**NAFSE Discovery Capacity Project- Summary Report**

**Research Archives: Ongoing Research: Current projects**

1. Unpublished Studies: (Archive)

Title: Ossipee Fuel Mapping Results and Recommended Fuel Models

Author: Michael Batcher, Ecologist and Environmental Planner

Abstract: This report summarizes the results of 1) data collected in 34 plots at Ossipee Pine Barrens in 2013 to describe vegetation and fuels, 2) interviews with several prescribed fire practitioners in the northeast and 3) recommendations on fuel models that could be used at Ossipee based on the above information.

Title: Analysis of Field Data for the Shawangunks Grassland and Forests Birds Habitat Study- Summary Report

Author: Michael Batcher, Ecologist and Environmental Planner

Abstract: In early 2008, The Nature Conservancy, in partnership with the Mohonk Preserve and the U.S. Fish and Wildlife Service, initiated a series of coordinated research projects to test the efficacy of several

management strategies to achieve specific goals for habitat management for both grassland and forest

nesting birds. The studies focused on several species listed as Species of Greatest Conservation Need

(SGCN) by the New York State Department of Environmental Conservation (Table 1).

Grassland treatment units were established at the Mohonk Preserve and at Shawangunks Grassland National Wildlife Refuge managed by the U.S. Fish and Wildlife Service. A forest treatment unit was established in the Mohonk Preserve to assess the effects of prescribed fire on bird habitat within the chestnut oak forest, the largest forest type in the northern Shawangunks and one of the largest examples of that community in New York.

In April of 2008, just before initiation of this study, there was a major wildfire in the Overlooks area in Minnewaska State Park Preserve which burned approximately 3,000 acres (1,250 ha) within the Park and some adjacent private lands. This was the largest fire in the Shawangunks since the 1947 wildfire that burned over 7,000 acres (3,000 ha). Given this opportunity, we established both vegetation and bird monitoring plots within the wildfire area and in some unburned areas nearby for comparison. The

locations of treatment units and of the wildfire are shown on Maps 1 and 2.

A series of reports including reviews of relevant literature, monitoring protocols and analyses of field data were completed for this study. Full citations are provided in the references sections and copies are available from The Nature Conservancy’s Shawangunk Ridge Program.

Title: Analysis of Field Data for the Shawangunks Grassland and Forests Birds Habitat Study – Grassland Management

Author: Michael Batcher, Ecologist and Environmental Planner

Abstract: We established plots and collected data at both the Mohonk Preserve and Shawangunk Grasslands National Wildlife Refuge (SGNWR) to compare management treatments for maintaining open fields at the Mohonk Preserve and grassland bird habitat at SGNWR. We chose a set of variables to measure including shrub cover, grass vs. forb cover, invasive species cover, height density, litter cover and litter depth.

The original, planned treatments included both mid-summer (July) and late summer (September) mow only and mow and burn treatments at SGNWR and the Mohonk Preserve. One field at the Mohonk Preserve was burned in the spring of 2009, but weather and other conditions prevented any other use of prescribed fire. Summer (July) mowing was completed in two of the SGNWR units and September mowing was completed in two of the Mohonk fields. The September mow at SGNWR did not occur. A spring mow was substituted and completed in one field at the Mohonk Preserve.

Total shrub abundance was generally reduced by all treatments. However, in many cases, short shrubs (< 0.5 m) remained stable or increased. Since these will enter taller height classes quickly, the effects of these treatments are temporary. One field that was burned in the spring was mowed in late summer, and the results indicated that multiple treatments in the same year can dramatically reduce shrub cover, which is an important goal both at the Preserve and SGNWR. Invasive species abundance

generally increased following all treatments.

Optimal grassland bird habitat includes grass as dominating vegetative cover (70%) with forb cover of 10-30%. Management resulted in mixed changes in grass and forb abundance with most treatments increasing forb abundance. Some treatments resulted in increases in grass in one field and decreases in another at the same site. Litter depth and cover remained relatively unchanged, except for a reduction following the spring burn and increases following mowing. As would be expected, height density decreased following treatments. Annual treatments will likely be needed to reduce height density to levels preferable to most grassland nesting birds.

Management objectives should be developed for each field with a prescription or set of protocols for achieving the desired status. Managing for grassland birds requires avoiding treatments during their breeding seasons which can run from April through July with possible second broods in August. However, individual fields or subareas can be treated in the spring provided sufficient area for breeding is left. To achieve management objectives, multiple treatments within a given growing season will likely be needed to substantially reduce woody species abundance. Once this is reduced, it may be possible to manage less frequently, but annual treatments will likely be necessary.

Mowing multiple times and/or mowing before the seed set of forbs may encourage grass cover and decrease forb cover. However, it may also be necessary to completely replant fields with a high proportion of grasses to achieve the low forb cover preferred by many grassland nesting birds. Fire can also be used if opportunities arise and resources are adequate. Invasive species control will require any of a series of methods including mechanical treatment, the use of fire in the growing season and the use of herbicides. Invasive species control will likely require annual treatments and monitoring of results to keep invasives from expanding.

Monitoring should address the specific management objectives of each field. So, using the shrub cover example, it may only be necessary to monitor shrub cover and not the other variables such as grass or forb cover as we did in this study. This will allow for an adaptive management approach based on solid information on management effectiveness while minimizing resource expenditures for monitoring.

Title: Analysis of Field Data for the Shawangunks Grassland and Forests Birds Habitat Study – Undercliff Oak Forest Management

Author: Michael Batcher, Ecologist and Environmental Planner

Abstract: As part of a study on the effects of prescribed fire on forest bird habitat, we established 16 plots within a 35.7 acre (14.4 ha) treatment unit in 2009. Target bird species were Black-throated Blue Warbler (*Dendroica caerulescens*), Scarlet Tanager (*Piranga olivacea*), Wood Thrush (*Hylocichla mustelina*) and Worm-eating Warbler (*Helmitheros vermivorum*), all of which are Species of Greatest Conservation Need (SCGN). We collected data on tree, shrub, sapling and seedling abundance. We also collected data specific to shrub nesting birds by measuring shrub abundance at 0.5 m height increments from zero to three meters. We burned the unit in late April and early May of 2010 and resurveyed all 16 plots.

Live woody stems and leaves were found relatively evenly distributed by height class prior to treatment in 2009. Most mountain laurel stems and leaves were found at a height of between 0.5 and 1.5 meters. Following the burn, shrubs were top killed, so that nearly all live woody material was relegated to less than 0.5 m as plants resprouted.

Tree mortality was negligible, and canopy cover did not change significantly, though there was some increase overall. There were small, but statistically significant reductions in litter cover and increases in duff.

Total seedling density in the 16 plots ranged from 5,333 to 18,416/ha prior to treatment and 7,666 to 31,250 after treatment. Both oaks and red maples showed a significant increase in density between pre and post treatment. Total sapling density ranged from 500 to 2,166/ha, prior to treatment and 0 to 750/ha after treatment. Sapling density decreased significantly for all species, though red maple did increase in one subunit. The proportion of hardwood and/or red maple to oak saplings was higher than for seedlings, both before and after treatment.

Both Black-throated Blue and Canada Warblers nest in the dense shrub layers of 1-3 meters that were reduced in height and cover by the prescribed fire. Clearly the fire was not favorable to those habitat characteristics needed for those species. Increases in seedling densities and regrowth of mountain laurel will likely result in suitable habitat again, though we cannot predict the time frame for that from this study. At the same time, there was negligible change in tree density or canopy cover, so some of the appropriate habitat characteristics for these species remain. Scarlet Tanagers require large, unbroken forests with closed canopy, so their habitat requirements remain unchanged. Litter cover remained relatively unchanged, and new litter will fall to replace what was burned. Therefore, habitat for Worm-eating Warblers should also remain relatively unchanged.

The methods used here could be modified for monitoring site treatments, and recommendations are included for both future research and monitoring.

Title: Analysis of Field Data for the Shawangunks Grassland and Forests Birds Habitat Study – Overlook Wildfire Study

Author: Michael Batcher, Ecologist and Environmental Planner

Abstract: The Overlooks Wildfire burned approximately 1,250 ha within Minnewaska State Park Preserve and some adjacent private lands in April of 2008. This was the largest fire in the Shawangunks since the 1947 wildfire that burned over 3,000 ha. To measure the effects of this fire, vegetation and other data were collected from 96 10-m radius circular plots (314 m2) in Minnewaska State Park Preserve from early June to mid- September of 2008. Fifty-five of these were in burned areas mapped as chestnut oak forest and 20 in nearby, unburned chestnut oak forest. Twenty-one plots were located within burned pitch pine-oak-heath rocky summit. In late May and early June of 2008 bird data was collected from 25 points within the boundary of the Overlooks Wildfire and from 15 points in a nearby, unburned chestnut oak forest. These were also included in the above vegetation plots. To provide further comparison of burned vs. unburned areas, data from 1995-96 mapping of the northern Shawangunks by John Thompson (1996), incorporated into New York Natural Heritage Program data (NHP), were also analyzed.

In 2009, bird data was again collected in the two unburned transects and in two of the burned transects. In 2010, we collected vegetation data in 36 plots mapped as chestnut oak forest and 10 plots in the pitch pine-oak-heath rocky summit in the burned area. We also collected bird data from 25 points in the burned area. No data were collected in unburned areas.

The wildfire reduced total canopy cover well below that of unburned plots from this study and NHP data. High intensity fire likely killed many canopy trees, creating open woodland areas distinct from forest types. These open woodland areas were discovered during field work in 2010 and were not observed in 2008. Tree cover substantially recovered in forest plots.

Overall tree density in the chestnut oak forest was 66.2/ha in 2010, compared to 487.7 in 2008. Plots designated as forested had a density of 244.0/ha, compared to 38.9/ha for open woodland plots. Oaks had higher importance value in the burned area in 2010 than in 2008, primarily due to values in open woodland plots where oaks (*Quercus montana, Q. rubra*) persisted and red maple did not. This supports the theory that the open woodlands were subject to higher intensity fires than the areas that remained as forest. After two years, more trees died, and it would appear that oaks had a higher survival rate than red maple (*Acer rubrum*) or other species. Pitch pine (*Pinus* *rigida*) also had a high importance value in these open woodland plots, which may indicate that those areas that became open woodland differed from other chestnut oak forest areas prior to the fire. Red maple continued to have high importance values in burned forested areas.

In the pitch pine-oak-heath rocky summit, tree density was 732.8 trees/ha in 2008 and 273.7 trees/ha in 2010 compared to 414.3 in unburned plots. Again, this community likely experienced high intensity fire. Red maple density and importance value were significantly lower in 2010 than in 2008.

In chestnut oak forest plots, red maple constituted 61.4% and sassafras 26.1% of seedlings. In open woodland plots, these proportions were 7.3% for red maple and 89.0% for sassafras, while in the pitch pine-oak-heath rocky summit, these proportions were 60.9% for red maple and 32.1% for sassafras. Only 15 pitch pine seedlings, representing 2.5% of total seedlings, were counted. In the chestnut oak forest, the total seedling density for all species ranged from 78,309/ha in chestnut forest plots to 96,833 in open woodlands, while overall density in the pitch pine-oak-heath rocky summit was 29,666/ha. By comparison, in a separate study of prescribed fire effects in the Undercliff treatment unit, densities across plots ranged from 5,333 to 18,416/ha prior to the 2010 burn and 7,666 to 31,250/ha following that burn.

In the chestnut oak forest, red maple constituted 50.0% and sassafras 40.0% of saplings. In open woodlands, these proportions were 22.8% for red maple and 69.3% for sassafras. Sapling densities were 476/ha in forested plots, 1,727/ha in open woodlands, and 233/ha in the pitch pine-oak-heath rocky summit.

For the chestnut oak forest, the average total cover of the S1 strata (2-5 m) was significantly lower for burned than unburned plots in 2008, likely the result of high intensity fire burning in mountain laurel (*Kalmia latifolia*). S1 cover for burned plots in 2010 was less than found in burned plots in 2008. There may have been some dieback in this stratum, or the 2010 plots were simply different from the 2008 plots in shrub cover. For the S2 layer (< 2m), total shrub cover in 2008 burned plots was significantly lower than for unburned plots. In addition, S2 cover for burned areas was significantly higher in 2010 than was found in 2008. This is likely the result of recovery of the S2 layer between 2008 and 2010.

For the pitch pine-oak-heath rocky summit the total S1 layer cover in both 2008 and in 2010 vs. NHP data (unburned) was significantly lower. Apparently S2 cover in the burned area was higher than that for the NHP plots. Little recovery in either the S1 or S2 strata seems to have occurred between 2008 and 2010.

Scorch height and the proportion of canopy scorched varied more in the chestnut oak forest than in the pitch pine oak-heath rocky summit. In the chestnut oak forest, the distribution of proportion of canopy scorched was such that most trees recorded either little or no proportion of canopy scorched or over 90% scorched, with a moderate number of trees in between. In the pitch pine-oak-heath rocky summit, most trees had at least 90% of the canopy scorched. This indicates generally high intensity fire in that community, as well as torching of pitch pine whereas the chestnut oak forest was subjected to much greater variation in fire intensity and, hence, effects.

In 2008, there was significantly less leaf litter cover in burned vs. unburned chestnut oak forest plots and significantly more duff in burned plots, indicating that some areas had burned into the upper organic layers of the soil. Litter cover in plots assessed in 2010 was significantly higher, and duff cover significantly lower, than either measurement in 2008 burned plots. However, for data collected in 2010, those plots designated as open woodland had less litter and more duff than those designated as forested. This may have resulted from greater litter deposition from trees in the forested plots, greater decomposition of litter in open areas, or the occurrence of high intensity fires in 2008 that reduced litter cover.

Forty species of birds were recorded in 2008 in burned areas while 31 were recorded in unburned areas. In 2009, 35 species were recorded in burned areas and 30 in unburned areas. In 2010, 52 species were recorded within the burned area. Changes in mean abundance between burned and unburned areas and between years for birds were inconsistent, both for many individual species as well as for bird guilds. The most consistent findings were for several of the species associated with forests. Ovenbirds, Black-throated Blue Warblers and Black and White Warblers all showed declines from

unburned to burned areas. On the other hand, Scarlet Tanagers were also more abundant in burned areas.

For species associated with open habitats, Prairie Warblers were more abundant in burned areas, but also declined in abundance in both burned and unburned areas. Common Yellowthroats, Morning Doves, Chipping Sparrows and Chestnut-sided Warblers increased in both burned and unburned areas.

For cavity nesters, which we would expect would increase with increased abundance of dead trees, Black-capped Chickadees, House Wrens and Eastern Bluebirds increased in abundance in the wildfire area, while the abundance of woodpeckers and Great-crested Flycatchers was more mixed.

Given the open woodland areas where tree mortality was apparently high and the trajectory of the community toward one dominated by sassafras and red maple, I conclude intervention will be needed to restore the chestnut oak forest in the Overlooks Wildfire area. Leaving the area alone will likely lead to the area stabilizing as a shrubland or a woodland dominated by red maple and sassafras. Fire should be introduced as early a possible to reduce seedling numbers for both of these. Mechanical and herbicide treatments will be needed to reduce sassafras and red maple trees and saplings to reduce seed input. It may even be necessary to distribute acorns in areas where oak density is too low to provide sufficient numbers and where rodents and deer reduce acorns and seedlings. These actions can be incorporated into a program of further research and long-term monitoring of fire effects to track changes resulting from the Overlooks Wildfire. This should be integrated into the prescribed fire program contemplated in the recently completed fire management plan for the Shawangunks.

Title: Prescribed Fire Science Research and Management at Head of the Plains, Nantucket Island, MA

Author: Karen Beattie, Nantucket Conservation Foundation

Summary: 1) In 2005, Science and Stewardship Department staff initiated a comprehensive research project aimed at documenting the effectiveness of prescribed fire in maintaining globally rare sandplain grasslands and heathlands at Head of the Plains. Prescribed fire is a key management tool for these early successional habitats, although the effectiveness of prescribed fire at maintaining ecological function by reducing encroachment by woody species had not been effectively examined. Efforts to restore or create sandplain grassland and coastal heathland communities from shrub dominated areas have seen limited success, placing high conservation priority on preventing existing grasslands and heathlands from succeeding to woody-dominated habitats. This research project compared the effectiveness of dormant season (spring and fall) and growing season (late summer) prescribed fire as a tool for maintaining existing sandplain grassland communities and reducing the cover of woody species in coastal heathland habitat adjacent to existing grasslands [see Karberg below]. 2) In conjunction with the vegetation community research project described above, the impacts of prescribed fire on key rare plant species were monitored either within established monitoring plots (for more locally-abundant species) or across the property (for less locally-abundant species). Analysis of the data from this long term project will provide a better understanding of the direct effects of prescribed fire on each species as well as the long term effects on overall population dynamics. 3) Nantucket shadbush is a regionally-rare low-growing, deciduous, clonal shrub. This species was generally known to respond well to periodic disturbances such as brush-cutting or prescribed fire, which reduces the height of competing vegetation. NCF’s Science and Stewardship Department examined the long-term effects of fire management on this species at Head of the Plains. Similar research was also conducted on the effects of brushcutting on this species at a different site (the Foundation’s Trots Hills property, approximately one mile northeast of Head of the Plains). In 2011, the Massachusetts Natural Heritage and Endangered Species Program de-listed Nantucket shadbush. However, it was still listed a “Species of Special Concern” when this prescribed fire research and management project was initiated [see Omand below].

Title: An Assessment of the Impact of Fire on Rare *Lepidoptera* in the Ossipee Pine Barrens Preserve

Author: Carly Brown

Abstract: The Ossipee Pine Barrens Preserve, managed by The Nature Conservancy (TNC), was once part of a much larger pine barrens ecosystem. Currently, the pine barrens stretch across the towns of Madison, Freedom, Ossipee, and Tamworth in Carroll County, New Hampshire. The pine barrens ecosystem is an imperiled rare natural community that was historically maintained by fire. Pitch pine, the dominant tree in the pine barrens, is well adapted to a fire regime. Scrub oak and blueberry, the dominant shrub and ground cover, can also flourish post-fire.

The Ossipee Pine Barrens host a suite of rare species, including Lepidoptera, i.e. moths and butterflies. The Nature Conservancy has identified 18 conservation target Lepidoptera that are expected to be present in the Preserve, though some have not been verified on the landscape for several decades. There have been multiple surveys of the Ossipee Pine Barrens moths, the most recent intensive survey having occurred in the summer of 2002. The goal of the 2002 survey was to identify rare and non-rare moths, and to provide management and monitoring recommendations that will most benefit these pine barrens specialists.

Prescribed fire is just one management technique for returning historically fire-adapted ecosystems to a desired condition. The Nature Conservancy first began burning the pine barrens in 2007, and as of the summer of 2011 had burned just under 400 acres. TNC also mows and harvests parts of the landscape as a way to remove unwanted encroaching vegetation. The goals of these management techniques are not only to favor the desired vegetation (pitch pine, blueberry, and scrub oak), but also to provide habitat for the fauna that rely on pine barrens conditions.

The goal of this project was to assess the impact that prescribed fire has had on rare moths, as well as to provide additional records of moth presence. We collected moths using black light bucket traps, black light sheet traps, and sugar baiting. I chose four land management units to sample intensively: two that have been managed by fire within the past four to five years, and two that have not burned for several decades. Three sample points were randomly selected in each management unit. I sampled from each of these sample points once a month from May to September in the summer of 2012. I also sampled for moth species presence in several other management units of interest to TNC. Furthermore, TNC sampled spring flying moths in March in five management units, generally using sugar bait.

During the course of the study, I collected 5,846 moths representing 290 species. Between June and September I collected six of the TNC defined conservation target Lepidoptera species in the four intensively sampled management units. I collected three additional species that I included in my analyses since they are described as pine barrens specialists and potentially rare (Wagner et al. 2003, Kart 2003). Using a chi-square analysis, I found that three Lepidoptera species (*Nepytia pellucidaria*, 2 *Zanclognatha martha*, and *Euretegrotis attentus*) were significantly higher in abundance in the unburned management units as compared to the burned. Six Lepidoptera showed no significant difference between burned and unburned units. I used a t-test to compare the abundance, richness, Shannon-Weiner Diversity Index, and Simpson Index of all moth species in the burned and unburned units and did not find a significant difference in these factors.

When I included the early spring collections, and those from the less intensively sampled management units, I identified a total of ten target Lepidoptera species: *Lithophane lepida lepida, Lycia rachelae, Nepytia pellucidaria, Sympistis dentata, Xestia elimata, Xylena thoracica, Zale lunifera, Zale obliqua, Zale submediana*, and *Zanclognatha martha*. I collected five additional pine barrens specialist species: *Abagrotis brunneipennis, Eueretagrotis attentus, Sideridis maryx, Xestia youngii*, and *Xylena cineritia* (Wagner et al. 2003, Kart 2003).

Based on the chi-square evaluation of target moth abundance between burned and unburned units, I do not recommend any drastic changes in the current prescribed fire management regime. While there were significant differences in three species, with the numbers being lower in the burned units, the majority of moth species showed no difference in abundance between burned and unburned units. Thus, after just a one-year monitoring effort, it is premature to alter the current prescribed fire practice. I do highly recommend that the conservation target Lepidoptera continue to be monitored. I also highly recommend following conservative guidelines on the length of burn intervals, in order to ensure that the moths have regained healthy populations prior to more burning.

Summary of the management recommendations based on my findings:

-Continue managing for pitch-pine scrub oak habitat, but pay particular attention to moth life histories as outlined in Kart 2003.

-Maintain corridors of unburned vegetation to provide a refuge and source population when burning larger management units.

-Coordinate the current post-burn vegetation surveys carried out by TNC with moth collections, as a way to evaluate the habitat moths are collected from.

-Monitor target moths more frequently using a less intensive sampling design that allows the target moths to be the focus in collections. Instead of collecting all moths in black light bucket traps, black light sheet traps will allow for target moths to be captured and released.

-Continue doing intensive monitoring every ten years or so, and include

microlepidoptera in the collection data.

-Explore the possibility of monitoring other well-known taxa in addition to the moths to track multiple responses to prescribed fire.

Title: Monitoring Protocols for the Ossipee and Waterboro Pine Barrens

Author: Tyler Bushell

Abstract: Fire suppression during the last 50-100 years has changed the composition and structure of northeastern pine barrens, a globally rare and fire-dependent natural community that provides habitat for numerous rare and declining Lepidopteran, plant and early successional/shrubland bird species. These changes have resulted in a number of deleterious effects to the natural community, including an increase in canopy cover and organic soils and the proliferation of tree species less tolerant of fire (such as red maple, white pine, red oak, aspen, and American beech). In some areas these species have invaded pine barrens to the exclusion of pitch pine and other constituent species. Additionally, in the absence of fire, fuel loads have in many areas reached a level that threatens nearby human development and could result in a catastrophic wildfire with an ecologically damaging intensity. As northeastern pine barrens shift away from their historic character the continued increase in hazardous fuels will be unabated and the composition of rare Lepidoptera and birds will shift, leaving some species more imperiled. In these scenarios, biodiversity—both in terms of natural communities and species—will be lost.

In response to these negative ecological changes the New Hampshire and Maine chapters of The Nature Conservancy (TNC) have set out to restore and/or maintain the northern pitch pine-scrub oak barrens (pine barrens) historically found at the Ossipee Pine Barrens (NH) and Waterboro Barrens (ME), as well as several other smaller sites. While managing the *entire* pine barrens system will include supporting viable wildlife populations and increasing herbaceous plant diversity, TNC is currently focusing on increasing the variability of the pine barrens seral stages to create a *woody plant composition* and *community structure* that is reminiscent of a pine barrens system historically influenced by fire. It is thought that promoting this structure and composition will support the constituent species dependant on it. After a pine barrens community structure and composition is present TNC will place emphasis on wildlife and herbaceous plant diversity objectives.

To manage the pine barrens and reduce fuel loads TNC has implemented a variety of ‘treatments’: timber harvest targeting fire-intolerant tree species, mowing of dense or senescent thickets of scrub oak, and prescribed burning. The ecological effects of these treatments are sometimes obvious but more often they are difficult to interpret. Because of this, TNC needs a systematic way to measure their progress towards meeting their ecological objectives (pg. 13). The purpose of this document is to assist TNC in carrying out the most cost and labor efficient approach to field-based data collection and data analysis.

I developed a set of monitoring protocols that yield quantitative information about five ecological attributes on treated lands, including:

1. The percent cover of exposed mineral soil,
2. The average height of scrub oak,
3. The percent cover of scrub oak,
4. The relative abundance of pitch pine saplings vs. fire-intolerant saplings, and
5. The condition of fire-intolerant tree species.

This quantitative information can be used to directly assess the progress land managers have made in their efforts to restore and/or manage the pine barrens as laid out in the TNC’s ecological objectives (pg. 13). These ecological objectives relate directly to the structure and composition of the pine barrens and 7 are a subset of the broader ecological objectives designed for the Ossipee Pine Barrens and the Waterboro Barrens, which include safeguarding populations of rare or declining wildlife (moth and bird species) and rare herbaceous plants.

Maintaining the pine barrens will rely on reoccurring fire, of which the frequency is unknown. The protocols described herein may produce ecological insight that helps The Nature Conservancy better understand the appropriate frequency of prescribed fire in their pine barrens.

In sections 7 of this document I outline a variety of analytical pathways and a sampling design alternative that, while using a common set of data collection methods, can be used to generate additional information about pine barrens ecology, including:

1. Tracking how ecological attributes (e.g., percent cover of mineral soil) change over time,
2. Measuring an ecological attribute in different structural types (e.g., relative abundance of pitch pine saplings in areas of high and low canopy cover)
3. Analyzing the relationship of ecological attributes on one another (e.g., percent cover of scrub oak vs. pitch pine relative abundance), and
4. Reporting the variation of an ecological attribute within a given area as ‘percent of sampling locations that meet the ecological objective’.

The data collection protocols are accompanied by sections about sampling design, sample size, data storage and data analysis. The document is intended to inform the reader about the current ecosystem management at Ossipee and Waterboro and guide TNC through their monitoring program. These protocols were specifically designed with Ossipee and Waterboro in mind, but they may be applicable to other northeastern pine barrens.

Title: A Vegetative Fuelbreak Protecting the Town of Bar Harbor, Maine – Acadia National Park, ME

Authors: Mark Herberger and William Patterson, UMASS

Abstract: The Bar Harbor Fire of 1947 burned a total of 17,188 acres (10,000 in Acadia National Park), killed three people, and destroyed 237 homes and the Jackson Laboratory on Mount Desert Island, Maine. The fire caused 23 million dollars in damages (1947 dollars). The volatile conifer forest that covered much of Mount Desert Island and contributed to the intensity of the fire was replaced by early successional species. Acadia National Park is evaluating the potential for using a deciduous fuelbreak to prevent a future fire from causing comparable damage. In this paper, I review literature related to the effective uses of fuelbreaks in general and report the results of a field study to evaluate the need for a fuelbreak on Mount Desert Island.

Previous studies suggest that a fuelbreak is most viable where, as at Acadia NP, large intense fires and human ignitions are the rule. Fuelbreaks are effective against intense crown fires if incorporated into an overall firefighting strategy. Tree species that are suitable for establishment on a vegetative fuelbreak include hardwoods that are fire resistant as a stand and as individuals and have low crown-fire potential.

I sampled 293 nested plots along the boundary between Acadia NP and the town of Bar Harbor. Cover types were determined for each point and were compared to 1979. During the past 18 years, conifers have increased in the overstory. Conifer regeneration was also sampled. I found that 9% of the plots sampled had conifer regeneration sufficient to form a future conifer overstory. Only 13% of all plots had hardwood regeneration sufficient to perpetuate present-day hardwood stands. If the corridor were to be treated to remove the conifer overstory and eliminate conifer regeneration with prescribed fire and/or mechanical means or encourage hardwood regeneration (vegetative reproduction or seedling establishment), I estimate that approximately 90% of the area [250 acre (101.2 ha)] will require treatment.

Title:Expanding the Interface in the Northeast’s “Asbestos Forests”: Exploratory Assessment in NH

Author: Lloyd C. Irland

Abstract: An initial exploration of the connections between land use and forest fire risk in New Hampshire is reported. Though forest fire occurs at a low level, it is still subject to occasional extreme events. There is a strong association between the occurrence of fire prone types and the

developed areas of the state. In the towns experiencing 100 acres or more of fire in 1947-48,

today there reside 100,000 people. Not only that, but population density is positively associated

with forest fire occurrence. The counties that experienced high levels of fire in 1947-48

continued to do so in 2002-2011, so the geography of fire was relatively stable. Further research is needed to modify, extend, and elucidate factors underlying these relationships and trends.

Title: Preliminary Data and Statistics for Determining Communities-At-Risk from Destructive WildfiresAuthor: Andrew T. Jacobs, New York State Department of Environmental Conservation, Forest Ranger Division

Abstract: Wildfire occurrence reporting in New York is based on two data sources. The New York State Forest Ranger force has fought fires and retained records for 125 years. Over the past 25 years (1985-2009), Division records indicate that rangers suppressed 7,672 wildfires that burned a total of 71,187 acres. This averages 307 fires burning 2,847 acres per year, however, New York does not have a consistent wildfire season. New York’s fire history indicates periods of time when wildfires are much more numerous and destructive than the 25-year average would indicate. 1985, 1986, 1988, 1989, 1991, 1995, 1998, 1999, 2001 and 2008 were all above average years with 11,730 acres burned in 1989 alone. In 2008, a 2,800 acre wildfire occurred in Minnewaska State Park killing approximately 50% of the old growth forest cover in this very popular and scenic park. In addition to Forest Rangers documenting wildfire occurrence, New York’s 1,700 fire departments do the same but in a significantly different format. Data collected by the NYS Office of Fire Prevention and Control (OFP&C) indicates that from 2000 through 2009, fire departments throughout New York responded to 76,479 wildfires, brush fires, grass fires or other outdoor fires (all natural vegetation fires). Although this averages approximately 7,648 fires per year, 2001, 2002, 2005, 2006 and 2008 were above average years with 10,169 fires reported in 2005 alone. Fire department data for 2005 through 2009 has been incorporated into the Department’s geographical information system (GIS) and several statistical occurrence maps and graphs have been produced.

Title: Prescribed Fire Management in Sandplain Grasslands and Heathlands: Impacts of Burn Seasonality and Intensity on Vegetation Composition, Head of the Plains, Nantucket MA

Author: Jennifer Karberg, Nantucket Conservation Foundation

Abstract: The effectiveness of prescribed fire as a tool for maintaining sandplain grasslands and coastal heathlands by reducing the encroachment of woody species and perpetuating important plant species has not been definitively documented (Dunwiddie, 1998; Niering & Dreyer, 1989; Vickery, 2002). Efforts to restore or create sandplain grassland and coastal heathland communities from current shrub dominated areas have seen limited success, placing high conservation priority on preventing existing grasslands and heathlands from succeeding to woody-dominated habitats. This research project was designed and initiated to examine the effectiveness of dormant season (spring and fall) and growing season (late summer) prescribed fire as a tool for maintaining existing grassland and heathland communities and reducing the cover of woody species in coastal heathland habitat adjacent to existing grasslands. The goals of this research are to: 1) Document the effectiveness of prescribed fire as a means of maintaining and increasing sandplain grassland and coastal heathland habitat composition, and; 2) Compare the effectiveness of spring dormant season, fall dormant season, and growing season (late summer) prescribed fire in reducing the abundance of woody species in areas of coastal heathland habitat.

Title: 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

Author: Jon Kart, UVM

Abstract: 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.

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.

Title: The importance of fire in the maintenance of jack pine at its southeastern range limit in Acadia National Park, Maine

Author: Charlie Laing and William Patterson, UMASS

Abstract:waiting for hard copy

Title: Landscape Disturbance and Succession Modeling in the Pinelands of New Jersey using LANDIS-II: The Implications of Human Influence on Fire and Forest Composition

Authors: Inga P. La Puma, Richard G. Lathrop Jr., Robert M. Scheller and Steve Van Tuyl

Abstract: Coupled human-natural systems present complex relationships between human influence and ecosystem response and services. The Pinelands of New Jersey represent a highly human influenced system noted for its fire regime which helps maintain pinelands cover and halt succession from pine to oak forest composition. The goal of this research was to use a landscape disturbance and succession model (LANDIS-II) to understand long term implications (over 100 years) of human altered land on fire regimes and thus pine versus oak forest cover. Previous research (Chapter 1) showed that fire frequency in the ecological wildland urban interface (EWUI) is depressed due to fire suppression and that these areas are transitioning from pine to oak forest composition at a faster rate. We modeled current altered land and future maximum build-out and added EWUI fire regimes for both of these scenarios to determine the extent of shifts for pine and oak forest cover under a modern fire regime. Increased fragmentation due to both the build-out scenario and added EWUI no-fire zones decreased average fire sizes and increased pine to oak transitions. LANDIS-II forecasts provide a range of possible future scenarios and a decision-support tool for understanding how land-use and fire management policies may affect ecosystem processes and patterns.

Title: Islands of Pine: Future Climate Scenarios in the NJ Pinelands using the LANDIS-II Forest Landscape Disturbance and Succession Model

Authors: Inga P. La Puma, Richard G. Lathrop Jr., Robert M. Scheller and Steve Van Tuyl

Abstract: Assessing forest resilience to disturbances including climate change is an important aspect of adaptive management. Climate change impacts on fire and forest composition in the Pinelands of New Jersey have not been assessed to date and the prospect of major shifts in forest composition present challenges to the mission of the Pinelands National Reserve to preserve the ecological integrity of the Pinelands. The balance of pine versus oak cover may have long term effects on accumulated biomass and other ecosystem services. Ecological interactions between reduced fire due to nearby altered land, available forested area for burning, and climate change effects on fire will determine fire size and frequency. Factors such as increases in aboveground net primary productivity and changes in species establishment probabilities in a warming climate are also key determinants of pine versus oak forest composition. We used climate change forecasts in combination with a landscape disturbance and succession model (LANDIS-II) to investigate the interactions between climate and altered land forecasts, fire regimes, and forest composition. Our modeling results suggest that with increasing temperature and CO2 the average fire size in the Pinelands of New Jersey will mimic base altered land scenarios and forest composition will change from pine to oak cover. Results can be used for incorporating climate change into adaptive management plans for Pinelands preservation efforts and as an example of a protected ecosystem highly dependent on human management decisions in an urbanized context.

Title: Vegetation, Landcover, and Fuel Mapping of the Ossipee Pine Barrens, Carroll County, NH

Author: Jeff Lougee, The Nature Conservancy

Abstract: Vegetation, landcover, and fuels were mapped within an 8,166-acre area of the Ossipee Pine Barrens in Carroll County, New Hampshire. The Nature Conservancy divides the Ossipee Pine Barrens landscape into three sections: White Lake State Park, Pine Barrens East, and the West Branch Pine Barrens. The mapping area covers the entire West Branch Pine Barrens, and a small portion of Pine Barrens East (see Map 1). The mapping area includes extensive amounts of pitch pine/scrub oak vegetation, hardwood forests, and wetlands. There are approximately 2,300 acres of pine-barrens vegetation, 1,000 acres of wetlands, and 2,650 acres of other forest types, including white pine dominated softwood stands, mixed hardwood-conifer forests, and pure hardwoods. Nearly 1,500 acres of the mapping area is developed, with much of this occurring in former pine-barrens areas.

The Ossipee Pine Barrens is a ca. 3,000-acre occurrence of globally rare northern pitch pine/scrub oak barrens. It is New Hampshire’s last viable occurrence of a pine-barrens, and is home to a number of rare and endangered species, including the only known occurrences in the state of several globally rare moth species. The site is also one of the few places in New Hampshire with robust populations of declining shrubland and early successional birds.

Northern pitch pine/scrub oak barrens are believed to be maintained by periodic fires that occur every 25 – 50 years (Sperduto et. al. 2000). These fires have played a critical role in the maintenance of these natural communities by releasing nutrients, recruiting fire adapted species, removing fire intolerant vegetation, promoting seed dispersal, creating diverse “seral” or “structural” stages, and preparing a seedbed for species, like pitch pine, that require mineral soil for seedling establishment. It has been nearly 50 years since the Ossipee Pine Barrens has been subject to ecologically beneficial fire. In the absence of fire, fuel loads have accumulated to hazardous levels in many areas, placing both the human settlements in Ossipee and the ecosystem at risk. Additionally, the lack of fire has led to ecosystem degradation in the form of encroachment by fire intolerant species like white pine and some hardwoods, and a noted loss of open habitat types.

This mapping is part of a comprehensive ecosystem management program launched by The Nature Conservancy in 2003. This program has simultaneous goals of restoring the integrity of the Ossipee Pine Barrens ecosystem, while reducing the hazardous fuels that have accumulated over the past 50-100 years. An improved understanding of the vegetation, landcover, and fuels at the site will enable the Conservancy, along with its partners, to effectively monitor the Ossipee Pine Barrens ecosystem over time, plan for restoration activities such as prescribed burns and other fuel treatments, and provide critical information to assist local communities with wildfire suppression.

Cover types were mapped using recent aerial photography and high resolution satellite imagery, with data from over 150 points on the landscape used to inform the mapping. Four thematic maps have been developed, including:

· Vegetation and landcover (Map 3)

· Generalized vegetation and landcover (Map 4)

· Fuel types (May 5)

· Crown fire hazards (Map 6)

Forty distinct cover types were mapped to illustrate vegetation and landcover across the landscape. These types follow several existing classifications, including Dacey (2003), Finton (1998), and Sperduto and Nichols (2004). The vegetation and landcover types show the distribution across the landscape of pine-barrens “seral” or “structural” stages, and when possible New Hampshire Natural Heritage Bureau natural communities types. The generalized vegetation and landcover provides a grouping of the detailed types into 8 broad categories for quick reference. Fuels are categorized into 12 types based on the standard fuel models developed by the United States Forest Service (Anderson 1982) and custom fuel models developed for the Ossipee Pine Barrens (Patterson 2001). The crown fire hazards map classifies areas into high, moderate, or low risk for crown fires. This map also shows the location of potential fire breaks and safety zones.

This is the first iteration of this mapping for the Ossipee Pine Barrens, and it is anticipated that future mapping exercises will include the remainder of Pine Barrens East and White Lake State Park. This expanded mapping will enable the Conservancy and its partners to develop a more comprehensive, landscape level approach to management at the site. It is also important to note that this mapping only provide a snapshot in time of the vegetation, landcover, and fuels at the site. This data will need to be updated at regular intervals in order to capture the sometimes rapidly changing landscape at Ossipee.

### Title: Microarthropod Communities in the New Jersey Pinelands

Author: Melanie Rose Maghirang, Rutgers University. Graduate School of Arts & Sciences at Camden

Abstract: The soil dwelling microarthropod communities in the New Jersey Pinelands were examined in two field study experiments. The microarthropod community response to low intensity prescribed burns was first examined in two recently burned forests and two unburned forests. The populations of phytophagous and saprophagous mites responded most negatively to low intensity fire disturbance. Although other feeding guilds examined such as: predatory mites, fungivorous mites and collembolans appear to be quite tolerant to fire-disturbance. There were minimal differences in the populations of fungivorous mites between treatments, with greater populations in the unburned experimental sites. A closer examination of fungivorous mite abundances revealed that parthenogenic mites in this guild contributed significantly to its total population, thus allowing this guild to thrive post-disturbance. The diurnal migrations of these soil dwelling communities were also examined in two field studies conducted in July and November to determine possible seasonal changes. Environmental measurements were taken along with soil sampling to determine which factors influenced microarthropod densities. There were no significant differences by time for the total populations of microarthropods in both the July and November studies. Minimal differences in populations of all feeding guilds by time and time X depth in the July study were detected.  Significant differences by depth were observed in all feeding guilds except phytophagous mites, which were sparsely collected beyond the 0-5 cm depths.  The studies revealed some seasonal changes particularly with mites of the family Eulohmannoidea. In addition, this study found that temperature, moisture content and organic matter (LOI) influenced microarthropod densities.

Title: Seasonal Variation in Foliage Moisture Content of Pine Species at Acadia National Park, Maine

Authors: Ed McGuire and William Patterson, UMASS

Abstract: An important factor on whether or not an intense surface fire with cause torching of individual trees, which can lead to the development of a crown fire, is the moisture content of the foliage in the overstory trees. The moisture content of the foliage of pitch pine (*Pinus rigida* Mill), white pine (*Pinus strobus* L.) and red pine (*Pinus resinosa* Ait.) was examined at Acadia National Park, Maine. Second- and third-year needles declined in moisture content in the spring, reaching a low point in late-May and early-June. There was also a brief decline in mid-August, possibly due to drought conditions. First-year needles began at high moisture levels and declined throughout the summer. White pine usually had the lowest moisture content, pitch pine usually the highest. The highest potential for a surface fire of a given intensity to develop into a crown fire in pine stands at Acadia is during late-May and early-June. Further study should be conducted on the effects of drought on foliage moisture content in the summer and fall.

Title: Head of the Plains Nantucket Shadbush (*Amelanchier nantucketensis)* Response to Prescribed Fire Management, Final Report 2014

Author: Kelly Omand

Abstract: Until 2011, Nantucket shadbush was listed as a species of “Special Concern” in Massachusetts, under the Massachusetts Endangered Species Act. While it is still considered uncommon throughout much of its range, recent surveys have led to the removal of its “Special Concern” status. However it still remains ranked “1” for rarity in the northeast, and the island of Nantucket is likely home to some of the largest and healthiest populations.

Nantucket shadbush is a low-growing deciduous, clonal shrub. It propagates itself mainly by sending up new stems from the root stock, rather than by producing seed. It typically blooms in May-early June, producing cream colored flowers which are smaller and less showy than many other shadbush species. The unassuming flowers distinguish this shadbush from its close relatives—its pollen is often born along the petals’ edges, rather than on anthers, which is a very rare plant trait in the plant.

Observations by ecologists and land managers indicated that this low growing shrub responds well to periodic disturbances that reduce the height of competing vegetation, such as brush-cutting or prescribed fire. As a result, NCF’s Science and Stewardship staff designed this long-term research project (2005-2011) at the Head of the Plains property to assess the effects of prescribed fire on this unusual and rare clonal shrub.

In order to better understand the response of Nantucket shadbush to prescribed fire, we monitored patches over time, following prescribed burns. Results of this study suggest that the primary immediate benefit of fire to Nantucket shadbush is vigorous re-sprouting. All burned patches survived fire and many produced numerous root and stump sprouts in the first year following the prescribed burn. Our research indicates that Nantucket shadbush tolerates both spring and fall burns, and requires a relatively long time frame for recovery (4-5 years).

While this species appears to flourish under current conditions on Nantucket, changes in management, such as reduced fire or brush-cutting, could lead to rapid declines in available habitat. Erosion of shoreline areas, development, or changes in climate could further affect populations. Management decisions on Nantucket should take into account the fact that this species is very uncommon elsewhere in the region, and that the Island’s early successional grasslands and heathlands are core habitat for this species. Based on the regrowth trajectory we observed in this study, care should be taken to choose an appropriate interval for management (every 4-5 years). Finally, this unusual shrub is linked to particular guilds of native bees. Given recent concerns about declines in native pollinators, particularly native bees, it is possible that although Nantucket shadbush itself has been removed from Special Concern status, it may be very important for these often understudied groups of insects.

Title: Vegetation and Fire History: Savanna above Buck Run, Oswego Drainage Basin, Pine Barrens, NJ

Author: Emily Russell, New Jersey Department of Environmental Protection, Bureau of Parks, Natural Lands Management Office

Abstract: In this study, the history of a savanna is traced using pollen and charcoal preserved in peat, especially to determine whether it predates Euroamerican clearing in the region, and to evaluate the importance of fire in its establishment and maintenance. Pollen that falls on a wet surface such as peat becomes incorporated into the sediment as the material accumulates over time. Most pollen grains are preserved in the acid conditions of a peat bog, so sediment many thousands of years old still contains pollen representing the plants that were growing in the vicinity at the time the peat was deposited. Sediment also preserves charcoal, both microscopic particles blown in from regional and local fires and large pieces from fires occurring on the site, providing a record of relative importance of fire in the landscape over time. While neither pollen nor charcoal provide direct evidence for vegetation or fires, they can both be interpreted to suggest changes in the proportions of important or key species over time and changing fire intensity.

Title: A Summary of the 2002 Lepidoptera sampling at The Ossipee, Carroll Co., NH Pine Barrens

Author: Dale Schweitzer, PhD

Abstract: 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. 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 rcord 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 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 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.

Title: Geomorphology of Selected Pine Barrens Savannas

Author: Scott Stanford, Supervising Geologist, Division of Science, Research and Technology – New Jersey Geologic Survey

Abstract: The geomorphology and surficial geology of 7 savannas in the Mullica and Oswego River basins was surveyed using airphoto analysis, soil augering, radiocarbon dating, and topographic profiling. The savannas are grassy alluvial wetlands within the modern floodplain. They are generally separated from the main stream channel by a low levee and from the adjoining upland by cedar swamps. Most are traversed and drained by seepage channels that flow to the main stream channel through breaks in the levee. Adjoining uplands are, at 6 sites, Pleistocene terraces with surfaces 2 to 5 m above the savannas and, at one site a higher surface formed on the Cohansey Formation, about 10 to 15 m above the savanna. Basal radiocarbon dates, peat distribution, and buried-channel topography indicate that the modern floodplains are dominated by organic deposition, perhaps in response to regional rise in water tables that has occurred in step with rising sea level over the past 10,000 years. Radiocarbon dates, thick peat, and surface morphology indicate that 2 savannas are probably undisturbed by bog iron mining and turf cutting. The other 5 savannas, all along the Batsto and Mullica Rivers, show evidence of surface disturbance.

Title: Vegetation of The Ossipee Pine Barrens Preserve: Description, Classification, and Successional Trends. Carroll County, NH

Author: Claire Dacey, UVM. Prepared for TNC-NH

Abstract: The Ossipee Pine Barrens Preserve is a high-quality example of the globally-rare Northeastern Pitch Pine-Scrub Oak Barrens natural community. In addition, it provides habitat for a number of globally rare moth and regionally-declining songbird species. Active fire-suppression over the last four decades threatens this rare community with succession to more common vegetation types, and loss of habitat for rare fauna. As part of its mission to protect biodiversity, The New Hampshire Chapter of The Nature Conservancy is planning active management to maintain both the mosaic of pine barrens vegetation found on the site, and habitat for the rare moths and declining songbirds.

To aid in management planning, I used analysis of current and historical aerial photos, data from 32 study plots and 10 observation points, and multivariate analysis to classify the vegetation of the Preserve into eight types, and to map and describe these types. Additionally, using historic aerial photos and field evidence of fire and logging, I attempted to reconstruct the patterns of vegetational change over the last 60-100 years. Using both evidence of past change and current data on seedlings and saplings, I created a model predicting successional changes for the current vegetation in the absence of disturbance.

I concluded that succession at the Ossipee Barrens is generally slow relative to many of the more southerly examples of this community. However, in the longterm, the absence of disturbance will lead to the replacement of much of the barrens vegetation with white pine and hardwoods such as red maple. Establishment of white pine and hardwoods appears to be slowest in areas with the most open canopies, accelerating as canopies close and the cover of scrub oak and blueberry decreases. Currently 11-18% of the Preserve appears to be occupied by relatively stable, open-canopied vegetation that has changed little in over 60 years. Another 50% or so is in open to semi-open canopy types that resulted from logging in the 1970s, and are at more immediate risk of succession to closed-canopy forest. Around 25% of the Preserve is covered in closed-canopy, pitch-pine dominated forests. Some of these forests are relatively young – arising from clear-cuts in the 1930s – while others appear to have been undisturbed for much of the last century, and have a good deal of hardwood regeneration. A variety of non-pitch pine riparian communities occupy the remainder of the Preserve. These communities were not described in this study.

I recommend that permanent plots be established throughout the Preserve to monitor both successional change and vegetation responses to management applications. This is the best way that the dynamics of vegetation change on the Preserve can be understood. The final chapter of this document contains recommendations for plot establishment specific to each vegetation type, with the

exception of riparian areas.

Title: Katama Plains Conservation Area Analysis of 1999--‐2014 Species Composition and Cover Data

Author: Megan Wheeler

Abstract: For this analysis, I considered species composition and cover data collected in 1x1 m plots in Management Units F (unit 3) and G (unit 1) of the Katama Plains Conservation Area from 1999 to 2014 (Figure 1). I compiled data from eight years of summer vegetation monitoring (1999, 2003--‐2008, 2014 in MU G; 2000, 2003--‐2008, 2014 in MUF). These areas have been burned regularly, with burn treatments in the spring of 1988, 1992, 1999, 2002, 2006, and 2010 in MUG and in 1989, 1994, 2000, 2005, and 2009 in MU F. Much of MU F also underwent topsoil removal in 1945. The primary purpose of this analysis was to assess how total sandplain diversity, guild cover, shrub cover, and rare species have changed over the monitoring period and with respect to burn treatments. Guild classifications for all species were as defined in the original data files. All averaged cover values were the average over all plots in a management unit, whether or not the species was present. Diversity was calculated using the Shannon--‐Weiner Diversity Index. Changes in total cover, species richness and diversity over time were evaluated with linear models of richness or diversity versus year and management unit. The significance threshold used was p = 0.05. All nalyses were performed in R (version 3.1.2).

1. Current Research: (Current)

Charpentier, J.E., P.A. Palmiotto, W.A. Patterson III, and R. Thiet. *Manuscript in preparation.* Wildfire disturbance – recovery dynamics in Acadia National Park: feedbacks between climate change and ecosystem resilience.

Abstract: With limited available funding and the high cost of fuel treatments, fire managers in the northeast have been challenged with quantifying and prioritizing which lands are in greatest need for fuel reduction. Our analysis of post-fire stand development and fuel loading will fill this data gap and provide managers a better understanding of long-term vegetation and fuel changes in forest communities that did and did not experience fire in the past century. We will provide empirical evidence of fire hazard, fuel loading, and vegetation changes after wildfire in Acadia National Park (ANP). Our spatial analysis will quantify and map existing live and dead fuel loads, and identify management units for fuel reduction action. We will use an integration of GIS software to extrapolate fuel loading spatially across the full extent of ANP. Spatial predictions will be calculated from empirical data by use of regression analysis. The co-occurrence model will include critical fire behavior factors such as elevation, aspect, slope, and fuel continuity. LANDFIRE data of expected fire behavior and effects will be used to compute and spatially portray current fire hazard. The goal is to provide information about current fuel loads for active fire management. Our fire hazard model is necessary to achieve the greatest possible benefits from limited resources for fire management, at a scale that is useful to National Park Service resource managers.

Gallagher, M.R., N.S. Skowronski, K.C. Clark, J.C. Thomas, E. Mueller, M. El Houssami, R. Kremens, A. Filkov, A. Simeoni, and J. Rua.  *Manuscript in preparation.* The estimation of burn severity using satellite imagery in a temperate deciduous forest.

Abstract: New methods for evaluating burn severity across broad spatial extents, using satellite imagery, have enabled new opportunities for wildland fire managers and researchers.  While numerous studies have calibrated burn severity for forest types of the western United States, comparatively little research has been conducted in forest types of eastern US, where seasonality modulates wildfire occurrence and reflectance patterns of vegetation.  Using common, slightly modified calibration methods, to standardize for seasonal variation in reflectance, we calibrated burn severity for a pitch pine dominated landscape (*Pinus rigida* Mill.) in the mid-Atlantic United States. This calibration was based on field data observed following dormant and growing season fire, and yielded similarly strong results as presented in studies focused in the western US.  This work provides justification for managers and researchers to use this tool for monitoring the effects of wildland fire, evaluating previous management efforts, and justifying future management strategies and budgets.  Future work focused on linking specific fire effects, such as forest recovery patterns and avian species occurrence, with burn severity will further enhance the utility of results produced by this methodology.

Heuss, M., A. W. D'Amato, K. J. Dodds. *Manuscript in preparation.* Evaluating the impacts of southern pine beetle on pitch pine forest dynamics in a newly invaded region.

Abstract: Southern pine beetle (SPB), a native insect that has historically affected pine ecosystems in the southeastern U.S., has recently expanded northward causing extensive tree mortality in pitch pine and pitch pine-oak forests across much of eastern Long Island, NY. Given the historic lack of SPB within these ecosystems, little is known regarding its potential impacts on forest ecosystem structure and function. This study examined the immediate effects of SPB-induced tree mortality on the structure and composition of pitch pine and pitch pine-oak communities to inform management recommendations and projections of future forest conditions. Results regarding patterns of regeneration abundance and composition following SPB mortality and the impacts of deer browse activity on understory responses to SPB will be presented. In addition, impacts of management activities for controlling SPB on levels of downed fuels and forest regeneration will also be discussed. Collectively, our results indicate SPB could functionally eliminate pitch pine from many of these areas leading to increasing dominance of hardwoods species.

Skowronski , N. et al. *Manuscript in preparation*. Multi-scale analyses of wildland fire combustion processes in open-canopied forests using coupled and iteratively informed laboratory-, field-, and model-based approaches.

Abstract: The goals of this research are to: 1. Improve understanding of the processes driving heat transfer, ignition, thermal degradation, flaming and smoldering combustion, mass consumption, and fire propagation at the scale of individual fuel particles and fuel layers in low-intensity surface fires; 2. Develop an understanding of how fuel consumption is affected by spatial variability in fuel particle type, fuel moisture status, bulk density, and horizontal and vertical arrangement of fuel components in low-intensity surface fires; 3. Increase understanding of the effects of multi-scale atmospheric dynamics, including ambient and fire- and forest overstory-induced turbulence, on fire spread and convective heat transfer in low-intensity surface fires, and; 4. Ensure that the measurements undertaken support the development and validation of physics-based fire behavior models using an iterative approach consisting of laboratory, field, and model simulations.

https://www.researchgate.net/project/Multi-scale-Analyses-of-Wildland-Fire-Combustion-Processes-in-Open-canopied-Forests-using-Coupled-and-Iteratively-Informed-Laboratory-Field-and-Model-based-Approaches

1. Grey Literature: (Archive)

\*\* The Sandplain Grassland Network is collecting reports and gray literature related to grasslands – TNC talked about giving NAFSE access to that literature. I am in touch with and waiting for more info on what they will provide.

Title: Northeast Wildfire Risk Assessment

Author: USDA Forest Service

Short Description: The objectives of this assessment were to identify areas in the Northeast and Midwest that are prone to wildfire; identify where hazard mitigation practices would be most effective in reducing fire risk within each State; identify and prioritize Communities at Risk from wildfire and; focus resources in the areas of greatest need within each State.

Abstract: Federal and State land managers have a critical need for a general baseline geospatial assessment of fire risk that identifies wildland-urban interface areas and communities at risk from wildfire. These managers include personnel from the U.S. Forest Service, Northeastern Area State and Private Forestry (NASPF); State Forestry agencies; and those who manage Federal lands in the Northeastern and Midwestern United States. The projected increase in population, pressure for land use change, effects of climate change, and declining State budgets will result in more complex fire suppression strategies. Fire management programs must continue to operate strategically and efficiently to meet this paradigm. In the State and Private Forestry Redesign process, States are being required to prepare State Forest Resource Assessments and Strategies. National and regional guidance suggest using geospatial analyses to identify priority areas for wildfire risk mitigation.

Title: Pine Snakes and Forestry: An Unlikely Match

Author: Bob Williams

Short Description: A New Jersey Forester explains how pine snakes, though a threatened species, have co-existed and thrived in managed forests.

1. Management Plans: (Current)

Title:Northern Shawangunk Ridge Fire Management Plan

Organization: Interagency

Contact: Gabe Chapin, Forest Restoration Ecologist, The Nature Conservancy- NY

Description: The Shawangunk Mountains—often referred to as the Shawangunk Ridge or simply the Gunks— are a long narrow mountain chain extending roughly from the confluence of the Rondout Creek

and Wallkill River in Ulster County, NY to the southwest into New Jersey and Pennsylvania. The Northern Shawangunks landscape covers approximately 90,000 acres along a 20-mile stretch between the town of Rosendale and Route 52 in the towns of Wawarsing and Shawangunk. This landscape also includes portions of the towns of New Paltz, Gardiner, Rochester and Marbletown, and the village of Ellenville.

Land ownership and management in the Northern Shawangunks is varied. The Palisades Interstate Park Commission (PIPC) and NYS Office of Parks, Recreation & Historic Preservation (NYS OPRHP), Mohonk Preserve and the Open Space Conservancy1 (OSC) own approximately 30,000 acres of land managed as Minnewaska State Park Preserve, Sam’s Point Preserve, Mohonk Preserve and Witch’s Hole State Forest. The Nature Conservancy (TNC) is responsible for the management of Sam’s Point Preserve under agreement with NYS OPRHP/PIPC and OSC.

Much of the vegetation that exists on the Shawangunk Ridge today is highly flammable and

prone to periodic wildfire. Many of the natural communities of plants and animals that now inhabit the ridge ecosystem evolved with fire over thousands of years, and depend on a regular cycle of fire in order to thrive. Over the past 50-100 years, fire has been effectively excluded from most portions of the ridge as fire suppression techniques have improved. This has led to the degradation of significant natural communities, as well as the accumulation of flammable forest debris. This abundant available fuel has now increased the potential for more intense wildfires to occur.

Members of the Shawangunk Ridge Biodiversity Partnership (SRBP)—a group of 12 public agencies and not-for-profit organizations—have long recognized the need to reintroduce fire as a

key ecological management tool to support the conservation of the Shawangunk ecosystem. The

SRBP’s guiding management document, *Protection and Management Guidelines for the Shawangunk Mountains of New York,* highlights fire exclusion as a key threat to the ecologicalintegrity of the Shawangunks.

The *Northern Shawangunk Ridge Fire Management Plan* has been developed to address the need for a more proactive approach to fire management to protect the ecological integrity and reduce hazardous fuel loads in the highly volatile Shawangunk environment. Accordingly, the purpose of the plan is to a) provide a planning framework for implementing fire management actions in accordance with the policies of the various partner organizations; b) ensure that all fire management activities are science-based and that potential negative impacts to the environment have been assessed and mitigated for as necessary; and c) ensure that fire management is a collaborative effort focused on improving public safety and ecosystem health.

Title: Pine River State Forest Fire and Ecological Management Plan

Agency/Organization: NH Division of Forest and Lands, Department of Resources and Economic Development (DRED) and The Nature Conservancy (TNC)

Description: The purpose of the Pine River State Forest fire management plan is to identify areas within Pine River which will be managed with a combination of prescribed fire, timber harvesting, and mowing to restore significant areas of pitch pine - sandplain natural communities. Management goals and objectives, and the actions that will be implemented within portions of Pine River State Forest over the next five to ten years are discussed. The purpose of this plan is to serve as a guiding document for the Forest Management and Natural Heritage Bureaus within the Division of Forests and Lands. The plan is meant to be a working document that is modified as more knowledge and research is discovered. Key aspects of an ecological and fire management approach at Pine River are to:

* Maintain the pitch pine sandplain natural communities that occur on the Forest
* Enhance habitat for rare and state-listed Lepidoptera, early successional and shrubland nesting birds, and other wildlife species for which critical habitat is present on the Forest
* Manage fuels to reduce the potential for wildfire that may threaten life and property

Management actions will include mechanical treatments to reduce fuels and improve habitat, and prescribed burns to maintain the pitch pine sandplain natural communities. Mechanical fuel reduction and treatments will include mowing of dense tall scrub oak and other trees and shrubs, and timber harvests to reduce canopy cover in selected areas to promote the recruitment and retention of plant species associated with the rare pitch pine sandplain types. Prescribed burning will be used to reduce residual fuels from mechanical treatments, to maintain the unique natural communities and habitats, and to reduce fuels. This plan provides for an adaptive management approach to balance the ecological needs of the unique natural communities and associated wildlife species with the need to reduce fuels. Monitoring, documenting methods, and reviewing results will direct future management.

The Division of Forests and Lands will work with partner organizations to reduce hazardous fuels and apply prescribed fire to maintain natural communities and rare species populations in at least the six Special Management Areas (SMA’s). Over the next five years, approximately 254 acres will be treated using mechanical fuel reduction methods and prescribed burning (Map 2). More areas may be treated depending on resources and the results of treatment of this first set of management units. The Division of Forests and Lands will also work with partner organizations and landowners to reduce fuels within wildland urban interface areas.

Title: Management Plan for Katama Plains Management area (sandplain grassland)

Organization: The Nature Conservancy

Contact: Karen Lombard, Director of Stewardship and Restoration

Description: This is a revised Management Plan for the 190 acre Katama Plains Conservation Area (KPCA) which represents one of New England’s largest and best remaining examples of sandplain grasslands, a globally rare natural community. The site also supports 18 rare or declining species of birds, invertebrates, and plants that depend upon the open grassy and shrubby habitat.

Title: Fire Management Plan for Ossipee Pine Barrens Preserve

Organization: The Nature Conservancy

Contact person: Jeff Lougee, Director of Stewardship and Ecological Management

Description: This fire management plan fulfills TNC’s requirements for an approved site fire management plan (Heumann 2012). This plan includes ecological goals, objectives and a program of actions to be implemented over the next five to ten years to:

* Restore and maintain the pitch pine - scrub oak woodland community and structural variants
* Enhance habitat for nineteen lepidoptera and five shrubland and early successional birds
* Manage fuels to reduce the potential for wildfire that may threaten life and property

Management will continue to include mechanical treatments to reduce fuels and improve habitat combined with prescribed burns to maintain the pitch pine - scrub oak woodland community and structural types. Mechanical treatments will include mowing of dense tall scrub oak and timber harvesting to reduce canopy cover and remove encroaching fire intolerant tree species. Prescribed burning will be used to reduce residual fuels from mechanical treatments, to maintain the natural community and habitat by promoting the germination of pitch pine and the persistence of fire maintained plants, and to reduce fuels. This plan provides for an adaptive management approach to balance the ecological needs of the conservation targets and the need to reduce fuels. Monitoring, documenting methods, and reviewing results will direct future management. The Nature Conservancy will work with state and local partner organizations to reduce hazardous fuels and apply prescribed fire to maintain natural communities and rare species populations.

Over the next five years, approximately 500 - 750 acres will be treated using mechanical fuel reduction methods and prescribed burning on Conservancy and partner-owned lands (Map 1). More areas may be treated depending on resources and the results of treatment of this first set of management units. The Nature Conservancy will also work with partner organizations and landowners to reduce fuels within the WUI.

1. Future/Potential Research: (Current)

Title: Historic and present day fire effects on Northern red oak in the tension zone and implications for increased abundance

Author: Natalie Laura Cleavitt, Research Associate, Department of Natural Resources, Cornell University

Abstract: Northern red oak (*Quercus rubra* L.; QURU), a valuable timber and wildlife species, is predicted to be favored by warmer, longer growing seasons and become more abundant within the WMNF.  This highly desirable species is already being managed for in stands where it is present using shelterwood – prescribed burn sequences.  However, in order to understand the ecological potential of QURU to respond to climate change, greater understanding of the unique impacts of fire on oak regeneration from seed is needed.  If fire is necessary for high QURU regeneration success, then northward migration would lag climate change considerably.  However, relative to other species of oak, QURU has a more ambiguous relationship to fire, and a number of studies using different time scales and approaches have suggested that QURU can maintain itself on the landscape in the absence of fire.  Several Canadian studies have suggested that QURU can establish in larger forest gaps and may be mainly dispersal limited at the northern edge of its range. In addition, recent evidence suggests that QURU may be particularly susceptible to belowground interactions that likely affect its ability to regenerate though the implications for management of QURU regeneration remain unexplored.  We propose to leverage ongoing silvicultural management for QURU in the tension zone between oak and northern hardwood forest within the WMNF to increase our understanding of factors important in controlling expansion of this species northward in New England.  In particular, we seek to clarify: 1) the differential impact of historic disturbance by clearcutting versus clearcutting followed by fire on QURU in the WMNF; and 2) the comparative role of fire in QURU ecology, specifically in relation to site factors, particularly soil.  The results of this study will inform management and improve predictions for the rate of increased presence by QURU on the landscape with climate change.

Land Manager: Robin Weber, Stewardship Coordinator

Organization: Narragansett Bay National Estuarine Research Reserve

Type: Future management activity/ vegetation plot analysis

Description: I hope to find funding support for a 200-250 acre burn on a heavily degraded portion of our properties comprised of coastal mixed forest and coastal shrubland with follow-up treatments in each of two subsequent years to include: prescribed fire, browsing, herbicide application, and mowing.  The intent is to monitor vegetation recovery to see which post-burn treatments are most effective at promoting native species recovery.

Land Manager: Karen Lombard, Director of Stewardship and Restoration

Organization: The Nature Conservancy

Type: Future vegetation plot analysis

Description: We hope to soon analyze some of our vegetation plots on the Mazar property, a 101 acre TNC conservation restriction that abuts Mashacket Cove of the Edgartown Great Pond in the Kanomika Neck area . TNC also owns in fee about 10 acres of abandoned hay field and 4.5 acres of restored grassland/heathland on the adjacent MacKenty Lots. This property is part of what TNC has designated its “Edgartown Plains Preserve” which includes Katama Air Park and Herring Creek Farm. The land protection efforts that created the Preserve were intended to protect, maintain, or restore sandplain habitat, especially early seral communities including sandplain grassland and shrubland.

1. Websites [only those not already listed on NAFSE website](Current):

<http://www.umass.edu/nebarrensfuels/publications/index.html> (there are a fair number of unpublished reports here)

<https://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/newhampshire/places-preserves/maintaining-fires-role-in-the-ossipee-pine-barrens.xml>

1. Datasets (Archive):

Andrew Jacobs with New York State Department of Environmental Conservation provided historic wildfire records and data analysis. See the accompanying folder titled “NYS Wildfire Data”.

Andrew Jacobs and Gabe Chapin, Forest Restoration Ecologist at TNC have a dataset from Minnewaska State Park Preserve following the Sam’s Point wildfire at Minnewaska State Park Preserve.  It was basically just looking at whether or not pitch pine were recovering after that fire.  They have not done any analysis of the data other than to make a few graphs, and no report has been written.  They will be re-measuring these plots again this summer (2017).

Gabe Chapin has a data set from the 2008 Wildfire at Minnewaska State Park Preserve (Overlooks fire bird data 2008-2010). TNC did an assessment after that fire and put together a series of reports (See Michael Batcher, unpublished studies).

Inga La Puma has the fire history geodatabase for New Jersey which includes large fires from 1924-2015 and all size Rx fires for Div B from 1956-2007 and ignitions from 1929, 1936-37, 39-44, 91-2006 for all size fires. NJFFS also has this data.

Inga La Puma has a dataset that includes standard forest inventory plots and fish-eye photos for approximately 20-30 sites within different fire frequencies (Rx and wildfire) and time since last burned for the Barnegat and Mullica River watersheds.

Inga La Puma has a dataset with water quality stations and fire history which was inconclusive due to lack of water quality readings in the post-fire time period.

Inga La Puma reported that the fire history paper records from the NJFFS have a ton of historic info which is explained in her NAFSE webinar titled: Fire History of New Jersey. These records include, weather, economic info, details of the fire, and when the area had burned before from 1924-1980s. These are most likely located in the Trenton, NJ office.

Jess Charpentier has a long-term dataset of (1947) post-fire succession and fuel loading in Acadia National Park, ME. Forest inventory sample dates include: 1980, 1993 and 2016. 1980 and 1993 data collected by Dr. Bill Patterson.