

Hypotheses Concerning Population Decline and Rarity in Insects

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Abstract — Although numerous insect species are considered "rare," many of them have not been listed as threatened or endangered species. There are numerous hypotheses as to the decline of specific insect populations. Among the most common of these hypotheses include mechanisms of habitat destruction, interactions with introduced species, and overkill or overcollecting. The Oregon Silverspot butterfly, *Speyeria zerene hippolyta*, is a federally threatened species under the Endangered Species Act, listed in 1980. Our work, in conjunction with the Nature Conservancy, the U.S. Forest Service, and independent researchers, has documented a decline in population numbers since the early 1960s. The Oregon Silverspot butterfly is found along the west coast, from San Francisco to southern Washington. In the 1960s, there were 15-20 strong populations recorded. Currently, there are seven to eight populations, with four of them containing fewer than 100 individuals. The current hypothesis for the decline in population numbers is from habitat destruction and fragmentation of original habitat due to development of coastal land, recreational use, and change in habitat management of current habitats. The goal is to understand the behaviors associated with habitat needs and, as a result, to implement effective management plans.

INTRODUCTION

The amount of attention that invertebrates receive from conservationists and governmental agencies compared to that of vertebrates is at least an order of magnitude less, if not more. This is despite the fact that there are far greater number of species of invertebrates than vertebrates. The majority of insect species (the largest class of invertebrates) are not favorably viewed by the public eye. The consensus on insects is that they are "pests" to humans. In direct competition with humans for certain food crops, billions of dollars are spent annually to eradicate local populations of insects. What is forgotten are the benefits humans gain such as pollination and decomposition from insects. However, as New stated in 1991, "The widespread

conceptual barriers to conserving lower animals is gradually being overcome, and many people now admit their importance in natural ecosystems and in maintaining our natural world."

There is one group of insects that has historically escaped this negative image—the butterflies. Butterflies are spectacular insects, often depicting the epitome of nature, wonder, beauty, and tranquility. Because of the popularity of the Lepidoptera, it is no wonder that butterflies have received more attention from conservationists than any other insect taxa.

This paper concentrates on the Oregon Silverspot butterfly, *Speyeria zerene hippolyta* (Lepidoptera: Nymphalidae), which has been on the federal threatened and endangered species list since 1980. This butterfly has seen population declines since the 1960s and is now to the point where extinction of the species is possible within the next decade if appropriate management strategies are not implemented. We discuss the current hypotheses concerning population decline in insects in general and address the probable reasons for the decline of the Oregon Silverspot butterfly.

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LIFE HISTORY OF THE SILVERSPOT

The Oregon Silverspot butterfly is a medium-sized, dark, orange-brown fritillary with black veins and spots on the margins of the upper surface of its wings and bright, metallic silver spots on the side of the hind wings. The larvae are dark, with long spines and have two tan lines running laterally along the dorsal surface. Each line has a row of black patches running parallel to it on the outside (personal observation). The bases of the spines are a straw color which camouflage the larvae in the thatch. The larvae take shelter in dead vegetation when not feeding on *Viola adunca*, the common blue violet, their obligate larval host (Hammond and McCorkle 1984).

The adult female butterfly lays single eggs near the blue violet plant. Females oviposit 200 or more eggs between mid August and mid September. The eggs hatch within two to three weeks, although the time is variable depending on the microhabitat (personal observations). The larvae overwinter as first instars and emerge in the spring to feed. In July, larvae commence feeding and pupate. Adults emerge about two weeks after the beginning of pupation. Males emerge several days before the females, in order to attain proper thermal conditions for successful nectaring and quick maturation and to search and wait for emerging females (McCorkle 1980). Mating takes place within hours of female emergence, but can last through late August, with ovipositioning occurring through September. Eclosion of the adults occurs from early July until early September. The long emergence span appears to be an adaptation to an unpredictable environment (McCorkle 1980).

Currently, the Silverspot is found at seven to eight sites along the Pacific Coast (Fig. 1). The four strongest populations are 1) Bray Point, located eight miles south of Yachats, Oregon 2) Rock Creek, located ten miles south of Yachats, Oregon 3) Cascade Head, located six miles north of Lincoln City, Oregon and 4) Mount Hebo, located 12 miles inland in the Coast Range, south of Tillamook, Oregon. Smaller populations (approximately less than 100 individuals at each site) include 1) Clatsop Plains, located 20 miles south of Astoria, Oregon 2) Camp Rilea, located just north of Clatsop Plains (may be considered one metapopulation) 3) Long Beach, southern Washington and 4) Del Norte, northern California.

REASONS FOR DECLINES

Overcollecting/Overkilling

Because of the threatened status of the Oregon Silverspot butterfly, overcollecting is not a problem since this activity is prohibited by federal law. But for other species of invertebrates, overcollection can pose a serious problem, especially if the species is already considered rare. While recreational collecting has been documented as being a minor factor in the decline of

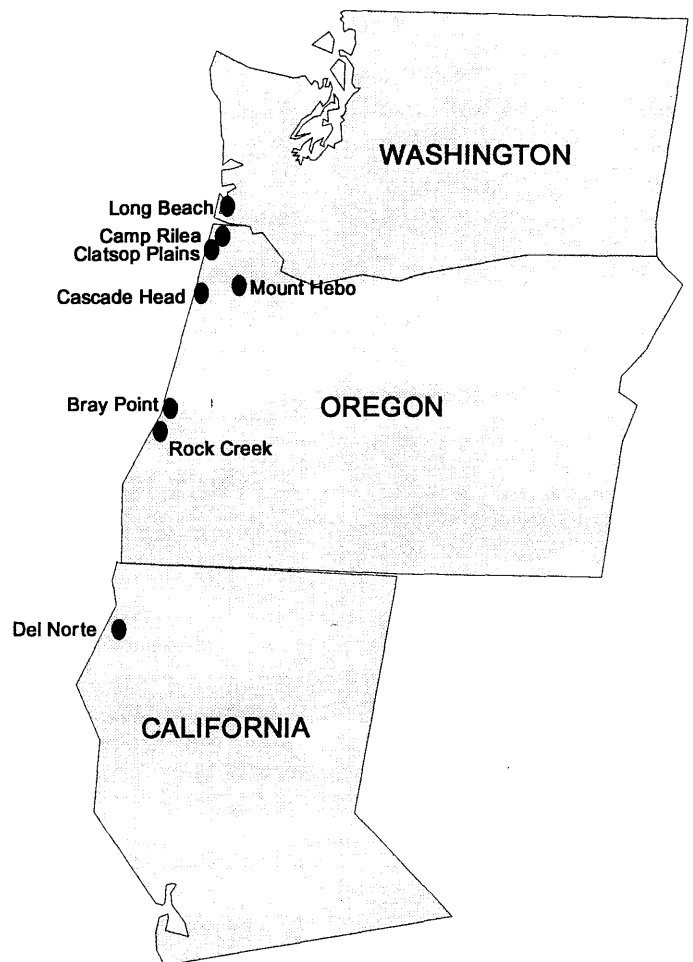


Figure 1. — Current locations of the Oregon Silverspot butterfly along the Pacific Coast.

arthropods (Pyle et al. 1981), commercial exploitation may threaten populations of economically important species, especially species that are already declining due to other reasons, such as habitat destruction. Examples include the tropical birdwing butterfly, which are collected and sold for their beauty (Collins and Morris 1985, New 1991) and female tarantulas due to their unusual body shape and their increased popularity as pets.

For the Silverspot butterfly, other mortality factors which may affect total population numbers do not appear to have a significant impact (Stine 1982). Predators and parasites are known to attack the larvae (McCorkle 1980), but do not appear to pose a significant problem to the Silverspot population as a whole. Birds have been seen eating adult butterflies, and several adults can be spotted with "beak marks" out of their wings (personal observations).

Other factors, such as road kill and insecticides from nearby lands appear to have an insignificant impact on the population, although no statistics are available at this time. Currently, the Oregon Department of Transportation is conducting field surveys on the amount of Silverspot butterflies killed by automobiles at one site, Rock Creek. This site is divided by Interstate Highway 101 and ovipositing females must cross

several times a day. This is discussed further under Habitat Destruction/Fragmentation. This study should provide statistics on the importance of roadkill as a factor affecting this population.

Introduced Species

Introduced Plant Species

The introduction of non-native species, both plant and animal, has been documented as a primary cause of invertebrate extinctions, especially on island communities such as Hawaii. There are over 2,000 species of non-native invertebrates that have successfully established on the islands of Hawaii (Howarth and Medeiros 1989).

For the Oregon Silverspot butterfly, the effect of introduced species on the decline of populations has not been seriously studied. Several species of introduced grasses are evident in the meadows which serve as Silverspot habitat, but their importance on the quality of the habitat is unknown. We can speculate that introduced grass species may have a large impact on the Silverspot (Schaeffer 1992). While it is known that the height of the vegetation in the meadows negatively affects the ability of females to oviposit on the larval host plant, *Viola adunca* (Schaeffer 1992), the types of vegetation present may also be important. Introduced species, such as *Anthoxanthum* sp., can dramatically change the overall vegetation height in the habitat (personal observations).

The impact of other introduced plant species becomes increasingly relevant if the habitat is left unmanaged. The non-native grass species could outcompete the blue violets, making for reduced violet density in the meadows. The elimination of the blue violet, being the only larval host plant, would lead to the local extinction of the butterfly. Sufficient data to support this hypothesis is not available at this time.

Management of the habitat for the introduced plant species (as well as overgrowth of native plant species) can be accomplished by a combination of mowing, slashing, grazing by animals, and burning to control the overgrowth of the meadows (Hammond 1980). A combination of these methods would provide the optimal solution for controlling the vegetation structure, since burning would not effectively control for bracken fern, *Pteridium aquilinum*, but would be the most rapid method for controlling large areas of habitat. Management needs to be site specific as well. For example, at Clatsop Plains, mowing of Scotch broom and reseedling of nectar species is of the utmost importance. However, at Cascade Head, bracken fern growth needs to be controlled, with recommendations including hand pulling and rotational burning (Kiser 1993).

Hammond (1993) reports that violet growth and butterfly numbers greatly increase in response to bracken fern removal. He performed an experiment where one quarter acre plots,

adjacent to one another, were used. One plot had bracken fern removed in a two year treatment, the other was a control. The experimental plot produced 900 blooming violets compared to 21 violets in the control plot (Hammond 1987). Within a few years after treatment, there were ten times more butterflies utilizing the plots with bracken fern removed (Hammond 1993).

Kiser (1993) also reports that butterflies respond favorably to the removal of bracken fern. The females are better able to locate violets in areas of low vegetation height (Schaeffer 1992). Bracken fern inhibits the growth of violets by shading them, allowing more aggressive species to outcompete the violets, eliminating them from the meadows (Kiser 1993).

Hammond (1993) cites that the removal of Salal (*Gaultheria shallon*) and spruce trees (*Picea sitchensis*) made the habitat much more suitable for the Silverspot butterfly by allowing dormant plants and seeds of violets space to bloom. He reports an increase of butterflies utilizing the managed area within three years, giving the meadow sufficient time for succession to occur and give the habitat a natural appearance.

Introduced Animal Species

The effect of introduced animal species on the Silverspot butterfly has not been studied. In other systems, the introduction of non-native animals into a habitat can have adverse effects on the species in question. These effects may include competition for food, shelter, or territory space. Often, introduced animal species, especially vertebrates, can cause fragmentation of an invertebrate's natural habitat. The fragmentation can lead to decreased population size in any one given area, thereby restricting dispersal between the fragmented habitats and breaking up the gene pool. Loss of genetic variation can lead to local declines and possibly extinctions.

The effect of animal species on the Silverspot butterfly needs to be studied in order to determine proper management strategies concerning grazing of habitat. While grazing would positively affect the Silverspot by keeping vegetation heights low, it may negatively affect the survival of larvae by trampling and removal of nectar species. A study to determine the relationship between the positive and negative effects is recommended.

Habitat Destruction/Fragmentation

The degree of extinctions or, at best, population declines of invertebrates can be seen to closely follow patterns of human population growth (Opler 1976, New 1991). The main reason is that people are reducing natural habitats to accommodate human lifestyles, including more housing, more recreation areas, and more farmland (Arnold 1987, New 1991). The reduction and/or fragmentation of these natural habitats is the biggest threat to invertebrate diversity.

Loss of Land

The majority of work on the effects of loss of natural habitat has been done on butterflies in the United Kingdom. C. D. Thomas (1985a) documented that *Plebejus argus*, the silver studded blue, is one of the most rapidly declining species in Northern Britain, already showing a two-thirds reduction in population numbers since 1945. The primary reason for the rapid decline is from habitat loss to accommodate "agricultural 'improvement'" and forestry and urban development (C. D. Thomas 1985a). He further acknowledges the fact that, not only habitat loss but decline of traditional management of the existing habitat is responsible for the decline of the silver studded blue (C. D. Thomas 1985b).

J. A. Thomas (1984) estimated that of the 55 species of resident butterflies in the United Kingdom, 44 of them had declined in population numbers and in number of successful colonies within the past 25 years. Most of these 44 species have declined from habitat loss and lack of management.

The decline of butterfly species as a result of habitat loss is seen in the United States as well. The Palos Verdes blue butterfly, *Glaucopsyche lygdamus palosverdesensis*, has been endangered since 1980. However, habitat destruction by housing or recreational development continued even after listing. No Palos Verdes blues have been spotted since 1983 and very intensive management, including the creation of new sites and restoration of current sites, is needed or this species will become extinct, if not already extinct (Arnold 1987).

Habitat loss is unquestionably the main reason for the threatened status of the Silverspot butterfly. In the 1960s, there were 15-20 stable, viable populations along the Pacific coast, ranging from San Francisco to southern Washington. As prime coastal land began to be developed to make larger cities and resorts along the beach, the natural meadows were being eliminated. This happened at a phenomenal rate to keep up with the demand for ocean-front real estate. Presently there are only seven to eight populations left, with four of these populations containing fewer than 100 individuals. If left unmanaged, these small populations will likely go extinct by the turn of the century.

With only a few populations remaining, being tens of miles apart, there is little or no movement of individuals from one area to the next annually. Each meadow containing Silverspots is virtually an island, with no migration of animals in or out. Thus, it is critical that the remaining habitat be properly managed if we are to sustain viable populations of butterflies there.

The acquisition of new land, to be converted into suitable Silverspot habitat, needs to be seriously considered. More areas of habitat will strengthen the current population of Silverspot butterflies. Since the ultimate goal is to delist the butterfly, land acquisition is of utmost importance.

The problem then becomes, where does this land come from, who will manage it, and how will it be paid for? These questions need to be addressed before any management plan can be accepted. There are also other considerations to be addressed as well (after Eagles 1984):

1. Ecological considerations. This considers the need to emphasize long-term protection over short-term results. Also, studies need to be conducted that incorporate standard criteria and environmental impact assessments.
2. Legal considerations. There must be a balance between landowner's rights and the protection of the Oregon Silverspot butterfly under the Endangered Species Act of 1973. There also needs to be conformation with all local regulations concerning mowing, burning, etc.
3. Political considerations. This considers the acceptability by the city, county, and state governments and the general public to manage lands. It also considers where the monies come from, in what proportion, and how education of the public will commence.

Unsuitable Habitat Areas

Along with the loss of habitat due to development, there is also loss of habitat due to its unsuitability. Personal observations conducted in 1991 at Clatsop Plains indicate that cattle grazing on available nectar sources for the Silverspot may be responsible for the butterfly's limited presence. Part of this site is privately owned, bought for the sole purpose of supporting cattle. Not only do the cattle help keep the vegetation height low, but the cattle eat the flowering species there as well, such as *Senecio jacobae*, *Achillea millefolium*, *Solidago canadensis*, *Hypochaeris radicata*, and *Cirsium edule*. These species represent the majority of nectar sources available to the Silverspot, without which sustainable populations cannot exist. Therefore, meadows without sufficient nectar sources available (or nearby) are deemed as unsuitable.

The change in current management practices also may make parts of current habitat unsuitable. C.D. Thomas (1985b) has shown that the silver studded blue butterfly is declining from lack of traditional management of the remaining sites. If sites are left without proper management, no vegetation exists in "pioneer" condition and the butterfly may be eliminated (C. D. Thomas 1985a). Therefore, active management is required.

Allowing succession to progress in the meadows may be just as deleterious as loss of habitat for the Silverspot butterfly. The Silverspot requires early seral habitat in order to allow for the blue violet, the larval host, to grow and reproduce (Kiser 1993).

If succession is left unchecked, the blue violet may be outcompeted by other species of plants, making for unsuitable habitat for oviposition.

Another way that habitat becomes unsuitable is if barriers prevent animals from crossing over from one part of the habitat to the other. Barriers can be in the form of housing, recreational facilities, ravines, rivers, or roads. For invertebrates, most barriers are not a problem. However, for the Silverspot butterfly, a road can be a major obstacle to overcome, especially if crossing several times a day.

At the Rock Creek site, the habitat is divided into two main areas. The dividing line is Interstate Highway 101. Traffic is heavy on this highway, especially in the summer months when tourists are travelling up and down the coast of Oregon. While there are no statistics on the amount of loss of Silverspot butterflies that cross the road, females must cross at least several times a day when ovipositing. The area to the west of the highway is where most of the violet habitat is found and, consequently, where most of the oviposition events take place; the area to the east is where most nectaring occurs (personal observations). As the population declines, the effect of roadkill may become important enough to cause the local extinction of this population of butterflies, primarily since the females comprise the majority of crossers.

Genetic Problems Due to Fragmentation

Habitat destruction can lead to extinctions by restricting the genetic pool to a small number of individuals. As population sizes decrease as a result of habitat loss, restricted genetic variability and/or catastrophic events can ultimately cause the extinction of these small populations. The question then becomes, how long can small populations persist and is genetics relevant? Even if we can estimate the amount of time that a population can be self-sustainable given the population parameters, this is still not an accurate indicator of the viability time of the population. There are extenuating circumstances that are often overlooked, such as catastrophes or the interplay between population dynamics and the loss of fitness due to genetic drift (Soulé and Mills 1992).

One of the ultimate long-term goals of conservation genetics is to maintain a "minimum viable population" (Gilpin and Soulé 1986) that allows "enough genetic variation so that future adaptation, successful expansion, or reestablishment in natural populations is possible" (Hedrick and Miller 1992). For the Silverspot butterfly, this may mean the rearing of individuals in the laboratory and the reintroduction of larvae and/or adults from lab populations. The transfer of individuals from one population to another, separated by a considerable distance, would allow for additional genetic variation into any one population. At the very least, heterozygosity of Silverspot populations may be kept in the range suitable for maintaining genetic diversity and keeping inbreeding at a minimum.

Further research should focus on determining what the minimum viable population is for the Silverspot as well as delimiting populations from subpopulations. Most of the sites are far enough away to obstruct migration of individuals from one site to the next. But, at Clatsop Plains, there are two populations close enough that they may be working in a source-sink fashion (Kiser 1993). The understanding of the genetic makeup of each population may facilitate determining the placement of new sites and the transfer of individuals from site to site.

CURRENT POPULATION DECLINE OF THE SILVERSPOT

Population censuses have been done on a regular basis for the Oregon Silverspot butterfly for the past few years. Censuses consist of observational records of the number of butterflies counted when walking along a transect. The transect passes through the habitat, not overlapping areas, and butterflies are counted within 15 meters of the transect line in all directions. Data that we present in this paper will include the 1990 and 1991 censuses for Mount Hebo and Cascade Head, the two strongest populations, both conducted between July and October of each year. These data were collected by Kiser and Schaeffer, along with The Nature Conservancy (data are included in The Nature Conservancy 1991, 1992). These sites have vastly different management plans. Cascade Head is a Nature Conservancy preserve with little active management. Mount Hebo has active management, including mowing, slashing, and burning every year.

In Figure 2, the maximum number of butterflies are plotted for each area. As the figure indicates, there was an increase in the number of butterflies seen at Mount Hebo and a decrease in numbers at Cascade Head.

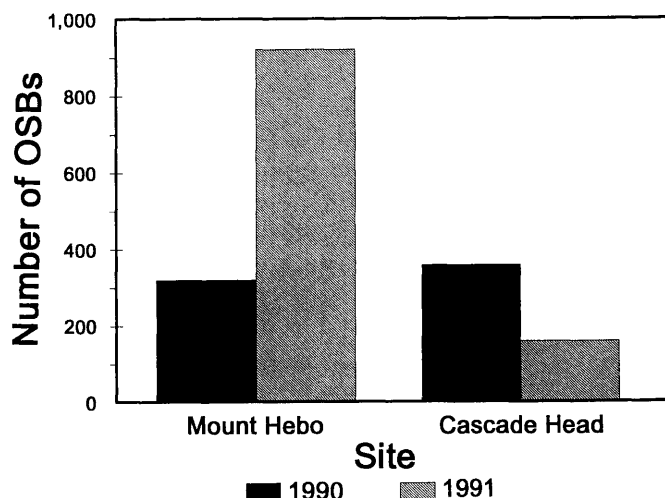


Figure 2. — Oregon Silverspot butterfly (OSB) maximum census counts for the 1990 and 1991 field seasons. Counts are done following a transect line and walking at a rate of 100 meters in 2.5 minutes. Adapted from The Nature Conservancy (1991, 1992).

Figures 3a and 3b represent the complete censuses for the two sites, plotting the number of Silverspot butterflies observed per given day. In Figure 3a, we observed an increase in the number of butterflies seen at Mount Hebo from 1990 to 1991. The peak number of butterflies occurs at around the same time of the year for two consecutive years. In Figure 3b, we observed a decrease in the number of butterflies at Cascade Head from 1990 to 1991.

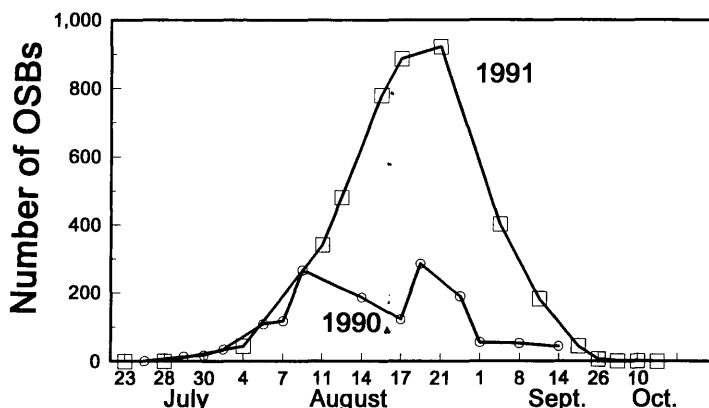


Figure 3a. — Graph of the complete censuses for 1990 and 1991 at Mount Hebo. Each point represents the number of individuals seen on any given day. Counts were done along a transect line. Adapted from The Nature Conservancy (1991, 1992).

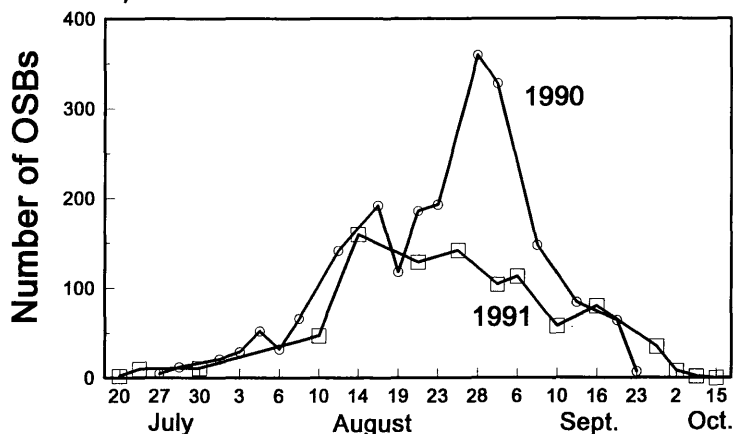


Figure 3b. — Graph of the complete censuses for 1990 and 1991 at Cascade Head. Each point represents the number of individuals seen on any given day. Counts were done along a transect line. Adapted from The Nature Conservancy (1991, 1992).

The discrepancies between sites may be due to the fact that Mount Hebo underwent intensive management in recent years to keep vegetation heights to a minimum and to remove bracken fern. On the other hand, Cascade Head has not had any management implemented in recent years, aside from removal of invading tree species. Cascade Head, being a nature preserve, is protected from grazing, recreational use except on a narrow path, and fires are suppressed as best as possible. Mount Hebo, U. S. Forest Service land, allows visitors to walk in the meadows, implemented mowing recently, and natural burns are not suppressed. If censusing continues in the current manner

under similar conditions, we imagine that the current rate of decline of Silverspots at Cascade Head will continue due to habitat decline.

Weather differences at the two sites may be partially responsible for the discrepancies as well. Mount Hebo's increase in butterfly abundance could be attributed to the fact that the meadows are higher in elevation, often avoiding days of cool, foggy weather. Cascade Head, being along the coast, receives several days of rainy, cool, foggy weather, often occurring during the peak of the flight season (personal observations). Mount Hebo, on the other hand, is often above the fog and in the sunshine, allowing for longer butterfly activity for more days during the flight season (The Nature Conservancy 1992).

RECOMMENDATIONS

Effective management is crucial and urgently needed if we are to reach a goal of removing the Oregon Silverspot butterfly from the endangered species list. This management needs to be done at specific times of the year in order to minimize damage done to eggs, larvae, or pupae. Hammond (1993) in his vegetation management proposal suggests mowing twice a year, leaving vegetation three inches off the ground. The mowings should occur in late fall or spring and then again around the first of June. This would minimize damage to early larvae. More research needs to be done to identify the components needed for the adult and larval stages. Monitoring also needs to follow any management for the effects on the Silverspot populations.

We suggest that active management needs to be undertaken at all sites in a mosaic pattern. This limits the impact on the site as a whole, while creating new patches of early successional habitat required by the violet. Each site is unique and poses different problems in terms of management. For the optimal solution, separate management plans need to be designed at each of the sites.

Along with active management comes changes in management. This topic has been partially discussed so far, but changes need to consider the pooling of resources from all agencies concerned. The Nature Conservancy, the U. S. Forest Service, the U. S. Fish and Wildlife Service, and private organizations need to coordinate their efforts in the best interest of the Silverspot. Monies from these agencies can be combined and additional funding may come in the form of grants. Organization is the key to taking immediate action to implement appropriate management at precise times to prevent further population losses.

To ultimately delist the butterfly, habitat at current sites needs to be improved and new sites, once created, need to be repopulated. With the current low number of highly fragmented, unstable populations, the future looks bleak for the Oregon Silverspot butterfly.

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