Conservation Assessment of Two Endemic Butterflies (White Mountain Arctic, *Oeneis melissa semidea,* and White Mountain Fritillary, *Boloria titania montinus*) in the Presidential Range Alpine Zone, White Mountains, New Hampshire

White Mountain Fritillary (*Boloria titania montinus)*
14 August 2003, Mt. Washington

White Mountain Arctic (*Oeneis melissa semidea*)
12 July 2002, Mt. Washington

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Introduction

The White Mountain Arctic (*Oeneis melissa semidea*) and the White Mountain Fritillary (*Boloria titania montinus*) are subspecies endemic to the alpine zone of the Presidential Range in the White Mountains of New Hampshire. They are not known outside of the ~1,130 hectare alpine zone.

These two populations are glacial relicts – organisms that were more widespread at the end of the last glaciation but which have since become isolated because of the loss of appropriate habitat in intervening areas as the climate has warmed. Macrofossil and pollen assemblages from lake sediment cores indicate that the White Mountain region was deglaciated prior to 13,000 years ago (Spear 1981). From 13,000 to 11,750 before present (B.P.) the highest elevations were barren with tundra vegetation covering the lower slopes and valleys and mean annual temperatures 5-10°C colder than today. *Salix*, *Juniperus* and *Betula* invaded the alpine zone and tundra gave way to woodlands around 10,300 B.P. From 10,300 to 9,000 BP temperatures increased to modern levels or slightly above and subalpine forests were established, effectively isolating the alpine vegetation from the retreating tundra vegetation to the north. During this period these two butterfly populations were effectively isolated from other populations that retreated northward, and they remain isolated to this day.

This conservation assessment is an effort to gather all known information regarding these two butterfly subspecies. A literature search yielded only one published study on these subspecies (see Anthony 1970). Information was augmented from studies of congeners and other populations, as well as unpublished observations of lepidopterists queried on the leps e-mail listserve (http://www.peabody.yale.edu/other/lepsl/).

Additional information was added to this report following field observations in 2002 and 2003.

Nomenclature and Taxonomy

Common Name(s): White Mountain Arctic, White Mountain Arctic, Melissa Arctic, Mottled Arctic, Norna Arctic, Mountain Butterfly, Brown Mountain Butterfly.
Scientific Name: *Oeneis melissa semidea*
Author and Publication Date: Say, 1828
Etymology: Genus is named after Oeneus, King of Calydon, an ancient city in western Greece. He is believed to be first man to have grown grapes. *Melissa* is “honeybee” in Greek, while the subspecies name is a combination of the Greek *semi*, meaning “half” and Latin *dea*, meaning “goddess”.
Discussion: First described by Say from specimens sent to him by Dr. Pickering and Mr. Nuttall of Boston (Scudder 1889).

In British Columbia, Norbert Kondla and Cris Guppy have been examining the taxonomy of the *Oeneis melissa* complex, but were missing specimens of *O. m. semidea* for their analysis (N. Kondla pers. comm.).

There are seven North American subspecies: *O. m. melissa* from Newfoundland and Labrador coast; *O. m. semplei* from Quebec, interior Labrador and Hudson Bay; *O. m. assimilis* in Northwest Territories; *O. m. gibsoni* from Alaska, Yukon and extreme northern British Columbia; *O. m. beanii* from Alberta and British Columbia; *O. m. lucilla* from central Rocky Mountains, and *O. m. semidea* in the White Mountains, New Hampshire.

Common Name(s): White Mountain Fritillary (subspecies name), Arctic Fritillary, Purple Lesser Fritillary, Purple Bog Fritillary, Purple Arctic Fritillary, Purplish Fritillary, Dappled Fritillary
Scientific Name: *Boloria titania montinus*
Author and Publication Date: Scudder, 1863

Etymology: Genus is named after Mt. Bolor in Asia. The species is named after the Titans, sons and daughters of the god Uranus in Greek mythology. Subspecies name means montane, presumably from its type locality on Mt. Washington, New Hampshire.
Discussion: This taxon has been cited as *B. chariclea, B. titania* and recently, *B. montinus* (NABA 2001). Currently, it is most widely accepted as being *B. titania montinus*, but no one has completed necessary studies to confirm or refute this alignment.

Higgins (1975) illustrated the differences in the male genitalia between European *B. chariclea* and *B. titania*. (Shepard 1998) compared the same male genitalia of the *B. chariclea/titania* complex in North America and found them to be most like *B. chariclea* and not *B. titania*. Based on this morphology he concluded that all North American forms of this complex must be one species, *B. chariclea*, with *B. titania* limited to the Eurasian continent.

Many taxonomists now disagree with this finding and continue to believe that there are two species in North America (J. Kruse pers. comm.). Lepidopterists in Alaska consistently note two biologically distinct species flying together without any evidence of intergradations (Layberry et al. 1998, Shepard 1998, N. Kondla, pers. comm., J. Kruse pers. comm.). In interior Alaska, where they are often found in the same bogs, *B. chariclea* is biennial, flying in May-June. However, *B. titania* is annual and flies in mid-July to August (Layberry et al. 1998, Shepard 1998, J. Kruse pers. comm.).

Since Shepard (1998) has shown that *B. titania* is an Old World species, and others give evidence that there remain two distinct species in this complex, the North American Butterfly Association Naming Committee (NABA 2001) concluded that *B. titania* needed both a new scientific and a new common name. They reported that the oldest available scientific name for populations called *B. titania* was *B. montinus* (Scudder. 1863. *Argynnis. Proc. Essex Inst.*, 3: 166, type locality – White Mountains, New Hampshire) (NABA 2001). Populations in North America previously referred to as *B. titania* became *B. montinus*, and far northern North American populations remained *B. chariclea* (NABA 2001). With this change, the population in the White Mountains formerly considered to be *B. titania montinus* becomes *B. montinus montinus*. The committee renamed the species Purplish Fritillary because a number of populations have been previously classified as such, and many do have a purplish cast. It is widely believed that the decision to reclassify these populations by NABA was premature and without scientific merit.

Until further scientific work has been completed and published on this complex, the White Mountain population should probably remain *B. titania montinus*. Dr. Jim Kruse of University of Alaska Museum is currently studying this complex. A road killed specimen from the Mt. Washington Auto Road from 2003 was provided to him for molecular analysis.

Description of Species

Descriptions rely heavily on the following sources: Glassberg (1999), Layberry et al. (1998), Opler and Krizek (1984), and Scott (1986). Extremely detailed descriptions can be found in Scudder (1889).

White Mountain Arctic (*Oeneis melissa semidea*)

Detailed color plate of each life history stage can be found in Edward (1879-1897).

Eggs: Pale yellow-white or gray-white and longer than they are broad.
Larvae: Striped, varying from dusky-green to red-brown, or red-brown with green sides. Stripes 1 and 2 have black interruptions, 3 gray-green, 4 blackish, 5 gray-green, and 6 dusky green. The mature caterpillar has a yellow-brown or dull green-brown head with black bands or spots and 6 separate lateral black and narrow dark-green stripes. All *Oeneis* species have six dark body stripes and six head stripes.

Pupa: Dull yellow-brown (lighter and more yellow on abdomen) with black head and black wing veins.

Adult: Uniformly gray-brown dorsally. Wings are translucent with fringes often checkered. The underside of the hind wing has a mottled blackish base and grayish outer area. Median band is lacking or faint with white outlines. Color and pattern are very cryptic, matching the gray, lichen-covered rocks where they often perch. Often there is a faint hint of a small spot comprised of a group of black scales between veins R_5 and M_1 in the submarginal area of the forewing apex; this is usually distinguishable on both the dorsal and ventral wing surfaces. The frequency of occurrence of a spot is higher in females than in males (Anthony 1970).

Forewing measurements are generally larger for females than males (Table 1 and 2) (Anthony 1970, Scudder 1889). Length of proboscis, as measured by Scudder (1889), was 8 mm.

White Mountain Fritillary (*Boloria titania montinus*)

Eggs: Whitish or pale yellow.

Larvae: Gray with black dorsal and lateral stripes and orange spines. First subdorsal pair longer and yellow. Head is black. This description is probably not from *B.t. montinus*, but rather from another form.

Pupa: Undescribed.

Adult: Many populations are tinged purple on underwing, but *B. t. montinus* mostly lacking and tending to be more red. Wings are orange-brown with dark markings. White horizontal lines along the forewing margin. Underside of hindwing margin has thin, flat white spots topped with brown. Median band is pale yellow-brown with a wavy black line. On the upper hindwing there are inwardly pointing triangles with flat bottoms along the submargin.

Male and female forewing length is 1.9 – 2.2cm (Opler and Krizek 1984). Length of proboscis, as measured by Scudder (1889), was 7.5mm.

Life History

White Mountain Arctic (*Oeneis melissa semidea*)

Univoltine. From late June to late July (confirmed dates: 27 June to 31 July). Adults are only active on bright sunny days with wind below 40 mph and temperature above 45° F (Anthony 1970). They rarely fly more than 0.5 m above ground, but if disturbed they may be carried by the wind for several hundred meters downslope (Opler and Krizek 1984). Males tend to fly farther than females, probably actively searching for females (Anthony 1970). Females remain in areas where sedges are dominant. Males perch and patrol hill tops and ridgelines during most of the day. Scott (1986) writes that adults rarely nectar. However, Scudder (1889) notes that they often nectar Moss Campion (*Silene acaulis*) and Mountain Sandwort (*Arenaria groenlandica*) as well as *Vaccinium* species. I found them nectaring Mountain Sandwort in 2002. There may be some environmental and ecological barriers stopping or slowing movements (hence gene flow) between populations within the Presidential Range (Anthony 1970).

Eggs are laid near base of sedges or in the litter around them (Scudder 1889). Most eggs apparently laid by last week of July (Scudder 1889). Eggs hatch in 9-14 days, usually during the first week of August (Scudder 1889). The only known host plant in the White Mountains is Bigelow's Sedge (*Carex bigelowii*) (Scudder 1889), but *C. rupestris* reported from western Canada (Layberry et al. 1998, Scott 1986). Larvae will eat grasses and sedges in the lab (Scott 1986). Larvae feed at night on sedge leaves and rest under stones during the day (Scudder 1889). Full grown larvae have been found from 20 July to 2 August (Scudder 1889).

Pupation occurs under moss, rocks or soil (Scudder 1889). Scudder (1889) reports that one person searched for 10-12 hours raising movable surface stones along the edges of fellfield areas and found two live pupae and nine others either infected with parasites or empty shells from the previous year. All of them were found imbedded between 0.5 – 1.5 inches below the surface. They were not attached to anything, but lay in horizontal oval cells. Areas chosen by larvae for diurnal concealment are probably the same places chosen for pupation; a level, damp and cool protected spot (Scudder 1889).

Two years are required for development (Scudder 1889, Scott 1986). The first winter is passed in second or third instar and the second winter as mature larvae (fifth instar) (Scott 1986). Scudder (1889) found a larva on 31 May. It changed to chrysalis on 2 June in captivity and emerged on 19 June, but development was probably faster due to warm conditions in captivity. He reported live chrysalis being found between 10 June and early July. Despite biennial development, adults fly every year.

White Mountain Fritillary (*Boloria titania montinus*)

Univoltine. Adults fly from mid-July to mid September (confirmed dates: 12 July – 15 September). Males patrol for females during warm hours, while females rest or bask in the vegetation (Seidl 2002). Females fly close to the ground and walk or test by drumming potential host plants with abdomen (Seidl 2002). During field observations in 2002-03, adults observed nectaring predominantly Alpine Goldenrod (*Solidago cutleri*), but also Purple-stemmed Aster (*Aster puniceus*) and Meadowsweet (*Spiraea latifolia*).

I observed a pair copulating while perched on Alpine Goldenrod on 15 August 2003. Another male was present, but flushed upon approach. Females found with well developed eggs on 2 August and as late as 15 September (Scudder 1889). Eggs laid singly on underside of leaves in midsummer and the newly hatched first-instar larvae hibernate before completing development during the following summer (Opler and Krizek 1984, Scott 1986, Seidl 2002). It is unknown if the first instar larvae feed in the wild, but they will feed in the laboratory (Seidl 2002).

Larvae from other populations are polyphagous, feeding on four chemically distinct plant familes: Polygonaceae, Salicaceae, Ericaceae, Violaceae (Scott 1986, Seidl 2002). Caterpillar host plants in eastern Canada are Dwarf Willows (*Salix arctica* and *S. herbacea*), Alpine Smartweed (*Polygonum viviparum*), Violets (*Viola* sp.) and Low Sweet Blueberry (*Vaccinium angustifolium*) (Layberry et al. 1998, Opler and Krizek 1984, Scott 1986). In the lab individuals from the northern Cascades of Washington readily fed on *Polygonum* (preference for ovipositing), *Salix* and *Viola*, while *Vaccinium* was refused (K. Wolfe, pers. comm.). In Asia *B. titania* is known to feed on plants in the families Rosaceae and Ranunculaceae (K. Wolfe, pers. comm.).

There are no specific reports of host plants for *B. t. montinus*. However, possible host plants that grow in the alpine zone in Presidential Range are: willows (*Salix herbacea, S. uva-ursi, S. argyrocarpa, S. planifolia*), Alpine Smartweed or Bistort, Alpine Marsh Violet (*Viola palustris*) and *V. adunca*, Alpine Bilberry (*Vaccinium uliginosum*), Dwarf Bilberry (*V. caespitosum*), Velvet Leaf Bilberry (*V. myrtilloides*), Low Sweet Blueberry, Mountain Cranberry (*V. vitis-idaea*), and Small Cranberry (*V. oxycoccos*) (Bliss 1963). Scudder (1889) reported that they often are seen around Dwarf Willow (*Salix herbacea*), but that despite searching no eggs were found. On one occasion he observed a female on Mountain Avens (*Geum peckii*) and was sure she laid eggs, but upon examination he found no eggs. He felt that Violaceae was a more likely host. A female (which later dissection showed to have ripe eggs) was kept for several days on a live violet plant on the summit, at treeline and at the base of Mt. Washington and never laid any eggs. Scudder tried this with several other individuals to no avail.

In other regions, larvae eat leaves of host plants and have no nest (Scott 1986). Larvae likely pupate in the leaf litter (Seidl 2002). In Colorado, adults eclose after larvae complete five instars, with males earlier than females (Seidl 2002).

Habitat Distribution and Abundance

White Mountain Arctic (*Oeneis melissa semidea*)

Rangewide- See discussion under Taxonomy.

Regionwide- The entire range of *O. m. semidea* is limited to the alpine zone of the Presidential Range in the White Mountains, New Hampshire, generally above 1,500 m elevation (Figure 1). Its presence is dependent upon quantity of host plants (sedges). Populations tend to be locally abundant around sedge meadows (Figure 2), with few individuals found between them. Alpine sedge meadows cover approximately 80 hectares (ha) or 7% of the alpine zone (Kimball and Weihrauch 2000) (Appendix A). Among alpine plant communities, sedge meadows are found on moderate slopes in the highest elevations (range = 1,345 – 1,901 m) with an aspect tending to be oriented to the northwest (Bliss 1963, Kimball and Weihrauch 2000, Sperduto and Cogbill 1999). These meadows are largely dominated by Bigelow's Sedge and Highland Rush (*Juncus trifidus*), with other potentially common species being Mountain Sandwort (*Arenaria groelandica*), Mountain Cranberry, Alpine Bilberry and Three-toothed Cinquefoil (*Potentilla tridentata*) (Kimball and Weihrauch 2000). Adults are most often reported from the following sedge meadows listed north to south: Monticello Lawn on Mt. Jefferson, area surrounding Gulf Tanks along the Mt. Washington Cog Railway between the summits of Mt. Washington and Mt. Clay, the Cow Pasture (relatively flat area at mile 7 on the auto road) (Figure 2), and Bigelow Lawn (directly south of Mt. Washington summit) (Figure 1, Tables 3, 4 and 5). The most northern record was from Mt. Adams and the most southern was from Bigelow Lawn. Anthony (1970) reported that the Alpine Garden on the west side of Mt. Washington was formerly considered to be a good area to collect individuals, but it was devoid of the butterfly in 1969. However, a report by H. Pavulaan in 1984 indicated that it can be present in relatively large numbers in this area. I visited the area in 2002 and found none despite extensively searching for them.

There are several small alpine vegetation areas relatively near the Presidential Range, including Mt. Moosilaukee, Franconia Ridge, and the Mahoosuc Range. Although there are no confirmed reports of *O. m. semidea* from these sites, there is one tantalizing record. In 1984, H. Pavulaan (pers. comm.) noted that he and a friend observed several *O. m. semidea* on Mt. Washington. The next day they visited Mt. Lincoln on Franconia Ridge, and separated for about an hour. Later that day, his friend reported to him that he observed at close range two of the same butterflies that they observed on Mt. Washington the previous day. Pavulaan, however, did not see any and noted that his friend may have misidentified the two individuals, as he apparently was not an experienced observer. Additionally, Anothony (1970) captured 13 females on Mt. Washington and released them on the summit of Mt. Moosilaukee. Given the relatively close proximity of these smaller alpine sites to the Presidential Range and the fact that Bigelow's Sedge occurs on all of these sites, further studies aimed at clarifying the species' restricted range seem warranted. I visited Mt. Moosilaukee on 10 July 2003. Despite extensive searches I found no individuals. The summit had relatively small amounts of Bigelow's Sedge and was dominated by Highland Rush.

Observations in 2002 in the Presidential Range found individuals from as far south as Mt. Monroe, an expected but previously unreported southernmost site, to as far north as Mt. Jefferson (Figure 4). Individuals were found in all areas from which the species was previously reported to be abundant, with the exception of the Alpine Garden area. It remains uncertain if *O. m. semidea* occurs on the more northerly Mt. Madison, where there are several sedge meadows.

White Mountain Fritillary (*Boloria titania montinus*)

Rangewide- See discussion under Taxonomy.

Regionwide- The entire range of *B. t. montinus* is apparently limited to the alpine zone in the Presidential Range in the White Mountains, New Hampshire above approximately 1,220m elevation in wet alpine meadows, wet springs around rock outcroppings, alpine streamside communities and snowbank communities (Figure 3). Popular areas to find the butterfly are Cragway Spring area on the Mt. Washington Auto Road and the Alpine Garden.

Historic data were gathered from published and unpublished sources, Yale Peabody Museum, and UNH entomology collection (Table 3). Specimens have been collected throughout the Presidential Range – from Mt. Pierce at the southern end of the Presidential Range to Mt. Madison at the northern terminus. Historic data with indicated elevations range from 1,220 – 1,645 m.

One dubious record outside of the Presidential Range was reported by Scudder (1889),*"It has been seen by Dr. Minot on the top of Black Mountain in Thornton, NH."* In a later publication, Scudder (1895) wrote, "*It has been reported as seen on Black Mountain near Thornton, NH, which is wooded to the summit; but an actual capture would be necessary to establish such a fact."* Three peaks are named "Black Mountain" in the AMC White Mountain Guide (1998), and none appear to be high enough: Benton Range – 2,830 ft, Jackson – 3,304 ft, and Sandwich Range – 2,732 ft. This record is probably incorrect. The only other known record outside the Presidential Range alpine zone was a specimen collected by D.J. Lennox on 27 August 1966 in Jefferson Notch at 2,950 ft elevation and deposited in the UNH collection.

Field work in 2002-03 found individuals from Mt. Pierce in southern Presidential Range to Mt. Jefferson (Figure 5). Searches on Mt. Adams failed to locate any individuals, however weather conditions were marginal. A previously unreported location where I observed large numbers was Mt. Clay. Searches south of Mt. Pierce to the summit of Mt. Jackson yielded no individuals and no potential habitat. I found adults at significantly higher elevations than previously reported. Along the auto road at 1,875 m elevation I observed individuals nectaring Alpine Goldenrod. Although this is 230m higher than previously recorded, it may simply be due to the presence of flowering Alpine Goldenrod which only occurs along the auto road at that elevation.

Population Biology and Viability

White Mountain Arctic (*Oeneis melissa semidea*)

The New Hampshire Natural Heritage global ranking is G5T2 – species is globally secure, but subspecies population imperiled because of rarity (generally 6 to 20 occurrences) or other factors demonstrably make it very vulnerable to extinction. Statewide ranking is S2 – state population imperiled because of rarity (generally 6 to 20 occurrences) or other factors demonstrably make it very vulnerable to extinction.

Scudder (1889) gives some historic perspective on the population, "…in its season this butterfly is exceedingly abundant." He also reports that Oakes (a botanist at that time) found them "abundant" in June 1826 and Morrison (unknown observer) called them "very abundant" in first week of July 1874.

Anthony (1970) studied the extent of isolation between colonies in the alpine zone of the Presidential Range by examining phenotypic evidence. He gave the following summary of his work:

> *...samples from four areas* [see Appendix A of this report for locations] *of the range were taken in an effort to determine the population structure of the butterfly. Statistical treatment of five characters yielded no conclusive evidence for either total isolation or lack of isolation between the populations inhabiting the four areas, but field observations combined with the statistics derived from*

the frequency of the occurrence of a spot on the forewing of the butterfly indicate that at least partial barriers probably exist between the sampling areas. Movement of individuals between any of the areas was not seen while in the field. Movement by action of the prevailing wind from the west is discussed and cited as probably the major contributor to the breakdown of any spatial or environmental barriers which do exist.

He conducted mark-recapture sampling in the Cow Pasture from 27 June – 7 July 1969, marking 51 individuals, but never recapturing any. From 8 July – 15 July he collected 5 males and 14 females at Monticello Lawn, 31 males and 11 females around Gulf Tanks, 58 males and 23 females in the Cow pasture, and 17 males and 10 females at Bigelow Lawn. Anthony also reported that the Alpine Garden on the west side of Mt. Washington was formerly considered to be a good area to collect individuals; however it was devoid of the butterfly in 1969. However, a report by H. Pavulaan in 1984, indicates that it can be present in relatively large numbers in this area. I visited the area in 2002 and found none despite searching extensively for them.

Other more recent reports include "great numbers" in the Cow Pasture area along the auto road on 8 July 1979 by A. Grkovich, over 100 in Alpine Garden on 13 July 1984 by H. Pavulaan, and ~30 individuals observed by M. Pelikan on northeast and east side of summit cone on 27 June 1995.

Transects walked in 2002 yielded from 0 in the Alpine Garden to 15 per 1,000 m in Monticello Lawn (Table 4). Expansive areas can be searched without finding a single adult until an area is reached where the species is very abundant. These areas tend to be a large boulder or rock outcrop near expansive sedge meadows. Males appeared to rest on the leeward side of the rocks and chased other individuals upon approach, sometimes into high spiral flights. This hilltopping or lek behavior has been observed and studied in the congeneric arctic *Oeneis chryxus* (Knapton 1985, Daily et al. 1992, Clayton and Petr 1992).

White Mountain Fritillary (*Boloria montinus montinus*)

The New Hampshire Natural Heritage global ranking is G5T2 – species is globally secure, but subspecies population imperiled because of rarity (generally 6 to 20 occurrences) or other factors demonstrably make it very vulnerable to extinction. Statewide ranking is S2 – state population imperiled because of rarity (generally 6 to 20 occurrences) or other factors demonstrably make it very vulnerable to extinction.

Scudder (1889) offers the earliest comments on the population status:
"*Probably no wandering collector has often seen more than eight or ten of these butterflies in a day's scramble among the mountains, but if sought early in July they might be found in greater abundance; on a single occasion only I have seen as many as four at one time; they are most common about the steep heads of the great ravines…"* He also wrote, "*The butterflies, never very abundant…"* and, *"…as it would seem as if some special device were needed to maintain this apparently nearly extinct species in such a desolate region."*

Later, Scudder (1897) wrote, "*The [Boloria] indeed seems really doomed to destruction. In the scanty numbers that one may find upon the mountain slopes, one sees the sign of their early departure; for, in the many years that I have searched for them with special pains, I have never seen more that a dozen or two specimens in a single day."*

I found similar numbers while walking transects in 2002-03 (Tables 4 and 5). However, I considered the species to be locally common and probably not "doomed to destruction" in the near future. Highest densities were found at Cragway Spring, with abundant Alpine Goldenrod, Purple-stemmed Aster and Meadowsweet, and Wamsutta Trail, which also has high densities of Alpine Goldenrod. In fact, a map of Alpine Goldenrod would probably overlap exactly with occurrences of adult *B. t. montinus* because of the species' intense affinity for nectaring this plant.

Potential Threats

Global climate change - Global climate change may exert profound, long-term impacts on alpine plant communities through displacement by lower-elevation species (National Assessment Synthesis Team 2000). The northeastern United States warmed by 0.74° F and precipitation increased by 4% from 1895-1999 (New England Regional Assessment Group 2001). New Hampshire warmed by 1.8° F (1.0° F summer) with a decrease of 2.5% precipitation during this period.

Two models used in the northeastern United States assessment indicate varying degrees of temperature and precipitation increases (New England Regional Assessment Group 2001). The Hadley Model projects a warming of 6° F for annual minimum temperature and a 30% increase in precipitation, while the Canadian Model projects a 10° F increase with a 10% increase in precipitation, with periodic extreme drought, over the next century. Either of these scenarios would produce greater climatic variation than any experienced in the last 10,000 years. Additionally, there is some evidence that the frequency of extreme weather events is increasing.

It appears that some species are responding to recent climatic warming by shifting ranges poleward and upward in elevation (Parmesan et al. 1999, Pounds et al. 1999, Thomas and Lennon 1999, Parmesan 1996, Grabherr et al. 1994). Populations at the edge of a species' range are often living near the limits of the species' physiological tolerances and are more likely to suffer from extreme weather events (Parmesan et al. 2000). For example, Edith's Checkerspot (*Euphydryas editha*) population extinctions have been associated with extreme climatic events such as drought, early loss of snowpack, late snow, and cold temperatures (Singer and Thomas 1996, Ehrlich et al. 1980, Thomas et al. 1996). Parmesan (1996) reported a range shift northward and increased elevation of Edith's Checkerspot during this century due to increased number of population extinctions at the southern boundary and lower elevations coupled with population stability or increase at northern and higher elevations of its range.

Both *O. m. semidea* and *B. t. montinus* are reliant on specific host plants to complete their life cycle. These host plants occur only at high elevations in this region. There are no data available documenting effects of recent climate change on host plant abundance or range shifts for these species. Research in the alpine zone of the Swiss Alps found that plant ranges had increased by 1-4 m elevation over the last 70-90 years while the mean annual temperature had increased by 0.7° C (Grabherr et al. 1994).

Interactions between insect herbivores, host plants and elevated CO_2 has been reviewed by Seidl (2002). Most plants experience nitrogen dilution and increases in allelochemicals when grown in elevated CO_2 conditions. Consequently, some herbivores are able to increase consumption to attempt to capture more nitrogen and are undeterred by higher allelochemical concentrations, but often experience a decline in growth rate.

Atmospheric pollution - Decline of high elevation forests in northeastern U.S. during 1960s and 1970s has been well documented (Johnson and Siccama 1984, Eager and Adams 1992). Atmospheric deposition of acidic ions from industrial sulfur and nitrogen oxides is strongly, although not conclusively, implicated as a causal factor in red spruce decline (DeHayes et al. 1999, Johnson et al. 1992, NAPAP 1992). Despite declining trends in atmospheric sulfate concentrations resulting from mandates of 1990 Clean Air Act amendments, acidity of precipitation in northeastern North America does not appear to be decreasing (Scherbatskoy et al. 1999).

Heavy metal toxicity from airborne pollutants has also been implicated as a contributing cause of high elevation forest decline in northeastern U.S., particularly in the Adirondack and Green Mts. (Gawel et al. 1996). However, several recent studies indicate that lead concentrations in the forest floor are rapidly decreasing (Friedland et al. 1992, Miller and Friedland 1994, Wang and Benoit 1997).

Atmospheric deposition of airborne mercury is 2-5 times higher in montane forests of Mt. Mansfield, Vermont than in surrounding low elevation areas (Lawson 1999). Methylation rates and possible uptake in the food chain of terrestrial montane species has been documented for Bicknell's Thrush (*Catharus bicknelli*), which feeds primarily on lepidoptera larvae (Rimmer et al. 2001).

There have been few studies examining the direct effects of atmospheric pollution on butterfly populations. Weiss (1999) found that Bay Checkerspot butterfly (*Euphydrias editha bayensis*) populations, which are confined to nitrogen poor serpentine soils, crashed in areas where nitrogen deposition from smog, coupled with cessation of cattle grazing, allowed invasive grasses to out-compete native forbs used as host plants. Kozlov (1996) censused two butterflies (*Clossiana euphrosyne* and *Vacciniina optilete*) and three day-active moths (*Rheumaptera subhastata, Ematurga atomaria,* and *Sympistis heliophila*) in 5 different pollution zones in northwestern Russia. Densities of the monitored species increased by a factor of 1.5 to 5 in early stages of pollution-induced forest damage, but declined with increasing pollution. Since the host plants of the monitored species, except that of *C. euphrosyne*, were found in all localities surveyed, the decline could be attributed to the SO_2 toxicity rather than to the lack of larval food.

UV-B light increase – The depletion of the stratospheric ozone layer and the concurrent increase in damaging ultraviolet-B radiation reaching the earth's surface has been a growing concern over the last several decades. Loss of stratospheric ozone by chlorofluorocarbons and other ozone depleting compounds has led to increased solar UV-B in alpine areas (Blumthaler and Ambach 1990). There have been many studies detailing the effects of UV-B light on herptiles and plants, but very few concerning lepidoptera. Most studies have examined insect herbivory, UV-B and host plant interactions (Seidl 2002).

UV-B light can have indirect, negative effects on herbivore success. Carroll et al. (1997) found that UV-B is an important concern for Parsnip Webworms (*Depressaria pastinacella*) larvae because it activates toxic properties of the furanocoumarins, chemicals found in large quantities in the host plants. However, carotenoids sequestered from the plants may prevent UV-B from damaging the insect either by absorbing the UV-B or by lessening the toxic effects of furanocoumarins. Alternatively, growth rates of larval Cabbage White buttefly (*Pieris rapae*) fed *Arabidopsis thaliana* grown under elevated UV-B conditions were unaffected despite high flavanoid levels in the host plant (Grant-Petersson and Renwick 1996).

Recreation and development – Prevention of development or trampling of habitat has been cited as a management need for these butterflies (Opler et al. 1995), as well as for alpine vegetation in general (Sperduto and Cogbill 1999). I used GIS alpine vegetation maps provided by the Appalachian Mountain Club (Kimball and Weihrauch 2000) and a GIS trail map obtained from the White Mountain National Forest (L. Prout pers. comm.) to estimate the total linear distance of trails through alpine habitat (Table 2). Additionally, buildings and roads impact approximately 3 ha of area in the alpine zone. The estimated percentage of impacted area by hiking trails was surprisingly small (Table 2). However, the width of two meters for impact area may be an underestimate in some places.

Collecting- An examination of collections at UNH and Peabody, published literature, and queries to the Yale lep list serve yielded approximately 380 *O. m. semidea* and 80 *B. t. montinus* specimens known to have been collected over more than a 100-year period. During a one-week period in 1969, Anthony (1970) reported collecting 115 specimens of *O. m. semidea* in his four study areas (see Figure 1 for study areas) and another collector taking 30 more in the Cow Pasture study area. Scudder (1889) reportedly collected over 100 one year. Although such intensive collecting may have been detrimental in the short term, current populations in these areas appear within reported historic levels. Recent collecting probably amounts to fewer than 10 individuals of each species each year. This is probably insignificant to the population dynamics of these two species. Continued light collecting by amateur and professional lepidopterists will probably yield no damage to the overall population.

Monitoring

There has been no systematic monitoring conducted for these two species to my knowledge. During my field observations in 2002-03, I evaluated the potential for future monitoring of these species. Such an effort, while valuable for the data it would provide, promises to be challenging.

Logistics of working in the alpine zone are generally difficult. Access to sites along the auto road for surveys is easy, but other sites can require long hikes. Weather is extremely limiting. I was disappointed many times when I arrived and found that despite excellent weather elsewhere, the alpine zone was very windy, cold and in the clouds (Table 7).

Expansive areas can be searched for *O. m. semidea* without finding a single adult until an area is reached where the species is very abundant. These areas tend to be a large boulder or rock outcrop near expansive sedge meadows. Males appeared to rest on the leeward side of the rocks and chased other individuals upon approach, sometimes into high spiral flights. This hilltopping or lek behavior has been observed and studied in the congener arctic *Oeneis chryxus* (Knapton 1985, Daily et al. 1992, Clayton and Petr 1992). This could create problems for some traditional monitoring schemes such as Pollard transects (see Pollard and Yates 1993).

Capture-recapture techniques have strong statistical underpinnings (e.g., Lebreten et al. 1992) and have been successfully used for *O. chryxus* (Knapton 1985, Daily et al. 1992, Clayton and Petr 1992) and *B. acrocnema* (Ellingson 2003). However, Anthony (1970) attempted it with *O. m. semidea* with poor results. He captured and marked 51 individuals in the Cow Pasture area from 27 June – 7 July and had no subsequent recaptures. He commented that "…a number of factors related to the marking technique itself were becoming serious problems…", although it is not clear exactly what these problems were.

While there is a large body of literature regarding butterfly population monitoring, many are plagued by statistical problems. Ellingson (2003) examined potentially robust methods with the endangered *B. acrocnema* in Colorado. He employed distance sampling (Buckland et al. 1993; see http://www.ruwpa.st-and.ac.uk/distance/) from line transects to estimate daily abundance and found substantial observer-induced variation in detection probabilities. This suggests that at least for that species at that location, ordinary Pollard transects would be significantly biased. He also used capture-recapture to estimate apparent survival. Total annual recruitment was then estimated by combining line transect and capture-recapture data in models of intra-annual population dynamics.

A minimum monitoring scheme would feature at least 20 randomly located transects throughout the alpine zone; these should be surveyed with the distance sampling method at least every 5 days through the flight periods of both species (A. Ellingson pers. comm.). Thus, to adequately monitor both species, each transect would need to be completed approximately 21 times over the course of 15 weeks. Given constraints of access, terrain and alpine weather, this would likely be very difficult to achieve.

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Table 1. Mean value (mm) and 95% confidence interval of forewing measurements of White Mountain Arctic (Oeneis melissa semidea) from the Presidential Range in the White Mountains of New Hampshire (from Anthony 1970).

	base to end R_4	**base of M_1 to end R_4**	**width of discal cell from base M_3 to base R_3**	**end of 2A to end of R_4**
Monticello Lawn				
male (n=5)	23.9 ±0.99	10.4 ±0.37	3.0 ±0.18	14.6 ±0.28
female (n=9)	24.4 ±0.82	10.9 ±1.5	3.0 ±1.34	14.5 ±0.34
Gulf Tanks				
male (n=30)	23.0 ±0.39	10.1 ±0.02	2.9 ±0.09	14.1 ±0.29
female (n=7)	24.3 ±0.83	11.1 ±0.73	3.0 ±0.25	14.6 ±0.50
Cow Pasture				
male (n=34)	23.2 ±1.04	9.8 ±0.59	2.9 ±0.19	13.9 ±0.95
female (n=12)	24.4 ±0.57	10.9 ±0.31	3.0 ±0.09	14.4 ±0.31
Bigelow Lawn				
male (n=20)	23.4 ±0.42	10.4 ±0.38	3.0 ±0.09	14.2 ±0.34
female (n=9)	24.9 ±0.97	11.3 ±0.46	3.1 ±0.19	14.8 ±0.59

Table 2. Measurements (mm) of White Mountain Arctic (Oeneis melissa semidea) from the Presidential Range in the White Mountains of New Hampshire (from Scudder 1889).

	Males (n=30)			Females (n=24)		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Forewing	21.5	23	23.75	21.5	23.5	24.5
Antennae	8.5	9.5	9.5	8.6	9.6	10
Hind tibiae and tarsi	6.25	7	7.25	6.5	7.6	7.25
Fore tibiae and tarsi	2	2.4	2.5	2	2.25	2.1

Table 3. Historic data gathered from published and unpublished sources, Yale Peabody Museum, and UNH entomology collection.

Voucher Location	Species	Date	Sex	Location	Observer	Numbers Reported	Comments
Peabody	Boloria titania montinus	01-Aug-1870	f	Mt. Washington	C.P. Whitney		Montshire Collection
Peabody	Boloria titania montinus	01-Aug-1870	f	Mt. Washington	C.P. Whitney		Montshire Collection
Peabody	Boloria titania montinus	01-Aug-1870	f	Mt. Washington	C.P. Whitney		Montshire Collection
Peabody	Boloria titania montinus	01-Aug-1870	f	Mt. Washington	C.P. Whitney		Montshire Collection
Peabody	Boloria titania montinus	31-Jul-1872	m	Mt. Washington	C.P. Whitney		Montshire Collection
Peabody	Boloria titania montinus	31-Jul-1872	m	Mt. Washington	C.P. Whitney		Montshire Collection
Peabody	Boloria titania montinus	31-Jul-1872	m	Mt. Washington	C.P. Whitney		Montshire Collection
Peabody	Boloria titania montinus	31-Jul-1872	m	Mt. Washington	C.P. Whitney		Montshire Collection
Peabody	Boloria titania montinus	31-Jul-1872	m	Mt. Washington	C.P. Whitney		Montshire Collection
Peabody	Boloria titania montinus	31-Jul-1872	m	Mt. Washington	C.P. Whitney		Montshire Collection
Peabody	Boloria titania montinus	31-Jul-1872	f	Mt. Washington	C.P. Whitney		Montshire Collection
	Boloria titania montinus	12-Jul-1880's		Mt. Washington	S.H. Scudder		first specimens noted. From Scudder 1889.
	Boloria titania montinus	21-Jul-1880's		Mt. Washington	S.H. Scudder		From Scudder 1889
	Boloria titania montinus	2-Aug-1880's		Mt. Washington	S.H. Scudder		had well developed eggs. From Scudder 1889
	Boloria titania montinus	11-Aug-1800's		Mt. Washington	S.H. Scudder		good condition. From Scudder 1889
	Boloria titania montinus	14-Aug-1800's		Mt. Washington	S.H. Scudder	2-3 dozen	14 collected, 4 females full of eggs. In "tolerably fresh condition". From Scudder 1889

Voucher Location	Species	Date	Sex	Location	Observer	Numbers Reported	Comments
	Boloria titania montinus	15-Sep-1800's		Mt. Washington	S.H. Scudder	1	searched several hours. Worn female with 15 eggs.From Scudder 1889.
UNH	Boloria titania montinus	28-Jul-1900			Fisk		
UNH	Boloria titania montinus	31-Jul-1900		Summits	Fisk		26-31 July 1900
UNH	Boloria titania montinus	22-Aug-1933		Mt. Adams	DJ Lennox		
Peabody	Boloria titania montinus	22-Jul-1936	m	Mt. Washington			Montshire Collection
UNH	Boloria titania montinus	18-Aug-1936	f	Mt. Adams	DJ Lennox		
UNH	Boloria titania montinus	18-Aug-1936	m	Mt. Adams	DJ Lennox		
UNH	Boloria titania montinus	18-Aug-1936	m	Mt. Adams	DJ Lennox		
UNH	Boloria titania montinus	18-Aug-1936	m	Mt. Adams	DJ Lennox		
UNH	Boloria titania montinus	18-Aug-1936	f	Mt. Adams	DJ Lennox		
UNH	Boloria titania montinus	18-Aug-1936	f	Mt. Adams	DJ Lennox		
UNH	Boloria titania montinus	14-Aug-1938	m	Mt. Jefferson	DJ Lennox		
UNH	Boloria titania montinus	21-Aug-1938	f	Mt. Madison	DJ Lennox		
UNH	Boloria titania montinus	11-Aug-1939	m	Mt. Madison	DJ Lennox		
UNH	Boloria titania montinus	11-Aug-1939	f	Mt. Madison	DJ Lennox		
UNH	Boloria titania montinus	11-Aug-1939	f	Mt. Madison	DJ Lennox		
UNH	Boloria titania montinus	11-Aug-1939	m	Mt. Madison	DJ Lennox		

Voucher Location	Species	Date	Sex	Location	Observer	Numbers Reported	Comments
UNH	Boloria titania montinus	16-Aug-1948	f	Mt. Washington	DJ Lennox		
UNH	Boloria titania montinus	16-Aug-1948	f	Mt. Washington	DJ Lennox		
UNH	Boloria titania montinus	16-Aug-1948	f	Mt. Washington	DJ Lennox		
UNH	Boloria titania montinus	16-Aug-1948	f	Mt. Washington	DJ Lennox		
UNH	Boloria titania montinus	16-Aug-1948	m	Mt. Washington	DJ Lennox		
UNH	Boloria titania montinus	16-Aug-1948	m	Mt. Washington	DJ Lennox		
UNH	Boloria titania montinus	16-Aug-1948	f	Mt. Washington	DJ Lennox		
UNH	Boloria titania montinus	16-Aug-1948	f	Mt. Washington	DJ Lennox		
UNH	Boloria titania montinus	16-Aug-1948	m	Mt. Washington	DJ Lennox		
UNH	Boloria titania montinus	22-Aug-1950	f	Mt. Washington	David Boufford		
UNH	Boloria titania montinus	22-Aug-1950	f	Mt. Washington	David Boufford		
UNH	Boloria titania montinus	22-Aug-1950	f	Mt. Washington	DJ Lennox		
UNH	Boloria titania montinus	22-Aug-1950	f	Mt. Washington	DJ Lennox		
UNH	Boloria titania montinus	22-Aug-1950	f	Mt. Washington	DJ Lennox		
UNH	Boloria titania montinus	22-Aug-1950	m	Mt. Washington	DJ Lennox		
UNH	Boloria titania montinus	22-Aug-1950	m	Mt. Washington	DJ Lennox		
UNH	Boloria titania montinus	22-Aug-1950	m	Mt. Washington	DJ Lennox		
UNH	Boloria titania	22-Aug-1950	m	Mt. Washington	DJ Lennox		

Voucher Location	Species	Date	Sex	Location	Observer	Numbers Reported	Comments
	montinus						
UNH	Boloria titania montinus	22-Aug-1950	m	Mt. Washington	DJ Lennox		
UNH	Boloria titania montinus	11-Aug-1951	f	Mt. Washington	DJ Lennox		
UNH	Boloria titania montinus	11-Aug-1951	m	Mt. Washington	DJ Lennox		
UNH	Boloria titania montinus	11-Aug-1951	f	Mt. Washington	David Boufford		
UNH	Boloria titania montinus	11-Aug-1951	m	Mt. Washington	David Boufford		
Peabody	Boloria titania montinus	15-Aug-1954	m	Mt. Washington - Cragway Spring	P. Ritterbush		pinned collection
UNH	Boloria titania montinus	07-Aug-1965	m		DJ Lennox		
UNH	Boloria titania montinus	07-Aug-1965	f		DJ Lennox		
UNH	Boloria titania montinus	06-Aug-1966	m	Mt. Washington			
UNH	Boloria titania montinus	06-Aug-1966	m	Mt. Washington			
UNH	Boloria titania montinus	06-Aug-1966	m	Mt. Washington			
UNH	Boloria titania montinus	06-Aug-1966	f	Mt. Washington			
UNH	Boloria titania montinus	14-Aug-1966		Mt. Washington	DJ Lennox		
UNH	Boloria titania montinus	14-Aug-1966	f	Mt. Washington			
UNH	Boloria titania montinus	14-Aug-1966	f	Mt. Washington			
UNH	Boloria titania montinus	27-Aug-1966		Jefferson Notch	DJ Lennox		approx 2950ft elev. from coordinates for record. Specimen in poor shape.
UNH	Boloria titania	22-Jul-1971		Mt. Jefferson	David Boufford		1670 m

Voucher Location	Species	Date	Sex	Location	Observer	Numbers Reported	Comments
	montinus						
UNH	Boloria titania montinus	22-Jul-1971			Ron Commeau		
UNH	Boloria titania montinus	31-Jul-1971		Mt. Washington	David Boufford		5000
UNH	Boloria titania montinus	31-Jul-1971		Mt. Washington	David Boufford		1500m
UNH	Boloria titania montinus	31-Jul-1971		Mt. Washington	David Boufford		1500m
UNH	Boloria titania montinus	31-Jul-1971		Mt. Washington	David Boufford		1500m
UNH	Boloria titania montinus	31-Jul-1971		Mt. Washington	David Boufford		5000ft
UNH	Boloria titania montinus	22-Jul-1974		Mt. Washington	WJ Morse		4000
UNH	Boloria titania montinus	17-Jul-1975		Mt. Washington	R M Reeves		5400
personal collection	Boloria titania montinus	04-Aug-1980	mf	Mt. Washington - Nelson Crag	A. Grkovich		fresh males and females
personal collection	Boloria titania montinus	28-Jul-1990	f	Mt. Washington - on plateau below peak leading to AMC lake of clouds hut (~5,400 ft elev.)	A. Grkovich		slightly worn
personal collection	Boloria titania montinus	28-Jul-1990	f	Mt. Washington - on plateau below peak leading to AMC lake of clouds hut (~5,400 ft elev.)	A. Grkovich		slightly worn
personal collection	Boloria titania montinus	14-Aug-1991	mf	Mt. Washington - Nelson Crag, Alpine Garden, and just below treeline between Nelson Crag and Alpine Garden	A. Grkovich		fresh males and females
personal collection	Boloria titania montinus	03-Aug-1993		Mt. Washington	J. Glassberg		in Butterflies Through Binoculars: The East
personal collection	Boloria titania	08-Aug-2000	m	Mt. Washington - Nelson	A. Grkovich	1	1 immaculate male

Voucher Location	Species	Date	Sex	Location	Observer	Numbers Reported	Comments
	montinus			Crag			
personal collection	Boloria titania montinus	08-Aug-2001	mf	Mt. Washington - Nelson Crag and along Wamsutta Trail (4500-5000 ft elev.)	A. Grkovich	"large numbers"	good to fresh males and fresh females in large numbers
	Oeneis melissa semidea	June 1826		Mt. Washington	Oakes	abundant	from Scudder 1889
	Oeneis melissa semidea	7-4-1869		Mt. Washington	Sanborn		"earliest date that year" from Scudder 1889
	Oeneis melissa semidea	7-8-1859		Mt. Washington - 1 mile from summit near trail from the Glen	S.H. Scudder	1	from Scudder 1889
	Oeneis melissa semidea	7-8-1859		Mt. Washington	S.H. Scudder	>40	from Scudder 1889
	Oeneis melissa semidea	6-26-1874		Mt. Washington	Dimmock		from Scudder 1889
	Oeneis melissa semidea	7-1-1874		Mt. Washington	Morrison		from Scudder 1889
	Oeneis melissa semidea	7-4-1874		Mt. Washington	Dimmock		from Scudder 1889
	Oeneis melissa semidea	7-6-1874		Mt. Washington	Dimmock		from Scudder 1889
	Oeneis melissa semidea	6-6-1886		Mt. Washington	Hayward and Scudder		from Scudder 1889. Saw 3 lepidoptera, but unable to fully confirm identity, but each thought was semidea.
Peabody	Oeneis melissa semidea	01-Jul-1913	m	Mt. Washington	C.W. Johnson		pinned collection
Peabody	Oeneis melissa semidea	07-Jul-1926	f	Mt. Washington	C.L. and P.S. Remington		pinned collection
UNH	Oeneis melissa semidea	17-Jul-1929		Mt. Washington	G.S. Walley		5000 ft
UNH	Oeneis melissa semidea	22-Jul-1929		Mt. Washington	G.S. Walley		5000 ft
UNH	Oeneis melissa semidea	22-Jul-1929		Mt. Washington	G.S. Walley		5000 ft
Peabody	Oeneis melissa	09-Jul-1934	m	Mt. Jefferson	D.J. Lennox		pinned collection

Voucher Location	Species	Date	Sex	Location	Observer	Numbers Reported	Comments
	semidea						
Peabody	Oeneis melissa semidea	09-Jul-1934	m	Mt. Jefferson	D.J. Lennox		pinned collection
Peabody	Oeneis melissa semidea	09-Jul-1934	f	Mt. Jefferson	D.J. Lennox		pinned collection
Peabody	Oeneis melissa semidea	09-Jul-1934	f	Mt. Jefferson	D.J. Lennox		pinned collection
Peabody	Oeneis melissa semidea	10-Jul-1934	m	Mt. Jefferson	D.J. Lennox		pinned collection
Peabody	Oeneis melissa semidea	10-Jul-1934	f	Mt. Jefferson	D.J. Lennox		pinned collection
UNH	Oeneis melissa semidea	10-Jul-1934		Mt. Jefferson	D.J. Lennox		
Peabody	Oeneis melissa semidea	07-Jul-1936	m	Mt. Washington	P.S. Remington		pinned collection
Peabody	Oeneis melissa semidea	07-Jul-1936	m	Mt. Washington	P.S. Remington		pinned collection
Peabody	Oeneis melissa semidea	07-Jul-1936	m	Mt. Washington	P.S. Remington		pinned collection
Peabody	Oeneis melissa semidea	07-Jul-1936	f	Mt. Washington	P.S. Remington		pinned collection
Peabody	Oeneis melissa semidea	07-Jul-1936	f	Mt. Washington	C.L. Remington		pinned collection
Peabody	Oeneis melissa semidea	13-Jul-1937	m	Mt. Washington			pinned collection
UNH	Oeneis melissa semidea	01-Jul-1939		Mt. Washington	D.J. Lennox		
UNH	Oeneis melissa semidea	04-Jul-1939		Mt. Washington	DJ Lennox		
UNH	Oeneis melissa semidea	04-Jul-1939		Mt. Washington	DJ Lennox		
Peabody	Oeneis melissa semidea	19-Jul-1940	m	Mt. Washington	presented by Starretts		pinned collection
Peabody	Oeneis melissa semidea	19-Jul-1940	m	Mt. Washington	presented by Starretts		pinned collection

Voucher Location	Species	Date	Sex	Location	Observer	Numbers Reported	Comments
Peabody	Oeneis melissa semidea	19-Jul-1940	m	Mt. Washington	presented by Starretts		pinned collection
Peabody	Oeneis melissa semidea	19-Jul-1940	m	Mt. Washington	presented by Starretts		pinned collection
Peabody	Oeneis melissa semidea	19-Jul-1940	m	Mt. Washington	presented by Starretts		pinned collection
Peabody	Oeneis melissa semidea	19-Jul-1940	m	Mt. Washington	presented by Starretts		pinned collection
Peabody	Oeneis melissa semidea	19-Jul-1940	m	Mt. Washington	presented by Starretts		pinned collection
Peabody	Oeneis melissa semidea	19-Jul-1940	m	Mt. Washington	presented by Starretts		pinned collection
Peabody	Oeneis melissa semidea	19-Jul-1940	m	Mt. Washington	presented by Starretts		pinned collection
Peabody	Oeneis melissa semidea	19-Jul-1940	m	Mt. Washington	presented by Starretts		pinned collection
Peabody	Oeneis melissa semidea	19-Jul-1940	m	Mt. Washington	presented by Starretts		pinned collection
Peabody	Oeneis melissa semidea	19-Jul-1940	m	Mt. Washington	presented by Starretts		pinned collection
Peabody	Oeneis melissa semidea	19-Jul-1940	f	Mt. Washington	presented by Starretts		pinned collection
Peabody	Oeneis melissa semidea	19-Jul-1940	f	Mt. Washington	presented by Starretts		pinned collection
Peabody	Oeneis melissa semidea	19-Jul-1940	f	Mt. Washington	presented by Starretts		pinned collection
Peabody	Oeneis melissa semidea	19-Jul-1940	f	Mt. Washington	presented by Starretts		pinned collection
Peabody	Oeneis melissa semidea	19-Jul-1940	f	Mt. Washington	presented by Starretts		pinned collection
Peabody	Oeneis melissa semidea	19-Jul-1940	f	Mt. Washington	presented by Starretts		pinned collection
UNH	Oeneis melissa semidea	04-Jul-1945		Mt. Washington	D.J. Lennox		
Peabody	Oeneis melissa	12-Jul-1950	m	Mt. Washington	C.L. Remington		pinned collection

Voucher Location	Species	Date	Sex	Location	Observer	Numbers Reported	Comments
	semidea						
UNH	Oeneis melissa semidea	12-Jul-1950		Mt. Washington	D.J. Lennox		
UNH	Oeneis melissa semidea	12-Jul-1950		Mt. Washington	D.J. Lennox		
UNH	Oeneis melissa semidea	12-Jul-1950		Mt. Washington	D.J. Lennox		
UNH	Oeneis melissa semidea	12-Jul-1950		Mt. Washington	D.J. Lennox		
UNH	Oeneis melissa semidea	12-Jul-1950		Mt. Washington	D.J. Lennox		
UNH	Oeneis melissa semidea	12-Jul-1950		Mt. Washington	D.J. Lennox		
UNH	Oeneis melissa semidea	12-Jul-1950		Mt. Washington	D.J. Lennox		
UNH	Oeneis melissa semidea	12-Jul-1950		Mt. Washington	D.J. Lennox		
UNH	Oeneis melissa semidea	12-Jul-1950		Mt. Washington	D.J. Lennox		
Peabody	Oeneis melissa semidea	15-Jul-1950	m	Mt. Washington	C.L. Remington		pinned collection
Peabody	Oeneis melissa semidea	15-Jul-1950	m	Mt. Washington	C.L. Remington		pinned collection
Peabody	Oeneis melissa semidea	15-Jul-1950	f	Mt. Washington	C.L. Remington		pinned collection
Peabody	Oeneis melissa semidea	15-Jul-1950	m	Mt. Washington	C.L. Remington		papered job lot no. 84P-00. YPM no. 74636
Peabody	Oeneis melissa semidea	15-Jul-1950	m	Mt. Washington	C.L. Remington		papered job lot no. 84P-00. YPM no. 74635
Peabody	Oeneis melissa semidea	15-Jul-1950	m	Mt. Washington	C.L. Remington		papered job lot no. 84P-00. YPM no. 74624
Peabody	Oeneis melissa semidea	15-Jul-1950	m	Mt. Washington	C.L. Remington		papered job lot no. 84P-00. YPM no. 74631
Peabody	Oeneis melissa semidea	15-Jul-1950	m	Mt. Washington	C.L. Remington		papered job lot no. 84P-00. YPM no. 74632

Voucher Location	Species	Date	Sex	Location	Observer	Numbers Reported	Comments
Peabody	Oeneis melissa semidea	15-Jul-1950	m	Mt. Washington	C.L. Remington		papered job lot no. 84P-00. YPM no. 74629
Peabody	Oeneis melissa semidea	15-Jul-1950	m	Mt. Washington	C.L. Remington		papered job lot no. 84P-00. YPM no. 74634
Peabody	Oeneis melissa semidea	15-Jul-1950	m	Mt. Washington	C.L. Remington		papered job lot no. 84P-00. YPM no. 74627
Peabody	Oeneis melissa semidea	15-Jul-1950	m	Mt. Washington	C.L. Remington		papered job lot no. 84P-00. YPM no. 74630
Peabody	Oeneis melissa semidea	15-Jul-1950	m	Mt. Washington	C.L. Remington		papered job lot no. 84P-00. YPM no. 74633
Peabody	Oeneis melissa semidea	15-Jul-1950	m	Mt. Washington	C.L. Remington		papered job lot no. 84P-00. YPM no. 74626
Peabody	Oeneis melissa semidea	15-Jul-1950	m	Mt. Washington	C.L. Remington		papered job lot no. 84P-00. YPM no. 74625
Peabody	Oeneis melissa semidea	15-Jul-1950	m	Mt. Washington	C.L. Remington		papered job lot no. 84P-00. YPM no. 74637
Peabody	Oeneis melissa semidea	15-Jul-1950	f	Mt. Washington	C.L. Remington		papered job lot no. 84P-00. YPM no. 74623
Peabody	Oeneis melissa semidea	18-Jul-1950	f	Mt. Washington	C.L. Remington		pinned collection
Peabody	Oeneis melissa semidea	18-Jul-1950		Mt. Washington	C.L. Remington		papered job lot no. 84P-00. YPM no. 74628. Box has note that says there is suppose to be 17 males and 3 females in it.
UNH	Oeneis melissa semidea	08-Jul-1952		Mt. Jefferson	D.J. Lennox		
UNH	Oeneis melissa semidea	08-Jul-1952		Mt. Jefferson	DJ Lennox		
UNH	Oeneis melissa semidea	18-Jul-1958		Mt. Washington	D.J. Lennox		
UNH	Oeneis melissa semidea	18-Jul-1958		Mt. Washington	D.J. Lennox		
	Oeneis melissa semidea	7/13/1959		Mt. Washington	S.H. Scudder	59	from Scudder 1889
UNH	Oeneis melissa	17-Jul-1965		Mt. Washington	AH Mason		6000

Voucher Location	Species	Date	Sex	Location	Observer	Numbers Reported	Comments
	semidea						
UNH	Oeneis melissa semidea	17-Jul-1965		Mt. Washington	D.J. Lennox		
UNH	Oeneis melissa semidea	17-Jul-1965		Mt. Washington	AH Mason		6000
UNH	Oeneis melissa semidea	17-Jul-1965		Mt. Washington	AH Mason		6000
UNH	Oeneis melissa semidea	13-Jul-1968	m	Mt. Washington			papered
UNH	Oeneis melissa semidea	13-Jul-1968	m	Mt. Washington			papered
UNH	Oeneis melissa semidea	13-Jul-1968	f	Mt. Washington			papered
UNH	Oeneis melissa semidea	13-Jul-1968	m	Mt. Washington			papered
UNH	Oeneis melissa semidea	13-Jul-1968	f	Mt. Washington			papered
UNH	Oeneis melissa semidea	13-Jul-1968	f	Mt. Washington			papered
	Oeneis melissa semidea	27-Jun-1969		Mt. Washington- Cow Pasture	C.S. Anthony	51 from 27 Jun and 7 July	between 27 Jun and 7 July marked 51 individuals here and never recaptured any.
	Oeneis melissa semidea	08-Jul-1969		Monticello Lawn, Gulf Tanks, Cow Pasture, Bigelow Lawn	C.S. Anthony	115 from 8 Jul - 15 July	collected 115 between 8 Jul and 15 July. 13 females kept alive and later released on Mt. Mooselauke. Field work ended 2 August.
	Oeneis melissa semidea	08-Jul-1969		Mt. Washinton - Cow Pasture	D. Lennox	30 on 8 and 15 Jul	Collect 30 on this date and 15 July.
	Oeneis melissa semidea	15-Jul-1969		Mt. Washinton - Cow Pasture	D. Lennox	30 on 8 and 15 Jul	Collect 30 on this date and 8 July.
UNH	Oeneis melissa semidea	15-Jul-1969		Jefferson, NH	D.J. Lennox		
UNH	Oeneis melissa semidea	21-Jul-1971		Mt. Washington	David E. Boufford		6000ft
UNH	Oeneis melissa semidea	21-Jul-1971		Mt. Washington	David E. Boufford		6000

Voucher Location	Species	Date	Sex	Location	Observer	Numbers Reported	Comments
UNH	Oeneis melissa semidea	23-Jul-1971		Mt. Washington	R. Commeau		5800ft
UNH	Oeneis melissa semidea	23-Jul-1971		Mt. Washington	David E. Boufford		6000ft
UNH	Oeneis melissa semidea	23-Jul-1971		Mt. Washington	R. Commeau		5800ft
UNH	Oeneis melissa semidea	23-Jul-1971		Mt. Washington	D. E. Boufford		6000
UNH	Oeneis melissa semidea	23-Jul-1971		Mt. Washington	David E. Boufford		6000
UNH	Oeneis melissa semidea	23-Jul-1971		Mt. Washington	David E. Boufford		6000
UNH	Oeneis melissa semidea	23-Jul-1971		Mt. Washington	R. Commeau		5800
UNH	Oeneis melissa semidea	23-Jul-1971		Mt. Washington	Ron Commeau		papered.
UNH	Oeneis melissa semidea	23-Jul-1971		Mt. Washington	Ron Commeau		papered.
UNH	Oeneis melissa semidea	23-Jul-1971		Mt. Washington	Ron Commeau		papered.
UNH	Oeneis melissa semidea	23-Jul-1971		Mt. Washington	David Boufford		6000
UNH	Oeneis melissa semidea	23-Jul-1971		Mt. Washington	David Boufford		6000
UNH	Oeneis melissa semidea	23-Jul-1971		Mt. Washington	David Boufford		6000
UNH	Oeneis melissa semidea	23-Jul-1971		Mt. Washington	David Boufford		6000
UNH	Oeneis melissa semidea	31-Jul-1971		Mt. Washington	David Boufford		6000
UNH	Oeneis melissa semidea	31-Jul-1971		Mt. Washington	David Boufford		6000
UNH	Oeneis melissa semidea	31-Jul-1971		Mt. Washington	David E. Boufford		6000
UNH	Oeneis melissa	31-Jul-1971		Mt. Washington	David Boufford		6000. very good condition

Voucher Location	Species	Date	Sex	Location	Observer	Numbers Reported	Comments
	semidea						
UNH	Oeneis melissa semidea	31-Jul-1971		Mt. Washington	David Boufford		6000
UNH	Oeneis melissa semidea	31-Jul-1971		Mt. Washington	David Boufford		6000
UNH	Oeneis melissa semidea	31-Jul-1971		Mt. Washington	David Boufford		6000
UNH	Oeneis melissa semidea	11-Jul-1977		Mt. Washington	WJ Morse		5500
UNH	Oeneis melissa semidea	11-Jul-1977		Mt. Washington	WJ Morse		5500
personal collection	Oeneis melissa semidea	08-Jul-1979	mf	Mt. Washington - auto road from just about Nelson Crag (4,800ft) and higher	A. Grkovich	"in great numbers"	in great numbers all along road
UNH	Oeneis melissa semidea	23-Jul-1981		Mt. Washington			papered.. 5200
	Oeneis melissa semidea	13-Jul-1984		Mt. Washington- Alpine Garden	H. Pavulaan	>100	Air temp 55F, 35 mph winds reported at summit, overcast with breaks of sunshine. I found O. melissa semidea (over 100 approximated). These were usually sitting in protected places between boulders and immediately took flight when approached. I came clo
UNH	Oeneis melissa semidea	04-Jul-1991			C.F. Goodhue		
UNH	Oeneis melissa semidea	04-Jul-1991		Mt. Washington	C.F. Goodhue		
	Oeneis melissa semidea	27-Jun-1995		Mt. Washington - NE and E sides of summit cone.	M. Pelikan	~30	Observed approx. 30 individuals.
	Oeneis melissa semidea	11-Jul-1995		Mt. Washington	J. Glassberg		in Butterflies Through Binoculars: The East
UNH	Oeneis melissa semidea	28-Jul-1996		Mt. Washington			

Voucher Location	Species	Date	Sex	Location	Observer	Numbers Reported	Comments
	Oeneis melissa semidea	28-Jun-1998		Mt. Washington - close to where trail meets cog railway about 500-800 ft below summit on west side, and rest of ascent	M. Walker	7	weather at 1200=40F. wind 3mph. short blasts of sun at 1400. 1530 when reached summit. Saw one sunning at cog area and then 6 on ascent. most low to ground flying or resting. some would rise up and away.
	Oeneis melissa semidea	19-Jul-2001		Mt. Adams - Lowe's Path-just above grey knob on the NNW side of Mt. Adams	J. Feder	2	Weather conditions: sunny 1100 20.8C 1330 25 c 1630 16.8c wind 1m high 1100 6.5 mph 1330 5 mph 1630 3 mph ground level wind 1100 <2 SSW 1330 <2 SSW 1630 3
UNH	Oeneis melissa semidea	August		Mt. Washington			"August" on tag
UNH	Oeneis melissa semidea	August			C.F. Goodhue		"August" on tag

Table 4. Transect data collected in 2002-03 in the Presidential Range, NH.

Transect	Date	Start Time	End Time	Total Time	Distance (m)	No. of Boloria titania montinus	No. Oeneis melissa semidea	Individuals / 1000m	comments
1	7/12/2002	12:30	12:40	0:10	0.425	0	0	0.0	searched entire area of sedge meadow. 0.425 acres. 4,500ft elev.
2	7/12/2002	13:05	13:27	0:22	375	0	2	5.3	cow pasture
3	7/12/2002	13:29	13:34	0:05	220	0	1	4.5	cow pasture
4	7/12/2002	14:36	15:41	1:05	1697	0	0	0.0	alpine trail and 75m length of stream halfway on trail
5	7/12/2002	15:41	16:30	0:49	1510	0	0	0.0	Nelson Crag trail from jct. Alpine garden to summit.
7	7/21/2002	13:00	15:20	2:20	2294	0	7	3.1	summit to Lake of Clouds mostly off trail
8	7/21/2002	15:30	17:00	1:30	2228	0	3	1.3	lake clouds around and over Monroe
9	7/21/2002	17:10	17:35	0:25	1030	0	4	3.9	Camel Trail
10	7/22/2002	9:45	11:00	1:15	735	0	11	15.0	Monticello Lawn
11	7/22/2002	11:00	12:00	1:00	2300	0	0	0.0	from Monticello Lawn to Clay loop via Gulfside trail
12	7/22/2002	12:00	12:50	0:50	1250	0	3	2.4	from Clay loop up Gulfside trail to great gulf trail, to tanks near Nelson Crag trail, then up to summit.
13	7/31/2002	12:00	13:45	1:45	1450	6	0	4.1	Cragway Spring
14	7/31/2002	15:05	16:00	0:55	1500	0	0	0.0	alpine garden
15	8/13/2003	14:00	15:45	1:45	615	12	0	19.5	Cragway spring

Transect	Date	Start Time	End Time	Total Time	Distance (m)	No. of Boloria titania montinus	No. Oeneis melissa semidea	Individuals / 1000m	comments
16	8/14/2003	9:00	10:00	1:00	2670	4	0	1.5	Alpine Garden trail
17	7/26/2003	9:55	10:10	0:15	600	0	0	0.0	Israel Trail - Mt. Madison. Filtered sun, 58F, NW wind 20-30mph
18	8/15/2003	9:30	10:20	0:50	1130	11	0	9.7	up road from pulloff to Wamsutta trail, down trail to cutoff for winter rd., down winter rd and then back up to car
19	8/15/2003	12:00	14:00	2:00	3875	23	0	5.9	Gulfside trail, Mt. Clay loop, Gulfside to east side of Mt. Jefferson
20	8/15/2003	14:20	14:50	0:30	1540	4	0	2.6	west side of Mt. Clay on Gulfside trail

Table 5. Locations of *O. m. semidea* and *B. t. montinus* observations during 2002 – 03 in the Presidential Range, NH.

Transect Number	Date	Time	No. of Oeneis melissa semidea	No. of Boloria titania montinus	Latitude	Longitude	Habitat indicated on AMC GIS coverage	Habitat description on site	Elev. (ft)	Comments
2	7/12/2002	13:13	1		44.27808	71.29452	sedge meadow	sedge meadow	5700	photos
2	7/12/2002	13:22	1		44.27782	71.29515	sedge meadow	sedge meadow	5750	
3	7/12/2002	13:30	1		44.27789	71.29526	fellfield	fellfield with sedge	5750	basking
7	7/21/2002	13:16	1		44.27124	71.30596	sedge meadow	sedge meadow	6150	sunning on flat rock
7	7/21/2002	13:26	1		44.27041	71.3072	sedge meadow	sedge meadow	6050	sunning on flat rock
7	7/21/2002	13:33	1		44.2703	71.30685	sedge meadow	sedge meadow	6050	sunning on flat rock. Butterfly wp2 flew by it and it chased it breifly, then landed on flat rock. Captured in net and released. Very tattered.
7	7/21/2002	14:02	1		44.26826	71.30999	fellfield/sedge meadow	sedge meadow	5600	flew across sedge meadow for 30m then circled back and landed on ridge above dry spring
7	7/21/2002	14:07	1		44.26801	71.31043	heath-shrub-rush	rock	5550	flushed off dark lichen and then landed back on dark lichen patch
7	7/21/2002	15:08	1		44.26236	71.3123	sedge meadow	sedge meadow	5350	sunning on flat rock. Very tattered, missing one hind wing.
7	7/21/2002	15:08	1		44.26257	71.3234	fellfield	sedge meadow	5350	good condition
8	7/21/2002	16:26	1		44.2546	71.32267	fellfield	rock ridge	5300	fairly good condition, no tatters. Photos
8	7/21/2002	16:39	1		44.2549	71.32132	fellfield	rock ridge	5370	sunning on summit Mt. Monroe. Flushed and flew with wind east over valley and out of sight.
8	7/21/2002	16:50	1		44.25587	71.32052	heath-shrub-rush	rock ridge	5250	sunning on flat rock on ridge.
9	7/21/2002	17:19	1		44.2589	71.30993	krummholtz-birch-alder	rock ridge	5350	flushed off flat rock
9	7/21/2002	17:30	1		44.25896	71.3048	fellfield	fellfield-sedge	5400	flushed off flat rock
9	7/21/2002	17:31	1		44.25877	71.30469	fellfield	fellfield-sedge	5400	flushed off flat rock. Very fresh.
9	7/21/2002	17:33	1		44.25887	71.30445	fellfield	fellfield-sedge	5400	flushed off flat rock. Very fresh.

Transect Number	Date	Time	No. of Oeneis melissa semidea	No. of Boloria titania montinus	Latitude	Longitude	Habitat indicated on AMC GIS coverage	Habitat description on site	Elev. (ft)	Comments
10	7/22/2002	9:55	7		44.30077	71.31265	sedge meadow	rock ridge	5300	on small col. 2 chasing each other into wind low. 3 in whirl together for 15 sec. Then break off and sun. all on east side out of wind. All in good condition.
10	7/22/2002	10:15	1		44.30082	71.31437	sedge meadow	sedge meadow	5400	photo
10	7/22/2002	10:18	1		44.30021	71.3142	fellfield	rock ridge	5350	east side of rock col sunning. Good condtion. Photos.
10	7/22/2002	10:53	1		44.29919	71.31555	fellfield	rock ridge	5350	east side of rock col sunning.
10	7/22/2002	10:57	1		44.29891	71.31575	fellfield	rock ridge	5350	flushed from rocks
12	7/22/2002	12:09	1		44.2768	71.3104	sedge meadow	sedge meadow	5500	flushed
12	7/22/2002	12:16	1		44.27692	71.3102	sedge meadow	trail	5500	flushed from Mtn. Sandwort
12	7/22/2002	12:22	1		44.27645	71.3102	sedge meadow	trail	5600	sunning along trail
13	7/31/2002	12:20		1	44.27949	71.27696	krummholtz	heath-krummholtz	4620	flushed
13	7/31/2002	12:50		1	44.28052	71.27528	fellfield	heath	4625	flushed
13	7/31/2002	13:15		1	44.27896	71.27486	krummholtz	heath-krummholtz	4510	on vaccinium spp. Flushed and flew fast.
13	7/31/2002	13:20		1	44.27883	71.27482	krummholtz	krummholtz	4510	flushed off fir and flew to another patch of fir
13	7/31/2002	13:38		1	44.27972	71.27403	krummholtz	trail-krummholtz	4530	nectaring Mtn. Goldenrod along trail. Flushed and went to fir patch.
13	7/31/2002	13:42		1	44.27942	71.27415	krummholtz	trail	4550	nectaring Mtn. Goldenrod along trail.
15	8/13/2003	14:00		2	44.28214	71.27736	roadside	roadside-spring	4800	nectaring goldenrod and steeplebush. Photos
15	8/13/2003	14:10		7	44.28148	71.27728	roadside	roadside-spring	4750	nectaring goldenrod, steeplebush and purple-stemmed aster.
15	8/13/2003	14:30		2	44.28043	71.27459	heath-shrub-rush		4550	flying fast.
16	8/14/2003	9:30		1	44.26633	71.29439	heath-shrub-rush	trail-krummholtz	5150	flushed from behind black spruce out of wind
16	8/14/2003	9:36		1	44.26562	71.29484	krummholtz	heath-trail	5150	sunning on laborador tea
16	8/14/2003	9:41		1	44.2648	71.29647	krummholtz	spring-krummholtz	5150	nectaring Mtn. Goldenrod
16	8/14/2003	9:48		1	44.26421	71.29749	krummholtz	trail	5100	sunning on dirt trail

Transect Number	Date	Time	No. of Oeneis melissa semidea	No. of Boloria titania montinus	Latitude	Longitude	Habitat indicated on AMC GIS coverage	Habitat description on site	Elev. (ft)	Comments
	8/14/2003	11:30		1	44.24243	71.34544	fellfield	trail-krummholtz	4450	fly down trail out of wind during short sunny break
	8/14/2003	12:07		1	44.23339	71.35143	no data	trail-krummholtz	4200	flying ~2m high along trail in 2.5m high patch of fir.
18	8/15/2003	9:30		1	44.28492	71.28298	fellfield	roadside	5100	sunning along road on dirt
18	8/15/2003	9:45		1	44.2838	71.28662	road	road	5350	road kill. Collected and sent to Alaska for DNA analysis.
18	8/15/2003	9:47		1	44.28336	71.28851	fellfield	trail	5250	sunning on rock on trail
18	8/15/2003	9:49		1	44.28334	71.28846	fellfield	trail	5250	nectaring Mtn. Goldenrod
18	8/15/2003	9:55		1	44.28404	71.28794	fellfield	trail	5150	sunning on trail
18	8/15/2003	10:00		2	44.28453	71.28768	heath-scrub-rush	trail	5125	nectaring Mtn. Goldenrod
18	8/15/2003	10:03		3	44.28507	71.28674	sedge meadow	trail	5100	On Mtn. Goldenrod. 2 mating, one other flushed away.
18	8/15/2003	10:09		1	44.28522	71.28646	sedge meadow	trail	5050	nectaring Mtn. Goldenrod
	8/15/2003	10:40		1	44.27012	71.30135	fellfield	sedge-goldenrod	6150	ragged. Nectaring Mtn. Goldenrod
	8/15/2003	10:49		2	44.26979	71.30128	fellfield	sedge-goldenrod	6100	nectaring and patroling Mtn. Goldenrod
19	8/15/2003	12:15		1	44.27933	71.31369	cushion tussock		5400	patroling and nectaring Mtn. Goldenrod
19	8/15/2003	12:17		1	44.27985	71.31382	krummholtz	trail	5400	sunning
19	8/15/2003	12:22		1	44.28007	71.31405	fellfield	snowbank community	5400	patrolling and landing on birch and Vaccinium uliginosum. Watched for egg laying, but none seen.
19	8/15/2003	12:30		1	44.28024	71.31453	fellfield		5500	blown far east by wind
19	8/15/2003	12:37		3	44.28183	71.31564	heath shrub-rush	snowbank community	5550	nectaring Mtn. Goldenrod and patrolling
19	8/15/2003	12:47		1	44.28412	71.31593	cushion-tussock		5450	flying into fairly strong wind
19	8/15/2003	12:49		2	44.28445	71.31548	fellfield	snowbank community	5450	nectaring Mtn. Goldenrod in small snowbank community. Short chase then one back to nectaring and one continue patrol
19	8/15/2003	13:01		1	44.28739	71.31471	heath shrub-rush	snowbank community	5400	nectaring Mtn. Goldenrod

Transect Number	Date	Time	No. of Oeneis melissa semidea	No. of Boloria titania montinus	Latitude	Longitude	Habitat indicated on AMC GIS coverage	Habitat description on site	Elev. (ft)	Comments
19	8/15/2003	13:04		2	44.28759	71.3147	fellfield	snowbank community	5400	nectaring Mtn. Goldenrod
19	8/15/2003	13:07		5	44.28781	71.31456	heath shrub-rush	snowbank community	5400	nectaring Mtn. Goldenrod
19	8/15/2003	13:27		1	44.29517	71.31698	krummholtz	trail	4950	sunning on dirt on trail
19	8/15/2003	13:46		1	44.29607	71.31694	krummholtz	trail	5100	sunning on dirt on trail
19	8/15/2003	13:46		1	44.30237	71.31369	sedge meadow	trail	5400	sunning on rock
19	8/15/2003	13:50		2	44.30315	71.31303	krummholtz	trail	5400	sunning and dabbing at dirt
20	8/15/2003	14:21		1	44.29112	71.31699	krummholtz	trail	5050	sunning on trail
20	8/15/2003	14:24		1	44.29069	71.31712	krummholtz	trail	5050	dabbing mud on trail
20	8/15/2003	14:28		1	44.28914	71.31737	krummholtz	trail	5150	
20	8/15/2003	14:35		1	44.28669	71.3177	heath shrub-rush	trail	5300	sunning and dabbing wet dirt on trail
20	8/15/2003	15:00		1	44.2767	71.31054	sedge meadow	snowbank community	5500	nectaring Mtn. Goldenrod
	11-Aug-2002			plentiful	44.28148	71.27728			4800	Reported by Alex Grkovich. Fresh individuals.Nelson Crag trail
	11-Aug-2002			2					4800-5300	Reported by Alex Grkovich. Road from Nelson Crag trail to Wamsutta Trail
	12-Jul-2003		1		44.28153	71.29233			5400	Reported by Alex Grkovich. Specimen in good condition. Weather bad and became worse and saw no others
	21-Jun-2003		1		44.27767	71.29451			5750	Reported by T. Dodd
	21-Jun-2003		5						5300-5500	Reported by T. Dodd. Alpine Garden trail from Toll Rd.
	04-Jul-2002		1+							Reported by R. Dirig. Mt. Washington

Table 6. Linear distance and area estimated to be directly impacted by hiking trails in selected alpine vegetation communities of the Presidential Range, New Hampshire. To determine impacted area, average trail width was estimated to be 2 meters.

Vegetation Community	Linear Trail Distance (m)	Impacted Area (Ha)	Total Area (Ha)	Percent Impacted
Sedge meadow	4654.475832	0.931	80	1.2
Herbaceous snowbank	140.3604	0.028	3	0.9
Cushion-tussock	6706.261416	1.341	94	1.4
Heath-shrub-rush	4589.218152	0.918	115	0.8
Total	16090.3158	3.218	292	1.1

Table 7. Weather summary from Mt. Washington Weather Center (from http://www.mountwashington.org/weather/index.php accessed 1 Oct. 2003).

Month/Year	No. Clear Days	No. Partly Cloudy Days	% Possible Sunshine
June 2002	1	11	31
June 2003	2	10	43
July 2002	0	7	20
July 2003	0	5	24
August 2002	5	14	45
August 2003	0	6	20

Figure 1. Current distribution of the major alpine plant communities in the Presidential Range, White Mountains, NH (vegetation data provided by Appalachian Mountain Club). White Mountain Arctic (Oeneis melissa semidea) populations are concentrated in and around sedge meadow communities where their host plant is abundant. White Mountain Fritillary (Boloria titania montinus) are concentrated in heath-shrub-rush, cushion-tussock, herbaceous snowbank and streamside plant communities.

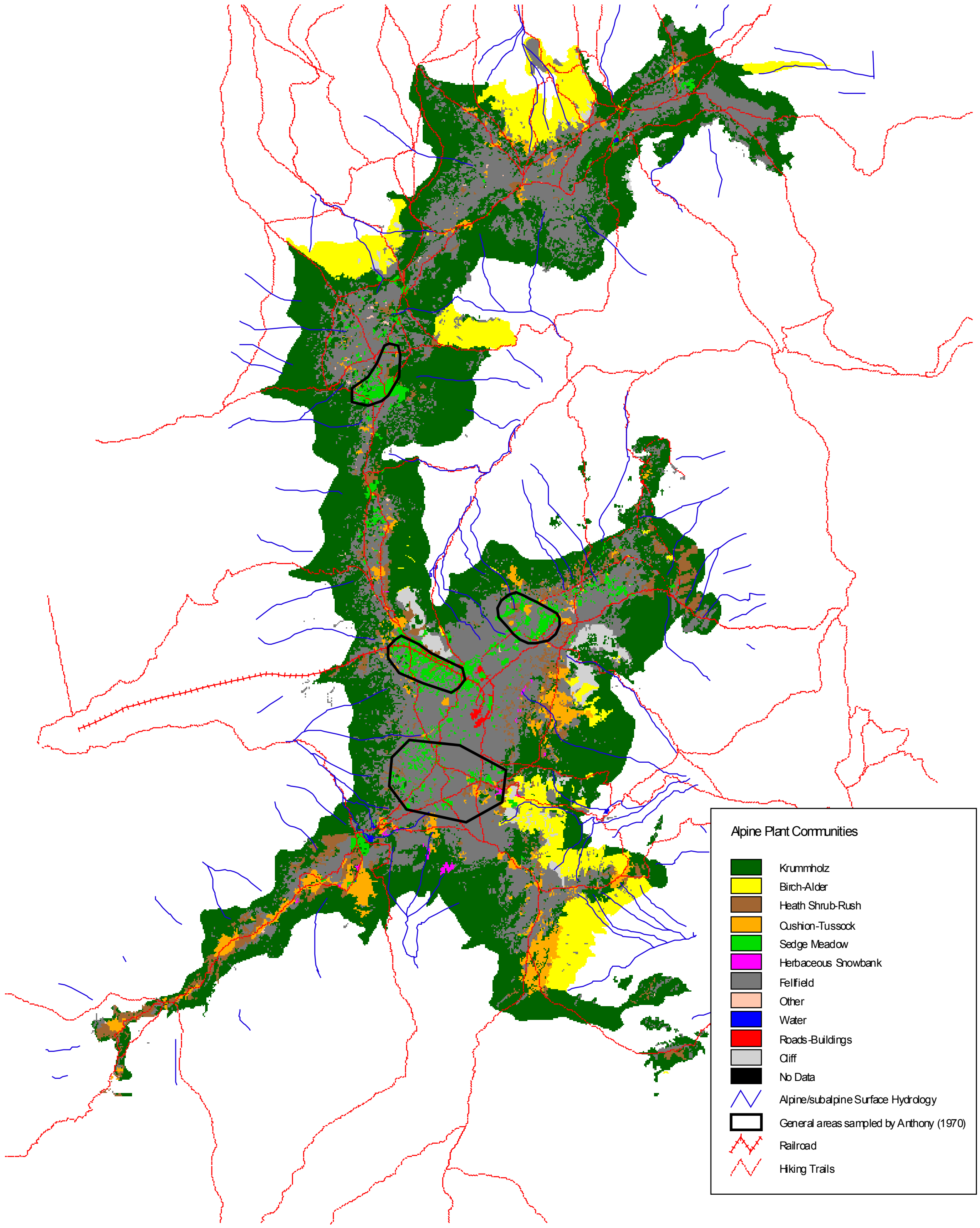

Figure 2. The Cow Pasture on Mt. Washington near mile 7 of the auto road, a typical sedge meadow and habitat of *O. m. semidea*.

Figure 3. Snowbank community on Mt. Clay with high density of flowering Alpine Goldenrod, typical habitat for B.t. montinus.

Figure 4. (blue dots) of O. m. semidea observed in 2002.

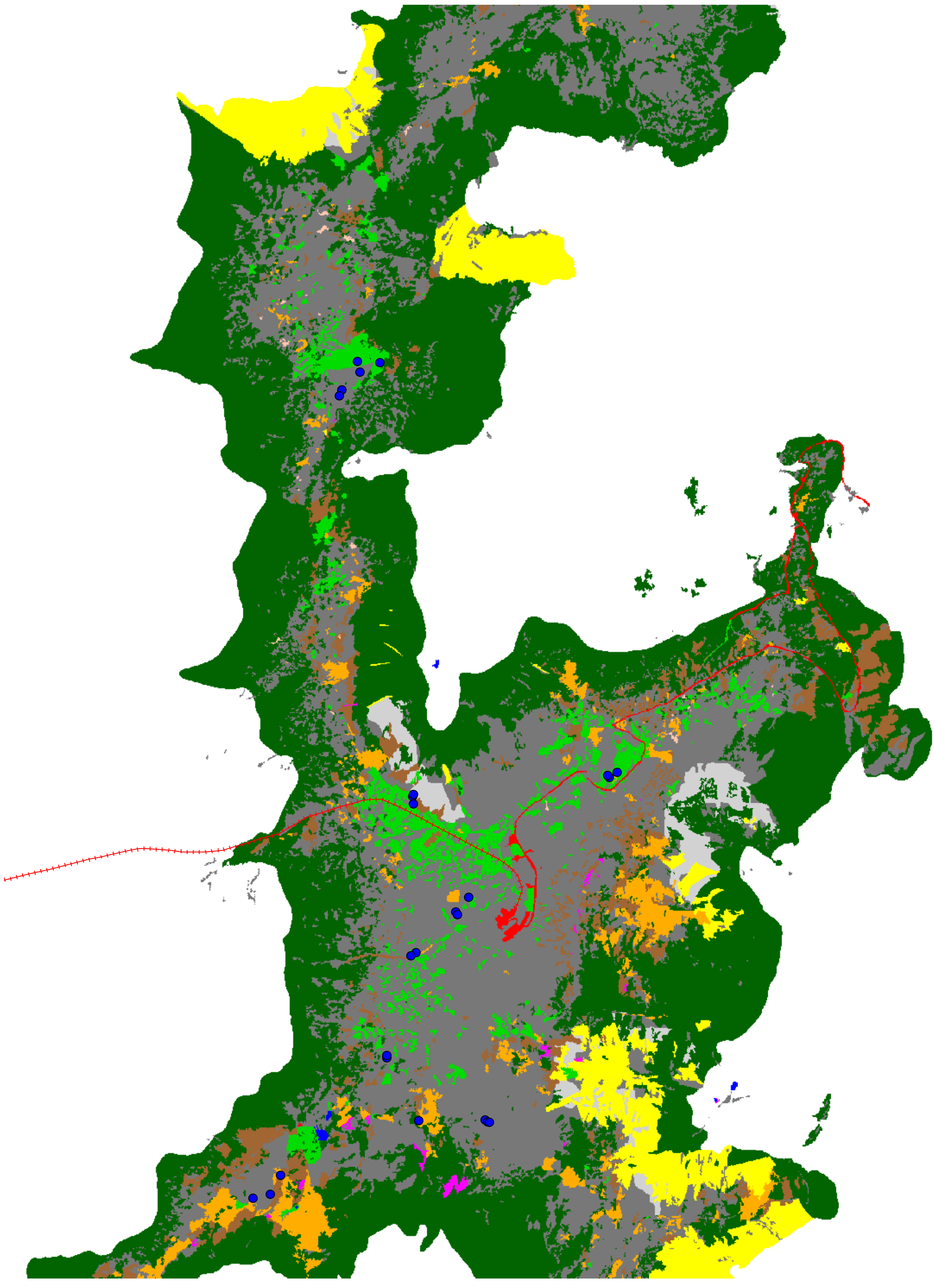

Figure 5. Locations (blue dots) of *B. t. montinus* observed in 2002 – 03.