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Planning Butterfly Habitat Restorations

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Introduction

Ecologists and entomologists in Britain and the United States have participated in numerous projects aimed at restoring, expanding, and mitigating losses of habitat for native butterflies. Some of these butterflies have been listed as threatened or endangered; others have been lost or are in decline in certain portions of their former ranges. The experiences and observations of these scientists illustrate potential needs and concerns when planning to restore or improve existing butterfly habitat. This paper will relate several cases in which complex biotic and abiotic interactions played important roles in the success or failure of butterfly habitat restoration and the reestablishment of butterfly populations.

Although each butterfly species has its own unique combination of habitat requirements and life history, some fundamental principles concerning butterfly biology (New 1991) are significant in planning habitat restorations. Most caterpillars are herbivores, and many are specialists which feed on only one kind or a few related kinds of plants. Therefore, the presence of appropriate larval host plants is the primary requirement of habitat restoration. In addition, many butterfly species require that the larval food plant be in a particular growth stage, of a certain height, exposed to the proper amount of sunlight, or in close proximity to another resource.

Adults typically utilize a wider range of plants or other resources as food, and flight gives them expanded mobility. However, adult dispersal ability varies from species to species. For some, physical features such as a few meters of open space, a stream, a hedge, or a change in gradient create intrinsic barriers to dispersal; other species routinely migrate long distances. Species with greater levels of mobility form "loose" or "open" populations with indistinct boundaries. Such a species may have a wide, relatively continuous geographic dispersion and may be considered rare if found in low density within its range.

In contrast, as many as 85 percent of butterflies in temperate regions may form "tight" or "closed" populations, discrete colonies with distinct geographic boundaries (New 1991). Closed populations may be restricted to particular geological formations, soil types which support characteristic vegetation, or an early successional stage of vegetation. These colonies are often part of "metapopulations," groups of local populations which occupy distinct habitat patches and interact through small-scale movement between colonies. Within a cluster of these habitat patches, a metapopulation can survive for many years, as long as the habitat remains suitable. Extinction of one colony will be offset by recolonization from another. However, when closed populations become isolated due to habitat degradation or fragmentation, they become more vulnerable to locally variable conditions and environmental changes. Also, the adaptive ability of an isolated population may be decreased as the gene pool is no longer refreshed by immigration. Low dispersal ability may then lead to species extinction.

Butterflies, like many other insects, are uniquely adapted to precise, fine-scaled environmental conditions. Meeting these subtle environmental requirements, often indiscernible to the human observer, is essential to restoring habitat for butterflies in human-dominated landscapes.

<u>Intensive Woodland Management: The Heath Fritillary</u>

The heath fritillary, *Mellicta athalia*, is a small brown, orange, and white butterfly that lives in sunny woodland clearings in southern England. Such clearings were a common feature of the English countryside for hundreds of years due to the practice of coppicing woodlands (harvesting wooded areas for fence posts and allowing trees to regrow from their bases). Within cleared areas, herbaceous plants, including common cow weed (*Melanpyrum pratense*), the main food plant of the heath fritillary, flourished for a few years (Warren 1987a). These woodlands were cut on 5 to 20 year rotation cycles. By the time one clearing was shaded and overgrown, another had been cut nearby, allowing the butterflies, which have a limited flight range, to move to a new, suitable location (Warren 1987c).

Because its dependence on the earliest stages of woodland succession was not initially understood, some populations of the heath fritillary died out in nature reserves which had been set aside but allowed to return to woodland. The butterfly became one of Britain's rarest species, with only 31 known colonies in 1980 (Chinery 1989). In order to create more habitat for the heath fritillary, coppice management was restored in 3 wooded areas in the 1980s. Because even narrow areas of unsuitable vegetation will restrict their movements (Warren 1987b), a network of wide paths was cut in each area to make it easier for the butterflies to move from one clearing to another. The creation of these clearings and paths proved to be an extremely successful intervention. In one area, the Blean Woods National Nature Reserve in Kent, the adult population of heath fritillaries went from a few individuals to almost 2,000 in only four years. However, the resumption of coppicing has inherent limitations: woodlands suitable for coppicing are rare in modern times, and the practice is time-consuming and costly (Pullin 1996).

<u>Understanding Complex Life Cycles: The Large Blue</u>

The large blue butterfly, *Maculinea arion*, became extinct in Britain in 1979. *M. arion* was one of five European species of *Maculinea*, a genus which became well-known in Europe because of its attractiveness, its rarity, and its unusual life history (Thomas 1995b). Britain's large blue lived in warm, dry grasslands, where the female butterfly laid a single egg on a flower bud of wild thyme (*Thymus praecox*). After hatching, the larva would eat the flowers and seeds for two or three weeks, then fall to the ground on the evening of its final molt and wait to be discovered by a red ant (*Myrmica sabuleti*). The butterfly larva (hereafter referred to as a caterpillar) produced a secretion and exhibited behavior which convinced the ant that the caterpillar was an escaped ant larva. The *M. sabuleti* worker ant then carried the caterpillar into the ant nest, where the caterpillar fed on ant eggs and grubs (Heath et al. 1984). The caterpillar spent eleven months in the ant nest, where it hibernated, resumed feeding, pupated, and crawled to the surface to expand its wings.

The large blue has been studied in Britain since the late 1800s when disappearance of some populations was first reported. Although the butterflies' unique relationship with red ants was discovered in 1915, what conservationists did not know until the late 1970s is that each species of *Maculinea* butterfly requires adoption by a different species of *Myrmica* host ant. Up to eight *Myrmica* species may forage under the food plants, and all will adopt the caterpillars; however, *Maculinea arion* which were adopted by species other than *M. sabuleti* died or were killed in the nest.

Early efforts to preserve the large blue included the fencing of a nature reserve in the 1920s to protect a large population of the butterflies there from collectors. Unfortunately, fencing this reserve also excluded grazing animals. Unlike all other species of *Myrmica*, *M. sabuleti* is abundant in Britain only on heavily grazed, south-facing sites, and populations of this ant species dwindled on any site where the vegetation was allowed to grow to over 5 centimeters in height (New 1991). Grazing also benefits wild thyme, the larvae's initial food plant, by reducing grass competition. The abundance of wild thyme is not important, but the distribution of this host plant is critical: in order to be found by a *M. sabuleti* worker ant and carried into the ant nest, the caterpillar must be within the foraging range of the ant (2-3 meters from the ant nest) when it falls from the *T. praecox* plant (Thomas 1995b).

For various reasons, grazing declined on many other sites in Britain; because other *Myrmica* species were still present, entomologists did not understand what was happening until it was too late to save Britain's large blue butterfly. Efforts to restore the species using similar European races seem promising (Pullin 1996). Creating habitat for the butterfly requires establishing high densities of *M. sabuleti* and *T. praecox* such that more than 50 percent of the food plants are within foraging range of the ant. Populations of *M. arion* which have been introduced to four such site since 1983 are increasing in accordance with predictive models.

<u>Creating Topographic Diversity: The Bay Checkerspot</u>

The Bay checkerspot (*Euphydryas editha bayensis*) is a threatened species which lives only in patches of native California grassland growing in soils derived from serpentine rock. The sensitivity of Bay checkerspot larvae to seasonal fluctuations in temperature and moisture conditions creates a need for fine-scale topographic variation as a source of microclimatic diversity (Singer 1972; Weiss and Murphy 1990).

Adult Bay checkerspots fly in March or April, as soon as the weather is warm and sunny; cold or wet conditions will significantly delay adult flight. The butterflies lay eggs at the base of the larval food plant, *Plantago erecta.* The eggs hatch in two weeks, and the larvae must feed for two or three weeks before they are large enough to enter summer diapause. Diapause is a state of suppressed development, and the larvae do not feed in this stage. Ideally, larval diapause coincides with the senescence of the host plant, which happens when hot or dry conditions trigger the leaves to drop from *P. erecta*. Senescence is broken when autumn rains stimulate the germination of the host plant. In response to the re-growth of vegetation, larval diapause ends, in late December or January. The larvae resume eating and bask in the sunlight to raise their body temperatures to a suitable range for rapid growth, which is followed by pupation.

Drought conditions cause very early plant senescence; wet, cloudy years will postpone senescence somewhat, but will have a greater impact on the Bay checkerspot by delaying adult flight. Even in moderate weather conditions, if late-emerging adults lay eggs on warm slopes where the host plant will soon drop its leaves, the larvae will starve. Therefore, the butterflies' habitat must include cool, north-facing slopes. However, because of lack of sunlight, the larvae that hatch and feed on north-facing slopes will develop more slowly during the post-diapause phase. The late pupation of these larvae places their offspring in greater risk of starvation in the following year. When warm, south-facing slopes are also available, the post-diapause larvae will migrate over 10 meters per day to reach these areas, where they may attain the adult stage more than one month sooner.

It is possible that the Bay checkerspot, a butterfly with a metapopulation structure, was once one of the most abundant and widespread butterflies in the California Coast Range. Urbanization, overgrazing, and invasion by non-native plants reduced the species to about a dozen colonies by the 1950s. When the Kirby Canyon Sanitary Landfill encroached on the single remaining large population of the Bay checkerspot near Morgan Hill in Santa Clara, California (New 1991), a habitat conservation agreement took the butterflies' complex topographic requirements into account. Initial impacts were minimized by protecting 100 hectares of the most topographically diverse habitat. This protected natural area, away from the landfill, is being managed specifically for the butterfly. As the landfill is completed, the filled area will be restored using stockpiled topsoil, seed collected on site, and contouring of the landfill surface in an attempt to create more butterfly habitat which includes adjacent areas of cool and warm slope exposures. In addition, long term monitoring of butterfly and plant responses will permit fine-tuning and improvement of restoration processes.

Finding the Right Angle: The San Bruno Elfin

On rocky outcroppings of the San Bruno Mountain in San Mateo County, California, grows the succulent plant *Sedum spathulifolium*, the larval food plant of the San Bruno elfin butterfly (*Incisalia mossii bayensis*). *S. spathulifolium* thrives on any cool, rocky slopes of the mountain, and the plant has quickly spread and colonized any north-facing slopes which have been created by road construction or quarrying on the mountain. Another result of road construction and quarrying on San Bruno Mountain has been the disturbance and destruction of habitat areas of the San Bruno elfin butterfly. Although quarrying and construction has increased the abundance of *Sedum* on the mountain, few areas where the plant grows provide suitable habitat for the butterfly.

Most butterflies fly only in sunshine, and the California coast is often covered with dense fog during late spring and summer. In order to avoid the fog, San Bruno elfin adults fly, mate, and lay eggs from late February through March. The combination of the adult butterflies' early emergence and the limitation of *Sedum* to northern exposures severely limits the amount of available habitat for the butterfly. Road cuts and quarry walls which face directly north are covered with *Sedum*, but these surfaces do not receive enough sunshine, particularly in the crucial flight time during February and March, to provide suitable habitat for the butterfly. Slopes which face northwest receive adequate sunshine in the afternoon, but westerly winds create unfavorable flight conditions. Cliffs or trees may increase shading in areas that would be otherwise suitable.

In order to mitigate losses of San Bruno Elfin colonies, both *Sedum* and adult nectar sources must be present in one of the following configurations: steep northeast-facing slopes which receive full sunlight until noon; north-facing slopes with an angle between 10 and 35 degrees in tilt; or northwest-facing slopes which receive direct afternoon sun but are mostly shielded from prevailing afternoon westerly winds (Weiss and Murphy 1990). These restrictions have complicated the process of site selection for proposed mitigation efforts.

East Side Homes and Hilltop Haunts: The Callippe Silverspot

Another strategy for butterflies to evade the fogs of San Bruno Mountain is to keep away from the coastward, western portions of the mountain. Avoiding foggy areas allows the callippe silverspot (*Speyeria callippe callippe*) to fly from May through July in search of its host plant, *Viola pedunculata*, and nectar sources in grasslands on San Bruno Mountain. The callippe silverspot is restricted to sunny north- and east-facing slopes on the mountain on the eastern side of the fog line (a topographic barrier to the fog). Above these slopes, on hilltops and ridges, the male silverspots gather in "mating assemblages", and females fly to the hilltops to choose mates from these groups. Therefore, planning to restore appropriate habitat for the silverspot must include considerations of location, vegetation, aspect, and large-scale topography.

Efforts have been made to revegetate grasslands containing *Viola* in order to increase habitat for the callippe silverspot. Unfortunately, the proposed restoration area was on the west side of the fog line, an area which will be unsuitable except on infrequent clear days during the flight season (Weiss and Murphy 1990).

Discussion

The essential features of butterfly habitat are not always apparent. Many species are restricted in their resource and habitat needs, and even very closely related species may differ substantially in their biology and behavior. As the example of the Large Blue butterfly shows, intensive investigation of insect habitats and life histories can yield complex and surprising results. Few butterflies have been studied so thoroughly.

The term "plagioclimax" can be applied to a vegetation community in which natural succession is halted by continuous management such as cutting, grazing, or fire (Thomas 1995a). Most plagioclimax vegetation consists of a mosaic of microhabitats and microclimates which is essential to butterflies and other insects which are adapted to the early successional environment. Management for butterfly species which inhabit the ephemeral plagioclimax will require ongoing intervention and a continuity of habitat types in close enough proximity to allow colonization. Some butterflies may require different host plants, habitats, or microhabitats in different years or different seasons. The best breeding habitat in a wet year may be different from the best breeding habitat in a dry year, so long-term conservation of these species requires larger areas which incorporate both habitat types (Thomas 1995a).

In Britain, butterfly reserves protect portions of metapopulations and provide habitat refuges from temporarily unsuitable environmental conditions. Habitat patches can then be re-colonized from these refuges, and the creation of habitat "stepping stones" can prevent colonies from becoming isolated. The probability of recolonization of a restored area, within a given time period, is a function of the distance of the restored area from existing populations and the size of each potential source population (Thomas 1995a). It is possible to model this probability, but the accuracy of such a model depends upon knowing vital population parameters, and they are often unknown.

There are numerous instances in which butterflies have become extinct in reserves, some designed primarily for their conservation, because little or no suitable breeding habitat was created or maintained. These examples should serve as an ongoing reminder that even our best-intentioned efforts may be counterproductive if undertaken without thorough scientific study. Specialist butterfly communities can serve as sensitive indicators of vegetation structure and change, and restorations which successfully create habitat for these butterflies will result in unique sites which contribute to the preservation of regional diversity.

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