Pine Barrens of the Northeastern U.S.

PINE BARRENS OF THE NORTHEASTERN U.S.

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Cover photo: "The Oaks and Pines of Stockton University" by David Carr

SUMMARY

Pine barrens forests of the Northeastern United States are characterized by sandy soils and fire-adapted plant communities. They provide critical ecosystem and human services, including water filtration, wildlife habitat, recreation, and biodiversity. These forests are threatened by fire suppression, pests, development, and other human pressures. It is estimated that nearly half of this forest type has been lost over the past 150 years. However, there are opportunities for private landowners, non-profit organizations, and the state and federal government to restore and protect the remaining pine barrens. Enhancing the ecological integrity of these forests will benefit the landscape and the human communities that surround them.

This document is meant to serve as a resource to scientists and forests managers alike. It combines scientific literature with success stories from the field to offer guidance to landowners who wish to restore or enhance the quality of pine barrens. The author's insights and contributions from managers throughout the region are reflected as well.

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WHAT ARE PINE BARRENS?

Pine barrens are forested ecosystems that generally have a sparse, open canopy of pitch pine (*Pinus rigida*) and an understory of scrub oak (*Quercus ilicifolia*) or heath shrubs (members of the Ericaceae family) (Milne 1985, Copenheaver et al. 2000, Latham 2003). Today, fewer than 20 pine barrens remain throughout the Northeast, making them one of the most critically imperiled ecosystems in the region (Noss et al. 1995, Kurczewski and Boyle 2000). They were once widely distributed across coastal and sand plains in the Northeast due to anthropogenic activities such as burning the land for agriculture, hunting, and foraging, but with an increase in population and development, and subsequent decrease in the use of fire, pine barrens have experienced decline and degradation throughout their range (Little 1974, Poulos 2015). Compared to historic levels, it is estimated that at least 48% of pine barrens have been lost (Noss et al. 1995) and the ones that remain are often small and isolated (Bried et al. 2014).

The disappearance of pine barrens is alarming because of their ecological and cultural significance. Many plants and animals depend on the habitat they provide. Prairie Redroot (*Ceanothus herbaceus*) and the white Moccasin Flower (*Cypripedium acaule* forma albiflora) are examples of rare plants found in northeastern pine barrens (Namestnik 2013). As many as two dozen endangered moths and butterflies use pitch pine, scrub oak, and heath shrubs as a food source and place to lay their eggs, including the federally endangered Karner blue butterfly (*Lycaeides melissa samuelis*), frosted elfin (*Callophrys irus*), and Acadian swordgrass moth (*Xylena thoracica*) (Wagner et al. 2003, Grand and Mello 2004, Bried et al. 2014, The Nature Conservancy 2016). Several birds also use pine barrens as breeding grounds, including the prairie warbler (*Dendroica discolor*), whip-poor-will (*Caprimulgus vociferus*), and Eastern towhee (*Pipilo erythrophthalmus*) (Gifford et al. 2010, The Nature Conservancy 2016). In addition to providing habitat for wildlife, pine barrens filter and purify water – an ecosystem service that is crucial for clean drinking water (The Nature Conservancy 2016). The Kirkwood Cohansey Aquifer, which covers

Figure 1. Lupine planted for Karner blue butterfly habitat in a restored section of the Albany Pine Bush, New York (APB 2011)

approximately 3,000 square miles in New Jersey and contains 17 trillion gallons of water, is both fed and filtered by the New Jersey Pinelands National Reserve.

The decline of pine barrens can be attributed to a complex interaction of factors including fire suppression, development, fragmentation, and forest conversion (Little 1974, Noss et al. 1995, Motzkin et al. 1999, Howard et al. 2011, Poulos 2015). Pine barrens are maintained primarily by anthropogenic activity (Little 1974, Poulos 2015). For at least one thousand years before European colonization, pine barrens were maintained by Native Americans who used fire for hunting, foraging, and agriculture (Dincauze and Mulholland 1977, Pyne 1982, Doyle et al. 1985, Poulos 2015). Native American populations were large enough to burn most of southern New England's landscape on a regular basis; some areas were even burned at an interval of three years or less (Poulos 2015). During European colonization, the use of fire peaked until the mid- to late-1800s, when farms were abandoned during the Industrial Revolution (Foster et al. 1998). Since the use of fire in the Northeast has mostly ceased, pitch pine regrowth has been inhibited and the pines are being replaced by shade-tolerant, fire sensitive hardwoods such as red maple (*Acer rubrum*), sugar maple (*Acer saccharum*), and American beech (*Fagus grandifolia*), as well as invasive species such as black locust (*Robinia pseudoacacia*) (Bernard and Seischab 1995, The Nature Conservancy 2016). These species are generally killed during fires while pitch pine is not (Little and Garrett 1990). The invasion of shade-tolerant, fire sensitive species into pine barrens habitat is a natural process called forest succession. However, succession is a threat to these ecosystems because they need periodic fires to maintain the unique vegetation.

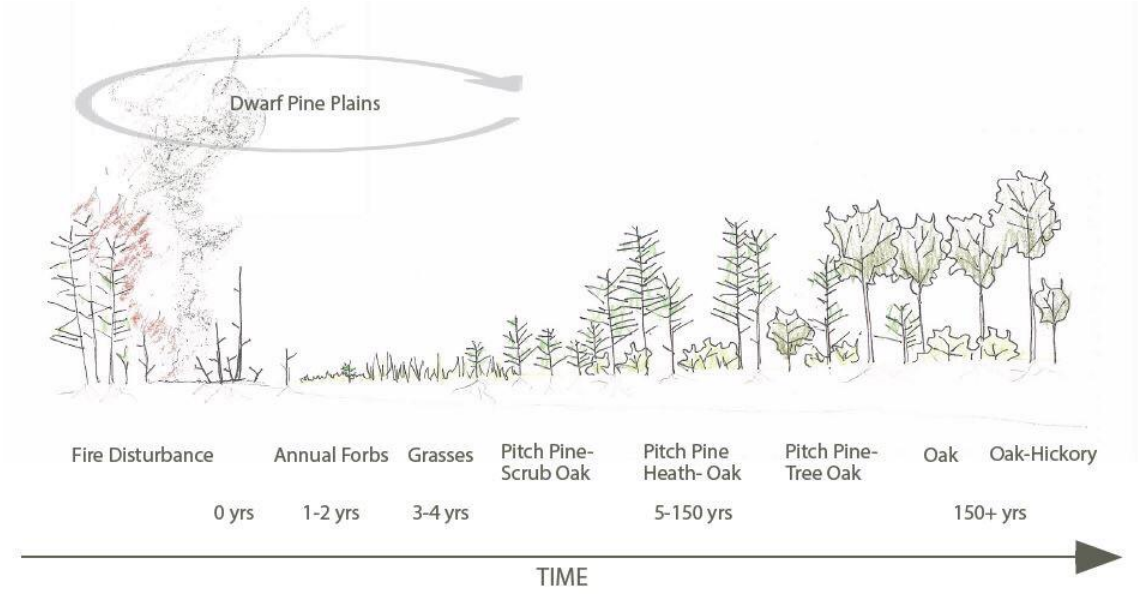

Figure 2. The succession of pine barrens (Amanda Branum 2018)

Multiple studies have found that fire exclusion is either degrading pine barrens ecosystems or causing them to be lost completely (see: Milne 1985, Bernard and Seischab 1995, Copenheaver et al. 2000, Howard et al. 2011).

"Pine barrens" were first named by European settlers who saw no agricultural value in their sandy soils and sparse canopy cover (Little 1974). Despite the name, pine barrens are not barren. They support habitat for rare plants and wildlife, provide valuable ecosystem services, and promote biodiversity across the landscape. Describing the dynamics of pine barren ecosystems throughout the region is critical to guiding conservation efforts: especially deciding whether the use of prescribed fire is appropriate and determining when and where to utilize it if so (Motzkin et al. 1995, Howard et al. 2011).

It is easy to forget about the role fire once had throughout the Northeast but excluding fire from the landscape has contributed to the decline of pine barrens. However, it is not too late to practice management that can protect them from further degradation. Pine barrens are an ecological reminder of the region's natural history – protecting them also means protecting a pillar of our vibrant culture.

THREATS TO PINE BARRENS

Fire suppression

While most people think of fires as harmful to forest, fire actually plays a critical role in pine barrens ecosystems. The pitch pine tree has developed many adaptations that not only protects it from fire but makes it *dependent* on fire. In a survey administered during the 1930s, foresters were asked to rate a list of trees in order of resistance to fire – pitch pine was consistently rated the most fire resistant (Starker 1932). Pitch pine has thick bark that prevents its sensitive inner tissue from being burned during a fire. Depending on the region, pitch pine also exhibits a trait called "serotiny", where its cones are sealed shut by resin and will only open up and release its seeds after a fire. Finally, if pitch pine's needles become

Figure 3. Pitch pine sprouting new needles after a fire (Rebecca Priddy 2010)

burned, it can sprout new ones (called "epicormic sprouting"). It is one of the only conifers in North America to exhibit this trait.

Not only can pitch pine tolerate fires, it needs periodic fires to reproduce. Other plant species found in pine barrens can also regrow or reproduce after fires. Therefore, the overall health of pine barrens depends on fire. This poses a problem since fires in the Northeastern are predominantly of human origin, and human-caused fires have declined rapidly since the mid-1800s. Unlike the West and Southeastern U.S., lightning causes less than 1% of forest fires. Beginning in the early 1900s, the federal government began an extremely successful campaign to suppress forest fires. While this policy, known as the Weeks Act, had the biggest consequences for the West, the Northeast has also suffered from fire suppression. 120 years later, Northeastern forests are overgrown and pose a wildfire danger. Some of the remaining pine barrens have persisted because of large wildfires during the 1950s. In pine barrens where fire has been excluded, other tree species have been able to grow and overtake pitch pine trees. Many pine barrens have since converted to hardwood forests, and it is now too late to restore them.

Development

The Northeast is the most developed region in the nation, with over 56 million residents and the highest concentration of urbanized areas (U.S. Census Bureau 2013). In 2003, over 76% of the forested land was privately owned and managed by family landowners (USDA 2005). 95% of these landowners own forested land less than 100 acres in size (Charnley et al. 2010). The fragmentation of the landscape makes it difficult to sustain any large tract of forestland, especially pine barrens because they need intensive management which is often undesired by the surrounding communities.

The following table outlines how much of the pine barrens ecosystem has been lost to development by region (Noss et al. 1995):

Region	**Percentage of forest that has been lost**
Lake Champlain Basin of Vermont	>97%
Massachusetts Pine Barrens	69%
Long Island Pine Barrens	60-68%
New Hampshire Pine Barrens	>50%
The New Jersey Pinelands	37%
Total Range	**48%**

Pests and Pathogens

Like most forests in the U.S., pine barrens are also threatened by pests and pathogens. The Southern Pine Beetle (SPB) is a primary threat. SPB has impacted approximately 26,600 acres of coniferous and coniferous-deciduous forest in New Jersey, and it is moving further North as the climate warms (NJDEP). It has been detected in Pennsylvania and New York as well. SPB kills pitch pines, among other pines, by burrowing into their bark disrupting the flow of nutrients to the needles (New York DEC). Infestations can be identified by numerous pitch tubes in between bark plates, blue stain fungi in the heartwood, and S-shaped galleries beneath the bark. While eradication of SPB is not possible, its impacts can be minimized by thinning trees from pine barrens to make them less dense. This makes it harder for SPB to travel between forests.

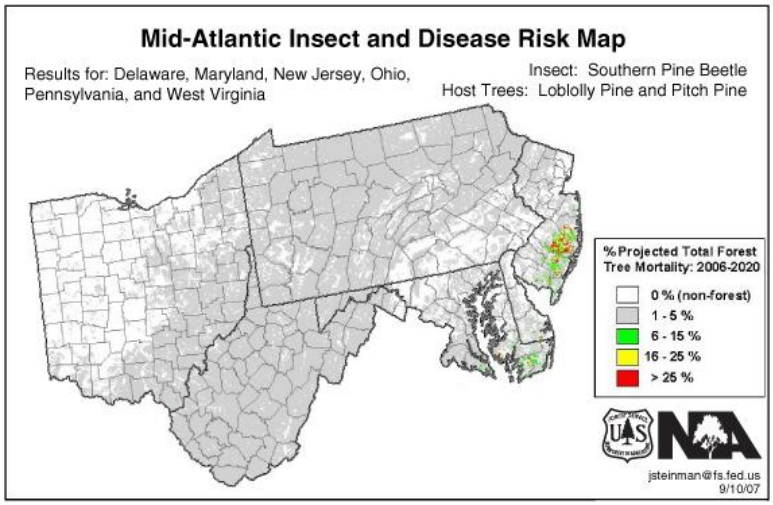

Figure 4. Projected range of Southern Pine Beetle by 2020 (USFS 2007)

A threat to the oak component of pine barrens forests are invasive gypsy moths. These moths completely defoliate oak trees – when the trees are healthy they can recover and produce a second leaf cover, but the tree will be more stressed and susceptible to other insects and diseases. A large infestation of gypsy moths can devastate the oaks in a pine barrens forest and decrease wildlife habitat/overall health (Hamilton et al. 2003).

MAJOR PINE BARRENS SYSTEMS IN THE NORTHEAST

Though "pine barrens" are referred to collectively throughout this report, they exhibit regional differences much like any other forest. Many "community types", or different assemblages of plant species, are found within pine barrens. For example, The Nature Conservancy identifies ten distinct community types in the Waterboro Barrens of

southern Maine. Some common community types include pitch pine-scrub oak, pitch pine-heath, boreal heath barrens, blueberry barrens, and pitch pine-rocky summits.

The greatest remaining concentrations of pine barrens are found along the Atlantic coastal plain, where anthropogenic fire was historically common and the soils are sandy, nutrient-poor, and well-drained (Lull 1968, Lorimer and White 2003, Poulos 2015). However, pine barrens are also found inland where glacial soil deposits or rocky outcrops exist (Abrams and Orwig 1994, Howard et al. 2011). The largest contiguous pine barrens forest is found in New Jersey and covers 1.1 million acres (Pinelands Commission 2015). By contrast, most other pine barrens cover less than 2,000 acres. The New Jersey Pinelands formed just south of Laurentide Ice Sheet and its soils are much older than ones found farther north. Additionally, this area was designated as the nation's first National Reserve in 1978 to protect the quality of the drinking water. These two factors are primarily responsible for the extent and health of this particular forest.

Figure 5. Major pine barrens systems in the Northeast (Kirchman et al. 2011)

More pine barrens are found along the coast: the Long Island Central Pine Barrens, Manuel F. Correllus State Forest on Martha's Vineyard, the Rhode Island Pine Barrens, and the Cape Cod Pine Barrens. In total, there are about 20 distinct pine barrens forests in the Northeast. Ownership ranges from private to non-profit to state/federal government. This adds a layer of complexity to management, as institutional knowledge and resources are not often shared among these entities.

MANAGEMENT CHALLENGES

One of the most common ways of restoring pine barrens is to decrease the density of trees by thinning them, then using prescribed fire to eliminate competition for pitch pine trees (Gifford 2017).

Figure 6. Myle Standish State Forest following a thinning treatment (Gregory 2018)

Many landowners are using this approach, but with the exception of the New Jersey Pinelands, ecological forest management of pine barrens didn't begin until the early 1990s. Compared to the timescale at which most forests are managed, this is an extremely short period of time. This has lead to conflicting scientific accounts, which has in turn lead to management failures – promoting invasive species, escaped prescribed burns, and degradation of existing habitat, to name a few (Saladyga 2017).

Due to the logistical and ecological complexity of managing pine barrens, some organizations would rather not manage them at all. The Jugtown Plains of Maine and the Clintonville Barrens of New York, both owned by The Nature Conservancy, have gone unmanaged for nearly two decades. Most of the original pitch pine-heath habitat has been lost since fire has not been used. Both of these properties exist within the wildland-urban interface (WUI) and the closest property owners have fought against the use of prescribed fire. Lack of education about the beneficial role of fire is partially responsible for property owners opposing prescribed burns.

The scarcity of resources poses another challenge. Many northeastern states have a single fire crew that is responsible for conducting all of the prescribed burns and can only burn several hundred acres a year as opposed to several hundred thousand out West. It can be challenging for individuals to attain the necessary qualifications if they are working for a National Wildfire Coordinating Group (NWCG) accredited organization to as well. This poses a resource problem when the fire season picks up in the West during the summer, because qualified individuals from the Northeast are often pulled from their duties to help fight wildfires.

Institutional barriers can prevent organizations from managing pine barrens. Many states make it difficult to conduct prescribed burns because of liability policies and concerns about human health. Most prescribed burns that take place in the Northeast have some sort of impact on human communities. Most landowners would rather avoid prescribed fire than face a potential lawsuit.

MANAGEMENT OPPURTUNITIES

Much like the Northeast is a matrix of human development, land-use, and populations, so should the pine barrens be managed as a patchwork mosaic of varying sizes, densities, and age classes (Bried et al. 2014). Managers can choose where to concentrate their resources to create high-quality habitat on a smaller scale, rather than trying to restore the landscape to what it resembled historically. Although the timber industry has declined in the Northeast, conservation-related positions are on the rise. Small-scale forest management can provide employment opportunities for foresters, scientists, and prescribed fire specialists/technicians while restoring functionality.

Another opportunity to manage pine barrens are the development of "prescribed fire training exchanges" (TREXs) in the region. TREXs are 10-day-long events where specialists from across the country are invited to participate in prescribed burns for a small fee. Having annual TREXs in the Northeast would alleviate some of the issues related to resource scarcities and enhance adaptive capacity for restoring fire-dependent ecosystems (Spencer et al. 2015). The TREX model has been replicated across the country several since they were created in 2008, but never in the Northeast. The Forest Stewards Guild and the North Atlantic Fire Science Exchange hope to host their first northeastern TREX in 2020.

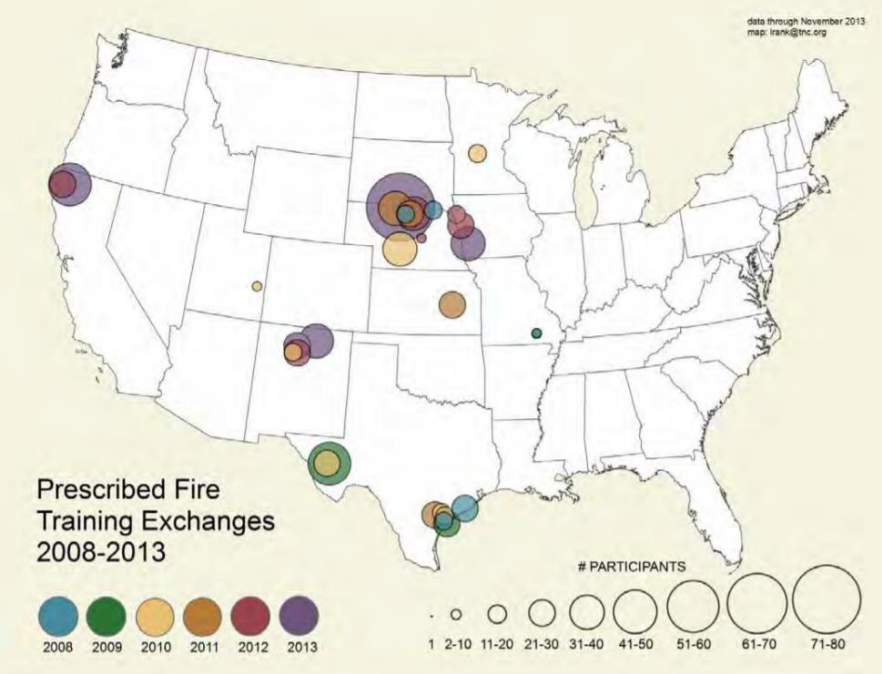

Figure 7. TREX events across the country from 2008-2013 (Jeremy Bailey 2013)

There has been a renewed interest in the role of fire in ecological forest management over the last several years. Social media, public outreach, and engagement with youth and students studying resource management is largely responsible. There are opportunities for schools and universities to build a natural history component into the curriculum and teach students about the importance of managing forests with fire. Stockton University in southern New Jersey has a robust Environmental Science program, where students enrolled

in the Ecological Forest Management course can participate in prescribed burns on their own campus. The university has partnered with the New Jersey Forest Fire Service to ensure students understand how to safely ignite and monitor the prescribed burns.

Figure 8. Students and New Jersey Forest Fire Service conduct a prescribed burn on Stockton University's campus (Allen 2015)

It is extremely important to create opportunities such as Stockton's prescribed burn program, since other regions of the country are experiencing aging populations and gaps in knowledge. Providing boots-on-the-ground training for students engages them with the forest and enhances skills that are critical in the field.

In January 2018, the North Atlantic Fire Science Exchange (NAFSE) and the Northeast Forest Fire Protection Compact (NFFPC) had their first partners' meeting. During the three-day-long exchange in Portland, Maine, scientists and managers had the opportunity to come together and share ideas and insights. This provides an excellent learning network for organizations and individuals throughout the region to connect with one another about the work they're doing.

CONCLUSIONS

While there are certain challenges to managing pine barrens forests, there are many management opportunities for a broad range of stakeholders as well. Feasible actions that can be taken include engaging students/youth in forest management, creating a hub of resources that is easy for landowners to access if they are thinking about restoring their forest, create job opportunities for prescribed fire technicians, and incentivize landowners to use prescribed fire. Pine barrens are a unique and resilient forested ecosystem and maintaining their ecological integrity should be a priority for resource managers in the Northeast.

ANNOTATED BIBLIOGRAPHY

The following is a list of relevant studies conducted in northeastern pine barrens and key findings/results.

Abrams, M.D., D.A. Orwig. 1996. A review of dendroecology and successional dynamics of old-growth and second-growth oak and pine forests in the eastern United States. *Tree Rings, Environment and Humanity* 343-352.

This paper focused on the structure and growth dynamics of a pitch pine community on a rocky outcrop in the Shawangunk Mountains of New York. This pitch pine community is one of the known oldest, showing continuous recruitment since the late 1600s. These "tree islands" represent later phases of succession and are excellent examples of relay floristics: lichens and mosses invaded bare bedrock, soil accumulated, understory vegetation established, followed by pitch pine and scrub oak. This study shows that succession might not be a threat to pine barren communities where edaphic conditions are extreme enough to prohibit the growth of other species such as Chestnut oak and black tupelo.

Abrams, M.D., D.A. Orwig. 1995. Structure, radial growth dynamics and recent climatic variations of a 320-year-old Pinus-rigida rock outcrop community. *Oecologia* 101: 353-360.

In this study, one of the oldest pitch pine communities was examined. The 320-year-old community exists on a rocky outcrop in the Shawangunk Mountains of New York, one of the most extreme sites in the northeastern US. This case interested me because it shows a pitch pine stand in a late successional stage and is an example of relay floristics. The outcrop was invaded by lichens and mosses, followed by grasses, sedges, and forbs once soil developed. The trees in this community and others like it may become important resources for dendroclimatology research in the future.

Bried, J.T., W.A. Patterson, N.A. Gifford. 2014. Why Pine Barrens Restoration Should Favor Barrens Over Pine. *Restoration Ecology* 22: 442-446.

This review paper discussed the merit of maintaining a more open canopy in pitch pine-scrub oak barrens. The authors suggest maintaining between 10-30% pitch pine cover for two main reasons: to promote biodiversity (shrubland birds, rare moths and butterflies,

understory plants), and to reduce the risk of wildfire. Pitch pine stands should be thinned so that the landscape is a mosaic of varying fire frequencies, stand ages, and community types.

Copenheaver, C.A., A.S. White, W.A. Patterson. 2000. Vegetation development in a southern Maine pitch pine-scrub oak barren. ***Journal of the Torrey Botanical Society*** **127: 19-32.**

This study focused on different factors influencing vegetation distribution in the Waterboro pine barrens of southern Maine. Pine barrens are dependent on edaphic and climate conditions, as well as disturbance (mostly fire). A wildfire that occurred in 1947 has protected the Waterboro Barrens from invasion by fire intolerant species, but on a regional scale, the researchers noted that fire dependent communities are being replaced with mixed deciduous forests. In order to preserve places like Waterboro, the disturbance regime must be maintained.

DeGraaf, R.M., M. Yamasaki. 2003. Options for managing early-successional forest and shrubland bird habitats in the northeastern United States. ***Forest Ecology and Management*** **185: 179-191.**

In this paper, the roles of pre-settlement disturbances including fire, wind, beaver, flooding, and Native American agriculture in creating early successional habitat were discussed, and how early successional habitat has become scarce due to the current lack of those disturbances. Maintaining the level of pre-settlement early successional habitat is now impossible, and this has implications for several bird species that depend on this rare habitat type. The authors provide an outline of management options that mimic the historical range of variation for maintaining early successional habitat.

Grand, J., J. Buonaccorsi, S.A. Cushman, C.R. Griffin, M.C. Neel. 2004. A multiscale landscape approach to predicting bird and moth rarity hotspots, in a threatened pitch pine-scrub oak community. ***Conservation Biology*** **18: 1063-1077.**

In many conservation plans, only one taxa and one scale is used. The goal of this experiment was to use a multi-taxa (birds and moths), multiscale approach to predict rarity hotspots that should be of management concern in a pine barrens community in southeastern Massachusetts. The researchers found that the association between bird and moth hotspots was weak (<5% overlap), which I found surprising because I assumed moths would be a

primary food source for birds. They also found that landscape variables had a larger role in habitat suitability than plot level variables did for both birds and moths. Most of the birds and moths studied preferred open canopy scrub-oak habitat; however, the surrounding landscape was comprised of later successional closed canopy forest. Managing for early successional stages could diversify the landscape and provide higher quality habitat for rare birds and moths.

Grand, J., M.J. Mello. 2004. A multi-scale analysis of species-environment relationships: rare moths in a pitch pine-scrub oak (Pinus rigida-Quercus ilicifolia) community. *Biological Conservation* 119: 495-506.

In this study, the importance of scale was assessed in determining distribution and abundance of 10 rare moth species in a Massachusetts pine barrens community. The researchers looked at environmental variables at the plot, patch, and landscape level, because in many conservation studies, only one of these scales is observed. They found that there wasn't a strong association of moth abundance or distribution at the plot and patch level. The results suggest that rare species dependent on pine barrens communities benefit more from landscape-based management than management practices that focus on small areas.

King, D.I., S. Schlossberg. 2014. Synthesis of the conservation value of the early-successional stage in forests of eastern North America. *Forest Ecology and Management* 324: 186-195.

In this review, the conservation implications of losing early successional habitat was discussed busing shrubland songbirds as an example. The authors conclude that early successional and late successional forest habitats must be maintained throughout the landscape.

Leuenberger, W., S. Bearer, J. Duchamp, S. Johnson, B. Leppo, P. McElhenny, J. Larkin. 2016. A Comparison of Lepidoptera Communities Inhabiting Restored and Late Successional Pitch Pine-Scrub Oak Barrens in Pennsylvania. *Natural Areas* 36: 38-47.

In this experiment, researchers wanted to see whether there was a difference in diversity and abundance of Lepidoptera between restored and late successional pitch pine-scrub oak barrens (PPSO) in Pennsylvania. Although they did not find much of a difference between

the two types of site, several species were unique to restored site and several species were unique to later successional sites. This gives support to the notion that a mosaic of successional stages in PPSO ecosystems should be maintained throughout the landscape.

Lorimer, C.G., A.S. White. 2003. Scale and frequency of natural disturbance in northeastern US: implications for early successional forest habitats and regional age distributions. ***Forest Ecology and Management*** **185: 41-64.**

In this paper, the loss of "young forests" across the northeast over the past 200 years, and the implication of those losses, was examined. Most of the northeast is in a second growth phase, and most early successional habitat has declined as a result. In pine-oak barrens specifically, lack of fire has caused this ecosystem to mature and become oak dominated. Pine-oak barrens probably had the most frequent and severe disturbances, and the alterations to their disturbance regime has had negative consequences. To restore these young forests, a proper understanding of historic disturbance regimes is critical.

Marschall, J.M., M.C. Stambaugh, B.C. Jones. 2016. Fire Regimes of Remnant Pitch Pine Communities in the Ridge and Valley Region of Central Pennsylvania, USA. ***Forests*** **7: 1-16.**

In this paper the authors recreated the disturbance regime of pitch pine in the Ridge and Valley Region of Central Pennsylvania. They reconstructed this region's fire history, from the pre-settlement era (pre-1755) to the fire suppression period (1915-2013). They found that the fire regime was frequent yet variable through time. The section on fire severity is particularly relevant to my project.

Matlack, G.R. 2013. Reassessment of the Use of Fire as a Management Tool in Deciduous Forests of Eastern North America. ***Conservation Biology*** **27: 916-926.**

Motzkin, G., D. Foster, A. Allen, J. Harrod, R. Boone. 1996. Controlling Site to Evaluate History: Vegetation Patterns of a New England Sand Plain. ***Ecological Monographs*** **66: 345-365.**

This paper emphasized the importance of understanding land use history when it comes to conserving sand plains/pitch pine-scrub oak (PPSO) habitat. Many studies have focused on fire ecology as a critical component of PPSO communities, but few have assessed the impact

of land use on these vegetation assemblages. The authors conclude by saying that the integrity of the varied landscape should be conserved rather than small patches that support rare species.

Motzkin, G., W.A. Patterson, D.R. Foster. 1999. A historical perspective on pitch pine-scrub oak communities in the Connecticut Valley of Massachusetts. ***Ecosystems*** **2: 255-273.**

This paper presented a historical view of pitch pine-scrub oak (PPSO) communities in the Connecticut Valley, and explored how they have changed since European settlement. The study concluded that PPSO has been altered substantially and that the current species assemblages, disturbance dynamics, and landscape setting do not resemble what they once did historically. The authors suggest it is "inappropriate" to assume current communities resemble past ones, and state is it unwise to manage them as such.

Patterson, W.A., G. Clarke. 2005. Restoring barrens shrublands: decreasing fire hazard and improving rare plant habitat. ***Tall Timbers Fire Ecology Conference Proceedings*** **23: 73-82.**

In this experiment, researchers tested different methods in the Manuel F. Correllus State Forest to examine their effectiveness in achieving two management objectives: decreasing fuels (fire hazard) and improving rare plant habitat. The methods included thinning, brushcutting, grazing, pile burning, and prescribed burning. The researchers found that fuel reduction improves rare plant habitat, and that some rare plants are dependent on exposed mineral soils. Treatments that included reducing fuels (such as mowing) then burning were the most effective.

Poulos, H. 2015. Fire in the Northeast: Learning from the Past, Planning for the Future. ***Journal of Sustainable Forestry*** **34: 6-29.**

This paper provided an excellent overview of the history of fire, and the implications of its suppression, in the Northeast. Throughout the paper, the author argues that (a) fire is natural, (b) fire is cultural, and (c) fire is economic. Native Americans began using fire in the region as early as the recession of the Laurentide Ice Sheet. Even after they were displaced, European settlers continued using fire to clear fields for agriculture. With the onset of the industrial revolution in the mid to late 1800's, use of fire declined, and was suppressed entirely starting in 1911. This has caused a major shift in community composition towards

more shade-tolerant, pyrophobic species. The author states that if we want to preserve biodiversity and stay connected with our natural heritage, we must return fire to the landscape.

Saladyga, T. 2017. Forest Disturbance History from 'Legacy' Pitch Pine (Pinus rigida) at the New River Gorge, West Virginia. ***Natural Areas*** **37: 49-57.**

In this study, the author reconstructed the disturbance history of a pitch pine-oak forest in Babcock State Park, West Virginia. He found that the fire regime was tightly coupled with both anthropogenic activities and drought, and that fire managers should reconstruct historic fire regimes before creating prescribed burn plans for their forests. In some areas, the fire return interval has been overestimated, leading to a decrease in oak regeneration and an increase in invasive species.

Wagner, D.L., M.W. Nelson, D.F. Schweitzer. 2003. Shrubland Lepidoptera of southern New England and southeastern New York: ecology, conservation, and management. ***Forest Ecology and Management*** **185: 95-112.**

This paper discussed species across the Lepidoptera order and their habitat preferences, host plant associations, and conservation statuses in relation to shrublands and pine-oak barrens across southern New England. The 56 species examined live exclusively in shrubland communities and depend on the plants that can be found there for food and larval hosts. The authors went on to talk about management strategies in order to conserve Lepidoptera populations and concluded that (a) small, remnants of barrens habitat might not be suitable to support specialized shrubland species, (b) in barrens not historically altered by humans it would be unwise to plow or "harrow" the understory, and (c) a management technique that has not been studied enough for restoring barrens is grazing by sheep or cattle.

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