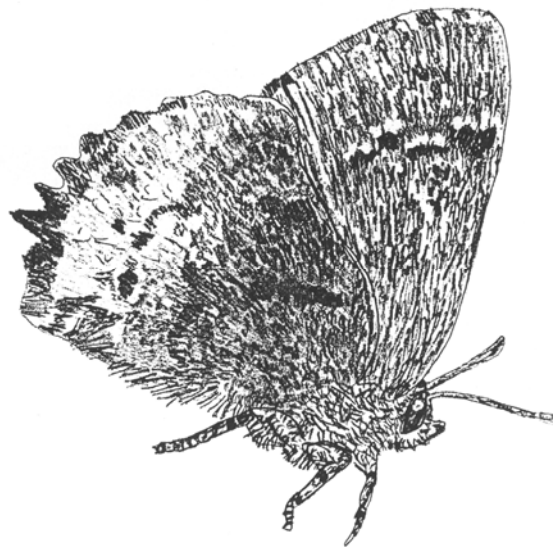


COSEWIC
Assessment and Status Report

on the

Frosted Elfin
Callophrys [Incisalia] irus

in Canada



EXTIRPATED
2000

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada



COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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COSEWIC Assessment Summary

Assessment summary — November 2000

Common name

Frosted Elfin

Scientific name

Callophrys [Incisalia] irus

Status

Extirpated

Reason for designation

This butterfly is known to have occurred in one restricted area of oak savannah. It was last recorded in 1988 and has not been seen since despite repeated surveys during the last 10 years.

Occurrence

Ontario

Status history

Extirpated by 1988. Designated Extirpated in April 1999. Status re-examined and confirmed in May 2000.



COSEWIC Executive Summary

Frosted Elfin *Callophrys [Incisalia] irus*

Description

The Frosted Elfin *Incisalia irus* is a hairstreak butterfly with a largely uniform brown upperside and variegated underside which has a dusting of pale scales on the outer third, a markedly disjointed white and dark postmedial line, a short “tail” on the hind wing and a dark “thecla” spot near the base of the tail. The larva is pale green with paler markings which vary between populations in the level of contrast with the background colouration.

Distribution

The Frosted Elfin occurs as three subspecies, one restricted to Arkansas, Louisiana and Texas, and a second to the coastal regions of the southeastern United States. The third, the nominate subspecies, occurs from Florida north to New England (and historically, southern Ontario) and west to Alabama and Wisconsin. However, there is some controversy as to whether or not the Lupine and Wild Indigo feeding ecotypes of the nominate subspecies represent different species. Both forms are found in the eastern United States but only the Lupine feeder has been found in Canada. The only known Canadian site for this species was near the St. Williams Forestry Station in Haldimand-Norfolk County in southern Ontario. An earlier record from the Pinery Provincial Park has been shown to be based upon a misidentification.

Population size and trend

The Frosted Elfin occurs in mostly small, isolated patches of oak savannah and pine barren habitat in the eastern parts of its range where its numbers appear to be declining. Further west, larger populations are found in areas of more contiguous habitat. In Ontario, the species appears to have occurred in comparatively small numbers at its recent locality, and although it was once described as “common”, it generally occurred in very small numbers and the last individual was seen in 1988. It seems fairly certain that the species no longer persists in Canada.

Habitat

The Frosted Elfin occurs predominantly in oak savannah and pine barren habitats where the larval foodplant *Lupinus perennis* occurs. In the east, small areas of suitable habitat may be occupied, whereas further west, larger areas are required for the species to persist. The butterfly has a preference for edge areas such as openings in more densely canopied woodlands, right-of-ways, powerline cuts, etc. Suitable habitat seems to have been maintained by occasional fires or grazing, but research shows that within its current range in Wisconsin, occasional mowing is preferable to rotational burns.

Biology

The adults emerge in spring and the flight period is usually over by mid-June. Males are territorial. Females oviposit on Lupine flowering spikes, preferring those which are in full sunshine. The larva feeds on Lupine flowers and, later, on developing seed pods. Pupation takes place either in the leaf litter at the base of the host plant or under the ground. Few natural enemies have been recorded.

Limiting factors

Reasonably extensive areas of patchily distributed Lupines are required. In the absence of influences preventing succession, the forest canopy in these areas becomes too dense and/or the understorey crowds out the Lupines. In turn, this leads to a reduction in the frequency of flowering or can prevent it altogether. The territorial behaviour of males, the females' preference for ovipositing only on flowering spikes that are in full sunshine, and the cannibalistic behaviour of larvae all contribute to reduce the effective population size of the species.

Protection

The species is listed as endangered in Ohio and New Hampshire but currently has no status in Canada.

Evaluation and status recommendation

The species has been repeatedly looked for in its one recent site in southern Ontario, but it has not been seen for 10 years. Other sites where the larval foodplant grows have also been surveyed, but it is extremely unlikely that the Frosted Elfin has ever occurred in any of these areas in historical times. The loss of this species from Ontario is fairly well documented. A status of extirpated should be assigned, and the butterfly should be considered for reintroduction. If and when this occurs, its status should be reviewed after suitable follow-up studies are performed.



COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) determines the national status of wild species, subspecies, varieties, and nationally significant populations that are considered to be at risk in Canada. Designations are made on all native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fish, lepidopterans, molluscs, vascular plants, lichens, and mosses.

COSEWIC MEMBERSHIP

COSEWIC comprises representatives from each provincial and territorial government wildlife agency, four federal agencies (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biosystematic Partnership), three nonjurisdictional members and the co-chairs of the species specialist groups. The committee meets to consider status reports on candidate species.

DEFINITIONS

Species	Any indigenous species, subspecies, variety, or geographically defined population of wild fauna and flora.
Extinct (X)	A species that no longer exists.
Extirpated (XT)	A species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A species facing imminent extirpation or extinction.
Threatened (T)	A species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Not at Risk (NAR)**	A species that has been evaluated and found to be not at risk.
Data Deficient (DD)***	A species for which there is insufficient scientific information to support status designation.

* Formerly described as “Vulnerable” from 1990 to 1999, or “Rare” prior to 1990.

** Formerly described as “Not In Any Category”, or “No Designation Required.”

*** Formerly described as “Indeterminate” from 1994 to 1999 or “ISIBD” (insufficient scientific information on which to base a designation) prior to 1994.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list.



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The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

on the

Frosted Elfin

Callophrys [Incisalia] irus

in Canada

Laurence Packer

2000

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DISTRIBUTION

The Frosted Elfin *Incisalia irus* (Godart) is a widespread species in North America with records available from Ontario south to northern Florida, and from the eastern seaboard states west to Wisconsin in the north and Texas in the south (Fig. 1). The species is divided into three subspecies: *Incisalia irus hadra* in the southwest—Louisiana, Arkansas and Texas; *I. irus arsace* (Boisduval and Le Conte) from coastal areas in the southeastern part of the species' range; and *I. irus irus*, the nominate subspecies which occupies the remainder of the area inland in the south east, north to New England, across to Michigan, Wisconsin and Minnesota in the north, and Tennessee and Alabama in the south. Earlier records from Colorado and Nevada are considered dubious (Gatrelle, 1991). *Incisalia i. arsace* is sometimes considered to be a separate species (Opler and Krizek, 1984). There is some confusion over the taxonomic status of Lupine and Wild Indigo feeding ecotypes of the nominate subspecies. The Lupine feeders are smaller and paler in colouration than the Wild Indigo feeders, and their larvae are less yellowish-green in colouration and the pale markings are much less distinct (Schweitzer, 1998a). Although most adult specimens of the two ecotypes may be fairly easily distinguished, this is not always possible (Schweitzer, 1998a). Thus, even for the nominate subspecies, it remains unclear whether there are two species-level taxa involved or a single variable one.

The Lupine feeding form of the Frosted Elfin (which is the one under consideration here as it is the only form that occurred in Ontario) is considerably rarer than the Wild Indigo feeding form and, in the east at least, should be considered rarer than the Karner Blue *Lycaeides melissa samuelis* (Schweitzer, 1998a). In the eastern United States, the Lupine feeding form is known from Florida, Delaware, Maryland, Massachusetts, New York, New Hampshire, Pennsylvania and Connecticut (Schweitzer, 1992, 1998a) and North Carolina (Webster, 1998), but appears extirpated from Maine (Schweitzer, 1992). The Wild Indigo feeder is known from Massachusetts, New Jersey, Rhode Island, Pennsylvania, New York, and Connecticut. Wild Indigo "ecotypes" (at least those from Rhode Island) can be reared in captivity on cultivated Lupine (Webster, 1998). The two forms are found almost sympatrically in Suffolk County, New York and in New Haven, Connecticut. Resolution of the taxonomic status of these two forms of the Frosted Elfin should be considered a high priority for insect conservation biology. It would also be well worth elucidating the level of genetic differentiation between the three named subspecies of Frosted Elfin. Because the Lupine feeder is the one we are concerned with here, details provided below are for this form unless stated otherwise.

In Canada, the species has been recorded from only one locality in the vicinity of the St. Williams Forestry Station (Fig. 2) (Packer, 1991). The more recent of these observations were at an area adjacent to the Forestry Station known as the Manestar Tract, named after the previous owner of this land. At this site, the butterfly was restricted to oak savannah remnants (Packer, 1991). It has not been seen in similar habitat in the Pinery/Port Franks area despite many butterfly surveys there (Schweitzer, 1984; Packer, 1991; Campbell *et al.*, 1991; Banks, 1998; Kerr *et al.*, in preparation). Earlier records of it from this area are based on misidentification (Layberry *et al.*, 1998).

The species has also not been seen in any of the other oak savannah habitats in Ontario where its foodplant, the Wild Lupine *Lupinus perennis*, occurs (Fig. 3); surveys specifically aimed at detecting the species failed to locate any adults in 1986 (Packer, 1991) and in many of the intervening years up to the present (Gartshore, 1998).

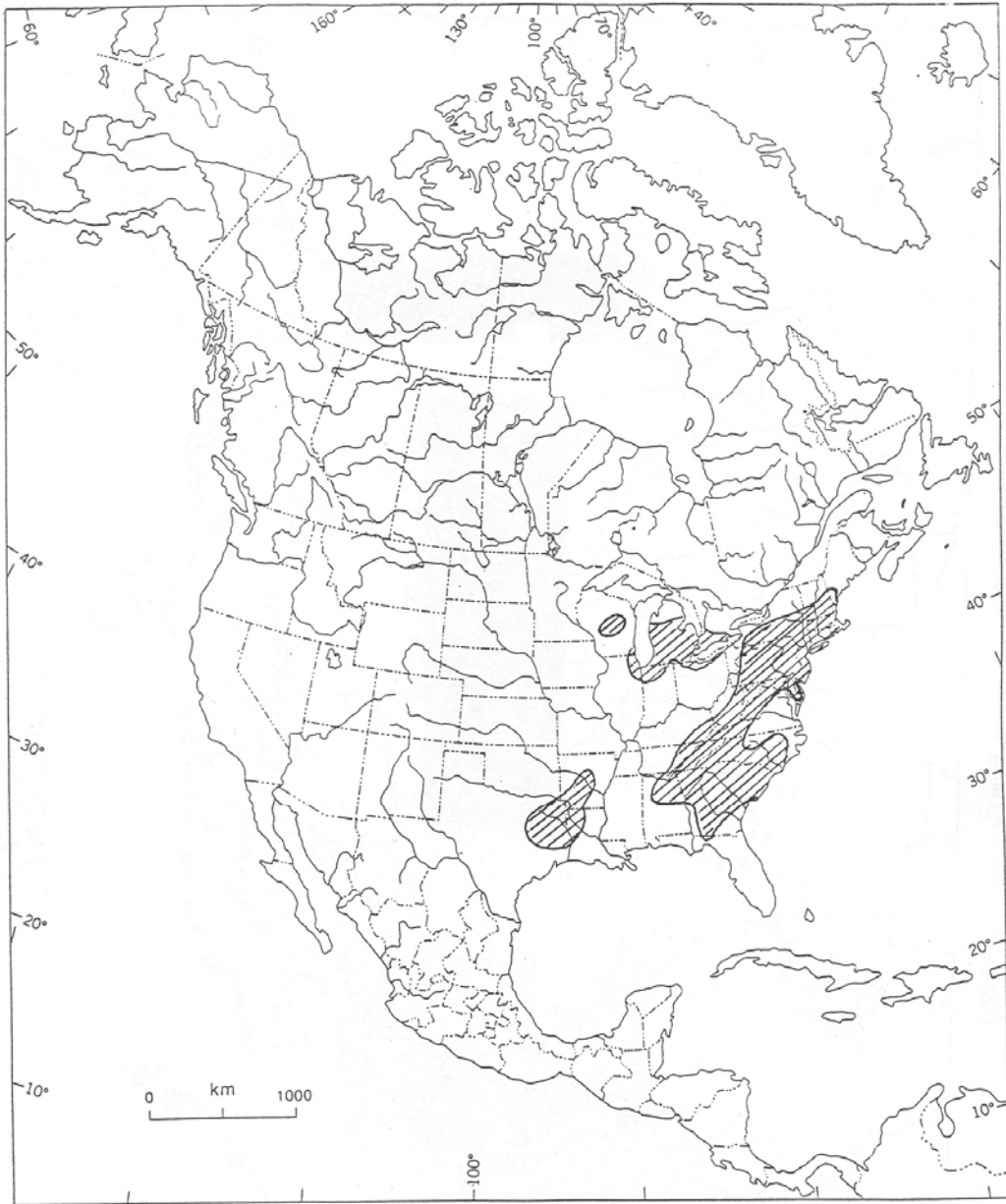


Figure 1. Distribution of the Frosted Elfin, from Opler and Krizek (1984).



Figure 2. Distribution of the Frosted Elfin in Canada, from Campbell *et al.* (1991).

PROTECTION AND STATUS

The Frosted Elfin is not protected in Canada. It is listed as endangered in Ohio (Grigore and Windus, 1994) and New Hampshire (Schweitzer, 1994) and is on the advisory list as rare to endangered in at least eight other states (Schweitzer, 1998a).

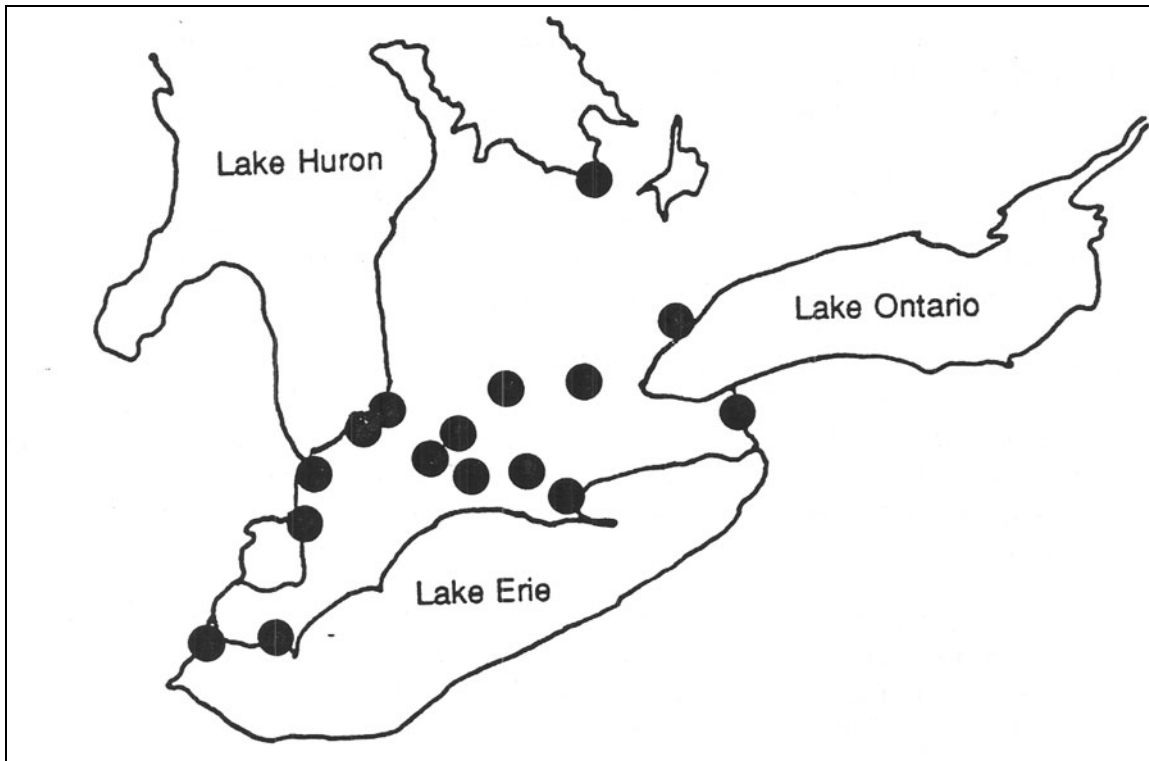


Figure 3. Distribution of Wild Lupine in Southern Ontario, from Packer (1991).

POPULATION SIZE AND TREND

Prehistoric and early historic expected ranges and abundance

Kurczewski (1998) has provided a detailed analysis of the history of oak savannah and pine barren habitats in order to investigate the biogeography of *Tachysphex pechumani*, the antennal-waving wasp, a species which generally occurs in the same habitats as the Frosted Elfin and Karner Blue butterflies. His findings, which are based on a wide range of geological, palaeontological and palynological evidence as well as early 19th century land survey records, are summarized here as they are useful in assessing the probable range of the Frosted Elfin prior to any direct observations being made on the distribution of the species.

During the peak of the last glaciation 20,000-14,000 years ago, almost all ecological zones in North America were pushed southwards. A large area of dry, sandy habitat occurred at this time in the coastal plain of the southeastern United States. Lowered sea levels resulted in this area being considerably expanded to the east to include areas that are now inundated. At this time, the Frosted Elfin was probably widespread and comparatively abundant in suitable areas, mostly to the south and east of areas it inhabits today.

Following glacial retreat beginning 14,000 years ago, areas of suitable habitat moved northwards, with much of the previous area becoming unsuitable as a result of rising sea levels and increased precipitation in much of the remaining land area. Kurczewski (1998) suggests that the northward migration of insects associated with oak savannah would likely have occurred through the New Jersey lowlands and a series of valleys leading to the Ontario-Erie Lake Plain. This route has also been suggested for other plant and insect groups (Schwert *et al.*, 1985; Hamilton, 1994). It is possible that this period of comparatively rapid distributional change would have resulted in a smaller distribution for the Frosted Elfin than during the periods immediately preceding and following this time. A similar argument has been developed to explain the extinction of many species of large land mammals at this time (Pielou, 1991).

The glacial hypsithermal occurred 8,000-7,000 years ago, and drier habitats such as oak savannah would have occurred in much more extensive and marginally more northern locations than they do now. At this time, the Frosted Elfin would likely have occurred over large portions of the Great Lakes basin and further south. With cooling and increased precipitation towards the end of the glacial hypsithermal, many of the previously suitable areas would have succeeded to closed canopy conditions, with oak savannah and pine barren habitat remaining only in drier areas with sandy soils. From this time to the present, it is probable that the global population of the Frosted Elfin has been in almost continual decline as the area of suitable habitat decreased and its degree of fragmentation increased.

At the time of European-American agricultural settlement, oak savannah occupied a total of 30 million acres in the Midwestern United States and southern Ontario (Nuzzo, 1986). In contrast, much of New York and inland New England was covered with dense woodland interspersed with wetland; drier habitat in these areas was rare. Occasional fires in the main area containing oak savannah would have been initiated by lightning strikes (which are more generally accompanied by heavy rainfall further east) and set by indigenous peoples (but see Swengel, 1996a for a disclaimer on this topic). Without these fires, many of the areas currently or recently occupied by oak savannah, particularly in Ontario, would have succeeded to closed canopy woodland.

Agricultural settlement initially had limited impact upon the extent of oak savannah habitat because these dry areas on sandy soils were not considered attractive for planting. Indeed, in the previously more densely wooded areas of New York and inland New England, an increase in savannah-like habitats is likely to have occurred as a result of logging and burning by the pioneers. With the later development of drier land crops, such as tobacco, and a forestry industry, this trend changed and oak savannahs were planted with both agricultural and forestry "crops". More recently, dry, sandy soil areas have become prime areas for housing and are particularly favoured by drivers of all-terrain vehicles. These recent land-use changes have helped precipitate the marked reduction in the range and abundance of the Frosted Elfin that we see today.

Iftner *et al.* (1992) state that during the dry “dust bowl” years of the 1930s, the Frosted Elfin was very common and widespread in the oak openings region of northwestern Ohio. This is evidence that the species can respond rapidly to an amelioration of its environment and also suggests the possibility of a population increase in the event of expected drying effects accompanying global warming.

United States

The only detailed information available on the population biology of the Frosted Elfin is from Swengel (1996b) who studied the species in Wisconsin from 1988 to 1995. She observed 139 individuals during transects carried out specifically to study the species. The transects covered a total of 180 km and searches totalled 93 hours. Although the butterfly was not evenly distributed in the area covered, the average observation rate of one individual per 1.3 km walked or per 40 minutes of survey suggests that the species is unlikely to be easily located through superficial searches.

Swengel made detailed observations of the surveyed sites to analyze the effects of habitat management methods on relative abundance of the Frosted Elfin. She found that the butterfly was found less often than expected in areas that were retained for forestry purposes, received mixed cutting or rotational burns, or received no management whatsoever. Conversely, the butterfly was found more often than random expectation in areas that had a recreational use, were disturbed by mowing or natural fires, or were subject to natural fires combined with some other form of disturbance. Over the duration of her studies, the species was noted to undergo marked population fluctuations even when different site effects were removed from the analysis. Similar fluctuations in numbers have been noted by some other observers (Glassberg, 1993), whereas others report stable numbers (Williams, 1998).

The Frosted Elfin appears to be declining in abundance in much of its range in the United States and has been extirpated from Maine (Schweitzer, 1992a). Decreases have been noted for Ohio (Iftner *et al.*, 1992) where it is now restricted to the northwest (Calhoun, 1993), New England (Schweitzer, 1992a) and the area from Boston through New York to New Jersey (Glassberg, 1993). *Incisalia irus irus* is apparently maintaining large populations in Michigan in particular (Shuey, 1998), Wisconsin (Swengel, 1996b), and possibly in northwestern Indiana (Shuey, 1998).

The population biology of the Frosted Elfin would seem to vary markedly in the Lupine feeding form between the eastern and western parts of its range. In the west, it has been described as requiring large areas of suitable habitat (Swengel, 1998) or as being widespread only where the larval foodplant covers large areas (Shuey, 1998). Further east, small isolated areas are often occupied, as noted by several authors (Allen, 1997 for the Wild Indigo ecotype; Ellis, 1998 for the Lupine feeder). It has also been recorded at a single, isolated Lupine plant (Cech, 1995) in Virginia, although this occurrence could not possibly represent a viable subpopulation. Schweitzer (1992b) states that in the east, the Lupine feeding form can be “locally rather numerous, unlike the *Baptisia* feeding ecotype” for which “observation of 20 per day would be

outstanding". Thus, it seems that the Wild Indigo feeding form in the east has a population structure more similar to the more western populations of the Lupine feeder than to the more geographically proximate Lupine feeding populations.

In summary, it would seem that the species is declining more rapidly in the east where it occurs in smaller and more isolated populations than in the west. The butterfly should be considered very rare and declining in the eastern United States. The observation that the species naturally undergoes marked fluctuations in abundance is of particular concern for the smaller, eastern populations.

Canada

No detailed quantitative studies have been performed on this species in Canada. It was first found at its only known Canadian site in the 1960s and has been described only once as occurring in more than small numbers: Troubridge (in Hess, 1981) stated that the species was "common" in 1977. However, in 1978, only five individuals were seen in an area of "1/2 square mile" (Daniels, in Hess, 1981), and in the following year, 12 were found (Hess, 1981). In 1986, Mary Gartshore did a detailed survey of the area and saw seven males in one section and Quimby Hess found one individual about "half a mile" from Gartshore's site. One individual was collected in 1988. Additional searches for the species in the St. Williams area in recent years failed to find any individuals despite detailed surveys in the precise location previously known to harbour the population.

A previous record of one specimen from the Pinery Provincial Park (Hess, 1981) has been shown to be based on a misidentification (Layberry *et al.*, 1998). Although this area has received repeated butterfly surveys (Schweitzer, 1984; Packer, 1991; Campbell *et al.*, 1991; Banks, 1998; Kerr *et al.*, in preparation), no Frosted Elfin have ever been seen there.

None of the counts noted above can be taken as accurate relative estimates of population size. Observations made on only one or a few days within a season may occur prior to the main period of emergence, at peak abundance, or while only the last individuals to eclose are active. Only detailed and repeated population estimates from mark-release-recapture studies or transect counts can provide useful population estimates. Nonetheless, the fact that repeated visits to the only known site by people who had previously found the butterfly have yielded no observations of the species in 10 years indicates clearly that it has been extirpated from Canada.

Interestingly, the only Canadian locality for the Frosted Elfin was adjacent to the St. Williams Forestry Station. It is highly likely that the development of this forestry station, the first in Canada, significantly reduced the area of suitable habitat for the Frosted Elfin.

At least during the 1980s, the area of suitable habitat for the Frosted Elfin in the St. Williams area was small and of low quality. At that time, the Lupines were increasingly becoming crowded out by taller vegetation (such as ferns), and the upper

story component of the habitat was dense, providing too much shade. These factors combined to create competition for both light and space for the Lupines; this competition was sufficiently intense to prevent flowering in most of the plants. This situation would have been particularly detrimental to the Frosted Elfin as its adults nectar on the flowers, the females oviposit on the flowers, and the larvae feed predominantly within the flowering spikes of the Lupine.

In 1987, Packer stated that the Frosted Elfin was “probably the most endangered butterfly in Canada”. He further noted that “Without active management of its only locality in the immediate future, this species will become extirpated in Canada before the turn of the century.” Unfortunately, this prediction was fulfilled before the end of the decade.

Historically, the trend in population size of the Frosted Elfin at St. Williams is best described as having been chronically small, with an average effective population size of almost certainly less than 100 individuals per annum and probably much less than this. Occasional favourable conditions may have led to noticeable population increases in some years, but the general trend was towards smaller numbers eventually declining to zero by 1990.

HABITAT REQUIREMENTS

Habitat

In eastern North American, the Frosted Elfin has a widespread geographic range within which it occurs in metapopulations comprised of small, often fairly isolated, populations in areas where the foodplant is found. In Ontario, it was found in only one area where it often occurred in very small areas separated by unsuitable habitat through which it probably could disperse.

For most of its range, woodland edges, roadsides, and power-lines or similar edge environments are frequently listed as the preferred habitat of the species (Opler and Krizek, 1984; Allen, 1997; Swengel, 1996b and c). Glassberg (1993) states that the habitat is “sandy or rocky acidic areas cleared by fire or, much more often, by man such as power-line cuts, railroad right-of-ways, and roadsides with good stands of one of its foodplants.” Most populations in eastern North America are found in oak savannah or pine barren habitats that provide both the intermediate levels of sun and shade required by the foodplant and the spotty edge effects favoured by the butterfly. Although Lupines grow best in areas that are partially shaded, Cook (1906) noted for a population in Albany, New York, that Frosted Elfin females oviposit only on plants that are in full sunshine. This observation badly needs confirmation. Swengel (1996b) found that 94% of the individuals that she detected were associated with savannahs and that these were “evenly split between comparatively open (10-24% canopy) and closed (25-49%) ones.” The preferences of the butterfly within these areas in terms of land uses that seem favourable or unfavourable were described above.

The extent of oak savannah in Canada has been well documented (Sutherland and Bakowsky, 1995), and the distribution of Wild Lupine is also well known (Fig. 3). However, the Frosted Elfin has only ever been recorded from one of these sites and not the one with the largest areal coverage of foodplant, which occurred in the area of the Pinery Provincial Park.

Habitat maintenance

The oak savannah habitat is an intermediate successional stage community, the long term persistence of which now requires occasional fires or other disturbance. In the absence of fire, the tall-grass prairie component of the ecosystem is crowded out by shrubs and trees leading to a closer-to-climax community which is completely unsuitable for the Frosted Elfin and its foodplant (Iftner *et al.*, 1992).

The Frosted Elfin has been reported to be susceptible to fire in most of its juvenile stages—eggs on the plants, feeding larvae, and pupae in the leaf litter. In the Wisconsin area, Swengel (1996b) found that there were fewer Frosted Elfins associated with areas which had received rotational, proscribed burns, and more butterflies were associated with areas that had received natural fires as long as these had occurred at least four years previously. In contrast, Schweitzer (1987, 1992b) found adults flying in a part of the Albany pine bush that had been burned two weeks previously and states “*I. irus* was the only species of Lepidoptera seen in the core of the burn area and they were numerous and often teneral.” This strongly suggests that the Albany population can survive fires that occur directly over the pupation site. The fact that laboratory-reared larvae from the New Hampshire population pupated “well under the soil surface—although not all do so in the field” (Schweitzer, 1987) suggests that some eastern populations may choose more fire-resistant pupation sites than western populations. It would be useful to have more detailed information on the pupation habits of this species from a variety of locations. Although the adults are volant and the species has been described as a “fairly rapid flier and good colonizer” (Allen, 1997), there are no data on the behaviour of adults in the presence of fire.

The metapopulation population structure of the species is well adapted for persistence in large areas containing a patchwork of a variety of habitats with small to large patches of foodplant separated by areas unsuitable for foodplant or butterfly. Such a population structure is ideally suited to the colonization, local extirpation and recolonization cycles required of species inhabiting fire-maintained patchy habitats.

Larval foodplant

Undoubtedly, the main determinant of the distribution and abundance of the Frosted Elfin is the availability of the larval food. The butterfly feeds on the flowering spikes of Wild Lupine (*Lupinus perennis*) and on Wild Indigo (*Baptisia tinctoria*), although the possibility that the two host “races” are discrete species remains untested (see above). Webster (1998) noted that in the sandhills area of North Carolina, *Lupinus villosus* is the species of Lupine used as the larval foodplant. Swengel (1996b) noted that Frosted Elfin in her study areas were associated with Lupines but not Indigos. Gatrell (1991) notes that the nominate subspecies is the Lupine feeder whereas the other two subspecies feed upon Wild Indigo. Schweitzer (1992, 1998a), Calhoun (1993) and Shuey (1998) state that the situation is more complex with the two forms co-occurring in many states. The two forms are almost locally sympatric in one county in each of New York and Connecticut (Schweitzer, 1998a).

There seem to be marked geographic differences in the abundance of foodplant required to support populations of Frosted Elfin. In Ontario, in the past and also to this day, and in parts of New England and the Virginias, small, isolated patches of Lupine can support local populations. However, further west, it seems that large areas containing dense patches of Lupine cover are required for any chance of the butterfly persisting (Swengel, 1998). Schweitzer (1987) suggested that in New England, small weedy patches of Wild Indigo “essentially never have” the Indigo feeding ecotype of the Frosted Elfin but that larger areas “sometimes” do. In contrast, Allen (1998) refers to a colony that has persisted “on a patch of *Baptisia* no larger than $\frac{1}{4}$ to $\frac{1}{2}$ acre in size consisting of no more than 100 plants”.

Swengel (1996b) found that 54% of all Frosted Elfin seen were directly associated with a Lupine plant and that only one individual out of a total of 149 occurred at a site where Lupines were rare (but this was in an area adjacent to a site where the foodplant was common). Another 13 individuals were found where the larval host was considered to be uncommon.

During the later years of its occurrence at St. Williams, the Frosted Elfin persisted in small patches of Lupine which were severely overgrown. The density of cover was such that the Lupines themselves rarely flowered and were being crowded out. Assuming that the female butterflies of this population, like those recorded by Cook in Albany, only oviposit on flower spikes exposed to the sun, this condition added another limitation to the suitability of this locality during the last years of the Frosted Elfin's occurrence in Canada.

The habit of the larvae of feeding only, or mostly, on the developing flowers of the Lupine plant means that the Frosted Elfin is more specialized than the ecologically similar Karner Blue butterfly. Lupines that persist without flowering and seem capable of doing so for quite a number of years are suitable for the Karner Blue but not the Frosted Elfin.

Nectar sources

Other habitat components necessary for the persistence of the Frosted Elfin include nectar sources for the adults. The butterflies have been recorded feeding predominantly at Lupine flowers but also on moist sand and violet flowers (Swengel, 1996b) and at *Rubus spp.* (Allen, 1997). Given the lack of nectar source specificity of most butterflies, it is probable that only the most complex of flower morphologies or the longest corollas (Opler and Krizek, 1984) lead to a flowering plant species being inappropriate as a potential nectar source. Consequently, flower abundance is likely to be more important than the particular specific make-up of the flowering plant community. The fact that Lupine flowers are used as both a nectar source and an oviposition site suggests that declines in the Frosted Elfin at St. Williams would have been at least partly due to decreased Lupine flowering, itself caused by overcrowding. It is noteworthy that in early June, 1986 in particular, there was a complete absence of flowers of any species at some Lupine sites in the St. Williams Forestry Station. The Manestar Tract, however, was not so devoid of alternative nectar sources.

Present condition of the habitat

The condition of the Manestar Tract has been greatly improved. Considerable effort has been put into partial clearing of the taller trees (predominantly conifers), scarification of the ground and small scale burns. This treatment has led to substantial increases in the size of the area covered by the wild Lupine. The very first attempt at clearing led to an increase in the proportion of Lupines that flowered the following spring. Thus, after a gradual decline in suitable habitat over many years, active management led to a marked and rapid increase in suitability of the site, but this only occurred after the Frosted Elfin had become extirpated from the area.

The area previously occupied by the Frosted Elfin is now owned by the Ontario Ministry of Natural Resources, with nearby areas forming part of the St. Williams Forestry Station. Other potentially suitable sites would include the Pinery Provincial Park and the Karner Blue Sanctuary at Port Franks. Although neither of these sites is known to have harboured Frosted Elfin in the recent past, there are patches of suitable appearing habitat in both, and both are being managed in a way likely to lead to increased suitability and areal coverage of appropriate habitat.

Both major areas suitable for the species in Ontario are owned by government agencies or private groups that wish to maintain the areas for butterfly conservation and reintroduction. Thus, there is ample suitable habitat where reintroduction could be attempted.

GENERAL BIOLOGY

Taxonomic status

Minot separated eight North American species of the genus *Thecla* into the newly described genus *Incisalia* in 1872 (Cook, 1906). The Frosted Elfin can be readily distinguished from other members of the genus by the following combination of characteristics: i) dusting of pale (hence “frosted”) scales on the outer third of the underside of the hindwing, ii) relatively long tail, iii) presence of a “thecla” spot on the underside of the hind wing, close to the base of the tail, and iv) markedly disjointed white and dark dashes in the postmedial line (frontispiece). Although heavily worn individuals may be very difficult to identify (Swengel, 1996b), the Frosted Elfin is more readily approached than most butterflies (Swengel managed to photograph 62% of the individuals that were approached for this purpose). Thus field identification is more easily confirmed for this species than for many of its relatives.

Presently, the species is divided into three subspecies, but no detailed analysis on the taxonomic status of the various forms has been performed. It has been suggested that the Lupine and Indigo feeding ecotypes represent separate species (Schweitzer, 1992; Shuey, 1998). Certainly there are some colouration and size differences between them, such that the Indigo feeding butterflies are larger, duller and darker (Gatrelle, 1991; Schweitzer, 1992; Shuey, 1998), but there is some intergradation in the eastern part of the range of the nominate subspecies (Schweitzer, 1998a). Floridian butterflies feed on Lupines (Minno, 1994) and appear to be of the nominate subspecies: they are smaller and darker than *I. i. arsace*, which separates them geographically from other more similar appearing Lupine feeding populations. Webster (1998) reared Wild Indigo feeding individuals from Rhode Island on cultivated Lupines in New Brunswick and found that the resulting adults were “larger in size than those from the wild (that fed on Wild Indigo)”. That Wild Indigo ecotypes fed upon Lupines were larger than usual is interesting as, in general, Indigo feeders are thought to be larger than Lupine feeders (Gatrelle, 1991; Schweitzer, 1992). Calhoun (1993) provided a photographic comparison of a variety of phenotypes of the species, including all three presently named subspecies and individuals from the northern and southern extremes of the range of the nominate subspecies.

Studies of population genetic differentiation within and among subspecies of Frosted Elfin could be useful, and they could quite easily be made geographically more extensive than similar analyses of the ecologically similar Karner Blue (Packer *et al.*, 1998). Mitochondrial DNA sequence data could also be applied to this problem (Vogler *et al.*, 1993) and is more suitable for assessment of past biogeographical patterns (Avice, 1994). Such analyses could be crucial in determining whether the Wild Indigo and Lupine feeding ecotypes of Frosted Elfin represent discrete species. Furthermore, because this technique can be used on some museum specimens, the relative position of the extirpated Ontario population within the phylogeographic pattern of *I. irus* could, perhaps, be elucidated. Empirically, it would certainly appear that the two foodplant ecotypes should be managed as separate units even in the

absence of detectable genetic differentiation, as has been suggested for other Lepidoptera (Legge *et al.*, 1996; Packer *et al.*, 1998).

Biology

Comparatively little is known about the biology of the Frosted Elfin. It is univoltine with adults active in spring. In the northern parts of its range, its abundance generally peaks in May. In Wisconsin, Swengel (1996b) found adults as early as May 10th in an advanced year and as late as June 14th in a retarded one. In Albany, New York, Cook (1906) found the species generally from late April until the end of May, with occasional old, worn individuals persisting as late as June 20th. Iftner *et al.* (1993) report a similar seasonal pattern for the species in Ohio. In Florida, the species is active earlier in the year, predominantly in March (Calhoun, 1998).

Males are territorial and defend small patches of suitable habitat (Allen, 1998; Swengel, 1996b; Gartshore, 1986). For the Lupine feeding form of the nominate subspecies, this would generally be clumps of the larval foodplant *Lupinus perennis*. Perching behaviour, which is likely to be a component of territoriality, is commonly observed, with twigs and other items of vegetation that stand out being chosen as perch sites.

Females oviposit on the flower buds of Wild Lupine, preferring flower spikes that are in full sunshine. Cook (1906) stated that females are only actively engaged in oviposition in the middle of the day. The average period between oviposition and hatching was four days and two hours with a range of three to five days (Cook, 1906, no sample sizes provided). Cook (1906) states that females can lay between 12 and 18 eggs; however, this would seem to be an underestimate and is likely based on a few examples from captive females which, based on other aspects of his account, may have been given an inappropriate host plant on which to oviposit.

Scudder (1898) states that eggs of *Incisalia* are flattened and round and those of *I. irus* are “very dark green” with the shell being “very thin, shining and smooth, ornamented with very high ridges, arranged with some regularity”.

According to Cook (1906), the larvae hatch from the egg and burrow into the flower by chewing a very small hole in a petal and then feed on the stamens, pistil and carina. When these flower parts are consumed, the larva moves onto another flower, this time gaining entry between the petals. If flowers are no longer available, the developing seedpods are consumed. There are three moults and larval life lasts approximately three months. Other authors state that terminal leaves of the host plant may also be used as larval food. Shapiro (1974) found that the larvae of the Lupine feeding ecotype were cannibalistic and would also consume larvae of other species. In contrast, Webster (1998) found that the Wild Indigo feeding form on Rhode Island was not cannibalistic. Larvae of the Wild Indigo ecotype feed on leaves, not flowers, of the foodplant which flowers too late in the year for flowers to be available (Schweitzer, 1992).

The fully grown larva has a grey-green or yellowish-green head, and the general background colour is pale green. There is a paler green mediodorsal line and a broader lateral line on either side. Between the mediodorsal and lateral lines is a narrow area of a green that is darker than is found anywhere else on the body. There are paler green oblique dashes running posteriorly from the mediodorsal line on the first through eighth abdominal segment. Schweitzer (1992, 1998a) states that the larva of the Lupine feeding form is almost uniformly pale green, of a similar shade to the larva of the Karner Blue, but that the Indigo feeder has a more yellowish green larva with more distinct markings. The two larvae successfully raised by Cook took 25 and 30 days to complete their development.

Pupation occurs in leaf litter at the base of the plant or below the surface of the soil. The larvae that pupate in leaf litter construct a shelter by using silk to join together several dried leaves. Again according to Cook (1906), the pupa is brownish-yellow with conspicuously yellow thoracic and abdominal spiracles and vaguely defined blotches of darker colouration. It has cuticular reticulations and, with the exception of the wing-cases, head, legs and ventral surface of the abdomen, is covered in short hairs. The pupal stage lasts from late summer until the following spring.

LIMITING FACTORS

There can be no doubt that the major limiting factor for the Frosted Elfin is habitat availability. In New England, the northeastern United States and southern Canada, oak savannah and pine barrens are the only communities suitable for the species. Kurczewski (1998) provides a detailed history of these habitat types, as summarized above.

Reduction in the quality of the remaining fragments of oak savannah and pine barren habitats has occurred as a result of fire suppression, leading to succession beyond the stage permitting persistence of Lupines in a condition suitable for the Frosted Elfin. Additionally, these habitats are commonly perceived as desirable property for development or are favoured by drivers of all-terrain vehicles. The former completely destroys the habitat whereas the latter mechanically damages Lupines and other understory plants. Nonetheless, Swengel (1996b) found that recreational use of an area was one of the habitat "management" types associated with increased rather than decreased abundance of Frosted Elfins. Kurczewski (1998) provided a detailed account of present-day threats to oak savannah and pine barren habitats.

There are three intrinsic features of the biology of the Frosted Elfin likely to make it more susceptible to extirpation than many other species. Firstly, the habit of feeding only on flowering spikes of Lupines renders many individual foodplants unsuitable and also more severely reduces the number of larvae that can feed upon any one plant. Secondly, the territorial behaviour of males means that the number of males contributing to the next generation (i.e. the paternally derived component of the effective population size) will be reduced in comparison to that of a non-territorial

species. Assuming that only territorial males obtain mates and that the number of suitable territories is limiting, a certain proportion of males will be restricted to the position of “satellites” or “floaters” flying around areas of suitable habitat looking for a territory and only rarely mating. Although it is extremely difficult to ascertain the magnitude of this effect, it would certainly be more important in localities where taller plants are crowding out the Lupines, as was the case at St. Williams in the 1980s. Thirdly, the larvae of the Lupine feeding ecotype of relevance here are cannibalistic (Shapiro, 1974) and, as a result, only one can develop per inflorescence or group of inflorescences. This, too, will lead to a drastically reduced population potential in a small area of habitat, especially one in which the condition of the Lupines is such that few of them will flower. Webster (1998) suggests the possibility that cannibalism occurs predominantly under conditions of poor food quality. This hypothesis was prompted by the observation that Wild Indigo “ecotypes” fed upon cultivated Lupine did not exhibit cannibalism but were larger than usual as adults.

Competition with the Karner Blue is a possibility that needs to be addressed as, at least in some parts of their range, including the extirpated Ontario populations, both species are restricted to the same foodplant. Shapiro (1974) assessed the probable extent of interspecific competition between these two species and also between them and two additional butterflies, the Eastern Tailed Blue, *Everes comyntas*, and the Wild Indigo Duskywing, *Erynnis baptisiae*, which also occurred at his study site in Genesee County, New York. Like larvae of the Frosted Elfin, those of the Eastern Tailed Blue, although generalist legume feeders, feed on Lupine flowers and developing seed pods. Because Frosted Elfin larvae are cannibalistic on one another and will also feed on larvae of other Lupine feeders, Shapiro concluded that these two species are in direct competition for the food resource and are involved in interference competition through predation.

Although Karner Blue larvae feed on the leaves of the Lupine and the Frosted Elfin on the flowers, they could have a potentially negative influence on each other's populations. Consumption of flowers reduces the seed set by the plant and thereby reduces Lupine recruitment. Shapiro (1974) noted that this reduced recruitment was only likely for the earlier flowering Lupine individuals at his New York study site. Consumption of leaves reduces the growth rate of the plant and must reduce its ability to produce flowers the following spring. It is noteworthy in this regard that during development of the larvae of the second brood of Karner Blue at Port Franks in July 1986, some small Lupines were host to two or three larvae (Packer, 1991). These plants were almost completely denuded and it is probable that some Karner Blue larvae had to disperse to a second plant to complete their development. Under these conditions reduced survival and productivity of the plants is highly probable and, if the Frosted Elfin were to have been in the area, negative effects of competition between Karner Blue and Frosted Elfin butterflies would likely have occurred. However, positive correlations are generally found between abundances of Karner Blues and Frosted Elfins (Swengel and Swengel, 1997), indicating that quality of habitat is more important for both species than are the potential effects of competition between them.

Few predators or parasitoids have been recorded for the Frosted Elfin. Cook (1906) observed one small larva being removed by “a small black spider”, one of the pupae he reared yielded a tachinid fly of the genus *Exorista* and another gave the ichneumon wasp *Agrypon pseudargioli* (as *Anomalon pseudargioli*). It is to be expected that the species suffers from the usual range of generalist predators and both generalist and more host-specific parasitoids. However, its habit of feeding inside Lupine flowers and seed pods is likely to diminish the relative frequency of generalists in comparison to more specialized natural enemies. Allen (1998) states that there are large numbers of predators and parasitoid wasps that attack the Wild Indigo “ecotype” of Frosted Elfin.

SPECIAL SIGNIFICANCE OF THE SPECIES

The Karner Blue and the Frosted Elfin are two animals that are known to be associated with the occurrence of at least reasonable quality oak savannah or pine barren habitat. A third butterfly, the Persius Duskywing, is also likely restricted to these habitats (Schweitzer, 1992b). A fourth insect, the antennal waving wasp, *Tachysphex pechumani*, has similar habitat requirements but seems capable of persistence in smaller areas (such as the Delhi-Simcoe oak savannah remnants) and is seemingly a little less habitat specific, occurring also in areas such as the Borden Military base (Kurczewski, 1998).

Oak savannah is probably the single most threatened habitat in eastern North America, presently occupying less than 0.2% of the area it covered in pre-agricultural settlement times (Nuzzo, 1986). At the glacial minimum some 8,000 years ago, this habitat probably occurred as a wide band in the Great Lakes region across to New England. With increasing precipitation and, more recently, agricultural and other anthropogenic influences (Kurczewski, 1998), it is now restricted to a few remnants, most of them of poor quality. Both Karner Blue and Frosted Elfin butterflies may be indicators of better quality oak savannah. If, as suggested by Schweitzer (1998a), the Lupine feeding form of the Frosted Elfin is even rarer than the Karner Blue, then it may take on greater significance as an indicator species.

With global climate change, it is highly probable that a warming and drying trend will occur in southern Ontario. This condition should be favourable for the maintenance of oak savannah habitat. Consequently, oak savannah specialist species deserve increased attention in terms of their potential for reflecting environmental change. That Frosted Elfins became comparatively common during the dust bowl conditions of the 1930s in Ohio suggests that the species can respond quite rapidly to appropriate conditions. However, the three oak savannah/pine barren specialist butterfly species are generally in marked decline (Schweitzer, 1992b; Andow *et al.*, 1994), suggesting that they are still suffering the effects of prolonged habitat degradation and fragmentation as a result of local anthropogenic factors, particularly fire suppression. The Karner Blue, at least, has been thought to have been adversely affected by drought conditions in the late 1980s (Packer, 1994). Given that oak savannah is a “dry” habitat, it is clear that balancing the need for the dry conditions with the necessity of maintaining Lupines in non-drought condition is likely to be a complex task.

In Canada, the largest area of oak savannah-like habitat is at the Pinery Provincial Park and the Karner Blue Sanctuary in nearby Port Franks. Despite intensive management, the quality of the Provincial Park site remains low, largely as a result of browsing of regenerating vegetation by deer. The next best site is the Manestar Tract in the St. Williams area. The quality of this site was very low in the mid-1980s, but intensive management has resulted in a substantial increase in areal coverage by the oak savannah community. Both sites recently maintained populations of Karner Blues, and the St. Williams site also harboured Frosted Elfin. Both butterfly species are now extirpated (Packer, 1994). Both sites also harbour additional species which are on the edge of their range, being found predominantly in prairie habitats or further south (Schweitzer, 1985; Sugar *et al.*, submitted; Skevington, 1996).

In recently completed analyses of limited samples of trapped Hymenoptera and more extensive transect surveys of butterflies (Sugar *et al.*, submitted; Kerr *et al.*, in preparation), it was found that species diversity of these two groups was positively correlated in southern Ontario oak savannah fragments. Furthermore, the Pinery and St. Williams areas had the highest and second highest diversity indices respectively, and the species compositions of the other, less rich, fragments were consistent with local extirpation being the cause of the community pattern. Nonetheless, few examples of species that may be considered oak savannah specialists in southern Ontario have been detected (Sugar *et al.*, submitted). Because there are many additional invertebrate groups remaining to be investigated in any detail, it is highly probable that there are quite a few species which, in Ontario, are or were restricted to oak savannah habitats. Many of these have almost certainly become extirpated even before being recorded (Packer, 1994; Schweitzer, 1998b). Those that remain probably do so largely because of efforts to conserve the oak savannah remnants, and these efforts would be unlikely to have been so energetic if it were not for the occurrence in the two main areas of one or both of the Frosted Elfin and Karner Blue.

Taken together, all ecotypes and subspecies currently referred to under the common name Frosted Elfin do not form an endangered species at the global level. However, it seems that the Lupine feeding ecotype of the nominate subspecies is endangered in the eastern portion of its range (Schweitzer, 1998a), and it is possible that it actually forms a distinct species (see discussion above). This form should be considered to be a highly significant indicator of moderate to good quality oak savannah and pine barrens habitats. Successful reintroduction of this species, if attempted, should be considered as a very positive indication of the success of restoration protocols in the Manestar Tract.

EVALUATION

In Canada, the Frosted Elfin declined in abundance from what was probably a chronically low but persistent population to zero as a result of succession of its early seral stage habitat and tree planting in its oak savannah habitat. Both changes increased the amount of shade, causing a decline in Lupines. In the last years of the butterfly's occurrence in Ontario, the foodplant persisted in crowded-out conditions in which most of the plants could not flower. As female Frosted Elfin oviposit on flowers in full sunlight and flowers and developing seed pods form the larva's food, the butterfly population gradually declined to zero.

The potential for reversing the trend in habitat quality has already been demonstrated: there is more suitable habitat in the St. Williams area now than there was in the late 1970s when the species was once described as "common".

Reintroduction would quite likely be successful in the short term. With continued vigilance and restoration efforts tailored to recommendations based on further empirical observations of the species, reintroduction would probably be successful in the intermediate term as well.

Given the confusion over the systematic status of Lupine and Indigo feeding forms of the Frosted Elfin, it is not easy to state how many populations of the former are in existence globally. Nonetheless, a status of G3 (globally rare to uncommon—with between 20 and 100 occurrences) seems reasonable. For Ontario, the species should be considered SX – apparently extirpated with little likelihood of rediscovery. Consequently, I recommend that COSEWIC assign to this species the status

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