Distribution, Status and Conservation of the Monarch butterfly, *Danaus plexippus* (L.), in Canada

A report submitted to the
Commission for Environmental Cooperation,
393 rue St. Jacques Ouest, Bureau 200,
Montréal, Québec, Canada, H2Y 1N9

Janine Ferretti, Director
jferrett@ccemtl.org

Phil Schappert

York University, Department of Biology,
4700 Keele St., North York, Ontario, M3J 1P3

416-736-2100 ext. 33492
PHILJS@YORKU.CA

Summary

The Monarch butterfly, *Danaus plexippus* (L.) (Lepidoptera: Danaidae), is a migrant which colonizes Canada each year in the late spring to breed, re-populating its range from its overwintering grounds. There are two distinct populations: a small western one found in Canada only in British Columbia, which overwinters in California, and a much larger eastern population, found east of the Rocky Mountains throughout the rest of Canada, which overwinters in central Mexico. The Monarch varies greatly in abundance and distribution from place to place and from year to year in Canada but, since the Monarch breeds in Canada and the northern U.S., having from one to three generations depending on latitudinal location and other edaphic factors, it generally becomes more common as the summer progresses. Monarchs are most often noticed when they assemble to begin the fall migration south. The large eastern population is most abundant in Ontario due in large part to the low latitude and modifying effect of the Great Lakes on the climatic regime. Eastern Canada provides a significant proportion of the fall migrants that overwinter in Mexico.

The distribution of the Monarch in Canada is determined largely by the distribution of its obligate larval hostplants, the Milkweeds (*Asclepias* sp.; Asclepiadaceae). There is little doubt that land use changes over the last 200 years have greatly aided the expansion of milkweeds, especially the Common Milkweed, *A. syriaca*, in the east and Showy Milkweed, *A. speciosa*, in the west, thus increasing the available range of the Monarch. For example, there has been a demonstrable increase in the abundance and distribution of Monarchs in Ontario over the last 5 decades. A number of conservation issues may affect this distribution greatly in the coming years. These issues include further land use changes, global warming and the concomitant increase in carbon dioxide and low-level ozone, weed control legislation and programs which have direct effects on hostplant availability as well as indirect effects on the habitat as a whole due to herbicide and pesticide spraying, and the spread of invasive alien plant species which alter open habitats and may compete as inappropriate larval hosts.

Of major importance also is the ongoing degradation and destruction of the overwintering roosts in Mexico, as well as future conservation efforts by the United States. All of the breeding Monarchs which make their way to eastern Canada each year have bred in the southern U.S. - the butterflies which reach Canada are one or two generations removed from those that overwintered in Mexico. International cooperation between these three nations is essential to encourage the continuation of the "endangered phenomenon" that is the migration of the Monarch butterfly. International cooperation can provide benefits through protection of the overwintering sites in Mexico and California and through protection of the spring and autumn migratory pathways through the United States. Their protection has a direct impact on the numbers of Monarchs that return to Canada each spring, in turn, Canadian conservation efforts have far-reaching effects on recruitment to the overwintering roosts.

Distribution

The Monarch butterfly, *Danaus plexippus* (L.), is the only species of the family Danaidae found in Canada (Monroe 1978; Scott 1986). The distribution of both the obligate larval hostplants, the Milkweeds (genus *Asclepias*), and the breeding range of the Monarch butterfly in Canada correspond quite closely to the Dfb zone (Humid microthermal climatic zone) of the Köppen climate and vegetation classification scheme described by Ackerman (1941; see also Fig. 3.1, pp. 89 of Scudder 1978; Appendix A). Monarch butterfly populations that enter Canada

are distinct, with the large, expansive eastern population found everywhere east of the Rockies, and the small western population found only in the interior of British Columbia. The breeding distribution, and the distribution of known strays that range far beyond the range of the obligate hostplants, is given in Figure 1.

Eastern Population

Monarchs are casual non-breeding strays along the south coast of Newfoundland but have not been recorded from Labrador (Morris 1985; H. Clase and C. Majka, pers. comm.). In New Brunswick, the Monarch is recorded as having two broods but is considered a rare migrant which is not found every year (Thomas 1995). C. Majka (pers. comm.) suggests that the Monarch breeds in Nova Scotia as they can be quite common along the Bay of Fundy, especially during the fall migration, however, there are no published breeding records. Ferguson (1955) states that Monarchs were seen daily in the spring and again in the fall of 1949 and that 236 fall migrants were recorded over a six day period at Lunenburg Co. in that same year which also suggests that Monarchs do breed in Nova Scotia in some years. The Monarch is recorded from Prince Edward Island but is considered to be very rare (C. Majka, pers. comm.).

Monarchs from the eastern North American population are most common in southern Ontario and possibly southwestern Quebec where the larval hostplants are most abundant. Across the prairies from northwestern Ontario through to Alberta, the Monarch breeds in a relatively thin band between the Canada-U. S. border (49° N) and approximately 52° N. In the prairie provinces, the Monarch is most common in Manitoba where it occurs every year (Klassen *et al.* 1989), is uncommon to rare in Saskatchewan although relatively common in some years (Hooper 1973), relatively uncommon in southeast Alberta (Bird *et al.* 1995) but rare elsewhere in the province (N. Kondla, pers. comm.). Urquhart & Urquhart (1977; 1979a) report the Monarch as rare from Alberta with only scattered records for the prairies.

Western Population

The western population of Monarchs breeds in Canada only in the interior of British Columbia between the Rocky and Coastal mountain ranges up to about 52° N latitude with occasional strays being recorded from further north and from the Victoria/Vancouver area where they've been reported to breed on garden milkweeds (C. Guppy, pers. comm.). Guppy has recorded larvae in late June in the Similkamen Valley (49° N), Okanagan Valley (49-50° N), and Thompson River Valley (51.5° N) and considers it to be relatively common in the Okanagan Valley, rare elsewhere and very rare on the coast (C. Guppy, pers. comm.). Urquhart & Urquhart (1977; 1979a) report few butterflies in B.C. C. Guppy suggests that less than 1% of the Monarchs found at California overwintering roosts are Canadian in origin (pers. comm.).

Protection

Historically, there has been no formal protection for the Monarch, or indeed for many insects in general, in Canada. Ontario is the only province that has had butterflies listed as endangered species (since 1976) but no other province has, and no federal laws exist to protect butterflies or other insects. The conservation of insects, butterflies specifically, is a relatively recent concept (Wells *et al.* 1983; Thomas 1984; New 1991). Pressure to recognize insects as endangered species which are intrinsically worthy of our protection, and butterflies as bio-indicators of general habitat health, is increasing rapidly. The current status of the Monarch in Ontario has been given as "apparently secure with many occurrences" by Holmes *et al.* (1991). The Natural Heritage Information Centre in Ontario suggests that the status is globally very common, but ranging from extremely rare and very rare, non-breeding to very common, breeding within the province, and continues to track records of the Monarch primarily due to its migratory behaviour (Sutherland 1994). Recently, three areas along the north shore of Lakes Ontario (Prince Edward Point National Wildlife Area) and Erie (Long Point National Wildlife Area and Point Pelee National Park) have been designated as part of an International Network of Monarch Butterfly Reserves (Anon. 1995).

Population Sizes and Trends

Land use changes in Ontario and most southern regions of Canada over the last 200 years have likely served to increase the range of Milkweeds, especially those species such as *A. syriaca* and *A. speciosa* which grow in open situations. There is no doubt that Monarch ranges have increased over the last 50 years. Urquhart & Urquhart (1979a) give the breeding range of the Monarch in Ontario during the years 1937-1940 as Kingston to Goderich (approx. 44° N) and south with low numbers breeding in Barrie and Midland to the north. By 1975 they found that the Monarch was commonly breeding along the north shore of Lake Huron from Sudbury to Sault Ste. Marie (47° N) and in Thunder Bay and that in 1977 Monarchs were considerably more common at Sault Ste. Marie than they were at Toronto (Urquhart & Urquhart 1979a). Similarly Urquhart & Urquhart (1979a) reported no breeding in B.C. or Alberta with only scattered larvae recorded through Saskatchewan and Manitoba in the 1940-44 period. More recent records show that breeding does occur in B.C. and Alberta (C. Guppy, pers. comm.; Bird *et al.* 1995) and that they are now more common in Saskatchewan and Manitoba (Hooper 1973; Klassen *et al.* 1989). This recent range expansion may slow somewhat but is expected to continue.

The western populations, based on counts at overwintering roosts, have declined over the last five years (Marriott 1994a; 1994b; 1995) possibly due to a Neogregarine protozoan parasite (Leong *et al.* 1992; Marriott 1993; 1995; Brower *et al.* 1995). Swengel's (1995) analysis of 4th of July Butterfly Count data shows that both the western and the eastern populations fluctuate dramatically from year to year, often coinciding with major widespread climatic perturbations, but found that no significant increase or decrease in the numbers of Monarchs censused persisted for more than two years. New (1991) and Gaston & McArdle (1993) note that insects whose populations fluctuate dramatically are more likely to become endangered if some catastrophic event occurs at a low point in the natural population cycle. Brower (1995) and others fear that the ongoing degradation and destruction of Mexican overwintering sites may constitute just such a catastrophic event (Wells *et al.* 1983; Pyle 1983; Brower & Malcolm 1989; Malcolm 1993).

General Biology

Monarchs, like all butterflies, have four distinct stages in their life cycle: egg, larvae or caterpillar, pupae or chrysalis and imago or adult butterflies. Mated adult females lay their eggs on a variety of Milkweeds. The egg stage in Monarchs lasts about 4 days, larvae grow and develop through 5 instars (growth stages) in approx. 15 days and the pupal stage lasts from 9 to 15 days (Urquhart 1987). Adult butterflies live 2-6 weeks in the summer broods and up to 8 months in the migratory stage. Monarchs are most vulnerable to a wide variety of mortality sources in the larval and pupal stages.

Monarchs obtain cardenolides (cardiac glycosides) - bitter, emetic compounds akin to digitalis - from their Asclepiadaceous hostplants which serve to protect them to some degree from their own predators (Brower 1984). The bold coloration of both larvae and adults advertises their unpalatability in such a way as to "train" their predators to avoid them (Brower 1984; Dempster 1984). Each different kind of Milkweed has a characteristic profile of cardenolides (a chemical "fingerprint") as do the butterflies that feed on them (Roeske *et al.* 1976). The concentration of cardenolides declines with age so that unpalatable butterflies become progressively more palatable as they age (Malcolm *et al.* 1993; Alonso-Meija & Brower 1994).

Classification and Description

The Monarch, *Danaus plexippus*, is the only Canadian representative of the family Danaidae or Milkweed butterflies (Monroe 1978). The Milkweed butterflies are closely allied to the Nymphalidae or Brushfoot butterflies and show similar reduction of the adult forelegs. The adult is probably the most familiar butterfly in North America, with its large size (wingspan approx. 10 cm) and distinctive orange and black colour pattern. The Viceroy (*Limenitis archippus*, Nymphalidae), a mimic of the Monarch, is somewhat smaller and has a very similar appearance in both colour and pattern (they can be differentiated from Monarchs by the curved vein which parallels the hind wing margin), so similar in fact that accurate identification of Monarchs can be confusing to the novice. Male Monarchs may be differentiated from females by the presence of patches of specialized pheromone scales ("alar" spots) on the centre of the hindwing of males. Fully grown larvae are large and conspicuous, transversely striped in black, white and yellow, and are considered to be aposematic or warningly coloured.

Reproductive Biology

Southern Canada offers perfect conditions, from June through August, for Monarch butterfly reproduction. Ovarian development (that is the time it takes eggs to develop) is optimal at 28° C and egg maturation takes longer both above and below this temperature (Barker & Herman 1976). There are two broods through most of Canada except for southwestern Ontario where 3 broods can occur (Holmes *et al.* 1991; Cockrell *et al.* 1993). Larvae are most successful on large plants which can support the full growth of the caterpillar (Cohen & Brower 1982), however, adult females often prefer to oviposit (lay eggs) on tender young plants (Borkin 1982; Urquhart 1987). Isolated plants are preferred over large patches, and plants on the edge of patches are preferred over central plants (Suzuki & Zalucki 1986; Zalucki & Suzuki 1987; Zalucki 1993). Herman (1981) suggests that reproductive diapause in the migrating generation is induced, likely by photoperiod (day length), in the larval or pupal stage. Females may mate up to 10 times, receiving a nuptial gift in the form of a spermatophore (sperm plus vital nutrients and salts), which makes males an important resource for females (Suzuki & Zalucki, 1986).

Population Dynamics

Borkin (1982) found that only 12% of immatures survived from egg to pupation in Wisconsin suggesting that egg and larval mortality are moderate to extreme at least in the northern part of the range. She reports that there is an initial "pulse" of larvae from immigrants followed by variation in local breeding yielding successive broods (Borkin 1982). Potentially the most limiting factor in butterfly populations is the ability of females to fly to find mates and then to lay their complement of eggs (Ehrlich 1984; Dennis 1993). A large suite of potential mortality sources - climatic events, predators, parasitoids, parasites, fungi and diseases (Dempster 1984) - can affect adult population levels. For example, female mortality in western populations appears to be more common than that experienced by males since more males are commonly found at the overwintering roosts (Frey & Leong 1993).

The vast majority of butterflies found at the eastern overwintering site, 85%, have been shown, *via* cardenolide amounts and types present in the butterflies, to have developed on the Common and Showy Milkweeds, *A. syriaca* and *A. speciosa*, which only grow north of 35° N latitude (Seiber *et al.* 1986; Malcolm 1987). Malcolm *et al.* (1987) have shown that Milkweeds in the south senesce and die in June at 30° N which pushes the Monarchs further north (see also Cockrell *et al.* 1993). Similarly, using wing wear, cardenolide profiles and amounts, Malcolm *et al.* (1993) have shown that re-colonization of eastern North America is by a series of successive broods, although Urquhart & Urquhart (1979b) have shown that Monarchs can migrate all the way from Mexico to latitudes similar to those found in southern Ontario.

Sensitivity

Eastern and western populations are likely distinct (there are differences in behaviour, size, colour, and palatability; Marriott 1994a; 1994b) throughout their range with little transfer of individuals and genes across the dividing mountain ranges (Brower & Boyce 1991; Brower, 1995; Brower *et al.* 1995 but see Urquhart & Urquhart, 1977 and Urquhart 1987 for a differing opinion). A risk to the eastern population at present, if gene flow exists, or inter-populational transfers of western individuals to the eastern range are made by man, is the current high infestation (55-65% of all butterflies; Leong *et al.* 1992) of the Neogregarine protozoan parasite, *Ophryocystis electroscirrha* (Leong *et al.* 1992; Marriott 1993; Brower *et al.* 1995). Both populations are sensitive to large scale weather patterns such as storm and cold fronts which can result in mortality from drowning (Brown 1992) or freezing, despite increased cold-hardiness of the migrating brood (Masters *et al.* 1988; Anderson & Brower, 1993), during migration. Also, as stated above, variable, fluctuating populations may be more at risk from such events.

Brower (1995) suggests that high predation rates being experienced by overwintering butterflies at the Mexican roosts are due to a historical land use shift which allowed for the expansion of Milkweeds which contain lower amounts and emetic potencies of cardenolides. If this is true then changes in land use patterns in Canada have been both a boon (allowing for significant range expansion) and a bane (leaving butterflies less protected against predators) for the Monarch. Brower (1995) also expresses concern over the widespread use of herbicides and pesticides in eastern North America to "control" Milkweeds and other organisms which are perceived as pests and predicts that the breeding range of the eastern population will decline markedly over the next 10 years if such use continues.

Migration

Monarchs exhibit a number of adaptations for their migration including increased cold-hardiness (Anderson & Brower 1993), reproductive dormancy or diapause (Herman 1981; Urquhart 1987), the ability to actively orient flight direction despite opposing winds and utilize gliding for long distances in order to conserve energy resources (Gibo 1986; Schmidt-Koenig 1993), the ability to store nutrients acquired from nectar sources in the form of lipids which allow for long storage and rapid metabolization of energy reserves (Urquhart 1987; Gibo & McCurdy, 1993a), the ability to behaviourally modify their body temperature to increase flight time (Masters 1993) and maintain lipid mass (Masters *et al.* 1988), and the ability to maintain their centre of gravity for flight by taking on water to compensate for lipid losses (Gibo & McCurdy, 1993b). Reproductive dormancy, large lipid reserves and the cool temperatures of the overwintering sites interact to greatly increase the lifespan of the migrating brood.

Spring migration into Canada depends greatly on the weather conditions experienced in any particular year but generally butterflies arrive in late May/early June in southern Ontario and in mid-June to early July throughout the rest of the country. Fall migration from southern Ontario is very well documented (Urquhart 1987; Walton 1993; Brenner 1993; Wormington 1994; D. Davis, pers comm.) by the tagging programs which eventually enabled the discovery of the Mexican overwintering sites (Urquhart 1987). Numbers can be very high (Wormington, 1994, estimates that as many as 96,000 butterflies moved through Point Pelee National Park in the space of a few hours on September 6, 1993) but more typically range from 100 - 500 butterflies per day (Brenner 1993; D. Davis, pers. comm.). Data on migration through other provinces is scarce.

Habitat

Habitat can be usefully defined as a distinctive vegetation community that is the natural home of an organism. Since Milkweeds are numerous and occur in a wide variety of habitats, from wet, sub-aquatic sites (*A. incarnata*) to forest borders (*A. exaltata*), habitat for Monarchs would appear to be plentiful. The quality of habitats, that is their suitability to Monarchs and actual use by Monarchs, however, varies substantially. It is useful also to differentiate between habitat requirements of breeding habitats and the requirements of migratory staging areas, however, it should be recognized that there is a great deal of overlap between the two.

Habitat Requirements

Hostplants

The distribution of Milkweeds in Canada, as previously mentioned, corresponds quite closely to the Dfb zone (Humid microthermal climatic zone) of the Köppen climate and vegetation classification scheme described by Ackerman (1941; see also Fig. 3.1, pp. 89 of Scudder 1978; Appendix A). The distribution and density of all of the species of Milkweeds found in Canada is given in Figure 2.

Interestingly, the more common species (*A. syriaca, A. incarnata, A. tuberosa,* and *A. speciosa*) have low quality cardenolides (*i.e.* less protective to the butterflies) while much rarer species have high quality cardenolides (Duffey & Scudder 1972; Roeske *et al.* 1976). The Common (*A. syriaca*), Swamp (*A. incarnata*) and Showy Milkweeds (*A. speciosa*) are, in most other respects, excellent quality hosts, however, the Butterfly-weed or Orange Milkweed (*A.*

tuberosa) is utilized less often due to its low nitrogen and water content (Ericson 1973). Some reports have shown that the importance of isolated hostplants, or small patches (less than 1 plant per m^2) is distinct from that of large patches since females prefer the former for oviposition but require the latter to find males which congregate in larger patches (Suzuki & Zalucki 1986; Zalucki & Suzuki 1987; Zalucki 1993).

Recent reports have suggested that the Swamp Milkweed is utilized to a larger extent than previously thought (Layberry 1995) possibly due to protection from ground-based predators which cannot access plants in standing water (Eickwort 1977). As mentioned previously, up to 85% of the overwintering butterflies tested at Mexican roosts are from the Common and Showy Milkweeds. Contrary to past literature (e.g. Scott 1986), it has recently been shown that Monarch larvae cannot subsist on Dogbanes, *Apocynum* sp. (Borkin, 1993).

Nectar Sources

The fuel for the migratory flight machinery is nectar obtained from fall wildflowers, especially Goldenrods (*Solidago* sp.) and Asters (*Aster* sp.). The dependence of the butterflies on large lipid reserves (up to 45% of dry weight with more than 90% stored in the abdominal fat body; Brown & Chippendale, 1974) makes the availability of adequate nectar resources an absolute requirement in potential habitats (Urquhart 1987). The availability of good quality and abundant nectar sources likely plays an important role in migratory staging area habitat selection (Urquhart & Urquhart 1979a; Ehrlich 1984).

Abiotic Factors

A number of abiotic (*i.e.* not biological in origin) factors also delineate suitable habitat. Obvious factors include climate (temperature and humidity) and weather (winds, storms, etc.). Less obvious factors include the use of hostplants that are isolated or occur in standing water and the total amount of sunshine received. For example, larvae spend as much as 90% of the time in which they're not eating "basking" on Milkweed leaves, in full view of potential predators due to their protective colouration, and are able to raise their body temperatures from 3° to 8° C above the ambient air temperature thus shortening their larval period, time in which they are vulnerable to other mortality sources (Dempster 1984), by as much as 50% (Rawlins & Lederhouse, 1981). Associated with the availability of abundant nectar sources is a migratory "window of opportunity" which involves factors such as photoperiod, temperature (cool nights and mild days) and the ability to maintain low temperatures to conserve vital lipid resources (Masters *et al.* 1988; Gibo & McCurdy, 1993a).

Migratory Staging Areas

The availability of suitable trees for overnight roosts in staging areas is often suggested to be an important factor in staging area site selection, however, Urquhart & Urquhart (1979a) could not substantiate this popular misconception. What does appear to be important is the combination of high quality, abundant nectar sources, abiotic conditions and location. The most popular staging areas, for the Monarchs, appear to be archipelagos or spits of land which provide protection from the elements and the shortest possible distance across large barriers such as the Great Lakes (Brenner 1993; Walton 1993; Wormington 1995; D. Davis, pers. comm.).

Trends in Habitat Quality, Quantity and Protection

Urban sprawl is altering the amount of habitat available in the interior of B.C. (C. Guppy, pers. comm.), in southern Ontario (pers. obs.) and no doubt in other provinces as well. Other factors which may affect habitat availability include global climate warming (likely to increase the range of highly successful hostplants such as *A. syriaca* in eastern Canada but may make areas of the central prairies unsuitable), pollution (increasing carbon dioxide levels, low-level ozone) and widespread herbicide and pesticide use (including the use of "biological" controls lacking in sufficient specificity, such as *Bt* (*Bacillus thuringiensis*), to control lepidopterous pests). The recent spread of the alien invasive weeds, Swallow-worts or Dog Strangling Vines (*Vincetoxicum rossicum, V. nigrum* and *V. hirundinaria*; Asclepiadaceae) in southern Ontario (see Moore 1959; Pringle 1973; McNeil 1981; Kirk 1985 and Kubisz 1992) is especially worrisome. These vines can be described as the "purple loosestrife of dry fields" due to their clonal nature, habit of choking out native vegetation forming large monoclonal stands and rapid reproduction. A further problem, specific to the Monarch, may be presented by the relatively close relationship of the acceptable *Asclepias* sp. and the invasives - both are members of the Milkweed family. Female butterflies have been observed to oviposit on *Vincetoxicum* in eastern Toronto but it is not known whether larvae are capable of surviving on the plants (T. Mason, pers. comm.).

A current problem, especially in Ontario, but also in Saskatchewan (B. Walters, pers. comm.) and in other provinces, is the existence of weed control legislation for "the control of noxious weeds that interfere with land used for agricultural or horticultural purposes" (Anon. 1990). Using Ontario as an example, this legislation (Anon. 1993) lists <u>all</u> *Asclepias* sp. as "noxious" weeds which landowners are obliged by law to remove from their lands in both agricultural and urban areas. Since these plants are the sole host of Monarchs this legislation can only be perceived as a direct threat to their habitat (Cundiff 1993). Problems with the current legislation include: rare plants (8 of the 12 *Asclepias* sp. which occur in Ontario are listed as rare, Argus & Keddy, 1984; M. Oldham, pers. comm.) listed as "noxious" weeds, the lack of a specific definition of what constitutes a noxious weed, enforcement by several levels of weed inspectors is often inconsistent from one area to another (in one example a superintendent of a "natural environment" provincial park was instructed to remove the Milkweeds from the park despite the existence of large numbers of plants just outside the park boundaries; D. Davis, pers. comm.), the use of a section of the act which enables Municipalities to designate their own "noxious weeds" (enabling one Guelph municipality to designate "goldenrods" as noxious in the mistaken belief that they cause hayfever; D. Davis, pers. comm.), the unknown impact of herbicide use and plant removal on pollinators, and conflicts between the mandates of different government Ministries (Schappert 1992; Ferris 1994; Schneider 1994).

A number of private and public organizations have been attempting to have the Weed Control Act in Ontario reviewed with the intent of obtaining a clear definition of what constitutes a noxious weed, the listing of specific species instead of wholescale listing of entire genera (7 of 24 taxa listed on the schedule of noxious weeds are for entire genera), the exclusion of native and rare species which are non-invasive and pose no defined threat to agriculture, a means of ensuring that the act does not become a barrier to naturalization projects, clarification of exemptions to the act and consistent application of the act across the entire province (Schappert 1992; Ferris 1994; Schneider 1994). At a symposium held in November of 1994 at Guelph all of these points were presented to the Ministry responsible for the administration of the Act, but as of this writing no formal report to the Ministry has been submitted (H. Lang, pers. comm.).

International Cooperation and Canadian Conservation Efforts

The Monarch butterfly is the only current example of what has come to be known as an "endangered phenomenon" (Wells *et al.* 1993; Pyle 1983; Brower & Malcolm 1989; Malcolm 1993). The scope of the migration undertaken by this species - where the return trip to the overwintering roosts is accomplished by butterflies that are five generations removed from those that made the re-colonization trip north the preceding spring (akin to a person having to find the origin of their great-great-great grandparent with no intergenerational information transfer!) - is truly a phenomenon. Brower (1995) fears that the phenomenon of the migration of the Monarch could become extirpated in North America in less than 20 years if nothing is done now. Canada is, in my opinion, the ultimate source of probably 25 to 35% of the eastern migrants which overwinter in Mexico each year, thus, conservation efforts here may have a large impact on recruitment to the overwintering roosts. Recruitment to the overwintering roosts in turn affects the numbers of spring migrants that return to Canada.

Unilateral conservation efforts by Canada will, however, be ineffective in conserving this endangered phenomenon - a concerted international effort is required. Absolute protection of the overwintering sites in Mexico and California is necessary, as are efforts to protect breeding and migratory habitats throughout the United States and Canada. Mexico especially should be encouraged to promote non-consumptive use of the eastern overwintering sites, for example through "controlled" tourism at only one or two of the sites and effective protection of all other roosts. In California, the loss of roosts to urban development must be halted immediately. Throughout the United States and Canada efforts to promote the breeding success of Monarchs, particularly through cessation of wide-scale herbicide/pesticide programs, should be encouraged. Similarly, efforts to protect significant staging areas used in migration should be continued. In all three nations, concerted education efforts - such as the various Monarch programs (Brower & Walton 1996; Hyslop 1996)) already in place and the Canadian Museum of Natures "Butterfly Beyond Borders" travelling exhibit (Hyslop 1996) - should continue and, if possible, be expanded upon.

Evaluation and Proposed Status of the Monarch in Canada

The recent designation of three Monarch butterfly reserves should be expanded to include (at the very least) Presqu'ile Provincial Park on the north shore of Lake Ontario and Rondeau Provincial Park on Lake Erie. Both of these parks are significant staging areas for the fall migration and should not be excluded simply because they are not federally-held lands. A review of known staging areas in all Canadian provinces should be completed as soon as possible in order to provide protection of those areas deemed significant. A review of the Weed Control Acts of Ontario and other provinces is of paramount importance. In Ontario, a minimum requirement is the removal of *Asclepias* as a genus from Regulation 1096, the schedule of noxious weeds. Additionally, the use of herbicides and pesticides to control economically harmful plants must be curtailed in favour of ecologically sound methods of biological control (Ferris 1994). It is obvious that in the case of Milkweeds, one preferred method would be to encourage the suite of herbivores, including the Monarch butterfly, that utilize the plants (Wilbur 1976; Morse 1985; Urquhart 1987). As Fred Urquhart (1987) maintains, if Milkweeds are perceived as noxious weeds then the Monarch butterfly is a beneficial insect.

The level of protection status due the Monarch is difficult to ascertain. As Sutherland's (1994) broad designation has suggested the status will differ greatly from place to place and from

year to year. Monitoring both the quality and quantity of breeding habitats, direct counts of Monarchs at various locations across the breeding range and at various times of year, as well as accurate counts of the numbers of migratory individuals at significant staging areas are necessary in order to determine the current status. Since the Monarch is a migratory species it seems fitting to offer it the same protection that is given to migratory birds (e.g. Migratory Birds Protection Act, 1994). Population levels of the Monarch should be closely monitored to determine if greater protection is required. A program to monitor Monarch and Milkweed population levels during the breeding season, possibly as monthly "Monarch Counts" undertaken by volunteers, at various locations across Canada would be beneficial.

Acknowledgements

I'm especially grateful to Don Davis, the Monarch's best friend in Canada, for service above and beyond the call of duty. I'd also like to thank Carolyn King of the Cartography office of the Geography Department at York University for providing the map outlines. This report would not have been possible without the help of a large number of people who were free with both their records and their time (from west to east): Cris Guppy, Norbert Kondla, Braden Walters, Al Wormington, Quimby Hess, David Gibo, Michael Oldham, Don Sutherland, Don Lafontaine, Jeff Crolla, Tony Thomas, Stuart Tingely, Chris Majka and Howard Clase. I also wish to thank Laurence Packer, Jeff Crolla and Don Lafontaine for comments that have greatly improved the accuracy and readability of this report.

Literature Cited

Ackerman, E.A. (1941) The Köppen classification of climate in North America. Geographical Review 31: 105-111.

Alonso-Meija, A. and Brower, L.P. (1994) From model to mimic: age-dependent unpalatability in Monarch butterflies. Experentia 50: 176-181.

Anderson, J.B. and Brower, L.P. (1993) Cold-hardiness in the annual cycle of the Monarch butterfly. *in* Biology and conservation of the Monarch butterfly, Malcolm, S.B. & Zalucki, M.P. (eds.), Natural History Museum of Los Angeles County Science Series No. 38, Los Angeles, California., pp. 157-164.

Anon. (1990) Weed Inspector's Guide. Ontario Ministry of Agriculture, Food and Rural Affairs.

Anon. (1993) Weed Control Act, revised statutes of Ontario, 1990 Chapter W.5. Ontario Ministry of Agriculture, Food and Rural Affairs.

Anon. (1995) Canada-Mexico Declaration: creation of an international network of Monarch butterfly reserves.

Argus, G.W. and Keddy, C.J. (1984) Atlas of the rare vascular plants of Ontario, Vol. 3, National Museum of Natural Sciences, Ottawa.

Argus, G.W. and Pryer, K.M. (1990) Rare vascular plants in Canada: our natural heritage. National Museum of Natural Sciences, Ottawa, 318 pp.

Barker, J.F. and Herman, W.S. (1976) Effect of photoperiod and temperature on reproduction of the Monarch butterfly, *Danaus plexippus*. Journal of Insect Physiology 22: 1565-1568.

Bhowmik, P.C. and Bandeen, J.D. (1976) The biology of Canadian weeds. 19. *Asclepias syriaca* L. Canadian Journal of Plant Science 56: 579-589.

Bird, C.D.; Hilchie, G.J.; Kondla, N.G.; Pike, E.M. and Sperling, F.A.H. (1995) Alberta butterflies. Provincial Museum of Alberta, Edmonton, 349 pp.

Borkin, S.S. (1982) Notes on shifting distribution patterns and survival of immature *Danaus plexippus* (Lepidoptera: Danaidae) on the foodplant *Asclepias syriaca*. Great Lakes Entomologist 15: 199-206.

Borkin, S.S. (1993) Rejection of *Apocynum androsaemifolium* and *A. sibiricum* (Apocynaceae) as food plants by larvae of *Danaus plexipppus*: refutation of early accounts. *in* Biology and conservation of the Monarch butterfly, Malcolm, S.B. & Zalucki, M.P. (eds.), Natural History Museum of Los Angeles County Science Series No. 38, Los Angeles, California., pp. 125-128.

Brenner, D. (1993) The flight of the Monarch. Long Point Bird Observatory Newsletter 25(1): 1-2.

Brower, A.V.Z. and Boyce, T.M. (1991) Mitochondrial DNA variation in Monarch butterflies. Evolution 45: 1281-1286.

Brower, L.P. (1984) Chemical defenses of butterflies. *in* The biology of butterflies, Vane-Wright, R.I. & Ackery, P.R. (eds.), Symposium of the Royal Entomological Society of London 11, Academic Press, London, pp. 109-134.

Brower, L.P. (1995) Understanding and misunderstanding the migration of the Monarch butterfly (Nymphalidae) in North America: 1857-1995. Journal of the Lepidopterists' Society 49: 304-385.

Brower, L.P.; Fink, L.S.; Brower, A.V.Z.; Leong, K; Oberhauser, K; Altizer, S.; Taylor, O.; Vickerman, D.; Calvert, W.H.; Van Hook, T.; Alonso-Meija, A.; Malcolm, S.B.; Owen, D.F. and Zalucki, M.P. (1995) On the dangers of interpopulational transfers of Monarch butterflies. BioScience 45(8): 540-544.

Brower, L.P. and Malcolm, S.P. (1989) Endangered Phenomena. Wings 14(2): 3-9.

Brower, L.P. and Walton, R.K. (1996) Report on the status of the Monarch butterfly (*Danaus plexippus*) in the United States (draft, 18 March 1996). Commission for Environmental Cooperation, Montreal, Quebec.

Brown, J.J. and Chippendale, G.M. (1974) Migration of the Monarch butterfly, *Danaus plexippus*: energy sources. Journal of Insect Physiology 20: 1117-1130.

Brown, K.S., Jr. (1992) More beached butterflies. News of the Lepidopterists' Society, May/June 1992 (No. 3), pp. 56.

Cockrell, B.J.; Malcolm, S.B. and Brower, L.P. (1993) Time, temperature, and latitudinal constraints on the annual recolonization of eastern North America by the Monarch butterfly. *in* Biology and conservation of the Monarch butterfly, Malcolm, S.B. & Zalucki, M.P. (eds.), Natural History Museum of Los Angeles County Science Series No. 38, Los Angeles, California., pp. 233-252.

Cohen, J.A. and Brower, L.P. (1982) Oviposition and larval success of wild Monarch butterflies (Lepidoptera: Danaidae) in relation to host plant size and cardenolide content. Journal of the Kansas Entomological Society 55: 343-348.

Cundiff, B. (1993) Why Butterflies aren't free. Seasons 33(1): 24-29, 37, Spring 1993, Federation of Ontario Naturalists.

Day, R. and Catling, P.M. (1991) The rare vascular plants of Prince Edward Island. Syllogeus 67, National Museum of Natural Sciences, Ottawa, 65 pp.

Dempster, J.P. (1984) The natural enemies of butterflies. *in* The biology of butterflies, Vane-Wright, R.I. & Ackery, P.R. (eds.), Symposium of the Royal Entomological Society of London 11, Academic Press, London, pp. 97-104.

Dennis, R.L.H. (1993) Butterflies and climate change. Manchester University Press,

Manchester, U.K., 302 pp.
Duffy, S.S. and Scudder, G.G.E. (1972) Cardiac glycosides in North American Asclepiadaceae, a basis for unpalatability in brightly coloured Hemiptera and Coleoptera. Journal of Insect Physiology 18: 63.
Ehrlich, P.R. (1984) The structure and dynamics of butterfly populations. *in* The biology of butterflies, Vane-Wright, R.I. & Ackery, P.R. (eds.), Symposium of the Royal Entomological Society of London 11, Academic Press, London, pp. 25-40.
Eickwort, K.R. (1977) Population dynamics of a relatively rare species of Milkweed beetle (*Labidomera*). Ecology 58: 527-538.
Ericson, J.M. (1973) The utilization of various *Asclepias* species by larvae of the Monarch butterfly, *Danaus plexippus*. Psyche 80: 230-248.
Ferguson, D.C. (1955) Lepidoptera of Nova Scotia. Part 1: Macrolepidoptera. Nova Scotia Museum, Halifax, 375 pp.
Ferris, L. (1994) An ecological appraisal of the Ontario Weed Control Act. Thesis course, ERS 390 for Dr. G. Michalenko, University of Waterloo.
Frey, D.F. and Leong, K.L.H. (1993) Can microhabitat selection or differences in 'catchability' explain male-biased sex ratios in overwintering populations of Monarch butterflies. Animal Behavior 45: 1025-1027.
Gaston, K.J. and McArdle, B.H. (1993) All else is not equal: temporal population variability and insect conservation. *in* Perspectives on insect conservation, Gaston, K.J.; New, T.R. & Samways, M.J. (eds.), Intercept, Hampshire, U.K., pp. 171-184.
Gibo, D.L. (1986) Flight strategies of migrating Monarch butterflies (*Danaus plexippus* L.) in southern Ontario. *in* Insect Flight: dispersal & migration, Danthanarayana, W. (ed.), Springer-Verlag, Berlin, pp. 172-184.
Gibo, D.L. and McCurdy, J.A. (1993a) Lipid accumulation by migrating Monarch butterflies, *Danaus plexippus* (Nymphalidae). Canadian Journal of Zoology 71: 76-82.
Gibo, D.L. and McCurdy, J.A. (1993b) Evidence for use of water ballast by Monarch butterflies, *Danaus plexippus* (Nymphalidae). Journal of the Lepidopterists' Society 47: 154-160.
Groh, H. and Dore, W.G. (1945) A Milkweed survey in Ontario and adjacent Quebec. Scientific Agriculture 25(8): 463-481.
Harms, V.L. and Dunbar, R.M. (1989) The silky milkweed in Saskatchewan. Blue Jay 47(1): 2-6.
Herman, W.S. (1981) Studies on the adult reproductive diapause of the Monarch butterfly, *Danaus plexippus*. Biological Bulletin 160: 89-106.
Hess, Q.F. (1994) The habitats and butterflies of the Hudson's Bay lowlands. Toronto Entomologists' Association Occasional Publication 27-94, pp. 6-18.
Hinds, H.R. (1986) The flora of New Brunswick. Primrose Press, Fredricton, 460 pp.
Holmes, A.M.; Hess, Q.F.; Tasker, R.R. and Hanks, A.J. (1991) The Ontario butterfly atlas. Toronto Entomologists' Association, Toronto, 167 pp.
Hooper, R.R. (1973) The butterflies of Saskatchewan. Saskatchewan Department of Natural Resources, Regina, 216 pp.
Howe, W.H. (1975) The butterflies of North America. Doubleday, New York, pp.76-77.
Hyslop, C. (1996) Background Note: Canada-Mexico-USA Monarch Butterfly Project. Canadian Wildlife Service, Ottawa, Ontario.
Kirk, M. (1985) *Vincetoxicum* spp. (Dog-strangling Vines): alien invaders of natural ecosystems in southern Ontario. Plant Press 3(4): 130-131.
Klassen, P.; Westwood, A.R.; Preston, W.B. and McKillop, W.B. (1989) The butterflies of

Manitoba. Manitoba Museum of Man and Nature, Winnepeg, 290 pp.
Kubisz, M. (1992) Swallow-wort: a pesky intruder puts a choke-hold on Ontario. Globe & Mail, July 25, pp. D8.
Layberry, R. (1995) Monarchs on swamp milkweed (*Asclepias incarnata*). Toronto Entomologists' Association Occasional Publication 27-95, pp. 6-7.
Leong, K.L.H.; Kaya, H.K.; Yoshimura, M.A. and Frey, D.F. (1992) The occurrence and effect of a protozoan parasite, *Ophryocystis electroscirrha* (Neogregarinida: Ophryocystidae) on overwintering Monarch butterflies, *Danaus plexippus* (Lepidoptera: Danaidae) from two California winter sites. Ecological Entomology 17: 338-342.
Looman, J. and Best, K.F. (1979) Budd's flora of the Canadian prairie provinces. Agriculture Canada Publication 1662, pp. 593-597.
Maher, R.V.; White, D.J.; Argus, G.W. and Keddy, P.A. (1978) The rare vascular plants of Nova Scotia. Syllogeus 18, National Museum of Natural Sciences, Ottawa, 37 pp.
Maher, R.V.; Argus, G.W.; Harms, V.L. and Hudson, J.H. (1979) The rare vascular plants of Saskatchewan. Syllogeus 20, National Museum of Natural Sciences, Ottawa, 55 pp.
Malcolm, S.B. (1987) Monarch butterfly migration in North America: controversy and conservtion. Trends in Ecology & Evolution 2(5): 135-138.
Malcolm, S.B. (1993) Conservation of the Monarch butterfly migration in North America: an endangered phenomenon. *in* Biology and conservation of the Monarch butterfly, Malcolm, S.B. & Zalucki, M.P. (eds.), Natural History Museum of Los Angeles County Science Series No. 38, Los Angeles, California., pp. 357-362.
Malcolm, S.B.; Cockrell, J.B. and Brower, L.P. (1987) Monarch butterfly voltinism: effects of temperature constraints at different latitudes. Oikos 49: 77-82.
Malcolm, S.B.; Cockrell, J.B. and Brower, L.P. (1993) Spring recolonization of eastern North America by the Monarch butterfly: successive brood or single sweep migration? *in* Biology and conservation of the Monarch butterfly, Malcolm, S.B. & Zalucki, M.P. (eds.), Natural History Museum of Los Angeles County Science Series No. 38, Los Angeles, California., pp. 253-268.
Marriott, D.L. (1993) The protozoan epidemic. Part II. Monarch Newsletter 4(3): 4-5.
Marriott, D.L. (1994a) Tracking North American Monarchs. Part II. The west. American Butterflies 2(2): 16-19.
Marriott, D.L. (1994b) Monarchs west of the Rockies (Part I). Monarch Newsletter 4(9): 4-5.
Marriott, D.L. (1995) Are California Monarchs doomed? Monarch Newsletter 5(5): 1-2.
Masters, A.R. (1993) Temperature and thermoregulation in the Monarch butterfly. *in* Biology and conservation of the Monarch butterfly, Malcolm, S.B. & Zalucki, M.P. (eds.), Natural History Museum of Los Angeles County Science Series No. 38, Los Angeles, California., pp. 147-156.
Masters, A.R.; Malcolm, S.B. and Brower, L.P. (1988) Monarch butterfly (*Danaus plexippus*) thermoregulatroy behavior and adaptations for overwintering in Mexico. Ecology 69: 458-467.
McNeil, J. (1981) Taxonomic, nomenclatural and distributional notes on Canadian weeds and aliens. Naturaliste Canadien 108: 237-244.
Monroe, E. (1978) Lepidoptera. *in* Canada and its insect fauna, Danks, H.V. (ed.). Memoirs Entomol. Soc. Can. 108: 427-481.
Moore, R.J. (1959) The Dog-strangling Vine *Cynanchum medium*, its chromosome number and its occurrence in Canada. Canadian Field-Naturalist 73: 144-147.
Morris, R.F. (1980) Butterflies and moths of Newfoundland and Labrador: the macrolepidoptera. Agriculture Canada Publication 1691, pp. 40-42.

Morse, D.H. (1985) Milkweeds and their visitors. Scientific American 253(1): 112-119.
New, T.R. (1991) Butterfly conservation. Oxford University Press, Melbourne, Australia, 224 pp.
Pringle, J.S. (1973) The spread of *Vincetoxicum* species (Asclepiadaceae) in Ontario. Canadian Field-Naturalist 87: 27-33.
Pyle, R.M. (1983) Migratory Monarchs: an endangered phenomenon. The Nature Conservancy News 33: 20-24.
Rawlins, J.E. and Lederhouse, R.C. (1981) Developmental influences of thermal behavior on Monarch caterpillars (*Danaus plexippus*): an adaptation for migration (Lepidoptera: Nymphalidae: Danainae). Journal of the Kansas Entomological Society 54: 387-408.
Roeske, C.N.; Seiber, J.N.; Brower, L.P. and Moffitt, C.M. (1976) Milkweed cardenolides and their comparative processing by Monarch butterflies (*Danaus plexippus* L.). Recnet Advances in Phytochemistry 10: 93-167.
Roland, A.E. and Smith, E.C. (1969) The flora of Nova Scotia. The Nova Scotia Museum, Halifax, 746 pp.
Schappert, P.J. (1992) Letter to Honourable Elmer Buchanan, Minister of Agriculture, Food and Rural Affairs. Toronto Entomologists' Association, 10 Dec. 1992.
Schmidt-Koenig, K. (1993) Orientation of autumn migration in the Monarch butterfly. *in* Biology and conservation of the Monarch butterfly, Malcolm, S.B. & Zalucki, M.P. (eds.), Natural History Museum of Los Angeles County Science Series No. 38, Los Angeles, California., pp. 275-284.
Schneider, D. (1994) Call for changes to Ontario's Weed Act. Seasons 34(4): 8, Winter 1994, Federation of Ontario Naturalists.
Scott, J.A. (1986) The butterflies of North America: a natural history and field guide. Stanford University Press, Stanford, California, 583 pp.
Scudder, G.G.E. (1978) Present patterns in the fauna and flora of Canada. Memoirs Entomol. Soc. Can. 108: 87-179.
Seiber, J.N.; Brower, L.P.; Lee, S.M.; McChesney, M.M.; Cheung, H.T.A.; Nelson, C.J. and Watson, T.R. (1986) Cardenolide connection between overwintering Monarch butterflies from Mexico and their larval food plant *Asclepia syriaca*. Journal of Chemical Ecology 12: 1157-1170.
Straley, G.B.; Taylor, R.L. and Douglas, G.W. (1985) The rare vascular plants of British Columbia. Syllogeus 59, National Museum of Natural Sciences, Ottawa, 165 pp.
Sutherland, D.A. (1994) Natural heritage resources of Ontario: butterflies (draft). Natural Heritage Information Centre, Peterborough, Ontario, 14 pp.
Suzuki, Y. and Zalucki, M.P. (1986) The influence of sex ratio on female dispersal in *Danaus plexippus* (L.) (Lepidoptera: Danaidae). Journal of the Australian Entomological Society 25: 31-35.
Swengel, A.B. (1995) Population fluctuations of the Monarch (*Danaus plexippus*) in the 4th of July butterfly count 1977-1994. American Midland Naturalist 134: 205-214.
Thomas, A.W. (1995) A preliminary atlas of the butterflies of New Brunswick. Published by the author (in press, New Brunswick Museum)
Thomas, J.A. (1984) The conservation of butterflies in temperate countries: past efforts and lessons for the future. *in* The biology of butterflies, Vane-Wright, R.I. & Ackery, P.R. (eds.), Symposium of the Royal Entomological Society of London 11, Academic Press, London, pp. 333-353.
Urquhart, F.A. (1987) The monarch butterfly: international traveller. Nelson-Hall, Chicago, 232 pp.

Urquhart, F.A. and Urquhart, N.R. (1977) Overwintering areas and migratory routes of the Monarch butterfly (*Danaus p. plexippus*, Lepidoptera: Danaidae) in North America, with special reference to the western populations. Canadian Entomologist 109: 1583-1589.

Urquhart, F.A. and Urquhart, N.R. (1979a) Breeding areas and overnight roosting locations in the northern range of the Monarch butterfly (*Danaus plexippus plexippus*) with a summary of associated migratory routes. Canadian Field-Naturalist 93: 41-47.

Urquhart, F.A. and Urquhart, N.R. (1979b) Vernal migration of the MOnarch butterfly (*Danaus p. plexippus*, Lepidoptera: Danaidae) in North America from the overwintering site in the Neo-volcanic plateau of Mexico. Canadian Entomologist 111: 15-18.

Walton, R. (1993) Tracking North American Monarchs. Part I: The east. American Butterflies 1(3): 11-16.

Wells, S.M.; Pyle, R.M. and Collins, N.M. (1983) The IUCN Invertebrate Red Data Book. IUCN, Gland and Cambridge, 632 pp.

White, D.J. and Johnson, K.L. (1980) The rare vascular plants of Manitoba. Syllogeus 27, National Museum of Natural Sciences, Ottawa. 52 pp.

Wilbur, H.M. (1976) Life history evolution in seven milkweeds of the genus *Asclepias*. Journal of Ecology 64: 223-240.

Wormington, A. (1994) A mass migration of Monarchs at Point Pelee, Ontario. Toronto Entomologists' Association Occasional Publication 27-94, pp. 26-27.

Zalucki, M.P. (1993) Sex around the milkweed patch: the significance of patches of host plants in Monarch reproduction. *in* Biology and conservation of the Monarch butterfly, Malcolm, S.B. & Zalucki, M.P. (eds.), Natural History Museum of Los Angeles County Science Series No. 38, Los Angeles, California., pp. 69-76.

Zalucki, M.P. and Suzuki, Y. (1987) Milkweed patch quality, adult population structure, and egg laying in the Monarch butterfly. Journal of the Lepidopterists' Society 41: 13-22.

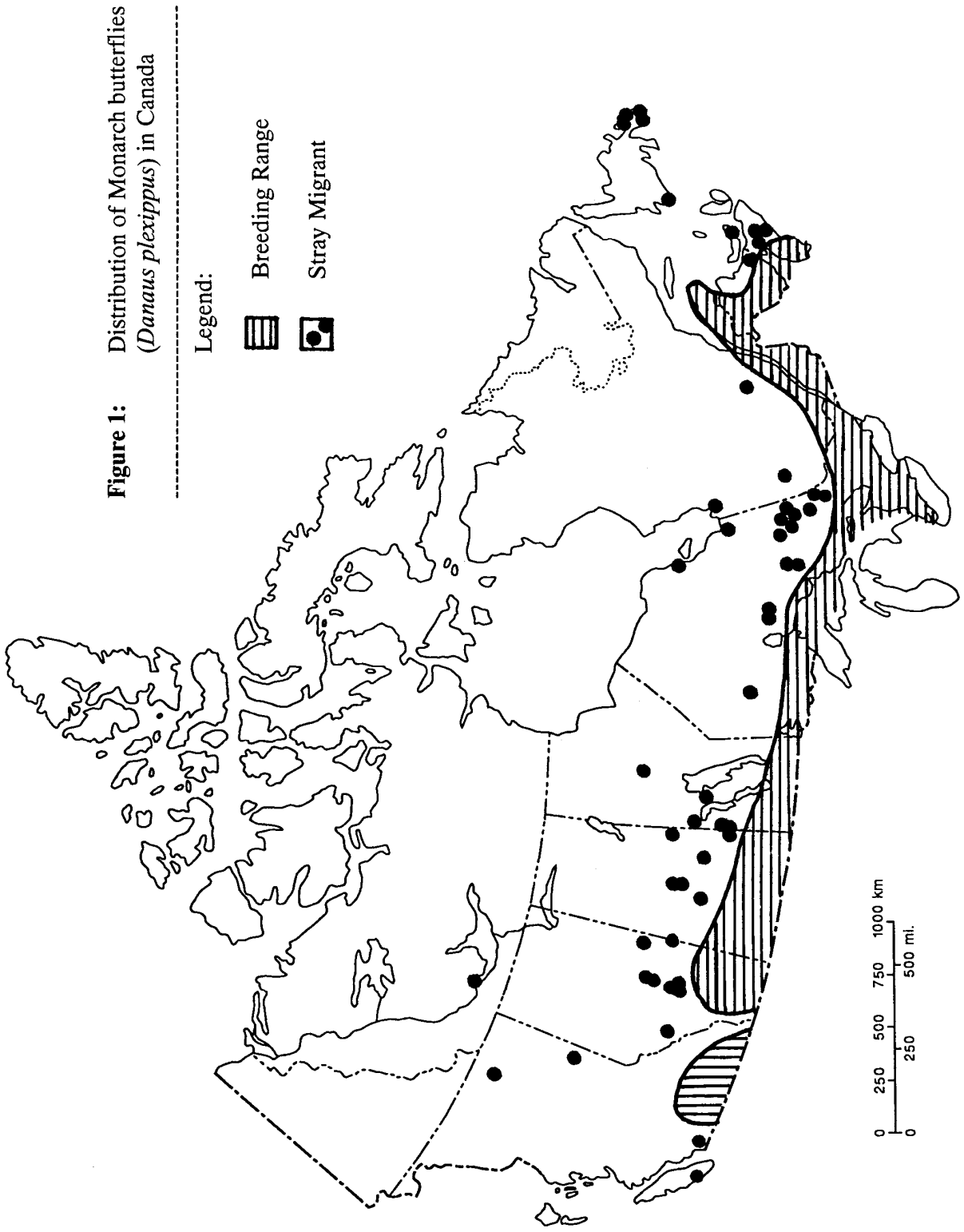

Figure 1. The breeding and stray migratory distribution of the Monarch butterfly (*Danaus plexippus*) in Canada. Data from: Ferguson 1955; Hooper 1973; Morris 1980; Klassen *et al.* 1989; Holmes *et al.* 1991; Hess 1994; Bird *et al.* 1995; Thomas 1995; J. Crolla, C. Guppy, D. Lafontaine, and C. Majka (pers. comm.)

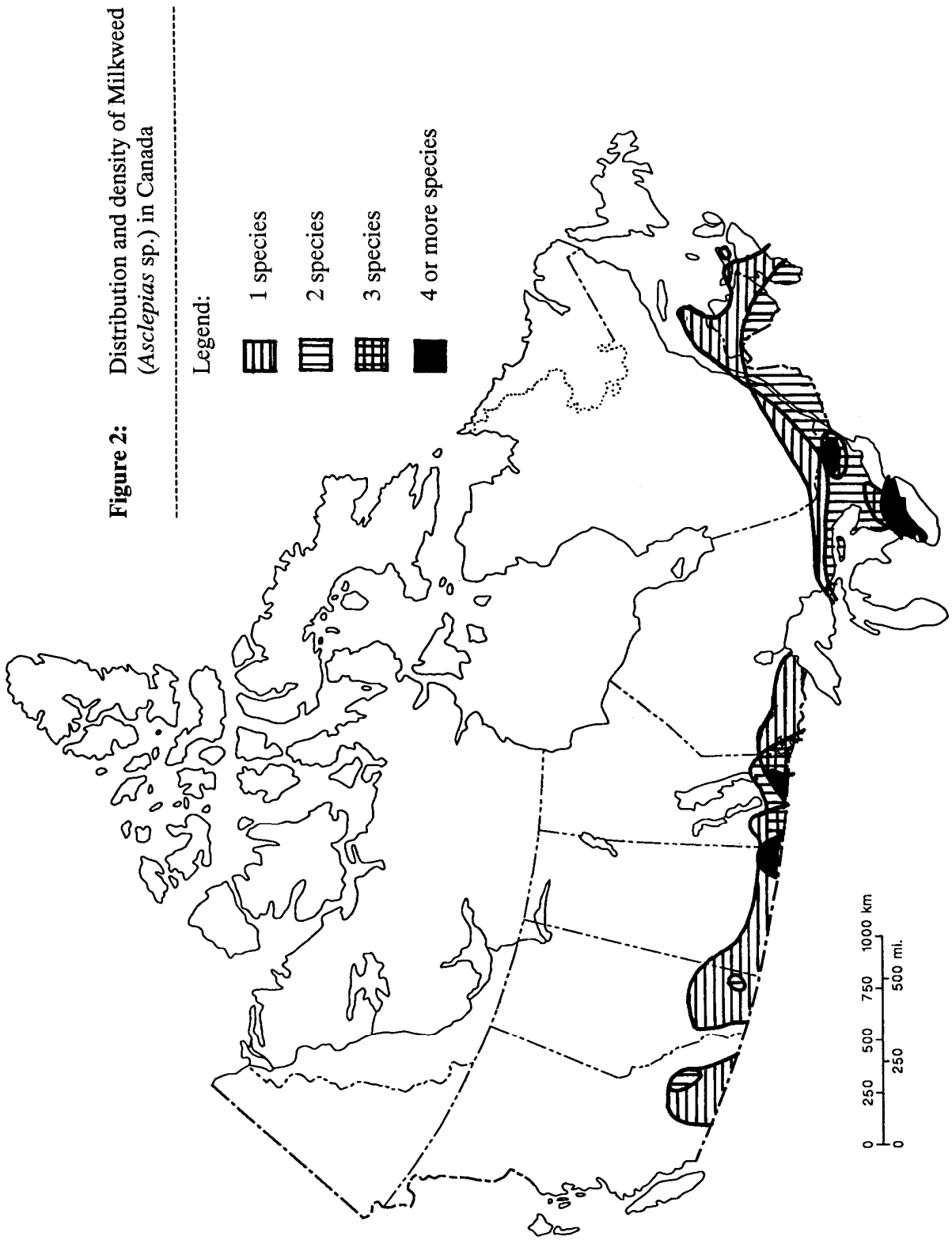

Figure 2. The distribution and density of Milkweeds (*Asclepias* sp.) in Canada. Data from: Groh & Dore 1945; Roland & Smith 1969; Bhowmick & Bandeen 1976; Maher *et al.* 1978; Maher *et al.* 1979; Looman & Best 1979; White & Johnson 1980; Argus & Keddy 1984; Straley *et al.* 1985; Hinds 1986; Harms & Dunbar 1989; Argus & Pryer 1990; Day & Catling 1991.

Appendix A: Figure 3.1, pp. 89 of Scudder, 1978: Climates of North America according to the Köppen classification (After Ackerman (1941).)

3. PRESENT PATTERNS IN THE FAUNA AND FLORA OF CANADA

G.G.E. SCUDDER

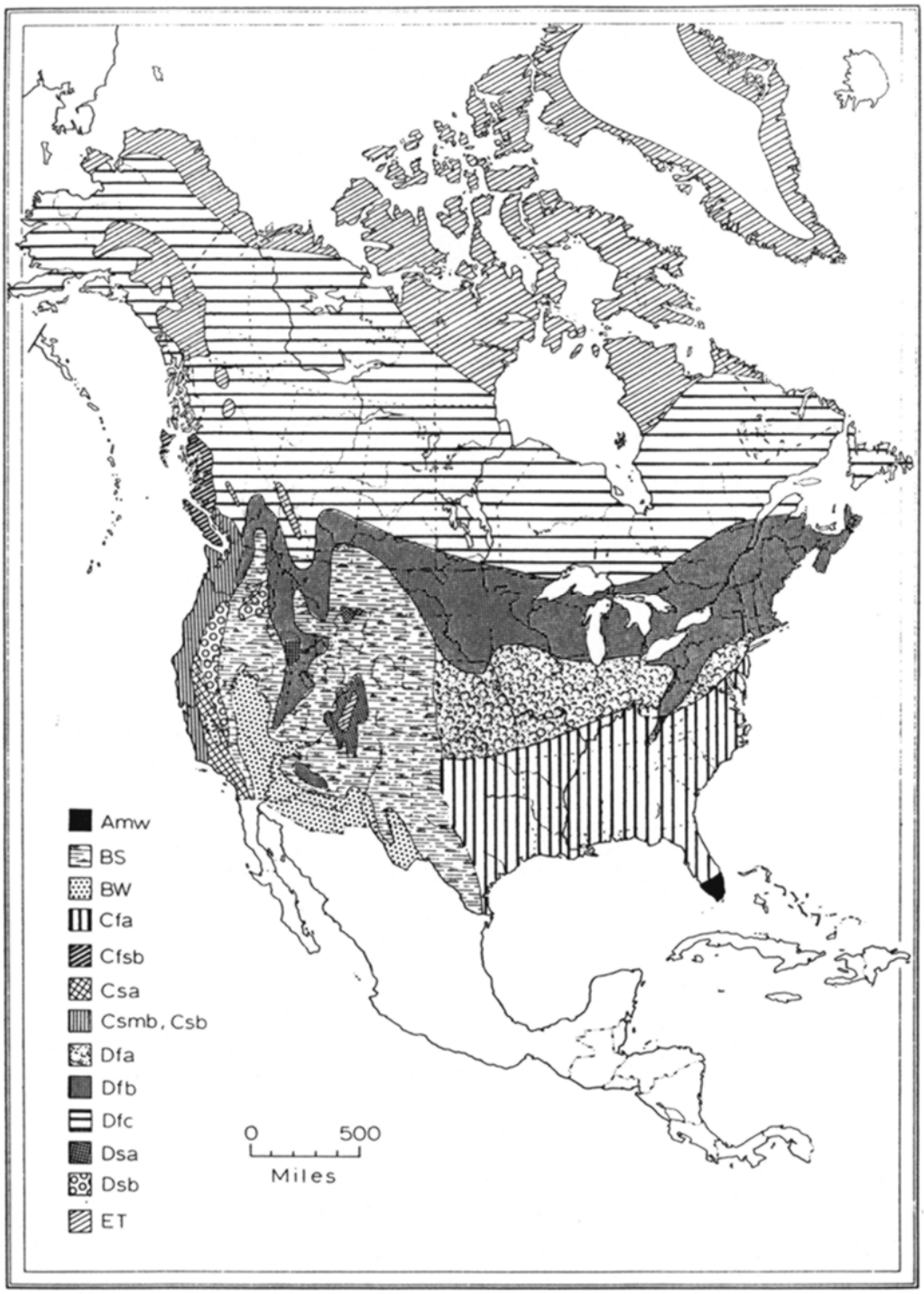

FIG. 3.1. Climates of North America according to the Köppen classification. (After Ackerman (1941).)