

Lakeside Daisy
(Tetraneuris herbacea)

5-Year Review:
Summary and Evaluation

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

2016

5-YEAR REVIEW

Lakeside daisy/*Tetraneuris 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 Jennifer Finfera, Fish and Wildlife Biologist, U.S. Fish and Wildlife Service (Service), Ohio Ecological Services Field Office, in consultation with other Field Office Biologists in the Midwest Region and species experts in the United States and 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 (79 FR 15867) initiating the 5-year review. We reviewed past and recent literature, public comments, the final listing rule (53 FR 23742), the Lakeside daisy Recovery Plan (USFWS 1990), and current information on continuing quarry operations on the Marblehead Peninsula. In the past five years, quarry activities in Ohio have accelerated and current efforts to recover the species focused on seed and plant collection for establishment of new populations on public land. We relied heavily on recent information on the status of introduced populations and current efforts to establish new populations. Peer review of this document was conducted by several species experts including Mike Penskar, retired from Michigan Natural Features Inventory, as well as by Jennifer Windus, a retired Ohio Department of Natural Resources plant biologist with many years of experience with Lakeside daisy.

1.3 Background:

1.3.1 FR Notice citation announcing initiation of this review:

79 FR 15867 (July 8, 2014) for nine listed animal and two listed plant 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 November 6, 1991 cursory 5-year review conducted for all species listed before 1991(56 FR 56882).

A 5-year review for this species was conducted in 2010 following initiation on April 22, 2008 (73 FR 21643).

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 is 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 25 years since the recovery criteria were developed and published. The speed of quarry operations has increased in recent years at the largest population site in the U.S. and ongoing quarry operations have impacted the core of this population. Since the recovery criteria were developed, a significant amount of occupied habitat has been destroyed by quarry activity and no additional habitat has been protected. In addition, reintroduced populations on protected sites in Illinois have been in decline. A small additional population was reported in Brevort Township, Mackinac County, Michigan in 1996 (Penskar 2015) and is located on lands managed by Hiawatha National Forest and the Michigan Nature Association. An additional population was found on the Hiawatha National Forest in 2014 near St. Martin Peninsula, Marquette Township, Mackinac County. There are plans by Hiawatha National Forest to establish new populations of this plant at the National Forest. The Michigan Nature Association has been taking steps to establish a reserve population for the last few years. Some genetics research has been performed on this species. Multiple efforts have been made to establish new populations in Ohio. The recovery criteria do not reflect all of these changes. Due to the ongoing quarry activities, most of the recovery criteria are no longer obtainable.

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.

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 Lafarge quarry has shifted due to the active quarrying at the previous population center (Windus 2009, personal communication). This area that previously contained the highest densities of mature plants no longer exists. In addition, removal and/or movement of quarry piles results in plants being dislodged and crushed with equipment. Essential habitat is defined as occupied and unoccupied suitable Lakeside daisy habitat between Hartshorn and Bay Shore Roads. No additional land has been acquired for this species since the acquisition of the Lakeside Daisy State Nature Preserve in 1988. Lafarge has not been interested in protecting this habitat until recently and thus, this criterion to protect essential habitat has not been met. Protection of this habitat can only be achieved through the cooperation of Lafarge.

Operations at Lafarge Quarry have continued and in recent years, the rate of quarrying has increased significantly. Quarry operations have eliminated significant areas of available habitat in the past 10 years and operations have accelerated in the last 5 years. Activity at the center of the quarry has resulted in deep excavation and removal of the gravel piles that the Lakeside daisy occupied. Due to the recent and continued activity in this area, these areas that have been disturbed no longer provide suitable habitat. Based on the results of the 2015 survey, the amount of suitable habitat available within the Lafarge property has decreased by 98.12 acres since 2009 due to quarry activities.

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. While the Service and ODNR have been working with Lafarge since at least 2012 to develop an agreement that would include protection of habitat for the Lakeside daisy, no formal conservation or acquisition plans have been completed. Land to the east of Alexander Pike and south of the Lakeside Daisy State Nature Preserve would be an excellent candidate for initial conservation efforts (Windus et al 1999). This area does provide suitable habitat. It currently has a relatively low density of individual Lakeside daisies, but this population could be enhanced. The Service and representatives of the Ohio Natural Areas and Preserves Association recently met with Lafarge to explore the potential of acquiring this area. Further action is required for this criterion to be met.

- 3) The variety [now a species] is restored to a minimum of one large (> 5,000), 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). The number of plants declined from 1989-1993 with a small increase in 1994. The population was augmented in 1994 with 90 seeds, and again in 1995 with 30 plants; however, the population remained under 200 plants (Simone 2015, personal communication). Two flowers were browsed in 2013 and no plants were found in 2014 (Simone 2015, personal communication).

Two Will County, Illinois sites were established with 1,100 Lakeside daisy transplants in 1988. These two public land sites include Lockport Prairie Nature Preserve and Romeoville Prairie Nature Preserve. No additional augmentation was conducted at that time and both sites have continued to decline. Currently each site contains fewer than 200 plants. The site in DuPage County, Illinois was monitored from 2009 to 2011. However, the method of monitoring was inconsistent, so no trends can be determined from the data available (Illinois Heritage Database 2015). The maximum number recorded at this site was 427 clumps in 2010 (Illinois Heritage Database 2015). These may represent rosettes and not individual plants. In Cook County, Illinois, the site at the Chicago Botanic Garden contained less than a dozen plants when it was monitored in both 2010 and 2009. The second site in Cook County,

Illinois contains less than 50 rosettes which may indicate significantly less than 50 plants (Illinois Heritage Database 2015).

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). While the minimal augmentation events of transplanting individuals in 1988 to three Illinois sites resulted in a significant temporary increase in these populations, no sustained efforts were made to augment or manage these populations. Hence, the populations at these sites have continued to decline with little evidence of recruitment. In reviewing the information from the other sites in DuPage and Cook County, none of the Illinois sites represent large or stable populations.

- 4) The maintenance of restored populations for 15 consecutive years, with monitoring to continue for an additional 10 years.

Criterion 4 has NOT been met.

According to available information, the reestablished population at Manito Prairie Nature Preserve in Tazewell County, Illinois was monitored from 1989 through 2002, except for 1996 for which no data are available (Simone 2015, personal communication). Recent monitoring did occur in 2013 and 2014.

The two populations in Will County, Illinois have been established for 27 years (1988 to 2015). While these populations continue to persist, they are not increasing and do not appear to be self-sustaining. Monitoring has occurred intermittently with no data available from 1993 until 2001. However, annual monitoring has occurred since 2002 and the populations have slowly been declining.

The population in DuPage County, Illinois was planted in 1994 with 100 individuals (Kobal 2016, personal communication). It has been monitored periodically with no data available from 2012 until the present (Illinois Heritage Database 2015). The two sites in Cook County, Illinois are also monitored infrequently with the most recent data available from 2010.

The population identified in Brevort Township, Michigan has an unknown origin and was reported in 1996. This population is relatively low in size and occupies a small area of habitat. Plants are located in an approximately 50-foot by 80-foot area (Windus 2015, personal communication). Monitoring of this site occurs regularly however, the information is not consistently recorded. A reserve population has also been established (Bozic 2015) due to concerns that the roadside population is not stable and could easily be damaged by road maintenance. The number of flowers in this reserve population is monitored as well as the number of individuals. After three transplanting events, this population has just over 400 individuals (Bozic 2015). This may be due to the poor habitat at this site. The reserve population is located on gravel ridges with frequent standing water around them (Windus 2015, personal communication).

The St. Martin Peninsula Population in Marquette Township discovered in 2014, on the Hiawatha National Forest, is of unknown origin. There is some thought that this population was established with seed from the Brevort Township Michigan population sometime around 2004 (Blumer 2016, personal communication). The St. Martin site occurs within a ½-acre opening adjacent to a major road (Blumer 2016, personal communication). The population is small with less than 30 individuals identified in 2014. The greatest threat to this site is the growth of woody vegetation and non-native species.

The populations originally introduced to Kelleys Island State Park in Ohio from 1989 to 1994 with seeds and adult plants, have been established for over 20 years and were monitored annually from 1990 to 2001, with additional monitoring occurring in 2014 and 2015. Due to the success of these populations, additional monitoring is expected to occur infrequently. Additional seed was dispersed on state park land at Kelleys Island in 2013 and 2014.

Seed was dispersed at Huntley Beatty Preserve on Kelleys Island and at Castalia Quarry Metropark in the fall of 2012, 2013, 2014, and 2015. These sites have been monitored every year since and will continue to be monitored for at least the first 5 years of establishment. It is anticipated that if these populations continue to increase, monitoring may occur on a more intermittent basis after the first 5 years.

2.3 Updated Information and Current Species Status

Since the species was listed as threatened in 1988 (53 FR 23742), 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 92.552 acres of the 2,500-acre quarry are presently occupied by Lakeside daisies. Many parts of the population are near active quarrying and have been destroyed or impacted by dumping of excess gravel or slag (Gardner 2015, personal communication). Continued coordination with Lafarge Quarry is necessary to ensure conservation of populations of Lakeside daisy within the quarry.

The restored and introduced populations in Illinois, the populations in Michigan, and the introduced populations in Ohio are under varying levels of protection with varying degrees of population growth success. The protected natural population at the 19-acre Lakeside Daisy State Nature Preserve is a dedicated state nature preserve owned by the ODNR Division of Natural Areas & Preserves.

2.3.1 Biology and Habitat

Lakeside daisy occurs on alvar habitat and was listed as federally threatened in 1988. According to the Alvar Working Group, alvar habitat consists of flat limestone or dolostone bedrock with thin to no soil, few to no trees, and is subject to seasonal drought (TNC 1999). This species also occurs on modified alvar habitat in which the original alvar habitat has been altered or removed by quarry activities. Modified alvar habitat differs from intact alvar habitat because the bedrock material has been broken up and is often in the form of gravel. In addition, these sites lack the complete association of alvar plants (Catling 2013). Modified alvar habitat does have some of the other characteristics of alvars including open habitat with few trees and little or no soil. The Lakeside daisy populations on the Marblehead Peninsula, as well as the introduction sites on Kelleys Island, and the introduced population in Castalia Quarry Metropark all occur on modified alvar habitat.

When Lakeside daisy was listed as endangered, only one fragmented population was known in the U.S., on the Marblehead Peninsula in Ottawa County, Ohio. The Lakeside daisy had also been recorded in Will and Tazewell Counties in Illinois, but was presumed extirpated prior to listing. Lakeside daisy is known from two regions in Ontario, Canada, consisting of nine sites on the Bruce Peninsula and 20 sites on Manitoulin Island or surrounding islands (Parks Canada Agency 2011).

In 2013, the Tazewell site in Illinois contained two flowering plants that had been lost due to browsing. The most recent information from 2014 indicates that no plants were found (Simone 2015, personal communication). Two additional introduced populations were transplanted into appropriate habitat in Will County, Illinois in 1988 and the populations at those sites continue with low success. Lakeside daisy had been historically identified in both Tazewell and Will Counties in Illinois. Therefore these sites are all identified as restored populations.

The site in DuPage County, Illinois was planted in 1994 and continues to persist (Illinois Heritage Database 2015). One of the sites in Cook County, Illinois is located at the Chicago Botanic Garden within prairie habitat. These plants most likely are maintained as a collection and not as a functioning ecological community. The other site within Cook County, Illinois is on public land. This site contains dolomite prairie, oak savanna, and oak woodland. These sites are identified as introductions as Lakeside daisy was not historically identified within these counties.

Since its listing in 1988, a population of Lakeside daisy was reported in 1996 (Penskar 2015, personal communication) in Brevort Township, Mackinac County, Michigan, on properties located along both sides of Brevort Lake Road. On one side of the road, the property is owned by the U.S. Forest Service and managed as part of the Hiawatha National Forest. Approximately 1-2 plants with 17 rosettes occur on this side of the road, as of 2015 (Windus 2015, personal communication). These plants were reportedly moved to the Forest Service side of the road from the other side soon after the population was discovered (Penskar 2015, personal communication). The opposite side of the road is owned by the Michigan Nature Association. This side contains most of the population, less than 200 plants with approximately 300 flowering stems as of 2015 (Windus 2015, personal communication). Due to the proximity of these sites, this area is considered to be a single population.

A reserve population has been established by the Michigan Nature Association with seed gathered from the Brevort Township population (Bozic 2015, personal communication). This reserve population was established due to concerns about the susceptibility of the original population to catastrophic events. The seed was collected in 2007 and grown in a greenhouse until 2010 when the plants were planted outside at the reserve site in 2010 (Bozic 2015). The reserve population was established with fifty-four plants. A second phase of planting occurred in 2013 with sixty-two seedlings (Bozic 2015). The number of flowers (not individual plants) was monitored in both 2013 and 2014. At the phase 1 site, the flower count of 115 in 2013 increased to 182 in 2014 (Bozic 2015). The overall number of flowers increased from 90 in 2013 to 408 in 2014 at the phase 2 site (Bozic 2014, personal communication).

A phase 3 planting was established in 2015 with the planting of 300 seedlings (Bozic 2015). Based on previous transplanting efforts, it would be expected that survivorship of individual plants should be relatively high if they are transplanted into high quality habitat. Plants that were transplanted from the Marblehead population to Kelleys Island experienced a survival rate of 83% the following year and 88% of those survived a second year (Windus and Cochrane 1998). In the third year following planting, the number of plants increased due to seedling establishment. The new plants identified in the third year may have been established onsite or they may have been small plants that were overlooked in previous

years. The location at Kelleys Island contained high quality habitat with little competition and very few low-lying wet areas. Seeding or planting in lower quality habitat, such as is present at the Michigan sites, is not expected to yield the same high survival documented at Kelleys Island.

The St. Martin Peninsula site discovered in 2014 has a small population. While these plants appear more robust than the plants in the Brevort Township population (Blumer 2016, personal communication), there is no information available on whether these plants are producing viable seed.

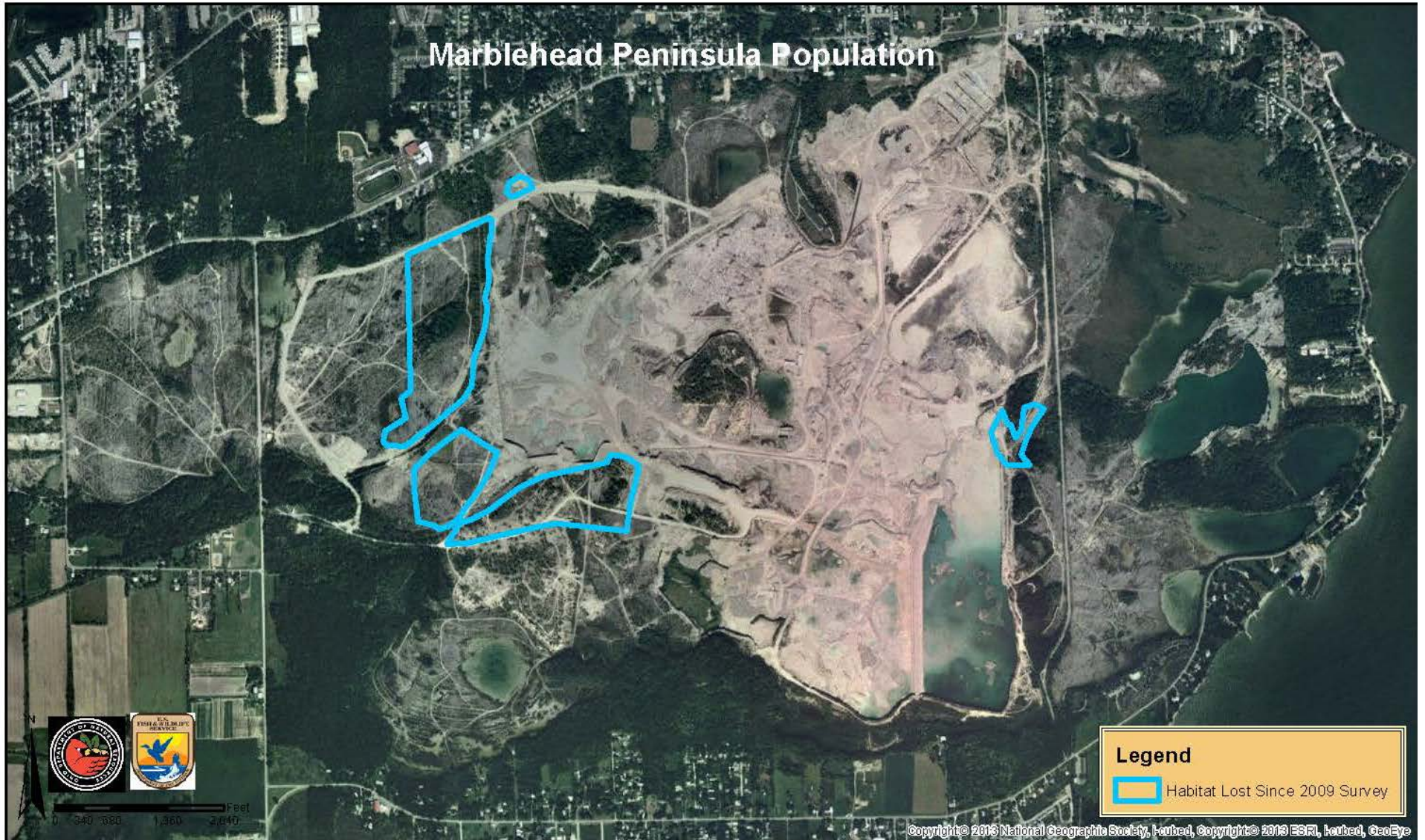
The population on the Marblehead peninsula in Ohio includes Lafarge Quarry and the Lakeside Daisy State Nature Preserve. The first population estimate of the Lafarge Quarry was developed in 1990 when the Recovery Plan was written. It was based on field data gathered in 1986 and 1989 (USFWS 1990). In 1995, the extent of habitat occupied by Lakeside daisy within the Lafarge Quarry was determined. This was completed to determine the area of occupied habitat and the loss of suitable habitat due to continued quarry activities. A survey was conducted in 2009 to determine the population of both the Lafarge quarry and the Lakeside Daisy State Nature Preserve site. The most recent survey was conducted in 2015 at both the Lafarge Quarry and the State Nature Preserve and involved sampling to determine density estimates.

By comparing survey data from 2009 and 2015, including the areal extent of Lakeside daisy, it is evident that a significant amount of habitat has been lost (Map 1). Approximately 98.12 acres have been lost since 2009 due to quarry activity (Gardner 2015, personal communication).

The introduced population on Kelleys Island in Erie County, Ohio has increased dramatically since 1989. During establishment, approximately 1,000 individual plants were transplanted to the north quarry and central quarry sites at Kelleys Island State Park. Monitoring of these plots in 2014 revealed that they now contain over 16,000 adult plants (Windus 2014).

Since Lakeside daisy had never been recorded on Kelleys Island prior to introduction efforts in 1989, the sites on Kelleys Island are identified as introduction sites. Additional populations were established at the Huntley-Beatty Preserve on Kelleys Island and at Castalia Quarry Metropark in Margaretta Township, Erie County in 2012. These populations appear to be at least stable with slow establishment of many seedlings and a few flowering plants in 2015. Augmentation of these sites is expected to continue for at least the next year. Lakeside daisy had not been recorded in Erie County prior to introduction in 2012, so the Castalia Quarry Metropark site is also identified as an introduced site.

Map 1. Lakeside Daisy Habitat Loss to the Marblehead Peninsula Population Due to Quarry Activity



2.3.1.1 New information on the species' biology and life history:

According to the Recovery Plan, the following types of insects have been observed to pollinate Lakeside daisy: bumble bees (Apidae), small carpenter bees (Xylocopidae), and halictid bees (Halictidae). During field work conducted in 2015, multiple insects were observed pollinating Lakeside daisy flowers. These included the pearl crescent (*Phycoides tharos*) (Parshall 2015, personal communication), a small butterfly.

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

Monitoring, restoration, and management efforts for some populations have been documented for this species. Naturally-occurring populations are known from two sites on the Marblehead Peninsula in Ottawa County, Ohio (Lafarge Quarry and Lakeside Daisy State Nature Preserve), and along the coast of Manitoulin Island and the tip of Bruce Peninsula in Ontario, Canada. Two populations of unknown origin are located in Michigan, with an additional reserve population established with seed from one of these sites. Restored and introduced populations are located in Illinois. Restored populations in Illinois include three sites. Two sites occur in Will County (Lockport Prairie Nature Preserve and Romeoville Prairie Nature Preserve) and one site in Tazewell (Manito Nature Preserve) County in Illinois. Introduced populations are located in Cook and DuPage Counties in Illinois. 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).

A restoration 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). While some plants may flower after two years, many individuals will take longer to flower. This was supported by the observance of a single flower stalk at the Huntley-Beatty Preserve in August of 2014 after seeding in late 2012 and 2013. Multiple flowers were observed at this site and Castalia Quarry in May 2015.

The only additional augmentation conducted at the Will County, Illinois sites after 1989 was the dispersal of a limited amount of seed from Ohio at Romeoville Prairie State Nature Preserve in 2014. The populations in Will County have been in decline for many years and now each remains at less than 200 plants. Population trends at the two Will County, Illinois sites currently appear relatively stable. While the populations may appear to be stable, there is little sign of recruitment and this may indicate that the plants are persisting vegetatively and that cross-pollination is not occurring. Based on the monitoring results, it appears that no significant recruitment has been occurring at the Romeoville site for the last 5 years as the total number of plants has been in decline every year the site has been monitored since 2009 (Armstrong-Ullberg 2014). At least three seedlings were observed at the site in 2015 and these may represent successful germination of the Ohio seed (Armstrong-Ullberg 2015, personal communication). The total number of plants at the Lockport site has been more variable. However, the total number of plants has not been over 200 since 2009 (Armstrong-Ullberg 2014). These low populations may be due to a lack of genetic diversity, loss of different mating types, changes in site hydrology, and the abnormally wet, cool springs that occurred in this area in 2013 and 2015 (Armstrong-Ullberg 2016, personal communication). In the early 1990's the site contained less vegetation and lacked a consistent soil layer. In recent years there has been an increase in the competition from native prairie

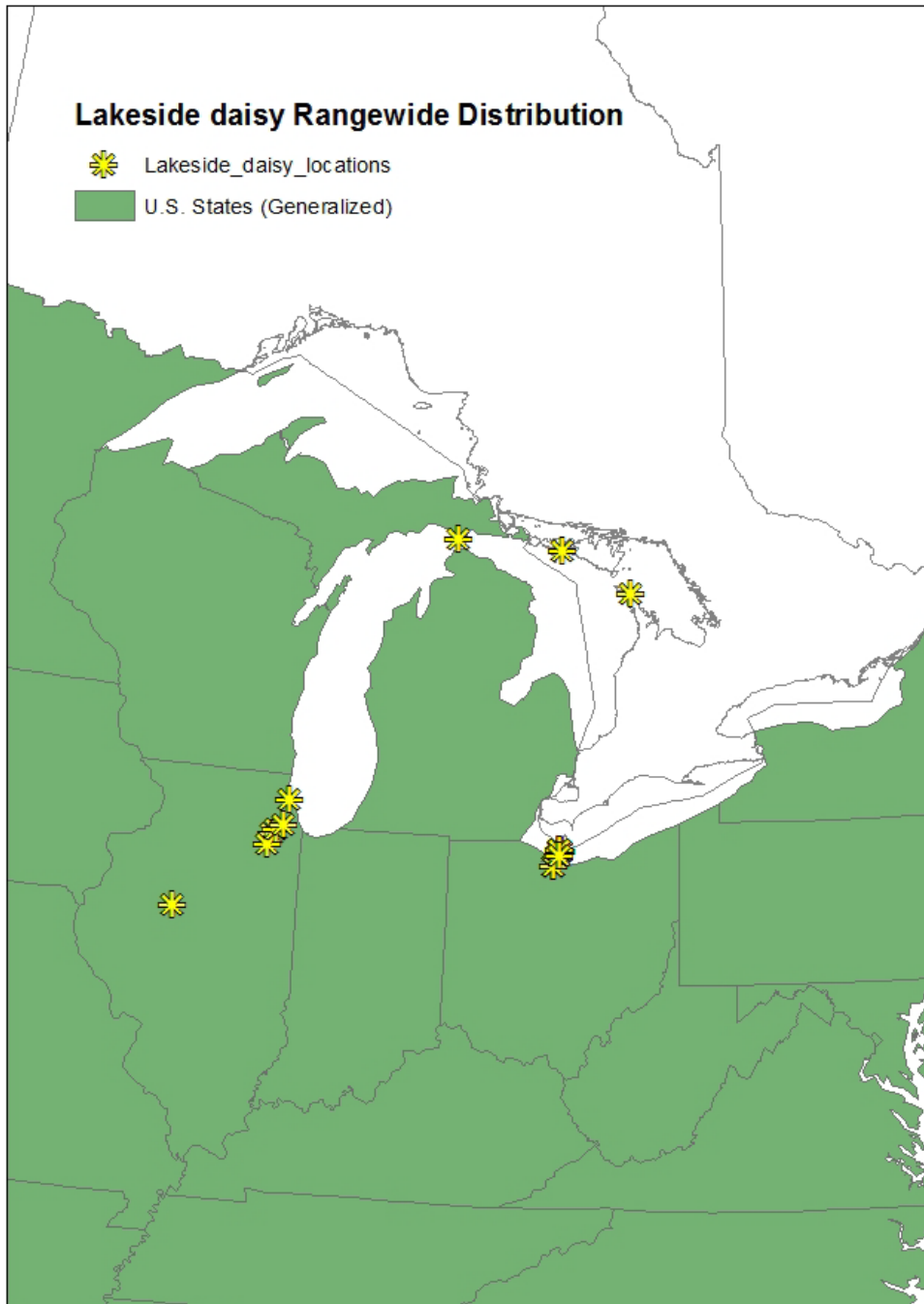
plants (Armstrong-Ullberg 2015, personal communication). These prairie plants also create a dense layer of organic matter when they senesce. This organic layer may reduce the amount of available sunlight to the Lakeside daisy as well as create more suitable soil for additional plant species leading to even greater competition. In an effort to increase the genetic diversity, seeds from Ohio were obtained and dispersed in November of 2013 at Romeoville, in a separate area of dolomite rubble (Armstrong-Ullberg 2016, personal communication).

The two sites in Will County also suffer from a lack of management, impacts to the hydrology of the site causing the habitat to become too dry, and increased dominance by grasses that compete with Lakeside daisy (DeMauro 2014, personal communication). In recent years both sites have been managed annually. Management activities include prescribed burning, invasive species control, and more recently deer management. Prescribed burning is conducted to reduce competition. However, Lakeside daisy is not found in habitats adapted to fire. The plant does not develop deep roots that would be protected from fire and individual plants would most likely not recover from significant damage to the above-ground growth. The management activities do not address hydrologic changes in the water table. They also cannot alleviate habitat alterations due to abnormal weather events that have occurred in recent years. Both 2013 and 2015 were dominated by excessive precipitation in the spring. Since both Lockport Prairie Nature Preserve and Romeoville Prairie Nature Preserve are located within the floodplain of the DesPlaines Riverway, the excess precipitation may have resulted in higher soil moisture levels, which provides more suitable habitat for other vegetation and increased competition for Lakeside daisy (Armstrong-Ullberg 2016, personal communication).

Introduced populations are located in DuPage and Cook County, Illinois. Little data about these sites are available, however at the DuPage County site, flowering individuals have been noted from 1995 –2011. More than 200 plants were noted in 2004 with a total of 81 flowers observed. Many of the plants appear to be expanding in rosette size since being planted. It is not certain if the plants are reproducing by seed or vegetatively, since small plants have been noted. The population consisted of a total of 234 flowering plants in 2006. Over 400 plants were observed in 2008. A total of 427 plants were observed in 2010. Only 64 plants were reported from the site in 2011 (Kobal 2015 personal communication). Both populations in Cook County have produced flowers (Illinois Heritage Database 2015). All of these sites are located on public land and therefore have some level of protection. Due to infrequent and inconsistent monitoring, long-term trends of these populations cannot be determined. However, the sites in both these counties are relatively small and could be very susceptible to catastrophic events, as the dramatic decline in plants from 2010 to 2011 identified above, indicate.

The Brevort Township population in Mackinac County, Michigan has an unknown origin. Several botanists and Lakeside daisy experts have questioned whether it may have been introduced to the roadside area sometime before it was reported in 1996. This population occurs in habitat very different from the alvar or modified alvar habitat where the naturally-occurring populations occur. However, its associates at the site include several other rare species that are known to occur on alvar habitat in Michigan (Penskar, personal communication 2015). Due to the fragile nature of the habitat at this location, the Michigan Nature Association has established a reserve population on gravel habitat. Seeds were collected and germinated in a greenhouse with plants transplanted to the reserve site in three separate phases from 2010-2015 (Bozic 2015).

Map 2. Lakeside Daisy Rangewide Distribution



The population in Brevort Township, Mackinac County, Michigan was first documented in 1996, but was identified at least a year earlier (Penskar 2015, personal communication). The population is small with less than 200 individuals on the preserve owned by Michigan Nature Association and 1-2 plants on property owned by Hiawatha National Forest (Windus 2015, personal communication). This 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; Penskar 2010, personal communication).

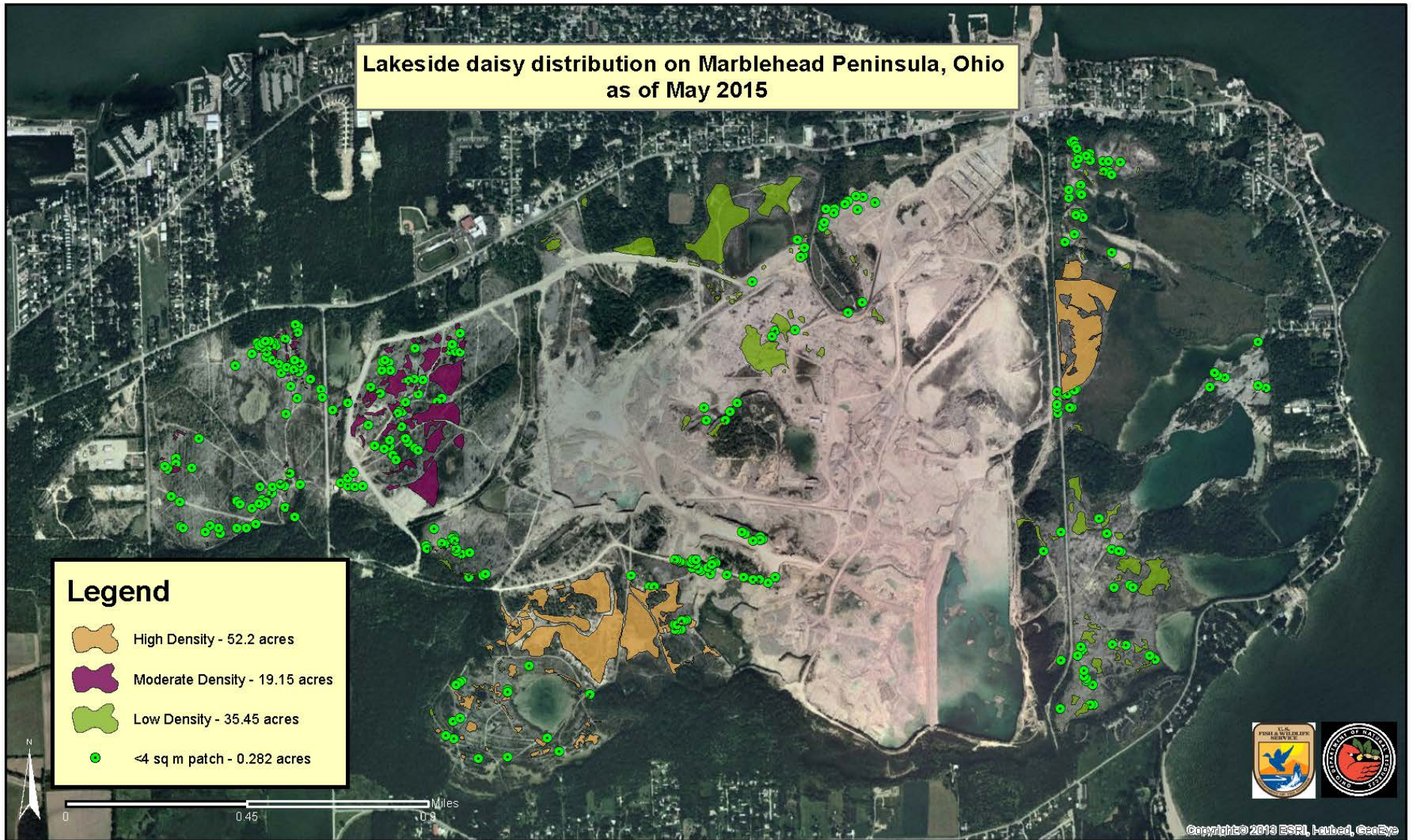
The origin of this population is unknown due to the small population size, its isolation, and habitat. In 2010, the Michigan Nature Association collected seed from this population and had it germinated in a greenhouse. The seedlings were then planted in an area of exposed limestone gravel. Seed collection and transplanting has since occurred in three phases since then (Bozic 2015). Currently there are less than 500 plants in the reserve population (Bozic 2015). Habitat at the reserve site also appears to be less than ideal with low-lying wet areas surrounding the gravel ridges that the daisies were established in.

The St. Martin Peninsula population also has an unknown origin, and due to its recent discovery, no genetic work has been conducted on this population. It is unlikely that this is a naturally occurring population and due to its small population size, it most likely exhibits little genetic diversity. This population would have a minor role in recovery of this species.

The largest natural population in the U. S., the fragmented area of Marblehead Peninsula in Ohio, has decreased in numbers due to quarrying activities and disposal of dredged material. The Recovery Plan indicates an approximate, conservative minimal estimate of approximately 1,000,000 adult plants within 400-450 acres at Lafarge Quarry in 1989. This number is based on the least dense areas that were sampled at the time. DeMauro's data also suggest that the population contained between 5.3 million to 5.9 million adult plants using an average density of 3.29 adults per meter² (Table 2 of USFWS 1990) that was calculated based on field data collected in 1989. The average density calculated from 7 sites in 1989 was significantly more than the density calculated based on research conducted in 1986 (USFWS 1990). Mapping was conducted in 1995 to determine the areas that were occupied by daisies. These locations were digitized and occupied habitat in 1995 was estimated to be 170 acres (Moser 2010). This compares to a total of 84 acres of occupied habitat based on the GPS survey data taken in 2009 (Moser 2010). Information based on mapping of specific population locations of Lakeside daisy in 2009 indicate that, assuming the same density of adults as in DeMauro's 1989 estimate, the number of Lakeside daisy at Lafarge Quarry decreased to approximately 1,116,243 adult plants in 2009 (Moser 2010). No density estimates were sampled in 2009. Some of the densest areas of daisy had been destroyed by mining as these sites had highly suitable habitat and had been occupied for multiple years. Due to active quarry operations not all areas of the quarry could be sampled. In addition, quarry operations had removed a considerable amount of occupied habitat between 1990 and 2009. Therefore, DeMauro's 1989 density estimates are not likely to be appropriate for a current comparison. As the plants mature, additional rosettes form as the plants enlarge in diameter. Therefore, large mature plants, with many rosettes, may occur at a reduced density. In highly disturbed areas, many small, young plants may dominate an area and create higher densities. However, due to the higher mortality of young plants, particularly seedlings, a high density of young plants does not indicate a high or stable population.

In 2015, in an effort to both map the remaining extent of the population within the Lafarge Quarry and estimate population numbers for the quarry and the state nature preserve, the extent of plants were mapped using GPS units. In each area, the approximate density was recorded as dense, moderate, or scattered (Map 3).

Map 3. Density of Lakeside Daisy



Density estimates were sampled at 6 locations within the quarry and one location in the preserve. At each of the 7 locations, the numbers of adult and juvenile plants were counted within a 5 by 5-meter plot (25 separate meter-plots). Three locations were identified as dense, two were considered moderate, and two were scattered (Table 1).

Table 1. Average Density of Adult and Juvenile Plants

Plot Locations	Number of Adults	Plot Size (Meters)	Number of Juveniles	Plot Size (Meters)
State Nature Preserve	256	25	811	25
South of pit	410	25	437	25
South of pit (east)	647	25	300	25
West of Quarry Road	298	25	436	25
West of pit, east of Quarry Road	118	25	316	25
Southeast, east of Alexander Pike	47	25	647	25
North end	92	25	171	25
Total	1868	175	3118	175
Average Density (Individuals/m²)	10.67		17.82	

Yellow indicates high density, green indicates moderate density, and blue indicates scattered density (Gardner 2015, unpublished data)

Adult plants are plants with more than one rosette or plants that indicated any signs of having flowered. Juvenile plants are one inch or more in height with a single rosette. Seedlings are single rosettes less than an inch in height and were not counted. Juveniles are expected to have higher mortality than adults as they are more susceptible to disturbance, drought, herbivory, and other impacts. However, they are more established than seedlings which may have only germinated this year and have a much higher rate of mortality. The demographics of the population will impact its rate of growth and stability. By identifying information on the quantity of juveniles, a more accurate measure of the status of the population can be determined.

Using the current average adult density and acreage of occupied habitat, the estimate for the adult population of the quarry is approximately 4.0 million adult individuals (Gardner 2015, unpublished data). Although the density of adult and juvenile plants increased significantly (Table 2), the amount of potential habitat decreased significantly from the habitat estimates in the Recovery Plan (USFWS 1990). Table 2 illustrates a higher density of juvenile plants in the quarry, indicating a growing population of smaller plants in the remaining acres. Most of the area which contained the heart of the population in 1989, particularly many large, mature plants, is now gone due to quarry activities, leaving smaller, less mature plants in the surrounding areas (increasing overall plant density). No estimates of plant density were conducted during 2009.

In the Recovery Plan, occupied habitat was determined to be between 400-450 acres (USFWS 1990). As stated above, the occupied habitat within the quarry has declined to approximately 92.552 acres in 2015 (Gardner 2015, personal communication). A 2010 report indicated that 84 acres of habitat were occupied at that time (Moser 2010). The current amount of occupied habitat is more than that identified in 2009.

However, the survey conducted in 2009 did not identify the occupied habitat on the floor of the quarry nor another portion of the quarry where spoil material was piled multiple years ago.

The current amount of occupied habitat is significantly less than that identified in 1989. Most of the loss in habitat is due to increased intensity in quarry activities. However, increased accuracy of both GPS and GIS technology allows for more specific mapping of plants and habitat. Mapping conducted in 1989 was completed by hand using topographic maps. Maps drawn in 2005 were digitized to determine the area (Moser 2010). In 2009, GPS and GIS were used to map habitat. Recent mapping has become more accurate. In addition, in 2015 a significant amount of time was spent surveying areas of the quarry that has not been visited for many years. As mapping has become more accurate and the area was surveyed more thoroughly, the occupied area calculated is smaller than that identified at the time of the Recovery Plan and yet more accurate for current daisy distribution.

Table 2. Density Comparison in the Lafarge Quarry Between 1989 and 2015

Lafarge Quarry	1989	2015
Average adult density (plants/m ²)	3.29	10.67
Average juvenile density (plants/m ²)	4.52	17.82
Estimate of adult plants	5.3 mil	4.0 mil

(Gardner 2015, unpublished data)

In 2015, to determine the population at the quarry more accurately, the average number of adults and juveniles per meter in areas of high, moderate, and scattered density was determined from the sampling plots. Information from the 6 plots within the quarry area was used. The seventh plot was a high density plot within the area of the state nature preserve and was not used to calculate the average density of the dense plots. These average densities were then multiplied by the acreage identified as high, moderate, and scattered density within the Lafarge quarry.

Table 3. Estimates of Adults and Juveniles at Various Densities

Dense	Number of Adults	Plot Size (Meters)	Number of Juveniles	Plot Size (Meters)
South of pit	410	25	437	25
South of pit (east)	647	25	300	25
Total	1057	50	737	50
Average Density (Individuals/m²)	21.14		14.74	
Moderate				
Moderate	Number of Adults	Plot Size (Meters)	Number of Juveniles	Plot Size (Meters)
West of Quarry Road	298	25	436	25
West of pit, east of Quarry Road	118	25	316	25
Total	416	50	752	50
Average Density (Individuals/m²)	8.32		15.04	
Scattered				
Scattered	Number of Adults	Plot Size (Meters)	Number of Juveniles	Plot Size (Meters)
Southeast area, east of Alexander Pike	47	25	647	25
North end	92	25	171	25
Total	139	50	818	50
Average Density (Individuals/m²)	2.78		16.36	

(Gardner 2015, unpublished data)

The estimate for adult plants within the quarry using the appropriate densities for areas identified as containing high, moderate, and scattered numbers of plants is now 4.27 million (Table 4). Unfortunately, approximately 3 million (79%) of the adult plants in the quarry occur in an area planned for imminent mining in the next 3-5 years (Gardner 2015, unpublished data). The estimate for juvenile plants within the quarry is 5.78 million individuals. The estimated number of adult and juvenile plants within the quarry is 10.05 million, based on the 2015 surveys which included the average density of areas of high, moderate, and scattered individuals.

Table 4. Total individuals in Lafarge Quarry Based on Specific Densities

Density	Area in m2	Adult Density (Adults/m2)	Adult Individuals	Juvenile Density	Juvenile Individuals (Juvenciles/m2)	Total Plants
Dense	152,445.22	21.14	3,222,692	14.74	2,247,042	5,469,734
Moderate	77,497.37	8.32	644,778	15.04	1,165,560	1,810,339
Scattered	144,602.40	2.780	401,995	16.36	2,365,695	2,767,690
Total			4,269,465		5,778,298	10,047,763

(Gardner 2015, unpublished data)

Using both the average density calculated for Lafarge quarry and the moderate density identified above, the population was calculated for both the Kelleys Island and the Lakeside Daisy State Nature Preserve.

Table 5. Total Number of Adult and Juvenile Plants Based on Average Density at Lafarge

Location	Area in m2	Average Adult Density (Adults/m2)	Adult Individuals	Average Juvenile Density (Juvenciles/m2)	Juvenile Individuals	Total Plants
Kelleys Island	60,703	10.67	647,700	17.82	1,081,726	1,729,426
Lakeside Daisy State Nature Preserve	58,801	10.67	627,405	17.82	1,047,832	1,675,237
Total			1,275,105		2,129,557	3,404,663

(Gardner 2015, unpublished data)

Table 6. Total Number of Adult and Juvenile Plants Based on Moderate Density at Lafarge

Location	Area in m ²	Moderate Adult Density (Adults/m ²)	Adult Individuals	Moderate Juvenile Density (Juveniles/m ²)	Juvenile Individuals	Total Plants
Kelleys Island	60,703	8.32	505,048	15.04	912,972	1,418,020
Lakeside Daisy State Nature Preserve	58,801	8.32	489,223	15.04	884,365	1,373,588
Total			994,271		1,797,337	2,791,608

(Gardner 2015, unpublished data)

The protected, introduced population at Kelleys Island State Park (adults and juveniles) is estimated at 1.4-1.7 million plants (using moderate and average density estimates from the quarry). Monitoring of established plots in 2014 yielded an estimate of over 18,800 adults plants within the original establishment plots, but this did not consider juveniles or any plants which had become established outside of the plots or the seeded areas (Windus 2014).

The estimated number of adult and juvenile plants in the state nature preserve is 1.4-1.7 million (Tables 5 and 6). These numbers are highly conservative as the plot at the Lakeside Daisy State Nature Preserve had a high density of individuals. However, only a single 25 m² plot was counted. It is very likely that this site has more than 1.7 million individuals. Using the density estimates for dense areas, it is estimated that the Lakeside Daisy State Nature Preserve contains approximately 2.2 million adult and juvenile plants (Gardner 2015, unpublished data).

In Ohio, populations were established on state-owned land at the Central Quarry and North Quarry sites at Kelleys Island State Park in Erie County. In 2012, an additional population was introduced to the Huntley Beatty Preserve on Kelleys Island and Castalia Quarry Metropark in Margaretta Township of Erie County, Ohio.

Annual monitoring of Lakeside daisy populations does not occur at all sites. Some sites are visited annually, while others may not get monitored for over 10 consecutive years. Monitoring of this species is not uniform across its range and therefore populations are not estimated in the same manner. In addition, for small sites such as those in IL, all individuals can be counted. For large sites, such as Lafarge Quarry and the Lakeside Daisy State Nature Preserve, population estimates are made by extrapolating from density measurements. Therefore, accurate population and demographic information rangewide are lacking.

Table 7. Range-wide Population Estimates

State	Location	Most Recent Monitoring	Number of Plants (Adults and Juveniles)
IL	Chicago Botanic Garden	2010	<12
IL	Cook County	2010	Present
IL	DuPage County	2015	Present
IL	Lockport Prairie	2014	<200
IL	Romeoville Prairie	2014	<200
IL	Tazewell County	2014	0
MI	Brevort Township	2015	<200
MI	Reserve Population	2015	>400
MI	Marquette Township	2014	<30
OH	Kelleys Island Populations Established Prior to 2010	2015	1,700,000*
OH	Kelleys Island Population established after 2010	2015	Present
OH	Lafarge Quarry	2015	10,000,000**
OH	Lakeside Daisy State Nature Preserve	2015	1,700,000*
OH	Margaretta Township	2015	Present

*Population estimate based on average 2015 density of Lafarge population

**Population estimate based on average density of areas of high, moderate, and scattered density

In summary, using the same methods as DeMauro in the Recovery Plan, multiplying the average density of adult plants by the amount of occupied habitat resulted in 4.0 million adult plants in 2015 compared to 5.3 million adult plants based on the 1989 field work (Table 2). Using more specific high, moderate, and scattered densities resulted in an estimate of 4.27 million adult plants on Lafarge Quarry (Table 4). While this is similar to the number of adults in 1990 from the recovery plan, there is now significantly less habitat available. It also appears that a higher percentage of plants are juveniles and therefore these plants may have a lower rate of survival due to the younger age of the population.

Population estimates from Lafarge Quarry provide limited information due to the large variation in plant densities. Plant density could be low in a mature population as older plants develop a large vegetative structure. In newly established populations, the density could be extremely high if seed is dispersed at a high rate, and most of the seed germinates and establishes small seedlings. A higher population estimate may reflect the loss of larger, mature plants and establishment of smaller, younger plants.

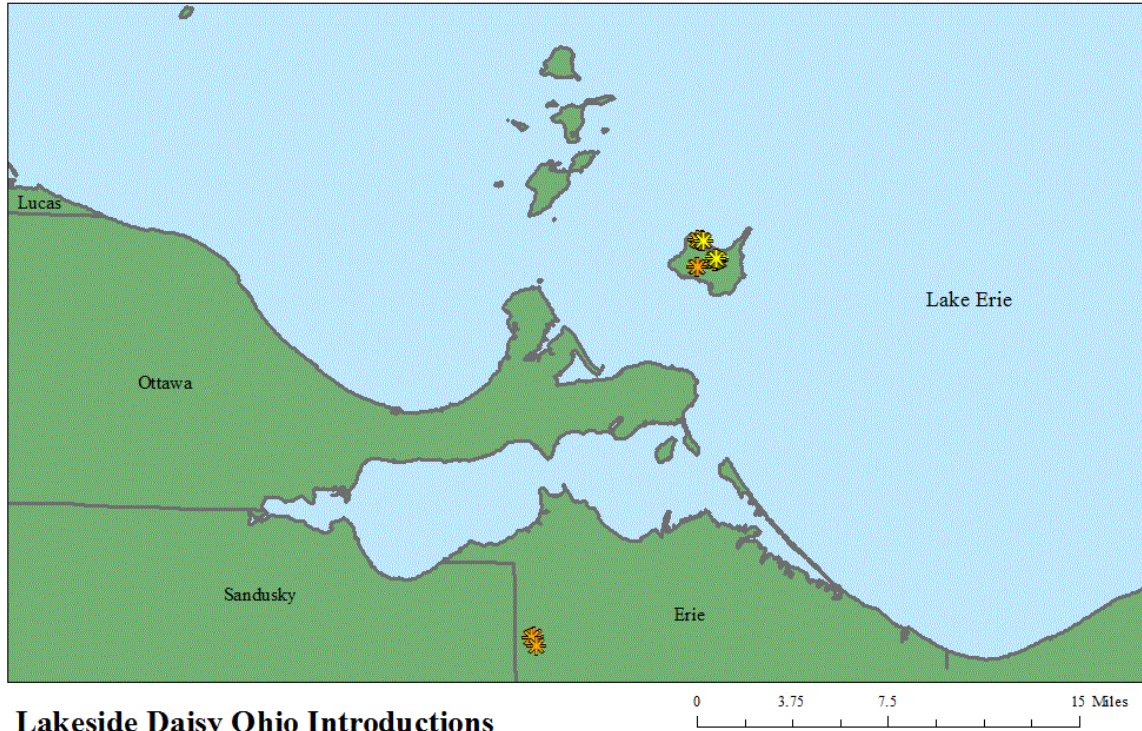
The populations originally introduced at Kelleys Island State Park in Ohio from 1989 to 1994 are increasing. Starting in 1989, over 1,000 individuals were transplanted and thousands of seeds from the Marblehead Peninsula have been sown at the Central Quarry and North Quarry sites on Kelleys Island. The results of annual monitoring from 1989 to 2001 suggest some mortality for transplants during the first several years, especially of the larger plants consisting of many rosettes, indicating root damage during excavation or inclement weather during or after transplanting. Survivorship at the introduced populations has been similar to that of individuals at the Lakeside Daisy State Nature Preserve, and recruitment suggests sufficient levels of flower, fruit, and seed production resulting from outcrossing (Windus and Cochrane 1999). In 2014 and 2015, 16 of 17 plots that had been planted between 1989 and 1994 were monitored. Overall these plots experienced a twenty-fold increase in the number of individual plants since the plots were established (Windus 2014). A total of over 18,800 adult plants were observed in the monitored plots. This number does not include seedlings and juveniles, nor the thousands of plants which have established outside the plots. Using the average density for the plots sampled at Lafarge, the total number of adult and juvenile plants on Kelleys Island is estimated to be 1.7 million (Gardener 2015, unpublished data).

Due to concerns about expanding operations at the Lafarge Quarry, seeds were again collected from the Marblehead Peninsula from 2012 to 2015 to establish additional populations on protected public land. After developing an agreement with the Erie County Metroparks, seed was placed at Castalia Quarry Metropark between 2012 and 2015. Seed was also dispersed at Huntley-Beatty Preserve on Kelleys Island during 2012-2015 after this property became public land and was protected by a conservation easement. Plants were observed blooming at both of these sites in 2015.

Sites were seeded multiple times with seed collected from different areas on the Marblehead Peninsula. This was an effort to maximize the available genetic diversity and provide sufficient numbers of different mating groups to create a self-sustaining population.

The existing population of Lakeside daisy at the North Quarry site of Kelleys Island State Park was augmented with seed from 2012 until 2015. Approximately 300 plants were also transplanted to the site in October 2013, with an additional 300 transplants added in 2015. At this time, no quantitative data have been collected for the sites introduced in 2012-2015 at the State Park. However, the presence of multiple seedlings has been noted every year since the seeds were dispersed. In addition, the area is known to contain excellent habitat due to the success of previous transplants at the site.

Map 4. Lakeside Daisy Ohio Introductions



- ✿ Post-2010 introductions
- ✿ Prior to 2000

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), a type of 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 Brevort Township, Michigan and the Bruce Peninsula populations, suggesting similar ancestry. They also suggest that the Brevort Township 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). This suggests that the Lakeside daisy will not be preserved by the establishment of small artificial

populations. Instead, successful establishment will only occur through numerous events to supplement individuals and genetic diversity, as has been conducted at Kelleys Island State Park in Ohio previously.

Additional research into clonal growth versus sexual reproduction showed that Lakeside daisy plants from the 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 explained and published 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 chromosomes. Additionally, *H. acaulis* has dull green leaves that are densely pubescent, while *H. herbacea* leaves are deep green with few hairs (Cusick 1991). Therefore, the taxonomic name for Lakeside daisy was *Hymenoxys herbacea* (Asteraceae). However, more recent treatment is to use Edward Greene's name of *Tetraneuris herbacea*. This is the name used by the Ohio Department of Natural Resources Division of Natural Areas and Preserves (DNAP), USDA, Center for Plant Conservation, Smithsonian National Museum of Natural History, and it is widely accepted by many other scientific organizations.

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.):

A new population of Lakeside daisy was recorded in Mackinac County, Michigan in 1996 (Penskar 2015, personal communication), 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*, *Pinguicula vulgaris*, *Solidago houghtonii*, *Carex richardsonii*, and *Carex scirpoidea* (Penskar 2015, personal communication). This population currently has less than 200 plants spanning the highest, driest mounds of tufa across Brevort Lake Road and associated powerline right-of-ways. The respective sides of the road are owned by a conservation organization and a public resource management agency. The origin of this population has yet to be determined (i.e., whether it is a natural population or a transplant from another population).

According to the Lakeside Daisy Recovery Plan (USFWS 1990), the center of the population within the Marblehead Peninsula has moved over time in a westerly direction. As quarry activities have eliminated the eastern side of the population, the western edge has continued to persist. 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 (Windus 2009, personal communication). 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. Plants were collected from the eastern side of the population in an effort to

maintain some of this genetic diversity. Some genetic diversity of the eastern side of the population may have been eliminated with the loss of this habitat and the associated individuals.

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 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.

Continued quarry operations at Lafarge have impacted the spatial core of the population as well as impacted the densest areas. Continued accelerated operations are expected to fragment this population even further as the area of quarry operations is expanded.

The establishment of introduced populations at the North Quarry and Central Quarry on Kelleys Island from 1989-1994 and the additional introduced population to Huntley–Beatty Preserve means that a significant number of the Ohio sites are located some distance from the mainland and are isolated by Lake Erie. These sites were selected because they contain suitable habitat, are of sufficient size, and are located on public land that is maintained by conservation organizations. In addition, the Columbus, Ohio Field Office of the U.S. Fish and Wildlife Service established a memorandum of understanding (MOU) with these sites that included management for Lakeside daisy. In Ohio, state listed plants, or any portion of, cannot be removed from public property without written permission from the owner and therefore have some limited protection from destruction. Many former quarries on the mainland are privately owned and fill with groundwater once operations have ceased. Therefore, opportunities to establish new populations on the mainland have been limited.

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, including the three sites at Kelleys Island, cannot migrate northwards due to the presence of the Great Lakes and/or development.

Lafarge continues its quarry operations which reduces the amount of modified alvar habitat available. It is anticipated that once quarry operations are complete, the quarry will then naturally fill with water and become a large lake. The only remaining upland habitat would be limited to the periphery. Alvar habitat cannot be created and attempts to restore alvar ecosystems have not successfully established a highly diverse ecosystem (Catling 2013). Thus, without permanent protection of alvar and modified alvar habitat, the amount of suitable habitat for this species will continue to decline.

Management requirements to maintain suitable habitat for the Lakeside daisy varies at different sites. The populations in Illinois experience greater competition, so greater levels of management are needed to maintain open habitat. In Ohio, some removal of cedar, and other woody species, is required to maintain sunny, open alvar habitat. This management is required infrequently. In general, suitable habitat for this species is not appropriate for many other species and therefore competition is limited.

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, due to self-incompatibility of related 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 competitive 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 Endangered Species Act (ESA) prevents the removal and possession of both federally listed endangered and threatened plants from federal property. Federally listed endangered plants are also protected from removal or destruction on private property if it violates any law or regulation of that state. The Marquette Township population located on the property of the Hiawatha National Forest is protected because it is located entirely on federal property. However, the Brevort Township population is only protected on the side of the road that is owned by the Hiawatha National Forest. The opposite side of the road is privately owned by a conservation organization.

Activities threaten the population of Lakeside daisy in Brevort Township Michigan. On-going road and powerline right-of-way maintenance has kept conditions open in the past, maintaining habitat for Lakeside daisy, though maintenance-related threats to this population include herbicide spraying, snow plowing in winter, 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 at the site, while small size and isolation further threaten this population's survival (Huebner 2009, personal communication). Threats to the St. Martin Peninsula population also include the growth of woody vegetation and nonnative invasive species (Blumer 2016, personal communication).

The Lockport Prairie Nature Preserve and Romeoville Prairie Nature Preserve in Will County, Illinois protect small populations of Lakeside daisy. Portions of both of these sites are dedicated as Illinois state nature preserves. This dedication provides permanent protection for the natural resources at the preserve.

The two sites in Cook County, Illinois and the site in DuPage County, Illinois are located on public land (Illinois Heritage Database 2015) and receive some level of protection and management. Both sites in Cook County attempt to manage invasive species and promote prairie habitat. Very limited information is available on the site in DuPage County, Illinois. The site is located on public land. However, the origin of the plants, the current population size, and the level of management are unknown.

The largest natural population in the United States is on private land within an active quarry (Lafarge Quarry, Ottawa County, Ohio) and as a plant, Lakeside daisy receives little protection by the ESA on private property. The Lakeside Daisy Nature Preserve in Ottawa County, Ohio, and the introduced populations at Kelleys Island at the North Quarry and Central Quarry in Erie County, Ohio are all located on land owned by the state of Ohio and are protected under Ohio law as this species is listed as state endangered in Ohio. In addition, the Lakeside Daisy State Nature Preserve is dedicated which provides a very high level of protection through deed restrictions. Huntley-Beatty Preserve is protected by a conservation easement which prohibits development and other activities. The Service has a Memorandum of Understanding (MOU) with ODNR for the North Quarry and Central Quarry at Kelleys Island State Park, an MOU with the Kelleys Island Park District for the Huntley-Beatty Preserve, and an MOU with Erie County Metroparks for the Castalia Quarry Metropark property. The MOUs were developed to ensure that these sites are managed appropriately for Lakeside daisy. These sites require regular monitoring by the Service to ensure that they are being appropriately managed to conserve and protect Lakeside daisy populations (e.g., from other development or dumping in the parks).

One serious threat to the species is that, of the approximately 2,500-acre area of former and active quarry at Marblehead Peninsula in Ottawa County, Ohio, only 19 acres are permanently protected in a dedicated state nature preserve (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 modified alvar habitat located within the abandoned areas of the quarry. These areas are threatened by the placement of spoil piles and other quarrying debris and may be quarried in the future. Lafarge intends to continue active quarrying throughout the entire property for the next 100 to 150 years. ODNR and Service biologists have requested Lafarge to discontinue the placement of quarry spoils on existing populations of Lakeside daisy. Lafarge allows monitoring of populations of Lakeside daisy on their property and collection of seed and plants by the Service and ODNR. However, so far Lafarge has not been willing to set aside conservation areas or sell portions of the property to protect the Lakeside daisy in perpetuity. Since 2009, when field data were collected to determine a population estimate for Lakeside daisy, Lafarge has quarried an additional 98.12 acres of suitable habitat (Gardner 2015, personal communication). This suggests that over 300 acres of occupied habitat have been lost since 1990 when the Recovery Plan was written and occupied habitat was estimated to be between 400 and 450 acres (USFWS 1990). Continued loss of habitat is expected to occur as quarry activities continue.

In some undisturbed areas of the quarry, Lakeside daisy will recolonize modified alvar habitat if competition is low. However, Lafarge is required by the ODNR Division of Mineral Resources Management to stabilize areas by planting with various grasses and other species, as a part of their mining permit. While these species may stabilize soil, they also create significant competition to the establishment of Lakeside daisy. It is expected that when all quarrying is complete, the only remaining habitat for the Lakeside daisy would be a small margin of modified alvar habitat along the perimeter of the property. The Service is working with ODNR-MRM to modify the Lafarge mining permit to reduce the required planting of grasses and other species which create competition for Lakeside daisy. This will

allow Lakeside daisy to colonize undisturbed gravel piles. Specific areas post-mining could be set aside as Lakeside daisy habitat without replanting for stabilization.

Both the Service and ODNR have spent a significant amount of time over the past twenty-five years to encourage Lafarge to protect habitat for the Lakeside daisy. The purchase of the nineteen acres that became the Lakeside Daisy State Nature Preserve was only achieved due to public pressure from concerned citizens all over the state. Lafarge has granted access to its property so that biologists from the Service and ODNR can monitor Lakeside daisy, and collect seeds and plants. However, to date it has not taken any action to permanently protect habitat for the Lakeside daisy. The Service and ODNR will continue to negotiate with Lafarge for additional land acquisition.

Recovery of Lakeside daisy can only be achieved if there is sufficient genetic diversity to allow the species to be self-sustaining. Loss of diversity of mating types through a significant removal of individuals at the Lafarge site or through inbreeding in small populations will prevent the long-term persistence of this species.

While the number of sites throughout the range of this species with some degree of protection is high, the combined population of all of these sites throughout the range of this species is a fraction of the number of individuals that do not receive any protection because they are located on privately owned land.

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, the potential for 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). 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). It is unlikely that the exchange of clones could pose a threat to the Lakeside daisy.

There likely are Lakeside daisy plants in privately owned gardens in the Chicago, Illinois area as well as on the Marblehead Peninsula. These were probably established with small collections of plants or seeds. Small collections likely do not have enough genetic diversity to successfully be pollinated and therefore do not contribute to recovery. A small population has been established at the Heritage Garden at the Ohio Governor's Residence in Columbus, Ohio to showcase the alvar habitat and its associated rare plants in Ohio. This population also does not contribute to recovery.

In the village of Lakeside, Ohio, for which the Lakeside daisy is named, there is a small garden area composed of approximately 100 plants in a 10-ft by 20-ft area. These plants also do not contribute to recovery but are an educational resource as the public can easily view these plants.

In addition, the plant has been proposed for use in rooftop gardens. The use of clones in gardening or establishment of plants for rooftop gardens does not contribute to the recovery of the species and should not be encouraged. Recovery of the species occurs when the plant is established in a genetically diverse population that is being successfully pollinated and is germinating within suitable natural habitat. The maintenance of plants in cultivated gardens or greenhouses does not constitute recovery, even if the number of plants is significant. Therefore, the Service does not support removal of plants or seeds from the wild for private or commercial use.

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 had appeared to increase within the introduced populations in Lockport Prairie Nature Preserve and Romeoville Prairie Nature Preserve in Will County, Illinois during the first few years that the plants were established (Lah 2006, personal communication). In recent years, rates of predation have been low (Armstrong-Ullberg 2015, personal communication). Small mammals may also feed on the seeds as a cluster of flower heads was found cached under woody debris at Lafarge Quarry (Denny 2014, personal communication). 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 (Armstrong-Ullberg 2010, personal communication).

Several species of Lepidoptera larva have been observed on Lakeside daisy plants. In September 2014, a larva of the White Lined Sphinx moth was observed on a cluster of rosettes. This species can be a pest in the western U.S., but is not known to be a threat in Ohio (Parshall 2014, personal communication). In the spring of 2014, a nocturnal larva was observed feeding on Lakeside daisy. It appeared to be some type of generalist cutworm (Wagner 2014, personal communication). Overall, predation by mammals or insects is not a significant threat unless the daisy populations are very small or the plants are facing other significant threats. These factors may pose a threat to Lakeside daisy populations if rosettes are not able to regenerate when 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 these laws require permission from the landowner before state listed plants can be removed as well as establish a permit system. The laws do not protect the habitat of rare plants. Lakeside daisy is now listed as state endangered in Michigan as well. Under Michigan code, it is unlawful to collect, pick, cut, dig up, or destroy any state threatened or endangered plant in Michigan without a permit from the Michigan Department of Natural Resources.

Currently, the population in Brevort Township, Michigan 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 private 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 (Huebner 2009, personal communication). It appears that legally preserving the area has not protected the Lakeside daisy plants from these threats. This population occupies more fragile habitat and therefore experiences additional threats. Regulation cannot address these threats or the questionable origin of this species. The St. Martin Peninsula site in Marquette Township has legal protection since it is located on federal land of the Hiawatha National Forest. However, threats from the growth of woody vegetation and non-native invasive plants can potentially still impact this species.

Additionally, populations of Lakeside daisy on private property are threatened by quarrying activities and are not afforded protection under the law. The ESA prevents the removal and possession of federally listed endangered plants from federal property. Federally listed endangered plants are also protected from removal or destruction on private property if it violates any law or regulation of that state. The largest natural population in the U.S., Marblehead Peninsula, Ottawa County, Ohio, has already lost the highest density area of plants due to quarrying, and population numbers will continue to shrink with continued quarrying activity. However, these actions do not violate state plant laws and since they occur on private land, they are not considered a violation of the ESA.

Since most of the populations exist on non-federal land, the ESA is providing minimal, additional protections. The ESA does reinforce state laws and makes it a federal crime to violate a state rule that regulates this plant species. ESA does prevent interstate commerce, however this is also regulated at the state level and the ESA does not provide any additional protections.

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 18 of the 29 sites partially or completely within a protected area (e.g., national or provincial park) (Parks Canada Agency 2011). The province of Ontario has enacted the Ontario Endangered Species Act which lists the Lakeside daisy as threatened and protects this species and its habitat on non-federal lands.

The inadequacy of regulatory mechanisms is a threat to this species on non-federal land. Populations in private ownership are continually threatened by the ability of the landowners to give permission to anyone to remove Lakeside daisy individuals. In addition, impacts to this species may occur on public land (both federal and non-federal) due to the multiple uses that public land often serves. In 2014, gravel material was removed from a site at Castalia Quarry Metropark where Lakeside daisy plants had germinated. Despite coordination between the Erie County Metroparks and the U.S. Fish and Wildlife Service, including an MOU, the removal of gravel impacted suitable occupied habitat. In addition, ATV use at Hiawatha National Forest may cause disturbance at the Brevort Township site.

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 have different self-incompatibility genes. 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). It is likely that the impacts of self-incompatibility are currently impacting the restored populations in Illinois and may affect the

populations in MI.

Populations are also threatened by human use of the habitat, including ATV activities, which can destroy plants and habitat. The population in Brevort Township, Michigan is threatened by ATV access due to its close proximity to a public road ROW and a utility ROW (Huebner 2009, personal communication). In addition, this site may be threatened by over-visitation and unauthorized seed collection (Bozic 2015). 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 (Huebner 2008; 2009, personal communication). To protect this population, regular maintenance is required to remove non-native invasive species and prevent 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; alvar communities, which are globally rare; and modified alvar habitat such as active and abandoned quarry locations in Ohio. According to precipitation and temperature models for the Great Lakes region, 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). More frequent heavy precipitation events could create standing water in alvar areas and impact habitat conditions for Lakeside daisy. It is not known how the Lakeside daisy will be impacted by temperature changes or the potential for an increased growing season. However, additional rainfall will likely not buffer the drought and lowered lake levels caused by increased temperature. The increased temperatures and decline of ice cover for the Great Lakes will result in increased evaporation leading to lower lake levels (Karl et al. 2009). 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 requirements and the limited 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 prior to 1996 in Brevort Township, Mackinac County, Michigan. Another population was found in 2014 in Marquette Township, Mackinac County, Michigan. Additionally, three populations have been restored (two in Will County, Illinois, one in Tazewell County, Illinois). Three populations have been introduced in Illinois (two in Cook County and one in DuPage County) and four populations have been introduced in Ohio (three on Kelleys Island and one in Margaretta Township, Erie County). The populations in Illinois and Michigan appear to be stable; however, it is likely that these maybe declining if long-term data were available. The population within Lafarge Quarry is at risk of significant reduction by active quarrying (Windus 2015, personal communication). Thus, although the number of populations has increased since 1988, the number of plants has most definitely declined and will continue to do so, primarily due to the quarry operations in Ohio.

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 population in Brevort Township, 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 populations known at that time. 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 by a single effort to establish an introduced population (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 many plants and/or seed from different mating groups in a repeated and sustained manner over multiple years, to increase the likelihood of success in establishing new populations. To insure long-term persistence of the population and viability of the habitat, habitat management also needs to be incorporated.

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. These criteria have not been met. Limited progress is being made on this species' recovery through continued efforts to establish introduced populations. The restored populations of Lakeside daisy in Will County, Illinois have survived for the past 21 years, although both populations are exceedingly small and do not appear to indicate any signs of significant sexual reproduction. This suggests that these populations may lack sufficient genetic diversity and may be functionally extirpated. Information from 2013 and 2014 indicates that the Tazewell County site contains very few individuals. The Michigan populations have an unknown origin and therefore they have limited value to recovery of this species. The two Kelleys Island populations established between 1989 and 1994 through repeated seeding and transplanting with individuals from many diverse sites within the Lafarge Quarry have steadily increased in size and provide a model of reintroduction techniques. While Lafarge will continue active quarrying throughout the site indefinitely, they do permit the efforts of the state and Federal agencies to monitor populations of Lakeside daisy as well as collect seed and obtain plants for transplant from the inactive sections of the quarry.

Some populations of Lakeside daisy occurring on preserves have been monitored and maintained infrequently for the continued survival and recovery of the species. The two introduced populations in Will County have been monitored every one to five years since their introduction. Regular monitoring occurred since its introduction in 1988 until 2002 at Manito Prairie Nature Preserve in Tazewell County, Illinois. However, there are limited data since then (Simone 2015, personal communication).

Twenty-three plots were established during 1989-1997 for the original sites at Kelleys Island in Erie County, Ohio. These were monitored from 1989 through 2001 (Windus 2014, personal communication). These sites were not monitored between 2002 and 2013 due to staff changes. However, the plants appeared to be reproducing successfully in 2012. Monitoring conducted in 2014 and 2015 confirms that these populations have been successful and are continuing to reproduce. During this monitoring, 16 of 17 transplant plots were censused; all have significantly increased except one, due to poor plot selection that included a low-lying area that was more wet than other locations.

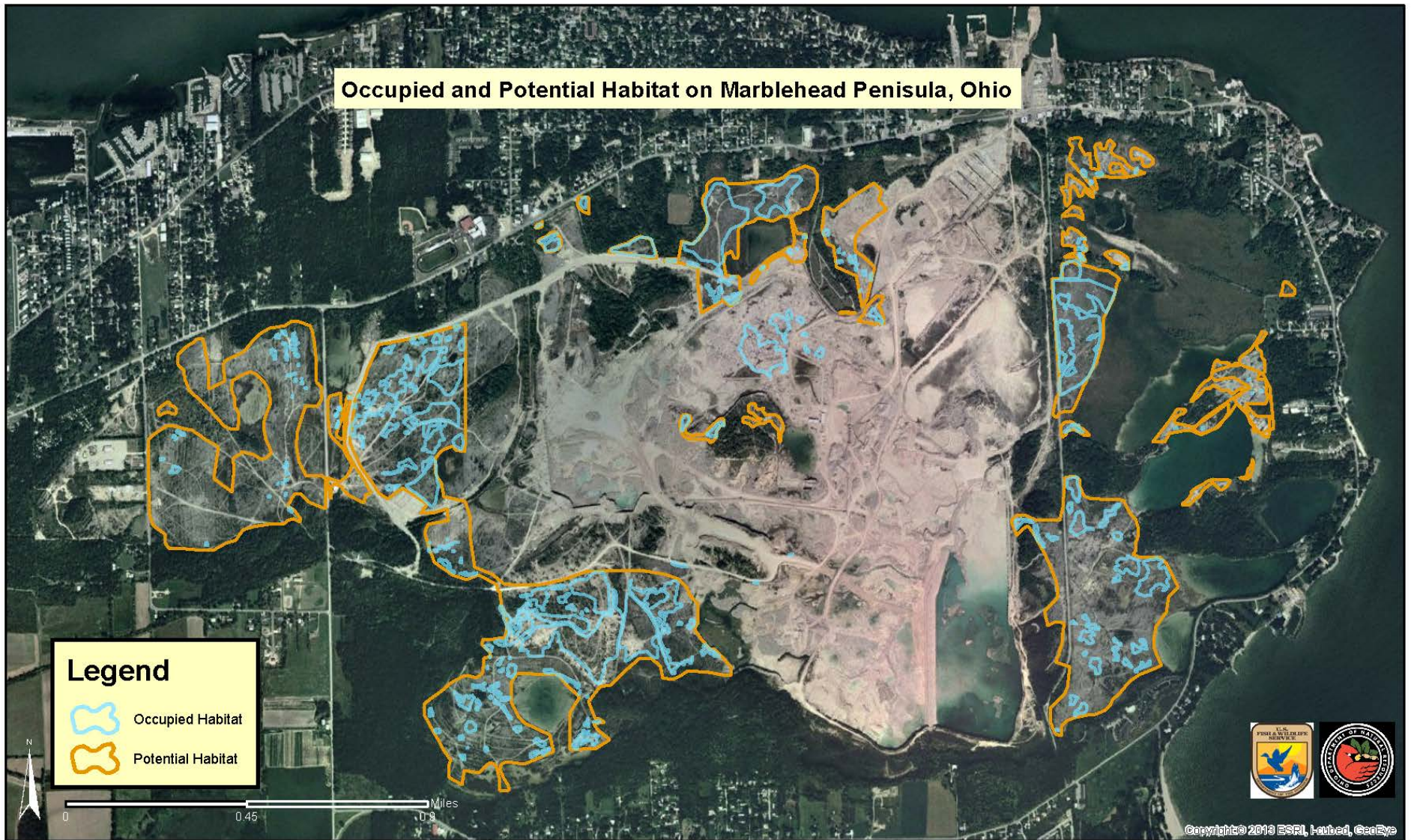
The Lakeside daisy population on the Marblehead Peninsula has been monitored periodically. Field data were taken in 1986, 1989, 2009, and 2015 to develop population estimates in 1990, 2010, and 2015. The

Lafarge Quarry includes a vast area of suitable habitat with varying densities of plants, while the Lakeside Daisy State Nature Preserve has a high, even density of plants in most areas of approximately 15 acres of suitable habitat. Transects in four different areas at Lakeside Daisy State Nature Preserve were established in 1989. Plots along transects, 160 m² total, were sampled in 1989 and then a subset were sampled five times during 1990-1999 (Windus 2015, personal communication). Individual plants were mapped and counted (adults, juveniles, and seedlings). While the density of plants has increased at the Lafarge Quarry, the amount of suitable habitat has significantly decreased. This has resulted in a decrease of over 1 million adults plants based on the average density identified in the recovery plan and the current average density and amount of occupied habitat remaining (Gardner 2015, unpublished data).

Threats including encroachment of woody species, non-native invasive species, ATV use, and herbivory continue to impact the Brevort Township, Michigan, population. 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 greatest threat remains the ongoing quarry activities which occur at the largest population in the U.S. (Table 3). Quarry activities since 1989 have reduced the amount of potential habitat for this species. In addition, activities are expected to expand to the west and south where some of the highest densities of Lakeside daisy occur. Protection of all available habitat to the east of Alexander Pike and south of the Lakeside Daisy State Nature Preserve would be an asset to the persistence of this species (Map 5). In addition, unoccupied habitat could be augmented with seed collected throughout the quarry to increase genetic diversity among the plants that currently exist at this site.

Map 5. Occupied and Potential Lakeside Daisy Habitat



The recovery criteria and recovery actions rely heavily on protecting, managing, and acquiring the habitat 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.

At this time, the acquisition of a significant amount of suitable habitat, as required by the recovery criteria, is no longer attainable due to the increased level of quarry activity at the Lafarge Quarry in Ohio since 1988. However, the Service continues to work toward protection of any occupied, suitable habitat. The Illinois populations are most likely declining and there is a lack of long-term data on both of the Michigan populations. The criteria and recovery actions need to be revised to reflect the current condition and updated information. More suitable habitat for the species should be acquired and permanently protected. Quarry activities permanently modify and can eliminate alvar habitat. Over 98 acres of suitable habitat have been lost between 2009 and 2015. In addition, due to this disturbance, large mature plants are being eliminated. The largest U.S. population is now being dominated by younger plants which experience higher mortality. Loss of mature plants may also result in permanent loss of genetic diversity which is especially crucial for a self-incompatible species.

Due to the continued and increasing threats to this species and the lack of significant recruitment on public land outside of Ohio, it is recommended that the priority number for this species be upgraded to 5 to illustrate the increased threats and limited ability of this species to recover.

3.0 RESULTS

3.1 Recommended Classification: Due to continued quarry activities and the potential threat of climate change, this species is now at an increased risk.

3.2 New Recovery Priority Number: Change to 5, which indicates that the species has a high degree of threat and a low recovery potential.

3.3.1 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. These actions are listed below with highest priority actions listed first:

- 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 suitable modified alvar habitat from Lafarge.
- Coordinate monitoring among all three states where this species currently occurs so that information is consistent and meaningful.
- Provide necessary management at all protected sites, including removing non-native invasive species and woody encroachment, deterring herbivory, limiting ATV access, and reducing competition.
- Continue to augment introduced Lakeside daisy populations on suitable sites within the species' historical range.
- Revise recovery criteria to include new data prior to next 5-year review.
- Continue to monitor populations of Lakeside daisy, both natural and introduced, for reproductive output, recruitment, individual plant growth, and survival.
- Cooperatively work with Lafarge Quarry to collect seed and transplant individuals from the areas of the quarry that are at greatest threat of being quarried and have the highest genetic and habitat diversity.
- Cooperatively work with the ODNR Division of Mineral Resources Management to amend the Lafarge Quarry mining permit so that undisturbed areas can be recolonized by Lakeside daisy, instead of being planted with other species and creating significant competition.
- Increase gene pools and population numbers in restored population sites by seeding and transplanting individuals from various locations within natural populations.
- Improve awareness to the public about the harm of collecting federally listed plant species and the importance of protecting and maintaining unique ecosystems, such as alvars, for recovery of plant species.
- 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.
- Further research into the origin of the Michigan populations to guide future recovery actions.

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U.S. FISH AND WILDLIFE SERVICE

5-YEAR REVIEW of Lakeside daisy (*Tetraneuris herbacea*)

Current Classification: Threatened

Recommendation resulting from the 5-Year Review:

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

Appropriate Listing/Reclassification Priority Number, if applicable: Upgrade to 5.

Review Conducted By: Jennifer Finfera, Ohio Ecological Services FO, USFWS

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve Tom Green Date 4-22-2016
The lead Field Office must ensure that other offices within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. The lead field office should document this coordination in the agency record.

REGIONAL OFFICE APPROVAL:

The Regional Director or the Assistant Regional Director, if authority has been delegated to the Assistant Regional Director, must sign all 5-year reviews.

Lead Regional Director, Fish and Wildlife Service

Approve _____ Date _____