

Lakeside Daisy
(Hymenoxys herbacea)

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Ohio Field Office
Columbus, Ohio

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5-YEAR REVIEW
Lakeside daisy/*Hymenoxys herbacea*

1.0 GENERAL INFORMATION

1.1 Reviewers:

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1.2 Methodology used to complete the review:

This 5-year review was prepared by Julie Proell, Plant and Wildlife Biologist, U.S. Fish and Wildlife Service (Service), Ohio Ecological Services Field Office, in consultation with other Field Office Staff in the Midwest Region and species experts in Ontario, Canada. The Service requested new scientific or commercial data and information that may have a bearing on the species' classification of threatened status through a Federal Register notice (70 FR 41423) initiating the 5-year review. We reviewed past and recent literature, public comments, the final listing rule (53 FR 23742) and the Lakeside daisy recovery plan which we relied heavily on (USFWS 1990), to prepare this 5-year review. Peer review of this document was determined to be unnecessary since information included here was previously published in peer-reviewed journals.

1.3 Background:

1.3.1 FR Notice citation announcing initiation of this review:
73 FR 21643 (April 22, 2008) for seven listed Midwestern species.

1.3.2 Listing history

Original Listing

FR notice: 53 FR 23742: Lakeside daisy, *Hymenoxys acaulis* var. *glabra*

Date listed: June 23, 1988

Entity listed: species

Classification: threatened

1.3.3 Associated rulemakings: none

1.3.4 Review History:

September 19, 1990: Recovery Plan for the Lakeside daisy (*Hymenoxys acaulis* var. *glabra*). Recovery plan summarized the species status, distribution, and recovery objectives.

The Lakeside daisy was included in a cursory 5-year review conducted for all species listed before 1991 (56 FR 56882). No other 5-year reviews have been completed for this species.

1.3.5 Species' Recovery Priority Number at start of 5-year review: 8, indicating a moderate degree of threat and high recovery potential.

1.3.6 Recovery Plan

Name of plan: Lakeside daisy (*Hymenoxys acaulis* var. *glabra*) Recovery Plan

Date issued: September 19, 1990

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1 Is the species under review a vertebrate? No, the species a plant, therefore the DPS policy is not applicable.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria? Yes

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?

No. The recovery criteria are not current. It has been 19 years since the recovery criteria were developed and published. An additional population has been discovered in Michigan and significant genetics research has been performed on this species.

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)? Yes. Listing factor C (disease or predation) is not considered relevant for this species, though new data suggests herbivory may pose a significant threat to population numbers.

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:

1990 Recovery Plan Criteria

Lakeside daisy (*Hymenoxys acaulis* var. *glabra*) [now *H. herbacea*] can be considered for delisting when:

- 1) 475 acres of essential habitat containing the population center at the Marblehead Quarry, Ottawa County, Ohio are acquired and managed,

Criterion 1 has NOT been met.

The population center of Lakeside daisy within the quarry has shifted due to the active quarrying at the previous population center (Jennifer Windus, Ohio Department of Natural Resources (ODNR), Division of Wildlife (DOW), pers. comm. 2009). Essential habitat is defined as occupied and unoccupied suitable Lakeside daisy habitat between Hartshorn and Bay Shore Roads. Additionally, little effort has been made in recent years to work with the owners of Marblehead Quarry (now known as Lafarge Quarry) to establish a conservation plan for or discuss public acquisition of the essential habitat for the Lakeside daisy population within the boundaries of the quarry.

Initial conversations between Lafarge Quarry, USFWS, and ODNR staff focused on the need to re-survey the quarry property for the Lakeside daisy and other rare species. Lafarge Quarry staff has agreed to work with ODNR to survey the entire site, and surveys began in spring of 2009 (Melissa Moser, ODNR Division of Natural Areas and Preserves (DNAP), pers. comm. 2009). Additionally, various methods that would lessen the impact of quarry operations on Lakeside daisy were discussed. Lafarge Quarry personnel began construction of an observation area with the intention of inviting the

public to view the quarry operation and the plants found within the quarry. They have moved several inches of the substrate (keeping the plants intact) from areas that would be destroyed and placed it in the observation area. Plants have survived the transplant and appear to be doing well (M. Moser,, pers. comm. 2009).

Lafarge Quarry owners are aware of the need to conserve the Lakeside daisy habitat, and they have allowed the Ohio Department of Natural Resources, Division of Natural Areas and Preserves to monitor populations of Lakeside daisy within their property. However, they plan to continue cycling through areas of the quarry for 100 to 150 years and will assist in population management as long as it does not interfere with their active mining operations (Don Peart in Ken Multerer's Lakeside Daisy Meeting Notes 1991). There are areas of the quarry that may be suitable for conservation in the future, though no immediate plans for formal conservation are being discussed at this time.

- 2) 465 acres of additional essential habitat at the Marblehead Quarry is protected through easements, restrictive covenances, or leases,

Criterion 2 has NOT been met.

Similarly to criterion 1, Lafarge Quarry plans to continue active mining throughout the property in cycles, and no formal conservation plans or acquisition plans have been discussed. Land to the east of Alexander Pike and adjacent to the Lakeside Daisy Nature Preserve would be a good candidate for initial conservation efforts (Windus et al. 1999).

- 3) The variety [now a species] is restored to a minimum of one large, stable population in each of two geographically distinct, protected sites of suitable size within the variety's historic range in Illinois, and

Criterion 3 has NOT been met.

The Manito Prairie Nature Preserve, Tazewell County, Illinois population was reestablished with 300 transplants in fall 1988, with a 78% survivorship in spring of 1989 (USFWS 1990), and no population monitoring results have become available since 1990.

The two protected Will County, Illinois sites where Lakeside daisy was established with 1100 transplants in 1988 (Lockport Prairie Nature Preserve and Romeoville Prairie Nature Preserve) each contain fewer than 500 plants today (see Figure 1). While Imrie suggests that a population must contain 32 individuals to maintain a minimum number of alleles for successful reproduction (Imrie et al. 1972), a model by Lande suggests that a minimum of 5,000 individuals is necessary to maintain the balance between mutation and genetic drift (Lande 1995). Additionally, fewer than 50 individuals will result in the loss of self-incompatibility alleles (Byers and Meagher 1992).

The recovery plan defines a large restored population as having greater than or equal to 5,000 adult plants within a minimum of 3 hectares (USFWS 1990). Additionally, variations in population size estimates across years at these sites indicate that these populations do not represent large, stable populations at this time.

- 4) Restored populations are maintained for 15 consecutive years, with monitoring to continue for an additional 10 years.

Criterion 4 has NOT been met.

The two restored populations in Will County, Illinois have only been maintained and monitored for 21 years (1988 to 2009) while the introduced population in Kelleys Island in Ohio has only been maintained for 21 years and monitored for 12 years (1989 to 2001). According to the best available data, the reestablished population at Manito Prairie Nature Preserve in Tazewell County, Illinois has not been monitored since 1998 following transplanting.

2.3 Updated Information and Current Species Status

Since the species was listed as threatened in 1988 (53 FR 23742), much research has been performed on species taxonomy, population assessments, and genetic distance of individuals within the same population. Quarry operations continue to threaten populations within the Lafarge Quarry. An estimated 225-450 acres of the 2,500-acre quarry are presently occupied by Lakeside daisies, and many parts of the population are near active quarrying and have been destroyed or impacted by dumping of excess gravel or slag. Future coordination with Lafarge Quarry is necessary to ensure conservation of populations of Lakeside daisy within the quarry.

The newly discovered population in Michigan and the introduced populations in Ohio and Illinois are under varying levels of protection with varying degrees of population growth success.

2.3.1 Biology and Habitat

When Lakeside daisy was listed as federally threatened in 1988, only one fragmented population was known in the United States, on the Marblehead Peninsula in Ottawa County, Ohio. The Lakeside daisy had also been recorded in Will and Tazewell Counties in Illinois, but presumed extirpated prior to listing. Lakeside daisy was also known from two places in Ontario, Canada, consisting of two populations on the Bruce Peninsula and 12 sites on Manitoulin Island (53 FR 23742). Since its listing in 1988, a population of Lakeside daisy was discovered in 1996 in Mackinac County, Michigan, and is being preserved by the Forest Service and the Michigan Nature Association as the Stratton Memorial Nature Sanctuary (Sara Huebner, Hiawatha National Forest, pers. comm. 2009). The introduced population on Kelleys Island in Erie County, Ohio has increased in number since 1988. Additionally, two introduced populations were transplanted into

appropriate habitat in Will County, Illinois in 1988 and the populations at those sites continue with low to moderate success.

2.3.1.1 New information on the species' biology and life history: Not applicable.

2.3.1.2 Abundance, population trends, demographic features, or demographic trends:

Monitoring, restoration, and protection efforts for many populations have been documented for this species (see Figure 1). Natural populations are known from two sites in Ottawa County, Ohio (Lafarge Quarry and Lakeside Daisy Nature Preserve), and along the coast of Manitoulin Island and the tip of Bruce Peninsula in Ontario, Canada. Introduced populations are located in Erie County in Ohio (Kelleys Island), and Will (Lockport Prairie Nature Preserve and Romeoville Prairie Nature Preserve) and Tazewell (Manito Nature Preserve) Counties in Illinois. The population in Mackinac County in Michigan (Hiawatha National Forest/Stratton Memorial Nature Sanctuary) may or may not be natural (see Figure 2). A few plants were rescued from the Tazewell County, Illinois population and moved to the Morton Arboretum in Illinois, where clones of individuals remain for scientific purposes (USFWS 1990).

Annual monitoring of Lakeside daisy populations do not occur at all sites. Some sites are visited annually while others have not been monitored in nearly 20 years. For example, the largest natural population in the United States, the fragmented area of Marblehead Peninsula, has decreased in numbers due to quarrying activities and disposal of dredged material. While many articles quote a rough, conservative minimal estimate of approximately 1,000,000 plants on Lafarge Quarry in 1990, DeMauro's data suggest that the population contained between 4,000,000 and 7,000,000 adult plants (99% C.I.: 1,200,000 to 1,300,000) with a density of 3.29 adults per meter² (Table 2 of USFWS 1990). Current preliminary studies based on mapping of specific population locations of Lakeside daisy indicate that, assuming the same density of adults as in DeMauro's estimate, the number of Lakeside daisy at Lafarge Quarry has decreased to approximately 3,000,000 adult plants in 2009 (M. Moser, pers. comm. 2009).

Figure 1. Lakeside daisy population estimates (natural and introduced populations). Marblehead Quarry population size estimates are not shown due to scale (see estimate in Section 2.3.1.2).

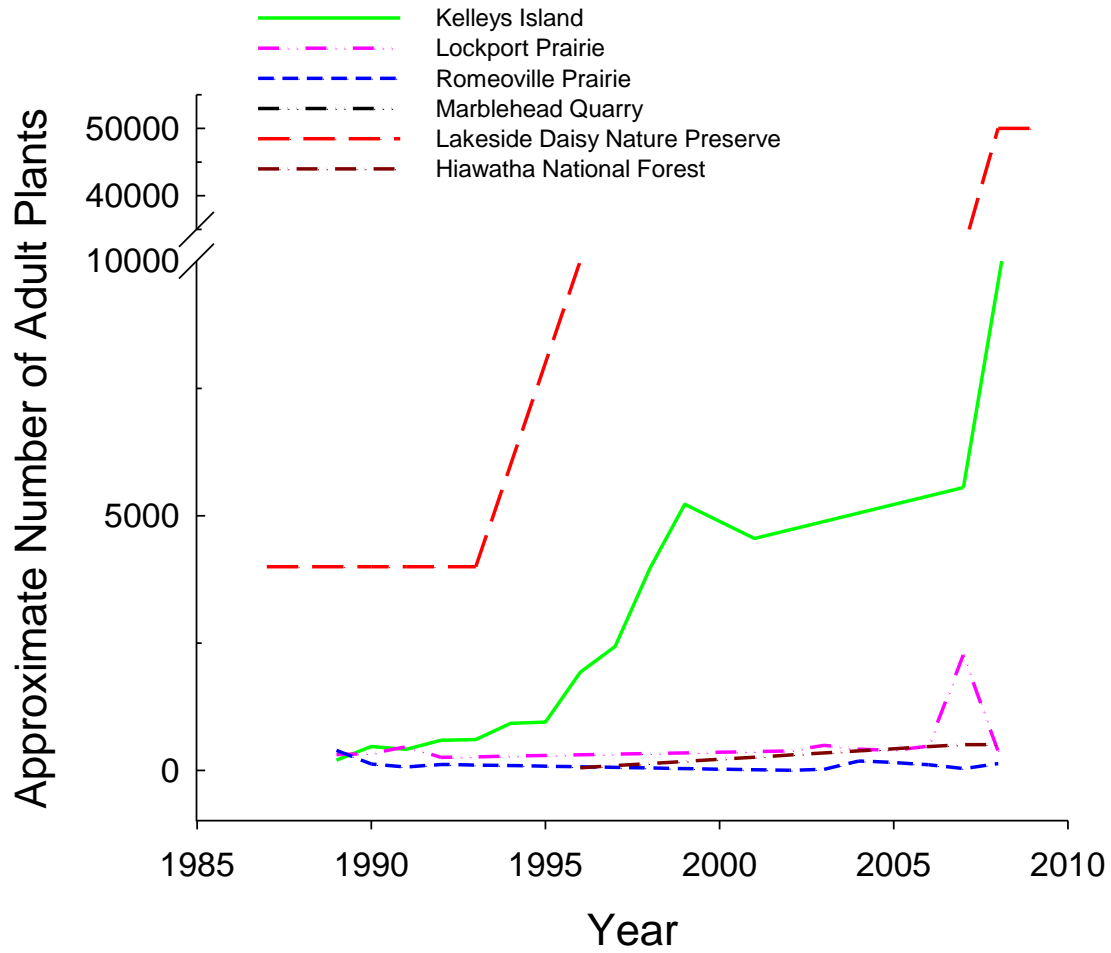
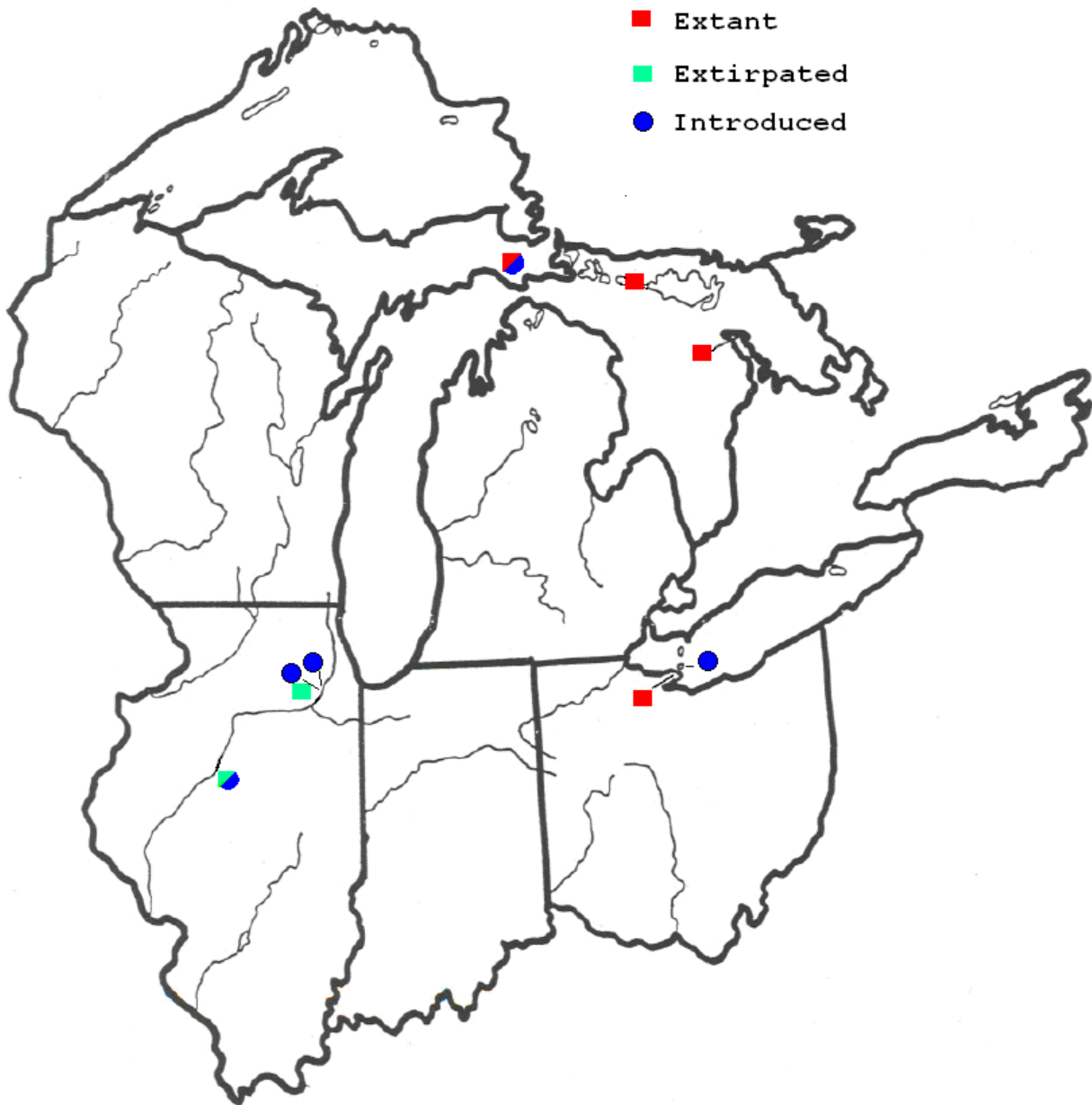


Figure 2. Historical and introduced range of Lakeside daisy in North America.



Since its discovery in 1996, the population on either side of Brevort Lake Road in Mackinac County, Michigan appears to be stable with approximately 500 individuals (approximately 500 plants on the preserve owned by Michigan Nature Association as Stratton Memorial Nature Sanctuary and 2-4 plants on property owned by Hiawatha National Forest; S. Huebner, pers. comm. 2009). The Brevort Lake Road population occurs along the roadside on a thin mat of vegetation underlain by a thick tufa deposit, which is a rock formation created by precipitation of calcium from alkaline groundwater seeps and springs (Michigan

Natural Features Inventory, 2002; Mike Penskar, Michigan Natural Features Inventory, pers. comm. 2010). The origin of this population is unknown due to the small population size, its isolation, and habitat.

The introduced population at Kelleys Island State Park in Ohio appears to be stable to increasing. Starting in 1989, over 1,000 individuals have been transplanted and thousands of seeds have been sown from the Marblehead Peninsula to Kelleys Island. The results of annual monitoring from 1989 to 2001 suggest high mortality through the first several years, especially in the larger plants consisting of many rosettes, indicating root damage during excavation or inclement weather during or after transplanting. Survivorship has appeared to be similar to that of individuals on the Lakeside Daisy Nature Preserve, and recruitment suggests sufficient levels of flower, fruit, and seed production resulting from outcrossing (Windus and Cochrane 1999).

An introduction occurred in Illinois where individuals were transplanted in the spring and fall of 1988 to Lockport Prairie Nature Preserve and Romeoville Prairie Nature Preserve in Will County. Survivorship was low for the spring 1988 transplanted individuals at the two Illinois restoration sites, due to severe summer drought, though subsequent transplants showed high success rates (85 to 90%; DeMauro 1993). Data from Lockport Prairie and Romeoville Prairie suggest that the minimum time between germination and flowering is two years (DeMauro 1993). Population trends at these sites appear stable, though Lockport Prairie shows increases while Romeoville Prairie shows slight, steady decline (Kristopher Lah, USFWS Chicago, Illinois Field Office, pers. comm. 2006).

2.3.1.3 Genetics, genetic variation, or trends in genetic variation:

The Lakeside daisy recovery plan (USFWS 1990) called for increased research into the genetics of the plant to aid in the understanding of its self-incompatibility as well as the origin of the species.

In a 2000 report studying the diversity of isozyme (an enzyme with differing sequences) and diversity within and between populations of Lakeside daisy, Esselman et al. determined that levels of genetic diversity are comparable to other outcrossing endemic species. They also determined that few genetic differences between populations restricted the ability to find geographical patterns (Esselman et al. 2000).

A later study using inter simple sequence repeats (ISSRs), which is a genetic marker for determining genetic diversity, determined that all of the known populations of Lakeside daisy were only slightly genetically distinct, and that Ohio populations were grouped with the population from Michigan and the Bruce Peninsula populations, suggesting similar ancestry. They also suggest that the Michigan population, due to its small size and low levels of genetic diversity, is at

risk to the effects of genetic drift, and they recommend that all populations of Lakeside daisy be protected to prevent the effects of genetic drift and reductions in seed set (Esselman et al. 2002).

An examination of the genetic diversity and seed set within the artificially established Illinois populations determined that the populations have lowered genetic diversity, increased asexual reproduction, and reduced seed production due to small population size (Esselman and Williams 2003). They suggest that the Lakeside daisy will not be preserved by the establishment of small artificial populations.

Additional research into clonal growth versus sexual reproduction showed that Lakeside daisy plants from Bruce Peninsula have higher asexual reproduction -- i.e., clonal growth mean was 0.61 (SE 0.90) than sexual reproduction; outcrossed seedlings mean was 0.041 (SE 0.039). These results suggest that asexual reproduction may play a role in mitigating stochastic loss of genetic information in populations (Campbell and Husband 2005).

2.3.1.4 Taxonomic classification or changes in nomenclature:

Within the Lakeside daisy Recovery Plan (USFWS 1990), it states that the Lakeside daisy is a divergent variety within the mostly western North American genus *Hymenoxys*, thereby giving it the taxon *Hymenoxys acaulis* var. *glabra*. Cusick has argued that the species name, *Hymenoxys acaulis* var. *glabra*, is the incorrect taxonomy of the species, citing the Lakeside daisy as its own species, *H. herbacea*, rather than a variety of *H. acaulis*. He supported his claim with evidence that *H. herbacea* is a self-incompatible, reduced aneuploid with 14 chromosomes, while *H. acaulis* has 14, 15, or 30. Additionally, *H. acaulis* has dull green leaves that are densely pubescent, while *H. herbacea* leaves are deep green with few hairs (Cusick 1991). Therefore, due to the best available scientific evidence, the taxonomic name for Lakeside daisy is *Hymenoxys herbacea* (Asteraceae).

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g., increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g., corrections to the historical range, change in distribution of the species' within its historic range, etc.):

According to the Lakeside daisy recovery plan (USFWS 1990), the center of the population within the Marblehead Peninsula has shifted over time in a westerly direction. This change in population center was caused by the relocation of active quarrying to the original center, and it may cause additional threats to the population, especially with the level of active quarrying occurring in the area (J. Windus, pers. comm. 2009). It is unknown whether the diversity within the

population center was matched elsewhere within Marblehead Peninsula and whether further stochastic events may decrease genetic diversity.

The spatial distribution of plants within populations have been shown to inhibit sexual reproduction in rare plants, particularly in the Lakeside daisy, where individuals nearby are likely related and share common self-incompatibility genes. Moran-Palma and Snow (1997) studied the effect of interplant distance on mating success in Lakeside daisy plants collected from Marblehead Peninsula and determined that over 80% of controlled crosses were compatible, regardless of mate distance. These results suggest that the distance between plants is not likely to limit seed production, and that population bottlenecks have not severely limited self-incompatibility alleles. These results, however, contradict the mating group self-incompatibility mating system where individuals cannot mate with nearby individuals due to shared mating group alleles. It is likely that Moran-Palma and Snow found no effect of spatial distance on incompatibility due to the genetic diversity of the population center on Marblehead Peninsula, which was their sample site.

A new population of Lakeside daisy was discovered in Mackinac County, Michigan in 1996, which is outside of the established species range. The habitat for this population is also different from typical substrate for Lakeside daisy, consisting of tufa (precipitated, congealed limestone), marl, and numerous alkaline springs, and association with rare fen species such as *Erigeron hyssopifolius*, *Solidago houghtonii*, *Carex richardsonii*, and *Carex scirpoidea* (M. Penskar, pers. comm. 2010). This population currently has approximately 500 plants spanning the highest, driest mounds of tufa across Brevort Lake Road and associated powerline right-of-ways. Both sides of the road are currently protected (Michigan Nature Association owns the Stratton Memorial Nature Sanctuary and the Hiawatha Forest Service owns the opposite side of Brevort Road; (Christie Deloria-Sheffield, USFWS East Lansing, Michigan Field Office pers. comm. 2005; S. Huebner, pers. comm. 2009). The origin of this population has yet to be determined (i.e., whether it is a natural population or a transplant from populations in Ohio).

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

Climate change may present a serious threat to this species, as the habitat for Lakeside daisy is restricted to rare dry, limestone prairies and alvar communities, and no refugia are present (Campbell et al. 2002). Populations of Lakeside daisy cannot expand to unsuitable habitat, and some, particularly those associated with the Great Lakes, cannot shift northwards due to the presence of the Lakes and/or development.

Pollinators also play a role in the recovery of the Lakeside daisy. A 2007 study focusing on the effect of Lakeside daisy population size on pollen limitation

found that small populations had more insect flower visitation than large populations, but that these populations had fewer available mates. This suggests that while small populations suffer from reduced potential mates, high pollinator visitation mitigated this effect, and plants were rarely pollen limited, regardless of population size (Campbell and Husband 2007).

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms):

The final rule (53 FR 23742) listing Lakeside daisy as threatened identified the threats to the survival of Lakeside daisy as habitat destruction, succession of overgrowth by woody species, over-collecting for gardens, inadequacy of existing regulatory mechanisms, and the species' self-incompatibility.

With the exception of over-collection, all of the threats described in 1988 are still affecting the species. Additionally, climate change is perceived as a threat not discussed previously. The most significant threats range-wide are habitat destruction and succession of woody species.

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

The largest natural population in the United States is on private land within an active quarry (Lafarge Quarry, Ottawa County, Ohio), and is not protected. However, the newly discovered, purchased, and reintroduced populations of Lakeside daisy are protected. Protected populations include the Hiawatha National Forest/Stratton Memorial Nature Sanctuary population in Mackinac County, Michigan; the Lakeside Daisy Nature Preserve in Ottawa County, Ohio; and the introduced populations at Kelleys Island in Erie County, Ohio; and the Lockport Prairie Nature Preserve, and Romeoville Prairie Nature Preserve in Will County, Illinois.

One serious threat to the species is that, of the approximately 2,500-acre area of suitable habitat at Marblehead Peninsula in Ottawa County, Ohio, only 19 acres are protected (Windus and Cochrane 2000). The majority of the population is found on private property owned by Lafarge Quarry. At this site, the natural habitat of the Lakeside daisy has been destroyed by limestone quarrying, forcing the species to retreat to abandoned areas of the quarry, which are threatened by the placement of spoil piles and other quarrying debris and may be quarried in the future. The owners of the quarry intend to continue active quarrying throughout the entire property on a cycle for the next 100 to 150 years. Ohio DNR DNAP, DNR DOW, and USFWS biologists have asked Lafarge Quarry to discontinue the placement of quarry spoils on populations of Lakeside daisy, though that practice continues at present. The quarry owners allow monitoring of populations of Lakeside daisy on their property, though no recent efforts have been made to set

aside conservation areas or purchase portions to create preserves within the quarry property.

Destruction threatens the population of Lakeside daisy at the Hiawatha National Forest/Stratton Memorial Nature Sanctuary in Mackinac County, Michigan. Ongoing Brevort Lake Road and powerline ROW maintenance has kept conditions open in the past, maintaining habitat for Lakeside daisy, though maintenance-related threats to this population include herbicide spraying, ATV use, and associated non-native invasive species introduction. The population is also at risk due to the instability of the tufa and marl substrate, which is eroding and causing some plants to fall into the roadside ditch (Bartoo et al. 2000). Additionally, overgrowth of adjacent northern white cedar limits the potential habitat within the site, while small size and isolation further threaten this population's survival (S. Huebner, pers. comm. 2009).

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

Overutilization of the Lakeside daisy for commercial use appears to be a minimal threat.

Due to the showy inflorescence and extended flowering period, it is possible that commercial sale of the Lakeside daisy could pose a significant threat (USFWS 1990). However, according to the *Federal Register* final rule at time of listing, an insignificant market for plants and seeds of the Lakeside daisy was recorded, including reports that several nurseries in Illinois and Wisconsin sold seeds (53 FR 23742). However, due to the present protection under the Endangered Species Act, it is unlikely that sales continue, and therefore, do not appear to be a threat to this species.

Additionally, according to the Recovery Plan, Lakeside daisy and other species of *Hymenoxys* were used in Chicago rock gardens. Cuttings were exchanged among the American Rock Garden Society because the clones did not produce seeds (USFWS 1990). Therefore it is unlikely that the exchange of clones could pose a threat to the Lakeside daisy.

2.3.2.3 Disease or predation:

Disease and predation were not listed as threats to the Lakeside daisy at the time of listing (53 FR 23742), though herbivory was included as an ecological threat to both natural and restored populations in the recovery plan (USFWS 1990). Predation, namely deer and rabbit herbivory, of this plant has appeared to increase within the introduced populations in Lockport Prairie Nature Preserve and Romeoville Prairie Nature Preserve in Will County, Illinois (K. Lah, pers. comm. 2006). Alternatively, inflorescences at these sites have been found on the ground next to rosettes, indicating trampling by wildlife or internal parasites, i.e., cut

worms or insects, within the plants (Juanita Armstrong, Natural Resource Land Manager, Forest Preserve District of Will County, Illinois, pers. comm. 2010). These factors pose a threat to Lakeside daisy populations since rosettes are not able to regenerate if herbivory on leaves is too intense (USFWS 1990), or if significant damage to the plants is caused by other sources.

2.3.2.4 Inadequacy of existing regulatory mechanisms:

Before the Lakeside daisy was federally listed in 1988 (53 FR 23742), it was listed as endangered by the States of Ohio and Illinois. At that time, however, those protections only warranted the prohibition of trade and collection, and did not specifically provide for the protection or management of the species' habitat. Currently, the Hiawatha National Forest/Stratton Memorial Nature Sanctuary in Mackinac County, Michigan population lies along a road and powerline right-of-way (ROW) and is subject to routine maintenance by those parties, though the population is mostly located on a nature preserve (protected by Michigan Nature Association) and a national forest (Hiawatha). Regardless of this protection, the population is suffering from the destructive forces of road and powerline ROW maintenance and the associated threats of ATV traffic and non-native invasive species (S. Huebner, pers. comm. 2009). It appears that legally preserving the area has not protected the Lakeside daisy plants from these threats.

Additionally, populations of Lakeside daisy on private property are threatened by quarrying activities and are not afforded protection under the law. The largest natural population in the United States, Marblehead Peninsula, Ottawa County, Ohio, has already lost the highest density area of plants due to quarrying, and population numbers may continue to shrink with future quarrying activity.

Outside of the populations on private land, it appears that, under Federal protection of the Endangered Species Act, regulatory mechanisms are providing adequate protection to populations of Lakeside daisy on public land in the United States. The Lakeside daisy was also listed as threatened under the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in May 2002 and is protected in Canada under the Species at Risk Act (SARA), with 23 of the 38 populations in conservation agreements (Campbell et al. 2002).

The inadequacy of regulatory mechanisms is not a severe threat to this species on land that is publicly owned, though populations in private ownership are continually threatened.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

The sporophytic self-incompatibility of the Lakeside daisy enforces outcrossing between individuals with different self-incompatibility genes. Populations within larger regions, such as those on Marblehead Peninsula and Manitoulin Island, are likely in contact with many individuals that each has a different self-

incompatibility gene. However, small populations tend to lose self-incompatibility genes, increasing the probability of nearby plants sharing the same gene, and therefore may not be able to effectively outcross. It is theorized that this may have been a leading factor in the natural disappearance of one of the last Lakeside daisy populations in Illinois (DeMauro 1982).

Populations are also threatened by human use of the habitat, including ATV access, which can destroy plants and habitat. The population at Hiawatha National Forest/Stratton Memorial Nature Sanctuary in Mackinac County, Michigan is threatened by ATV access due to its close proximity to a public road ROW and a utility ROW (S. Huebner, pers. comm. 2009). Non-native invasive species, such as Oxeye daisy, *Leucanthemum vulgare*; Spotted knapweed, *Centaurea stoebe*; and Smooth brome, *Bromus inermis*, are threatening Lakeside daisy with their introduction through ATV access (S. Huebner, pers. comm. 2008; 2009). To protect this population, regular maintenance is required to remove non-native invasive species and woody encroachment.

Climate change may be a serious threat for a rare, endemic plant species like the Lakeside daisy. The habitat for the Lakeside daisy currently spans a narrow range of habitat types, including dry, limestone prairies and alvar communities, which are globally rare. According to regional precipitation and temperature models, increased temperatures and increased rainfall may alter the habitat for the Lakeside daisy in such a way that the plant cannot adapt or invasive plants may encroach (Union of Concerned Scientists 2009). It is not known how the Lakeside daisy will be impacted by temperature or precipitation increases. However, additional rainfall will likely not buffer the drought and lowered lake levels caused by increased temperature, and lowered lake levels will further alter the climate through decreased evaporation and precipitation (Easterling and Karl 2000). Furthermore, the largest population of Lakeside daisy in the United States is situated in Ottawa County, Ohio, on the coastline of Lake Erie, and no refugia are available nearby for this plant. Therefore, climate change poses a serious threat to the Lakeside daisy due to the severely restricted habitat and range of the species.

2.4 Synthesis

Since the Lakeside daisy was listed as threatened in 1988 (53 FR 23742), the number of populations in the United States has increased from the single large, fragmented population at Marblehead Peninsula in Ottawa County, Ohio. A population of unknown origin (either natural or introduced) was found in 1996 at Hiawatha National Forest/Stratton Memorial Nature Sanctuary in Mackinac County, Michigan. Additionally, four populations have been introduced (two in Will County, Illinois, one in Tazewell County, Illinois and one in Erie County, Ohio). The populations on protected land appear

to be stable (See Figure 1), while the population within Lafarge Quarry is at risk of destruction by active quarrying (J. Windus, pers. comm. 2009).

Additionally, research into the genetics and pollination biology of the Lakeside daisy has provided new information regarding the minimum viable population size and the nature of the sporophytic self-incompatibility of the species. Work has also been performed to understand the geological patterns associated with the species and to determine the origin of the newly-discovered population in Mackinac County, Michigan, with limited results (Esselman et al. 2000; Esselman et al. 2002). Neither isozyme nor ISSR genetic markers provided enough genetic differentiation between populations to determine the cladistics of the known populations. However, results of a genetic diversity and seed set study within the introduced Illinois populations found that these populations suffer from reduced genetic diversity, increased asexual reproduction, and reduced seed production, suggesting the Lakeside daisy will not be preserved only by creation of introduced populations (Esselman and Williams 2003). These results suggest that Recovery Criteria 3 and 4 are not being met currently, and will not be met with existing recovery actions. Genetic diversity should be increased at these sites through the addition of plants from different mating groups, to increase the likelihood of the recovery criteria being met.

According to the recovery criteria outlined in the recovery plan (USFWS 1990), the species can be considered recovered when essential habitat at the Marblehead [Lafarge] Quarry is restored, the species is restored to one large population in each of two geographic areas in Illinois, and a minimum of 5,000 individuals in one restored population per Illinois county is restored for 15 consecutive years with an additional 10 years of monitoring. While these criteria have not been met, some progress is being made on this species' recovery through continued protection of established introduced populations. The introduced populations of Lakeside daisy in Will County, Illinois have survived for the past 21 years, although neither population contains 5,000 individuals as required by the recovery criteria. The Kelleys Island population in Erie County, Ohio has steadily increased in size and provides a model of reintroduction techniques. While the owners of Lafarge Quarry will continue active quarrying throughout the site indefinitely, they are cooperative with efforts of the state and Federal agencies to monitor populations of Lakeside daisy in inactive sections of the quarry.

Some populations of Lakeside daisy occurring on preserves have been monitored and maintained for the continued survival and recovery of the species. The two introduced populations in Will County have been monitored every year to every five years since their introduction and are managed with prescribed burns. However, little detailed demographic monitoring has occurred at Manito Prairie Nature Preserve in Tazewell County, Illinois since its introduction, and the Kelleys Island population in Erie County, Ohio has not been monitored since 2001. Threats including encroachment of woody species, non-native invasive species, ATV use, and herbivory continue to impact species on the Hiawatha National Forest/Stratton Memorial Nature Sanctuary. Additionally, the threat of climate change may be serious for the Lakeside daisy, because its habitat range is restricted to rare alvar and limestone areas and constrained by the Great Lakes.

The recovery criteria and recovery actions rely heavily on protecting, managing, and obtaining the habitats on which Lakeside daisy needs to maintain viability (USFWS 1990). In addition, recovery of the Lakeside daisy relies on a greater understanding of the biotic and abiotic needs of the species in order to apply adequate management. Therefore, because the criteria for delisting have not been met, the Lakeside daisy continues to meet the definition of a threatened species.

3.0 RESULTS

- 3.1 Recommended Classification:** No change is needed
- 3.2 New Recovery Priority Number:** Retain as 8, which indicates that the species has a moderate degree threat and a high recovery potential.
- 3.3 Listing and Reclassification Priority Number:** Not applicable.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

Future actions required to proceed with the recovery of this species focus on revision of current recovery criteria, population habitat management and protection, as well as research into the genetics of Lakeside daisy:

- Revise recovery criteria to include new data prior to next 5-year review.
- Provide adequate habitat protection for the only large, naturally-occurring population in the United States, i.e. Marblehead Peninsula, through the purchase or establishment of conservation easements of abandoned quarry property.
- Cooperatively work with Lafarge Quarry to protect areas of the quarry that are least likely to be quarried and have the highest genetic and habitat diversity.
- Determine the presence or absence of seed banks and the duration of seed viability.
- Establish Lakeside daisy populations on suitable sites within the species historical range.
- Botanical and geological surveys should be performed throughout Ohio, Indiana, Illinois, Michigan, and Wisconsin to assess the potential for suitable habitat of Lakeside daisy introduction.
- Continue to monitor populations of Lakeside daisy, both natural and introduced, for reproductive output, recruitment, individual plant growth, and survival.
- Increase gene pools and population numbers in restored population sites by seeding and transplanting individuals from various locations within natural populations.
- Provide necessary management at all protected sites, including removing non-native invasive species and woody encroachment, deterring herbivory, limiting ATV access and prescribed burning (in Illinois only).
- Conduct genetic research using highly polymorphic genetic loci to determine the genetic distance of natural populations and determine the viability of small, introduced populations.
- Inform the public about the harm of collecting federally listed plant species and the importance of unique ecosystems.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Lakeside daisy (*Hymenoxys herbacea*)

Current Classification: Threatened

Recommendation resulting from the 5-Year Review

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change is needed

Appropriate Recovery Priority Number: Remain at 8

Review Conducted By: Julie M. Proell, Ohio Ecological Services FO, USFWS

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve Mary M. Knapp Date 2-2-2010
Mary M. Knapp

REGIONAL OFFICE APPROVAL:

Assistant Regional Director, Ecological Services, Fish and Wildlife Service, Midwest Region

Acting Approve [Signature] Date 3/4/10