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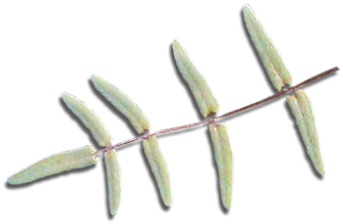
Biota of Wisconsin's Niagara Escarpment



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ABSTRACT

The physical attributes of the Niagara Escarpment provide unique microhabitats for animals and plants, contributing to Wisconsin's biological diversity at multiple scales. Within the predominantly forested landscape that existed before European settlement, dens and caves provided shelter for wide-ranging animals like reptiles, bats, and terrestrial mammals. Changes in the surrounding landscape have led to the regional loss of many of these species, but ecologically significant caves and denning habitats still exist in protected areas along the escarpment. On a more local scale, rock cliffs and associated features of the escarpment provide home for rare plants, ancient trees, and a rich assemblage of land snails, including relicts of post-glacial environments that have otherwise long disappeared from the region. Despite its obvious prominence as a geologic feature, the ecological significance of the Niagara Escarpment has only recently been demonstrated. Few of these studies of the escarpment's biota have been conducted in Wisconsin. However, careful studies of land snails during the 1990s suggest that future investigations of other taxa (especially invertebrates) will lead to new discoveries about the ecology and conservation value of the Wisconsin's Niagara Escarpment.

Recent studies have revealed a unique biota that deserves wider attention and increased conservation efforts, and our goal is to evaluate the biological significance of the Niagara Escarpment in Wisconsin and to help identify conservation needs and gaps in our current knowledge.

INTRODUCTION

In addition to its geologic and cultural significance, the Niagara Escarpment has helped sustain some of Wisconsin's most interesting and mysterious plants and animals. In several cases, significant populations have been discovered only recently, suggesting that future research might reveal additional species or ecological interactions that are linked to the escarpment's unique geology and microclimate. Destruction and degradation of native habitats, in addition to other factors, have led to the disappearance of wider-ranging species that once used the escarpment regularly. Nevertheless, the escarpment remains a significant ecological element in eastern Wisconsin; in fact, some of the little-known species found on the Niagara Escarpment are regionally and even globally significant.

Paleoecological studies from Ontario (Yu, 2003) and Wisconsin (Rech and others, 2012) have shown that after Pleistocene glaciation the region encompassing the Niagara Escarpment was characterized by a tundra-taiga landscape. By about 12,000 to 10,000 years ago, shrubby boreal habitats dominated by alder (*Alnus*), willow (*Salix*), and cedar (*Juniperus*) had given way to forests dominated by spruce (*Picea*) and, later, pine (*Pinus*). Mixed forests of eastern hemlock (*Tsuga*) and hardwoods such as beech (*Fagus*) and elm (*Ulmus*) became prominent by about 7,500 years ago and have persisted until modern times. Plants and animals of the escarpment have been drawn from these varying regional biotas, in some cases forming unique combinations of species

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from ancient environments and more recent landscapes. In this paper we describe some of the most prominent and special species that can be found in and near the Niagara Escarpment.

THE NIAGARA ESCARPMENT AS A LANDSCAPE FEATURE

Except for dramatic cliffs along the Green Bay shoreline in Door County and several other places such as High Cliff State Park in Calumet County, the Niagara Escarpment in Wisconsin is a narrow and relatively inconspicuous geologic feature embedded in a glacially derived landscape of till plains, moraines, and lake basins.

Before settlement, most of this landscape was forested, supporting a typical eastern North American flora and fauna of mesic deciduous forests and oak savannas. Any discussion of the animals and plants of the escarpment must consider the influence of this surrounding landscape. Biotic influences include the day-to-day movements of individual animals as well as the large-scale population dynamics of species that occur on both the escarpment and in the surrounding landscape.

Today, many of the forests and savannas of eastern Wisconsin have been fragmented or replaced by agricultural and urban land uses (Flader, 1983; Waller and Rooney, 2008). Unsurprisingly, these changes have influenced the composition of animal and plant populations on the Niagara Escarpment itself. Likewise, the ecological features associated with the escarpment (den sites, forest corridor, etc.) influence animal and perhaps plant populations in the surrounding landscape.

PLANTS OF THE NIAGARA ESCARPMENT

Several hundred species of vascular plants are clearly associated with the Niagara Escarpment in Wisconsin, and the number grows quickly if we include habitats that are influenced locally by the escarpment. The most consistently conspicuous species of the Wisconsin escarpment is northern white cedar (*Thuja occidentalis*), which often occurs above the cliffs as well as in cracks and ledges on the cliffs and at the base of the cliffs below the talus slope. In some cases, tall individuals of white pine (*Pinus strobus*) and red pine (*Pinus resinosa*) are present along the top of cliffs; a variety of somewhat dry forest habitats also may occur near the upper part of the escarpment. Paper birch (*Betula papyrifera*) is often conspicuous above and below the cliffs. In a very few locations, the rapidly disappearing Canada yew (*Taxus canadensis*) is abundant. On shaded cliff faces and especially on the talus slopes below, dense growths of bulblet fern (*Cystopteris bulbifera*) and the shrubs mountain maple (*Acer spicatum*) and red elderberry (*Sambucus racemosa*) are often prominent. A substantial number of native ferns can be found on cliff faces and associated boulders and talus slopes.

Studies of the Niagara Escarpment in southern Ontario have described the fascinating old-growth vegetation of cliffs (Larson and others, 1989; Larson and Kelly, 1991). Plant communities associated with the escarpment cover a physical gradient ranging from the exposed plateau at the top of the cliff to shady talus deposits at the base. The rocky cliffs themselves harbor ancient trees of wide-ranging species like northern white cedar and eastern red cedar (*Juniperus virginiana*), as well as locally rare or uncommon plant species like the maidenhair spleenwort (*Asplenium trichomanes*), dwarf cliff brake (*Pellaea glabella*, fig. 1), and bird's-eye primula (*Primula mistassinica*) (Larson and others, 1999b). Other more familiar plant species like Canada columbine (*Aquilegia canadensis*, fig. 2) and the fern *Polypodium virginianum* (fig. 3) thrive along the rocky cliff faces and outcrops associated with the Niagara Escarpment. Distinct assemblages of bryophytes, epilithic (rock-attached) lichens, and endolithic (within rock) algae and cyanobacteria have also been documented from cliffs of the Niagara Escarpment in Canada (Cox and Larson, 1992; Gerrath and others, 2000; and Matthes and others, 2000).

Trees and shrubs along Niagara Escarpment cliffs represent an often-overlooked old growth community type associated with rugged rock faces throughout the world (Larson and others, 1999, 2000). In the steepest cliffs of Wisconsin's Niagara Escarpment, stunted, slow-growing northern white cedar, eastern red cedar, and other tree species can persist for hundreds, sometimes thousands, of years. Cliff height, aspect, and rock type are not significantly correlated with the presence of ancient cliff woodlands; the primary factor in maintaining these unique communities appears to be simply imperviousness to human disturbance and fire (Larson and others, 2000). Likewise, uncommon Wisconsin plants like Canada yew are able to grow locally along Niagara Escarpment despite widespread

range reductions elsewhere due to browsing by white-tailed deer (*Odocoileus virginianus*) and domestic animals. Larson, Matthes-Sears, and Kelly (1999), whose studies began at the Niagara Escarpment of Ontario, maintain that extensive cliff outcrops, including portions

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of the escarpment in eastern Wisconsin, support some of the most ancient and least-disturbed wooded habitats on Earth.

In Wisconsin, several rare or uncommon forbs are known primarily from the Niagara Escarpment, including two rare members of the Brassicaceae (mustard family), rock whitlow-grass, *Draba arabisans*, and hoary whitlow-cress, *D. cana*. Rock whitlow-grass occurs on exposed dolomite cliffs, especially in shady forests dominated by northern white cedar. This small perennial is native from eastern Canada to New York, westward to Minnesota (Voss, 1985; Penskar and Crispin, 2008). It has been designated a species of special concern by the state. Hoary whitlow-cress is a plant of the North American arctic and alpine habitats in western North America, occasionally found in northern states of the eastern U.S. (Al-Shehbaz, 2010). In Wisconsin, this species is found only in Door County and has been designated endangered by the state. Other Wisconsin rare species occurring on the Niagara Escarpment include limestone oak fern (*Gymnocarpium robertianum*) and Allegheny-vine (*Adlumia fungosa*). If we include wet and dry habitats of shallow soil over the Niagaran rocks, we can add to this list species such as elk sedge (*Carex garberi*), small-flowered grass-of-parnassus (*Parnassia parviflora*) and spoon-leaf moonwort (*Botrychium spathulatum*), a species known in Wisconsin from only a

Figure 1. *Dwarf cliff brake (*Pellaea glabella*) is characteristic of rocky habitats along the Niagara Escarpment in eastern Wisconsin.*

Figure 2. *Flower of Canada columbine (*Aquilegia canadensis*), a widespread plant that is common in slopes and forest openings of the Niagara Escarpment.*

Figure 3. *The fern,* Polypodium virginianum*, is tolerant of periodic drying (Reynolds and Bewley, 1993) making it well adapted to rock outcrops associated with the Niagara Escarpment.*

single location in Door County. Other uncommon but more widely distributed species such as small white lady's slipper (*Cypripedium candidum*), snow trillium (*Trillium nivale*), and low calamint (*Calamintha arkansana*) also occur on the calcareous substrates associated with the Niagara Escarpment (Anderson and others, 2002).

ANIMALS OF THE NIAGARA ESCARPMENT

Animals associated with the escarpment can be grouped into two general categories: (1) wide-ranging species that use the escarpment seasonally or temporarily for shelter or feeding and (2) small animals or micro-organisms that are permanent residents in the unique microhabitats of the escarpment. Not surprisingly, species in the latter category are relatively unnoticed by the general public and some may even await discovery.

Bats are probably the clearest examples of animals that use the Niagara Escarpment for part of their daily or seasonal activity schedule. At least four of Wisconsin's bats (little brown myotis, *Myotis lucifigus*; northern long-eared myotis, *Myotis septentrionalis*; big brown bat, *Eptesicus fuscus*; and tri-colored bat, *Perimyotis subflavus*) inhabit caves as roost sites or winter hibernacula (Barbour and Davis, 1969; Kurta, 1995; Tuttle and Taylor, 1998). At the Neda Mine in Dodge County, an estimated 150,000 to 200,000 individuals of these four species use the mine as an overwintering refuge, making it one of the largest (if not the single largest) bat hibernacula in the Midwest. The mine opens on an exposure of the Niagara Escarpment that is today a designated Wisconsin State Natural Area. Although this feature was created by human excavation of the Iron Ridge/Neda iron formation in the late 1800s and early 1900s (Frederick, 1993), the concentration of bats demonstrates the regional significance of caves for bat populations (Tuttle and Taylor, 1998). The Niagara Escarpment supports the largest number of underground caves in Wisconsin (Kluessendorf, 2010), and bats undoubtedly use many of these caves for roosting and overwintering. Along its entire length, the Niagara Escarpment is likely a major contributor to bat populations in Wisconsin and nearby states. The emergence of white-nose syndrome in bats of eastern North America (Blehert and others, 2009) underscores the importance of multiple bat roosting sites for conserving bat populations.

Other Wisconsin mammals use caves and crevices for shelter (for example, Fitch and Shirer, 1970; Weller and Pelton, 1987; Endres and Smith, 1993; Kurta, 1995). Bobcats (*Lynx rufus*), for example, frequently use rock outcrops as den or resting sites (Bailey, 1974; Anderson, 1990), although rocky habitats like those associated with the Niagara Escarpment are only used temporarily and individuals are able to survive and reproduce in the absences of rocky shelters (Kolowski and Woolf, 2002). Mammal species that have been shown to use rock crevices and caves when available include Virginia opossum (*Didelphis virginiana*), eastern chipmunk (*Tamias striatus*), porcupine (*Erethizon dorsatum*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), gray fox (*Urocyon cinereoargenteus*), and black bear (*Ursus americanus*). Like bobcats, these species undoubtedly use or have used caves and crevices of the Niagara Escarpment. Indeed, rocky crevices and small caves of the Niagara Escarpment might be more important than ever because alternative denning sites like hollow logs, large stumps, and tree cavities are less common than they were before the replacement of old growth forest by agricultural land and secondary forests (Frelich, 1995). No comprehensive study has explored the importance of the Niagara Escarpment as a refuge for non-flying mammals. Nevertheless, use of denning sites along the escarpment is dependent on the availability of other habitats nearby. The rugged terrain of the escarpment has largely prohibited certain land uses like farming, but the width of the natural corridor and land use in the adjacent landscape might be the most important factor in determining the mammal fauna associated with the Niagara Escarpment today.

The availability of nearby habitats is likely even more important for birds, which can easily fly to and from distant feeding or roosting areas. Two bird species, turkey vulture (*Cathartes aura*) and peregrine falcon (*Falco peregrinus*), use the Niagara Escarpment for nesting. Mossman (2006) noted that about half of the turkey vulture nests reported during the Wisconsin Breeding Bird Atlas survey were located in rock outcroppings, including sites along the Niagara Escarpment. Turkey vultures fly great distances from their nests for feeding, so the importance of places like the Niagara Escarpment for this species can be easily overlooked. Peregrine falcons no longer nest on cliffs of the Niagara Escarpment in Wisconsin, although historical records document peregrine nesting on the steep cliffs in Door County (Septon, 2006). As populations of this

Figure 4. *Red-backed salamander (*Plethodon cinereus*), a common inhabitant of forested habitats along the Niagara Escarpment in Wisconsin.*

species continue to recover in eastern North America, re-establishment of nesting sites in Door County cliffs are possible, if not likely.

Specialized cliff-nesting species like cliff swallow (*Petrochelidon pyrrhonata*) now make extensive use of human-made structures for nesting, although even today 11 percent of the cliff swallow nests reported in the Wisconsin Breeding Bird Atlas were located on natural cliffs (Davis and Davis, 2006). Common raven (*Corvus corax*), red-tailed hawk (*Buteo jamaicensis*), and great horned owl (*Bubo virginianus*) occasionally use cliffs for nesting (Watts, 2006), but the large majority of the nests of these species are located in trees.

Matheson and Larson (1998) conducted a community-level analysis of bird assemblages along the Niagara Escarpment in Ontario, Canada. The escarpment provides natural edge-related habitats and microhabitats that are atypical in continuous forest landscapes of the region. Consequently, species like eastern phoebe (*Sayornis phoebe*), warbling vireo (*Vireo gilvus*), cliff swallow, winter wren (*Troglodytes hiemalis*), and dark-eyed junco (*Junco hyemalis*) are present, leading to higher species richness than in typical forests of Ontario. Matheson and Larson recognized four habitat zones associated with the escarpment: plateau, cliff edge, cliff face, and talus slope, the last three occurring on the escarpment itself. Overall, the three escarpment zones yielded higher species richness than the adjacent plateau forest. At the same time, birds of forest interior were present in the vicinity of cliffs, suggesting that the negative effects of forest edge (Yahner, 1988) do not necessarily apply to openings associated with Niagara Escarpment cliff faces. Matheson and Larson concluded that the Niagara Escarpment provides habitat qualities that are not found in adjacent closed-canopy forests, while at the same time causing no significant negative effects on forest interior species.

Whereas birds and mammals typically include the Niagara Escarpment as only a small (but often important) portion of their home range, less mobile animals like reptiles, amphibians, and invertebrates rely more continuously on the rocky habitats for day-to-day activities. Several species of snakes use rocky crevices and talus along the escarpment for winter hibernacula and for temporary shelter throughout the year, especially in the vicinity of open habitats. Eastern garter snake (*Thamnophis sirtalis*), eastern milk snake (*Lampropeltis triangulum*), northern ring-necked snake (*Diadophis punctatus edwardsii*), northern red-bellied snake (*Storeria occipitomaculata*), DeKay's brown snake (*Storeria dekayi*), and western fox snake (*Elaphe vulpina*) have been observed by us or reported by others in rocky habitats along the Niagara Escarpment. The venomous timber rattlesnake (*Crotalus horridus*) once occurred on the Niagara Escarpment in Ontario (Environment Canada, 2010) and probably also lived along the Escarpment in Wisconsin, although no documentation exists.

Forested talus slopes along the Niagara Escarpment provide ideal habitat for red-backed salamanders (*Plethodon cinereus*, fig. 4) and other animals that live in moist soil under leaf litter, rocks, and debris. A large population of red-backed salamanders lives in the vicinity of the Niagara Escarpment in Brown County and probably along the entire length of the escarpment in Wisconsin. Ongoing studies by students at the University of Wisconsin-Green Bay have shown that salamander populations are much higher in the vicinity of rocky

outcrops along the escarpment than in the surrounding forest. Perhaps like many other escarpment-associated animal species, salamander numbers vary seasonally and respond to local weather conditions.

Spring-fed ponds at the base of the Niagara Escarpment in eastern Wisconsin support isolated populations of blue-spotted salamander (*Ambystoma laterale*) and other species of interest such as fairy shrimp (*Eubranchipus* sp.) and frogs (spring peeper, *Pseudacris crucifer*, for example). Relatively undisturbed vernal ponds have become rare in Wisconsin (Reinartz, 2003; Jass and Klausmeier, 2006), so these habitats, fairly common below some segments of the Niagara Escarpment, deserve future research and protection efforts.

Perhaps the most interesting element of Wisconsin's Niagara Escarpment biota is the unique assemblage of land snails that have been described in a number of papers, including Nekola, Smith, and Frest (1996), Nekola and Smith (1999), and Nekola (2003). Initially reported in unpublished reports and conservation assessments, Frest and later Nekola led surveys to document extant populations of rare Upper Midwest land snails, some of which were known previously only as Pleistocene fossils or from widely disjunct montane/boreal regions (Nekola 1999a; Ostlie, unpub. report). Like relict snails of northern Eurasia (Horsák and others, 2010), a unique assemblage of land snails in North America once inhabited cool, moist environments near the margins of Pleistocene glaciers (Kuchta, 2009). Since the retreat of the glaciers, beginning approximately 18,000 years ago (Pielou, 1991), many Midwestern snail populations became extinct or retreated to highly localized microhabitats. For example, in the Paleozoic Plateau of northeastern Iowa and adjacent parts of Minnesota, Wisconsin, and Illinois, algific (cold-producing) talus slopes provide cold airflow from subterranean ice that persists throughout the year (Howe, 1984; Nekola, 1999b). These slopes provide microenvironments for otherwise out-of-place plants and animals such as the boreal plant, *Chrysosplenium iowense* (Levsen and Mort, 2008), and the federally endangered land snail, *Discus macclintocki* (Ross, 1999).

During the 1990s Nekola and students from the University of Wisconsin–Green Bay discovered populations of Pleistocene relict land snails and a wide variety of other snail species (fig. 5) along the Niagara Escarpment in Brown and Door Counties of northeastern Wisconsin (Nekola and others, 1996; Nekola and Smith, 1999). In their initial report, Nekola and others (1996)

Figure 5. Zonitoides arboreus*, a common land snail found along the Niagara Escarpment in northeastern Wisconsin. Rarer species, typically smaller than this snail, were documented along Wisconsin's Niagara Escarpment by Jeffrey Nekola and students in the 1990s.*

documented 12 notable land snail taxa (subspecies, species, or species groups) at study sites associated with the Niagara Escarpment (table 1). Subsequent studies (Nekola, 2003; Nekola and Coles, 2010; Ostlie, unpub. report) have re-interpreted these findings based on new field data and more detailed taxonomic analyses, but the significance of the Niagara Escarpment for land

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snails has not been diminished. In fact, the disjunct distribution of rare snail populations along the Niagara Escarpment in northeastern Wisconsin suggests that they have experienced a unique postglacial history that is mostly, if not entirely, independent of land snail populations in the Paleozoic Plateau of southwestern Wisconsin and nearby states.

Land snail distributions (Hubricht, 1985, Nekola, 2003) underscore the ecological importance of the Niagara Escarpment. Nekola and Smith (1999) reported extremely high species richness of snails along the Niagara Escarpment, reaching 21 species per square meter at one site (Nekola and Smith, 1999). Richness was significantly greater near the base of the cliff, especially at undisturbed, forested localities. Cliffs of the Niagara Escarpment in Wisconsin lack the cold-air circulation patterns of algific

Table 1. Unique or relict land snails along the Niagara Escarpment of the Door Peninsula in northeastern Wisconsin.

Scientific name	Habitat and range	Notes
Carychium exile canadense	Present in cliff communities in Brown and Door Counties. This subspecies is locally distributed in northern states (Hubricht, 1985); *C. exile* species is considered common in deciduous forest leaf litter in much of eastern North America (Lewis, 2002).	
Catinella gelida	Dry areas of algific talus slopes and cold cliff microhabitats. Found at a single Brown County study site, where it is common. Also present in northeastern Iowa and Black Hills of South Dakota.	State status:[a] special concern. Rare glacial relict. Shell characteristics are distinctive. Discovered by Frest in northeastern Iowa in 1983.
Gastrocopta corticaria	Limited to rock outcrops. Found locally on ledges and wooded calcareous outcrops across much of eastern North America, including eastern Wisconsin south from Door Peninsula.	
Hendersonia occulta	Found in algific talus slopes or cool, forested rock outcrops and cliffs. Known from numerous localities near western Lake Michigan shore.	State status:[a] threatened. Glacial relict. Common as a fossil in central U.S.
Paravitrea multidentata	Limited to rock outcrops and upland forests. Rare in Wisconsin but fairly widespread in eastern North America.	State status:[a] special concern. Reported from 68 sites by Nekola (2003), primarily in Door County.
Striatura exigua	Mesic forest species. Fairly widespread in northeastern North America.	State status:[a] special concern. Reported from 70 sites by Nekola (2003).
Striatura ferrea	Found in forests, especially in lowlands. Widespread in northeastern Wisconsin and eastern Upper Peninsula of Michigan.	State status:[a] special concern.
Succinea bakeri	Habitat and range uncertain (see note).	Glacial relict. Taxonomy of this group is notoriously problematic. Early identifications from Niagara Escarpment might have been incorrect (Ostlie, unpub. report)—specimens probably not *S. bakeri*, which is otherwise known only from Pleistocene fossils.
Vallonia cyclophorella	Primarily found in dry conifer forests of western U.S. (Hendricks, 2012).	Glacial relict.
Vertigo bollesiana	Found in rock outcrops in moist forests of Door Peninsula. Nekola (2003) reported this species from 73 stations in Door County and eastern Wisconsin and the eastern Upper Peninsula of Michigan. Also found locally but widely in northeastern North America.	
Vertigo hubrichti group	Found in cool microclimates in leaf litter, especially in northern white cedar forests. Found widely on rock outcrops of Door Peninsula and at about 50 sites on Paleozoic Plateau of southwestern Wisconsin and adjacent states. Also reported from scattered localities in eastern Canada along Niagara Escarpment.	State status:[a] endangered. Originally described as a Pleistocene fossil.
Vertigo pygmaea	Found in a variety of habitats including roadsides and disturbed grasslands (Nekola, 2003). Fairly widespread in northeastern North America.	Some populations may have been introduced from Europe (Nekola and Coles, 2010).

[a]State status (protection categories designated by the Wisconsin DNR): **Endangered** = species whose continued existence in Wisconsin is in jeopardy; **threatened** = species which appears likely to become endangered within the foreseeable future; **special concern** = species about which some problem of abundance or distribution is suspected but not yet proven.

talus slopes from the Paleozoic Plateau of northeastern Iowa and nearby parts of Minnesota, Wisconsin, and Illinois (Howe, 1984; Nekola, 1999b), but the effects of shade, aspect, and climate amelioration by Lake Michigan might combine to favor the persistence of relict land snails and other small organisms (Nekola, 1999b). Frest and Johannes (unpub. report) attributed the biological significance of the Niagara Escarpment and nearby habitats to special microclimatic conditions of soil, temperature, and relative humidity, influenced significantly by proximity to a large lake (Ostlie, unpub. report). The importance of these local microclimate conditions to other organisms deserves further study.

CONCLUSION

The Niagara Escarpment is important to plants and animals at multiple scales. The rugged topography and shallow soils have helped protect forest and natural habitats from intense development, benefitting both wide-ranging and local species. On a smaller scale, microhabitats associated with north- or northwest-facing rock outcrops along the escarpment, perhaps further influenced by the climatic effects of Lake Michigan, have created cool, moist conditions that harbor unique species like Pleistocene relict land snails and perhaps undiscovered populations of other rare taxa. Efforts to protect these habitats and microhabitats are important. The cliff faces, in particular, are sensitive to disturbance and should be a high priority for careful management. Hiking and rock climbing activities concentrated at the base of the cliffs can be particularly damaging (McMillan and others, 2003). Other priorities that will help sustain populations of unique Niagara Escarpment plants and animals include maintenance of an intact forest canopy, establishment of minimally disturbed buffer zones, and protection or restoration of natural biophysical processes such as hydrologic drainage patterns (Moss and Milne, 1998; Niagara Escarpment Commission, 2005).

Viable populations of large or wide-ranging animals that use the Niagara Escarpment require large areas of suitable habitat. Due to the narrow geographic region occupied by the Niagara Escarpment, protection of remnant natural areas along this corridor will make a modest contribution, at best, toward conservation of these species. However, viable populations of small species like land snails and salamanders require much less area, and formal protection of remnant natural or semi-natural areas along the Niagara Escarpment can have an extremely high benefit-cost ratio. Conservation of critical habitats for these species might literally involve the enlightened management of a single landowner's backyard.

Studies by Larson, Nekola, and others have demonstrated that careful research along the Niagara Escarpment reveals a unique but fragile biota (Haig and others, 2000). The composition of this biota and the ecological interactions on which they depend are just beginning to be appreciated. Finally, given the sensitivity of many escarpment species to unusual microclimate conditions, identification and regular monitoring of local populations can play a major role in understanding and mitigating the impacts of climate change on native plants and animals in the western Great Lakes region.

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