PETITION TO LIST

The island marble butterfly, *Euchloe ausonides insulanus* (Guppy & Shepard, 2001)

AS AN ENDANGERED SPECIES

UNDER THE U.S. ENDANGERED SPECIES ACT

Island marble butterfly adult. Photograph by Robert Michael Pyle, used with permission.

Prepared by

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The Xerces Society for Invertebrate Conservation

Submitted by

The Xerces Society for Invertebrate Conservation

August 22, 2012

The Honorable Ken Salazar

Secretary of the Interior

Office of the Secretary

Department of the Interior

1849 C Street N.W.

Washington D.C., 20240

Dear Secretary Salazar:

The Xerces Society hereby formally petitions the U.S. Fish and Wildlife Service (USFWS) to list the island marble butterfly, *Euchloe ausonides insulanus*, as endangered pursuant to the Endangered Species Act (ESA), 16 U.S.C. § 1531 *et seq*. This petition is filed under 5 U.S.C. § 553(e), 16 U.S.C. § 1533(b)(3), and 50 C.F.R. § 424.14 (1990), which grants interested parties the right to petition for issuance of a rule from the Secretary of the Interior. Petitioners also request that critical habitat be designated concurrent with the listing, as required by 16 U.S.C. § 1533(b)(6)(C) and 50 C.F.R. § 424.12, and pursuant to the Administrative Procedure Act (5 U.S.C. § 553). Due to the threat of extinction and because of its small population size, restricted distribution, and the numerous factors threatening the species and its remaining habitat, we request an emergency listing and emergency critical habitat designation pursuant to 16 U.S.C. § 1533(b)(7) and 50 C.F.R.§ 424.20. While the species is emergency listed, the U.S. Fish and Wildlife Service should finalize a standard listing rule for the island marble butterfly.

Island marble is among the most imperiled North American butterflies, already extirpated from Canada and known in the United States from just two small islands (San Juan and Lopez) in northwest Washington. Serious threats to island marble and its habitat exist at all island marble sites, including host plant removal and mowing, deer grazing, agricultural disturbance, herbicide use and other management activities, and other natural and anthropogenic threats. Although this species was petitioned for ESA listing in 2002 and received a negative 12-month finding from the USFWS in 2006, a substantial amount of research and monitoring has occurred since that time. This new information shows that this butterfly clearly meets the criteria of an endangered species under the ESA. Extensive annual surveys since 1998 have confirmed that island marble is limited in distribution to just San Juan and Lopez Islands. A total of 52 sites have been documented, representing an estimated five populations, the largest of which is centered on San Juan Island National Historic Park (SJINHP) and surrounding area. Despite the efforts of many agencies working to conserve and protect this rare butterfly and its status as a “conservation priority” for the U.S. Fish and Wildlife Service (SJINHP & USFWS 2006), the island marble continues to lose habitat each year and the vast majority of sites that were previously occupied no longer support this butterfly. As of 2011, the island marble has been confirmed at just six of 12 previously occupied sites within SJINHP, and just two of 40 previously occupied sites outside of SJINHP (Potter 2012, *unpublished data,* Weaver 2012, *pers. comm.*). All of these sites are in close proximity on southern San Juan Island, resulting in just one confirmed population of island marble. In addition to declines in extant populations and occupied sites, steep abundance declines have been recorded in core occupied areas in recent years, resulting in greater than 70% reduction in island marble encounters at several key sites. Paralleling these declines, the island marble has undergone significant habitat loss throughout its range, and is subjected to numerous threats at all sites, including deer herbivory, mowing and removal of host plants, agricultural practices that are not compatible with island marble, improperly-timed management practices, prairie succession to forest, invasive species, and other natural and anthropogenic threats. According to Potter *et al.* (2011), the combined factors of (1) a small number of individuals, (2) restricted range, (3) distribution limited to a few sites, (4) apparent limited connectivity between sites, (5) decreasing habitat, (6) recent reduction in number of extant populations and occupied patches, (7) minimal efforts underway to increase or enhance habitat, and (8) ongoing threats, indicate that this narrowly endemic butterfly is highly imperiled and in imminent danger of extinction. As such, the island marble butterfly should be granted immediate protection under the Endangered Species Act.

For all the reasons provided in our petition, listing of the island marble butterfly and designation of its critical habitat is warranted under 5 U.S.C. § 553(e), 16 U.S.C. § 1533(b)(3), and 50 C.F.R. § 424.14. Emergency listing is also warranted to protect the species pending completion of the final listing rule.

We are aware that this petition sets in motion a specific process placing definite response requirements on the U.S. Fish and Wildlife Service and very specific time constraints upon those responses. 16 U.S.C. § 1533(b). We will therefore expect a finding by the Service within 90 days, as to whether our petition contains substantial information to warrant a full status review. 16 U.S.C. § 1533(b)(3)(A).

Sincerely,

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The Xerces Society is a nonprofit organization that protects wildlife through the conservation of invertebrates and their habitat. Established in 1971, the Society is at the forefront of invertebrate protection worldwide, harnessing the knowledge of scientists and the enthusiasm of citizens to implement conservation programs.

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I. **EXECUTIVE SUMMARY**

The island marble butterfly, *Euchloe ausonides insulanus,* has a remarkable history in that it is one of the few species in the world that was rediscovered long after it was thought to be extinct (Lambert 2011). Since its rediscovery in 1998 (Fleckenstein & Potter 1999), extensive searches have established that this extremely rare butterfly is present on just two small islands (San Juan and Lopez) in the San Juan Archipelago in northwest Washington, making it one of the most restricted endemic butterflies in the continental United States (SJINHP & USFWS 2006). Annual surveys from 1998 to 2011 have identified 52 island marble sites representing five populations on the two islands. Over the past few years, however, it has become clear that the majority of sites that were previously occupied by island marble no longer support this butterfly, and only one population is currently confirmed extant (Potter 2012, *unpublished data*). As of 2011, just two of the 40 sites outside of San Juan Island National Historic Park (SJINHP) and six of the 12 sites within the Park were confirmed extant (Potter 2012, *pers. comm.,* Weaver 2012, *pers. comm.*). Even relatively large subpopulations are being quickly lost; for example, the population at one site outside the park was estimated at 75 to 111 adults in 2008 (Peterson 2009), and has since declined to the point that its presence could not be confirmed at the site in 2011 (Potter 2012, *unpublished data*). Within the core population at SJINHP, annual transect counts at sixteen transects from 2004 to 2008 revealed a decline from 270 total adults in 2004 to just 63 adults in 2008 (Lambert 2011). Monitoring has continued at three of these transects in recent years, two of which have exhibited greater than 70% decline in island marble adult encounter rate between 2004 and 2011 (Lambert 2011, Peterson 2009, 2010, Weaver 2012, *pers. comm.*).

Serious threats to island marble and its habitat exist at all island marble sites. On private land, island marble is threatened by herbicide use, mowing, and removal of host plants, as well as by outright destruction of habitat due to development or landscaping (Miskelly 2005, Miskelly & Fleckenstein 2007, Miskelly & Potter 2009, Hanson *et al.* 2009, Hanson *et al.* 2010, Potter *et al.* 2011, Potter 2012, *pers. comm.*). Additionally, island marble is threatened by large-scale soil-disturbing agricultural practices which result in the growth of significant patches of mustard host plants that are subsequently destroyed by tilling or harvesting. Rather than being beneficial to or compatible with the island marble by increasing host plants (as asserted by USFWS 2006), these host plant flushes often act as ecological traps, attracting island marble adults (and subsequent eggs), but not persisting long enough to provide eggs and larvae a chance of surviving to adulthood (Hanson *et al.* 2010). Grazing by deer and livestock poses another threat on private land as these animals selectively browse on the inflorescences of island marble host plants, inadvertently consuming island marble eggs and larvae along with the host plant (Lambert 2011, Potter *et al.* 2011). On public land, the butterfly is threatened primarily by deer grazing, storm tides, prairie succession to forest, global climate change, and improperly timed management activities, including herbicide use and prescribed burns that have occurred within core island marble habitat during island marble flight period on multiple occasions, causing direct damage to island marble larvae and hosts plants (Miskelly 2005, Potter *et al.* 2011). These stressors, in combination with the species' limited range, and limited dispersal ability collectively threaten this rare and remarkable butterfly with extinction. The island marble should be given immediate protection under the Endangered Species Act ("ESA").

II. CANDIDATE BACKGROUND, STATUS, AND LISTING HISTORY

The island marble butterfly (*Euchloe ausonides insulanus* Guppy & Shepard 2001) was originally known from fourteen specimens collected on Vancouver and nearby islands in southwestern British Columbia, Canada between 1861 and 1908. It was believed to be extinct (extirpated from historically known locations) until it was discovered in 1998 on San Juan Island, marking the first observation of this subspecies in 90 years, as well as the first record of its occurrence in the United States. On December 10th, 2002, a petition to emergency list this butterfly as an endangered species was filed by The Xerces Society, Center for Biological Diversity, Friends of the San Juans, and Northwest Ecosystem Alliance, citing the butterfly's limited geographic distribution, small population size, narrow habitat requirements, and numerous current and potential threats (Black & Vaughan 2002). On March 13th, 2006, the 90-day finding for this butterfly reported that the petition presented substantial information to indicate that listing may be warranted (USFWS 2006). The 12-month finding, however, reported that ESA listing was not warranted, citing the butterfly's reliance on non-native, disturbance-associated mustards, the lack of significant threats (e.g., "only 18% of habitat is threatened long term, while the remaining 82% is subjected to short-term threats that are compatible with sustaining the species long term"), and the butterfly's apparent ability to persist on San Juan and Lopez Islands for many years (the past century) without management (USFWS 2006).

In the years following the 12-month finding, a significant amount of island marble survey and research work has greatly increased our understanding of this butterfly's life history, habitat requirements, abundance, distribution, current status, and threats (Miskelly & Fleckenstein 2007, Lambert 2008, Miskelly & Potter 2009, Hanson *et al.* 2009, 2010, Potter *et al.* 2011, Potter, *pers. comm.* 2012). As such, several assertions in the 12-month finding are now well-known to be incorrect, for example, contrary to USFWS (2006), island marble survival is *not* compatible with agricultural disturbance (Hanson *et al.* 2010), invertebrate predation *is* a significant threat (Lambert 2011, Hanson *et al.* 2010), deer browsing *is* at a level that significantly affects the butterflies (Lambert 2011), and storm tide damage *does* result in long-term population loss (Lambert 2011). Additionally, a decade of island marble monitoring has produced substantial evidence of island marble declines that was not available when this butterfly was first petitioned for ESA listing in 2002. Overall, this petition contains a significant amount of new information demonstrating that the island marble butterfly warrants ESA protection.

The island marble butterfly currently receives no federal protection apart from collection restrictions on federal land. At the state level, Washington State has designated the island marble as a candidate species, but this designation does not provide any additional protection for the island marble or its habitat, apart from further collection restrictions on both private and public land (collection is prohibited without a state permit) (WDFW 2012). There are currently no other federal, state, county, or local regulations that can be applied to directly protect the island marble or its habitat. Island marble is designated as globally Critically Imperiled (T1) by NatureServe (2012), but this designation does not provide protection to the butterfly.

In 2006, a conservation agreement and strategy was developed by USFWS and SJINHP for the purpose of "helping ensure the long-term continued existence of the island marble butterfly and contributing to its recovery" at American Camp (SJINHP & USFWS 2006). This conservation agreement articulates several goals, including developing a monitoring plan for assessing the response of the island marble and its host plants to management actions. The agreement also provides a number of management suggestions pertaining to island marble. According to the 12-month finding, this conservation agreement did not influence the decision not to list this subspecies, nor was any other conservation action mentioned in the 12-month finding as influencing the decision not to list. However, email correspondence between agency staff a few weeks later implies otherwise. It was stated, for example, that "we did not list [island marble] partially due to conservation actions/agreements," and "the not-warranted [finding] was largely based on NPS and others efforts contributing to the conservation of the butterfly." (USFWS F.O.I.A. 2006). Island marble was also considered appropriate for inclusion in a list of species for which listing was made unnecessary due to conservation efforts (e.g., agreements/actions by the agency), even given the stipulation that conservation efforts for these species must be "substantial enough that 'but for' the conservation efforts, [USFWS] probably would have concluded that listing was warranted" (USFWS F.O.I.A. 2006). Regardless of the ambiguous role of the conservation agreement or other unidentified conservation action in the decision not to list island marble in 2006, the butterfly has only continued to decline in abundance, occupied sites, and population number in the years since, underscoring the inadequacy of existing regulations and conservation efforts to protect this butterfly. As discussed in Section D of this petition (The inadequacy of existing regulatory mechanisms), the conservation agreement between SJINHP and USFWS does not provide island marble with adequate protection at the American Camp sites in the Park and provides no protection for the butterfly across the rest of its range.

III. SPECIES DESCRIPTION

The island marble (*Euchloe ausonides insulanus*) is a member of the family Pieridae, subfamily Pierinae, commonly known as the whites and marbles (Pyle 2002). It is a subspecies of the *Euchloe ausonides* species, commonly known as the large marble, and the largest marble butterfly in North America (Guppy & Shepard 2001). At the species level, *E. ausonides* is a whitish butterfly with greenish-yellow marbling ventrally, and sparse black markings, dorsally. The marbled pattern on the ventral wings characterizes the species (Guppy & Shepard 2001). Ventrally, both the hindwing and forewing are crossed by roving yellow-green marbling that crosses the yellow veins (Guppy & Shepard 2001, Pyle 2002). Marbling occurs in large patches with equally large white patches between them (Guppy & Shepard 2011). The dorsal wings of *E. ausonides* are creamy white with a black pattern on the forewing tip and a thin black rectangle in the dorsal forewing cell which is lightly white-scaled in the middle (Guppy & Shepard 2001, Pyle 2002). In females, the white of the hindwings is frequently tinged with yellow, while the forewings remain pure white (Guppy & Shepard 2001).

The island marble, *E. ausonides insulanus,* is genetically isolated from all other *E. ausonides* subspecies and is morphologically distinct (Guppy & Shepard 2001, Pyle 2002, 2004). With a wingspan of ~45mm, it is larger than the other subspecies and also differs in wing pattern (Guppy & Shepard 2001, Lambert 2011). The most easily recognized trait is the greatly expanded marbling on the ventral hindwing, which is frequently strongly suffused with yellow scales and hairs (Guppy & Shepard 2001). This expansion and yellowing of markings also occurs on the ventral apical and subapical forewing. Additionally, the dark markings of the dorsal forewing are expanded and the wing bases are heavily suffused with black scaling (shadowed) (Guppy & Shepard 2001, Pyle 2004). In the immature stages, the most distinct morphological difference between island marble and other *E. ausonides* subspecies is the coloration and pattern of stripes of larvae in instars III and IV (Lambert 2011). The white spiracular stripe subtended by yellow-green subspiracular stripe and green-yellow ventral areas are notably different from the stripe coloration and pattern described for *E. ausonides* (Lambert 2011).

Island marble eggs are approximately 1 mm in height, columnar shaped, and have approximately 15 vertical ridges that adjoin at the top of the egg (Lambert 2011). Eggs are initially greenish-white in color but develop an orange tint in 24 – 48 hours, and continue to change color with development, from bright orange to deep red to brown. Orange-red is the predominant color phase. In the final stages of development prior to hatching, black coloration (the head of the developing larva) appears at the distal end of the egg (Lambert 2011). Island marble eggs are very similar to the eggs of Sara's orangetip (*Anthocharis sara*), but can be distinguished by subtle differences in appearance and placement on the host plant (Potter 2012, *pers. comm.*).

Newly emerged, first instar island marble larvae are golden-yellow in color with a distinct black head (Lambert 2011). Prior to molting, they become dark grey-brown and hirsute. The mean length of first-instar larvae is 2 mm. Second instar larvae have a golden-yellowish-green body with a black head; larvae become darker in color prior to molting. The mean length of second-instar larvae is 5 mm. Primary setae (hairs) and pinaculae (flat hardened plates on the surface of the skin from which hair grows) become more visible in the second instar. In the third instar, grey-green and yellow-green stripes are visible on dorsal and subdorsal areas of the body. Early third-instar larvae have a greenish head that is larger or proportional to the width of the body, while late third-instar larvae have a brownish head that is smaller than the width of the body. The color white surrounds the spiracles, and yellow-green subspiracular stripes are visible on the lower sides of the body. Setae and pinaculae are easily recognizable in the field at this stage in development. The mean length of third-instar larvae is 9 mm. In the fourth-instar larva, the coloration is the same as third-instar although the white area surrounding the spiracles is more developed and appears as a distinct white stripe along the lower side of the body. Pinaculae are also more prominent and easily recognizable in the field. The mean length of fourth-instar larva is 16 mm. Fifth-instar larvae are substantially larger in size and stripes are bold in color compared to fourth-instar larvae. Stripes are solid grey and yellow in the dorsal and subdorsal area, followed by a thin light-grey supraspiracular stripe and well-defined white spiracular stripe. Early fifth-instar larvae have disproportionately large, bulbous heads in comparison to the width of the body. The mean length of fifth-instar larvae is 26 mm. Island marble pupae are pale brown, long, slender and tapered to a point. Pupal length is approximately 17- 20 mm. Pupae are cryptically colored during the winter and resemble the stems of senescent vegetation (Lambert 2011).

IV. TAXONOMY

The island marble (*Euchloe ausonides insulanus*) is a subspecies of the large marble, *Euchloe ausonides.* Although only recently described, the island marble was long recognized as distinct, listed as "*Euchloe ausonides*, unnamed subspecies" (*e.g.*, Shepard 1995, Layberry *et al.* 1998, Shepard 2000) until its formal description in 2001 (Guppy & Shepard 2001). The subspecies epithet *insulanus* is Latin for islander, in reference to the island locations of all historical and modern populations (Guppy & Shepard 2001). All populations of *Euchloe a. insulanus* are insular, geographically isolated from other subspecies of *E. ausonides* by both oceanic and continental geography (Shepard 2000, Lambert 2011). San Juan and Lopez Islands contain the only *E. ausonides* populations (*i.e.*, island marble) west of the Washington Cascade Mountains (Lambert 2011). The subspecies description cites numerous morphological characters unique to the island marble (Guppy & Shepard 2001). As such, the island marble is recognized as "a distinctive subspecies in complete genetic isolation" (Pyle 2004) and the taxonomic status is accepted as valid and is uncontested (Pelham 2008). In addition to morphological distinctions, Lambert (2011) suggests a possible behavioral difference between the island marble and the rest of the *E. ausonides* species; in other *E. ausonides* subspecies, pupation occurs directly on the host plant, while in island marble, pupation has not been observed on the host plant, but rather, larvae have been observed to engage in a "wandering" phase prior to pupation, wandering up to 4 meters in search of a non-host plant pupation site. Molecular work to examine the taxonomic placement of the island marble with regard to other *Euchloe ausonides* subspecies is in the early stages of development (Potter 2012, *pers. comm.*).

V. POPULATION DISTRIBUTION AND STATUS

A. Historic distribution

This taxon was historically known solely from Vancouver Island and Gabriola Island in the Gulf of Georgia, British Columbia (Guppy & Shepard 2001). Records on Vancouver Island are from Nanaimo in the north, southward along the eastern edge of the island to Beacon Hill Park, Victoria (Shepard 2000). Fourteen historic specimens collected between 1861 and 1908 are known to exist, all of which represent collections of single specimens (Shepard 2000). The butterfly was recorded only at lower elevations and was apparently rare, but may have been locally common at some sites (Miskelly 2000). It was not recognized as endangered prior to its extirpation in Canada (Shepard 2000). Having not been seen at historic sites since 1908, this butterfly was believed to be globally extinct for many years (Pyle 2002).

B. Current distribution

In May 1998, 90 years after the last specimen was collected in Canada, the island marble was discovered on San Juan Island at American Camp, San Juan Island National Historic Park (SJINHP). Presence/absence surveys have occurred annually since 1998, resulting in surveys at over 150 distinct sites in six counties of coastal NW Washington, including potential habitat on over 16 islands and the adjacent mainland (Pyle 2004, Miskelly 2005, Miskelly & Fleckenstein 2006, Miskelly & Potter 2009, Hanson *et al.* 2009, Hanson *et al.* 2010, Potter *et al.* 2011, Potter 2012, *unpublished data*). These surveys have clearly delineated the distribution of the Island Marble and demonstrated that the island marble occurs in only a few populations on San Juan Island and the neighboring Lopez Island (Figure 1, Peterson 2010). The other islands in the archipelago, including Orcas, Shaw, Waldron, Stuart, Decatur, and Henry have very little potential habitat and are considered adequately surveyed (Miskelly & Fleckenstein 2007, Potter 2012 *pers. comm.*).

In all, island marble has been observed at total of 52 sites on San Juan and Lopez Islands, including twelve sites within the American Camp Unit of SJINHP, and 40 sites outside of the Park. In 2006, following NatureServe guidelines, all sites where the island marble had been observed to date were assigned to five populations: three on San Juan Island, and two on Lopez Island (Miskelly & Fleckenstein 2007, USFWS 2006). Since that time, one additional population was located on San Juan Island (Miskelly & Potter 2009), and it was concluded that the Lopez Island sites represent just one population, resulting in a total of five known populations to date (Potter 2012, *pers. comm.*). Most of these populations are either extirpated or persisting in very low (undetected) numbers; as of 2011, only one population is confirmed extant (Potter 2012, *unpublished data*). The location and current status of each population is presented below.

<u>San Juan Island</u>

1) **Southern San Juan Island population,** located on lands managed by the National Park Service (NPS), Bureau of Land Management (BLM), San Juan County, Washington Department of Natural Resources (WDNR), private lands managed as rural farm and forest, and private lands managed as rural residential that are relatively highly developed. <u>Population status</u>: considered the core island marble population; confirmed extant as of 2011 although the number of occupied sites and number of individuals have declined from previous years. As of 2011, only 8 of the 28 documented sites representing this population are confirmed extant (Tables 1 & 2, Weaver 2012, *pers. comm.,* Potter *et al.* 2011, Potter 2012 *unpublished data*).

2) **San Juan Valley population,** located on private lands managed for agricultural resources. Population status: island marble habitat and host plants have decreased in the area, and the number of occupied sites and number of individuals have declined from previous years. None of the eight sites representing this population are currently confirmed to support this species, but since permission was not granted to access two sites that supported relatively high numbers of island marble in the past, there is a possibility that this population is extant (Table 2, Potter *et al.* 2011, Potter 2012 *unpublished data*).

3) **Northwest San Juan Island population**, located on private land managed as rural farm and forest. Population status: presumed extirpated, island marble has not been observed at the one documented site since 2006, despite comprehensive surveys (Table 2, Miskelly & Fleckenstein 2007, Miskelly & Potter 2009, Hanson *et al.* 2009, 2010, Potter *et al.* 2011, Potter 2012 *unpublished data*).

4) **Pear Point population**, located on lands managed by San Juan County and private residential land within the Friday Harbor city limits. Population status: may persist in low numbers or is possibly extirpated. Four of the five sites were occupied in 2009, just one in 2010, and island marble was not confirmed at any of the sites in 2011 (Table 2). Eggs may have been detected at one site but identification was uncertain (Potter *et al.* 2011, Potter 2012 *unpublished data*).

Lopez Island

5) **South and Central Lopez Island population**, located on private lands and lands owned by the Lopez Island School District, managed as rural farm and forest and rural residential. Population status: persists in very low numbers or possibly extirpated; number of occupied sites and number of individuals less than in previous years; island marble was not confirmed at any of the 10 known sites in 2011; one potential island marble egg was detected at one site but identification was uncertain (Potter *et al.* 2011, Potter 2012 *unpublished data*).

Population size: The largest population (American Camp) produces a few hundred adults in some years, however the other colonies are at best a few dozen, and some are probably too small to persist as independent units (NatureServe 2012). In 2009, a review by NatureServe (2012) estimated the global population size of this butterfly at 250 to 2050, stating that it appeared very unlikely that the known sites totaled over 1000 adults in recent years. Since that time, the butterfly has continued to decline in both the number of occupied sites and in abundance at occupied sites. Currently, the entire island marble population is estimated at just 200 to 400 individuals (Potter 2012, *pers. comm.*), based on recent survey efforts (Hanson *et al.* 2009, 2010, Potter *et al.* 2011, Potter 2012, *unpublished data*) and subpopulation estimates that have been completed for some sites (Peterson 2009, 2010).

Since the island marble was rediscovered in 1998, a variety of monitoring methods have been employed to answer questions relating to its distribution, abundance, and dispersal (*reviewed in* Peterson 2010). These studies, including (1) patch occupancy surveys, (2) transect counts, and (3) mark-release-recapture studies have provided a substantial amount of evidence that both the number of sites (Hanson *et al.* 2010, Potter *et al.* 2011, Potter 2012, *pers. comm.*) and number of individuals (Lambert 2011, Potter 2012, *unpublished data*) are declining with time, and that dispersal is highly limited in this subspecies (Peterson 2009). The results of these three categories of monitoring are summarized below.

C. Population status: Patch occupancy (presence/absence) surveys

Presence/absence surveys involving careful searches of habitat for egg, larval, and adult island marbles have been conducted annually in known or suspected island marble habitat since the butterfly's discovery at American Camp in 1998 (Pyle 2004, Miskelly 2005, Miskelly & Fleckenstein 2007, Miskelly & Potter 2009, Hanson *et al.* 2009, 2010, Potter *et al.* 2011, Potter 2012, *unpublished data*). Surveys have been conducted primarily by the Washington Department of Fish and Wildlife (WDFW) working in cooperation with site landowners, which are mostly private, but also include the National Park Service, BLM, DNR, and San Juan County. In general, these surveys have utilized a patch occupancy approach in which surveys are designed to determine occupancy of a site, while also recording observed abundances of adults, larvae, and eggs (Pyle 2004, Miskelly 2005, Miskelly & Fleckenstein 2007, Miskelly & Potter 2009, Hanson *et al.* 2009, 2010, Potter *et al.* 2011, Potter 2012 *unpublished data*). Adult surveys were performed when temperature, wind speed, sunlight and time of day were appropriate, following standards developed by Pollard (1977), and many sites were visited on multiple dates in a given year. In all years, survey effort has included both known and new sites, including unsurveyed sites and sites which had been previously surveyed but not found to be occupied. In recent years, WDFW's survey efforts have focused on monitoring habitat patches where the butterfly has been found in the last six years to determine if the habitat and butterfly are still extant. Monitoring patch occupancy (*i.e.* patterns of presence/absence), in addition to within-patch abundance, is very important for species that occur in networks of habitat patches because reductions in patch occupancy can trigger the collapse of an entire metapopulation (Peterson 2010). Results of island marble patch occupancy surveys are presented by survey year, below.

From 1998-2004, about 100 sites were surveyed for island marble in the San Juan Islands and surrounding area (Miskelly & Fleckenstein 2007). No new sites were found, although surveys around the known site resulted in slight expansion of the area known to be used by the butterfly (Pyle 2004, Fleckenstein & Potter 1999).

In 2005, survey effort for island marble intensified; 225 surveys were conducted at 110 sites with suitable habitat in six coastal northwest Washington counties (Clallum, Island, Jefferson, San Juan, Skagit, and Whatcom) (Miskelly 2005). Island marble was discovered on Lopez Island, and detected at 23 sites on San Juan and Lopez Island combined (Tables 1 & 2). On San Juan Island, all but two sites were in a continuous block surrounding the American Camp unit of San Juan Island National Historic Park (SJINHP) (Miskelly 2005). In total, 90 adults, 195 larvae, and 207 eggs were detected during these surveys.

In 2006, 146 surveys on 72 sites (including known and new) were conducted (Miskelly & Fleckenstein 2007). Island marble was found at 16 sites, including two sites in new areas (San Juan Valley area, and Richardson community on Lopez) (Tables 1 & 2). Island marble was not found (in any life stage) at two sites that had been occupied in 2005, and low numbers of individuals were observed at most sites (*e.g.*, one or two adults or larvae). The exception was the Twigg-Smith Easement in the San Juan Valley, where 21 adults were recorded on one survey day (Miskelly & Fleckenstein 2007). In total, 82 island marble adults, 16 larvae, and 44 eggs were detected during 2006 surveys.

In 2007, 147 surveys were conducted at 58 sites on San Juan and Lopez Islands, including known sites, unsurveyed sites, and suitable sites that had been surveyed with no detections (Miskelly & Potter 2009). Island marble was detected at eight of 27 new survey locations, only one of which had significant numbers (Pear Point Gravel Pit: 3 adults, 21 larvae, 14 eggs). Eight sites previously occupied by island marble had no detections in 2007 including three sites that had encounters in both 2005 and 2006 (Miskelly & Potter

2009) (Tables 1 & 2). The number of adults this year was very low, with consistently fewer butterflies at known occupied sites than in prior years. A total of 64 adults, 62 larvae, and 213 eggs were detected during 2007 surveys (Miskelly & Potter 2009).

In 2008, a total of 153 surveys for island marble were conducted at 53 sites (Hanson *et al.* 2009). Twenty-six of the 31 previously identified island marble sites located outside of San Juan Island National Historic Park were surveyed, and island marble was detected at 14 (54%) (Table 2). Within San Juan Island National Historic Park, three of the 12 known island marble sites were visited, and island marble was found at just one site (Table 1). Island marble was found at four of 25 new sites, although all four of these sites were immediately adjacent to known sites, and in each case only a single adult was found (no significant new occupied areas were discovered). No adults were found during surveys on Lopez Island, although the presence of larvae and eggs confirmed that the species persisted there, at least in small numbers. Island marble was not found (in any life stage) at 15 sites where it had been previously detected, including seven sites where it had been previously detected during multiple years (Tables 1 & 2). The number of island marble adults, eggs, and larvae encountered during 2008 surveys was even lower than in 2007, with consistently fewer observations at known occupied sites than in prior years (Hanson *et al.* 2009). A total of 30 adults, 38 larvae, and 134 eggs were detected during surveys.

In 2009, 146 surveys for island marble were conducted at 53 sites (Hanson *et al.* 2010). Twenty-eight of the 35 sites where island marble had previously been detected outside of SJINHP were surveyed, and island marble was detected at just 10 of these sites (36%) (Table 2). Within SJINHP, six of the 12 known island marble sites were surveyed, and island marble was detected at three (50%) (Table 1). Island marble was found at three of 25 new sites, all of which were in the immediate vicinity of the Pear Point Gravel Pit (no significant new occupied areas were discovered) (Table 2). As in 2008, no adults were found during surveys on Lopez Island, although the presence of larvae and eggs confirmed that the species persisted there, at least in small numbers at one site (Sweetbriar Farm). No signs of island marble were found at 22 previously occupied sites, including 9 sites where the butterfly had been detected during multiple years (Tables 1 & 2). The number of island marble adults, eggs, and larvae encountered during 2009 surveys was low, resembling results from 2008, but a marked reduction from the 2005-2007 period. A total of 37 adults, 68 larvae, and 246 eggs were recorded during the 2009 surveys (Hanson *et al.* 2010).

In 2010, a total of 119 surveys were conducted at 50 sites (Potter *et al.* 2011). Twenty-four of the 39 sites where island marble had previously been found outside of SJINHP were surveyed, and island marble was detected at only 8 (33%) (Table 2). Survey visits were made at six of 12 known island marble sites within SJINHP and the butterfly was detected at four (67%) (Table 1). Eleven of the 50 searched sites were previously unsurveyed; island marble eggs and larvae were detected at one of these, a new site in a previously occupied area on Lopez Island. Island marble was not found at 18 sites where it had previously been detected, including 9 sites (located across all four population regions) where detections had spanned multiple years (Tables 1 & 2). These numbers do not include an additional eight documented island marble sites that were not surveyed because recent landscaping, weed control, or the construction of new buildings eliminated or severely limited appropriate conditions for the butterfly. Island marble was not observed in the San Juan Valley this year: 10 of the 12 sites in this area were surveyed without detection, including five previously-occupied sites; however, the landowner of two consistently occupied San Juan Valley sites (Twigg-Smith North and South) declined permission to conduct surveys this year. Again, the number of island marble adults, eggs, and larvae encountered during 2010 surveys was low, resembling results from 2008 and 2009 but a marked reduction from the 2005-2007 period. At the Pear Point gravel pit, island marble occurred in remarkably low numbers relative to prior years; only one egg and larva and a handful of adults were detected. No adults were observed on Lopez Island, although low numbers of eggs and larvae were found at three sites. In all, only 35 adults were observed during 2010 surveys and only ten of those were found outside of the American Camp unit of SJINHP. In addition to adults, a total of 32 larvae and 67 eggs were detected.

In 2011, 18 sites which had been occupied in prior years were selected for island marble survey, based on habitat availability, occupancy patterns of previous years, and landowner permission (Table 2, Potter 2012, *unpublished data*). At an additional eight previously-occupied sites, the area known to be used by island marble was inspected from the road, but surveys were not conducted due to lack of access, and/or a significant or complete loss of island marble habitat due to agriculture or other factors (Table 2). A few new patches of potential island marble habitat were also searched. Of the 18 previously occupied sites with full surveys, island marble eggs, larvae, or adults were detected at just five (28%) (Tables 1 & 2, Potter 2012, *unpublished data*). Of the 13 sites located outside of SJINHP, island marble was found at just two sites (15%), both of which are in close proximity to SJINHP sites and belong to the same population (Table 2). Within SJINHP, 10 visits at five sites revealed island marble at three sites. (Additional occupancy and abundance data for SJINHP in 2011 was gathered by the National Park Service (NPS), discussed under Transect Counts, below.) At the additional eight "roadside inspection" sites, no island marble adults were observed, and very little to no habitat was present (see legend in Table 2). Likewise, island marble was not detected at any of the new sites. No island marble larvae or adults were found on Lopez Island this year. Two eggs may have been present, although they were unable to be conclusively identified (the eggs appeared to be Sara's orangetip, but not conclusive; no island marble larvae were observed on subsequent visits). Similarly, two additional sites on San Juan Island revealed only inconclusive sightings of one to three unidentifiable eggs. Again, the number of island marble adults, eggs, and larvae encountered during 2011 surveys was low. At one of the sites outside SJINHP (Eagle Cove Park), just 2 adults were observed despite four visits during appropriate adult flight conditions. At the other site (Olympic Lights Bed and Breakfast), four larvae and one egg were observed, although the landowner stated that the entire area occupied by the eggs and larvae is regularly mowed, suggesting that this is by no means a secure island marble site, and may not even be accurately designated as "occupied", since mowing is lethal to island marble immatures (Potter 2012, *pers. comm.*). Within SJINHP, two adults were seen at each of two sites, and 37 to 42 adults were recorded at the third site. In total, ~46 adults, four larvae, and one egg were observed at SJINHP and non-SJINHP sites, combined.

Overall, patch occupancy surveys have clearly demonstrated a decline in the number of sites occupied by the island marble, the number of island marble adults, larvae, and eggs observed, and the number of suitable island marble of habitat patches (Tables 1 and 2, Hanson *et al.* 2010, Potter *et al.* 2011, Potter 2012, *unpublished data*). Over the past 15 years of surveys, island marble has been found at a total of 52 sites in five populations. As of 2011, only eight of these sites in just one population are confirmed by either WDFW or NPS surveys to support this butterfly, including the regularly mowed (*i.e.*, highly inhospitable) site described above (Tables 1 and 2, Hanson *et al.* 2010, Potter *et al.* 2011, Potter 2012, *unpublished data*, Weaver 2012, *pers. comm.*). Each year, the percentage of previously or newly-occupied sites surveyed that are currently occupied has declined, from 96% in 2005 to 28% in 2011 (Figure 2). Abundance values detected in patch occupancy surveys have gone from 90 adults in 2005 to about half that number in 2011 (Miskelly 2005, Potter 2012, *unpublished data*). Paralleling these declines, surveyors have recorded reduction or elimination of suitable habitat for this butterfly at almost all sites (Table 5, legend in Table 2). While statistical analyses of annual changes observed during these surveys aren't possible due to constraints of the patch occupancy study design, the very drastic declines in island marble sites, habitat, and observations in recent years are clear, and warrant serious attention (Hanson *et al.* 2010, Potter *et al.* 2011, Potter 2012, *unpublished data*).

D. Population status: Transect count surveys

In addition to the WDFW presence/absence surveys described above, Amy Lambert (University of Washington) conducted transect count surveys annually from 2004 to 2008 at a selection of sites within the American Camp unit of SJINHP (Lambert 2008, 2011). These surveys utilized set transects to monitor relative adult abundance over time, following methods outlined by Pollard and Yates (1993). A total of 16 200 m transects were established through many different habitats, including introduced grassland, remnant prairie, sand dune and tidal lagoon habitat (Figure 3, Table 3). Transect surveys occurred under appropriate conditions for butterfly activity (>14°C, <12mph wind speed, and relatively low cloud cover) every six to nine days throughout the adult flight period (Lambert 2011). As such, the number of butterflies observed on transects provides a measure of presence/absence of adults occurring in different habitats at American Camp as well as general trends in the abundance of adults over the study period (2004−2008) (Lambert 2008, 2011).

A steep decline in total numbers of adults was observed from 2004−2008 (Table 3, Figure 4). In 2004, 270 adults were counted on transects compared to just 63 in 2008, indicating a downward trend in relative adult abundance from 2004−2008 (Table 3, Figure 4). Additionally, a downward trend in peak abundance was recorded from 2004-2008. Eighty-four adults were observed at peak abundance in 2004, compared to just 15 in 2007 and 23 in 2008 (Lambert 2011).

Since the conclusion of Amy Lambert's research at American Camp in 2008, the National Park Service (NPS) has continued annual transect counts at three core occupied American Camp sites (Slope South of Redoubt, Dunes, West End Uplands) (Peterson 2009, 2010, Weaver 2012, *pers. comm.*). The transects at these sites are the same as those originally established by Lambert to cover the main host plant patches at American Camp, and *remain* the primary host plant patches at American Camp (*i.e.,* island marble habitat has not drifted away from the transect locations over time) (Potter 2012, *pers. comm.*). Transects were 200m in length in 2008 and 2009 (the same length as Lambert's transects), and 400m in 2010. The NPS surveys were designed to be comparable with those conducted by Lambert (2011), however, rather than Lambert's ~weekly surveys, NPS surveys occurred daily throughout the flight period in 2008, 2009, and 2011, and 10 times over a 22 day period in 2010 (Peterson 2010, Weaver 2012, *pers. comm.*). Since transect length and visitation frequency varied over the eight-year period, Peterson (2010) reports island marble **encounter rates** (transect counts divided by transect length and number of visits, Table 4) rather than raw transect count data as reported by Lambert (Table 3). In order to compare the encounter rates reported by Peterson (2009, 2010) with the transect count data from earlier years (Lambert 2011), we converted the transect count totals reported in Lambert (2011) into encounter rates using 200m transect lengths and the specific number of site visits provided by Lambert (2012, *pers. comm*.) (Table 4). Of the three sites where transect count monitoring has continued since 2008, two of these (Slope South of Redoubt and West End Uplands) have experienced steep abundance declines over the eight-year period, resulting in greater than 70% reduction in island marble encounters between 2004 and 2011 (Table 4, Lambert 2011, Peterson 2009, 2010, Weaver 2012, *pers. comm.*). The greatest decline at the Slope South of Redoubt site occurred over a one year period between 2004 and 2005, and encounters in recent years have increased relative to all-time lows in 2005 and 2007 (Table 4). Still, recent encounter rates at this site are dramatically lower than were observed in 2004 (Table 4). At the West End Uplands site, encounter rates have gradually declined over the eight-year period to an all-time low in 2011, when only nine individuals were observed (Weaver 2012, *pers.*

comm.). Encounter rates at the remaining site (Dunes) have remained relatively stable over the eight year period, with the highest encounters in 2005 and the lowest in 2008 (Table 4).

Overall, eight years of transect count surveys at the core island marble population in American Camp have shown a complete loss of island marble at several previously occupied sites, as well as dramatic abundance declines at all but one site (Lambert 2011, Peterson 2009, 2010, Weaver 2012, *pers. comm.*). As of 2011, only six of the 12 previously occupied sites at American Camp are confirmed to remain extant by WDFW or NPS surveys, and only three of these sites are known to have relatively substantial numbers of adults (Slope South of Redoubt, Dunes, and Redoubt, Table 1). Daily monitoring of three sites in 2011 over 26 survey days recorded a total of 79 adults at the Slope South of Redoubt site (zero to 15 per day, average: 4.2), 87 adults at the Dunes site (zero to 13 per day, average: 4.4), and nine adults at the West End Uplands site (0 to 3 per day, average: 0.6) (Weaver 2012, *pers. comm.*). Many of these observations are expected to have been of the same individuals, since the adult life span of this butterfly is approximately six to nine days (Lambert 2011), but the surveys took place daily (weather permitting) (Weaver 2012, *pers. comm.*). 2009 population estimates (generated by Mark-Release-Recapture studies, discussed below) were 38.8 individuals for the Slope South of Redoubt site and 23.8 for the Dunes sites (Peterson 2009, 2010). Since American Camp hosts the core (and only confirmed extant) island marble population, and is the only place where native host-plants are used, the drastic decline in abundance and occupied sites in this area seriously jeopardizes the long-term security of island marble.

E. Population status: Mark-release-recapture studies

In an effort to examine the relationship between island marble transect count observations and actual population size (*e.g.*, the proportion of local populations that is typically revealed by transect counts) a Mark-Release-Recapture (MRR) study was conducted at two American Camp sites and one additional site on San Juan Island (Pear Point Gravel Pit) in 2008, and at three American Camp sites in 2009 (the two that were studied in 2008 plus one additional site) (Peterson 2009, 2010). Results of this study were largely limited by the inability to capture and recapture sufficient numbers of island marble adults, despite selection of sites presumed to have high enough island marble abundances for these efforts, and a rigorous survey process involving daily visits under suitable conditions throughout the adult flight period (Peterson 2009, 2010). Over the course of both years, just three meaningful population estimates resulted from this study, highlighting the very small size of even the largest island marble populations and subpopulations (Peterson 2009, 2010). The population estimates that were generated are useful in helping to quantify the extent of abundance decline that island marble has experienced in recent years. For example, the MRR-generated population estimate at Pear Point Gravel Pit was 93.6 individuals (95% confidence interval: 75.8 to 111.4) in 2008. Since this time, the population at this site has declined to the point that it was not detected in any life stage in 2011, but for 3 potential eggs whose identification was inconclusive (likely Sara's orangetip) (Potter 2012, *unpublished data*). This result shows that even relatively large island marble populations can be quickly lost. The two successful MRR population estimates at American Camp in 2009 provide even lower estimates for island marble: 23.8 (95% CI 19.1 to 28.4) for the entire Dunes subpopulation, and 38.8 (95% CI 28.5 to 49.0) for the Slope South of Redoubt subpopulation (Peterson 2009). These low numbers highlight the extreme vulnerability of island marble to extinction, even within American Camp where the butterfly has been anticipated to be secure (USFWS 2006).

Due to the difficulty in obtaining sufficient data for MRR analysis, little was learned with regard to the relationship between transect counts and population sizes. Overall, MRR-estimated population sizes were found to be weakly correlated with daily transect counts, with transect counts representing an average

17.3% of the MRR-estimated population, although transect count representation was highly variable, ranging from 0% to 50% in 2008, and 0% to 100% in 2009 (Peterson 2009, 2010). For a butterfly with extremely small population sizes, these broad ranges in detectability are not surprising (Peterson 2009, 2010). Overall, a comparison of the three MRR population estimates listed above and their associated transect count data suggests that an index based on mean transect counts (sampled daily) is sensitive to among-site differences in abundance (Peterson 2010). (Among-year comparisons were not made, as neither of the sites examined both years had sufficient capture/recapture data in multiple years.) Additionally, MRR-based estimates of population size appear to correlate with the mean number of adults observed on transects, although more data are needed to verify this conclusion (Peterson 2010).

MRR studies also provided important findings on the dispersal potential in this butterfly (Peterson 2009, 2010). Recaptured individuals were almost always found in their original site of capture, and most dispersal events were less than 0.6 km. Over the two years of MRR studies, only one among-site dispersal event covering the ~1.9 km distance between the two nearest study sites occurred, and no dispersal was found between the study sites which were 6.8 km apart. These results suggest that, while occasional long-distance dispersal is possible (*e.g.*, Miskelly & Potter 2009), the island marble may be more dispersal limited than previously assumed (*e.g.,* USFWS 2006).

F. Weather effects

Short-term trends in island marble abundance may be related to weather patterns, and cool spring conditions have likely played a role in the apparent decline in island marble abundance at American Camp (Peterson 2010). Wetter, cooler conditions in early spring may reduce the amount of time females have to lay eggs and therefore contribute to reduced fecundity (Lambert 2011). A marked reduction in island marble patch occupancy and abundance was first observed by WDFW in 2008, a year which was noted for an unseasonably cool and cloudy spring, and it was suggested that warmer weather in a subsequent year would lead to an increase in island marble population size and site occupancy (Hanson *et al.* 2009, 2010). In 2009, however, the weather throughout the adult flight period was unusually warm, clear, and calm, and yet low numbers of island marbles were again observed (Hanson *et al.* 2010). According to Potter *et al.* (2011), although limitations of survey data preclude statistical analysis of population trends, 2008 through 2011 have clearly been challenging years for the island marble, and factors in addition to weather are likely playing a major role in this butterfly's downturn (Potter *et al.* 2011, Potter 2012, *pers. comm.*). Numerous natural and anthropogenic threats to the island marble and its habitat are discussed in Section VII of this petition (Current and Potential Threats – Summary of Factors for Consideration).

VI. HABITAT REQUIREMENTS

A. Larval food plants

Island marble host plants are defined as those plants that support development of larvae through the final instar under field conditions. Three larval hostplants, all in the Brassicaceae (mustard) family, have been identified for the island marble: the native *Lepidium virginicum* var. *menziesii* (tall peppergrass), the non-native *Brassica rapa* L. var. *rapa* (= *Brassica campestris,* field mustard), and the non-native *Sisymbrium altissimum* (tall tumble mustard) (Lambert 2011). Island marble eggs and larvae have also been observed on *Cakile edentula* (sea rocket) which is common at several sites, but in all known cases the larvae failed to develop to maturity on this plant, and it is not considered a potential host (Miskelly 2005, Lambert 2005, Potter *et al.* 2011). Undocumented but potential hosts are limited to plants of the family Brassicaceae, particularly the genera of the known host plants, and the genera *Sinapis* and *Barbarea* (Potter *et al.* 2011).

Brassica rapa is the most abundant and widely distributed of the three host plants and occurs in anthropogenically disturbed sites as well as in introduced grasslands with moderate levels of disturbance created by small mammals. *Sisymbrium altissimum* occurs in areas of high disturbance and, at American Camp, is most often found in sand dunes (Lambert 2011). Both *B. rapa* and *S. altissimum* are introduced host plant species, planted at American Camp with other agricultural crops in the early 1850's (Lambert 2011). *Lepidium virginicum* var. *menziesii* is the only known native island marble host plant and its use has been documented only within American Camp, where this plant occupies intermediate beaches between tidal lagoons and shoreline (Pyle 2004, Miskelly & Fleckenstein 2007, Lambert 2011). As such, the marine foreshore is the only habitat where island marble is currently found in association with native host plants (Miskelly 2000, Pyle 2004). According to Pyle (2004), it is possible that island marble wasn't aboriginally a meadow organism, but a coastal strand specialist on *L. virginicum* var. *menziesii* that moved upslope only with the introduction of exotic mustards. It is also possible that native mustards may have occurred in disturbed areas of native grassland before the introduction of weedy non-native species, thus supporting upslope populations of island marble (Miskelly 2000).

Despite the island marble's extensive use of two nonnative host plants, a recent research study tracking the survivorship of 1617 eggs through all immature stages of development until death or disappearance found survivorship of eggs and larvae to be greatest on the native host plant, *L. virginicum* var. *menziesii* (Lambert 2011). For example, the odds of survival to instar II on *L. virginicum* var. *menziesii* were 5.6 times that of survival on *B. rapa*, and the odds of survival beyond instar IV were estimated to be 2.45 times higher in *L. virginicum* var. *menziesii* and 1.79 times higher in *S. altissimum* compared to *B. rapa*. Eggs and instar I larvae on *B. rapa* had significantly higher estimated odds of mortality than both *L. virginicum* var. *menziesii* ($p<0.001$, $p=0.001$) and *S. altissimum* ($p<0.001$, $p<0.001$), and egg mortality was also significantly higher in *S. altissimum* compared to *L. virginicum* var. *menziesii* ($p=0.016$). Overall survivorship of eggs beyond instar IV was 8.5% on *L. virginicum* var. *menziesii,* 7.1% on *S. altissimum,* and just 3.8% on *B. rapa*.

Host-plant related differences in survivorship may be attributed to a variety of factors. Miskelly (2000) reports that island marble larvae appear to feed more readily on the native *L. virginicum* var. *menziesii* than on the introduced host plants. On the introduced hosts, especially *S. altissimum*, larvae feed only for short periods of time and spend a lot of time wandering, while on *L. virginicum* they spend much more time feeding, and do not hesitate to feed (Miskelly 2000). According to Lambert (2011), relatively low survivorship on *B. rapa* is influenced by high browsing pressure by deer on this plant; 58% of the total egg mortality on *B. rapa* in this study was attributed to deer consumption of eggs (n=478 egg deaths on *B. rapa*).

B. Adult nectar plants

Island marble adults feed on floral nectar. More than ten plant species have been documented as nectar sources, primarily the island marble larval food plants (*B. rapa*, *S. altissimum*, and *L. virginicum* var. *menziesii*), but also *Cakile edentula* (American searocket, native), *Amsinckia menziesii* (Menzies' fiddleneck, native), *Zigadenus venenosus* (meadow death-camas, native), *Rubus ursinus* (trailing blackberry, native), *Erodium cicutarium* (common stork's bill, nonnative), *Hypochaeris radiacata* (hairy cat's ear, nonnative), *Taraxacum officinale* (dandelion, native & nonnative subspecies), and *Cerastium arvense* (field chickweed, native & nonnative subspecies) (Miskelly 2000, Pyle 2004, Miskelly 2005, Miskelly & Fleckenstein 2007, Miskelly & Potter 2009, Lambert 2011). Research and monitoring at American Camp sites suggests that native forbs are important resources for island marble, not only in providing nectar, but also in providing mating sites for adults and pupation structures for mature larvae (Lambert 2011, Lambert 2005). Adults were observed on transects without host plants but with native forbs every year from 2004−2008 (Lambert 2011).

C. Habitat characteristics

The island marble is restricted to open grassland habitat with appropriate mustard host plants and nectar plants present. Habitat types include sheltered shorelines, sand dunes, grasslands, roadsides, and agricultural and disturbed land. Despite previous assertions that the island marble utilizes open habitat in Garry oak woodlands (Guppy & Shepard 2001, Shepard 2000, USFWS 2006), extensive surveys on hillside balds and openings in oak woodland have found that this butterfly is not associated with these habitats (Miskelly 2005, Miskelly & Fleckenstien 2007). Mustard plants rarely occur in these habitats, resulting in little or no potential to host island marble populations (Miskelly & Fleckenstien 2007, Hanson *et al.* 2010). Likewise, suitable habitat conditions for island marble are not found in areas above 92 m (300 ft.) elevation, or areas occupied by trees or by European rabbits (*Oryctolagus cuniculus*) (USFWS 2006).

At the American Camp Unit of SJINHP, the island marble occurs in three habitat types (grasslands, sand dunes and tidal lagoons), each of which contain specific host plants, nectar resources, mating sites, and pupation sites, as well as some type of topographic relief, such as slopes, bluffs, sand banks or driftwood berms (Lambert 2011). Lambert (2011) reports that of the 16 survey transects at American Camp, the transect with the greatest number of adults over the five year survey period was characterized by having one of the largest patches of host plant (*B. rapa*) bordered by a relatively abrupt south facing slope. Host plant density was consistently patchy within the transect site offering adults sufficient edge habitat, and the site gradient combined with dispersed patches of host plant habitat provided ample topographic relief for patrolling males and edge habitat for ovipositing females (Lambert 2011).

Soil disturbance often favors the growth of island marble's mustard host plants and, as such, is an important element of this butterfly's habitat. At most island marble sites, particularly where the larvae feed on non-native mustards (*B. rapa* and *S. altissimum*), there has been some type of past or current soil disturbance that allowed these plants to persist (Miskelly 2005). Disturbance factors include soil mounding from housing site preparation and pond excavation, soil cultivation at agricultural sites, small mammal burrows at grasslands, and erosion in unstable soils and along shorelines (Miskelly 2005). Prior to human disturbance and the introduction of non-native mustards on the islands, rodent burrows and shoreline disturbance may have been sufficient to maintain populations of native *Lepidium* host plants (Miskelly & Fleckenstein 2007, Miskelly 2000). It is important to note that while soil disturbance can benefit island marble by stimulating the growth of mustard host-plants, it can also be highly detrimental to island marble if the host plants are removed, tilled, sprayed, or mowed before the butterfly has completed its life cycle (Potter *et al.* 2011). In recent years, it has become clear that island marble's use of disturbance-associated plants render it prone to occur in unstable habitats (*e.g.*, agricultural fields, roadsides, and lawns) where it has an unlikely chance of both short and long-term survival (Potter *et al.* 2011). As noted by Miskelly & Potter (2009), the mustard plants on which island marble feeds can survive conditions that the butterfly cannot, largely due to the mustards' ability to persist in the seed bank, ability to survive direct damage, and much shorter generation time. As such, many areas that still support (or have the potential to support) island marble host plants are often not suitable habitat for the butterfly itself (Miskelly & Potter 2009).

D. Life Cycle

Lambert (2011) reports the first comprehensive field study of island marble life history, including adult phenology, mating behavior, and oviposition patterns, as well as the biology, morphology and behavior of each immature stage (egg, larva and pupa). Results of this study, which took place from 2004 to 2008 at the American Camp Unit of SJINHP, are summarized below.

The island marble is a spring butterfly, flying from early-April to mid-June (Lambert 2011). The univoltine (one brood per season) life cycle is closely associated with host plant phenology, and host plants and butterflies emerge in synchrony at different times in the spring. In general, males eclose from pupae in early April (depending on weather), shortly after *B. rapa* leaves and flower stalks emerge. Males emerge about four to seven days before females, and patrol hillsides in search of females. Mating in this butterfly lasts approximately four hours, and takes place *outside* of the host plant patches, often a considerable distance away. For example, Lambert (2011) reports island marble mating in native prairie 284 m from the nearest host plant.

Upon mating, females fly to host plant habitat to deposit eggs. On all three host plants, females are known to exhibit a significant oviposition preference for plants that are taller and have a greater number of racemes (Lambert 2011). Additionally, females preferentially deposit eggs on unopened, terminal flower buds (79.6%, n = 1048), although eggs are also deposited on the pedicle of flower buds, axillary buds, leaves, and occasionally on stems of host plants (Lambert 2011). Female island marbles typically lay one egg per plant and subsequent females avoid laying eggs on a plant that is already occupied (Miskelly 2000, but see Lambert 2011, for variation on this).

The majority of island marble eggs have been recorded from May 21st to May 24th, with the earliest record on April 25th and the latest on June 22nd (Lambert 2011). Egg development typically takes about 8.5 to 13 days. Upon emerging from the egg, larvae generally feed on the egg shell, although Lambert (2011) observed that 31% (n = 873) of newly emerged larvae did not immediately feed on the egg shell and instead began feeding on buds and flowers (Lambert 2011). First and second instar larvae feed primarily on buds and flowers, and movement is minimal (1 – 2 cm.) As larvae grow larger and become more mobile, movement increases between plant racemes; by late third instar, larvae are able to feed on three or four inflorescences and travel to two or three branching racemes. Third instar larvae feed on buds, flowers and newly developing fruits but rarely leave the original host plant. In contrast, fourth instar larvae move along stems, between branches and even between adjacent host plants in search of food, especially if the original host plant has matured and the larva is unable to consume the tougher vascular portions of the plant. The fourth instar is the most active and mobile larval stage, although larvae tend to stay in the upper reaches of host plants, moving from one plant to another when the top of two or more host plants are in contact. Lambert (2011) observed several individuals moving from one plant to another with assistance by light wind which blew host plants closer together allowing larvae to “reach” for branches that came into contact (Lambert 2011). Fourth instar larvae feed on developing fruits but also eat buds, flowers, petioles, young stems and leaves of host plants. Early fifth instar larvae feed voraciously on plant material often consuming whole fruits, pedicles and stems until the food plant is completely defoliated. Late in the season, larvae avoid over-mature fruits and senescent plant material and often leave the primary host plant in search of more nutritious plant material. In Lambert’s study (2011), fifth instar larvae were notorious for disappearing from their food plant when not carefully observed (Lambert 2011). In late stages of fifth-instar development, larvae cease feeding, crawl down the stem of the host plant and position their head downward, entering a 16 – 48 hour sedentary phase prior to crawling off the host plant in search of a pupation site.

Unlike other *E. ausonides* species, pupation in island marble does not occur on the host plant but instead in surrounding vegetation, including senescing grasses such as *Holcus lanatus,* and perennials such as *Salicornia virginica* (Lambert 2005, 2011). By late June, Lambert (2011) found most larvae had completed development and began "wandering" in search of a pupation site, although fifth instar larvae were observed on host plants as late as July 12th. Observed wandering distances from the host plant to the pupation site range from 0.5 to 4 m. Following the selection of a pupation site, mature larvae position themselves upright (anterior upwards), attach themselves to vegetation by a silk girdle, and begin pupation. The development time of island marble from egg to pupa is about 38 days, following which the pupal stage enters diapause and overwinters until the following spring. One pupa was recorded to be in diapause for 334 days (11 months) before emergence as an adult in late spring (Lambert 2011). The adult life span of island marble is approximately six to nine days (Lambert 2011).

E. Dispersal

Adult island marbles are considered to be strong flyers, and individuals have been observed flying at least 300 m without landing (Miskelly 2000). Despite the strong flight of individuals, island marble does not appear to be a strong disperser, and movement by adults appears to be largely confined to small spatial scales (Peterson 2009, 2010). In mark-release-recapture studies, Peterson (2009, 2010) found very little dispersal among sites, and conclude that island marble adults seldom move among habitat patches separated by >0.6 km (Peterson 2010). However, observations of small numbers of larvae found 2 to 3 km from the nearest known island marble populations suggest that at least a few females within a given population can disperse moderate distances from their natal areas and lay eggs (Miskelly & Fleckenstein 2007).

VII. HABITAT STATUS AND CONDITION

A. Geographic and ecological characteristics

Geographic and ecological conditions for the five island marble populations on San Juan and Lopez Island are summarized in Section V. B. (Population Distribution and Status: Current distribution), above.

B. Land ownership

Site-specific land ownership information is provided in Tables 1 & 2. In summary, the majority of known island marble sites are found on private land, including both agricultural land and residential developments. The largest and most viable island marble population is on a continuous block of habitat on southwest San Juan Island, managed by San Juan Island National Historic Park, the Department of Natural Resources' Cattle Point Natural Resources Conservation Area (NRCA), and private landowners. Four sites on San Juan Island (Eagle Cove Park, Pear Point Gravel Pit, and Pear Point Barge Landing) are under ownership of San Juan County Parks. On Lopez Island, the Lopez School site is located on public land managed by the Lopez Island School District, and the Fisherman Bay tombolo site is under San Juan County Parks and San Juan County Land Bank ownership (Miskelly 2005). Two agricultural sites on San Juan Island have San Juan Preservation Trust easements.

VIII. CURRENT AND POTENTIAL THREATS—SUMMARY OF FACTORS FOR CONSIDERATION

The continued existence of the island marble is threatened by numerous natural and anthropogenic activities, including direct damage to island marble individuals and host plants by mowing, landscaping, herbicide use, agricultural practices, invertebrate predators, and grazing deer and livestock. Additionally, this butterfly is threatened by loss of grassland habitat due to forest succession and invasive species, development for housing, road construction and maintenance, and storm and tidal surges that inundate and bury habitat. The island marble is further threatened by dispersal limitations in highly fragmented habitat, the inherent vulnerability of small populations to stochastic events, projected increases in extreme weather events due to global climate change, and the inadequacy of existing regulations to protect the butterfly.

A. The present or threatened destruction, modification, or curtailment of its habitat or range

Over the last seven years of searching for and visiting island marble sites throughout the island marble's range, a significant loss of habitat for this butterfly has been witnessed (Miskelly & Potter 2009, Hanson *et al.* 2009, Hanson *et al.* 2010, Potter *et al.* 2011, Potter 2012, *unpublished data*). The habitat loss observed has been a decline in both the number of host plants and the number of host plant patches across the species range (Hanson *et al.* 2010). Host plants have decreased in abundance at sites that supported small and large patches, and new host patches are not becoming established in secure environments (Hanson *et al.* 2010, Potter *et al.* 2011). Significant loss of host plants has been observed at several key island marble sites, including Pear Point gravel pit, Cattle Point BLM – Lighthouse Trail, American Camp – Cattle Point NRCA Border, and Fisherman Bay tombolo, to the point that the island marble has been extirpated or is persisting in very low numbers at these sites (Tables 1 & 2).

The island marble is subjected to numerous threats at all sites, including deer herbivory, mowing and removal of host plants, agricultural practices that are not compatible with island marble, improperly-timed management practices, prairie succession to forest, invasive species, and other natural and anthropogenic threats. Since two of the three known island marble host plants are non-native, disturbance-associated mustard species known to experience resurgence following anthropogenic soil disturbance, it has been presumed that this butterfly is not negatively impacted by (and even benefits from) ground-disturbing activities via the potential subsequent increase in larval host plants (USFWS 2006). In contrast, the island marble's ability to use non-native "weedy" mustards as host plants is highly problematic to the butterfly for several reasons. In agricultural areas, large flushes of mustards appear after the fields are tilled, and island marble adults are attracted to the area and lay their eggs on the host plants, only to have the mustards destroyed (*e.g.*, tilled under or inadvertently harvested along with a crop) shortly after-- a lethal event for eggs, larvae, and pupae. In roadside areas, mustard plants are often sprayed with herbicides, mowed, or covered with gravel, which may also cause egg, larval, or pupal mortality. In lawns and landscaped areas, mustards are often regularly mowed or selectively removed, often after island marble eggs and larvae are already present on the plants. On protected lands managed for conservation of native plant communities, non-native mustard plants are not desirable species and are prone to herbicide treatments and prescribed burns as part of restoration efforts. Thus, the island marbles' use of a non-native, disturbance-associated host plant is highly detrimental, rather than beneficial, to the butterfly.

1. Herbivory

Deer

Blacktail deer (*Odocoileus hemionus*) are extremely abundant on San Juan and Lopez Islands. Although this animal is endemic to the Gulf and San Juan Island archipelago, reduced predation and hunting pressure has allowed deer populations to increase above those likely to have existed in pre-European times (Martin *et al.* 2011). As a result, deer have become locally abundant and largely unregulated, and the direct and indirect impacts of elevated deer browsing on plant and animal species and communities are a cause for concern (Martin *et al.* 2011).

Blacktail deer frequently browse on island marble hostplants (Hanson *et al.* 2010, Lambert 2011). While feeding, deer remove most of the flowering stems of mustard plants and in the process consume not only island marble larval food and oviposition sites, but also the eggs and larvae themselves (Hanson *et al.* 2010, Lambert 2011). The threat of being consumed by deer is heightened for island marble, as deer and adult females of this butterfly appear to select for similar plant traits (Lambert 2011). As noted previously, ovipositing island marble select relatively robust plants (tall with many plant racemes) in early stages of growth and growing in isolation or on the edges of host plant patches. Similarly, deer are known to select plants based on plant size, phenology, and edge position, and in Lambert (2011), were observed to select robust plants of *B. rapa* having several inflorescences containing compact flower buds (plant traits also preferred by ovipositing females). Thus, the removal of large compact inflorescences by deer reduces the availability of potential oviposition sites, and also reduces survivorship of eggs and larvae, since inflorescences that are already occupied by island marble eggs may be selectively consumed by deer (Lambert 2011). Although deer browsing early in the season stimulates the regeneration of plant racemes and new flower buds, providing females with new sites for oviposition, the host plant racemes are typically browsed more than once and in many cases, multiple egg loads of island marble are consumed by deer, effectively acting as a local population 'sink' (Lambert 2011). For example, at an American Camp site in 2007, 43 plants of *B. rapa* were eaten by deer which stimulated new growth and oviposition sites that were later occupied by eggs. However, of the 43 plants with new growth, 33 (77%) were browsed multiple times, and multiple browsing events contributed to 41% of the total egg and larvae mortality at this site (Lambert 2011).

Deer herbivory is a common threat at all of the known island marble sites, with the exception of one site (Olympic Lights Bed & Breakfast) with high fencing that prevents deer from access, although this site is regularly mowed (Table 5, Hanson *et al.* 2010). Research by Lambert (2011) found extensive evidence of deer herbivory during almost every study period over the course of four years of study at American Camp sites, and a significant portion of plants were regularly browsed by deer (Lambert 2011). Furthermore, death due to deer consumption of eggs and larvae accounted for a large percentage of total island marble mortality; 415 island marble immatures were eaten by deer, 26% of all eggs tracked. Deer herbivory caused particularly high levels of mortality on the non-native *B. rapa*, with 58% of the total egg mortality on *B. rapa* due to deer consumption of eggs (n=478 egg deaths on *B. rapa*). Even though mortality on *B. rapa* was reduced in later stages (instars II and III), the difference was not large enough to compensate for the heavy losses of eggs due to deer (Lambert 2011).

Host plant habitat can significantly influence the threat of deer grazing on island marble. For example, Lambert (2011) found mortality due to deer herbivory was twice as high on *S. altissimum* located in introduced grasslands than on *S. altissimum* located in sandy soils in sand dune habitat. For *B. rapa,* browsing pressure on plants located within close proximity of forest cover was particularly high and contributed greatly to overall deer related mortality. For example, scattered *B. rapa* host plants located in a small open grassland bordered by forest and shoreline were browsed consistently over the four year study, to the extent that 69% of all eggs present at the research site (n=276) were consumed by deer (Lambert 2011).

Contrary to previous assertions (USFWS 2006), deer are a significant limiting factor to the island marble, reducing the butterflies' abundance by direct consumption of eggs and larvae and by limiting the availability of oviposition sites (Lambert 2011, Hanson *et al.* 2011). According to Lambert (2011), deer density is expected to increase in the absence of active deer management on San Juan Island, further increasing browsing pressure on island marble food plants. Conservation and protection of island marble may require the exclusion of deer from host plant patches that are susceptible to deer browsing (*e.g.*, in short distance from forest cover), especially plants occupied by multiple eggs and larvae. Such efforts have already been initiated by the WDFW (Hanson *et al.* 2010), further highlighting the seriousness of this threat.

Livestock

Grazing by domestic animals is a significant and immediate threat to the island marble, especially in the San Juan Valley (Hanson *et al.* 2010). Sheep and cattle readily consume mustards, even under light grazing regimes, and horses consume mustards when pastures are overgrazed (Hanson *et al.* 2010). As discussed previously, since island marble eggs are laid and resulting larvae feed on the inflorescence and upper leaves, they are easily eliminated (*i.e.*, eaten) by grazing animals, and grazing also reduces the availability of oviposition sites for adults.

In Canada where the island marble is now extirpated, elimination of the larval food plant by grazing sheep and/or cattle is considered to be a likely cause for extirpation (Guppy & Shepard 2001). At present, eight island marble sites, all on private land on San Juan Island, are threatened by livestock grazing (Table 5, Potter *et al.* 2011).

Rabbits

In the American Camp and Cattle Point areas, introduced rabbits have created an extensive system of warrens and greatly disturbed and denuded the surrounding vegetation (SJINHP & USFWS 2006, SJINHP 2008). Since rabbits have explosive populations and have been observed feeding on island marble hostplants in primary island marble habitat in the American Camp area, rabbit herbivory has the potential to be a very serious threat to the island marble (Potter 2011, *pers. comm.*). To date, however, rabbit grazing has not been found to be highly problematic to this butterfly (Potter 2011, *pers. comm.*). Unlike deer and cattle, rabbits are known to chew on the bases of host plants rather than the inflorescences where island marble eggs and larvae tend to occur (Potter 2011, *pers. comm.*). Still, the virtual absence of plants in the heavily populated rabbit warrens at American Camp (SJINHP & USFWS 2006) suggests that rabbit population growth and/or spread of rabbits into new areas could be a potential threat.

Invertebrates

Competition with other invertebrates for plant resources (and inadvertent predation) can also limit the survival of island marble. The non-native snail *Helix aspersa* was first noted feeding in great numbers on island marble host plants (along with island marble larvae) at the Pear Point gravel pit in 2009 (Hanson *et al.* 2010). This snail was even more abundant at the site in 2010, to the point that surveyors acquired permission to hand-remove snails from both *Brassica* and *Sisymbrium,* including 70 snails from a single *Brassica* plant over the course of two visits (40 the first visit, 30 the second) (Potter *et al.* 2011, Potter 2012, *pers. comm.*). In recent years, the population of this snail has continued to explode, and has likely contributed to the apparent extirpation of island marble at this site (Potter 2012, *pers. comm.*). Island marble competition with moths for plant resources has also been observed. At an American Camp site, sixteen percent of all eggs tracked (n=341) died as a result of competition with an unidentified moth species on *S. altissimum* (Lambert 2011).

2. Mowing, removal of host plants, and landscaping

Mowing of island marble host plants is a common practice across the butterfly's range (Miskelly 2005, Miskelly & Fleckenstein 2007, Hanson *et al.* 2010) and has been identified as a threat at 31 island marble sites (Table 5). Since island marble females selectively lay their eggs on the inflorescences of tall, robust plants (Lambert 2011), host plant mowing greatly reduces the availability of suitable oviposition sites for the island marble, and can also have direct lethal effects on island marble individuals, since this activity often takes place while immature stages are on the plant. In both 2005 and 2006, for example, mowing was observed to cut mustard plants, including those that were occupied by island marble eggs and larvae, at several sites (Miskelly 2005, Miskelly & Fleckenstein 2007).

In addition to mowing, direct removal of hostplants is a factor threatening island marble at 21 sites, and landscaping/yard maintenance is a threat at 22 sites (Table 5). In 2005, for example, mustard plants, including plants that supported island marble eggs and larvae, were selectively removed from three sites (Eagle Cove development, Cattle Point-McMillen property, and Olympic Lights Bed and Breakfast), and again at two of these sites in 2006 (Miskelly 2005, Miskelly & Fleckenstein 2007). According to Miskelly & Potter (2009), all private-land sites with island marble on both San Juan and Lopez Islands should be considered marginal island marble habitat because of the constant threat of these types of habitat destruction and disturbance.

3. Agricultural practices

Contrary to previous assertions that management of agricultural land is compatible with the long term survival of island marble (USFWS 2006), agricultural activities have recently been identified as a serious threat to this butterfly (Potter *et al.* 2011). In the San Juan Valley, in particular, island marble survival is jeopardized by large-scale agricultural practices which disturb soil and result in a temporary flush of mustards that are subsequently destroyed (*e.g.*, harvested or plowed under). Such flushes can act as a "sink" for island marble eggs, larvae, and pupae, since ovipositing females are attracted to the large area of host plants and proceed to "waste" their eggs on an unstable plant resource that will not support the full life cycle of the butterfly (Potter *et al.* 2011). Even if the host plant persists long enough for larvae to survive to pupation, any resulting pupae are destroyed by subsequent plowing (NatureServe 2012). In particular, grain farming practices that promote growth of *Brassica rapa* host plants during the island marble flight period (*e.g.*, via winter plowing) and then inadvertently harvest the host plant (with the grain) are a serious threat (Potter *et al.* 2011). Eleven sites on San Juan Island, mostly in the San Juan Valley, are influenced by agricultural practices (Table 5, Potter *et al.* 2011, Potter 2012, *pers. comm.*). On Lopez Island, tilling of mustards is a threat at one site on private land. Although island marble was present at this site in 2005 and 2006, island marble was no longer seen in 2007, following tilling of garden mustard areas and removal of mustards from soil piles at the site (Miskelly & Potter 2009). Similarly, island marble has not been detected at any of the San Juan Valley agricultural sites in recent years, although it may be persisting at two sites where access was not permitted in 2010 or 2011 (Table 2).

4. Improperly-timed management/restoration practices

Although certain management techniques can be useful in restoring native prairie plants, they are often inadvertently detrimental to native animal species, such as the island marble (Erhardt 1985). According to SJINHP & USFWS (2006), the National Park Service has programs in place (and is developing additional programs) to restore the American Camp grasslands to a more native ecological condition using a combination of prescribed burning, mechanical and/or chemical control of invasive plants, and planting of native grasses and forbs. However, the nearly unique presence of the island marble, and its dependence on non-native hostplants, creates distinct management challenges. Two of the three island marble larval host plants are non-native, weedy species, resulting in an "enigmatic management challenge whereby a species of high concern depends upon non-native species whose eradication in native-dominated habitats, if not a priority, would be otherwise desirable" (SJINHP & USFWS 2006).

Glyphosate (in Round-up™) is the most commonly employed non-selective broad spectrum herbicide in the United States and worldwide (EPA 2011). In prairie management, glyphosate is broadcast-sprayed to reduce vegetation in preparation for reseeding with natives, and spot-sprayed to control patchy infestations. It is also wiped onto taller target invasive species, such as tall oatgrass, growing above a native prairie plant community (Schultz *et al.* 2011). Since non-selective herbicides (such as glyphosate) are designed to kill most vegetation, use of these herbicides poses serious threats to rare butterflies by eliminating or drastically reducing both host and nectar plants in treated areas. In addition, many herbicides are directly toxic to butterflies, leading to decreased survival, altered development time, and/or reduced body size in exposed individuals (*reviewed in* Labar 2009). For example, eggs of the Karner blue butterfly (*Lycaeides samuelis*) suffer reduced hatching when treated with a glyphosate- triclopyr mixture (Sucoff *et al.* 2001), and glyphosate and triclopyr have both been identified as a "definite concern" for the Oregon Silverspot butterfly (*Speyeria zerene hippolyta*), based on toxicity indices and exposure scenarios (USDA 2005). In a laboratory study, Russell and Schultz (2010) found that sethoxydim and fluazifop-p-butyl herbicides (the two most widely used grass-specific herbicides in the region) result in reduced development time of Puget blue (*Plebejus icarioides blackmorei*) butterflies, and reduced survival, pupal weight, and wing size of cabbage white (*Pieris rapae*) butterflies. In this study, survivorship of cabbage white butterflies was reduced by 32% after exposure to sethoxydim and 21% after exposure to fluazifop-pbutyl (Russell & Schultz 2010). Similarly, in a recent evaluation of the potential toxic effects of three common herbicides (triclopyr, sethoxydim, and imazapyr) to first instar larvae of Behr's metalmark butterfly (*Apodemia virgulti*), it was found that exposure to the recommended field rates of all three herbicides significantly reduced the number of pupae produced, and thus the number of adults that emerged from pupation (24-36% reductions) (Stark *et al.* 2012). Field trials of sethoxydim effects on Puget blue butterflies found that adult females had lower residence time in sethoxydim treated plots than in control plots (LaBar 2009). First instar larva of the large white butterfly (*Pieris brassicae*) have been shown to experience delayed development when feeding on plants treated with the broadleaf herbicide chlorsulfuron (Kjaer & Elmegaard 1996).

Herbicides have been applied to core island marble habitat at the American Camp (SJINHP) on several occasions. In 2005, Round-up™ herbicide (active ingredient: glyphosate) was applied to island marble habitat around the Redoubt site at American Camp, as part of experimental applications to test methods for reducing the distribution and spread of nonnative grasses at American Camp (USFWS 2006). Herbicide application covered an area of approximately 3.7 acres, including areas within the core of the island marble population (USFWS 2006). Since application occurred during the island marble flight period, not only were mustard host plants killed, but also a number of larvae that were known to be present on these plants (Miskelly 2005). Herbicide treatment was followed by a prescribed fire on the same footprint of land, likely causing harm to eggs, larvae, and adult island marbles still utilizing the herbicide treated area (USFWS 2006). According to SJINHP & USFWS (2006), although the 2005 herbicide and prescribed fire treatment may have caused significant mortality of marble eggs and larvae, 2006 surveys revealed abundant regrowth of the host mustards, and “prolific visitation” of these mustards by adult island marbles (SJINHP & USFWS 2006). However, the observed abundance of island marble adults on transects in the Redoubt area has either declined or remained low since 2006 (Table 3), suggesting that the “subsequent strengthening of the population” hoped for by SJINHP & USFWS (2006) has not occurred, possibly due, at least in part, to irrecoverable effects of initial mortality caused by the treatment.

In 2010, WDFW surveyors reported another herbicide application in an occupied island marble habitat patch within the American Camp Redoubt site, once again during the adult flight and larval activity period (acreage of application has not been reported) (Potter *et al.* 2011). According to SJINHP, herbicide spraying in the Redoubt area has occurred a few times between 2008 and 2010 during the island marble activity period, although pre-disturbance surveys, at least in 2010, did not find island marble host plants present (Weaver 2011, *pers. comm.*). In this year, island marble’s use of the sprayed area was only determined after the fact, when one or more adults were documented inside of the treatment area (Weaver 2011, *pers. comm.*, Potter *et al.* 2011). Regardless, this action was in direct disagreement with the 2006 conservation agreement between NPS and USFWS, which states that “for proposed NPS actions in island marble butterfly habitat, all vegetation treatments (such as mowing, herbiciding, and burning) will occur in the fall, when pupation will have occurred” (SJINHP & USFWS 2006).

Since most of the remaining island marble butterflies reside in the American Camp Unit of San Juan Island and surrounding areas, the security of this species is highly dependent on a strong population at American Camp (Miskelly 2005, Lambert 2011). Thus, it is critical that management of this area be carefully tailored to protect and support island marble (Miskelly 2005). However, the improperly-timed management activities described above make it clear that island marble and its habitat are not well-protected within the Park, presumably as a result of conflict of interest in conservation goals (*i.e.*, island marble vs. native plant communities). Although managing habitat for rare plant and animal species and communities is always complex, the small population sizes of the island marble and its dependence on two non-native host plants render this butterfly particularly sensitive to even well-intentioned management practices. Since the loss of even a few individuals can decrease the overall breeding population, herbicide use in endangered butterfly habitat should be carefully considered by weighing all risks and benefits. (Note that the native island marble hostplant, *Lepidium virginicum var. menziesii*, is not known to be threatened by management in the Park, however this plant occurs at just a few (~3) of the smaller sites, in lagoon-shoreline habitat where it is threatened by storm tides and other factors, discussed below).

5. Prairie succession to forest

Succession of prairie to native shrub-land or forest is among the most urgent threats to western prairie species. Prairies in the southern Puget Sound of Washington have been lost at an average rate of approximately 100 acres per year since the 1850s due to the rapid conversion of grassland to Douglas-fir forest (Kruckeberg 1991). In the San Juan archipelago, coastal grassland communities are being similarly encroached by Douglas-fir, rose, and snowberry. American Camp contains one of the largest remaining grassland expanses in the San Juan and Gulf Island archipelago. However, during the past 150 years, a number of influences have degraded the American Camp grasslands from their aboriginal condition, including the invasion of trees and woody shrubs resulting from the exclusion of fire (SJINHP & USFWS 2006).

Forest succession reduces available open habitat for island marble and its host plants, and also limits connectivity between habitat patches (Potter 2012, *pers. comm.*). Additionally, fire suppression increases tree density and combustible fuel loads, rendering the habitat susceptible to catastrophic, large scale, and high temperature fires (Huntzinger 2003). A single fire event in an area where this species is concentrated could extirpate the entire population. Finally, since deer herbivory appears to be higher in areas where deer have access to cover and connectivity to forest vegetation (Lambert 2011), succession to shrubs and trees may further increase the threat of deer browsing at some sites (Potter 2012, *pers. comm.*).

At Pear Point gravel pit, a large, recently retired gravel pit on San Juan Island, a different form of succession has occurred in which mustard host plants have been intentionally replaced by planted grasses, shrubs, trees, alfalfa, and other plants as part of the required reclamation process for the retired gravel pit (Potter 2012, *pers. comm.*). This ~10 acre site was an active gravel pit until around 2001-2003, following which it was reclaimed, a process which involved restructuring the topography to create gentle slopes, and seeding and outplanting various plants, listed above (Potter 2012, *pers. comm.*). The site was privately owned and gated until sometime in 2006, when it was acquired by San Juan County. Public access was allowed at this time, and island marble was discovered at the site in 2007 in relatively high numbers (2 adults, 21 larvae, 14 eggs). The topography at this time had been restructured as a large ~5 acre bowl, with ~5 acres of flat or gentle-sloped rim. Two island marble host plants were plentiful; *Brassica rapa* dominated the south facing slope and occurred in several places along the rim, while *Sisymbrium altissimum* was widespread across the bottom of the bowl. However, even in 2007, the potential for the numerous and vigorous introduced plant species to outcompete the island marble hosts was apparent (Potter 2012, *pers. comm.*). In 2009, mark-release-recapture studies estimated the population at this site to consist of 93.6 adults (Peterson 2009, 2010), the largest population of this species outside of the SJINHP American Camp sites. Around this time, the adjacent public road edge was re-contoured and hydro-seeded with grass in ~2009, resulting in a further loss of habitat (Potter 2012, *pers. comm.*). By 2011, very few host plants remained, and island marble presence was not confirmed at the site in any life stage (Potter 2012, *unpublished data*). The primary cause for the apparent extirpation of island marble at the site appears to be succession of new plant growth overtaking the more diminutive island marble host plants. Additionally, an increasingly abundant non-native snail has been consuming island marble host-plants at this site (see section VII.A.1. Herbivory: Invertebrates above).

WDFW (with financial support from USFWS) has attempted to establish small patches of *B. rapa* at the Pear Point gravel pit site by seeding the host plant in ten plots (each plot was two m^2). Only a few host plants resulted from this effort, probably due to the lack of knowledge regarding habitat management techniques including how to enhance or establish these plants (Potter 2012, *pers. comm.*).

6. Invasive species

Invasion and dominance of native grasslands by exotic plants is a common threat to grassland butterflies (Warren 1993, Schultz & Crone 1998). Invasive species dramatically change the structure of prairies, often forming tall, dense patches that shade out butterfly host plants and compete for water and nutrients. A number of highly invasive plants, including Himalayan blackberry and non-native grasses, occur in island marble habitat. Although the number of sites where island marble habitat is threatened by invasive species has not been quantified, even the most protected sites (*e.g.*, American Camp area) are known to be invaded by a long list of noxious weeds (SJINHP & USFWS 2006).

7. Development

Permanent loss of habitat through conversion of native grassland to residential and urban development has played a major role in the decline in prairie butterflies in the western United States (Shultz *et al.* 2011). This threat is particularly acute on San Juan Island, which supports the largest and fastest growing human population in the San Juan archipelago. Both residential development and associated landscaping have been identified as major and realized threats to the island marble, resulting in permanent destruction, degradation, and fragmentation of island marble habitat (Miskelly & Potter 2005). The threat of development in occupied island marble habitat is reviewed in USFWS (2006).

8. Road development and maintenance

Several sites for island marble are situated adjacent to roads. Routine roadside maintenance generally involves herbicide application or mowing, which can reduce or even eliminate populations of the island marble butterfly. In 2005, for example, roadside mowing cut mustard plants, some of which were occupied by the island marble, at three island marble sites (Eagle Cove Development, Old Johnson Road, and Fisherman Bay Rd./Center Rd. Jct.) (Miskelly 2005). In 2009, it was reported that while habitat was still present at Fisherman Bay Rd./Center Rd. Jct. and San Juan Valley Rd./Douglas Rd. Jct., host plants at these sites are regularly destroyed by roadside mowing and/or herbicide application (Hanson *et al.* 2010). Island marble has not been found at either of these sites in recent years (Table 2, Potter *et al.* 2011, Potter 2012, *unpublished data*). At another site in 2005 (Fisherman Bay tombolo), roadside mustard plants with island marble larvae on them were buried by a load of sand placed there to create a pullout from which to launch a fireworks display. The butterfly was not seen at this site the following year (2006), occurred in small numbers in 2007, and has not been seen since (Table 2, Hanson *et al.* 2009, 2010, Potter *et al.* 2011).

Road construction and maintenance activities are also expected to have a negative impact on the island marble at American Camp, particularly in the Cattle Point area, where the island marble occurs directly within the project area of an upcoming road relocation and development project (SJINHP 2010). Various alternatives for the project range from minor modifications to the existing road, including construction of various tunnels, to a complete realignment of more than one mile of road (SJINHP & USFWS 2006, SJINHP 2010). Seven of the ~ten nectar plants and larval food plants used by island marble at American Camp occur within the project area (SJINHP 2010), and, according to SJINHP & USFWS (2006), the impacts of this road construction could result in up to 13 acres of temporary loss of island marble butterfly habitat, removing island marble individuals, host plants, and nectar sources. Long-term, approximately 3 acres of permanent habitat would be lost (SJINHP & USFWS 2006). Since the NPS is planning to restore the former road bed using native grasses and forbs, it has been stated that project mitigation could potentially provide the means for improvement of island marble butterfly habitat and populations over the long term (SJINHP 2010). However, given the island marble's small population size and current patterns of decline at American Camp, it should be noted that even "temporary" loss of individuals and habitat can have devastating effects, to the point that there might not be a "long term" for this butterfly.

9. Storm tides

Storm tides and flooding of near-shore habitat pose a threat to the island marble at coastal sites (Miskelly 2005), and island marble decline at several sites has been attributed to flooding events. For example, flooding from a strong windstorm that coincided with a high tide in February 2006 may be responsible for the low numbers of adults observed at American Camp lagoons that spring, as well as the absence of island marble at the Fisherman Bay tombolo site, largely due to high mortality of overwintering pupae and destruction of host plants at these sites (Miskelly & Fleckenstein 2007, Lambert 2011). At one lagoon site (Jakle's Lagoon), the *L. virginicum* var. *menziesii* host plant population was reduced by more than 50% due to wave action that deposited large volumes of sand and gravel on extant populations of host plants (Lambert 2011). Plants that recovered from the soil disturbance were short in stature and in very early stages of development (lacking robust flower buds), thus unavailable to ovipositing island marble females. Flooding and reshaping of the backshore and lagoon environment also likely caused significant mortality to overwintering pupae at this site (Lambert 2011). Despite the expectation by the USFWS (2006) that this site would be recolonized following the 2006 storm tide flooding, the population has not recovered and appears to be extirpated (four adults were observed in 2006, one in 2007, zero from 2008 to present) (Lambert 2011, Potter *et al.* 2011, Potter 2012, *unpublished data*, Weaver 2012, *pers. comm.*). Loss of American Camp coastal populations, such as this one, is a serious concern, as these populations are the only ones still utilizing *L. virginicum* var. *menziesii,* the native island marble host plant which was recently found to generate higher survivorship of island marble than its non-native counterparts (Lambert 2011).

10. Recreation

Areas inhabited by island marble may be impacted by many recreation activities, particularly at the American Camp sites within San Juan Island National Historic Park, and surrounding areas. According to the Park Service, 260,000 people typically visit the San Juan Island National Historical Park (American and English Camps) annually (National Parks Conservation Association 2007). Hikers, cyclists and horses may crush or uproot plants or kill butterfly larvae, and seeds of invasive species may be spread by vehicle tires (including bikes) and horse manure. The burgeoning human population in the San Juan archipelago and adjacent mainland suggests that threats from recreation will likely increase in this region.

11. Application of insecticides

Insecticides are well-known to have direct and indirect negative impacts on pierid butterflies, including lethal and sublethal effects to the particularly vulnerable larval stages (Davis *et al.* 1991). To date, insecticides are known to have been sprayed at one island marble site to control a moth that was damaging a cypress windbreak (Miskelly & Fleckenstein 2007), and some land owners and farmers on San Juan Island use Btk (*Bacillus thuringiensis* var. *kurstaki*) to control tent caterpillars (USFWS Draft A; Potter 2012, *pers. comm.*). Btk is a Lepidoptera-specific larvicide which kills butterfly and moth larvae by multiplying in the gut, releasing toxic substances, and eventually causing the larva to stop feeding. Since Btk has become the pesticide of choice to treat defoliators such as the Asian gypsy moth (Wagner & Miller 1995), this insecticide is a notable threat to the long term security of the island marble. According to Potter (2012, *pers. comm.*), if there was a gypsy moth infestation on the San Juan Island, the island marble would be highly threatened and probably lost by gypsy moth control efforts. Since Btk has been shown to drift at toxic concentrations for distances greater than two miles from target spray areas (Barry *et al.* 1993; Whaley *et al.* 1998), aerial spraying of even relatively small areas with Btk could have significant adverse effects on nearby island marble populations. Because island marble larvae are active during the springtime Btk application period, the threat of Btk is heightened for this species.

B. Overutilization for commercial, recreational, scientific, or educational purposes

1. Over-collecting

Rare butterflies are often the target of butterfly collectors. While collecting this butterfly on both public and private land is prohibited without a permit (WDFW 2012), enforcement of this law is difficult and the rarity of the island marble makes it particularly vulnerable to poaching. The majority of island marble sites are on private land where restrictions to collection are not likely to be enforced, making the butterfly particularly susceptible to over-collection (Miskelly & Potter 2005). Given the extremely small population size of the island marble, collecting even a small number of individuals is likely to significantly reduce the production of offspring and increase the species risk of extinction.

2. Research activities

Increasing our knowledge of island marble life history and population trends is vital to successful conservation of island marble, however, research itself can be a threat. Extensive research of the island marble, including larval food preference experiments and mark-release-recapture of adults, has been conducted at American Camp sites in recent years (Lambert 2005, 2011, Peterson 2009, 2010). Additionally, survey and monitoring of island marble has occurred annually at most active sites (Pyle 2004, Miskelly 2005, Miskelly & Fleckenstein 2007, Miskelly & Potter 2009, Hanson *et al.* 2009, 2010, Potter *et al.* 2011, Potter 2012 *unpublished data*). While this work contributes enormously to our understanding of the butterfly, even careful research and photography can have detrimental impacts to butterflies (Ehrlich & Murphy 1987, NatureServe 2012). For example, increased foot traffic in fragile habitats can crush butterfly larvae or host plants, and collection or experimentation with even a small number of individuals can further reduce small population sizes (Ehrlich & Murphy 1987, NatureServe 2012).

C. Disease or predation

Small and fragmented populations face a greater extinction risk from normal population fluctuations due to disease and predation than large, unfragmented populations (*reviewed in* Shaffer 1981). Many, if not most insect populations normally experience large fluctuations in size (Ehrlich 1992, Schultz 1998). Predation and disease may cause annual changes in butterfly numbers of an order of magnitude or more. Normal population fluctuations, coupled with habitat alteration or loss (sometimes seemingly minor habitat alterations) can result in population extirpations (Hanski *et al.* 1995). Since island marble is restricted to two islands with only five populations – and probably only one viable population – this species is vulnerable to extinction from naturally occurring or exotic diseases and predation (Warren 1993).

Although predation and parasitism are normal population stressors, these threats are intensified when populations are so small that the loss of even a few individuals affects the viability of the population. Contrary to previous assertions that predation is not a significant threat to the island marble (USFWS 2006), an extensive, four-year study at American Camp found predation to be the greatest source of island marble egg and larval mortality (n=752; 47% of all eggs tracked) (Lambert 2011). Predation by spiders, including crab (Family Thomisidae) and wolf spiders (Family Lycosidae), was observed most often (n=109) although social paper wasps (Family Vespidae, *Polistes* spp.) were also observed to predate on larvae. Wolf spiders in nearshore habitat hunting from driftwood logs may account for some of the high percent predation of eggs and larvae on *L. virginicum* var. *menziesii* (77%). Although not documented in island marble, predation by ants and mites and other non-arthropod herbivores have been documented in other species of

Pieridae, and also likely contributed to death of eggs and early instar larvae of island marble (Lambert 2011). Fifth-instar larvae are particularly conspicuous and vulnerable to predators, especially in the initial molting phase when larvae are immobile and defenseless (Lambert 2011). Larvae wandering from their original, senescing host plant in search of an alternative food plant may also be more susceptible to predation (Lambert 2011).

Although parasitism is common among pierid butterflies, no parasitoids of island marble have yet been recorded, possibly because the low population abundance of this species is unable to support parasitoid populations (*reviewed in* Lambert 2011). According to Miskelly (2000) some island marble larvae are killed by an unidentified disease.

In addition to invertebrate predators, both larvae and adults of island marble have been observed being eaten by birds and small rodents, the latter of which are common in the habitat of the island large marble, and probably feed on pupae from late summer to spring (Miskelly 2000, Potter *et al.* 2011). The rarity of this butterfly and its confined range make it particularly sensitive to even moderate levels of predation. Even a small loss of individuals by predators may lead to extreme population declines for the butterfly, often resulting in local extirpation and increasing the risk of global extinction.

D. The inadequacy of existing regulatory mechanisms

Despite being in danger of range-wide extinction, there are currently no federal, state, or local regulations (with the exception of collection restrictions) that can be applied to directly protect the island marble or its habitat. Washington State has designated the island marble as a candidate species, and it is designated as globally Critically Imperiled (T1) by NatureServe (2012), but these designations provide no additional regulatory protection for the species or its habitat. There are no county regulations that protect the island marble.

Because of concern about the long-term fate of the island marble at San Juan Island National Historic Park (SJINHP), a conservation agreement and strategy was developed by USFWS and SJINHP for the purpose of "helping ensure the long-term continued existence of the island marble butterfly and contributing to its recovery" at American Camp (SJINHP & USFWS 2006). This conservation agreement articulates several goals, including developing a monitoring plan for assessing the response of the island marble and its host plants to management actions. The agreement also provides a number of management suggestions that if fully implemented, may favor island marble. However, this document has no legal standing and, as such, important guidelines presented in the conservation agreement have not been completed. For example, the conservation agreement states that "for proposed NPS actions in Island Marble butterfly habitat, all vegetation treatments (*i.e.*, mowing, herbiciding, and burning) will occur in the fall, when pupation will have occurred. Actions will not occur in the spring, when most immature forms of the island will be present." However, on multiple occasions, SJINHP has applied herbicides in occupied and critical island marble habitat *during* (rather than after) the island marble flight period, when the most vulnerable immature stages of the island marble were present (Miskelly 2005, Potter *et al.* 2011). This discrepancy highlights the status of the conservation agreement as a suggestive management tool with no legal standing, and although the agreement has led to monitoring that gives us a better understanding of the island marble's imperiled status, it does not provide island marble with adequate protection in the Park and provides no protection for the butterfly across the rest of its range. Despite assertions by USFWS (2006) that the island marble will continue to persist without management as it has for many years on San Juan and Lopez Islands, the butterfly has been recently extirpated from most previously-occupied sites outside SJINHP, and is currently confirmed to persist in very low numbers (a few individuals) at just two sites, both on San Juan Island in close proximity to SJINHP (Table 2). Within SJINHP, island marble is no longer known from five previously-occupied sites, and has dramatically declined in abundance at extant sites (Tables 1, 3, & 4, Lambert 2011, Weaver 2012, *pers. comm.,* Potter 2012, *pers. comm.*). Even some of the largest subpopulations at SJINHP are estimated to have smaller populations (e.g., 23.8 and 38.8 adults) than the population size estimated for Pear Point Gravel Pit, a key site outside of the Park that was estimated to consist of 93.6 adults in 2009 and appears extirpated as of 2011 (Peterson 2009, 2010, Potter 2012, *unpublished data*). Overall, the rapid and range-wide losses in island marble populations, occupied sites, and abundance underscore the inadequacy of existing regulations to protect this butterfly.

E. Other natural or manmade factors affecting its continued existence

1. Small population size and stochastic events

In addition to destroying habitat, many of the threats detailed above (in Section A: The present or threatened destruction, modification, or curtailment of its habitat or range) can fragment remaining habitat into pieces that are too small or too distant to support healthy metapopulation structures. As small, isolated populations get smaller and more separated from adjacent populations, the pool of local genetic material shrinks and breeding between closely related individuals can result in inbreeding depression, a fitness reduction which lowers the population's ability to survive and reproduce. Extinction may result from this loss of genetic variability and reduced fitness due to the unavoidable inbreeding that occurs in such small populations (*reviewed in* Shaffer 1981).

Small and fragmented populations may also be less resilient to environmental change, and have a greater risk of extirpation from normal population fluctuations due to predation, disease, and changing food supply, as well as from natural disasters such as fire, flooding, or unusually wet or dry years (*reviewed in* Shaffer 1981). The American Camp site, Jakle's Lagoon, is a good example of a small, isolated island marble population that was unable to recover from a natural disaster. Following the severe storm in 2006, the population at this site declined gradually from 11 adults (pre-storm) to zero adults in 2008, and hasn't been observed at the site since (Lambert 2011, Potter 2012, *unpublished data*). This site is surrounded by forest and open water with limited connectivity to other island marble sites, making recolonization of the site unlikely (Lambert 2011).

With a very low number of individuals located primarily in one small geographic area (one confirmed population as of 2011), the island marble is likely already experiencing reduced gene flow and increased susceptibility to local population extirpation. The populations found on San Juan Island display classic metapopulation dynamics in which a core population exists with several outlier subpopulations connected to the core by migration (Ehrlich & Hanski 2004). As such, habitat fragmentation and other barriers to dispersal seriously jeopardize the island marbles' ability to maintain metapopulation structure and long-term security.

2. Global climate change

Rapidly changing climate conditions are hastening the extinction of many plants and animals in the western United States (*e.g.* McLaughlin *et al.*, 2002), to the point that 15–37% of species, globally, are predicted to be 'committed to extinction' by 2050 as a result of mid-range climate-warming scenarios (Thomas *et al.* 2004). In the Northwest region, annual average temperature over the past century has risen about 1.5°F, with some areas experiencing increases up to 4°F (U.S. Global Change Research Program 2012). The region's average temperature is projected to rise another 3 to 10°F in this century, with higher emissions scenarios resulting in warming in the upper end of this range (U.S. Global Change Research Program 2012). Increases in winter precipitation and decreases in summer precipitation are also projected by many climate models, although these projections are less certain than those for temperature. Impacts related to changes in snowpack, stream flows, sea level, forests, and other important aspects of life in the Northwest are already underway, with more severe impacts expected over the coming decades in response to continued and more rapid warming (U.S. Global Change Research Program 2012).

Due to their sensitivity to changes in temperature, precipitation, and other environmental conditions, butterflies are particularly vulnerable to climate change, and have experienced shifts in range and phenology induced by changing global temperatures (*reviewed in* Lambert 2011). Lambert (2011) documented a phenological shift in the island marble flight period between 2004 and 2008, with peak abundance shifting from early-mid May in 2004 to late May/early June in 2008, and an overall reduction in the adult flight period from approximately 10 weeks in 2004 to approximately five weeks in 2008. Although this phenological shift was likely due to progressively cooler spring conditions from 2004 to 2008 (Peterson 2010, Lambert 2011), it demonstrates the tight relationship between climatic conditions and adult emergence time and flight period.

Climate change also causes shifts in host plant phenology that can, in turn, affect the growth, survival, development, and fecundity of butterfly species (*reviewed in* Lambert 2011). For the island marble, the ability of the larvae to acquire sufficient food is strongly tied to climatic conditions governing the emergence, growth and development of the host plant (Lambert 2011). As such, temperature increases and other climate changes have the potential to increase larval mortality in this species. For example, Lambert (2011) found larval death due to starvation and disappearance (wandering in search of a new host plant) was substantially higher on *S. altissimum* host plants located in sand dunes compared to *S. altissimum* located in grassland habitat, potentially due to stressful environmental conditions (low precipitation and high temperatures) causing *S. altissimum* to develop at a faster rate in sand dune habitat (Lambert 2011).

Butterfly species endemic to islands are expected to be even more vulnerable to changes in climate due to habitat loss caused by a rise in sea level, as well as limited potential for long-distance dispersal (*reviewed in* Lambert 2011). According to the Intergovernmental Panel on Climate Change (2007), global sea level is expected to increase an average of 19 inches by 2100, and sea-level rise has also been identified as a key issue along vulnerable coastlines in the Pacific Northwest, resulting in increased erosion and loss of land (U.S. Global Change Research Program 2012). Habitat occupied by island marble may become unsuitable or unavailable with even a small rise in sea level, and island marble subpopulations feeding on the native host plant, *L. virginicum* var. *menziesii* are particularly threatened by sea level rises and storm events. While occasional disturbance (shifting sand and gravel) is needed to maintain *L. virginicum* var. *menziesii* habitat, intense and frequent disturbance appear to be highly detrimental to host plant habitat as well as overwintering island marble pupae (Lambert 2011). As climate warming continues, the intensity and frequency of off-shore storm surges is expected to increase, further limiting the survival of island marble at coastal sites (*reviewed in* Lambert 2011).

IX. CRITICAL HABITAT

Petitioners request the designation of critical habitat for the island marble concurrent with its listing. 16 U.S.C. § 1533(b)(6)(C) and 50 C.F.R. § 424.12.

X. CONCLUSION

For the above reasons, the island marble meets the criteria under the Endangered Species Act for consideration as an endangered species: 16 U.S.C. § 1533 (a)(1)(A-E) (Section 4) including: (A) The present or threatened destruction, modification, or curtailment of its habitat or range; (B) Overutilization for Commercial, Recreational, Scientific, or Educational Purposes; (C) Disease or Predation; (D) The inadequacy of existing regulatory mechanisms; and (E) Other natural or manmade factors affecting its continued existence.

The island marbles' extremely small population size, isolation, and restricted distribution make its long-term security questionable. These factors, combined with numerous threats to the butterfly and its remaining habitat, indicate that there is a very high likelihood that the island marble will soon be driven to extinction. As such, the Xerces Society for Invertebrate Conservation formally petition the U.S. Fish and Wildlife Service to list the island marble (*Euchloe ausonides insulanus*) as an endangered species. Furthermore, we request the Service use its authority to establish Critical Habitat based on the facts presented to prevent the extinction of this rare and vulnerable butterfly. Given the recent loss of island marble at the vast majority previously-occupied sites, the dramatic reduction in abundance and encounter rates within the core population, and continued threats to island marble habitat, emergency listing is necessary to protect the island marble pending completion of the final listing rule.

XI. REFERENCES

Barry, J.W., Skyler, P.J., Teske, M.E., Rafferty, J.A., and B.S. Grim. 1993. Predicting and measuring drift of *Bacillus thuringiensis* sprays. Environmental Toxicology and Chemistry 12: 1977-1989.

Black, S. and M. Vaughan. 2002. Petition to Emergency List the Island Marble Butterfly (*Euchloe ausonides insulanus*) as an Endangered Species Under the U.S. Endangered Species Act. Submitted by The Xerces Society, Center For Biological Diversity, Friends of the San Juans, and Northwest Ecosystem Alliance. December 10, 2002.

Erhardt, A. 1985. Diurnal Lepidoptera: sensitive indicators of cultivated and abandoned grassland. Journal of Applied Ecology 22: 849-861.

Ehrlich, P.R. 1992. Population biology of checkerspot butterflies and the preservation of global biodiversity. Oikos 63:6-12.

Ehrlich P.R. and D.D. Murphy 1987. Conservation lessons from long-term studies of checkerspot butterflies. Conservation Biology 1(2): 122-131.

Ehrlich, P.R. and I. Hanski 2004. Checkerspot research: background and origins. *In*: Ehrlich, P.R. & Hanski, I. (Eds.), On the Wings of Checkerspots: A Model System for Population Biology, pp. 3-16. Oxford University Press, Oxford.

Environmental Protection Agency. 2011. Pesticides Industry Sales and Usage: 2006 and 2007 Market Estimates. By Arthur Grube, David Donaldson, Timothy Kiely, and La Wu. Washington, DC. 41 pp.

Fleckenstein, J., and A. Potter. 1999. 1997 and 1998 project summary of Puget prairie butterfly surveys. Page 11 *in* N. H. P. Washington State Department of Natural Resources, editor.

Guppy, C. S. and J. H. Shepard. 2001. Butterflies of British Columbia. UBC Press (Vancouver, BC) and Royal British Columbia Museum (Victoria, BC). 414 pp.

Hanson, T., Potter, A., Miskelly, J., and S. Vernon. 2009. Surveys for the Island Marble butterfly (*Euchloe ausonides insulanus*) in San Juan County, Washington, 2008. Washington Department of Fish and Wildlife report.

Hanson, T., Potter, A., and S. Vernon. 2010. Surveys for the Island Marble butterfly (*Euchloe ausonides insulanus*) in San Juan County, Washington, 2009. Washington Department of Fish and Wildlife report.

Hanski, I., Poyry, J., Pakkala, T. and M. Kuussaari. 1995. Multiple equilibria in metapopulation dynamics. Nature 377: 618-621.

Huntzinger, M. 2003. Effects of fire management practices on butterfly diversity in the forested western United States. Biological Conservation 113: 1–12.

Intergovernmental Panel on Climate Change. 2007. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (eds). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Kjaer, C. and N. Elmegaard. 1996. Effect of herbicide treatment on host plant quality for a leaf-eating beetle. Pesticide Science 47(4): 319-325.

Kruckeberg, A.R. 1991. The Natural History of Puget Sound Country. University of Washington Press, Seattle. 468 pp.

LaBar, C. 2009. Investigating the use of herbicides to control invasive grasses in prairie habitats: effects of non-target butterflies. M.S. Thesis. Vancouver, Washington: Washington State University. 37 pp.

Lambert, A., 2005. Population study of the Island Marble butterfly (*Euchloe ausonides insulanus*). Draft report dated October 2005. University of Washington.

Lambert, A.M. 2011. Natural history and population ecology of a rare pierid butterfly, *Euchloe ausonides insulanus* Guppy and Shepard (Pieridae). Doctor of Philosophy Thesis, University of Washington, 199 pp.

Layberry, R. A., Hall, P. W., and J. D. Lafontaine. 1998. The Butterflies of Canada. University of Toronto Press, Toronto. 280 pp.

Martin, T.G., Arcese, P. and N. Scheerder. 2011. Browsing down our natural heritage: Deer impacts vegetation structure and songbird assemblages across an island archipelago. Biological Conservation 144: 459-469.

McLaughlin, J.F., Hellmann, J.J., Boggs, C.L. and P.R. Ehrlich. 2002. Climate change hastens population extinction. Proceedings of the National Academy of Sciences 99: 6070-6074.

Miskelly, J.W. 2000. Habitat requirements and conservation of the butterflies *Euchloe ausonides insulanus* (Pieridae) and *Euphydryas editha taylori* (Nymphalidae) in southwestern British Columbia. Master of Science Thesis, University of Victoria, 115pp.

Miskelly, J. 2005. 2005 surveys for Island Marble butterfly (*Euchloe ausonides insulanus*) in northern coastal Washington. Washington Department of Fish and Wildlife report.

Miskelly, J. & J. Fleckenstein. 2007. Surveys for Island Marble butterfly (*Euchloe ausonides insulanus*) in San Juan County, Washington, 2006. Washington Department of Natural Resources report.

Miskelly, J. & A. Potter. 2009. Surveys for Island Marble (*Euchloe ausonides insulanus*) in San Juan County, Washington, 2007. Washington Department of Fish and Wildlife report.

National Parks Conservation Association. 2007. State of the Parks: San Juan Island National Historic Park. Washington, DC. 24 pp.

NatureServe. 2012. *Euchloe ausonides insulanus* Version 7.1 (2 Feb. 2009). Data last updated July 2011. Available at: www.natureserve.org (Accessed 15 April 2012).

Pelham, J. 2008. A catalogue of the butterflies of the United States and Canada with a complete bibliography of the descriptive and systematic literature. Journal of Research on the Lepidoptera 40: 658 pp.

Peterson, M.A. 2009. Population ecology of the Island Marble butterfly (*Euchloe ausonides insulanus*): quantifying abundance and dispersal. Unpublished report to SJINHP.

Peterson, M.A. 2010. Monitoring Plan for the Island Marble Butterfly (*Euchloe ausonides insulanus*) at American Camp, San Juan Island National Historical Park. Unpublished report to SJINHP.

Pollard, E. 1977. A method for assessing changes in the abundance of butterflies. Biological Conservation 12: 115-134.

Pollard, E. and T.J. Yates. 1993. Monitoring Butterflies for Ecology and Conservation. Chapman & Hall, London.

Potter, A., Hanson, T., and S. Vernon. 2011. Surveys for the island marble butterfly *(Euchloe ausonides insulanus*) in San Juan County, Washington, 2010. Washington Department of Fish and Wildlife report.

Potter, A. 2012. Summary of 2011 surveys by WDFW for island marble *(Euchloe ausonides insulanus*) in San Juan County, Washington. Unpublished data.

Pyle, R.M. 2002. The Butterflies of Cascadia. Seattle Audubon Society. Seattle, WA. 420 pp.

Pyle, R.M. 2004. The butterflies of San Juan Island National Historic Park. A final report to San Juan Island National Historic Park. 50 pp.

Russell, C. and C. B. Schultz. 2010. Investigating the use of herbicides to control invasive grasses: effects on at-risk butterflies. Journal of Insect Conservation 14: 53-63.

San Juan Island National Historical Park, National Park Service and U.S. Fish and Wildlife Service. 2006. A conservation agreement and strategy for the Island Marble butterfly *(Euchloe ausonides insulanus* Guppy & Shepard). October 31, 2006. Prepared with the assistance of Robert Michael Pyle. 17 pp.

San Juan Island National Historical Park. 2008. Draft General Management Plan and Environmental Impact Statement. January 2008. National Park Service U.S. Department of the Interior.

Schultz, C.B. 1998. Ecology and conservation of the Fender's blue butterfly. PhD. Dissertation, University of Washington. Seattle. 145 pp.

Schultz, C.B. and E.E. Crone. 1998. Burning prairie to restore butterfly habitat: a modeling approach to management tradeoffs for the Fender's blue. Restoration Ecology 6(3): 244-252.

Schultz, C.B., Henry, E., Carleton, A., Hicks, T., Thomas, R., Potter, A., Collins, M., Linders, M., Fimbel, C., Black, S., Anderson, H.E., Diehl, G., Hamman, S., Gilbert, R., Foster, J., Hays, D., Wilderman, D., Davenport, R., Steel, E., Page, N., Lilley, P.L., Heron, J., Kroeker, N., Webb, C. and B. Reader. 2011. Conservation of prairie-oak butterflies in Oregon, Washington, and British Columbia. Northwest Science 85: 361–388.

Shaffer, M.L. 1981. Minimum population sizes for species conservation. BioScience 31(2): 131-134.

Shepard, J.H. 1995. The status of butterflies of conservation concern on southeastern Vancouver Island and the adjacent Gulf Islands. British Columbia Ministry of Environment, Lands, and Parks and Conservation Data Centre. Victoria, British Columbia.

Shepard, J. H. 2000. Status of five butterflies and skippers in British Columbia. Wildlife Working Report No. WR-101. British Columbia Ministry of Environment, Lands, and Parks, Victoria, British Columbia, 27 pp.

Stark, J.D., Chen, X.D., and C.S. Johnson. 2012. Effects of herbicides on Behr's metalmark butterfly, a surrogate species for the endangered butterfly, Lange's metalmark. Environmental Pollution 164: 24-27.

Sucoff, E., Nichols, T., and E. Lu. 2001. Herbicide effects on host plants of Karner blue butterfly and on butterfly development from egg to adult. University of Minnesota.151. Department of Forest Resources Staff Paper Series 151.

Thomas, C.D., Cameron, A., Green, R.E., Bakkenes, M., Beaumont, L.J., Collingham, Y.C., Erasmus, B.F., De Siqueira, M.F., Grainger, A., Hannah, L., Hughes, L., Huntley, B., Van Jaarsveld, A.S., Midgley, G.F., Miles, L., Ortega-Huerta, M.A., Peterson, A.T., Phillips, O.L., and S.E. Williams. 2004. Extinction risk from climate change. Nature 427(6970): 145-8.

U.S. Department of Agriculture: Forest Service. April 2005. Preventing and managing invasive plants: Final Environmental Impact Statement. Pacific Northwest Region. 173 pp.

U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; 12-month finding on a petition to list the Island Marble butterfly (*Euchloe ausonides insulanus*) as threatened or endangered. Federal Register 71 (219): 66292-66298.

U.S. Fish and Wildlife Service F.O.I.A. Document 2006. Email communication between USFWS agency staff regarding island marble's status as a species for which conservation action/agreements have contributed to the decision not to list as endangered. Email dates: November 28th through 30th, 2006. F.O.I.A. request for island marble butterfly filed January 2010.

U.S. Global Change Research Program. 2012. Regional climate information: Northwest. Available at: http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts/regional-climate-change-impacts/northwest (Accessed 18 April 2012).

Wagner, D. and J.C. Miller. 1995. Must butterflies die for the gypsy moth's sins? American Butterflies 3(3): 19-23.

Warren, M.S. 1993. A review of butterfly conservation in central southern Britain: II. Site management and habitat selection of key species. Biological Conservation 64: 37-49.

Washington Department of Fish and Wildlife. 2012. Island Marble Butterfly *(Euchloe ausonides insulanus)* Fact sheet. Available at: http://wdfw.wa.gov/conservation/island_marble_butterfly/ (Accessed 15 July 2011).

Whaley, W.H., Arnold, J., and B.G. Schaaleje. 1998. Canyon drift and dispersion of *Bacillus thuringiensis* and its effects on selected nontarget lepidopterans in Utah. Environmental Entomology 27(3): 539–548.

XII. PERSONAL COMMUNICATIONS

Potter, Ann. Washington Department of Fish and Wildlife. March-July 2012.

Weaver, Jerald. National Park Service, San Juan Island National Historic Park. April 2012.

Lambert, Amy. University of Washington. May 2012

APPENDIX. Tables and Figures

Table 1. History of island marble detection (egg, larval, or adult) at the 12 sites in the American Camp Unit of SJINHP. WDFW columns are based on Table 3 in Potter *et al.* (2011), with additions from Potter (2012, *unpublished data*). NPS column is based on Lambert (2011), Peterson (2009, 2010), and Weaver (2012, *pers. comm.*). In WDFW columns, Y indicates positive detection of one or more island marble individuals in any life stage (egg, larva, or adult). N is shown for surveys that failed to find island marble individuals in any life stage. In NPS column, bold text indicates sites that were confirmed extant in 2011, either by NPS or WDFW surveys.

Occupied Island Marble Site Name by Region	Land ownership	WDFW Detections							NPS Detection Summary
South End San Juan Island: Cattle Point to False Bay		2005	2006	2007	2008	2009	2010	2011	2004-2011
American Camp-Cattle Point NRCA Border	NPS/DNR	Y	Y	Y	N	N	N	N	No sightings in recent years.
American Camp-Dunes	NPS	Y	No survey	N	No survey	No survey	Y	No survey	Regular monitoring 2004-2011. As of 2011, confirmed extant, and one of two larger subpopulations of island marble.
American Camp-East End Uplands	NPS	Y	No survey	No survey	No survey	No survey	No survey	No survey	No sightings in recent years.
American Camp-Jakle's Lagoon	NPS	No survey	N	No survey	No survey	N	No survey	N	Regular monitoring from 2005-2008, occasional monitoring since. No sightings in recent years, despite two days of survey effort in 2011.
American Camp-North of Redoubt Rd	NPS	No survey	No survey	No survey	No survey	No survey	No survey	No survey	Regular monitoring from 2004-2008. One or more individuals have been observed in recent years, but numbers and dates not recorded/monitored. 2011 occupancy not examined.
American Camp-Old Town Lagoon	NPS	No survey	N	Y	No survey	Y	Y	Y	Regular monitoring from 2004-2008. Small number of individuals have been observed at site in recent years, but numbers not recorded/monitored. Monitoring may begin again in 2012.
American Camp-Rabbit Grasslands	NPS	No survey	No survey	No survey	No survey	No survey	N	No survey	No sightings in recent years. Very few mustard plants present.
American Camp-Redoubt	NPS	Y	No survey	Y	Y	Y	Y	Y	Individuals have been regularly observed in recent years, but numbers not recorded/monitored. Site appears contiguous with American Camp Slope south of Redoubt.
American Camp-Slope above Grandma's Cove	NPS	Y	No survey	No survey	No survey	No survey	No survey	Y	One or more individuals have been observed at site in recent years, but numbers not recorded/monitored.
American Camp-Slope south of Redoubt	NPS	Y	No survey	No survey	No survey	Y	Y	No survey	Regular monitoring 2004-2011. As of 2011, confirmed extant, and one of two larger subpopulations of island marble.
American Camp-Third Lagoon	NPS	Y	N	N	N	N	No survey	No survey	Regular monitoring from 2005-2008, no sightings in recent years.
American Camp-West End Uplands	NPS	No survey	No survey	No survey	No survey	No survey	No survey	No survey	Regular monitoring 2004-2011. As of 2011, confirmed extant, but both host plant and island marble numbers are going down; marked decline in adult abundance between 2010 and 2011.

Table 2. History of island marble detection (egg, larval, or adult) at 40 sites outside of the American Camp Unit of SJINHP where island marble has been found during WDFW surveys (2005-2011). Based on Table 3 in Potter *et al.* (2011), with additions for 2011 from Potter (2012, *unpublished data*). Y indicates positive detection of one or more island marble individuals in any life stage (egg, larva, or adult). N is shown for surveys that failed to find island marble individuals in any life stage.

Occupied Island Marble Site Name by Region	Land ownership	WDFW Detections						
South End San Juan Island: Cattle Point to False Bay (cont.)		2005	2006	2007	2008	2009	2010	2011
Brandt property[1]	Private	Y	N	No survey	No survey	No survey	No survey	No survey
Browne property	Private	No survey	No survey	Y	Y	Y	Y	?[a]
Cattle Point BLM-Lighthouse Trail	DNR	Y	Y	Y	Y	N	N	N
Cattle Point DNR NRCA-East Meadow	DNR	N	N	N	Y	N	N	N
Cattle Point Estates[1]	Private	Y	No survey	No survey	No survey	No survey	No survey	No survey
Cattle Point-McMillen	Private	Y	Y	Y	Y	N	Y	N
Eagle Cove Park	San Juan County	Y	Y	Y	Y	Y	Y	Y
Eagle Cove subdivision[2]	Private	Y	No survey	Y	Y	Y	No survey	No survey
Franklin property[3]	Private	No survey	No survey	Y	Y	No survey	No survey	No survey
Illg property	Private	No survey	No survey	Y	N	N	No survey	No survey
Mar Vista Resort	Private	Y	Y	Y	N	Y	Y	N
Mulno Cove Farm	Private	No survey	Y	N	N	No survey	No survey	No survey
Neukom property	Private	Y	Y	Y	N	N	N	No survey
Old Johnson Road	Private	Y	Y	Y	Y	Y	Y	N[b]
Olympic Lights B&B	Private	Y	Y	Y	Y	Y	Y	Y
Straits View Farm	Private/ SJPT easement	Y	Y	N	N	N	N	No survey

Occupied Island Marble Site Name by Region	Land ownership	WDFW Detections						
Pear Point, San Juan Island		2005	2006	2007	2008	2009	2010	2011
Argyle Rd/Pear Point Rd jct	Private	No survey	No survey	Y	Y	N	N	No survey
Buck-Boreen property	Private	No survey	No survey	No survey	No survey	Y	N	N
Pear Point barge landing	San Juan County	No survey	No survey	No survey	N	Y	N	N
Pear Point gravel pit	San Juan County	No survey	No survey	Y	Y	Y	Y	?[a]
Pear Point Rd/Jackson Beach Rd jct	Private	No survey	No survey	No survey	Y	Y	N	No survey
San Juan Valley								
Friday Harbor Airport hangars[1]	unknown	No survey	No survey	Y	N	N	No survey	No survey
No. 2 Schoolhouse Road	Private	No survey	No survey	No survey	Y	No survey	N	N[c]
San Juan Valley Road/Douglas Road jct	Private	No survey	No survey	No survey	Y	No survey	N	N[d]
San Juan Valley Road/Strawberry Lane jct	Right of way/private	No survey	No survey	No survey	Y	N	N	N[d]
San Juan Valley Road/ Valley Farms Road jct	Private	No survey	No survey	Y	Y	N	N	N[d]
Schramm property	Private	No survey	No survey	Y	Y	Y	N	N[d]
Twigg Smith North[3]	Private	No survey	Y	Y	Y	Y	No survey	N[e]
Twigg Smith South[3]	Private	No survey	Y	Y	Y	N	No survey	N[e]
Northwest San Juan Island								
Lacrover Farm	Private/ SJPT easement	Y	Y	N	N	N	No survey	No survey

Occupied Island Marble Site Name by Region	Land ownership	WDFW Detections						
Lopez Island		2005	2006	2007	2008	2009	2010	2011
Center Church to Kjaargard ditches	Private	No survey	Y	N	N	N	Y	N
Chandler property[1]	Private	No survey	Y	No survey	No survey	No survey	No survey	No survey
Fisherman Bay Rd/Center Rd jct[1]	Private	Y	Y	N	N[f]	N[f]	No survey	No survey
Fisherman Bay-Tombolo	SJCLB and County	Y	N	Y	N	N	N	No survey
Jenison, Richard and Mary property[1, 4]	Private	No survey	No survey	Y	N	No survey	No survey	No survey
Knight property	Private	No survey	No survey	No survey	No survey	No survey	Y	N
Kretschmer property[4]	Private	No survey	No survey	Y	N	N	N	No survey
Lopez School	School district	Y	N	N	N	N	N	No survey
Pope property[1, 4]	Private	No survey	No survey	Y	N	N	No survey	No survey
Sweetbriar Farm (former Whitecap Farm)	Private	Y	Y	Y	Y	Y	Y	?[a]
Total number of previously or newly occupied sites surveyed/(% Y):**		24 (96%)	24 (71%)	33 (73%)	36 (58%)	36 (42%)	32 (44%)	18*** (28%)

[1] Surveys discontinued because recent landscaping, weed control, or the construction of new buildings eliminated appropriate conditions for the butterfly, and previous detections had been minimal.

[2] This site represents a tiny amount of habitat (strips of roadside vegetation on small lots) and since it is right next to the occupied Eagle Cove Park site, it hasn't been a survey focus in recent years.

[3] Permission to survey was not granted from land-owner in recent years.

[4] These three Richardson-area sites were documented as occupied based on a single butterfly flying through all three properties in 2007.

[a] One or more eggs were detected but were unable to be positively identified. May have been either island marble or Sara's orangetip eggs.

[b] Survey not conducted, but site visible and inspected from a public road. Area of remaining habitat was very small (a few plants in a short road edge strip right next to the grain-farming field). No island marble observed.

[c] Survey not conducted, but site visible and inspected from a public road; area of habitat determined to be regularly cultivated for agricultural purposes. No island marble observed.

[d] Survey not conducted, but site visible and inspected from a public road; few to no mustard host plants observed; no island marble observed.

[e] Survey not conducted; sites are partially visible from a public road. Some host plants persist, but the current status of island marble is unknown. Landowner access has not been granted since 2010. No island marble observed.

[f] Survey not conducted, but site visible and inspected from the road; the few mustard hosts that were present were subsequently removed by landowner with herbicide application.

**Surveys and positive detections from Table 1 (American Camp sites) are included in these values.

***Not including the additional eight sites with negative detections based on roadside inspections, only (N[a]-N[e]).

Table 3. Number of adults observed on transects at American Camp, San Juan Island National Historical Park, San Juan Island, Washington, 2004−2008 (Lambert 2011). Surveys on each transect were conducted every six to nine days throughout the adult flight period, during appropriate conditions for adult butterflies. Results show steady reduction in the number of adults observed over the five year survey period, as well as reduction in the area occupied by island marble. Island marble was not observed at over half of the survey transects at American Camp by 2008. See Figure 3 for a map of transects, and Figure 4 for a graphical representation of the last row in this table.

American Camp Transect Number (Site name or area)	Total Adult Abundance from Annual Transect Counts				
	2004	2005	2006	2007	2008
1 (Redoubt)	16	17	12	5	1
2 (Slope South of Redoubt)	43	4	12	5	9
3 (Redoubt)	17	7	1	4	1
4 (North of Redoubt Rd.)	2	1	0	0	0
5 (Slope South of Redoubt area)	47	31	21	12	12
6 (West End Uplands)	16	4	6	4	6
7 (Slope South of Redoubt)	57	34	37	16	20
8 (Slope South of Redoubt)	9	4	0	1	0
9 (Slope South of Redoubt)	2	2	0	0	0
10 (North of Redoubt Rd. area)	5	1	0	0	0
11 (Redoubt)	1	1	0	0	0
12 (North of Redoubt Rd.)	5	0	0	0	0
13 (Old Town Lagoon)	38	41	9	5	1
14 (Dunes)	12	33	22	18	13
15 (Jakle's Lagoon)	–	11	4	1	0
16 (Third Lagoon)	–	3	1	0	0
Total Adults	270	194	125	71	63

Table 4. Island marble adult encounter rates for the three American Camp sites where monitoring has occurred from 2004 to 2011. Encounter rates are calculated using transect count totals standardized by transect length and number of visits (adults counted/100m/#visits). Results from 2004 to 2008a were calculated using transect count totals reported in Lambert (2011), 200m transect lengths, and the specific number of site visits provided by Lambert (2012, pers. comm.): 2004=8, 2005=11, 2006=6, 2007=8, 2008=5. Results from 2008b to 2010 are taken directly from Peterson (2010). In 2008 and 2009, transects were 200m long, and sites were visited daily (rather than ~weekly) during the adult flight period. In 2010, transects were 400m long, and sites were visited 10 times over a 22 day period from 20 May to 11 June. Table 4 shows a dramatic decline of island marble encounters at two sites (Slope South of Redoubt and West End Uplands), and relatively stable adult encounters at the third site (Dunes). See Figure 3 for a map of transects.

American Camp Site/Year	2004	2005	2006	2007	2008a	2008b	2009	2010	2011
Slope South of Redoubt	2.69	0.18	1.00	0.31	0.90	--	0.50	1.25	0.76
West End Uplands	1.00	0.18	0.50	0.25	0.60	0.27	0.30	0.30	0.09
Dunes	0.75	1.50	1.83	1.13	1.30	0.31	0.87	0.65	0.84

Table 5. Observed and potential threats at sites where island marble has been observed (2005 to 2011). Based on table in Hanson *et al.* (2010) with additions from Miskelly & Potter (2009), Miskelly (2005), Potter *et al.* (2011), and Potter (2012, *pers. comm.*). Land ownership for each site is presented in Tables 1 and 2.

Occupied Island Marble Site Name	Large-scale agricultural soil-tilling	Removal of host plants	Rabbit grazing	Storm tide	Mowing	Collection	Deer browsing	Livestock grazing	Landscaping/ Yard maintenance	Development	Habitat disturbance	Recreation	Grassland Restoration/ Herbicides	Insecticides	Land snail predation	Succession and invasion of non-natives	Insect and spider predation
American Camp (12 sites)[1]			X	X		X	X				X	X	X[2]			X[3]	X
Argyle Rd./Pear Point Rd. Jct.		X			X		X		X								X
Brandt property					X		X		X								X
Browne property	X				X		X		X								X
Buck-Boreen property		X			X		X	X	X	X	X					X	X
Cattle Point BLM-Lighthouse Trail			X			X	X					X				X	X
Cattle Point DNR NRCA-East Meadow			X		X		X					X					X
Cattle Point Estates		X			X		X										X
Cattle Point-McMillen		X		X			X		X			X					X
Center Church to Kjaargard ditches		X			X		X										X
Chandler property		X			X		X		X								X
Eagle Cove Park					X	X	X										X
Eagle Cove subdivision		X			X		X		X								X

Occupied Island Marble Site Name	Large-scale agricultural soil-tilling	Removal of host plants	Rabbit grazing	Storm tide	Mowing	Collection	Deer browsing	Livestock grazing	Landscaping/ Yard maintenance	Development	Habitat disturbance	Recreation	Grassland Restoration/ Herbicides	Insecticides	Land snail predation	Succession and invasion of non-natives	Insect and spider predation
Fisherman Bay Rd./Center Rd. Jct.		X			X		X				X		X				X
Fisherman Bay-Tombolo		X		X	X	X	X				X	X					X
Franklin property					X		X		X								X
Friday Harbor Airport hangars					X		X			X							X
Illg property	X						X		X								X
Jenison, Richard and Mary property		X			X		X		X								X
Knight property		X							X								X
Kretschmer property		X			X		X		X								X
Lacrover Farm		X			X		X	X			X						X
Lopez School					X	X	X		X								X
Mar Vista Resort							X									X	X
Mulno Cove Farm							X		X								X
Neukom property	X				X		X		X								X
No. 2 Schoolhouse Road	X	X															X
Old Johnson Road		X			X		X			X							X
Olympic Lights B&B		X			X				X								X

Occupied Island Marble Site Name	Large-scale agricultural soil-tilling	Removal of host plants	Rabbit grazing	Storm tide	Mowing	Collection	Deer browsing	Livestock grazing	Landscaping/ Yard maintenance	Development	Habitat disturbance	Recreation	Grassland Restoration/ Herbicides	Insecticides	Land snail predation	Succession and invasion of non-natives	Insect and spider predation
Pear Point barge landing		X					X			X	X				X		X
Pear Point gravel pit		X				X	X		X		X				X	X	X
Pear Point Rd./Jackson Beach Rd. Jct.		X			X		X		X		X						X
Pope property		X			X		X		X								X
San Juan Valley Rd./ Valley Farms Rd. Jct.	X				X		X	X			X						X
San Juan Valley Rd./Douglas Rd. Jct.	X				X		X	X			X						X
San Juan Valley Rd./Strawberry Lane Jct.	X				X		X	X									X
Schramm property	X	X			X		X		X								X
Straits View Farm	X			X	X		X							X			X
Sweetbriar Farm (former Whitecap Farm)					X		X	X			X						X
Twigg Smith North	X				X		X	X	X	X	X					X	X
Twigg Smith South	X				X		X	X	X	X	X						X

[1] Threats listed in this row apply to one or more of the twelve American Camp sites
[2] Threat applies to American Camp Redoubt site
[3] Threat applies to the following American Camp (AC) sites: AC East End Uplands, AC Redoubt, AC Slope above Grandma's Cove, AC slope south of Redoubt, AC West End Uplands.

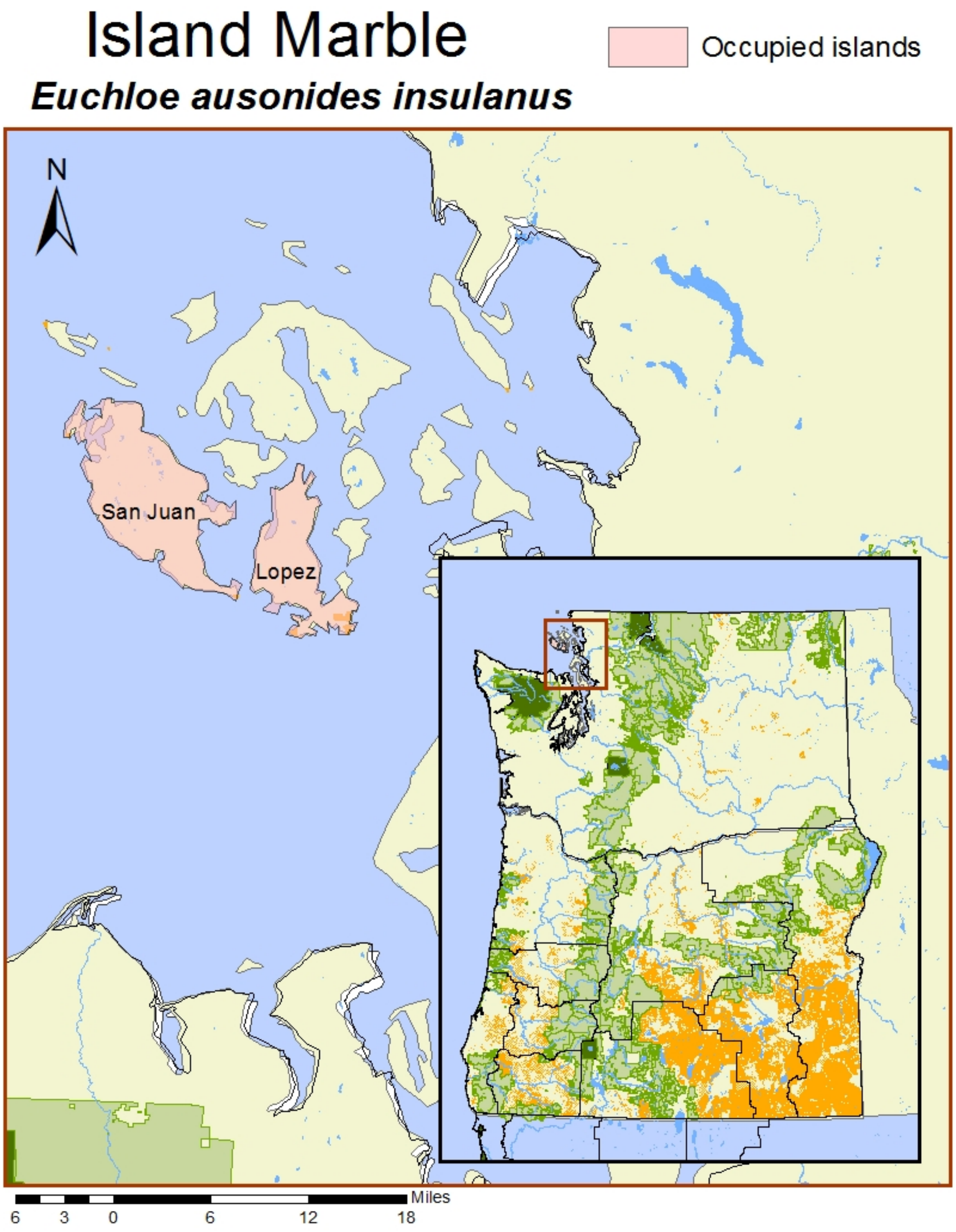

Figure 1. Global distribution of the island marble, showing the only two islands in northwest Washington where the butterfly has been located during extensive annual surveys from 1998 to present. In all, the island marble has been observed at total of 52 sites on San Juan and Lopez Islands, representing five populations (Tables 1 & 2). As of 2011, it is confirmed from just eight of these sites, representing just one population on Southwest San Juan Island (Tables 1 & 2).

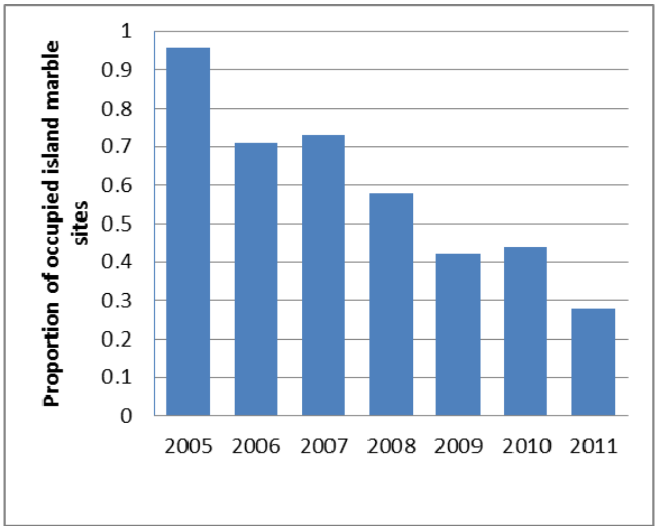

Figure 2. Annual proportion of sites occupied by island marble relative to all previously- or newly-occupied sites surveyed (WDFW patch occupancy surveys, Tables 1 & 2). Each year, the percentage of previously or newly-occupied sites surveyed that are currently occupied has declined, from 96% in 2005 to 28% in 2011. This figure likely under-represents the level of decline of island marble site occupancy in recent years because previously occupied sites where habitat was eliminated and/or the butterfly had gone undetected for multiple years often went unsurveyed due to unlikelihood of detection. For details on the number of sites surveyed per year, see Table 2 (bottom row).

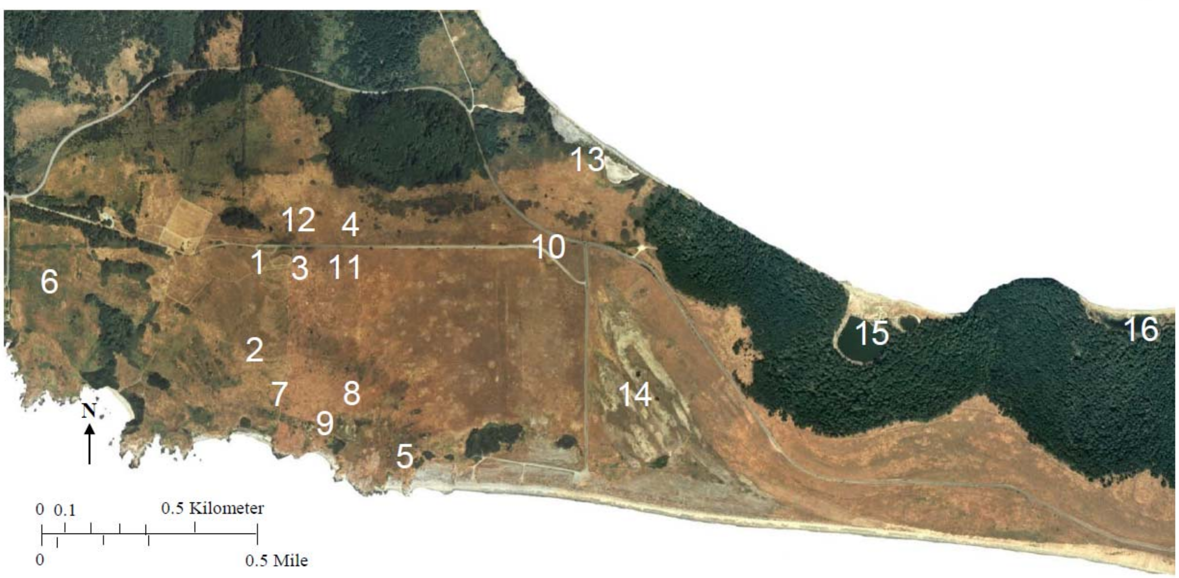

Figure 3. Location of belt transects at island marble sites in the American Camp unit of San Juan Island National Historic Park, San Juan Island, Washington. Transects 1-14 were surveyed for island marble from 2004 to 2008, and transects 15 and 16 were surveyed from 2005 to 2008 (Lambert 2011). Transect count monitoring has continued at Transects 2, 6, and 14 (2008 to 2011 and ongoing) (Weaver 2012, *pers. comm.*). Map extracted from Lambert (2011), used with permission. See Tables 3 and 4 for corresponding transect count data.

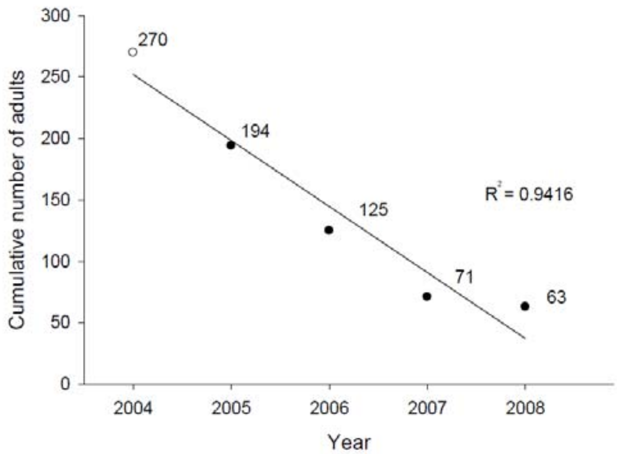

Figure 4. Relative adult island marble abundance (cumulative number) recorded during annual transect counts at American Camp sites from 2004 to 2008. Points correspond to the cumulative number of adults observed on the transects each year. Fourteen transects were surveyed in 2004, and two additional transects were added in 2005, for a total of 16 transects from 2005 to 2008 (Lambert 2011). Annual transect data is shown in Table 3. Figure extracted from Lambert (2011), used with permission.