THE GREAT LAKES ISLANDS COLLABORATIVE
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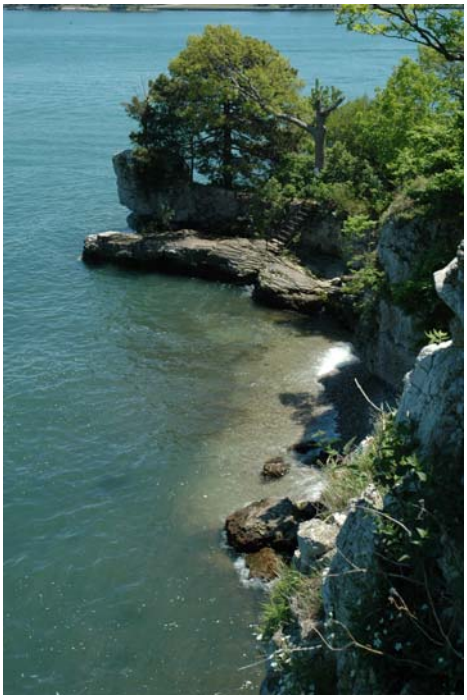
# GREAT LAKES ISLANDS WORKSHOPS
JULY AND AUGUST 2006



For today's workshop, we have put together a package of information regarding some of our accomplishments to date. The *Biological Ranking Criteria for Conservation of Islands in the Laurentian Great* Lake report, the 2004 International Association for Great Lakes Research session on Great Lakes islands, and State of the Lakes Ecosystem (SOLEC) island indicators are completed. Forthcoming are the island workshops and *Framework for the Binational Conservation of Great Lakes Islands* report.

Please check our website for details.

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**GREAT LAKES ISLANDS COLLABORATIVE**

**2006 Island Workshop Schedule and Program**

## PROGRAM

Open House: View maps and talk with presenters
PowerPoint Presentation: Latest information about Great Lakes islands
Question-and-answer period
Dialogue: Opportunity to network and discuss follow-up

## SCHEDULE

| Date | Location | Details |
|---|---|---|
| Friday<br>July 28, 2006<br>11 a.m. - 2 p.m. | **Traverse City, Michigan**<br>Hagerty Conference Center, Northwestern Michigan College, 715 E. Front Street, Traverse City, Michigan<br>(231) 995-1146<br>www.nmc.edu/hagertycenter | Room 112<br>A light lunch will be provided. At 2 p.m. we may be able sail on the *Inland Seas* to Power Island, returning about 5:30 p.m. |
| Monday<br>July 31, 2006<br>1 p.m. - 4 p.m. | **Thunder Bay, Ontario**<br>Prince Arthur Waterfront Hotel, 17 N. Cumberland St., Thunder Bay, Ontario<br>(800) 267-2675 for room reservations | Bertrand Room<br>A block of rooms under "Island Workshop" is held at $79.95/night |
| Thursday<br>August 3, 2006<br>1 p.m. - 4 p.m. | **Grosse Ile, Michigan**<br>EPA Large Lakes Research Station, 9311 Groh Road, Grosse Ile, Michigan 48138<br>(734) 692-7600 | Assembly Hall — Bldg. is at the south intersection of Meridian & Groh roads |
| Monday<br>August 21, 2006<br>1 p.m. - 4 p.m. | **Clayton, New York**<br>Clayton Opera House, 405 Riverside Drive, Clayton, New York (315) 686-2200 | The main auditorium |

For more information, email info@greatlakesislands.org or call Megan Seymour at (614) 469-6923 ext. 16 or Dr. Karen Vigmostad at (313) 530-2558. $50 honorariums are available for members of NGOs, tribes, and First Nations. See website: www.greatlakesislands.org.

## Biological Ranking Criteria For Conservation of Islands in The Laurentian Great Lakes

This peer-reviewed report presents the scientific criteria underlying this project. Island team member David N. Ewert of the Nature Conservancy's Great Lakes Program Office was lead author with co-authors Michele DePhilip, August Froehlich (The Nature Conservancy, Dublin, OH) and another island team member, Daniel Kraus (Nature Conservancy of Canada, Guelph, ON). Funding was from the U.S. Fish and Wildlife Service and GLNPO.

Copies are available by request from Nature Conservancy's Great Lakes Program Office and on-line at http://www.greatlakesislands.org/islands_products.htm.

*Recommended citation: Ewert, D.N., M. DePhilip, A. Froehlich and D. Kraus. 2004. Ranking biological criteria for conservation of islands in the Laurentian Great Lakes. Final report to the U.S. Fish and Wildlife Service.*

## Framework for the Binational Conservation of Great Lakes Islands

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# Chapter Three: The Islands of the Great Lakes

## GREAT LAKES ISLANDS: BIODIVERSITY ELEMENTS

In this chapter we provide information and perspectives on the biodiversity of Great Lakes islands—the largest collection of freshwater islands in the world—that complement and update previous excellent reviews of island biodiversity (Soule 1993, 1999). This review is not intended to be a complete review of Great Lakes island biodiversity literature (see Soule 1993 for a comprehensive island research bibliography for Michigan), but rather to provide background information to help focus island conservation programs.

## GREAT LAKES ISLANDS: ABIOTIC FEATURES

The physical setting of Great Lakes islands was well described by Soule (1993):

> Sprinkled across all five of the Great Lakes, thousands of islands form a landscape unique in the world. Nowhere else does the combination of vast, interconnected, mid-continental bodies of freshwater and such a number and variety of islands occur.

Found from $49^0$ to $41^0$ N and $92^0$ to $76^0$ W, islands occur in different climatic zones and thus support a wide range of species and natural communities.

The biological diversity and distinctiveness of Great Lakes islands is due to the interaction of several factors, which include: (1) island size, (2) isolation of the island from the mainland and other islands, (3) latitude and longitude of the island, (4) bedrock (e.g., metamorphic, igneous, sandstone, and limestone) and surficial soils of the island, (e.g., silt, glacial till, and sand, see Boerner 1984), (5) exposure to wave action, (6) influence of near shore bathymetry on island dynamics, (7) effects of fluctuating water levels on islands, (8) climate, current and historical, especially microclimates generated by the Great Lakes (see Eichenlaub 1979), and (9) the amount of time islands have been isolated from the mainland.

### *CLIMATES AND REFUGIA*

Lake Erie islands and the Apostle Islands, like many other Great Lakes islands, tend to have warmer winters, later springs, cooler summers, and longer lasting autumns than adjacent mainland areas; these effects are especially pronounced for islands furthest from the mainland (Heredendorf and Stuckey 1977, Judciewicz and Koch 1993; see Eichenlaub 1979). Consequently islands serve as refugia, or "safe havens," for many species and communities during periods of environmental stress, as they have in the past and may in the future. Davis et al. (2000) noted that,

> The contrast in reconstructed temperatures at Voyageurs and Isle Royale indicates that the ameliorating effect of the Great Lakes on temperatures has been in effect throughout the Holocene and presumably will continue in the future, thus reducing the potential for species loss caused by future temperature extremes....If future temperature changes, like those in the past,

are buffered by lake effects, lakeside parks will continue to serve as temporary refuges for animals and plants that may not be able to survive at inland sites. Of course, large and continuing regional changes in temperature will eventually be felt in lakeside parks as well."

## GEOLOGICAL HISTORY

The 31,407 islands of the Great Lakes are geologically recent, having appeared only in the last 15,000 to 2,500 years (see Dorr and Eschman 1970). Because of their isolation and complex history (e.g., islands have at various times been submerged or connected with the mainland, been of different sizes, and degrees of isolation), many islands lack species common on the mainland, support other species in great abundance, or harbor species largely restricted to islands given their land area. This unusual species composition, including Great Lakes endemic species and communities, results in island biotas that are globally distinctive and therefore of great importance (Soule 1993).

## ISLANDS: BIOTIC PATTERNS OF DISTRIBUTION AND MODES OF DISPERSAL

### *PATTERNS OF DISTRIBUTION*

Biological diversity patterns have been generally described for islands: (1) larger islands tend to be more species-rich than small islands, (2) less isolated islands tend to be more species-rich than more isolated islands, (3) species-richness is lower on small, isolated islands than on large, less isolated islands due to higher extinction rates and slower colonization rates (McArthur and Wilson 1963, 1967), (4) high rates of endemism are found on islands, especially islands that have been isolated for long time periods (tens of thousands to millions of years) and (5) some species are absent or disproportionately abundant on islands. Many of these concepts best apply to oceanic islands but these principles apply to other islands, including Great Lakes islands, and islands of terrestrial habitat.

In addition, islands may support (1) relict species and plant communities, (2) unusual or high quality plant communities due to the absence of some biota (e.g., some herbivores or invasive species), (3) high concentrations of migrating and nesting birds, perhaps migratory bats and other taxa (e.g., snakes), and (4) important spawning areas for fishes in offshore shoals (Manny 2004). These characteristics are among the properties that define island biotas and thus their importance for conservation purposes.

### *MODES OF DISPERSAL*

The biota of an island is dynamic. For islands once part of the mainland, species composition includes the original suite of species that has persisted plus those species that have dispersed to the island. Mechanisms that bring species to islands include flotsam, air transport (e.g., seeds carried to the island via birds or bats), swimming to or walking over ice from the mainland, deliberate or accidental anthropogenic introductions, and wind (see Scharf 1973; Morton and Hogg 1989). For example, all but 6.5 percent of approximately 210 plant species on Barrier Island, Lake Huron, Ontario, have adaptations for dispersal by water or birds (Morton and Hogg 1989). It has been postulated that certain reptiles and amphibians arrived on some Great Lakes islands via flotsam (see Hatt et al. 1948) or simply carried by water currents to island shorelines. Gulls are thought to transport seeds of plants on their feathers and feet and via disgorged pellets when they fly from mainland feeding sites to island nesting

areas (Hogg and Morton 1983). Migratory birds visit islands frequently during migration; some remain to breed (see Scharf 1973). Mammals, such as Black Bears (*Ursus americanus*), are known to cross water barriers of at least several kilometers to visit islands (Cortin 1976) while non-hibernating mammals, such as Coyotes (*Canis latrans*), wolves *(Canis lupus)*, and cervids travel to islands over the ice (Judziewicz 2001; Peterson 1995), thereby increasing their chances of colonization, even if they remain for short periods of time . Anthropogenic activities may be increasingly important mechanisms for dispersing species to islands. Some introductions are deliberate, including introduction of White-tailed Deer (*Odocoileus virginianus)* to islands in the Beaver Island archipelago (Hatt et al. 1948), while other introductions are almost certainly accidental, such as the arrival of Garlic Mustard (*Alliaria petiolata*) on Washington Island in Lake Michigan (Judziewicz 2001).

Possibly all but the smallest islands have received new species through either direct or indirect anthropogenic activity and this trend is likely increasing. Non-native, invasive species occur on every Apostle island (Judziewicz and Koch 1993), Isle Royale (Slavik and Janke 1993), all islands of the Grand Traverse archipelago (Judziewicz 2000) and relatively small, isolated islands of the Beaver Island archipelago (Whately et al. 2005).

## GREAT LAKES ISLANDS: BIOTIC FEATURES

The biota of Great Lakes islands is almost entirely a subset of the regional biota (Lomolino 1994, Hecnar et al. 2002. Although the biota of islands is most similar to the immediate Great Lakes mainland shoreline, Great Lakes islands have an extremely diverse biota including endemic species, a subspecies of snail on Lake Erie islands (Herendorf and Stuckley 1977), and even some species, such as the Lake Erie Watersnake (*Nerodia sipedon insularum)*, whose populations are concentrated on islands. Distinctive plant communities composed of many rare species, including refugia for boreal and other communities, characterize many islands. Canadian islands, for example, support 100 percent of Canadian populations of 35 species and 18 communities and over 50 percent of the Canadian distribution of 113 species and 38 communities (*fide* Mary Harkness, The Nature Conservancy, personal communication).

It is likely that populations of other animal and plant species, especially those resident on islands, will diverge from their mainland counterparts. The Lake Erie Watersnake (*Nerodia sipedon insularum)*, which evolved from the Northern Watersnake (*Nerodia sipedon sipedon*), is a striking example of this divergence as is the relatively high incidence of melanistic Eastern Garter Snakes (*Thamnophis sirtalis*) on western Lake Erie islands (see King et al. 1997). Other island populations, including Black Bears on the Apostle Islands (Belant et al. 2002) genetically differ from mainland populations.

Island populations also differ from mainland populations ecologically and morphologically. Southern Red-backed Voles (*Clethrionomys gapperi)* occupy ecological niches on Poverty Island that are distinct from the mainland (Judziewicz 2001), and Deer Mice (*Peromyscus maniculatus gracilis*) on the Grand Traverse Islands, Lake Michigan, have smaller cranial measurements than those on the mainland (Long 1978). Although some differences between island and mainland populations have occurred, there are also examples where this has not been the case such as the pollination system of the Bird's-eye Primrose (*Primula mistassinica*) (Larson and Barrett 1998).

Great Lakes islands are important conservation areas that support distinctive flora and fauna (Soule 1993, Soule *in* Vigmostad 1999) and, with time, more distinctive flora and fauna are likely to evolve. In short, the freshwater islands of the Great Lakes support a globally important set of diverse flora, fauna, and natural communities. The wide latitudinal and longitudinal distribution of the islands and the range of underlying bedrock and surficial glacial deposits have produced a rich biotic community. Given the complexity of interactions that govern dispersal and survival of organisms, and vast array of islands distributed over the large Great Lakes region, it is no surprise that the flora and fauna of Great Lakes islands is so complex and diverse.

## *SPECIES RICHNESS AND SUSCEPTIBILITY TO CHANGE AS A FUNCTION OF ISLAND SIZE*

### *Species richness and island size and isolation*

Species richness of islands is reduced when compared to plants and animals on the adjacent mainland; this observation is consistent with relatively small islands elsewhere in the world. For example, the Beaver Island archipelago, Lake Michigan, supports only 62 percent of the mainland amphibian fauna, and 60, 66, 87, and 39 percent of the snake, turtle, bird and mammal faunas, respectively (Hatt et al. 1948). The relatively depauperate species richness for taxa on islands relative to the mainland has also been described for Isle Royale, Michigan (*in* National Park Service 1998), the Apostle Islands (Belant and Van Stappen 2002), Grand Traverse archipelago, Lake Michigan (Long and Long 1976, Long 1978), Huron Islands, Lake Superior (Corin 1976), South Manitou Island, Lake Michigan (Scharf 1973), and islands in Lake Erie (Heredorf and Stuckley 1977).

Large Great Lakes islands tend to have higher species richness than small islands. Plant species richness, for example, is positively correlated with island size on the Grand Traverse islands in Green Bay, Lake Michigan (Judziewicz 2001), Apostle Islands in Lake Superior (Judziewicz and Koch 1993) and the Beaver Island archipelago (Whately et al. 2005). Larger numbers of mammal species are associated with larger islands on the Grand Traverse islands where there are as few as three species of mammals on 490-acre Little Summer Island, but 12 species on 14,000-acre Washington Island (Long 1978). Similarly, there are fewer mammal species on small islands than large islands on the Apostle Islands (Belant and Van Stappen 2002); island area and winter activity of mammal species were the primary determinants of species composition on this archipelago. Island isolation was not a key factor affecting mammal distribution on the Apostle Islands even though the islands are close to the mainland and each other. Similarly, non-volant mammal species richness (Lomolino 1994) and amphibian and reptile species richness (Hecnar et al. 2002) appear to be less associated with island isolation than island size.

Species richness on islands is not only a function of size and isolation but probably also reflects time since isolation and habitat diversity. Hazlett (1988) in Voss (2001) noted that for recently formed islands, the amount of habitat diversity, itself a result of topographic, edaphic and other factors, may be an important determinant of plant species richness. In addition, human activities have influenced species richness through extirpation (see Hatt et al. 1948) and species introductions.

***Susceptibility to change***

The relatively small size and isolation of islands favors the potential for rapid change (Judziewicz 2001) and make islands especially vulnerable to change from natural processes and human-induced activities. For example, rapid ecological changes on islands occur as a result of fluctuating water levels that may inundate islands or alter shoreline habitat for birds and plants (e.g., Cuthbert 1985), increases in deer density (Judziewicz 2001) following natural dispersal or planned introductions, and in response to the colonization and abandonment of an island by colonial nesting birds (Hogg and Morton 1983, Hebert et al. 2005). Finally, impacts on communities and entire ecosystems have been well documented as a result of colonization of aquatic and terrestrial systems by numerous invasive species in the Great Lakes and islands may be particularly at risk. These observations confirm that extra care be exercised, for example, to avoid bringing non-native species to islands, perhaps especially small islands. However, given the generally small land mass and isolation of most Great Lakes islands, eradication programs can be especially successful, as has been demonstrated on islands world-wide (see Veitch and Clout 2002).

## SPECIES AND COMMUNITY COMPOSITION ON GREAT LAKES ISLANDS

***NO ISLAND IS THE SAME***

Although a very few species may be found on many islands throughout most of the Great Lakes, most species have a patchy distribution on islands. This patchy distribution can be seen at large scales (e.g., among archipelagos) and small scales (e.g., islands within an archipelago). Although virtually each island, even islands close to each other, has a unique species assembly, some species appear to be quite widespread on islands and other species are consistently absent from Great Lakes islands even when present on the closest mainland areas.

Some species, whose range includes all or much of the Great Lakes basin, are also commonly found on islands in each of the Great Lakes. Examples include a diverse set of taxa including the American Toad (*Bufo americanus*) (see Hatt et al. 1948, Long and Long 1976, Scharf 1973, Corin 1976, National Park Service 1998), Eastern Garter Snake (*Thamnophis sirtalis*), (see Hatt et al. 1948, Scharf 1973, Long and Long 1976, Corin 1976 , Herendorf and Stuckley 1977, National Park Service 1998, Tiessen 2003), Song Sparrow (*Melospiza melodia*) (see Hatt et al. 1948, Scharf 1973, Corin 1976, Cadman et al. 1987, Peterjohn and Rice 1991, Apostle Islands National Lakeshore annual research, monitoring and restoration report 2004, Penskar et al 2001), and Woodland Deer Mouse (*Peromyscus maniculatus)* (Burt 1948, Hatt et al. 1948, Scharf 1973, Corin 1976, Long 1978) . Why these species are typically found on islands is largely unknown, but each is common, have broad geographical ranges, and is seemingly ecologically resiliant; at least one these species, Song Sparrow, is common in habitat fragments (Crook et al. 2004), which have much edge as do many islands. Other taxa, such as the American Redstart (*Setophaga ruticilla*), are frequent on islands (see Hatt et al. 1948, Corin 1976, see map in Cadman et al. 1987; Peterjohn and Rice 1991, Apostle Islands National Lakeshore annual research, monitoring and restoration report 2004, Penskar et al. 2001). This species, also common along many mainland forested shorelines, may select islands because of the relative abundance of aquatic-dependent volant insects (Ewert, Hamas and Smith, unpublished data).

By contrast, some species are typically absent from islands except perhaps for the very largest islands such as Manitoulin or Isle Royale. Ruffed grouse, short distance flyers, and large, wide

ranging mammals such as Black Bear are among the species frequently absent from islands, especially relatively small and isolated islands, except where introduced. However, Black Bears have prospered on Stockton Island, Apostle Islands, Lake Superior (Peggy Burkman, Apostle Islands National Lakeshore, personal communication) after swimming to the island and occur on some large islands close the mainland, such as Drummond Island, Michigan (Baker 1983). Even many species of small rodents and others such as cottontail rabbits *(Sylvilagus floridanus)* are frequently absent from islands. For example, common mammals on the mainland, e.g., White-footed Mouse (*Peromyscus leucopus*), Cottontail Rabbit (*Sylvilagus floridanus*), American Beaver (*Castor canadensis)*, American Badger (*Taxidea taxus*), Long-tailed Weasel (*Mustela frenata*), Mink (*Mustela vison)*, and Black Bear, are largely absent from the Grand Traverse (Long 1978) and Beaver Island archipelagos (Hatt et al. 1948) except where introduced. Clearly dispersal ability and seasonal activity patterns strongly influence species compostion on islands.

Island archipelagos differ in species composition. The mammal fauna of two archipelagos in the same Great Lake at the same latitude reveals interesting contrasts. For example, the Grand Traverse islands in Green Bay, Lake Michigan, lack Eastern Chipmunks (*Tamias striatus*) but Eastern Chipmunks are abundant on the Beaver Island archipelago (Hatt et al. 1948), which is barely 60 miles away. However, Red squirrels are absent from the Beaver Island archipelago but occur on most Grand Traverse islands (Long 1978) as well as the Isle Royale and Apostle islands (Hatt et al. 1948). The boreal fauna, however, is similar between the Grand Traverse and Beaver Island groups (Long 1978). Additionally, the Apostle Islands also lack Eastern Chipmunks but support Red Squirrels (see Smith and Maragi 2004) while the Huron Islands, Lake Superior, have neither Red Squirrels nor Eastern Chipmunks (Corin 1976). Distribution knowledge of these two species of squirrels highlights the idiosyncratic distribution patterns of species on Great Lakes islands.

At finer scales, species distribution and species-specific ecology, also varies on islands within an archipelago. The distribution of mammals on islands in Green Bay (Long 1978) illustrates how diverse the mammalian fauna may be from island to island within an archipelago while revealing patterns common to the islands and other island archipelagoes. Only two species, White-tailed Deer and Coyote, which can disperse over ice, were found on all islands and no two islands had the same mammalian fauna (the range of similarity was 16 percent to 86 percent) even though no island was more than 6 miles (10 km) from another island. Species that hibernate, or that are less likely to disperse over ice, tend to be absent from or have restricted ranges on islands as in the Apostle Islands (Belant and Van Stappen 2002). However, when a species reaches an island without competitors, it may expand its niche and become abundant as Long (1978) found for Deer Mice and Southern Red-backed Vole, have done on some Grand Traverse islands (Long 1978), Woodland Deer Mice have on some islands in the Beaver Island archipelago, Lake Michigan (Hatt et al. 1948), and Southern Red-backed Voles have on Devil's Island, Apostle Islands (Smith and Maragi 2004).

## GREAT LAKES ISLANDS: SUPERABUNDANCE AND CHANGE OVER TIME

Islands, in large part because of their relatively small size and isolation, often lack keystone predators, or herbivores, so some species become disproportionately abundant. This results in distinctive ecological systems that result from natural processes and processes set in motion due to anthropogenic activity. Isle Royale, famous for the intensively studied relationships

between Moose (*Alces alces*) and Eastern Timber Wolves (*Canis lupis*), differs from similar mainland systems with large fluctuations and high densities of Moose populations (Peterson 1995). Some islands in Lake Michigan and Lake Erie support high densities of watersnakes, perhaps a reflection of the absence of mesopredator mammals or even ants (see Hatt et al. 1948). Ground-nesting songbirds have been reported as relatively abundant on the Apostle Islands (Apostle Islands National Lakeshore annual research, monitoring and restoration report 2004). Additionally, colonial nesting waterbirds are concentrated on islands throughout the basin (Upper Mississippi Valley/Great Lakes Waterbird Conservation Plan, draft 3, October 2005), especially where mid-size mammalian predators such as Raccoon (Procyon lotor), Gray Fox (*Urocyon cinereoargenteus*) and Red Fox (*Vulpes vulpes*) are absent and there is suitable nesting substrate. Further, because colonial nesting waterbirds tend to occupy islands with relatively little vegetation and low relief, the distribution of nesting colonies varies with water level as some islands may be flooded during high water periods or the birds may abandon a site for other reasons. The result can be large fluctuations in numbers of birds over time as environmental conditions change.

Populations of some plant species can remain abundant, perhaps similar to presettlement conditions, where herbivores are absent. Canada Yew (*Taxus canadensis*), which has declined dramatically on the mainland due to deer browsing (Jalava et al. 2005; Whately et al. 2005), occurs in dense colonies on islands, or portions of islands, where deer or moose are absent or scarce (Table 2). The distribution of Canada Yew has been greatly reduced so that the species has a relict distribution analogous to species restricted to specific microclimate or edaphic conditions. In this case, however, the relict distribution of yew is a consequence of accessibility of the species to deer rather than change in climate or other abiotic factors. For example, when deer swim to islands with yew, populations of yew may decline (Peggy Burkman, personal communication). The status of yew on any island is dynamic and contingent upon the ability of deer to colonize an island.

***Table 2. Some Great Lakes islands with significant Canada Yew populations. Data from Corin (1976), Hatt et al. (1948), Jalava et al. (2005), Judziewicz (2002), Judziewicz and Koch (1993) Judziewicz and Kopitzke (1999), Mike Grimm (The Nature Conservancy, personal communication), Slavik and Janke (1993), and Whately et al. (2005).***

| Island | Archipelago | State/Province | Great Lake |
|---|---|---|---|
| Birch | Les Cheneaux | Michigan | Huron |
| Thunder Bay | Thunder Bay | Michigan | Huron |
| High | Beaver | Michigan | Michigan |
| Hog | Beaver | Michigan | Michigan |
| Poverty | Grand Traverse | Michigan | Michigan |
| St. Martin | Grand Traverse | Michigan | Michigan |
| Trout | Beaver | Michigan | Michigan |
| Au Train | | Michigan | Superior |
| East Huron | Huron Islands | Michigan | Superior |
| Huron | Huron Islands | Michigan | Superior |
| Outlying islands | Isle Royale | Michigan | Superior |
| Many islands | Georgian Bay | Ontario | Huron |
| Adventure | Grand Traverse | Wisconsin | Michigan |
| Cat | Apostles | Wisconsin | Superior |
| Devils | Apostles | Wisconsin | Superior |
| Eagle | Apostles | Wisconsin | Superior |
| Green | Grand Traverse | Wisconsin | Michigan |
| Ironwood | Apostles | Wisconsin | Superior |
| Michigan | Apostles | Wisconsin | Superior |
| North Twin | Apostles | Wisconsin | Superior |
| Otter | Apostles | Wisconsin | Superior |
| Outer | Apostles | Wisconsin | Superior |
| Raspberry | Apostles | Wisconsin | Superior |
| Sand | Apostles | Wisconsin | Superior |
| York | Apostles | Wisconsin | Superior |

While Canada Yew provides the highly visible result of overbrowsing, many other plant species, including orchids, lilies, and White Cedar (*Thuja occidentalis)* appear to have been severely overbrowsed as well (Judziewicz and Kopitzke 1999, Juziewicz 2001, Rooney et al. 2002). Yew may be an easily monitored indicator of island plant community composition and integrity relative to one threat, deer browsing. Islands without deer, due to their relative small size and isolation, may be prime areas to protect both rare and once common ecological systems because of the pervasive threat of overabundant deer in most of the upper Midwestern landscape (see Whately et al. 2005). Furthermore, deer can be removed from islands and thus permit vegetation recovery as has been done on Chambers Island, Wisconsin.

Introductions of species, deliberately or accidentally, are a special case of island colonization. There have been many cases of deliberate introductions, especially White-tailed Deer and game or fur-bearing mammals. Hatt et al. (1948) reported that Raccoons, Striped Skunks (*Mephitis mephitis*), Eastern Gray Squirrels (*Sciurus carolinensis*), Eastern Fox Squirrels (*Sciurus niger*), Beaver and Muskrat (*Ondatra zibethicus*) have all been deliberately introduced to the

Beaver Island archipelago, Lake Michigan while other species, such as Norway Rat (*Rattus norvegicus*) and House Mouse (*Mus musculus*), were introduced to islands unintentionally. The Grand Traverse archipelago, Lake Michigan, has also had intentional mammal introductions, such as Striped Skunk and Eastern Gray Squirrel and unintentional introductions including the House Mouse (Long 1978). At least some species have failed to persist, including Raccoons and Norway Rats on South Manitou Island, Lake Michigan (Hatt et al. 1948, Scharf 1973).

The colonization of islands by non-native plant species appears pervasive on Great Lakes islands, even fairly remote islands with rare human traffic. Virtually every island that has been botanically surveyed has non-native species (see Judziewicz and Koch 1993, Judziewicz 2001). The proportion of non-native plant species on an island ranges from six to 48 percent on the Apostle Islands, Lake Superior, averaging about 21 percent; the highest proportion of non-native species occurred on Gull Island, a major waterbird colony site (Judziewicz 2001). On Hog Island, a relatively remote island in the Beaver Island archipelago, 12 percent of the flora was identified as non-native. These species may have been brought to the island by animals or by humans even though human visits to the island are rare (Wakely et al. 2005). On Isle Royale approximately 15 percent of the flora is non-native (Judziewicz 1995). Although the ecological consequences of these non-native species are often uncertain, at least the spread of invasive species such as Timothy Grass (*Phleum pratense)* in open areas, European Helleborine (*Epipactus helleborine*) and Garlic Mustard (*Alliaria petiolata)* in forests, Eurasian Water-milfoil (*Myriophyllum spicatum*), in aquatic systems, Glossy Buckthorn (*Rhamnus frangula*) and European Marsh thistle (*Cirsium palustre*) in wetlands, Spotted Knapweed (*Centaurea biebersteinii*) on dunes, Common Hound's Tongue (*Cynoglossum officinale)* on dolomite cliffs, and Gold-moss Stonecrop (*Sedum acre*) on shoreline wetlands is of concern to conservationists (Judziewicz 2001, Voss 2001). At least some of these species, such as Garlic Mustard, may be inadvertently transported to islands by hikers (Judziewicz 2001).

### GREAT LAKES ISLANDS, A SPECIAL CASE: RELICT AND DISJUNCT DISTRIBUTION

Some species and communities on islands are relict or disjunct communities. Most likely, these were species or communities that were once more widespread in the region. It is widely believed that as climate changed, selected organisms became restricted to small, isolated areas with microclimates and edaphic conditions that favored their survival. For example, northern species, such as Caribou (*Rangifer tarandus*) have an isolated population on the Slate Islands, Lake Superior, Ontario (Peterson 1966, Great Lakes Heritage Coast 2000). Additionally, over 20 species of arctic-alpine disjunct plant species, including Bird's-eye Primrose (*Primula mistassinica*) and Common Butterwort (*Pinguicula vulgare*), occur on islands in Lake Superior (Slavik and Janke 1993, Albert et al. 1997, see Judziewicz and Koch 1993), and the mainland shoreline as well, and range south and east to both the mainland and islands in northern Lake Huron and northern Lake Michigan (*in* Judziewicz and Koch 1993; Guire and Voss 1963, Great Lakes Heritage Coast 2000). Many of these plants hug the shoreline where the cool and moist summer climate allows these northern species to persist (Given and Soper 1981 *in* Judziewicz and Koch 1993). At least 30 plant species, such as Mooseberry (*Viburnum edule*) on Isle Royale and Manitou Islands, Michigan, reach their southern limits on Great Lakes islands (Anthony Reznicek, University of Michigan, personal communication). On some islands, as well as some mainland sites, krummholz (wind-swept sites with stunted trees) communities exist on exposed areas near the shoreline (Judziewicz and Koch 1993; Albert et al. 1997)

Other species, such as Prairie Dropseed (*Sporobolus heterolepis*) and Prairie Smoke (*Geum triflorum*), are disjunct from prairie regions to the west (Brownell and Riley 2000). Another group of plant species from the mountains of the western United States and Canada is now concentrated around Lake Superior.. At least three western cordilleran disjunct plant species are on the Slate Islands, Ontario, eleven on Isle Royale, Michigan, and three on the Apostle Islands, Wisconsin (*in* Judziewicz and Koch 1993).

Still other species, though not with a relict distribution, have colonized islands from other regions. Both the Eastern Redbud (*Cercis canadensis*) and Yellow-breasted Chat (*Icteria virens*), species typically found south of the Great Lakes region, have their largest, northern populations in Canada on Pelee Island in Lake Erie (Tiessen 2003, Cadman et al. 1987). The Timber Rattlesnake (*Crotalus horridus*), which has been extirpated from Lake Erie islands (Herendorf and Stuckley 1977), is another species whose northern limits of distribution included Great Lakes islands.

### BIOTA ENDEMIC OR LARGELY LIMITED TO THE GREAT LAKES REGION

Although very few subspecies, species or communities are restricted to Great Lakes islands some endemic (found exclusively in a region) or limited range (range is primarily in one ecoregion but extends to one or two other ecoregions) species and communities occur disproportionately on islands (see Table 1). Further, a disproportionate number of locations with endemic or limited species or communities are found on Great Lakes islands (Soule 1993; see Appendix XXX for a partial list of islands with endemic or limited species and communities). For some species, such as Lakeside Daisy (*Hymenoxys herbacea*), Dwarf Lake Iris (*Iris lacustris*), and Pitcher's Thistle (*Cirsium pitcheri*), some of the largest populations in the Great Lakes, and thus in the world, are found on islands (www.speciesatrisk.gc.ca/search/speciesdetails_e_cfm?SpeciesID=225); Brownell and Riley 2000, Cockburn, U.S. Fish and Wildlife Service 2002).

**Table 1.** ***Species and communities endemic or largely limited to the Great Lakes region identified in the Great Lakes (United States only) ecoregion plan (The Nature Conservancy 1999) where 10 or more of element occurrences (EOs) are on Great Lakes islands (Mary Harkness, The Nature Conservancy, personal communication).***

| *Species/community* | **Distribution** | **Percent of EOs on Great Lakes islands** |
|---|---|---|
| Dwarf Lake Iris | Endemic | 24 |
| Michigan Monkey Flower (*Mimulus glabaratus michiganensis*) | Endemic | 12 |
| Lakeside Daisy | Endemic | 44 |
| Houghton's Goldenrod (*Solidago houghtonii*) | Endemic | 16 |
| Pitcher's Thistle | Endemic | 27 |
| Snail (*Triodopsis albolabris goodrichi)* | Endemic | 100 |
| Snail (*Anguispira kochi strontiana)* | Endemic | 100 |
| Lake Huron Locust (*Trimerotropis huroniana*) | Endemic | 11 |
| Eastern Fox Snake (*Elaphe vulpina gloydi*) | Endemic | 16 |
| Lake Erie Watersnake | Endemic | 65 |
| Piping Plover (*Charadrius melodus*)[1] | Endemic | |
| Kirtland's Warbler (*Dendroica kirtlandii*) | Endemic | 0 percent breeding; migrant on some islands |
| Great Lakes Limestone bedrock lakeshore | Endemic | 26 |
| Great Lakes shoreline cattail-bulrush marsh | Endemic | 18 |
| Lakeplain wet-mesic oak openings | Endemic | 22 |
| Great Lakes pine barrens | Endemic | 20 |
| Great Lakes alkaline cobble/gravel shore | Endemic | 12 |
| Great Lakes granite/metamorphic cliff | Endemic | 11 |
| Prairie Dunewort (fern) (*Botrychium campestre*) | Limited | 20 |
| Ram's head Lady's Slipper (*Cypripedium arietinum*) | Limited | 20 |
| Auricled Twayblade (*Listera auriculata*) | Limited | 17 |
| Hill's Pondweed (*Potamogeton hillii*) | Limited | 18 |
| Eastern Massassauga (*Sistrurus catenatus*) | Limited | 12 |
| Tufted hairgrass wet alvar grassland | Limited | 23 |
| White cedar alvar savanna | Limited | 67 |
| Alvar nonvascular pavement | Limited | 11 |
| Juniper alvar pavement | Limited | 17 |

[1]Great Lakes population

In addition to species and communities that are endemic and largely restricted to the Great Lakes ecoregion, some plant communities have a distinctive composition on islands. For example, the forests on Lake Erie islands have a relatively depauperate shrub layer and smaller proportion of species whose seeds are dispersed by animals compared to the mainland. This difference is attributed to an interaction between elevation, and insular, topographic, edaphic, and historical factors (Boerner 1984).

## GREAT LAKES ISLANDS, A SPECIAL CASE: COLONIAL NESTING WATERBIRDS

Islands in the Great Lakes are important sites for globally significant populations of colonial nesting waterbirds. Eighty to 94 percent of the world's breeding population of Ring-billed Gulls *(Larus delawarensis)* and perhaps as much as 28 percent of world's population of breeding Double-crested Cormorants *(Phalacrocorax auritus)* occur in the Great Lakes, mostly on islands, and as much as 60 percent of breeding Herring Gulls *(Larus argentatus)* nest in the Great Lakes, mostly on islands (Upper Mississippi Valley/Great Lakes Waterbird Conservation Plan, draft 3, October 2005). Also of interest is high species richness of colonial waterbirds found on some islands in the Great Lakes. For example, West Sister Island, Lake Erie, was used for nesting by six waterbird species in the late 1990s (Wires and Cuthbert 2001). The islands provide refuge from mammalian and other predators (e.g., great horned owls) due to their isolation. In addition, shoals and near shore shallow coastal waters are used by many species as important foraging sites. Islands, then, attract colonially nesting waterbirds due to the combination of being relative predator-free and resource rich. Although most colonial nesting waterbirds are found in Lakes Michigan, Huron, Erie and Ontario even islands in oligotrophic Lake Superior host colonial nesting waterbirds (Wires and Cuthbert 2001). Marsh-nesting terns, Black *(Chlidonias niger)* and Forster's *(Sterna forsteri)*, are locally concentrated along the Great Lakes shorelines, especially in and near protected bays such as Les Cheneaux islands in Lake Huron and islands in the St. Marys River and Lake St. Clair (Wires and Cuthbert 2001).

Colonial nesting waterbirds often nest at very high densities on islands. Guano produced by the birds creates nutrient-rich water around islands kills plants on land through excessive levels of nitrogen. At one Ring-billed Gull colony on South Manitou Island, Lake Michigan, Shugart (1976) documented high mortality of Creeping Juniper (*Juniperus horizontalis*), Common Juniper (*Juniperus communis*), Poison Ivy (*Toxidendron radicans*), Choke Cherry (*Prunus virginiana*), and Sand Cherry (*Prunus pumila*) within approximately five years of establishment of the nesting colony. On Knife Island, Lake Superior, the number of plant species, especially trees and forest forbs, declined between 1971 and 2004 apparently a result of guano deposition from nesting Herring Gulls and Double-crested Cormorants; Canada Yew also declined dramatically (Anderson et al. 2005). Despite these examples, once a colony is abandoned, there is rapid recovery to native plant species even though soil conditions are changed (Hogg and Morton 1983). Consequently potentially distinctive nutrient-rich terrestrial, and near shore aquatic systems, may characterize islands with colonially nesting waterbirds.

## GREAT LAKES ISLANDS, A SPECIAL CASE: STOPOVER SITES FOR MIGRANTS

The islands of the Great Lakes are harbors of refuge for migrating landbirds. Large concentrations of landbird migrants have been noted from the western Lake Erie islands (Campbell 1968, Herendorf and Stuckey 1977, Anderson et al. 2002, Kelleys Island Audubon Club 2005, Bird Studies Canada 2006a, 2006b), northern Lake Michigan islands (Scharf *in* Vigmostad 1999), Apostle islands, especially Outer Island (Van Stappen and Doolittle 1993), Isle Royale (Peet 1908) in Lake Superior, and some Lake Huron islands, including Bois Blanc Island (Penskar et al. 2001), the Les Cheneaux islands (David Ewert et al., unpublished data) and Mackinac Island (White 1893). Perhaps especially for migrants caught over the lakes at dawn, islands may be the nearest and/or only readily available habitat for these birds (Scharf

1999, see Diehl et al. 2003). Consequently, Great Lakes islands are essential refuge for many migrants, especially during storms. Although rigorous studies of migrants on islands are few, observations suggest that islands may be used extensively as stopover sites by migrating birds and perhaps bats.

## NEAR-SHORE WATERS AROUND ISLANDS

Characteristics of near-shore waters around islands vary with substrate, bedrock, exposure to waves and other features and are probably similar to mainland near shore waters. Although most known biotic features of islands are terrestrial, there may also be differences in the aquatic biota. Pollution intolerant species, including amphipods, mayflies, and caddisflies, were noted by Herendorf and Stuckey (1977) to be more abundant around islands than mouths of major rivers in Lake Erie. The shoals and reefs offshore of the Lake Erie islands are used extensively by fish, including spawning and nursery areas (see Trautman 1981), and by Double-crested Cormorants and other waterbirds, during the breeding and immediate non-breeding season (Stapanian and Waite 2003). The near-shore waters of islands with colonial nesting waterbirds may be distinct from near-shore waters of the mainland, and other islands, due to the nuturient enrichment of the water from guano produced by the birds. This may produce distinctive near-shore communities of biological significance.

## DISTINCTIVE PROPERTIES OF GREAT LAKES ISLANDS THAT SERVE TO BUFFER ISLANDS

At least two factors may play a disproportionately important role in buffering islands from some types of change, or at least rates of change. Islands, especially small islands relatively isolated from the mainland, have microclimates that can be highly modified by the surrounding waters of the Great Lakes. This effect will modify the magnitude and rate of climate change on these islands. Ultimately, climate change may also dramatically result in large changes of biota, but there may be a lag effect compared to most mainland areas so islands provide at least temporary refugia.

Clearly, isolation of islands may also buffer islands from other changes as well. Non-anthropogenic dispersal by all species to islands, including pathogens and introduced species, will be reduced compared to most mainland sites. The reduction in dispersal to islands results in a depauperate biota, especially for relatively isolated, small islands, but also may result in higher biotic integrity to the extent that introduced species do not reach islands. Further, anthropogenic activity on islands is often relatively low [e.g., expense and logistics of timber removal (Jalava et al. 2005)].

## CONCLUSION

Great Lakes islands, the largest collection of islands in any freshwater lake system in the world, support globally rare species and natural communities. They also are home to distinctive communities composed of species able to colonize islands or, for those islands that once were part of the mainland, were able to persist on islands following isolation. The net result is a rich biological legacy that includes colonial nesting waterbirds, species and communities endemic to the Great Lakes region, disjunct species, critical stopover sites for migratory birds, rich reptile faunas on some island archipelagos, and important fish spawning and nursery areas. Islands may also provide important refugia for species sensitive to climate

change and be buffered from the onslaught of invasive species. Consequently, protection of islands for their native species and communities is of particular concern.

### *LITERATURE CITED FOR CHAPTER THREE*


Albert, D.A., P. Comer, D. Cuthrell, D. Hyde, W. MacKinnon, M. Penskar, and M. Rabe. 1997. The Great Lakes bedrock lakeshores of Michigan. Michigan Natural Features Inventory. Report to Land and Water Management Division, Michigan Department of Natural Resources (CZM grant 96D-0.07).

Anderson, D., J. Brandt, L. Wright, and D. Davidson. 2005. Ecology and floristics of Knife Island, a gull and cormorant rookery on Lake Superior, near Two Harbors, Lake County, Minnesota. Michigan Botanist 44:95-104.

Anderson, M., E. Durbin, T. Kemp, S. Lauer, and E. Tramer. 2002. Birds of the Toledo area. Ohio Biological Survey, Columbus.

Apostle Islands National Lakeshore annual research, monitoring and restoration report. 2004.

Baker, R. H. 1983. Michigan mammals. Michigan State University Press, East Lansing.

Belant, J. L. and J. F. Van Stappen. 2002. Island biogeography of mammals in Apostle Islands National Lakeshore, USA. Natural Areas Journal 22:180-185.

Belant, J. L., J. F. Van Stappen, and D. Paetkau. 2005. American black bear population size and genetic diversity at Apostle Islands National Lakeshore. Ursus 16:85-92.

Bird Studies Canada. 2006a. Pelee Island Natural Areas. Southwest Lake Erie, Ontario. http://www.bsc-eoc.org/iba/site.jsp?siteID=ON013. Accessed 14 February 2006.

Bird Studies Canada. 2006b. Pelee Island Archipelago. Western Lake Erie basin, Ontario. http://www.bsc-eoc.org/iba/site.jsp?siteID=ON014. Accessed 14 February 2006.

Boerner, R. J. 1984. Forest composition on the Lake Erie islands. American Midland Naturalist 111:173-184.

Brownell. V. R. and J. L. Riley. 2000. The alvars of Ontario. Significant alvar natural areas in the Ontario Great Lakes region. Federation of Ontario Naturalists, Don Mills, Ontario.

Burt, W. H. 1948. The mammals of Michigan. University of Michigan Press, Ann Arbor.

Cadman, M. D., P. F. J. Eagles, and F. M. Helleiner. 1987. Atlas of the breeding birds of Ontario. University of Waterloo Press, Waterloo, Ontario.

Campbell, L. 1968. Birds of the Toledo area. Toledo Blade Company, Toledo, Ohio.

Corin, C. W. 1976. The land vertebrates of the Huron Islands, Lake Superior. Jack-Pine Warbler 54:138-147.

Crooks, K.R., A.V. Suarez, and D.T. Bolger. 2004. Avian assemblages along a gradient of urbanization in a highly fragmented landscape. Biological Conservation 115:451-462.

Cuthbert, F.J. 1985. Intraseasonal movement between colony sites by Caspian Terns in the Great Lakes Wilson Bulletin 97:502-510.

Davis, M., C. Douglas, R. Calcote, K. L. Cole, M. G. Winkler, and R. Flakne. 2000. Holocene climate in the western Great Lakes national parks and lakeshores: implications for future climate change. Conservation Biology 14:968-983.

Diehl, R. H., R. P. Larkin, and J. E. Black. 2003. Radar observations of bird migration over the Great Lakes. Auk 120:278-290.

Dorr, Jr., J. A. and D. F. Eschman. 1970. Geology of Michigan. University of Michigan Press, Ann Arbor.

Eichenlaub, V. 1979. Weather and climate of the Great Lakes region. University of Notre Dame Press, Notre Dame, Indiana.

Given, D. R. and J. H. Soper. 1981. The arctic-alpine element of the vascular flora of Lake Superior. Natural Museum of Natural Sciences, Ottawa, Canada Publications in Botany Number 10, 70 pp.

Great Lakes Heritage Coast. 2000. Great Lakes Heritage Coast Project Office, Ministry of Natural Resources, Government of Ontario, Thunder Bay, ON.

Guire, K. E. and E. G. Voss. 1963. Distribution of distinctive shoreline plants in the Great Lakes region. Michigan Botanist 2:99-114.

Hazlett, B. T. 1988. Factors influencing island floras in northern Lake Michigan. Ph.D. dissertation, University of Michigan, 223 pp.

Hatt, R. T., J. VanTyne, L. C. Stuart, C. H. Pope, A. B. Grobman. 1948. Island life: a study of the land vertebrates of the islands of eastern Lake Michigan. Cranbrook Institute of Science, Bulletin 27, Bloomfield Hills, Michigan.

Hebert, C.E., J. Duffe, D.V. Chip Weseloh, E.M. Ted Senese, G. Douglas Haffner. 2005. Unique island habitats may be threatened by Double-crested Cormorants. Journal of Wildlife Management 69:68-76

Hecnar, S.J., G.S. Casper, R.W. Russell, D.R. Hecnar, and J.N. Robinson. 2002. Nested species assemblages of amphibians and reptiles on islands in the Laurentian Great Lakes. Journal of Biogeography 29:475-489.

Herdendorf, C. E. and R. L. Stuckey. 1977. Lake Erie and the Erie islands. Clear Technical Report No. 74, Center for Lake Erie Area Research, Columbus, Ohio.

Hogg, E. H. and J. K. Morton. 1983. The effects of nesting gulls on the vegetation and soil of islands in the Great Lakes. Canadian Journal of Botany 61:3240-3254.

Jalava, J. V., W. L. Cooper, and J. L. Riley. 2005. Ecological survey of the eastern Georgian Bay coast. Nature Conservancy of Canada, Toronto, and Ontario Ministry of Natural Resources, Peterborough, Ontario. 180 pp. + CD-ROM.

Judziewicz, E.J. 1995. Survey of nonnative (exotic) vascular plant species of campgrounds, developed areas, and Passage Island Lighhouse and trail at Isle Royale National Park, Michigan, 1994. Resource Management Report 95-1, Isle Royale National Park, MI.

Judziewicz, E. J. 2001. Flora and vegetation of the Grand Traverse Islands (Lake Michigan), Wisconsin and Michigan. Michigan Botanist 40:81-208.

Judziewicz, E. J. and R. G. Koch. 1993. Flora and vegetation of the Apostle Islands National Lakeshore and Madeline Island, Ashland and Bayfield Counties, Wisconsin. Michigan Botanist 32:43-189.

Judziewicz, E. and D. Kopitzke. 1999. Wisconsin Lake Michigan Island Plant Survey II. 1998 and 1999. Report to Wisconsin Coastal Management Program.

Kelleys Island Audubon Club. 2005. http://kelleysislandnature.com/island_birding/banding_stats.htm. Accessed 3 September 2005.

King, R.B., M.J. Oldham, W.F. Weller, and D. Wynn. 1997. Historic and current amphibian and reptile distributions in the island region of western Lake Erie. American Midland Naturalist 138:153-173.

Larson, B.M.H. and S.C.H. Barrett. 1998. Reproductive biology of island and mainland populations of *Primula mistassinica* (Primulaceae) on Lake Huron shorelines. Canadian Journal of Botany 76:1819-1827.

Lomolino, M.V. 1994. Species richness of mammals inhabiting near shore archipelagoes: area, isolation, and immigration filters. Journal of Mammalogy 75:39-49.

Long, C. A. 1978. Mammals of the islands of Green Bay, Lake Michigan. Jack-Pine Warbler 56:59-82.

Long, C. Alan and C. A. Long. 1976. Some amphibians and reptiles collected on islands in Green Bay, Lake Michigan. Jack-Pine Warbler 54:54-58.

MacArthur, R. H. and E. O. Wilson. 1963. An equilibrium theory of insular zoogeography. Evolution 17:373-387.

MacArthur, R. H. and E. O. Wilson. 1967. The theory of island biogeography. Princeton University Press, Princeton, New Jersey.

Manny, Bruce. 2004. IAGLR.

Morton, J.K. and E.H. Hogg. 1989. Biogeography of island floras in the Great Lakes. II. Plant dispersal. Canadian Journal of Botany 67:1803-1820.

National Park Service, U.S. Department of the Interior. 1998. Draft management plan environmental impact statement. Isle Royale National Park. Keweenaw County, Michigan.

The Nature Conservancy, Great Lakes Ecoregional Planning Team. 1999. Great Lakes ecoregional plan: a first interation. The Nature Conservancy, Great Lakes Program, Chicago, Illinois.

Peet, M. M. 1908. The fall migration of birds at Washington Harbor, Isle Royale, in 1905. Michigan Geological Report.

Penskar, M. R., D. A. Hyde, J. A. Olson, M. A. Kost, P. J. Higman, J. J. Paskus, R. L. Boehm, and M. T. Fashoway. 2001. Biological inventory for conservation of Great Lakes islands: Year 2000 Progress Report. Michigan Natural Features Inventory. Report submitted to Michigan Coastal Management Program, Coastal Management Program Grant # 00-309-06

Penskar, M. R., J. A. Olson, M. A. Kost, J. J. Paskus, D. L. Cuthrell, R. L. Boehm, E. H. Schools and M. T. Fashoway. 2002. Biological inventory for conservation of Great Lakes islands: Year 2001 progress report. Report submitted to Michigan Coastal Management Program, Coastal Management Program Grant #01-309-10.

Peterjohn, B. G. and D. L. Rice. 1991. The Ohio Breeding Bird Atlas. Ohio Department of Natural Resources, Division of Natural Areas and Preserves, Columbus.
Peterson, R. O. 1995. The wolves of Isle Royale: a broken balance. Willow Creek Press, Minocqua, Wisconsin.

Peterson, R. L. 1966. The mammals of eastern Canada. Oxford University Press, Toronto

Rooney, T.P., S.L. Solheim, and D.M. Waller. 2002. Factors affecting the regeneration of northern white cedar in lowland forests of the Upper Great Lakes region, USA. Forest Ecology and Management 163:119-130.

Scharf, W.C. 1999. The Importance of Great Lakes Islands to Nearctic-Neotropical Migrant Birds. In State of the Great Lakes islands: Proceedings from the 1996 U.S.-Canada Great Lakes islands workshop, K.E. Vigmostad, ed., Department of Resource Development, Michigan State University, East Lansing. 124 pp. [need to fix this citation.]

Scharf, W.C. 1973. Birds and land vertebrates of South Manitou Island. Jack-Pine Warbler 51:3-19.

Scholtens, B. and J. Holland. 1997. Distribution and habitat selection of the Lake Huron Locust (*Trimerotropis huroniana*). Report to Michigan Department of Natural Resources.

Shugart, G. W. 1976. Effects of Ring-billed Gull nesting on vegetation. Jack-Pine Warbler 54:50-53.

Slavik, A. D. and R. A. Janke. 1993. The vascular flora of Isle Royale National Park. Third edition. Isle Royale Natural History Association.

Smith, G. and F. Maragi. 2004. Small mammal inventory of the Apostle Islands National Lakeshore. Technical report to the National Park Service Great Lakes Network. GLKN/2004/01.

Soule, J.D. 1993. Biodiversity of Michigan's Great Lakes islands: Knowledge, threats and protection. Michigan Natural Features Inventory, Michigan Department of Natural Resources, Lansing.

Stapanian, M. A. and T. A. Waite. 2003. Species density of waterbirds in offshore habitats in western Lake Erie. Journal of Field Ornithology 74:381-393.

Tiessen, R. 2003. Pelee Island human and natural history: guide to a unique island community. Wilds of Pelee Island.

Upper Mississippi Valley/Great Lakes Waterbird Conservation Plan, Draft 3, October 2005. http://www.fws.gov/birds/waterbirds/UMVGL/ Accessed 26 January 2006.

U.S. Fish and Wildlife Service. 1997. Recovery plan for Michigan Monkey-flower (*Mimulus glabaratus* var. *michiganensis*). Fort Snelling, Minnesota. vii + 37 pp.

U.S. Fish and Wildlife Service. 2001. Recovery plan for Hine's emerald

U.S. Fish and Wildlife Service. 2002. Pitcher's Thistle (*Cirsium pitcheri*) Recovery Plan, Fort Snelling, Minnesota. vii + 92 pp.

Van Stappen, J. F. and T. C. J. Doolittle. 1993. 1991 Migratory bird survey-Apostle Islands National Lakeshore. Passenger Pigeon 55:43-49.

Veitch, C.R. and M.N. Clout. 2002. Turning the tide: the eradication of invasive species. Proceedings of the International Conference on eradication of island invasives. Occasional Paper of the IUCN Species Survival Commission No. 27 (C.R. Veitch and M.N. Clout, eds.).

Vigmostad, K.E. 1999. State of the Great Lakes islands: Proceedings from the 1996 U.S.-Canada Great Lakes islands workshop. Department of Resource Development, Michigan State University, East Lansing. 124 pp.

Voss, E. G. 2001. Flora of St. Helena Island (Straits of Mackinac), Michigan. Michigan Botanist 40:27-47.

Whatley, C. E., D. E. Wujek, and E. E. Leuck II. 2005. The vascular flora of Hog Island, Charlevoix County, Michigan. Michigan Botanist 44:29-48.

White, S. E. 1893. Birds observed on Mackinac Island, Michigan, during the summers of 1889, 1890, and 1891. Auk 10:221-230.

*Preliminary Analysis – Please Do Not Cite*

## First Binational Analysis of Great Lakes Islands

July 2006

| Great Lakes Islands by Waterbody | # of Great Lakes Islands | | |
|---|---|---|---|
| | US | Canada | **Total** |
| **Lake Superior** | 624 | 1,967 | 2,591 |
| **St Mary's River** | 384 | 246 | 630 |
| **Lake Michigan** | 329 | 0 | 329 |
| **Lake Huron** | 597 | 927 | 1,524 |
| **Georgian Bay** | 0 | 22,195 | 22,195 |
| **Lake St. Clair/St. Clair River** | 31 | 308 | 339 |
| **Detroit River** | 19 | 42 | 61 |
| **Lake Erie** | 157 | 1,567 | 1,724 |
| **Niagara River** | 19 | 17 | 36 |
| **Lake Ontario** | 407 | 720 | 1,127 |
| **St Lawrence River** | 514 | 337 | 851 |
| **TOTAL** | 3,081 | 28,326 | 31,407 |

| Length and Area of U.S. Great Lakes Islands by Waterbody | Island Coastline | | Island Area | |
|---|---|---|---|---|
| | Miles | Kilo-meters | Acres | Hectares |
| **Lake Superior** | 585 | 941 | 188,835 | 76,418 |
| **St Mary's River** | 183 | 295 | 42,256 | 17,100 |
| **Lake Michigan** | 472 | 760 | 231,962 | 93,872 |
| **Lake Huron** | 447 | 720 | 110,360 | 44,661 |
| **Lake St. Clair** | 111 | 179 | 11,013 | 4,456 |
| **Detroit River** | 42 | 68 | 5,942 | 2,404 |
| **Lake Erie** | 140 | 226 | 7,757 | 3,139 |
| **Niagara River** | 43 | 69 | 16,352 | 6,617 |
| **Lake Ontario** | 199 | 320 | 19,122 | 7,738 |
| **St Lawrence River** | 152 | 244 | 6,717 | 2,718 |
| **TOTAL** | 2,374 | 3822 | 640,316 | 259,123 |