Conservation of an Endangered Butterfly and the Management of Novel Plant Assemblages

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Colleagues and students at the University of Washington who have inspired and supported this work over the years including Dr. Kern Ewing, Dr. Regina Rochefort, Dr. Julie Combs, Dr. Kristin Gustafson, Dr. Martha Groom and Dr. Bruce Burgett. Practitioners, managers, regulators and planners who work tirelessly to conserve and protect rare, threatened and endangered species and habitats including Xerces Society: Bob Pyle local independent naturalists: James Miskelly (B.C.), Thor Hanson and Susan Vernon San Juan Island National Historical Park: Elexis Freddy, Jerald Weaver, Jenny Shrum, Raena Parson, Steve Ray and Ken Morgan US Fish and Wildlife: Ted Thomas, Karen Reagan and Zach Radmer Washington Department of Fish and Wildlife: Ann Potter, Dave Hays, Hannah Anderson and Ruth Milner San Juan Preservation Trust and SJ County Land Bank: Kathleen Foley, Eliza Habegge, seasonal ecologists, Dineh Judd and Claire Crawbuck Center for Natural Lands Management: Sierra Smith and Sara Hammam Washington Natural Areas Program: John Fleckenstein and Dave Wilderman
Believed extinct for 90 years

American Camp, San Juan Island National Historical Park, San Juan Island, Washington (1998)

Vancouver Island, British Columbia, Canada (1908)
BACKGROUND

14 specimens exist in museum collections

Island marble (*Euchloe ausonides insulanus*) Guppy and Shepard 2001

“greatly expanded marbling”
San Juan Island
Lopez Island
American Camp, SAJH
Large marble
Island marble
Vancouver Island, BC
Distribution
2005-2010
Relative Abundance
American Camp, SAJH

![Graph showing the number of adults over time with data points and a trend line. The R² value is 0.2762.](image)
...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...

...propose to list the island marble butterfly (Euchloe auronides insulanus) as an endangered species...812 acres (329 hectares) on the south end of San Juan Island, San Juan County, Washington, fall within the boundaries of the proposed critical habitat designation.
STUDY SITE

American Camp, San Juan Island National Historical Park

- open area (full sunlight)
- topographic relief

Mt. Finlayson 87m
HOST PLANT HABITAT

NON-NATIVE field mustard
Brassica rapa L. rapa

- availability of appropriate host plants (glucosinolates)
NON-NATIVE tumble mustard
*Sisymbrium altissimum* L.
HOST PLANT HABITAT

Brassica rapa

Sisymbrium altissimum
HOST PLANT HABITAT

NATIVE tall peppergrass
*Lepidium virginicum* var. *menziesii* (DC) Hitchc.
HOST PLANT HABITAT

- Brassica rapa
- Sisymbrium altissimum
- Lepidium virginicum var. menziesii (native)
HOST PLANT HABITAT

• suitable state of growth (i.e., plant phenology)
LIFE HISTORY

late April

May 21 - May 24
LIFE HISTORY
LIFE HISTORY
LIFE HISTORY

June 25 - May 24
QUESTIONS

What factors influence the rarity of island marble?
What factors cause mortality?
METHODS
Survivorship and mortality

• Survey 3-5 days for eggs, instar III and IV every 1-2 days, instar V several times a day

• Identified larval instars based on coloration of eggs, larvae size and morphology

• In 2005-2008, sampled 1617 individuals

• Logistic regression models were used to examine the relationship between host plant species and survival beyond IV
RESULTS

Yearly survivorship of larvae (beyond instar IV) on three host plants species (2005-2008)

Survivorship

No significant difference in survival between host plant species was detected (logistic regression, Wald test of host plant effect, p=0.11). In terms of percentage, survivorship was highest on *L. virginicum var. menziesii* in 2007 (14.2%) (Lambert 2011)
RESULTS
Causes of mortality

PREDATION
46% (n=752)

Family Thomisidae (crab spider)
RESULTS
Causes of mortality

DEER HERBIVORY
26% (n=415)

145 eggs/18 plants
111 eggs consumed by deer (77%)
RESULTS

Causes of mortality

STARVATION
9% (n=139)

HOST PLANT DAMAGE
6% (n=102)

Family Cercopidaeae (spittle bug)
RESULTS

Causes of mortality

Host-specific sources of mortality of all life stage, among all sites and host plant species (2005-2008)

- L. virginicum var. menziesii
- S. altissimum
- B. rapa

Predation: 77%
Deer: 43%
Starvation: 11%
Damage: 14%
Disappearance: 20%

Percent mortality within host plant species (n=1515); 51 unknown causes of death and 51 likely walked to pupate (Lambert 2011)
Reduction of field mustard (*Brassica rapa*) due to non-native perennial grasses and deer herbivory
Relative Abundance
American Camp, SAJH

NUMBER OF ADULTS

YEAR

R² = 0.2762
CONSERVATION AND RESTORATION

- Reintroduction of a native host plant, 2007
- Captive rearing, 2012-ongoing
- Habitat restoration, 2013-2018
- Excluding deer, 2013-ongoing

UW Bothell students planting native plants
Western buttercup (*Ranunculus occidentalis*), Meadow death camas (*Zygadenus venenosus*), Roemer’s fescue (*Festuca roemerii/idahoensis*), Leichtlin’s camas (*Camassia leichtlinii*), Harvest brodiaea (*Brodiaea coronaria*)
Agropyron repens, Holcus lanatus, Poa pratensis, Rumex acetosella, Hypochaeris radicata, Vicia sativa and Teesdalia nudicaulis

• 41 species (31 introduced species)
Treatment effects on germination and early establishment of eight native species

<table>
<thead>
<tr>
<th>Native species</th>
<th>S or NS?</th>
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<tbody>
<tr>
<td><em>Luzula multiflora</em></td>
<td>S ↑ F+H, H</td>
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<tr>
<td><em>Trifolium tridentatum</em></td>
<td>S ↑ F+H</td>
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<tr>
<td><em>Bromus sitchensis</em></td>
<td>NS</td>
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<tr>
<td><em>Festuca roemerii</em></td>
<td>NS</td>
</tr>
<tr>
<td><em>Lomatium utriculatum</em></td>
<td>NS</td>
</tr>
<tr>
<td><em>Lomatium nudicaule</em></td>
<td>NS</td>
</tr>
<tr>
<td><em>Elymus glaucus</em></td>
<td>NS</td>
</tr>
<tr>
<td><em>Danthonia californica</em></td>
<td>NS</td>
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</tbody>
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ANOVA (α=0.05)
HABITAT RESTORATION

How do we increase the abundance of island marble in the short term while ensuring the conservation of the species over the long term?

Create multiple patches of habitat that includes host plants and native grasses and forbs that island marble relies on to find a mate, reproduce, mature and pupate.

Research design takes into account both butterfly biology and plant community dynamics.
• Open habitat (south-facing for wind dispersal)
• Topographic relief
• Close proximity to sites of prairie restoration
STUDY DESIGN

Each site is 175m x 80m and contains 20 paired plots.

25m x 10m paired plot
STUDY DESIGN

- Staged approach to restoration treatments
- Poly barrier fence to prevent deer herbivory
- Distance between plots maximize dispersal and number of eggs
YR 1: Establish moderately dense patches of host plants
- Mow and treat with herbicide
- Add seed of *B. rapa* and native perennial forbs
YR 2: Close study plots to protect overwintering pupa
- *B. rapa* declines as introduced grasses re-establish
YR 3: Collect larvae for captive rearing
- *B. rapa* continues to decline
- Increase in seed bank
YR 4: Plant with native grasses and perennial forbs
• Mow and treatment with herbicide
• Add seed of *B. rapa*
• *B. rapa* increases in response to disturbance
YR 5: Establish novel plant assemblage
- *B. rapa* seed bank replenished
- *B. rapa* follow small-scale disturbance (small mammals)
YR 8
QUESTIONS

Can we build it?
If we build it, will they use it?
If they use it, will they survive?
Can we build it?  Yes!

- Field mustard established in all research plots
- Native species including four species of grasses Bromus *sitchensis*, *Elymus glaucus*, *Festuca roemerii* and *Achnatherum lemonii* (~5,000 plugs), two bulbs, *Camas quamash* and *Fritillaria affinis* (~5,000 bulbs) and five forbs including *Cerastium arvense*
Can we build it?

Still some challenges…
• Host plant phenology can differ between years
• Capacity to manage and implement restoration is limited by funding (e.g., collecting seed, managing propagation efforts and out-planting)
• Limitations in seed availability for some native plants

Dineh Judd and Claire Crawbuck collecting demographic data
If we build it, will they use it?
Yes!

Success. Eggs were laid across all plots every year (e.g., 716 eggs in year one plots in 2017).
Sources of mortality are diverse and complex…

- Survival of eggs to instar V were similar across years, 1% (n=5) in 2017, 3% (n=8) in 2016 and 2% (n=13) in 2005-2008
- Greatest source of mortality was predation
- Second greatest source of mortality was starvation

If they use it, will they survive? Yes!

Lambert 2017
Important lessons

- Species interactions are complex and require multiple solutions
- Consider a staged research design that can be monitored and adapted as needed
- Produce restoration management protocols that can be implemented by conservation managers outside of the local restoration site

Candidate Conservation Agreements with Assurances (CCAA), voluntary conservation activities that benefit island marble

Photo courtesy SJ Preservation Trust, Kathleen Foley tends an island marble butterfly habitat expansion plot on Frazer Homestead Preserve
Reintroduction of Native Host Plant

tower mustard (*Turritis glabra*)

Adult resting on container plant of tower mustard, South Beach dunes, SAJH, 2006
Reintroduction of Native Host Plant

Some success \((n=1)\).  

More experimental work needed…variation in plant phenology.
Captive Rearing

Very successful, 98-77% survival to adult
Captive Rearing

However, some challenges remain…

…matching phenology to variable environmental conditions in the field.
Excluding deer

Success. After three years of trial and error (2013-2015), deer exclusion increased survival of egg and early instar larva on field mustard.

However, some challenges remain including:
• Compliance with NPS cultural landscape policies
• Increase in browsing pressure
• Hindered movement of adults
• Potential predation by birds
Methods
Relative adult abundance

• not an absolute count
• low impact methodology
• high correlation w/ MRR for conspicuous butterflies

• weekly counts (6 – 9 days)
• behavior recorded
• environmental parameters (e.g., temperature)
Mission blue *Plebejus icarioides missionensis* Hovanitz resting on silver leaf lupine *Lupinus albifrons* var. *collinus*
Painted lady *Vanessa cardui* Linnaeus resting on creeping thistle *Cirsium arvense*
Island marble *E. ausonides insulanus* resting on field mustard *Brassica rapa* L. *rapa*
Island marble is a subspecies of the large marble (*Euchloe ausonides*) Lucas 1852

Photos by JK Combs
Perhaps Island Marble has been around as long as people have been observing them in the landscape.

Many of the Native American peoples living in the Northwest are the descendants of people who have lived in the area for thousands of years.

Annie Yellow Bear pounding camas bulbs, Kamiah, Idaho, 1890

Island marble in native prairie...
Coast Salish

Fish trap workers, Salmon Banks Beach camp, 1894-1934

...along sandy beaches.

Coast Salish reef netting off Stuart Island

...between coastal lagoons.

Photos courtesy of Photo Gallery (U.S. NPS), San Juan NHP

San Juan Historical Society/ Video: Solarsalmon
Early Colonial Settlement

Belle Vue Sheep Farm, turnip fields (*Brassica rapa*) were planted to increase forage for sheep, 1884; present-day American Camp grasslands

...and introduced grasslands.
Early Colonial Settlement


Photos courtesy of Mike Vouri, Julia Vouri and San Juan Historical Society. San Juan Island (Images of America)
The number of species extinctions in the history of life is almost the same as the number of origins…

- David M. Raup

The number of species that have gone extinct in the last century would have taken,… between 800 and 10,000 years to disappear...indicating that a sixth mass extinction is already under way.

- Gerardo Ceballos, et.al.