Natural history and population ecology of a rare pierid butterfly, 
*Euchloe ausonides insulanus* Guppy and Shepard (Pieridae)

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The island marble butterfly, *Euchloe ausonides insulanus* Guppy and Shepard 2001 (Pieridae) is one of the most restricted butterfly endemics in the continental United States. While much research has been devoted to understanding the species level biology of the large marble, *Euchloe ausonides* Lucas 1852 (Pieridae), relatively little is known about the biology of the subspecies, *E. ausonides insulanus*. This thesis focuses on the biology, natural history and population ecology of *E. ausonides insulanus*. Conservation and management issues related to the biology and population ecology of *E. ausonides insulanus* are discussed in the context of my research findings.

Chapter 1 summarizes the first comprehensive field study of the biology, morphology and behavior of each immature stage (egg, larva and pupa) of *Euchloe ausonides insulanus*. There are many morphological and behavioral similarities between the species (*E. ausonides*) and subspecies (*E. ausonides insulanus*) however, this study revealed several key differences. The most distinct morphological difference between species and subspecies is the coloration and pattern of stripes of larval stages instars III and IV. The white spiracular stripe subtended by yellow-green subspiracular stripe and green-yellow ventral areas are notably different from stripe coloration and pattern described for *E. ausonides*. In addition, the species is known to pupate directly on the host plant whereas *E. ausonides insulanus* larvae will wander up to 4 meters in search of a pupation site. Knowledge of the “wandering” behavior of *E. ausonides insulanus* provides managers with information to design conservation buffers for overwintering pupae.
In Chapter 2, I investigate the relationship between egg-laying patterns and host plants *Brassica rapa* L. var. *rapa*, *Sisymbrium altissimum* L., and *Lepidium virginicum* var. *menziesii* (DC) Hitchc. I have two overall research objectives; 1) I explore how adult biology may influence egg-laying patterns using descriptive studies that focus on adult phenology, mating behavior, egg phenology and egg dispersion and 2) I further explore egg-laying patterns related to host plant traits, density and patch size. My results indicate that females prefer to oviposit on plants that are taller and have a greater number of racemes among all three host plant species. In *B. rapa*, the presence of eggs was also highly dependent on plant phenology. In the host plant density study, egg loads were highest in areas where host plants (*B. rapa* and *S. altissimum*) occurred at low densities. The host plant patch study showed that medium size, moderately dense patches received the highest number of eggs per square meter and that dense (>1 plant/m²) host plant patches received the lowest numbers of eggs per square meter. Understanding the relationship of oviposition site selection to host plant traits and host plant density is important because if *E. ausonides insulanus* preferentially lays eggs on plants of particular size or arrangement (e.g., large plants on the edges of dense host plant patches) then larvae may be limited to such plants. This study aims to help researchers predict the occurrence of eggs and larvae among host plants and host plant patches and design host plant habitat that maximizes oviposition site selection by *E. ausonides insulanus*.

In Chapter 3 I quantify larval survival and mortality that may contribute to the rarity of *E. ausonides insulanus*. This study is the first to provide insights into the key role of immature stages in the demography of *E. ausonides insulanus*. The objectives of this study were to 1) assess whether survivorship differed among the three host plant species (one native and two non-native host plant species), 2) assess which factors cause mortality (e.g., predation and deer herbivory) of immature stages and 3) determine which immature stages (egg, instars I-V larval stages) are most vulnerable to different sources of mortality. My results indicate that high egg mortality on host plants of *B. rapa* and *S. altissimum* was mainly attributed to predation and deer herbivory. Predation was the greatest source of egg and larval mortality throughout the four year study period; 47% of all eggs tracked. Predation by spiders was observed most often although social paper wasps (Family Vespidae, *Polistes* spp.) were also observed to predate on larvae. Deer herbivory reduced *E. ausonides insulanus* abundance by indirectly reducing availability of oviposition sites and by direct consumption.
of eggs and larvae. Over the course of four years of study 26% of all eggs tracked were eaten by deer. This study also showed that the only known native host plant, *L. virginicum* var. *menziesii* supported the highest percent survivorship from the egg stage to larval instar IV but that *L. virginicum* var. *menziesii* habitat was susceptible to offshore storms and tidal flooding that likely contributed to an observed local population extinction of *E. ausonides insulanus* from one research site over the course of the four year study.

In Chapter 4, I explore the use of an alternative native host plant in an effort to enhance prairie remnants to support rare butterfly populations. *Turritis glabra* L., tower mustard, a potential native host plant, was selected for research. This study experimentally tested restoration treatments to foster establishment of *T. glabra* in introduced grasslands, compared plant traits of *T. glabra* and *B. rapa* as they related to *E. ausonides insulanus* oviposition site selection (based on research described in Chapter 2), tested whether *E. ausonides insulanus* would oviposit on *T. glabra* and tested whether *T. glabra* could support egg and larvae development. The findings indicate that *T. glabra* may be a good candidate for native host plant introduction. However, more study is warranted to confirm whether *T. glabra* can support the development of larvae under field conditions. The comparative study indicated that *T. glabra* was significantly shorter in height that *B. rapa* and may have contributed to the low number of eggs observed on *T. glabra* in areas of *B. rapa*. I also found that the establishment of *T. glabra* requires disturbance and seed input and that the exclusion of deer may be necessary to the long-term establishment of *T. glabra*.

Finally, in Chapter 5, I discuss key ecological issues related to the conservation and management of *E. ausonides insulanus* including potential impacts of climate change, host plant patches dynamics, disturbance, topographic and habitat heterogeneity and significant mortality factors that likely contribute to overall population abundance. Numerous processes can lead to extinction and many of the processes discussed in this thesis (e.g., disturbance, host plant availability etc.) can operate at different temporal and spatial scales. My findings show that a combination of factors likely influence overall low population numbers and local population extinctions related to patch dynamics in *E. ausonides insulanus*. Thus, managers should consider multiple management strategies to maintain and increase abundance of *E. ausonides insulanus* at American Camp including further experimental research to better understand the ecological mechanisms that contribute to overall population abundance.