Conservation Matters: Contributions from the Conservation Committee

Recovery of the Karner Blue (*Plebejus samuelis*) in the Albany Pine Bush Preserve, Albany, NY

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Recovery is the goal for all species listed as threatened or endangered with extinction, but to date no Lepidoptera have been removed from the federal endangered species list (**https://ecos.fws.gov/ecp/report/species-delisted**) due to recovery. The task is often complicated by incomplete knowledge of a species' ecology, ongoing and emerging threats, and limited financial and logistical resources necessary to protect and restore degraded ecosystems (Tear 1995). Examples of successfully pulling a species, or even individual populations of a listed species, back from the brink of extinction are therefore something to herald and study. The successful recovery of the Karner blue (*Plebejus samuelis*) at the Albany Pine Bush Preserve in eastern NY, is one such example. Like a small blue phoenix, its literal rise from the ashes is a remarkable story of renewed ecological vitality that offers inspiration for similar successes of other rare Lepidoptera.

The Karner blue is a small (22–24 mm), non-migratory butterfly of oak savannas in the upper Midwest and pine barrens in the northeastern United States (Fig. 1). The caterpillars feed exclusively on the leaves of wild blue lupine (*Lupinus perennis*), a shade-intolerant perennial wildflower. The species' annual cycle spans two generations or broods. The first emerges in May/June to mate and lay eggs during their short (< 7 days) life span; the second brood emerges in July to mate and lay eggs that overwinter until the following spring (Schweitzer et al. 2011). Karner blues persist within a given landscape as metapopulations (i.e., groups of connected subpopulations) in which individuals occupy or abandon patches of habitat as their suitability changes following disturbance. Wildland fire, grazing, and dry soil conditions historically maintained Karner blue habitat (USFWS 2003).

Figure 1, top: An adult male Karner blue and its only known larval food source, wild lupine (*Lupinus perennis*); bottom: habitat in the Albany Pine Bush Preserve, Albany NY.

The decline of the Karner blue typifies the plight of many 20th century wildlife populations and was a symptom of declining ecosystem health. The loss, fragmentation, and degradation of the oak savanna and pine barrens ecosystems resulted in a 99% decline in Karner blue abundance and distribution since the 1970s (USFWS 2003). Due to its rapid decline in New York, the New York State Department of Environmental Conservation (NYSDEC) listed the Karner blue as endangered in 1977. As the species continued to decline across its range, the United States Fish and Wildlife Service (USWFS) listed it as endangered in 1992. As part of

the federal Karner blue recovery plan (USFWS 2003), the USFWS established 13 recovery units in six states, one of which is the Glacial Lake Albany (GLA) recovery unit in eastern NY. Within GLA, there are four state recovery areas that each support remnant Karner blue metapopulations: Saratoga Sandplains, Saratoga West, Queensbury, and the Albany Pine Bush. Whereas the USFWS requires the restoration of viable metapopulations in three of the state recovery areas for the species to be delisted, the NYSDEC recommends viable metapopulations in all four areas of the state for delisting.

The Albany Pine Bush Preserve is an urban preserve sandwiched between the cities of Albany and Schenectady, NY that protects a 1,400-ha remnant of a northeastern interior pine barrens; it is also the type locality for the Karner blue (Fig. 2). This ecosystem once encompassed more than 10,000 ha (Barnes 2003). Paralleling patterns in the species' range-wide habitat decline, the barrens here suffered significant loss, fragmentation, and degradation from human development, fire suppression, and invasive species (APBPC 2017). The resulting contemporary landscape includes a mix of remnant barrens and non-barrens ecological communities. Remnant barrens communities include the globally rare pitch pine-scrub oak barrens, pitch pine-oak forests, and successional northern sandplain grasslands (NYNHP 2020).

Given the loss and deterioration of the barrens, recovery of the Karner blue in the Albany Pine Bush has depended on the acquisition and restoration of degraded barrens, the establishment of suitable Karner blue habitat within the barrens, and the reintroduction of key ecological processes, especially wildland fire. To this end, preserve managers worked with state and federal recovery teams and academic partners to define suitable Karner blue habitat, implement ecosystem management strategies, and conduct monitoring to gauge progress (APBPC 2017).

Suitable Karner blue habitat requires ≥ 2,000 lupine stems per ha, ≥ 4 species of adult nectar plants per brood, and 5–30 percent tree and shrub cover (USFWS 2003, APBPC 2017). At the time of its listing in 1992, there were fewer than a dozen sites, supporting < 6 ha of suitable habitat in the Albany Pine Bush. To meet recovery criteria here we needed at least 130 ha of suitable habitat distributed across five or more subpopulations (APBPC 2017). Restoring the barrens to achieve this goal involved thinning 990 ha of native and non-native forest and mowing and thinning 148 ha of scrub oak thickets. Depending on site conditions, we applied dormant- or growing-season prescribed fire alone and in combination with these other techniques on 550 ha. Finally, we seeded lupine and other locally derived native plants across 280 ha of the preserve. We continue to employ these methods as we expand ecosystem restoration and Karner blue habitat to additional areas of the preserve.

Restoring habitat was only the first stage of Karner blue recovery. Karner blues still needed to colonize newly restored sites in sufficient number to establish viable subpopulations - a highly improbable task for a low-vagility and short-lived butterfly in a landscape fragmented by barriers of pavement and forest. We accelerated the colonization of restored habitat through a captive rearing and release program in collaboration with the New Hampshire Fish and Game Department. During each year of the program (2008-2015), we provided them 20 presumed-gravid, first brood females from the preserve and other nearby sites; they returned pupae to us that we cared for until adults eclosed and could be released. Over this time, we released 7,868 Karner blue butterflies at 27 sites. These

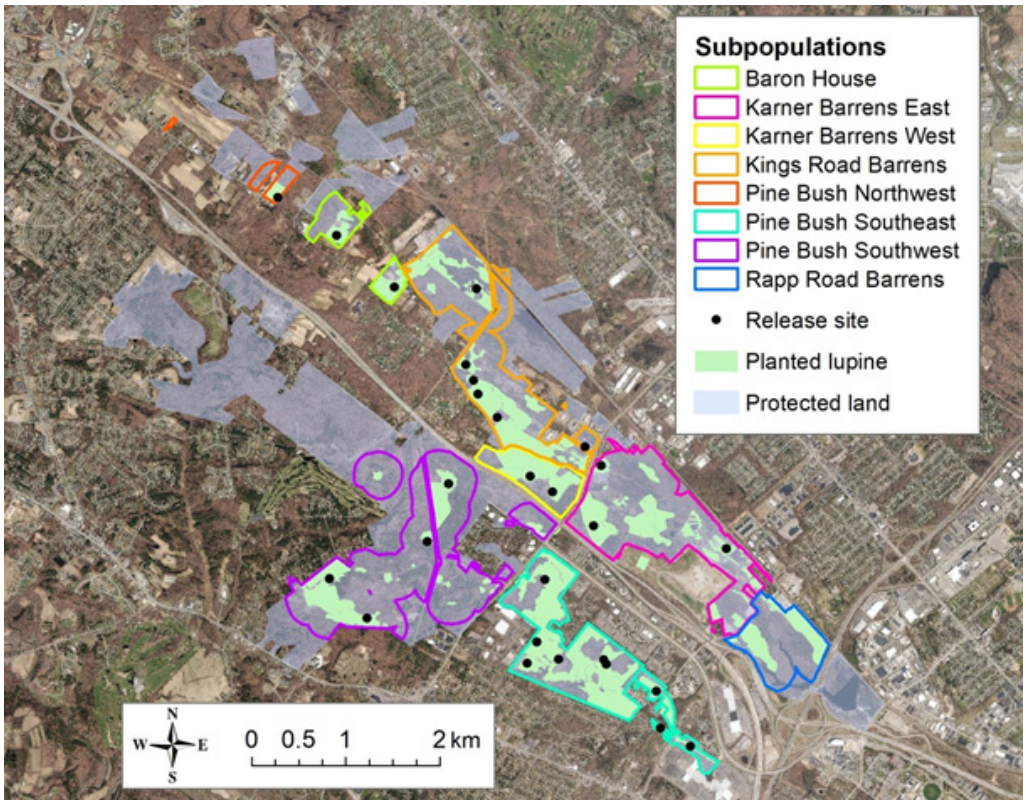

Figure 2. Areas in the Albany Pine Bush Preserve planted with lupine and other native species between 1995 and 2019. Hundreds of butterflies were released in restored areas between 2008 and 2015. Karner blue habitat patches are grouped into subpopulations based on their proximity (< 200 m) to each other and their location relative to geographic barriers such as roads.

efforts facilitated the colonization of nearly all areas of lupine planted across the preserve (Fig. 2). We suspended accelerated colonization in 2015, when it appeared that butterflies were established in numerous sections of the preserve and colonizing new sites on their own.

From 1992 to 2006 we used butterfly counts along meandering transects as an index of population size and change. In 2007, we began using distance sampling in conjunction with insect population curves to produce rigorous estimates of brood size (i.e., the cumulative number of butterflies that emerge within a brood). The resulting estimates can be compared to federal and state recovery criteria. In years when there are enough observations, we also estimate brood sizes of individual subpopulations (Fig. 2).

The results of our efforts exceeded expectations (Fig. 3). Prior to 2007, we suspected population size to be only several hundred butterflies in the best years. Brood sizes grew consistently between 2007 and 2015, with the first brood increasing from an estimated 700 to 14,600 butterflies and the second brood increasing from an estimated 850 to 18,700 butterflies. First and second brood sizes fluctuated around 6,000 and 12,000 butterflies respectively between 2015 and 2019, before increasing sharply to 46,100 butterflies during the 2020 second brood. Over this time, we have also increased the distribution of the butterfly from one to eight subpopulations. The most recent survey year documents the eighth consecutive year that the metapopulation exceeded the recovery threshold established by USFWS and NYSDEC for the Albany Pine Bush recovery area, i.e., 3,000 adults in either the first or the second brood (Fig. 3). Similarly, brood sizes have exceeded the target we set (7,640 adults) to ensure that the number of butterflies in the preserve remains above regulatory minimums in the worst years. Additionally, annual brood size estimates are conservative since they only apply to the small portions of the restored areas that we surveyed. For example, in 2020 we surveyed 13% of the 280 ha known to contain Karner blues (Fig. 2) in the preserve.

Observed trends are likely a result of a complex combination of biotic and abiotic factors. First, the amount of vegetation in successional stages that are most favorable for the Karner blue varies annually. Habitat quality at any given site is in constant flux as conditions transition from relatively low quality immediately after management, to high quality after 1–3 years of regeneration, and then again to lower quality as sites become overgrown (Fig. 4). Second, seasonal weather differentially affects Karner blue life stages (survival, growth, and fecundity) which determine the magnitude of between-brood changes and ultimately the sizes of each brood (Bristow 2017; Fig. 3). The interplay between biotic and abiotic factors appears to have been particularly important in 2020. Through ecosystem restoration we provided suitable habitat such that when the weather was favorable the metapopulation was able to increase rapidly.

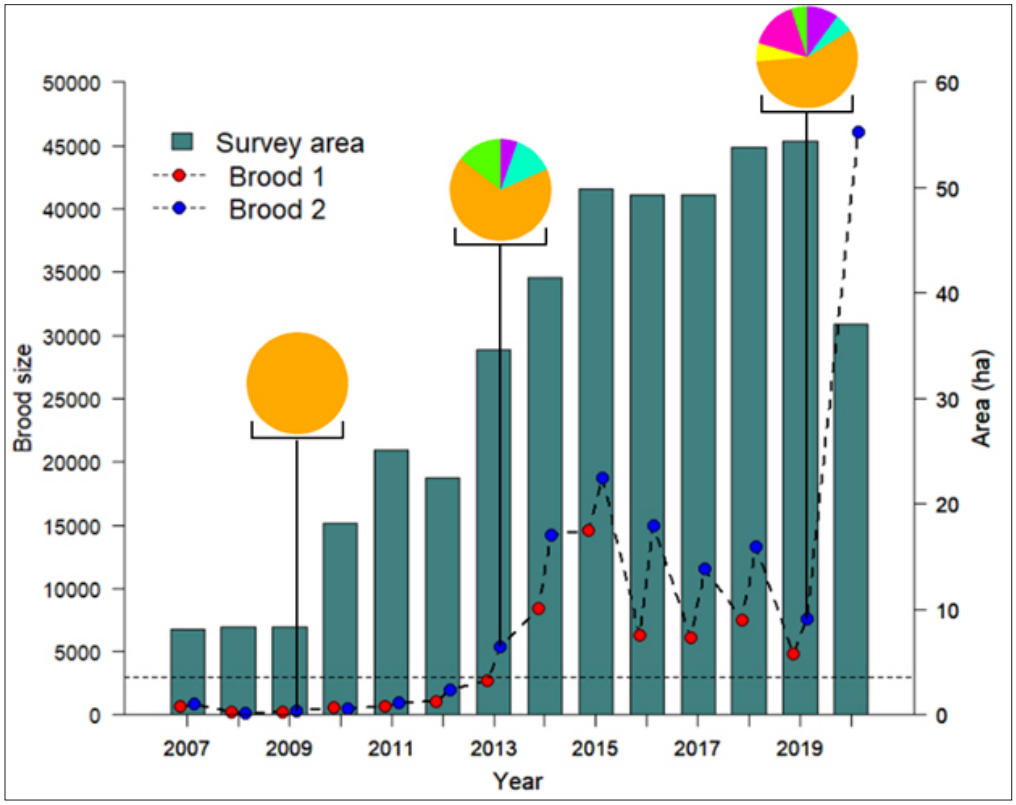

Figure 3. Brood size estimates of adult Karner blues in the Albany Pine Bush Preserve and the relative contributions of subpopulations to a subset of second broods, 2007-2020. Dashed horizontal line represents the state and federal recovery criteria (i.e., 3000 butterflies in the first or second brood). Colors in subpopulation pie charts correspond to those in Fig 2.

The recovery of the Karner blue in the Albany Pine Bush Preserve has been inspiring. It is surreal to walk through acres of dense lupine in high-quality barrens and see hundreds of endangered butterflies, when only a decade ago much of the area was overgrown and the butterflies dangerously close to extirpation. The recovery has also been instructive. Monitoring Karner blues has helped us understand that the understory of "high-quality" pitch pine-scrub oak barrens is not characterized by thickets of scrub oak, but rather by an open grassy shrubland, where scrub oaks, New Jersey tea (*Ceanothus americana*), heaths (*Vaccinium*, *Gaylusacia*, and *Kalmia*), and other dwarf shrubs are distributed among a matrix of prairie grasses (*Andropogon* and *Sorghastrum*) and

Figure 4. Patches of lupine remain unburned following a growing-season prescribed fire in the Albany Pine Bush Preserve. Such patches serve as refugia for Karner blues as the vegetation in the surrounding areas regrows.

wildflowers (*Lupinus*, *Lespedeza*, *Monarda*, *Asclepias*, *Viola*, and *Lillium*); and that these conditions have proven favorable to other rare plants and animals, among them nine Lepidoptera, including the frosted elfin (*Callophyrus irus*), mottled duskywing (*Erynnis martialis*), and inland barrens buckmoth (*Hemileuca maia maia*). We have improved our knowledge of how to combine pyric, mechanical, and chemical tools to achieve desired effects. Experience has taught us how growing season prescribed fires can produce mosaics, frequently burning around lupine patches, which serve as effective refugia for Karner blues within burn units (Fig. 4). We have witnessed how fire diversifies the phenology, quantity and quality of lupine, with obvious benefits for Karner blues. Lupine experiencing fire in the growing season resprouts, flowers, and persists until a killing frost, while unburned mature lupine plants senesce in mid-summer. Working with our partners in New Hampshire, we also learned that feeding Karner blue larvae lupine from burned sites can increase fecundity.

We have also come to appreciate that education and outreach is essential to implementing highly visible and somewhat controversial management techniques in an urban preserve. We share information with tens of thousands of preserve neighbors annually by mail, on our website (**www.albanypinebush.org**), on portable roadside billboards, on social media (Facebook, Twitter and YouTube), and through television, radio and print news. We also engage people in guided and self-guided recreation, education, and volunteer opportunities. Cornell University's Center for Conservation Social Sciences found that doing so has helped us build an informed public that is not only less likely to oppose our work but also willing to support its continuation (Naiman et al. 2018).

Although the Karner blue metapopulation at the Albany Pine Bush Preserve has exceeded all regulatory recovery criteria, its stability and long-term future remains uncertain. Invasive species and climate change will continue to challenge our conservation successes. We will therefore need to continue to enlarge and diversify the metapopulation by protecting and managing additional lands. Monitoring will also continue to be critical to evaluating how population size compares to recovery criteria and to investigating how biotic and abiotic factors affect metapopulation dynamics. In the near term, we can relate changes in metapopulation size to changes in habitat (e.g., management and succession) and weather. Understanding the influence of these factors will help us ensure that metapopulation size remains above the minimum recovery thresholds. In the long-term, we can also begin to examine the effects of climate change on important aspects of the species' phenology and use this information to adapt our management as the species advances toward viability in the 12 other recovery units across its historic range. Delisting the species appears more possible than ever before.

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