mapping Survey

record in data book

site	time of observation
date	observation # & species code
start time	sex (m, f, p, b, u)
weather @ start	age (ad, fl, mx,un)
end time	behavior code(s)
weather @ end	seen or heard
	additional comments

Weather (record in data book and on maps)

Temp: Wind: none, light, moderate, strong
Sky: clear, partly cloudy, mostly cloudy, overcast, fog
Precipitation: none, mist, shower, light rain, moderate rain, flurries

Sex categories

f female
m male
p pair
b both (family group)
u unknown

Age categories

ad adult
fl fledgling or
rf recent fledgling—down present, barely flying,
of older fledgling, flies well)
mx mixed (family groups)
un unknown

Fledgling Characteristic

bp begging posture
cl clumsy landing
dp down present
eg expanded gape
fw flying well
st stubby tailed
nf not capable of sustained flight

Birds

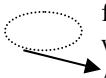
BRTH Brown Thrasher
BRCO Brown-Headed Cowbird
CONI Common Nighthawk
EATO Eastern Towhee
WHIP Whip-poor-will

Behavior Codes

agch aggressive chase (inter/intraspecific)
agit agitated
atfl attending fledgling
café carrying fecal sac
cafo carrying food
call calling
canm carrying nesting material
coch courtship chase
cofe courtship feeding
copu copulation
cshp other courtship activity
dist distraction display
famg family group
fefl feeding fledgling
fled unaccompanied fledgling
fora foraging
movi moving (in or below canopy)
nebu nest building
neeg nest w/ eggs
neyg nest w/ young
onne on nest
pequ perched quietly
secr secretive female
sing singing
unch unknown chase
vins visiting nest site
vofl fledging vocalizations

Map Notes (include observation #)

X observation of known location
• observation of unknown location
(X) nest site
X——X movement of individual
X——> movement of individual (endpoint unknown)
3≠4 simultaneous observation of #3 & 4
X~~X pair (Wavy line)



family group faraging w/in this area.
Arrow indicates direction of travel

…..…scattered multiple fledgling

Appendix I: Population Viability Analysis for the eastern towhee

The eastern towhee had the largest population of all Target Species (brown thrasher, common nighthawk and whip-poor-will) at the Ossipee Pine Barrens. A large population, however, does not necessarily mean that the population is growing, or even stable. To determine the population trajectory of the eastern towhee at the Ossipee Pine Barrens I conducted a population viability analysis using data from the 2002 survey (Table 1).

Table 1: Eastern towhee (*Pipilo erythrophthalmus*) territories, on three study plots, Ossipee Pine Barrens, Carroll County, NH 2002.

	Forest	Mixed	Thicket	Territory Rank	Forest	Mixed	Thicket
Plot Size (ha)	19	20	16		19	20	16
Successful Fledging (SUFL)	1	1	2	4	4	4	8
total number of fledglings detected	2	3	5				
Nesting Attempt (NEAT)	0	1	0	3	0	3	0
Pair (PAIR)	1	2	3	2	2	4	6
Partial Pair (PTPR)	0	2	0	1	0	2	0
Established Home Range (ESHR)	0	0	3	1	0	0	3
Partial Home Range (PTHR)	0	1	0	0.5	0	0.5	0
cumulative rank points					6	13.5	17

For local recruitment to sustain a population it must compensate for adult and juvenile mortality. Where this occurs, a population remains stable and could be a source of emigrants to other areas. When recruitment does not meet or exceed adult and juvenile mortality, and the system is closed to immigration, the population will decrease (a population sink) (Soulé 1987). To test whether the eastern towhee population at Ossipee is a source or sink I employed a two-stage population projection model (Ricklefs 1973):

$$N_{A(t+1)}=(N_{At} \times S_{At})+N_{At} \times F_t \times S_{Jt})$$

$\mathbf{N_A}$= number of breeding females, estimated to be 0.58 (Greenlaw 1996).

t= year of simulation

$\mathbf{N_{At}}$= number of adult breeding females in year t

$\mathbf{S_{At}}$= survival of breeding female adults from year t to t+1

$\mathbf{S_{Jt}}$= survival of juvenile offspring year t to breeding in year t+1. I used 0.29, 50% of adult survival, as no information on juvenile, age or sex-specific survivorship was found in the literature for towhees.
Broods were considered 50% male and 50% female.

$\mathbf{F_t}$= number of female fledglings per adult in year t, or 50% of observed fledglings. Because Wells (2003) found that behavior mapping of towhees detected only 50% of total fledgling, I then doubled the number calculated number of female fledglings to get F_t.

This analysis indicates that local recruitment was only 84.4% of adult and fledgling mortality in 2002 (Figure 1), and that local towhee recruitment does not make up for adult and juvenile mortality. If this analysis is accurate then Ossipee is currently a towhee sink and immigrants from elsewhere maintain the current population.

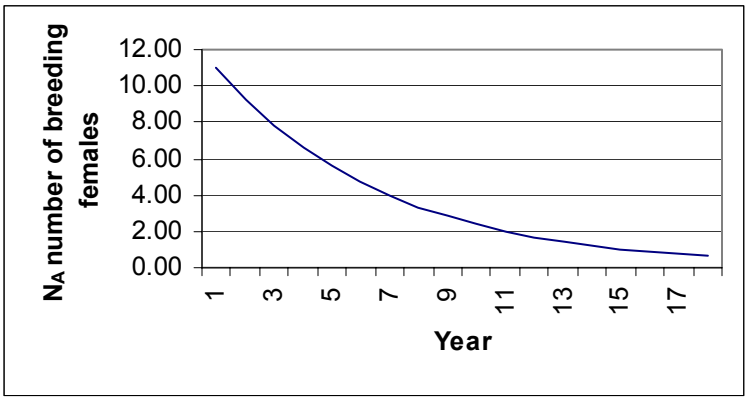


Figure 1: Expected population of breeding female eastern towhee in three study plots at the Ossipee Pine Barrens without immigration.

It is possible that immigrants have historically maintained the Ossipee population. Ossipee is near the northern limit of the towhee range. Furthermore a study of similar habitat in southeast New Hampshire, heath-shrub powerline right-of-ways, were identified as sink habitat for towhees—though source habitat for prairie warblers (Wells 2003) Decreases in avian fecundity have also been documented as populations of other species reach their northern limits (Vickery et. al. 1997).

Though this does not bode well for the Ossipee towhee population, there are a number of confounding factors that may have lead to a single-year decrease in fecundity or to an undercount of the towhee population in general and fledglings in specific. These factors include: a late start to surveying in 2002, working with a limited amount of data, the possible failure of the first brood due to anomalous weather conditions, difficulties detecting towhee adults and fledglings and difficulties estimating brood size. See Study Limitations in the Methods section of the main report for a broader discussion.

One or all of these factors could be sufficient to reverse the projected towhee population trend from falling to rising, or at least to a maintenance level. If these confounding factors mean that survival rate of breeding females (S_{At}) was at least 16% greater than estimated (0.74 instead of

0.58), or if fledgling survival (S_J) was 60% greater than observed (16 fledglings in 2002 instead of 10), then the population would be at a maintenance level (Figure 2).

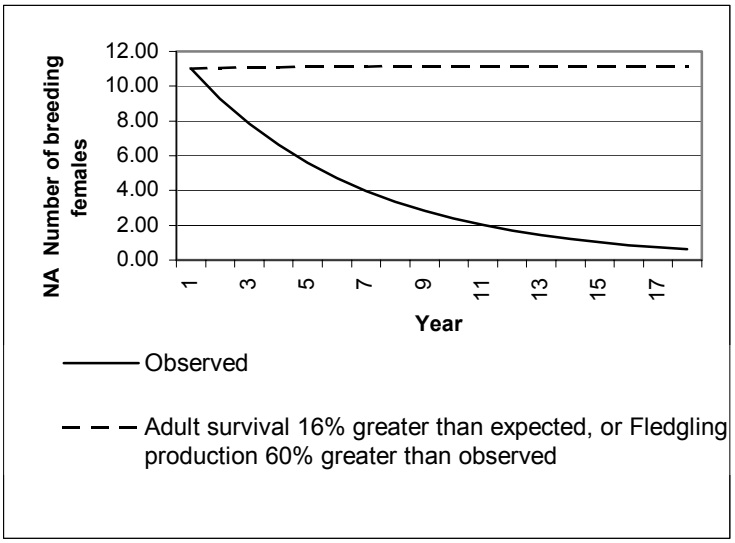


Figure 2: Expected population of breeding female eastern towhee in three study plots at the Ossipee Pine Barrens compared with expected populations with either a greater breeding females survival rate or greater fledgling production.

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Appendix J: Descriptions of Ossipee's Avian Target Species

Eastern Towhee (*Pipilo erythrophthalmus*) G5/S2

Except where noted, information in this section comes from the extensive literature review of this species compiled by Greenlaw (1996).

Greenlaw, J.S. 1996. Eastern Towhee (*Pipilo erythrophthalmus*). In The Birds of North America, No 262. Poole, F and Gill, F.B. editors. The Birds of North America, Inc., Philadelphia, PA.

An eye-catching member of the sparrow family, the eastern towhee (formerly the rufous-sided towhee) is often found on the ground in dense scrubby habitat near forest edges. Not a shy species, male towhees regularly perch conspicuously in tall trees in their territory and sing for minutes at a time using their distinctive "drink-your-teeeeee" song. Unfortunately little is known about the ecological, behavioral and demographic factors affecting towhees.

Towhee populations, particularly in the Northeastern US have dropped dramatically in the past century, primarily due to loss of habitat from reforestation and human development. Their highest breeding densities are in Northeastern pine barrens.

Appearance: Sexually dimorphic, with the males' dark above with rufous underside. Females are duller both above and below. See any standard bird guide for specific and images.

Distribution: Breeds from the Canada border south to Florida and Texas (Sauer 2001). Winters in the southern US—it is not considered a neo-tropical migrant.

Habitat: Alternately considered an edge generalist (Morrimoto and Wasserman 1991) and a forest generalist (Hagan 1993). Prefers shrubby, early to mid-successional habitat with and open overstory but also found in patchy later succession forests, but not interior forests. Pine woodlands, pitch pine-scrub-oak barrens, xeric hardwood forests are all satisfactory for the towhee.

Little is known about the ecological, behavioral and demographic factors controlling within habitat density. Furthermore, differences in population density among habitats may be a poor indicator of differences in habitat quality and territory densities for a single population has varied by more than 300% in different years.

Food selection and feeding habits: An omnivorous species its diet includes seeds, fruit and invertebrates. Primary invertebrates include beetles, Lepidoptera (adults and larvae), ants, bees, grasshoppers, bugs and spiders. During the breeding season diet is principally invertebrates. In a New Jersey pine barrens beetles, Lepidoptera and ants were the key dietary taxa. Towhees feed primarily on the ground by uncovering food as it hops backward dragging its feet to move litter. They will also glean insects in above-ground foliage especially when caterpillar density increases. In the late summer and fall, blueberries and blackberries, acorns and may other fruits and seeds become important food resources.

Water: It is not known what Towhee requirements are for water or the distance they will travel to a water source.

Sounds: The primary song, "drink-your-teeeeee" can be heard for more than 100 m and is often sung by males in the breeding season from high in treetops. Towhees have several other calls including the frequent "tow-hee!," or "Chewink" used by both adults and juveniles of both sexes. Additional calls include a "tic" and a "seeee-call" as well as growls, whinnies, and screams. Fledglings use an almost constant, bubbling "chip" for a location call when waiting for food or moving through the scrub with an adult.

At Ossipee, adults were most vocal, and active in the early mornings from approximately 5am-9am after which they quieted down. Late in the afternoon activity picked up but at most it seems to be 40% or less of the morning hustle and bustle.

Behavior: At Ossipee, males were brash and showy. They routinely chose one or more high points within their territory from which to belt out their songs from, as well as their "tow-hee" call. Territorial males also regularly took extra-territory trips as much as 300 m out of their territories before returning.

Females were conspicuous until late May after which they became much scarcer. One female spotted on a nest did distraction display consisting of a rapid walk with wings somewhat spread and low to the ground. The male was just a 2-3 meters away in the shrubs scolding as best he could.

Demographics/Nesting and Fledgling care: Towhee survival is generally 1-4 years with one wild adult known to have lived for 12 years. They are capable of breeding by their second year.

At Ossipee in 2002, courtship and nesting began in mid-late May. Females became scarce by late-May. It is assumed that they were on nests. The first fledglings were not seen till early July. This seems too long an incubation and nestling period. Incubation averages 12 days and nestlings leave generally leave the nest 10-11 days afterwards.

Females build nests with little assistance from the males. Early season nest are usually on the ground. Later season nesters are more frequently found in thick shrubs. Nest sites are probably chosen for secrecy. Early in the season, if leaf-out isn't complete (as was the case at Ossipee) the lowbush blueberry and litter provides a substantial degree more cover. After leaf-out above ground nests are likely preferred in order to escape ground-based predators such as cats, rodents and snakes.

Multiple broods have been documented in the central and southern parts of the towhee's range. Double brooding was not seen at Ossipee. Records of double brooding in New Hampshire are high speculative (Wells 2003). It does seem that towhees will initiate a second clutch if the first fails.

Adults practice brood splitting with fledglings. Each adult will take half of the fledglings on foraging trips. If a second brood does occur, the male supposedly raises the first brood and the female the second.

Predators and brood parasites: Cats (a problem in the Mixed study plot), rodents (including chipmunks), snakes, weasels, blue jays and crows will all taken eggs, nestling and fledglings whenever they can get them. Birds of prey, including shrikes, will take adults when possible.

Towhee nests are commonly parasitized by brown-headed cowbirds. The degree of parasitism ranges from 4.9% in Massachusetts to 54.2% in Pennsylvania. There are no records for Northern New England. Though present at Ossipee, cowbirds were not seen parasitizing towhee nests.

Brown Thrasher (*Toxostoma rufum*) No rank

Except where noted, information in this section comes from the extensive literature review of this species compiled by (Cavitt and Haas 2000).

Often found foraging on the ground in dense scrubby habitat near forest edges and hedgerows the brown thrasher's long-bill, streaked breast and extended song are key identifiers. Despite its distribution, little is known about the ecological, behavioral and demographic factors affecting this species.

Appearance: The brown thrasher also sports a reddish-brown back, streaked breast and a long, slightly decurved bill. See any standard bird guide for specifics and images.

Distribution: The only thrasher east of the Rocky Mountains the brown thrasher breeds from the just north of the Canada border south to Texas and Florida (Sauer 2001). Winters in the southern US—it is not considered a neo-tropical migrant. Some will overwinter locally throughout their range.

Habitat: Alternately considered a grassland-shrub species (Vickery 1997) and a forest generalist (Cavitt and Haas 2000). Found in prairie and shrubby, early to mid-successional habitat with and open overstory but also found in patchy later succession forests, but not interior forests. Mid-successional pine woodlands, pitch pine-scrub-oak barrens, xeric hardwood forests are all satisfactory for the towhee (Cade 1986).

Food selection and feeding habits: An omnivorous species, its diet is primarily insects (beetles) and other invertebrates including Lepidoptera larvae during the breeding season. Later into summer seeds and fruit (blueberries) take on greater importance.

Thrashers feed almost exclusively in the leaf litter using their long bills to move litter to uncover food. They will also glean insects in above-ground foliage especially when caterpillar density increases. In the late summer and fall, blueberries and blackberries, acorns and may other fruits and seeds become important food resources.

Water: Though they've been observed drinking dew from vegetation, it is not known what thrasher requirements are for water or far they will travel to a water source.

Sounds: Thrashers have one of the largest repertoires of any North American bird with greater than 1,100 song types identified. Similar to Charlie Parker, they continually improvise on their primary song. Though related to the mockingbird it does not mimic other birds and whereas the mockingbird generally repeats phrases three times, the brown thrasher repeats phrases twice when singing. The primary song: "bury it, bury it, cover it up, cover it up, pull it up, pull it up" was heard by Ossipee males both high tree tops and in lower shrubs.

At Ossipee, adults were most vocal, and active early in the breeding season in the early mornings from approximately 5am-8am after which they quieted down. They were not heard in the afternoons but this is most likely due to their scarcity and not inactivity. By mid-June males quieted down considerably and more were seen than heard after this time.

Behavior: After a showy and vocal courtship period in mid-May thrashers become quite spending most of their time on the ground in shrub thickets. Flights within a territory are generally short and low to the ground. They are intolerant of other thrashers in their territories but not other species.

Demographics/Nesting and Fledgling care: Average thrasher survival is four years. One wild adult lived for 12 years and two others for eight years. Thrashers are capable of breeding by their second year.

At Ossipee in 2002, courtship and nesting began in mid-late May and males became much quieter by early June. Both male and females build nests usually located in or at the base of dense, particularly, thorny shrubs (Cade 1986). In New England nesting is often on the ground whereas farther south nesting is above ground. This may be a result of the timing of leaf-out.

Incubation is approximately 12 days and both male and female share incubation duties and feed young after hatching. Nestlings leave the nest after approximately 12 days. Multiple broods have been observed in Tennessee but it has not been documented elsewhere.

Predators and brood parasites: Cats (a problem in the Mixed study plot), rodents and snakes are also common predators of thrasher nests. Adult thrashers actively harass would-be predators.

Brown thrashers are the largest birds parasitized by brown-headed cowbirds. The degree of parasitism ranges from 7.8% in Kansas to 12% in North Dakota. Adult thrashers will remove cowbird eggs from their nests. There are no records for Northern New England. Though present at Ossipee, cowbirds were not seen parasitizing towhee nests.

Common Nighthawk (*Chordeiles minor*) G5/S2B

Except where noted, information in this section comes from the extensive literature review of this species compiled by (Poulin et al. 1996*).*

A crepuscular, rather than a nocturnal, bird nighthawks are often seen early in the evening flying high over the trees and urban areas. They fly with a chimney swifts' odd flutter and male nighthawks make steep diving courtship displays accentuated by a booming sound from their

wings. Despite its distribution, little is known about the ecology and life-history of this species. Nighthawks and whip-poor-will are members of the order *Caprimulgiformes*, a term derived from a Greek word for "goat sucker," based on a superstition that these nocturnal birds take milk from goats.

Appearance: Blue jay-sized, nighthawks have a large head, big eyes and a huge mouth and long slender wings each marked with a single white wing bar on each primary that are visible in flight. At rest the nighthawk is cryptically camouflaged and blends in well with surrounding vegetation and bare ground.

Distribution: Breed virtually throughout North America from the Yukon to Labrador and south to Panama and into South America.

Habitat: Nests in bare, rocky ground, gravel rooftops, open sage, prairie and grasslands, sand dunes and disturbed forest sites. One of the later migrants to arrive on breeding grounds an one of the first to leave in the fall.

Food selection and feeding habits: Flying insects including Lepidoptera, Coleoptera, Hymenoptera and Diptera. Crepuscular, feeding primarily at dusk hawks insects in flight and rarely landing during its feeding period. Will hunt low over roads, fields and water or 80 m or more above tree tops. Hunts alone and in large groups.

Water: Drinks water in-flight by skimming over streams, pools and lakes.

Sounds: Males and females have a single call/song, a nasal "peent." Males also produce a courtship boom during diving displays as air rushes through primaries. Calls and booms usually occur just after sunset.

Behavior: Often seen flying high (>50 m) above fields, trees and urban areas. Booms are reserved for mating season; dives are primarily during mating season and are directed at competing males, females, fledged young and humans. Flight is graceful though reminiscent of chimney swifts and bats. Walking and hopping somewhat ungainly due to short legs and a body built for flight.

Demographics/Nesting and Fledgling care: At least four to five years with some nine-year old records from band recovery. Age at first breeding isn't known but is suspected breed yearly. Nighthawks have a single brood only in northern part of range, including New Hampshire.

At Ossipee in 2002, courtship and began in late May. Nighthawks do not build nests. Eggs are laid on gravel, wood chips, forest duff, sand and bare rock. Incubation is approximately 18 days usually by female but occasionally by the male. Young fledge at about 18 days and can feed and care for themselves at 25 days.

Predators and brood parasites: Cats (a problem in the Mixed study plot), dogs, skunks, foxes, kestrels, peregrine falcons. Brood parasitism by brown-headed cowbirds never reported and not suspected.

Whip-poor-will (*Caprimulgus vociferus*) G5/S3B

Except where noted, information in this section comes from the extensive literature review of this species compiled by (*The Nature Conservancy. 1999*)

A secretive and seldom seen nocturnal bird the whip-poor-will was often heard singing its repetitive eponymous "whip-poor-will, whip-poor-will" song just after dusk and before sun-up in the Ossipee Pine Barrens. As with all of Ossipee Target Species, the whip-poor-will is a poorly studied species and little information is available on its habitat use and requirements, status, and nesting success. Whips are members of the order *Caprimulgiformes*, a term derived from a Greek word for "goat sucker." Because they often fly around livestock at dusk feeding on insects swarming over the animals, on a superstition arose that they take milk from goats.

Appearance: Robin-sized and cryptically colored with mottled gray-brown above with a black throat, the whip-poor-will sits quietly during the day blending in with shrubby vegetation and leaf litter. Its surprisingly wide gape, when seen from close up, can scare the heck out of a surprised researcher. See any standard bird guide for specific and images.

Distribution: Breeds from North-central Saskatchewan east across southern Canada to Nova Scotia south to southeast US and as far south as Honduras west to California.

Habitat: Breeds in open coniferous and mixed woodlands with well spaced trees and a low canopy in much of the Eastern U.S. and montane woodlands in the southwest. Uncommon in mature forests, "whips" prefer even-aged successional habitats from regeneration to pole-stage stands. May need a relatively dense oak understory for nesting perhaps intermixed with more open habitat for foraging.

Food selection: Lepidoptera and other insects are primary food source.

Water: It is not known what the whip-poor-will's requirement is for water or the distance they will travel to a water source.

Sounds: At Ossipee Males sing a repetitive "whip-poor-will, whip-poor-will" song ad nauseam in the after nightfall and early in the mornings—nearing 5am. Reproduction: Other vocalizations are not know.

Behavior: Not nearly as active or gregarious as the common nighthawk, whip-poor-wills typically fly low to the ground and forage in open patches and along roads. Whips sally after prey from a perch rather than hawking as the common nighthawk does.

Demographics/Nesting and Fledgling care: Lifespan 9-10 years. Nests on ground in open site under trees or under bush, usually on a bed of dead leaves at woods edge or in open woodland. Eggs laid mostly May-June in north. Incubation is 17-20 days, by female (male possibly helps). Young tended mainly by female, male brings food. Young first fly at about 20 days.

Threats include loss of breeding and winter habitat loss.