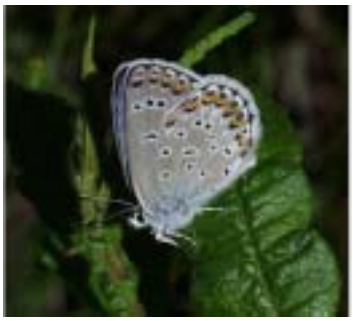
Conservation Assessment
for
Northern Blue Butterfly - Plebejus (Lycaeides) idas nabokovi Masters
and
Dwarf Bilberry -Vaccinium caespitosum (*Michx*)



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This Conservation Assessment was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation Assessement for the Eastern Region of the Forest Service. It does not represent a management decision by the U.S. Forest Service. Though the best scientific information available was used and subject experts were consulted in preparation of this document, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if you have information that will assist in conserving the subject taxon, please contact the Eastern Region of the Forest Service- Threatened and Endangered Species Program at 310 West Wisconsin Avenue, Suite 580 Milwaukee, Wisconsin 53203.

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ABSTRACT

The Northern Blue Butterfly (*Plebejus (Lycaeides) idas nabokovi* Masters) is part of a complex of North American Lycaenids ("blues") that includes two closely related species and many subspecies. The subspecies *P. idas nabokovi* occurs in the Great Lakes Region, where it is distinguished ecologically by its exclusive larval host plant, *Vaccinium caespitosum* Michx. Populations of the butterfly and plant tend to occur in geographic clusters or "metapopulations" linked by distances of 2-3 km. Fewer than 5 metapopulations are known to occur in each of the Lake States (Michigan, Minnesota, and Wisconsin); several of the most important sites occur on U.S. Forest Service lands. Both species are designated as Regional Forester's Sensitive Species in Region 9 of the USDA Forest Service. Like *P. idas nabokovi, Vaccinium caespitosum* also is rare or uncommon in the Lake States, although it occasionally occurs where the butterfly is absent, including small patches beneath a canopy of jack pines (*Pinus banksiana*) or other conifers. *V. caespitosum* is widespread in western North America, where it is associated with *P. idas* in some areas but apparently not in others. The typical habitat of *Vaccinium caespitosum* and *Plebejus idas* consists of natural or human-created openings on nutrient poor soils. In Wisconsin most sites occur on sandy soils, while populations in Michigan and Minnesota often occur on thin soils over bedrock or gravel as well as on sandy soils. Some populations in Ontario and elsewhere occur in topographic depressions or "frost pockets." Scattered conifers (pines or spruce) are usually associated with these sites. Active forest management can play a major role in conservation of these rare species. Encroachment of dense vegetation and woody plants is a major threat to existing populations, especially in the southern part of their geographic ranges. Fire suppression has likely been responsible for loss of habitat for *V. caespitosum* during the past 50 years or longer. Today, controlled burning in small units may be appropriate for maintaining vegetation openings at the larger sites, but risks to butterfly eggs, larvae, and pupae make burning a dangerous option for most existing sites in the Lake States, which are generally small and patchy. Manual removal of trees and dense ground vegetation (e.g., grasses, ferns, and *Rubus* spp.) is a desirable alternative to controlled burning. Threats from global warming, parasitoids, and exotic species are not clearly understood and deserve future study.

INTRODUCTION

The National Forest Management Act (2000) and U.S. Forest Service policy require that Forest Service lands be managed to maintain viable populations of all native plant and animal species. A viable population is one that has the estimated numbers and distribution of reproductive individuals to ensure the continued existence of the species throughout its existing range within a given planning area (FSM 2670.5.22, 2001). In addition to those species listed (or designated as candidates for listing) as endangered or threatened under the Endangered Species Act or state endangered species laws, the Forest Service designates species which are sensitive within each Region as Regional Forester's Sensitive Species. Both *Plebejus (Lycaeides) idas nabokovi* and *Vaccinium caespitosum* are endangered in Wisconsin and both are threatened in Michigan, while *P. idas nabokovi* is listed as special concern in Minnesota. *Vaccinium caespitosum* is a Regional Forester's Sensitive plant for the Hiawatha, Ottawa and Chequamegon-Nicolet National Forests. It occurs, but does not have Regional Forester's Sensitive status, on the Superior and Green Mountain National Forests. *Plebejus (Lycaeides) idas nabokovi* is a Regional Forester's Sensitive animal for the Hiawatha, Ottawa, Chequamegon-Nicolet, and Superior National Forests.

The goal of this conservation assessment is to review and compile currently known information on the biology, status, and distribution of *Plebejus (Lycaeides) idas nabokovi* and *Vaccinium caespitosum* and define what is needed to develop a plan to conserve these taxa. If you have

information that will assist in conserving these taxa, please contact the Natural Heritage Programs of the Minnesota, Michigan, or Wisconsin Departments of Natural Resources; Dr. Amy Wolf at the Cofrin Center for Biodiversity, University of Wisconsin Green Bay; or the Forest Service National Forests in Michigan, Minnesota, or Wisconsin.

Plebejus (Lycaeides) idas nabokovi

NOMENCLATURE AND TAXONOMY

Species/Subspecies name: Plebejus (Lycaeides) idas nabokovi *(Masters)*
Common name: Northern Blue Butterfly
Order: Lepidoptera
Family: Lycaenidae
***Other Names for Great Lakes Taxon*:** *Plebejus (Lycaeides) idas nabokovi* Masters; *Plebejus idas* (Scott 1986); *Plebejus (Lycaeides) argyrognomon scudderii (*Edwards) (Ebner 1970)

The Northern Blue Butterfly belongs to a taxonomically complex group of small Northern Hemisphere butterflies in the family Lycaenidae ("little butterflies") represented by approximately 4,700 species worldwide; 142 of these are found in North America (Scott 1986). Two subfamilies of Lycaenidae occur in North America; the Riodininae (metalmarks) and Lycaeninae (harvesters, hairstreaks, coppers and blues). *Plebejus idas* belongs to the tribe Polyommatina or blues, one of 4 tribes within the Lycaeninae subfamily. A recent worldwide revision of this group (Balint and Johnson 1997) replaces the widely used genus name, *Plebejus (Lycaeides),* with *Plebejus*. Scott (1986) recognized 32 species of blues for North America north of Mexico. Most authors include only two species in the subgenus *Plebejus (Lycaeides)* in North America: *Plebejus idas*, the northern blue, and *Plebejus melissa*, the Melissa blue (Higgins 1985, Miller 1992), but this is based on incomplete taxonomic study and is likely to change upon more detailed analysis. As early as 1916, for example, Barnes and McDunnough (1916) treated *Plebejus anna* as a separate species, and this opinion has been endorsed recently by Balint and Johnson (1997). The Melissa blue complex includes the federally endangered Karner Blue, *Plebejus (Lycaeides) melissa samuelis* and 5 other subspecies (Lane and Weller 1994).

The Great Lake States subspecies, *Plebejus (Lycaeides) idas nabokovi*, is part of the northern transcontinental geographic group (Scott 1986). *P. idas nabokovi* was first recognized as a distinct taxon by Vladimir Nabokov, the well-known lepidopterist and author whose works include *Lolita* and 16 other novels, in addition to poems, plays, screenplays, and other stories (Johnson and Coates 1999). Nabokov formally described the Northern Blue from specimens sent to him by Louis Griewisch (1953), who was the first to report the butterfly in Wisconsin. It wasn't until many years later that *P. idas nabokovi* was officially named as a distinct subspecies in honor of the famous author (Masters 1972). Today, Nabokov's taxonomic publications on temperate and tropical butterflies remain as some of the most authoritative taxonomic references on the family Lycaenidae.

Many questions still exist about the status of North American members of the genus *Plebejus*. Tuzov (2000) argues that Asian members of the *P. idas* complex need revision, and Kondla (pers. comm.) and Balint and Johnson (1997) maintain that North American members of the genus also deserve a thorough taxonomic re-analysis. Kondla suggests that boreal North American butterflies in this group should be placed in the taxon *Plebejus scudderi*, with *P. idas* reserved for the European members of this complex. Observations by Gorbuv (2001) support this view.

The genetic relationships among North American species and subspecies in this group were the focus of studies by Nice and Shapiro (1999). Their analysis concluded that the taxon occurring in the Great Lakes region is similar to *P. idas* subspecies in the western U.S., although this investigation was based only on allozymes and a very limited portion of mitochondrial DNA. According to their limited analysis *P. idas* as a whole is not very different genetically than *P. melissa*. Nice and Shapiro reasoned that differences in male genital morphology, wing patterns, and habitat use have evolved recently and more rapidly than the allozymes and mitochondrial DNA that they evaluated. Ecologically, certain populations of *P. idas* exhibit divergent host plant associations and probably represent incipient species or at least distinct host races. Like other researchers, Nice and Shapiro (1999) acknowledged clear differences in male genital morphology, wing color patterns and habitat characteristics across the range of *P. idas*.

DESCRIPTION OF SPECIES

Adult males of *P. idas nabokovi* are a bright shade of purple-blue above with a narrow black band along the wing margins (Figure 1). Females are considerably more variable, and display a gray-brown color over much of the wings, with blue confined to basal areas Figure 2). The undersides of both sexes are largely dull gray speckled with black spots; a series of submarginal black-capped, orange crescents with metallic blue spots occur on the margins of the hind wings. These spots generally show less orange than in *P. melissa* (Opler and Malikul 1992). The best character for distinguishing *P. idas* from *P. melissa* is the shape of the male abdomen, which is shorter and thicker near the tip in *P. idas* (Scott 1986). Females are distinguished by a darker brown upperside. They also have crescent-shaped submarginal designs along the dorsal hind wing, although these are much less conspicuously colored than in males.

Today, between 11-13 subspecies of *Plebejus idas* and four subspecies of *P. melissa* are recognized in North America (Appendix A). Two subspecies of *P. idas* (*empetri* and *aster*) occur in the Maritime Provinces to eastern Maine. All the rest occur in western North America except for *P. idas nabokovi*, the only subspecies present in the Great Lakes region.

The subspecies *Plebejus idas scudderii* has been confused with *P. idas nabokovi* and with *P. melissa samuelis*. According to Masters (1972), Lake Winnipeg and the Red River Valley currently form a barrier between *scudderii* and *nabokovi*. He speculates that the two subspecies have been isolated since the Pleistocene, when the area between their ranges was occupied by glacial Lake Agassiz. Masters (1972) presents detailed morphological characteristics separating these two subspecies.

Plebejus melissa samuelis, the Karner Blue, is a federally endangered species that can also be found in the Great Lakes Region. *P. melissa samuelis* is ecologically separated from *P. idas nabokovi* by habitat and larval host plant. *P. melissa samuelis* occurs in oak openings and savannas on sandy soils and feeds on *Lupinus perennis*, while *P. idas nabokovi* is confined to Canadian zone (northern U.S. to Arctic regions of Canada and Alaska) forest openings and feeds on *Vaccinium caespitosum*. By far the largest populations of *P. melissa samuelis* occur in central and southern Wisconsin (Wisconsin DNR 2000). *P. melissa samuelis* is bivoltine (two life cycles per year), whereas *P. idas nabokovi* has only one generation of adults each year. Masters (1972) describes morphological differences between the two taxa: "The ventral wing margin in *P. melissa samuelis* has a narrow but solid and straight terminal line, while in *P. idas nabokovi* this line is usually broken into triangular shaped spots at the vein terminals (Figure 1). Dissection of the male genitalia provides a clear separation of these two

species".

Larvae of *P. idas nabokovi* are slug-shaped, green and very cryptic with a dark dorsal line and light yellow lateral stripes (Figure 3). The head capsule is small and black. Newly formed pupae are green, but turn yellow, then brownish black just before adults emerge. Pupae are approximately 10-11 mm long and typically are attached loosely to leaves or stems on *V. caespitosum* or surrounding vegetation. Occasionally pupae are found lying loose in the litter near *V. caespitosum* plants.

Other species of blues (Family Lycaenidae, Subfamily Polyommatinae) in the Lake States include the widespread Eastern Tailed Blue (*Everes comyntas*) and Spring Azure (*Celastrina argiolus*), in addition to the less abundant Western Tailed Blue (*Everes amyntula*), Reakirt's Blue (*Everes comyntas*), Silvery Blue (*Glaucopsyche lygdamus*), and Greenish Blue (*Plebejus saepiolus*). All but the Eastern Tailed Blue can be distinguished from *P. idas nabokovi* (and *P. melissa*) by the lack of orange spots on the underside margin of the hind wing. The Eastern Tailed Blue has several marginal orange spots, but the uppersides of the wings are much lighter than in *P. idas nabokovi* and *P. melissa* and the hind wings of the Eastern Tailed Blue possess a distinctive projection or "tail" (Opler and Malikul 1992).

LIFE HISTORY

P. idas nabokovi is univoltine, having a single flight period each year. The peak adult flight of *P. idas nabokovi* in Wisconsin usually occurs during the first two weeks of July, with the earliest and latest reported dates of adults occurring during mid-June and mid- August, respectively. Males emerge earlier than females.

Male butterflies patrol areas where *V. caespitosum* occurs and attempt to mate with newly emerged females (Opler and Krizek 1984). Females lay eggs singly on *Vaccinium caespitosum* or beneath *V. caespitosum* on surrounding vegetation or dead twigs. Individuals overwinter in the egg stage. Larvae hatch in May and pass through 3-4 instars. Pupation occurs during mid-June in northeastern Wisconsin (Wolf 1993).

Feeding areas are centered on *V. caespitosum* patches but extend into surrounding openings and along roadsides where nectar sources are available. Adults nectar on a variety of nectar-producing flowers including yellow clover (*Trifolium aureum*), *Potentilla* spp. (e.g., *P. norvegica*, *P. recta*, and *P. arguta*), white clover (*T. repens*), red clover (*T. pratense*), tower mustard (*Arabis glabra*), yarrow (*Achillea millefolium*), harebell (*Campanula rotundifolia*), as well as several other species that flower during the flight period (Wolf 1993). Larvae feed exclusively on *Vaccinium caespitosum* in the western Great Lakes region and are restricted to habitat patches containing this plant. An experiment by Wolf (1993) with captive larvae showed that individuals avoided eating leaves of *Vaccinium angustifolium* and *V. myrtilloides* while defoliating *V. caespitosum* leaves in the same petri dish.

Adult males congregate at small areas of moist soil, urine, or dung (Scott 1986). Many species of Lepidoptera (primarily males) exhibit this behavior, known as "puddling". It seams to be important for gathering mineral salts. Adults of both sexes feed on nectar.

Adult butterflies seem to show little preference for specific plant species while resting. In Wisconsin (Wolf 1993) they rested most commonly on grasses and sedges, which were the most abundant plants in terms of % cover in the vicinity of *V. caespitosum* patches.

Plebejus idas nabokovi has a facultative association with *Formica* ants which tend larvae (Wolf 1993). Ants (*Formica obscuriventris* Mayr.) were found tending nearly all larva located in Wisconsin during 1990 and 1991. Most pupae (65%) were also found to have ants present.

HABITAT

Detailed studies by Wolf (1993) in Wisconsin demonstrated several important characteristics of *P. idas* habitat. All populations occurred in savanna or savanna-like openings with *Vaccinium* ground cover, including at least one patch of *V. caespitosum*. Soils consist of a thin surface layer of organic material (litter and < 5 cm organic soil) underlain with deep, well-drained permeable sand. In Minnesota and possibly elsewhere, this plant also occurs in gravel areas over sandy loam (R. Dana, pers. comm.). In general, the habitat of *V. caespitosum* includes a relatively dry substrate. The McNair Site in northeastern Minnesota, however, occurs at the edge of a moist meadow near an extensive conifer bog. Many of the northern populations occur in "frost pockets," semi-open topographic depressions in white pine, jack pine, or red pine forest. Some populations also occur along roadsides or in small patches within clearcuts where disturbance has created opportunities for natural populations to expand into artificial openings.

Tree species associated with *P. idas nabokovi* populations in the western Great Lakes region are typically pines (*Pinus strobus, P. resinosa, P. banksiana*), often interspersed with small numbers of black cherry (*Prunus serotina*) or other small trees. At several sites (Plouff Creek in Minnesota, McCormick Wilderness) the forest is or was dominated by upland black spruce (*Picea mariana*). As mentioned above, *Vaccinium (V. angustifolium, V. myrtilloides, V. caespitosum*) always is prominent in the ground layer, along with *Comptonia peregrina*, *Waldstenia fragarioides*, and several grasses. Bracken fern (*Pteridium aquilinum*) is present along the forest edges near *P. idas* habitat, but it is conspicuously absent from the areas used by the butterflies for egg-laying. On a microhabitat scale, other plants that tend to be associated with egg laying sites (in addition to *V. caespitosum*) include *Carex pensylvanica*, mosses, lichens, and *Viola pubescens* (Wolf 1993).

Similar to many other butterflies, the distribution of *P. idas nabokovi* is limited by the ranges of its host plants. Species interactions, however, also might play a significant role. Egg mortality from parasitoids is a major factor influencing *P. idas* populations in Wisconsin (Wolf 1993) and may help explain the restriction of this species to regions with relatively severe winters. Eggs in a Wisconsin population showed 62% mortality from parasitoids.

Populations of both species are known to occupy semi-open depressions or "frost-pockets" of less than 0.5 ha (Figure 4). Within larger sites, host plants are typically distributed in small patches separated by 25 - 200 m. In other words, *V. caespitosum* in the Great Lakes region rarely occurs in extensive patches, although in several places (Plouff Creek, McCormick Tract, Marinette I and II) patches are scattered over a fairly extensive area. *P. idas nabokovi* has occurred at sites where *V. caespitosum* occupies a total area of 100 m^2 or less. Note, however, that the butterfly has become locally extinct at some of these localities (e.g., Spruce Site in Oconto County, WI; Florence County Site, WI).

DISTRIBUTION

The species *Plebejus idas* has a Holarctic distribution across boreal regions of North America and Eurasia (Opler and Krizek 1984, Struttmann 1999). Significant subspecific variation occurs within its range. In North America, at least 10 subspecies (Appendix A) are known in addition to *P. idas nabokovi* (Nabokov 1949, Masters 1972, Scott 1986). One of these (*P. idas lotis*) is federally endangered, restricted to a small region in northern California where it is possibly extinct (Arnold 1983*).* In Eurasia *P. idas* is widely distributed in the southern taiga zone and at high altitudes, but it is extinct in the Netherlands and Belgium and is listed as endangered in Germany (Harmsen 2001). Like populations in North America, host plants of *P. idas* in Europe include species in the Fabaceae, Ericaceae, and Empetraceae. In North America, some western subspecies occur on plants in the pea family (Fabaceae) and at least one subspecies (*P. idas alaskensis*) appears to feed exclusively on *Vaccinium caespitosum* (Guppy and Shepard 2001; Guppy, pers. comm.). Eastern North American subspecies *P. idas aster* and *P. idas empetri* feed on plants in the family Empetridae (crowberry, *Empetrum*) and other Ericaceae (*Ledum*, *Kalmia*) (Opler and Krizek 1984). At least one Eurasian subspecies feeds on *Vaccinium uliginosum* P., a plant that is very similar in habit and appearance to *V. caespitosum*.

In North America *P. idas* occurs discontinuously from Newfoundland and Nova Scotia to Alaska and British Columbia, with southward extensions into central California, southern Idaho, southwest Colorado, and the western Great Lakes region of Minnesota, Upper Michigan, and Wisconsin (Map 1).

P. idas nabokovi is known only from the western Great Lakes region of southeastern Manitoba, western Ontario, Minnesota, northern Wisconsin, and the Upper Peninsula of Michigan, where it is distinguished from other subspecies by subtle taxonomic characters (genitalia) and, most significantly, its dependence on *V. caespitosum* as a larval food plant (Nielson and Ferge 1982). Little is known about the historic distribution of *P. idas nabokovi*, although probably it was once more widespread, especially near the periphery of its range where native plant communities have undergone significant changes since the late 1800's and early 1900's. Land survey notes in northeastern Wisconsin indicate that openings or "barrens" were more numerous and more extensive than they are today (Wolf 1993). Establishment of pine plantations and agriculture are likely responsible for the disappearance of many local populations of *P. idas nabokovi* and *V. caespitosum*. Fire suppression might have led to a reduction in the number of openings where *V. caespitosum* could become established, but extensive fires after land clearing in the late 1800's (Flader 1983) probably did not benefit these species appreciably. Today, populations of both species tend to be clustered in local areas (see below) where unproductive soils and microclimate combine to maintain natural upland openings.

Notably, neither *V. caespitosum* or *P. idas nabokovi* occurs on large barrens maintained today by aggressive fire management (e.g., Spread Eagle Barrens and Dunbar Barrens in northeastern Wisconsin).

Mean June temperatures (coinciding with the period of larval development) within the geographic range of *P. idas nabokovi* typically vary between 8°C (low) and 22°C (high). The growing season is approximately 120-130 days, perhaps even shorter in the microhabitats where *V. caespitosum* occurs.

Vaccinium caespitosum

NOMENCLATURE AND TAXONOMY

Species name: *Vaccinium caespitosum* Michx.
Alternative spelling: Vaccinium cespitosum Michx. (Gleason and Cronquist 1991)
Common name: *Dwarf bilberry, Dwarf huckleberry, dwarf blueberry, dwarf whortleberry*
Family: Ericaceae (Heath Family)

Vaccinium caespitosum is believed to be the obligate host plant of *P. idas nabokovi*. It is a boreal member of the genus *Vaccinium*, which includes blueberries and cranberries (Gleason 1952). Until recent observations of its association with the northern blue butterfly (Nielson and Ferge 1982), the plant was thought to be extirpated from Wisconsin (Brynildson 1982). *Vaccinium caespitosum* can be distinguished from all other blueberry-like plants in the Great Lakes Region by its low stature (5-13 cm), presence of only 2 bud scales, wedge-shaped (obovate) leaves, and solitary nodding flowers (VanderKloet 1988). Gleason and Cronquist (1991) describe the height as up to 20 cm, but most plants are much shorter.

V. caespitosum is a low-growing clonal plant (Figure 4), forming mats from superficial rhizomes. Leaves are smooth, shining, deciduous, firm, oblanceolate or cuneate to obovate, obtuse or rounded above, tapering to the base, finely aristate-serrulate at least in the upper half (Figure 5). Flowers are 4-5 mm long, solitary on short pedicels in the leaf axils, nodding, light pink; sepals five, short and blunt, petals five, fused into an urceolate or ellipsoidal tube; stamens ten, the anthers spurred (VanderKloet 1988). The edible berries are blue, 6-8 mm in diameter (Figure 5).

Vaccinium caespitosum can be confused with other *Vaccinium* species, especially two co-occurring species *Vaccinium angustifolium* and *V. myrtilloides*. If flowers are present a definitive identification can be made by the spurred anthers inside the urn-shaped corolla and the fact that they are solitary, on curved pedicels, in the lower leaf axils. The true blueberries produce flowers and fruit in clusters in the upper leaf axils. The berries of dwarf bilberry do not have the persistent five-pointed sepals on the end. The leaves of dwarf bilberry (Figure 5) can be distinguished from *V. angustifolium* and *V. myrtilloides* in that they are more spatulate (wider near tip). The leaves and stems are smooth (glabrous), unlike those of *V. myrtilloides*.

According to Tirmenstein (1990), the genus *Vaccinium* is taxonomically complex, and *V. caespitosum* is particularly difficult. Rapid speciation is believed to have occurred among polyploids as a result of hybridization with backcrosses (Camp 1942). Like *P. idas*, current identification of subspecies and ecological variants is probably incomplete.

LIFE HISTORY

Vaccinium caespitosum is a clonal, low-growing plant that forms mats from superficial rhizomes. Leaves emerge in May. Flowers are formed in May and June; in northeastern Wisconsin flowers appear by early to mid-June. *Vaccinium caespitosum* is pollinated primarily by bees (personal observation, Wolf 1993) and many flowers are damaged by nectar-robbing bumblebees (*Bombus* spp.), which may pierce the corolla to obtain nectar without brushing against the pollen-containing anthers. Fruits form during July and ripen in August. *V. caespitosum* has deciduous leaves, and the plant overwinters as woody stems and underground rhizomes. Leaves emerge in May. The leaves

turn reddish-brown and abscise during September and October.

HABITAT

The habitat for *Vaccinium caespitosum* is generally cool and dry. It does well in Canada in the heart of its range on dry sandy ledges and is locally abundant in the region of the coniferous forest, especially under jack pine (Tirmenstein 1990). In the Great Lakes Region it is known from open pine barrens, sandy clearings or swales, gravelly openings, and occasionally in pine woods (Soper and Heimburger 1994).

Associate species include blueberries (*V. angustifolium* and *Vaccinium myrtilloides*), *Comptonia peregrina*, *Poa compressa*, *Agropyron repens*, and *Schizachne purpurascens*. Sparse pines (*Pinus resinosa* and *Pinus strobus*) or planted pines are often associated with these openings. Black cherry (*Prunus serotina*) is frequently found scattered among the openings. In Minnesota (R. Dana pers. comm. 2001) *Epigea repens* and *Salix humilis* are faithful associates, while black cherry is absent.

Local populations of *P. idas* and *V. caespitosum* in northeastern Wisconsin and Ontario are often separated by < 100 m, while clusters of patches may be separated by 5 km or more. Movement of butterflies between these more isolated (> 5 km apart) clusters is probably very rare, occurring at frequencies in the order of decades or centuries. During historic times, plant populations separated by several km probably could persist because numerous sources of colonists were available in the landscape. The occurrence of plants in recent clearcuts suggests that dispersal from source populations is somewhat effective if habitat conditions are appropriate. Based on the occurrence of plants in fairly wooded locations in Minnesota, R. Dana also suggests that plants might persist under the canopy at very low densities, expanding after clearcut or disturbance.

DISTRIBUTION

The range of *Vaccinium caespitosum* (Map 2) extends across the subarctic zone from Alaska to Labrador, with southward extensions into the Sierra Nevada Range of California, the Rocky Mountains to New Mexico, and locally into northern Minnesota, northern Wisconsin, Michigan, northern New York, and northern New England (Vander Kloet 1988). Gleason and Cronquist (1991) describe this species as circumboreal, but others maintain that *V. caespitosum* is restricted to North America (Rosendahl 1928, Voss 1996). Differences in interpretation presumably rest on definitions of Eurasian taxa. In the western Great Lakes region, *Vaccinium caespitosum* has been reported as far south as central Wisconsin, where it occurred locally in rock crevices along the Wisconsin River.

Association between Plebejus idas and Vaccinium caespitosum

The obligate larval host plant association between *P. idas* and *V. caespitosum* has been established most directly in a region where *V. caespitosum* is uncommon. In the vast regions of western North America where *V. caespitosum* is often abundant (Tirmenstein 1990), the relationship between this plant and *P. idas* is not as clear. Guppy and Shepard (2001) believe that *V. caespitosum* is the likely food plant of *P. idas scudderii*, which they consider to be a separate species from *P. idas anna* (*P. anna* following Barnes and McDunnough 1916). According to Guppy and Shepard, *P. (idas) anna* feeds on plants in the pea family (Fabaceae). Scott (1986) contends that all western subspecies of *Plebejus (Plebejus) idas* tend to use herbs and shrubs in the Fabaceae, whereas plants in the Ericaceae and Empetraceae are used by eastern subspecies. Information about larval host plants of *P. idas* in

North America appears to be incomplete or possibly even incorrect. Future studies are needed to help elucidate the biogeography of the *P. idas*/*V. caespitosum* association and to help us understand the evolutionary and ecological factors that are responsible for its origin. The possibility exists that *P. idas nabokovi* diverged from other populations of *P. idas* due to coevolutionary interactions with *V. caespitosum* in the Great Lakes region. If true, this would underscore the conservation significance of these two species in Minnesota, Wisconsin, and Upper Michigan.

Populations of Plebejus idas nabokovi and Vaccinium caespitosum

Extant populations of *P. idas nabokovi* and *V. caespitosum* in the western Great Lakes region are concentrated in a relatively small number of localities. In most cases, multiple populations or "patches" of *V. caespitosum* occur within an area of several square kilometers or less. *P. idas* populations are all associated with *V. caespitosum,* but the opposite is not always true. Small *V. caespitosum* patches, especially in shady places, occasionally have no nearby populations of *P. idas*; the number of *V. caespitosum* patches without a local population of *P. idas*, however, is surprisingly small in the western Great Lakes region.

Appendix B describes the major localities for both species in Upper Michigan, Minnesota, and Wisconsin. Searches by Wolf (1993) in northern Ontario suggest that the distributions of *P. idas nabokovi* and *V. caespitosum* in the northern Great Lakes region are not dramatically different than in the Lake States; populations appeared to be fairly numerous, but all of the sites located by Wolf were small, typically less than 5 acres.

Distribution in National Forests

Plebejus idas nabokovi and *Vaccinium caespitosum* occur in national forests of all three Lake States; in all three cases at least one of the sites is critical for regional persistence of these species. Minnesota populations all occur in human-made openings. The recently discovered Plouff Creek site could support the largest population of *P. idas nabokovi* anywhere in the U.S. Populations in and near the McCormick Wilderness also appear to be very large. *V. caespitosum* populations at this locality occur on shallow soils with bedrock outcrops. Howe and Wolf found a small patch in a clearcut several kilometers from the large population, suggesting that the plant is capable of colonizing newly created openings (Figure 12). In Wisconsin, the Waubee Lake site and nearby populations probably support Wisconsin's second largest metapopulation, although these populations are threatened by competition from plantation trees and tall ground vegetation. At all of these localities, active management may help maintain existing metapopulations.

Table 1. ***Plebejus idas nabokovi*** habitat in Lake States National Forests.

Forest	Habitat of Northern Blue Butterfly
Chequamegon-Nicolet National Forest	In Wisconsin, found almost solely in openings among pine forest of some form, including savannah-like habitat.
Chippewa National Forest	No records
Hiawatha National Forest	Near Shingleton, host plants occur in small, dry openings among jack pine / spruce woodland.
Huron-Manistee National Forest	No records
Ottawa National Forest	In vicinity of McCormick Wilderness *V. caespitosum* and *P. idas* occur among upland black spruce and jack pine in thin-soil openings, sometimes with rocky outcrops. Like Shingleton sites, plants often grow among ground lichens.
Superior National Forest	Virtually all known sites of *P. idas* are associated with human disturbance, either clearcuts in upland conifers or openings created by settlements. Small patches of *V. caespitosum* (but not the butterfly) occur rarely in jack pine or black spruce forest openings.

Status

Neither *Plebejus idas nabokovi* or *Vaccinium caespitosum* has federal status. The Nature Conservancy ranks both *P. idas* and *V. caespitosum* as G5, or globally secure, although the ranking of *P. idas nabokovi* is G5TU, which indicates that the trinomial is "Currently unrankable due to lack of information or due to substantially conflicting information about status or trends." In other words, current information is inadequate to justify a clear ranking of this subspecies. Based on the distinctive ecology and natural history of *P. idas nabokovi*, we recommend a significantly higher global ranking for this taxon. On a local level, both the butterfly and *V. caespitosum* are given protected status in Michigan and Wisconsin (Tables 2 and 3), whereas in Minnesota only *P. idas nabokovi* is given special concern status. *V. caespitosum* also is ranked by The Nature Conservancy as critically imperiled (S1) in New York and imperiled (S2) in Wyoming, Manitoba, Vermont, and Nova Scotia. *Vaccinium caespitosum* is State Endangered in New York (http://www.dec.state.ny.us/website/dfwmr/heritage/plants.htm) and state threatened in Vermont, the only states other than Michigan and Wisconsin where this species has official status. *P. idas nabokovi* is not listed as a species of concern in Ontario or Manitoba, the only other states or provinces where this subspecies is known to occur. Both species are designated as Regional Forester's Sensitive Species in Region 9 of the USDA Forest Service.

The subspecies *P. idas lotis* of northern California is federally endangered and is probably extinct (Arnold 1983), and European subspecies of *P. idas* have been extirpated from Belgium and the Netherlands. European subspecies of the closely related *Plebejus argyrognomon* (Reverdin's Blue) are vulnerable in Sweden, endangered in Belgium, Germany, and Switzerland (Harmsen 2001).

Table 2. State Ranks for *Plebejus idas nabokovi* in the Lake States.

State	State Threatened/Endangered or Special Concern Listing	State/Province Heritage Status Ranks (TNC)
Michigan	Threatened	S2
Minnesota	Special Concern	S2
Wisconsin	Endangered	S1

Table 3. State Ranks for *Vaccinium caespitosum*

State	State Threatened/Endangered or Special Concern Listing	State/Province Heritage Status Ranks (TNC)
Michigan	Threatened	S1
Minnesota	Not listed as T/E or Special Concern	SR
Wisconsin	Endangered	S1

S1=Critically imperiled. S2= Imperiled: rarity or because of other factors making it very vulnerable to extirpation from the state. Typically 6 to 20 occurrences or few remaining individuals (1,000-3,000). SR=Reported.

POPULATION BIOLOGY AND VIABILITY

Wolf (1993) studied the population characteristics of *P. idas nabokovi* at the Marinette County, Wisconsin site. Life table analysis showed that the population was producing an excess number of individuals (net reproductive rate (R) > 1.0) despite high mortality of eggs and larvae. Because the population has remained relatively stable in size, excess individuals must have migrated from the population. Most adults stayed within the 5 ha opening where *V. caespitosum* occurred, but some individuals wandered as far as 2.1 km from the home site. These results suggest that *P. idas* adults can (at least rarely) move significant distances and are capable of sustaining a metapopulation if multiple *V. caespitosum* patches are present in a local area. Indeed, multiple patches of *V. caespitosum* are present in the vicinity of several well-documented localities. The plant itself is (presumably) dispersed by fruit-eating birds and mammals, which are capable of dropping seeds a considerable distance from the site of origin (Johnson et al. 1985). The existence of small patches of the plant in recent clearcuts is consistent with the notion that successful dispersal occurs at least occasionally in the vicinity of known populations. These patches also might be derived from plants that have persisted for many years in small patches beneath a forest canopy. If local migration is fairly common, then many of the extant populations in the Lake States therefore can be treated as metapopulations. This has important implications for management; habitat rehabilitation near existing populations may have a significant positive effect on both species.

The fact that several of today's known populations have persisted for 30 years or more (e.g., at Minnesota's McNair site and Wisconsin's Waubee Lake site) suggests that *P. idas* and *V. caespitosum* can maintain viable populations for decades in relatively small areas. Interconnection between small, local populations may promote the persistence of small populations through the "rescue effect" (Brown and Kodric-Brown 1977). In addition, small populations of *P. idas* might not be as small in numbers as they first appear. Individual adults are present in the population for only 1-3 weeks (Wolf 1993), so a given count of individuals represents only a portion of the local population (new individuals emerge later, replacing counted individuals that die). Furthermore, the numbers of eggs and larvae greatly exceed the numbers of adults, probably by a factor of 10x or greater. A daily

population count of 100 individuals, for example, might represent a total adult population of more than 1000, and this population might be represented by well over 10,000 overwintering eggs. Using mark-recapture methods Wolf (1993) estimated that the Marinette County II site in Wisconsin supported more than 3000 adult butterflies, even though daily counts (Pollard 1977) often yielded fewer than 100 individuals.

CONSERATION AND MANAGEMENT

Threats

Encroachment of woody vegetation, overgrowth by grasses and other forbs, and active planting of conifers in openings represent immediate threats to *P. idas nabokovi* and *Vaccinium caespitosum* in the Lakes States. Use of herbicides along railroad right-of-ways or road corridors also might be a threat for several of the populations (e.g., Shingleton). Although non-native species are present at many existing *V. caespitosum* sites, invasive weeds and grasses are dominant in some localities (e.g., "frost pockets" in Wisconsin) that appear to be otherwise suitable for *V. caespitosum*. Presumably a disturbance has modified the vegetation at these sites, providing an opportunity for non-native plants to invade. These non-native species may prevent *V. caespitosum* from re-establishing or perhaps they have even played a role in the disappearance of *V. caespitosum* from some places.

The fire ecology of *V. caespitosum* and *P. idas* is an important and perhaps controversial issue for management. Tirmenstein (1990) reports that *V. caespitosum* responds favorably to fire in black spruce forests of Canada (Foster 1985) and in conifer forests of western North America. The occurrence of *V. caespitosum* in dry openings in the Lake States is consistent with Tirmenstein's generalization. This species has shallow rhizomes that can resprout after fire. On the other hand, *V. caespitosum* also occurs in areas that burn very infrequently. Barrens habitats that have been burned regularly in Wisconsin and Upper Michigan are missing *V. caespitosum* despite the presence of associated species like *V. angustifolium* and *V. myrtilloides* (pers. obs.). Patchy fires may be important for *V. caespitosum* at large spatial scales and with a fairly low local frequency (e.g., every 20+ years); regular and extensive burning appears to be unsuitable for persistence of this plant. More importantly, *P. idas* is vulnerable to fire at all stages of development based on observations of similar species (Swengel and Swengel 1997). If fires are to be used as a management tool, burns should be carried out on only a fraction of the available habitat to ensure that a significant portion of the population survives. At most of the sites described here, patches of *V. caespitosum* are small and can be located precisely. Prescribed burns can be designed so that they avoid these patches altogether, while they open new areas for colonization of the plant. An extensive discussion of fire effects on the closely related Karner Blue Butterfly (USFWS 1997) probably also applies to *P. idas nabokovi.* In general, fire has been demonstrated as having a negative effect on individuals, but a positive effect on populations by maintaining open habitat. The key issue is survival of one or more source populations during episodic fires. For small populations at several localities (e.g., Waubee Lake, WI), fire is not likely to be a viable management option at all unless it is used to burn similar habitats nearby, creating opportunities for *V. caespitosum* and *P. idas nabokovi* to spread.

The national PLANTS database lists *V. caespitosum* as a species that is not resistant to fire (USDA, NRCS 2001). This apparent contradiction with Tirmenstein's (1990) analysis may be related to indirect vs. direct impacts. The creation of openings by fire clearly provides opportunities for establishment and growth of *V. caespitosum*. Persistent fires at the same locality, however, might disadvantage *V. caespitosum* by favoring bracken fern (*Pteridium aquilinum*) and other highly fire

resistant species. Fire can be a tool for controlling woody encroachment, but over-aggressive or poorly designed fire management plans could destroy an entire population of both *P. idas* and its host plant.

The attraction of adult Northern Blues (especially males) to puddles on roads makes them vulnerable to motorized vehicle traffic. Reducing travel on roads near breeding populations could help minimize this source of mortality during late June and July. Travel on the rough track through the Marinette County II site in Wisconsin presents a potential risk because the track receives major use by butterflies and is currently seldom used by vehicles. If this track were upgraded for increased traffic, significant butterfly mortality would be inevitable (Wolf 1993). Motor vehicle traffic on gravel roads adjacent to the Waubee Lake site (WI), Hasseib Lake sites (MI), and virtually all of the Minnesota sites could be a significant source of adult mortality when puddles are present.

Threats to early life history stages are not well documented but deserve attention. Wolf (1993) found that the 72% of 149 eggs did not hatch, mostly because of parasitism by a small hymenopteran parasite. Larval survivorship also was low, only 41% for late instar larvae followed in the field. Overall, only 11% of the eggs that were followed reached the pupal stage. Causes of mortality at these early stages are not well known. Exotic parasitoids or predators which have spread into the Lake States (or native parasitoids whose abundance has increased because of some ecological imbalance) could be involved, but future studies will be needed to determine the whether or not high mortality rates of *P. idas* eggs and larvae are different than they would be under relatively undisturbed conditions. A recent study by Henneman and Memmott (2001) has shown that parasitoids or predators introduced for biological control can have unwanted effects on non-target native species. Noyes and Valentine (1989) report that many exotic Hymenopteran parasitoids arrived with their hosts during the early days of European settlement in New Zealand; the extent to which exotic parasitoids affect native Lepidoptera in North America is a potential conservation concern that deserves significant future study, especially given the fact that by far the highest proportion of mortality in species like *P. idas nabokovi* occurs during the egg and larval stages of development. Other non-specific control measures for Lepidoptera pests, such as the spraying of *Bacillus thuringiensis* for control of Gypsy Moth (*Lymantria dispar*), may be a future concern at existing *P. idas nabokovi* sites. *Bacillus thuringiensis* (Bt) is non-specific for Lepidoptera and may kill *P. idas nabokovi* larvae just as it does target species like the Gypsy Moth (Johnson et aP. 1995).

Population Monitoring

A systematic monitoring program will be necessary for implementation of any effective conservation strategy for these species. We recommend a model patterned after the protocol developed for the Karner Blue Butterfly (Wisconsin Department of Natural Resources 2000). This plan would consist of three levels: 1) monitoring for presence/absence of *Vaccinium caespitosum*; 2) monitoring for presence/absence of *P. idas,* and 3) quantitative sampling for populations of *V. caespitosum* and *P. idas*. Results of continuous monitoring will help guide emergency conservation measures and will enable land managers to implement long-term adaptive management (Walters 1986).

Level 1 monitoring for presence/absence of *V. caespitosum* can be carried out by visiting known localities anytime between late May and the end of August. Whenever possible, GPS localities should be recorded for patches of the plant, thereby creating routes for future checking or sampling. In order to assure quality, a plant identification guide should be developed to help field observers differentiate *V. caespitosum* from other *Vaccinium angustifolium, V. myrtilloides,* Bearberry

(Arctostaphylos uva-ursi), and other low-growing plant species with spatulate leaves. National Forest botanists can be contacted to verify the identification of plant samples or photographs.

Level 2 monitoring for presence/absence of adult *P. idas* is valid during a more restrictive time period, typically from 20 June to 1 August. Again, GPS records for butterfly localities are essential; boundaries of the local population can be documented by taking multiple readings at each *P. idas* occurrence. Photographs of the butterfly should be provided to verify identification. These surveys should be conducted on mostly sunny days between 8:00 a.m. and 6:00 p.m. when temperatures are higher than 55° F. (Cloud conditions are not relevant if temperatures are above 70°F.) Surveys also should not be conducted during rain or drizzle and when winds exceed 20 miles per hour. The entire habitat area should be walked leisurely until all likely areas of *P. idas* concentration have been covered. The start time and end time of the survey should be recorded.

Level 3 monitoring is designed to provide an index of relative abundance that can be compared between sites and between years. Despite its shortcomings, we recommend a standardized "Pollard Walk" transect (Pollard et al. 1975) for quantifying relative abundance of butterflies. At each site, one or more transects (survey lines) of fixed length and location should be established using GPS readings at starting and ending points. These transects should be designed to pass through the major areas of butterfly concentrations. Time permitting, a series of transects may be appropriate at larger sites. Precise time should be recorded at the beginning and end of the survey. All butterflies observed from the transect should be recorded, with care to avoid double-counting individuals. The same route should be surveyed annually to document population changes. Transects at different sites can be compared by calculating the numbers of butterflies counted / meter or by applying more rigorous estimations of population size that take into account the total area of suitable habitat. Availability of field personnel and other logistic factors might dictate the specific monitoring protocol. Nevertheless, several key criteria of Level 3 monitoring effort need to be fulfilled: 1) the monitoring protocol should be standardized across all populations; 2) quantitative results should be scalable to account for different-sized sample areas; 3) the protocol should be cost-effective and easily repeatable; and 4) sampling should yield results that clearly reflect the local population dynamics. In order to achieve the last objective, samples will have to be conducted during the peak flight period of adult butterflies. For *P. idas*, this usually occurs from late June through mid-July.

Population Management

Habitat management at existing sites involves maintaining openings for successful growth of *Vaccinium caespitosum* patches (see above). Forest management activities also create openings that might be suitable for the plant and butterfly if they were able to reach the appropriate places. Translocation of local *Vaccinium caespitosum* (first) and *Plebejus idas* (if necessary) among openings might enhance populations and can take advantage of temporarily suitable openings. This possibly controversial management strategy would be effective only if 1) plants and butterflies were translocated only from local populations (within < 10 km), 2) source populations are not depleted by translocations, and 3) target localities contain suitable substrate and microclimate. Research on the ability of *V. caespitosum* seeds to germinate or vegetative transplants to survive in new openings is needed before such measures can be recommended, but translocation might be an effective conservation tool in areas where the local populations are very small and isolated.

Research Priorities

Perhaps the most important research need for *P. idas nabokovi* is a clear determination of its taxonomic status. The obligate association with *V. caespitosum* might warrant designation of species status for Great Lakes populations of this butterfly given the widespread use of reproductive isolation as a criterion for defining a species (Futuyma 1998). Host preferences of *P. idas* in other regions needs to be clarified, especially in western North America, where *V. caespitosum* is more common than it is in the Great Lakes region (Tirmenstein 1990). Divergence of *P. idas nabokovi* from other populations of *P. idas* apparently has been fairly recent in geologic time, and speciation processes are probably still in progress (Nice and Shapiro 1999).

A rigorous study on the effects of fire needs to be conducted if fire management is considered as a tool to maintain existing *V. caespitosum* sites. There is no clear evidence that *Vaccinium caespitosum* benefits directly from fire. In fact the national PLANTS database lists *V. caespitosum* as a species that is NOT fire resistant (USDA, NRCS 2001). Researchers have found that bracken fern increased following fire (Henning and Dickmann 1996); bracken fern appears to be a threat to *V. caespitosum* by outcompeting the low-growing plants. On the other hand, fire may have an important indirect benefit to *V. caespitosum* and *P. idas nabokovi* by maintaining or generating openings where *V. caespitosum* can colonize or re-establish. Tirmenstein (1990) argues that light fires may favor dwarf huckleberry (*V. caespitosum*) "by reducing competitors, increasing nutrient availability, and opening the canopy so that greater amounts of light reaches low shrubs." He also notes that reestablishment after light fires can be rapid because rhizomes are capable of resprouting. J. Greenlee (pers. comm.) observed that in western Montana *V. caespitosum* is abundant in areas that experience frequent light underburns.

Other research needs include more detailed life history studies, especially an analysis of parasitoid predation on *P. idas* eggs, which has been demonstrated as the major source of annual mortality. A better understanding of dispersal in both the butterfly and *V. caespitosum* will provide important information for metapopulation management near known localities in the Lake States. Finally, research on the inherent variability of sampling methods will help in the design of an effective monitoring program.

Summary of Management Recommendations

The following measures are recommended to be implemented on a regional basis through cooperation of Forest Service units, National Park Service, state agencies and county forest programs.

- Identify boundaries of existing metapopulations and acquire additional land, where appropriate (e.g., near Hasseib Lake / McCormick Wilderness in Michigan).

- Develop a standardized monitoring program to track population changes.

- Prevent encroachment of bracken fern, grasses, and woody shrubs at Wisconsin sites, especially Waubee Lake, Florence County, and the Forest/Langlade County site near Mole Lake. Because of the small size of these sites, fire management is probably not appropriate.

- Establish cautious, long-term management strategy at larger sites in Michigan, Minnesota, and Wisconsin. If fire is used as a management tool, only small units of existing *V.*

caespitosum openings (preferably avoiding existing patches of the plant altogether) should be burned during any given year, and fire at any unit should be imposed infrequently. Burning (or clearcutting) wooded or shrubby habitats on appropriate soils nearby existing *V. caespitosum* sites could be a very beneficial management prescription.

- Prevent or minimize vehicle traffic on forest roads through existing populations of *P. idas* during June and July. The road openings themselves might be important for maintaining nectar plants and areas for "puddling" of the butterflies. Establishment of alternative puddling areas and lower speed limits might help minimize losses of adult butterflies.

- Promote additional research on butterfly life history and collect information on ongoing taxonomic studies of the *P. idas* complex. Studies of *P. idas* in other areas such as western Manitoba (*P. idas scudderii*) and elsewhere may help resolve taxonomic uniqueness of the Great Lakes form.

- Provide educational materials for land managers to help ensure that a long-term management program will be sustained.

- Conduct additional field surveys at areas with appropriate soils in Minnesota, Michigan, and northern Wisconsin. Revisit *V. caespitosum* sites that have not been searched for *P. idas nabokovi* as well as historical localities where neither species has been verified recently.

- Initiate an extensive survey for both species in Ontario and Manitoba to better establish global status of *P. idas nabokovi*.

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Review Requests

This document was sent to the following for review:

Robert Dana, Minnesota Natural Heritage Program, Minnesota DNR
Wisconsin Natural Heritage Program, Madison, WI
Michigan Natural Features Inventory, Lansing, MI
Ottawa National Forest
Hiawatha National Forest
Chippewa National Forest
Superior National Forest
Gary Fewless, University of Wisconsin-Green Bay

APPENDICES

APPENDIX A. Subspecies of *Plebejus (Lycaeides) idas and P. melissa*.

Plebejus (Lycaeides) idas alaskensis (Chermock) 1945	(northern Canada, Alaska)
Plebejus (Lycaeides) idas anna (Edwards) 1861	(Sierra Nevadas, CA to sw BC)
Plebejus (Lycaeides) idas aster (Edwards) 1882	(Newfoundland, Nova Scotia, ??)
Plebejus (Lycaeides) idas atrapraetextus (Field) 1939	(Montana to s Alberta to Colorado)
Plebejus (Lycaeides) idas empetri (Freeman) 1938	(NS and Prince Edward Island)
Plebejus (Lycaeides) idas ferniensis (Chermock) 1945	(Rocky Mts.)
Plebejus (Lycaeides) idas vancouverensis	
Plebejus (Lycaeides) idas longinus Nabokov 1949	(Rocky Mts., Wyoming)
Plebejus (Lycaeides) idas lotis (Lintner) 1879	(northern CA endemic)
Plebejus (Lycaeides) idas nabokovi Masters 1972	(Great Lakes region)
Plebejus (Lycaeides) idas ricei (Cross) 1937	(West Coast)
Plebejus (Lycaeides) idas scudderii (Edwards) 1861	(c and se BC to AK, east to Newfld.)
Plebejus (Lycaeides) idas sublivens Nabokov 1949	(Colorado endemic)
Plebejus (Lycaeides) melissa annetta Edwards 1882	(Utah, Colorado, Sierra Nevadas)
Plebejus (Lycaeides) melissa melissa (Edwards) 1873	(much of western NA)
Plebejus (Lycaeides) melissa paradoxa (Chermock) 1945	(Tehachapi Mts., California)
Plebejus (Lycaeides) melissa samuelis Nabokov 1944	(Karner Blue; MN to eastern US)

APPENDIX B. Descriptions of known localities of *Plebejus (Lycaeides) idas nabokovi* and V*accinium caespitosum* in the Lake States.

Wisconsin

Only a single locality (Marinette County) in Wisconsin supports a large population that is not threatened by habitat degradation. One of the others (Waubee Lake) is still viable and may persist with careful management, but the other localities in Wisconsin appear to be destined for local extinction.

Marinette County

Located near Shrine Road on Marinette County Forest lands, the Marinette County Sites I and II described by Wolf (1993) consist of two savanna-like openings of approximately 5 ha each (Figure 8). The vegetation is dominated by grasses and ericaceous plants, especially *Vaccinium angustifolium*, *V. myrtilloides*, and *Comptonia peregrina*. Trees include large, scattered red pines and white pines, in addition to cherries (*Prunus* spp.) and scattered aspen. *V. caespitosum* covers only about 4% of the ground, but a mark-recapture study in the early 1990's indicated that these plants supported an *P. idas* population of over 5000 adults. Visits during 2001 by Howe and Wolf suggest that the population is still thriving at this site, although the extent of *V. caespitosum* appears to be reduced and the numbers of *P. idas* lower than in the earlier study. No other patches of *V. caespitosum* have been identified within 5 km of this site.

Florence County

A small population of *V. caespitosum* (Figure 6) occurs in several patches near Bass Lake Tower Road (a continuation of Shrine Road), approximately 7.4 km north of the Marinette I and II sites. A small number of *P. idas* were observed at this site in 1982 (Nielson and Ferge 1982), 1988 (Wisconsin Natural Heritage Program data base), and again in 1991 (Wolf 1993). An exhaustive search by Howe and Wolf during mid-July 2001, when *P. idas* adults were active at other Wisconsin localities, failed to locate any individuals. The *V. caespitosum* population is reduced to just a few small patches within an opening that is overgrown by *Rubus* sp. and other low shrubs. Given the direct connection between this site and the Marinette County sites along Shrine / Bass Lake Tower Road, the Florence County site might be considered part of the Marinette County metapopulation. Unfortunately, a local extinction of the butterfly appears to have occurred during the past decade.

Forest/Langlade County

During 1994 a team of scientists conducting an environmental assessment of a proposed mine near Crandon discovered a small population of *P. idas* and (subsequently) *V. caespitosum* on the Forest/Langlade County line about 500 m east of Highway 55 south of Mole Lake. On July 9th 2001 Howe and Wolf found 2 males at the site and a very small patch of *V. caespitosum* (Figure 7). Several places where the plant had been observed earlier were overgrown by *Rubus* sp. and other plants. The extant *P. idas* and *V. caespitosum* were on the Langlade County side of the road that marks the county line. Management is badly needed to ensure that this small population does not become extinct.

Waubee Lake

Known since the 1950's (Ebner 1970), the Waubee Lake site (Figure 7) includes an important historical locality for *P. idas* and *V. caespitosum* in Wisconsin along Jack Pine Camp Road, approximately 2 km east of Waubee Lake. Wolf (1993) estimated a population of almost 1000 adults during 1991, and the population has persisted through summer 2001, when Howe and Wolf observed approximately 50 individuals on July 13th. The main population center consists of a small (< 1 ha) opening in a depression near a red pine plantation and an aspen-dominated hillside. *P. idas* adults frequently leave the *V. caespitosum* patch to seek nectar or puddles near the road, sometimes wandering farther than 200 m from the host plants. This site is entirely on U.S. Forest Service property. Since 1991 bracken, grasses, and other forbs have overgrown a significant portion of the *V. caespitosum* population, and the long term survival of both *V. caespitosum* and *P. idas* at this site will depend on active management of red pines and other plant species in the ground layer.

At least 4 other *V. caespitosum* patches occur within 5 km of the main Waubee Lake site, including 3 sites on Chequamegon-Nicolet National Forest lands. One of these, named the Spruce Site by Wolf (1993), has become overgrown by plantation white spruce, and is now reduced to just a single small patch of *V. caespitosum*. No *P. idas* were observed at this site despite an intensive search by Howe and Wolf in July 2001. Because these sites are near the southern range limit of *V. caespitosum*, unusually mild winters (like those during recent years) tend to favor more aggressive plant species at the expense of the low-growing *V. caespitosum*. Like many of the other localities, the Waubee Lake sites probably represent a metapopulation, with occasional local extinction and recolonization. The area consists of pitted outwash plains with scattered "frost pockets" in which several of the *V. caespitosum* patches occur.

Other Wisconsin Records

No other locality for *P. idas* or *V. caespitosum* has been documented during the past 25 years according to Wisconsin Department of Natural Resources / Bureau of Endangered Resources records. Old records of *V. caespitosum* exist from several other counties, including Chippewa (1933), Columbia (1861), Lincoln (1952), and Portage (1894), but none of these has yielded recent records. Likewise, *P. idas* records from Peshtigo Valley in Marinette County (1936), and Menominee County (1921) have not yielded recent verification. Ebner (1970) published other *P. idas* reports from Brown County (near Green Bay), Waupaca County, and Burnett County, but he did not distinguish *P. idas* from the similar looking Karner Blue (*P. melissa samuelis*). Nevertheless, virtually all reported localities from southern and central Wisconsin no longer support *P. idas nabokovi* or *V. caespitosum*, indicating that the geographic ranges of both species have contracted northward during the past century (like they apparently have in Minnesota).

Michigan

Like those in Minnesota, records of *P. idas* and *V. caespitosum* in Michigan are clustered in several important localities:

Shingleton

Numerous patches of *V. caespitosum* and a well-documented population of *P. idas* occur along the Wisconsin Central Railroad right-of-way approximately 2 miles east of Shingleton in Alger County (Figure 9). The plant grows in small openings among jack pine, balsam fir (*Abies balsamea*), aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*) and spruce (*Picea* sp.). Lichens and mosses are common in the microhabitats where *V. caespitosum* occurs, typically 5 meters or more off the managed railroad right-of-way. Many of the plants occur in natural gaps formed by fallen trees or on relatively sterile soil; in general, the plants here occur in relatively shady conditions compared with most other *V. caespitosum* occurrences in the western Great Lakes region. Accidental and prescribed fires associated with the railroad right-of-way undoubtedly have contributed to the persistence of these populations by keeping small areas free of woody vegetation. At least 4 other populations of *V. caespitosum* have been documented within 10 km of the Shingleton railroad site, including a recently described colony about 3 km northwest of Shingleton (near Hickey Creek) and a site near Creighton, 7 miles east of the railroad site. *P. idas* was observed with *V. caespitosum* at an upland opening about 1 km northwest of Creighton. Extensive lowland conifers dominate this part of Michigan's Upper Peninsula. *V. caespitosum* and *P. idas* occur on sandy ridges or knobs in this landscape; additional surveys of uplands will help guide a comprehensive metapopulation management strategy for these species in the vicinity of Shingleton. Documented populations near Shingleton occur in the Lake Superior State Forest or (one *V. caespitosum* record) in the nearby Hiawatha National Forest.

Isle Royale National Park

P. idas was reported at two localities within Isle Royale National Park in 1986 by Mueller (1987). No additional information about the recent status of the butterfly or *V. caespitosum* at Isle Royale was available for this writing, but the population presumably is persisting in this pristine environment. Approximately 12 individuals of both sexes were reported from one locality. Surveys of this area for both the plant and the butterfly are recommended.

Pictured Rocks National Lakeshore

Several small colonies of *V. caespitosum* have been reported in Pictured Rocks National Lakeshore on "thin sand soils." Given the proximity to the Shingleton metapopulations and the sandy soils that are characteristic of this area, additional populations within Picture Rocks are likely. *P. idas* has not been reported from this *V. caespitosum* site, although we have no evidence that anyone has looked for it there. Surveys of this area for both the plant and the butterfly are recommended.

McCormick Wilderness Area

Some of the most productive populations of *V. caespitosum* and *P. idas* occur in the vicinity of the McCormick Wilderness Area, a separate part of the Ottawa National Forest Marquette County. Perhaps the largest population (Figure 11) occurs in a series of openings (Peshekee Meadow) northeast of the Peshekee Grade, just north of the entrance to the Wilderness Area, about 11 miles from Champion. *V. caespitosum* occurs on very thin soils over bedrock, with scattered white spruce (*Picea glauca*) the dominant tree species. At least 200 adults were observed at this site in 1994, and R. Howe and A. Wolf observed well over 100 on July 14th, 2001. The population here could exceed 500-1000 adults during the course of a summer. Other occurrences have been documented approximately 5 km northwest of the wilderness area entrance (Figure 12), and near Hasseib Lake, just south of the wilderness area. During July 2001 Howe and Wolf observed more than 50 *P. idas* in openings both east and west of the road near a private drive south of the wilderness area boundary (Figure 10). *V. caespitosum* also has been documented in an open "bedrock knob" east of the North Country Trail, about 1 km north of Hasseib Lake. These records suggest that very significant metapopulations of both species occur in this area, probably including undiscovered patches in and around the McCormick Wilderness. Surveys of this area for both the plant and the butterfly are recommended.

Other Michigan Populations

Several other observations of *P. idas* and *V. caespitosum* have been reported from the Michigan Upper Peninsula. The earliest occurrence of *P. idas* in Michigan came from an area of sandy soils near the Iron Mountain airport in Dickinson County. Howe and Wolf searched this area thoroughly on July 15th, 2001 and found no evidence of either species. *V. caespitosum* has been reported from Upper Montreal Falls near the tip of the Keeweenaw Peninsula in 1983 and near Mulligan Creek, approximately 10 km east of the McCormick Wilderness. *P. idas* has not been documented from these sites, although again we have no evidence that anyone has conducted a search at the appropriate time of year. According to records of the Michigan Natural Features Inventory these populations of *V. caespitosum* themselves have not been verified for over 15 years.

Minnesota

McNair

The McNair Site (Figure 13) is historically important as the type locality where *P. idas nabokovi* was first described (Masters 1972). *V. caespitosum* occurs in small patches within an upland opening that was created as a small settlement during the logging era of the early 1900's. After the site was abandoned in the 1940's, the opening developed as an important site for a diverse assemblage of

northern Minnesota butterflies (R. Vora and R. Dana, pers. comm.). The Nature Conservancy purchased 80 acres of the area in 1980, and transferred the property to The Superior National Forest in 1991. With recommendations from several scientists including Les Ferge, Robert Dana, and a team from North Dakota State University, the USDA Forest Service in cooperation with the Minnesota Department of Natural Resources has begun to implement a monitoring and management plan for *P. idas* and other important butterfly species at this locality. Robert Dana (pers. comm.) estimated that the population of adults was less than 500 but more than 100 during the years 1999, 2000, and 2001. The population has persisted at this site for more than 30 years, and management by U.S. Forest Service biologists is likely to improve conditions during the coming decades (see Conservation and Management section).

Patches of *V. caespitosum* occur at several wooded sites near the McNair Site, and Robert Dana observed 2 *P. idas nabokovi* males on a damp road approximately 4.5 km SW of the McNair Site, and another male was observed at this same spot during 2001 (R. Dana pers. comm.). Chances are good that additional small populations of *P. idas* occur in the vicinity of the original site, perhaps undergoing local extinctions and colonizations from persistent sources like the McNair Site.

Lima Mountain / Pat Bayle State Forest

This locality includes more than 10 documented butterfly occurrences within a 15 km radius of Lima Mountain, a promontory located near the Gunflint Trail (County Highway 12) approximately 25 km north of Grand Marais. Virtually all of the *P. idas* sites occur in clearcuts, pine plantations, or along roads on Minnesota State Forest and U.S. Forest Service lands. Both *P. idas* and *V. caespitosum* appear to have significant metapopulations in this area, perhaps the core of Minnesota's distribution for both species. Logging during the past 150 years probably has enhanced or initiated the spread of these local populations, which now are maintained by ongoing rotations of clearcuts in this region. Good numbers of *P. idas* have been observed in openings planted to young red pine (*Pinus resinosa*) and jack pine (*Pinus banksiana*). Occurrences are characterized by sandy upland soils of the Vermillion Moraine, a narrow band of sandy, well-drained soils that extends through western Cook and central Lake Counties (MacLean 2000). Quantitative estimates of butterfly numbers are available at 10 sites visited by MacLean in the summer of 2000. During most visits fewer than 40 (often less than 10) individuals were observed at each site, but the total adult population during the course of the summer undoubtedly was in the hundreds at several localities, including a pine plantation of about 150 acres near Binagami Lake and near Forest Road 152 (Lima Mountain Road). Chances are good that additional, undiscovered pockets of *V. caespitosum* and *P. idas* are present in this region. Answers to questions about the movement of *P. idas* among isolated *V. caespitosum* patches and the dispersal of V. *caespitosum* fruits among clearcut openings would help us better understanding the long term prospects for survival of both species in northeastern Minnesota. As MacLean recommends in his 2000 report, strategic timber cutting and well planned controlled burning in the area defined by the Vermillion Moraine can help ensure long-term conservation of *P. idas* and *V. caespitosum* in northeastern Minnesota.

Plouff Creek

During summer 2001 David MacLean (personal communication via Robert Dana) discovered an important new locality for *P. idas* and *V. caespitosum* in western Cook County near the point where County Road 3 crosses Plouff Creek (Figure 14). Abundant *V. caespitosum* and *P. idas* were reported here by Dana (personal communication) in an area of at least 200 acres. Most of the area was clearcut

in the late 1980's; today the area is mostly open with scattered black spruce and a few pines. I visited the site on July 28th 2001 and observed many *V. caespitosum* fruits in small patches through much of the clearcut opening. Dana found abundant *V. caespitosum* in upland black spruce woodland adjacent to the clearcut. This site lies about 22 miles west of the Lima Mountain / Pat Bayle State Forest metapopulation.

Other Minnesota Localities

Only 2 other records of *P. idas nabokovi* are recorded in the database of the Minnesota Natural Heritage and Nongame Research Program. One of these, a 1935 collection in Cook County, includes no locality details and might represent one of the sites mentioned above. The other occurrence, derived from an undated specimen collected near Tower in St. Louis County, has not been verified during recent years.

Fauske et al. (1993) report previously recorded localities of *P. idas* by Masters (1973) near Pequot Lakes in Crow Wing County, along the Echo Trail in St. Louis County, along the Gunflint Trail (T64N R1W) in Cook County, and near Pengilly in Itasca County. Only the Gunflint Trail localities are known to support populations today. Wolf (1993) discovered 2 additional sites along the Arrowhead Trail northeast of Grand Marais, but these have been included above as part of the Lima Mountain / Pat Bayle State Forest locality. A female specimen labeled "Itasca State Park, MN June 18, 1966. Barker" is held in the entomological collection at St. Cloud State University. This locality, in either Clearwater or Hubbard County, has not been searched for *P. idas* during recent years (R. Dana, pers. comm.).

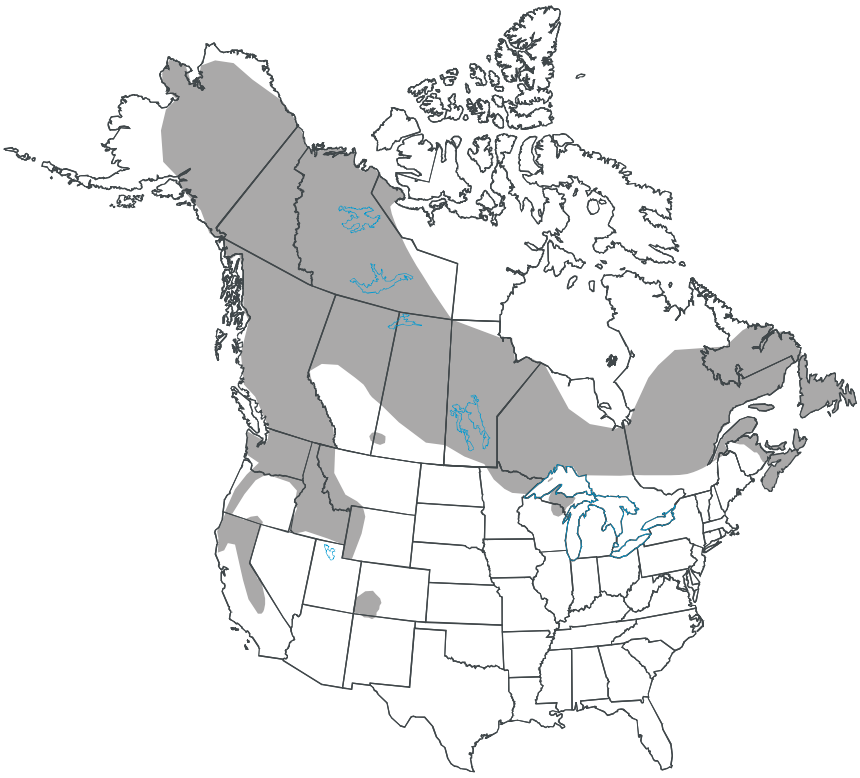
V. caespitosum is not considered to be rare in Minnesota by the Minnesota DNR's Natural Heritage and Nongame Program. Although it is certainly not common, records are documented from at least 10 counties, including Cass, Clearwater, and Kittson Counties in western Minnesota (Ownbey and Morley 1991). The distribution of these sites suggests that *P. idas* either has a more widespread distribution than is currently known, that it has not colonized all of the areas where *V. caespitosum* occurs, or (perhaps quite likely) that it has gone extinct at a number of historical sites. Surveys for *P. idas* at additional *V. caespitosum* localities during late June or July will help resolve this uncertainty.

Although *V. caespitosum* is not listed or tracked by the Minnesota Department of Natural Resources, it is also possible that many of the Minnesota populations of *V. caespitosum* also have disappeared during the past century. Ian Shackleford (pers. comm.) points out that University of Minnesota herbarium (http://www.wildflowers.umn.edu/default.asp) lists 27 records of *V. caespitosum* in their database, from eleven counties. Specimens from Clearwater, Hubbard, Cass, and Carlton counties (in more central Minnesota) were all collected before 1950, whereas more recent collections are all from more northern sites. This is similar to the pattern in Wisconsin, where it appears that southern populations have become locally extinct. Almendinger and Hanson (1998) describe how fire-dependent communities are being replaced by fire-sensitive communities within the Northern Minnesota Drift and Lake Plains Section. An altered disturbance regime due to fire suppression and intensive forestry might be responsible for a northward range contraction of *V. caespitosum* in both states during the past century.

APPENDIX C. Summary of *P. idas* (Pi) and *V. caespitosum* (Vc) occurrences in the Lake States. Information was provided by state Natural Heritage Programs. *V. caespitosum* is not considered rare in Minnesota, so occurrences are not tracked. Shaded entries occur in or near national forest.

State	Li	Vc	County	Location	Status
WI	Y	Y	Florence	T38N R17E Sec35 SE¼ NW¼; T38N R17E Sec36 SW¼NS¼	Checked in July 2001 by Wolf and Howe. Several small patches of Vc are thriving. No *P. idas* found despite thorough search.
	Y	Y	Forest	T35N R12E Sec34 SE¼SW¼; T34N R12E Sec3 NE¼NE¼NE¼	Only one patch of Vc and two butterflies found by Wolf and Howe in July 2001. *Vc* is being overgrown by taller vegetation.
	Y	Y	Marinette	T37N R17E Sec13 S½ E¼; SE ¼ SW ¼ T37N R17E Sec24 N ½ NE ¼	Checked by Wolf and Howe in July 2001. Both species present; *P.idas* not abundant but widespread.
	-	-	Menominee	T37N R15E	1921 record of *P. idas*
	Y	Y	Oconto	T33N R17E Sec5 SE¼ SW¼ SW ¼	Waubee Lake; small population still present but threatened by overgrowth of grasses and trees
	Y	Y	Oconto	T33N R17E Sec5 SW¼ SW¼	Jack Pine site in Wolf (1993)
	Y	Y	Oconto	T33N R17E Sec8 SW¼NW	Spruce site in Wolf (1993); only plants found in 2001; threatened by growth of white spruce plantation
	Y	Y	Oconto	T33N R17E Sec20 NW¼ SW¼	Peek I in Wolf (1993); not located in 2001 by Wolf
	Y	Y	Oconto	T33N R17E Sec19 NE¼SE¼	Peek II in Wolf (1993); not located in 2001 by Wolf
	N	Y	Chippewa	T32N R6W S28	1933 record of *V. caespitosum*
	N	Y	Columbia	T13N R6E	1861 record of *V. caespitosum*
	N	Y	Lincoln	T31N R6E Sec9	1952 record of *V. caespitosum*
	N	Y	Portage	T23N R8E Sec15-22	1894 record of *V. caespitosum*
	N	Y	Portage	T24N R7E Sec2-4,9-10,15,34-35	1894 records of *V. caespitosum*
MI	Y	Y	Keweenaw	T66N R34W Sec22	Isle Royale Wilderness National Park
	Y		Keweenaw	T65N R34W Sec5	Isle Royale Wilderness National Park
	Y		Dickinson	T40N R31W Sec34	1980 *P. idas* record near Iron Mt. airport; not present in 2001
	Y	Y	Alger	T46N R17W Sec33 NE ¼ NE ¼	Shingleton Railroad Site; Lake Superior State Forest
	Y	Y	Marquette	T49N R30W Sec15 NW ¼	McCormick Wilderness, Ottawa NF; large population of both butterfly and plant; one of most important sites in Lake States
	Y	Y	Marquette	T49N R30W Sec6	Peshekee Meadow; W of McCormick Wilderness
	Y	Y	Marquette	T49N R30W Sec22 NW ¼	Near road south of McCormick Wilderness; good population of both species in several openings; verified in 2001
		Y	Marquette	T49N R30W Sec 14 SW¼ SW¼	N of Hasseib Lake
	Y		Schoolcraft	T46N R16W Sec27	Lake Superior State Forest; near Creighton powerline corridor
		Y	Keweenaw	T58N R28W Sec27	Upper Montreal Falls
		Y	Alger	T46N R17W Sec28	Lake Superior State Forest; near Shingleton site
		Y	Schoolcraft	T45N R17W Sec5	Hiawatha National Forest
		Y	Schoolcraft	T45N R16W Sec6	Hiawatha National Forest
		Y	Alger	T46N R17W Sec34	Lake Superior State Forest
		Y	Marquette	T50N R28W Sec32	Mulligan Creek
		Y	Alger	T48N R17W Sec19	Pictured Rocks National Lakeshore
		Y	Alger	T46N R18W Sec23	Small Vc patch discovered in October 2000
MN	Y	Y	Lake	T56N R11W 0W0E24	McNair Site; Superior National Forest
	Y		Cook	T63N R01W	Brule River Road; *P. idas* collected in 1980
	Y		Cook	T63N R01E 05	3 mi SE of Lima Mt.
	Y		St. Louis	T63N R15W	Near Tower, MN; exact site not known
	Y	Y	Cook	T64N R1E Sec32 SW ¼ NE ¼	Young red pine plantation near Lima Mt.
	Y	Y	Cook	T64N R2E Sec31	Approx. 6 mi E of Gunflint Trail; last observed 1991
	Y	Y	Cook	T62N R1E Sec17 NW ¼	Numerous *Vc* patches and some *Pi* in this vicinity; last reported in 2000 by R. Dana; apparently an extensive population
	Y	Y	Lake	T56N R11W Sec27 SE ¼ SW ¼	Near McNair Site; a few *Pi* along road, small patches of Vc in nearby woods
	Y	Y	Cook	T63N R1E Sec16 NW ¼ SE ¼	Along FR 325 near Lima Mt; small numbers of *Pi* and Vc observed by MacLean and Dana in 2000
	Y	Y	Cook	T63N R1W Sec3 SE ¼ SE ¼	*Vc* common, several *Pi* observed by Dana and MacLean in 2000; small clearing adjacent to FR 152
	Y	Y	Cook	T63N R1E Sec1	Pine plantations off FR 154; many *Pi* reported by MacLean in 2000
	Y	Y	Cook	T63N R1E Sec 31 and 32	Several sites along Lima Mt. Rd (FR 152); reported by MacLean 2000 (possibly T64N R1E ??)
	Y	Y	Cook	T62N R1W Sec10, Sec12, Sec14	Sites along Cook County Road 27
	Y	Y	Cook	T61N R5W Sec 2	Near Plouff Creek; one of most important sites in Lake States

Map 1. Distribution of *Lycaeides idas* (shaded area). Modified from Scott (1986).



Map 2. Distribution of *Vaccinium caespitosum* (shaded area).
Modified from Vander Kloet (1988).