Dwarf Lake Iris Recovery and Population Monitoring: Final Report

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We collectively acknowledge that Michigan State University occupies the ancestral, traditional, and contemporary Lands of the Anishinaabeg – Three Fires Confederacy of Ojibwe, Odawa, and Potawatomi peoples. In particular, the University resides on Land ceded in the 1819 Treaty of Saginaw. We recognize, support, and advocate for the sovereignty of Michigan's twelve federally recognized Indian nations, for historic Indigenous communities in Michigan, for Indigenous individuals and communities who live here now, and for those who were forcibly removed from their Homelands. By offering this Land Acknowledgement, we affirm Indigenous sovereignty and will work to hold Michigan State University more accountable to the needs of American Indian and Indigenous peoples.

Cover: Flowering dwarf lake iris (*Iris lacustris*) and population monitoring quadrat in Emmet County, Michigan (EO ID 7130) on June 8, 2020. Photograph by Rachel A Hackett.

EXECUTIVE SUMMARY

Dwarf lake iris (*Iris lacustris* Nutt.) is a perennial iris endemic to the Great Lakes region with its greatest stronghold in Michigan, USA. The species is Threatened in the United States of America under the Federal Endangered Species Act and Threatened in the States where it resides; it is listed as Special Concern in Canada and Ontario. Dwarf lake iris has 177 documented populations, only 81% are considered currently extant, with 14% considered currently extinct, 5% of unknown status. Greatest threats to dwarf lake iris include habitat destruction, habitat degradation, succession, sand dune erosion, invasive species, and effects of climate change.

To update the status and better understand dwarf lake iris population growth and persistence, spatial, qualitative, count and demographic surveys were conducted at 62 Michigan populations from 2019 to 2023. For count and demographic surveys, a census of the number of ramets in each life stage were counted for each 0.25 m^2 plot. Population estimation methods provided count-based population data for a population viability. The combination of new count data and existing count data found in literature was able to produce 65 population change increments across 17 subpopulations, allowing us to reliably project 7 to 13 years in the future. The mean instantaneous stochastic growth rate was negative but near zero (μ = -0.0641) with large variance that could span positive values (σ^2 = 0.474): although the populations were likely to decrease, positive growth of the population was inside the realm of possibilities. We used these values and the most recent population estimates to simulate population change 10 years into the future. A 38% probability of population extinction across dwarf lake iris populations was predicted. The extinct populations were disproportionately in Wisconsin.

The population viability analysis conducted for this project indicated a decline in growth for the species, but its variance throws uncertainty onto any sweeping statements about its growth, stability, or decline. Collecting more count-based population data can not only contribute to being able to predict population viability further into the future, but also more data will allow for more variables to be included in the model. The simulations were based wholly on populations estimates, smaller populations more likely to be affected negatively, so it could be that a variable not yet able to be incorporated into the equation could influence the outcome. The continued documentation of dwarf lake iris population response throughout fluctuating water events and research into the effects of substrate deposition on dwarf lake iris ramet growth and reproduction could lend itself to improved viability and extinction predictions of shoreline populations and the threat of greater, more frequency changes in the Great Lakes.

Representation of dwarf lake iris species is needed of populations across the four identified genetic groups, especially the most genetically diverse western group, populations found uniquely inland, and populations with colonies of white flowers. Resiliency can be found in preserving populations across the nine groups with local adaptations, watching for new or increased threats to sterile adult life stage, and preserving population growing in a variety of habitats. Redundancy should be shown in the numbers of the populations described above that are protected as well as by protecting large populations that can withstand catastrophic changes by shear extent and abundance.

ACKNOWLEDGEMENTS

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INTRODUCTION

Dwarf lake iris (*Iris lacustris* Nutt.; henceforth DLI) is a perennial iris endemic to up to 32 km from northern shores of Lake Michigan and Lake Huron of the Great Lakes of North America. The small, blue, or rarely white DLI flower usually blooms from mid-May to mid-June (Figure 1). Its flowering abundance and fruit set is affected by light levels and litter depth (Van Kley 1989, Brotske 2018). Reproduction of DLI has been contributed to mostly asexual means of rhizomatous growth, although recent seed dispersal and germination experiments have increased the likelihood that sexual reproduction is contributing to populations (Brotske 2018). The species is listed as threatened at the Federal- and State-level in the USA and as Special Concern in Canada and Ontario. Greatest threats to DLI include habitat destruction, habitat degradation, succession, sand dune erosion, invasive species, and effects of climate change (e.g., extreme drought, variable Great Lake water levels; USFWS 2013).

To best conserve a rare species, a species' representation, resiliency, and redundancy must be examined across its range (USFWS 2016). This involves research into a species status, its population genetics, its growth, and viability based on current occurrences across its range. Population viability analysis (PVA) was a step in the US Fish and Wildlife Service recovery plan (2013).

A count-based analysis requires population census data for at least 10 years to predict long-term species viability. DLI fits most assumptions of a count-based approach to PVA for plants: no extreme fluctuations in population size, are easily identified, can have population turnovers between 10-20 years (e.g., not long-lived trees), whose population growth is not density dependent, have infrequent sexual reproduction, have low genetic variation within populations, and lack of large dormant seed banks (Dennis et al., 1991; Morris et al., 1999; Brigham and Thomson, 2003). Chicago Botanic Garden conducted a count-based PVA while examining local and regional threats on a rare species of similar habit using forked aster (*Eurybia furcata*; Bernardo et al., 2018).

A demographic analysis differs from count-based analysis in that it differentiates between life stages and requires more field intensive work. Census data is gathered for each categorized life stage of the species and fecundity data for at least 2 years, preferably more to capture greater inherent variation and increase reliability (Zeigler et al., 2013). Demographic data is more field intensive, but the data is more informative and can examine or predict effects of management and threats on a population (Morris et al., 1999).

Our efforts from 2019-2023 focused on 1) updating status of accessible DLI populations in Michigan, 2) collecting data for and conducting count-based and demographic-based population viability analyses, 3) using population viability analyses to predict extinctions of known DLI occurrences across its range, and 4) conducting population genetic analyses using current methods.

Figure 1. Relative size of dwarf lake iris (*Iris lacustris*) flower and ramets compared to adult hand. Photograph by Rachel Hackett, May 25, 2022.

METHODS

The methods, results, and discussion included here summarize efforts funded across several awards (i.e., F18AC00566, F19AC00653, F20AC10391) as it would be incomplete to describe only that for which data collection was funded for the current award. As such, some of the data collection that was funded by F20AC10391 (e.g., one further year of demographic surveying) was collected and analyzed in time for the final report for F18AC00566. For the reader's convenience and clarity, some of the following text and tables are sourced from previous reports of those awards (i.e., Hackett et al. 2021, 2022) to provide a full and final summary of the work conducted.

Study Area

Natural Heritage Databases in Michigan, USA; Wisconsin, USA; and Ontario, CA; have 177 element occurrence (EO) records of DLI (COSEWIC 2010, USFWS 2013, WDNR 2023, MNFI 2024; Table 1, Figure 2). The extant records stretch west to east from Door County, Wisconsin, USA, near the shores of Lakes Michigan and Huron through the Straits of Mackinac to Bruce Peninsula and Bruce County in Ontario, CA. There are extirpated records in Essex County, ON, CA, and Milwaukee County, WI, USA beyond its current range. Most populations are in what Albert dubbed the Niagara Escarpment and Lake Plain Ecoregion VIII.1 (Albert 1995). Geologically, this region follows Niagara escarpment, other limestone and sandstone features, and lake plain formations. The climate in this region is heavily influenced by the Great Lakes with longer growing seasons and milder temperatures near the lakes. Prior to European colonization, the natural communities in these areas were extensive dune and swale systems, bedrock glades, coastal wetlands, conifer forests, with some mixed forests in dry and mesic areas.

Table 1. List of dwarf lake iris (*Iris lacustris* Nutt.) Element Occurrence (EO) records from Michigan, Wisconsin, and Ontario (COSEWIC 2010, USFWS 2013, WDNR 2023, MNFI 2024). EO ID is a unique identifier for each EO record a State/Provincial Natural Heritage Database. Rank is a qualitative assessment of estimated viability of species described in Table 2. Ownership are categories for owners of EO land: Federal (F), Municipal (M), Non-Governmental Organization (N), Private (P), State/Provincial (S), and Tribal/First Nation (T). Last Visit Date is the most recent visit, regardless of species presence. Michigan field surveys conducted from 2019 to 2023 were marked with a S for spatial survey, Q for qualitative survey, C for count survey, D for demographic survey, and G for genetic sampling. A key linking EO ID to colloquial survey site name is found in APPENDIX A: Key for Element Occurrence Identifier (EO ID) to Survey Site Name.

State/ Province	County	EO ID	Rank	Ownership	Last Visit Date	Michigan Field Survey			
MI	Alpena	256	A	P, S	2021-05-26	S[1]	Q		G
MI	Alpena	1625	C	P, S	2002-08-08				
MI	Alpena	2440	AB	N, P	2023-08-23	S[1]	Q		
MI	Alpena	2837	F	P, S	2020-06-11		Q		
MI	Alpena	3403	A	N, P	2023-06-05			C	G
MI	Alpena	6713	F	P, S	2021-06-14	S	Q		
MI	Alpena	8385	B	P	2023-08-24	S	Q		G

[1] Visited subset of area of EO record depending on landowner permissions granted.

State/ Province	County	EO ID	Rank	Ownership	Last Visit Date	Michigan Field Survey				
MI	Alpena	8775	B?	P	2010-08-11					
MI	Alpena	9817	CD	F	1981-06-07					
MI	Charlevoix	1369	B	P, S	2022-06-22		Q			G
MI	Charlevoix	2472	BC (F)[2]	P	2019-06-25		Q			
MI	Charlevoix	8033	C	S, T	2000-05-19					
MI	Charlevoix	18917	D	S, T	2019-06-26		Q[3]			G
MI	Charlevoix	22194	D	S, T	2019-06-27	S	Q			G
MI	Cheboygan	6907	B	P, S	2018-06-20					
MI	Cheboygan	8439	B	N, S	2023-06-01	S		C		G
MI	Cheboygan	10464	BC	P	2021-06-16	S[1]	Q			
MI	Cheboygan	22657	D	N	2023-08-21	S	Q			G
MI	Chippewa	743	F	P	2019-07-10	S	Q			
MI	Chippewa	10263	F	P	2021-06-16	S	Q			
MI	Chippewa	10288	B	P	1998-08-28					
MI	Chippewa	12375	F	P	2019-07-10	S	Q			
MI	Delta	116	H	S	1968-06-01					
MI	Delta	2811	A	S	2023-06-03	S[1]	Q[3]			
MI	Delta	3132	C	F	2017-08					
MI	Delta	3615	H	P	1968-05-30					
MI	Delta	4466	C	N	2023-05-24	S		C		G
MI	Delta	4640	F	P	2019-06-19		Q			
MI	Delta	5552	BC (F)[2]	P	2019-06-19	S[1]	Q			
MI	Delta	5633	A	S	2023-06-15		Q			G
MI	Delta	10711	X	S	1939-05-30					
MI	Delta	11586	F	F	2021-07-28	S				
MI	Delta	11928	CD	S	1995-06-23					
MI	Delta	22191	E	P, S	1998-05-29					
MI	Delta	23699	F	F, P	2021-06-03	S	Q			
MI	Delta	23701	D	F	2021-06-04	S	Q			
MI	Emmet	3606	B	M, P, S	2021-06-18	S[1]	Q			
MI	Emmet	7130	C	S	2023-05-30	S		C	D	G
MI	Emmet	10381	C	S	2023-05-30	S	Q			G
MI	Emmet	11844	F	S	2020-06-20	S	Q			
MI	Emmet	13051	CD	P, S	1981-05-14					
MI	Mackinac	834	C	P	2021-06-11	[1]	Q			
MI	Mackinac	835	B	S	2020-06-18		Q			
MI	Mackinac	1885	F	P	2023-06-07	S				
MI	Mackinac	3635	BC	P	2023-08-09	S	Q	C		
MI	Mackinac	4458	F	F	2021-06-10		Q			
MI	Mackinac	5377	AB	P	1999-06-11					
MI	Mackinac	5954	B	S	2020-06-17	S	Q			G
MI	Mackinac	8201	C	P	2001-05-23					
MI	Mackinac	8202	C	P	2001-06-04	[1]	Q			
MI	Mackinac	8623	B	S	2020-06-17	S[1]	Q			G
MI	Mackinac	8964	A	N, P, S	2023-05-31			C		G
MI	Mackinac	10153	C	S	2019-06-21	S	Q			
MI	Mackinac	10154	BC	F	2008-06-19					
MI	Mackinac	12221	AB	P, S	2020-06-19	S[1]	Q			G
MI	Mackinac	12376	AB	P, S	2023-05-23			C	D	G

[2] Although surveyors failed to find in surveyed area, EO rank was not changed due to inability to survey portions of mapped area due to lack permission from land owner.
[3] Population in archeologically sensitive area, so qualitative survey was modified.

State/ Province	County	EO ID	Rank	Ownership	Last Visit Date	Michigan Field Survey				
MI	Mackinac	12503	AB	P	1999-06-11					
MI	Mackinac	12547	C[2]	P	2020-06-12	S[1]	Q			
MI	Mackinac	12548	B	P	2019-06-10	S[1]				
MI	Mackinac	12862	A	N, P, S	2020-06-16	S[1]	Q			G
MI	Mackinac	15825	C	P	1993-08-12					
MI	Mackinac	15826	C	P	1993-08-10					
MI	Mackinac	24196	E	S	2019-07-12					
MI	Mackinac	24245	C	F	2023-06-16	S	Q			
MI	Mackinac	TBD	E	P	2024-05-30	S				
MI	Menominee	5149	BC	P	2021-06-05	S[1]	Q			
MI	Menominee	15125	BC	S	2023-05-22	S		C	D	G
MI	Menominee	15176	C	S	2019-06-18	S	Q			G
MI	Menominee	16477	AB	P	2005-05-26					
MI	Presque Isle	1854	C	P	1981-06-26					
MI	Presque Isle	2058	C	P	2002-07-11					
MI	Presque Isle	2235	D	P, S	2022-05-27	S[4]	Q[3]			
MI	Presque Isle	4553	C	P	1996-06-28					
MI	Presque Isle	5551	AB	S	2023-06-06	S[4]	Q			
MI	Presque Isle	8162	B	P, S	2023-06-02	S		C		G
MI	Presque Isle	10080	A	S	2022-05-26	S[4]	Q			
MI	Presque Isle	10481	C	P	2019-05-28	S	Q			
MI	Presque Isle	10888	B	P	2023-08-22	S[1]	Q			
MI	Presque Isle	10918	A	P, S	2022-05-28	[1]	Q[3]			G
MI	Presque Isle	11321	B	P	2019-05-31	S[1]	Q			
MI	Presque Isle	15944	B	S	2020-06-30		Q			
MI	Presque Isle	23795	C	P	2019-05-28	S	Q			
MI	Schoolcraft	973	C?	P	2001-08-13					
MI	Schoolcraft	1788	C	P	2000-08-08					
MI	Schoolcraft	3589	BC	P, S	2021-06-07	S[1]	Q			
MI	Schoolcraft	4465	BC	P	2021-06-09		Q			
MI	Schoolcraft	6351	C	P	2021-06-03	S	Q			
MI	Schoolcraft	6809	B	P	2021-06-03		Q			
MI	Schoolcraft	8015	BC	P, S	2021-06-02		Q			
MI	Schoolcraft	8842	C	P	2000-08-08					
MI	Schoolcraft	9196	C	P	2000-08-09					
MI	Schoolcraft	12942	B	P	2021-06-04	S	Q			
ON	Bruce	UNK[5]	E	P	2006					
ON	Bruce	3	E	P						
ON	Bruce	3133	X	S	2008					
ON	Bruce	3134	E	N, P	2008					
ON	Bruce	3135	E	S	2008					
ON	Bruce	3136	E	S	2005					
ON	Bruce	3137	F	P	2003					
ON	Bruce	3138	E	T	2003					
ON	Bruce	3140	E	P	2008					
ON	Bruce	3142	E	N, P	2006					
ON	Bruce	3144	E	P	2003					
ON	Bruce	3145	X	P	1954					

[4] With new survey, EO ID 2235, 5551 and 10080 no longer have sufficient separation distance and will be combined.

[5] Listed as "new" without a EO identifier in USFWS *Dwarf Lake Iris (*Iris lacustris*): Recovery Plan* (2013) and in COSEWIC *Assessment and Status Report on Dwarf Lake Iris* (2010).

State/ Province	County	EO ID	Rank	Ownership	Last Visit Date	Michigan Field Survey
ON	Bruce	3147	E	F, P	2007	
ON	Bruce	3148	E	F, T	2007	
ON	Bruce	3149	E	P	2007	
ON	Bruce	3150	E	N, P	2004	
ON	Bruce	3151	H		2003	
ON	Bruce	3153	H	P, T	2006	
ON	Bruce	3155	F	F	2007	
ON	Bruce	3161	H	F	2007	
ON	Bruce	3162	E	P	2006	
ON	Bruce	3163	F	N	2004	
ON	Bruce	5930	E	S	2008	
ON	Bruce	5931	E	F, N	2005	
ON	Bruce	5932	F	S	1982	
ON	Bruce	5933	E	T	1996	
ON	Bruce	5934	E	N	2006	
ON	Bruce	18251	E	T	1991	
ON	Bruce	64287	E	S	2006	
ON	Bruce	64288	E	P	2003	
ON	Bruce	84791	F	P	2007	
ON	Bruce	91764	E	P	2003	
ON	Bruce	91788	E	N, P, S	2007	
ON	Bruce	92779	F	P	2008	
ON	Essex	3154	X		1901	
ON	Manitoulin	[5]	E	M	2008	
ON	Manitoulin	[5]	E	T	2008	
ON	Manitoulin	[5]	E	T	2007	
ON	Manitoulin	[5]	E	T	2007	
ON	Manitoulin	64	E	M, P	2006	
ON	Manitoulin	3156	E	T	2007	
ON	Manitoulin	3157	F	M, P	2006	
ON	Manitoulin	3158	E	M, P	2006	
ON	Manitoulin	3159	X	M, P	2006	
ON	Manitoulin	3159	H	P	2007	
ON	Manitoulin	7834	E	S	2004	
WI	Brown	545	B	N, S, P	2021-04-29	
WI	Brown	4670	C	P	2005	
WI	Brown	12720	C	P	1999-09	
WI	Door	46[6]	BC	M		
WI	Door	393	CD	P	1988	
WI	Door	47[6]	C	P		
WI	Door	832	C	S	2017-05-23	
WI	Door	1294	H	M, P	1979	
WI	Door	2253	C	S	2019-05-29	
WI	Door	3026	C	M, P, S	2017-08-23	
WI	Door	3194	D	P, S	1998-05-14	
WI	Door	3750	B	M, P	1981-08-22	
WI	Door	4237	A	M, N, P	2007-05-15	
WI	Door	4554	H		1921-06-16	
WI	Door	4999	A	M, P, S	2017-06-01	

[6] Instead of EO ID, the EO number is listed as an identifier. An EO report and ID for this site was not listed in the Wisconsin Natural Heritage Database (WDNR 2023), but population information was included in USFWS *Dwarf Lake Iris (*Iris lacustris*): Recovery Plan* (2013) with this EO number.

State/ Province	County	EO ID	Rank	Ownership	Last Visit Date	Michigan Field Survey
WI	Door	6415	D	P	2017-05-24	
WI	Door	7158	D	P	1981-08-20	
WI	Door	7490	C	M, P,	1981-08-22	
WI	Door	7737	D	F	2021-07-13	
WI	Door	8106	D	N	2017-05-24	
WI	Door	9835	D	P	1985-06-10	
WI	Door	11021	AB	S, P	2020-07-25	
WI	Door	11433	D	M, N, P	2015-06-24	
WI	Door	11811	D	P	1998-05-15	
WI	Door	12950	C	S	2018-05-13	
WI	Door	13459	E	S	1980	
WI	Door	14382	C	P	2017-05-25	
WI	Door	14918	C	P, S	2017-05-24	
WI	Door	15783	B	S	2018-06-04	
WI	Door	16329	B	M, P	2017-08-23	
WI	Door	17529	D	M, P	2000-05-05	
WI	Door	17672	C	S	2017-05-23	
WI	Door	20250	BC	P	1990-07-23	
WI	Door	21172	C	P	2017-05-25	
WI	Door	21175	D	M	2000-07-20	
WI	Door	21610	H		1952-09-15	
WI	Door	24438	D	P	2017-05-31	
WI	Door	30001	C	N	2017-05-23	
WI	Milwaukee	6287	X		1898-05-17	
WI	Milwaukee	17954	X		1943	

Table 2. Definitions of element occurrence (EO) Ranks for species as defined by NatureServe. Abridged table of that developed by NatureServe (2021).

Rank	Definition
A	Excellent estimated viability (species) - Based on current information on EO rank factors (i.e., condition, size, and landscape context) for the EO, it is believed to have an excellent probability of persisting, if current conditions prevail, for a defined period of time, typically 20-100 years.
B	Good estimated viability (species) - Based on current information on EO rank factors (i.e., condition, size, and landscape context) for the EO, it is believed to have a good probability of persisting, if current conditions prevail, for a defined period of time, typically 20-100 years.
C	Fair estimated viability (species) - Based on current information on EO rank factors (i.e., condition, size, and landscape context) for the EO, it is believed to have a fair probability of persisting, if current conditions prevail, for a defined period of time, typically 20-100 years.
D	Poor estimated viability (species) - Based on current information on EO rank factors (i.e., condition, size, and landscape context) for the EO, it is believed to have a poor probability of persisting, if current conditions prevail, for a defined period of time, typically 20-100 years.
E	Verified Extant (species) - EO has been recently verified as still existing, but sufficient information on the factors used to estimate viability of the occurrence has not yet been obtained. Use of the E rank should be reserved for those situations where the occurrence is thought to be extant, but an A, B, C, D, or range rank cannot be assigned.
H	Historical (species) - There is a lack of recent[7] field information verifying the continued existence of the E0, such as when the occurrence is based only on historical collections data, or when the occurrence was ranked A, B, C, D, or E at one time and is later, without field survey work, considered to be possibly extirpated due to general habitat loss or degradation of the environment in the area.
F	Failed to find - EO has not been found despite a search by an experienced observer at a time and under conditions appropriate for the Element at a location where it was previously reported, but that still might be confirmed to exist at that location with additional field survey efforts. For EOs with vague locational information, the search must include areas of appropriate habitat within the range of locational uncertainty. An F rank, when applicable, supersedes an A, B, C, D, E, or H rank.
X	Extirpated - There is documented destruction of the habitat or environment of the EO, or persuasive evidence of its eradication based on adequate survey (i.e., thorough or repeated survey efforts by one or more experienced observers at times and under conditions appropriate for the Element at that location).
U	Unrankable - An EO rank cannot be assigned due to lack of sufficient information on the occurrence.
NR	Not Ranked - An EO rank has not yet been assigned to the occurrence.

[7] The term *recent* is generally interpreted as follows: […] For plants or communities, there has been a field survey of the occurrence within the last 20 to 40 years. This higher maximum time limit is based upon the assumption that occurrences of these Elements generally have the potential to persist at a given location for longer periods of time due to plant biology and community dynamics. However, landscape factors must also be considered; thus, areas with more anthropogenic impacts on the environment will be at the lower end of the range, and less-impacted areas will be at the higher end. These time frames represent suggested maximum limits, however the actual time period for historical EOs may vary according to the biology of the Element and the specific landscape context of each occurrence (including anthropogenic alteration of the environment).

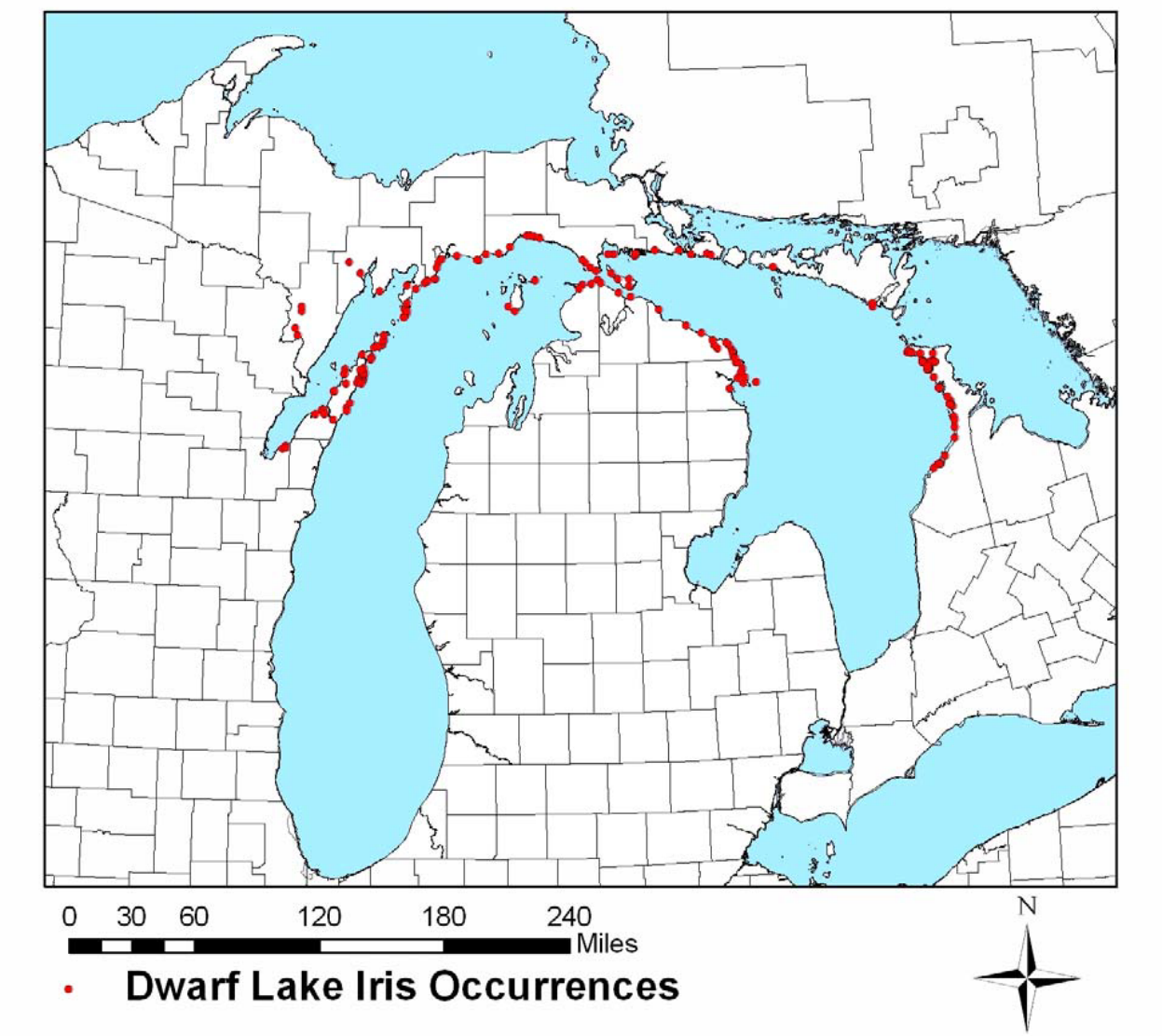

Figure 2. Global distribution of dwarf lake iris (*Iris lacustris*) is centered near the northern shores of Lake Michigan and Lake Huron in the Great Lakes Region of North America. Source: *USFWS Dwarf Lake Iris (Iris lacustris): Recovery Plan* (2013).

Michigan field surveys

Site selection
From 2019 to 2023, selected Michigan DLI EOs were visited (Table 1). These sites were selected and the surveys conducted based on the following criteria:

- Cost of access (e.g., ferry costs)
- Previous research
- Survey needs mentioned in record
- Uncertainty of spatial extent of population
- Year since last observation
- Ownership and likelihood to gain access
- Variety of rank
- Both inland and shore locations

Spatial surveys
Records of DLI EOs are only as good as their source information. The geographic information available for EO records can be vague, especially for older records. For other EOs resources were not available to allow for the full extent of the population to be determined.

Records with uncertain extent were prioritized for landowner contact to achieve survey status. Prior to field survey, the aerial imagery and land cover/use maps were used to determine likely extent of population and area to survey. Land access permissions were sought for survey when costs were not prohibitive.

In the field, a meander survey in areas of suitable habitat was conducted to assess the extent of the DLI population. Photographs and Global Positioning System (GPS) coordinates were collected at significant transitions and points of interest. Often qualitative surveys were conducted in conjunction with spatial surveys. Spatial surveys could be conducted during any point of the growing season.

Qualitative surveys
Qualitative surveys provide current information and estimates to use in EO ranking for a record. These surveys are quick, provide presence/absence data, produce a density range estimate, generate a current assessment of threats to the population, and can provide qualitative population trends over time. Qualitative surveys can be conducted during any point of the growing season. Soil depth, soil type, litter depth, and canopy openness were measured in at least three points for each qualitative survey (Table 3). Soil moisture in each site was categorized into dry, moist, wet, saturated, inundated, or other. Invasive plant species were noted and classified into DAFOR abundance scale (Voss and Reznicek, 2012). Signs of animal impact (e.g., browsing, trampling) were noted and categorized into no impact (0% of DLI population affected), low impact (0 – 50% of DLI population affected), or high impact (51 – 100% of DLI population affected) as used by the Chicago Botanic Garden's Plants of Concern program (Bernardo et al., 2018; Goad et al., 2018).

On lands indicated by landowners or managers to be sensitive to ground disturbance (e.g., of archeological significance), some habitat measurements were not collected (Table 3).

Table 3. Differences in data collection for each survey type.

	Spatial	Qualitative – Sensitive sites	Qualitative	Count	Demographic
Sampling method:	Meander	Meaner	Meander	Transect-quadrat	Transect-quadrat[8]
Data collected:					
GPS coordinates	X	X	X	X	X
Photographs	X	X	X	X	X
Presence/absence	X	X	X	X	X
Density Range Est.		X	X		
Threats		X	X	X	X
Soil Depth			X	X	X
Soil Type			X	X	X
Litter depth			X	X	X
Canopy openness		X	X	X	X
Soil Moisture			X	X	X
Invasive Plant Species Density Estimate		X	X	X	X
Quadrat (0.25 m^2) ramet counts				X	X
Specimens collected			X[9]	X	X

Count surveys

Count surveys produce precise data with repeatable methods to be used to predict population trends using PVA derived from other populations or, if collected for at least 10 growing seasons, as a portion of a count-based PVA (Eldred et al. 2003, Bernardo et al. 2018). Count surveys are best conducted during flowering or fruiting periods.

The methods of Van Kley (1989) were adopted to maintain consistency among usable count census records. Ten random transects were placed approximately perpendicular the shore. At inland sites, the transects were placed perpendicular to the topography. If there was not a colony intersecting the random transect, the transect was conducted at the nearest colony of DLI. A belt transect was used to determine the number of colonies and percent DLI cover for each transect. The separation distance between colonies was at least 1 m between ramets. Each colony that had a ramet that falls within 2 m of the belt transect was considered intercepted. The transect ran until no DLI was intercepted for 40 m. For records with multiple delineated polygons for the same population, one of three courses of action was taken: 1) if the record was a site of previous research, only polygons included in that study were surveyed, 2) polygons were selected based on accessible permissions, or 3) transects were divided among

[8] Quadrats and plants marked for revisitation.
[9] Only at sites with large populations (i.e., ranks A to BC) or unique features (e.g., white flowers, inland).

the polygons in an area-proportional manner with at least one transect in a polygon greater than 1 ha.

Quadrats of 0.25 m^2 area were placed on a randomly selected intercepted colony. At least 10 quadrats were placed for each EO. The quadrats were placed a random distance between the first and last colonies intercepted the transect. If no ramets were at the random distance, the quadrat was placed at the edge of the nearest colony.

A census of the number of ramets in each stage, flowers, and capsules were counted for each quadrat (Table 4). Soil depth, soil type, litter depth, canopy openness, and categorical sunlight amount (e.g., partial sun) were measured. Soil moisture in each transect and quadrat was categorized into dry, moist, wet, saturated, inundated, or other. Signs of animal impact (e.g., browsing, trampling) were noted and categorized for each belt transect and quadrat into no impact (0% of DLI affected), low impact (0 – 50% of DLI affected), or high impact (51 – 100% of DLI affected) as used by the Chicago Botanic Garden's Plants of Concern program (Bernardo et al. 2018, Goad et al. 2018).

At least one photograph was captured from approximately 1.5 m above the quadrat so that the entire quadrat is contained in the frame (Figure 3b). At least one of the sides of the quadrat was marked in metric units to provide a unit measurement for image comparison.

Table 4. Description of dwarf lake iris life stages for surveys at/after flowering time.

Stage	Description
Juvenile	Ramet less than 5.25 cm tall and lacks sexual reproductive organs (i.e., flower, fruit)
Sterile Adult	Ramet greater than 5.25 cm, but lacks sexual reproductive organs
Reproductive Adult	Ramet has sexual reproductive organs
Dead	No vegetative growth in subsequent year (demographic survey only)

Figure 3. Examples of photographs taken at a quadrat during a count survey at EO 8439, Cheboygan County, Michigan, on June 1, 2019: a) a photograph of the habitat, b) a photograph of the quadrat and density. Photographs by Rachel Hackett.

Demographic surveys

Belt transects were conducted in the same manner as for the count surveys as for demographic surveys. The quadrats for demographic surveys were permanently marked flags in the two opposite corners of the quadrat. Each ramet received a marked fluorescent tee at its base, labeled with unique sequential numbers. Each ramet was designated a life stage class (Table 4). In subsequent years, the quadrats were located using GPS coordinates and the quadrat flags, ramets linked to nearest marker, and their stage recorded. Demographic surveys were conducted during flowering (preferred) or fruiting period.

Genetic sample collection and analysis

In collaboration with James Cohen (formerly Kettering University, now Weber State University), we collected leaf samples for genetic analysis within and among DLI populations.
At the 10 count sites, leaf samples from up to 10 individuals across each population were collected. Leaf samples were also collected at unique populations visited (e.g., white flowers, inland sites) and at other populations to ensure genetic material from across the species Michigan range was collected. Collected leaves were stored in a dry and cool plastic collection bag until transferred to the possession of Cohen.

Samples were sent to Data2Bio LLC for sample analysis. Cohen analyzed and interpreted the genetic data from the sample analysis. DLI is polypoid, so they used single nucleotide polymorphism (SNP) matrices using polyRAD to recognize diploid and tetraploid loci among their analyses.

Count-based population viability analysis

The methods of population estimation used by Chicago Botanic Gardens in their Plants of Concern Volunteer program were adapted to provide count-based population data for a PVA (Bernardo et al. 2018, Goad et al. 2018). For the populations that underwent count surveys, each mapped subpopulation of the population was called a subpopulation and had a separation distance of at least 50 m between DLI colonies. The mean ramet count per quadrat in each subpopulation during the same year was used to determine plants per 1 m^2 in each subpopulation. The mapped area was used to extrapolate DLI from population density to the total area of the subpopulation for estimated total ramets per subpopulation, although it is recognized that DLI was not contiguous throughout the area.

We followed the methods of Dennis et al. (1991) as described by Elderd et al. (2003) to determine the mean instantaneous stochastic growth rate (μ) and variance of stochastic growth (σ^2). In alignment with this process, we transformed the count data to be described by a linear model of the rate of population change over time verses the length of time using the formulas:

$$x = \sqrt{t_j - t_i}$$
$$y = \frac{\ln(N_j) - \ln(N_i)}{x}$$

where *j* is the later year of the two counts, *i* is the earlier year of the two counts, *t* is year value, and *N* is the population estimate. Using a linear regression on the resulting line with *y*-intercept set at 0, the slope of the line is an estimate of μ and the variance of the individual data points on the line gives variance σ^2.

Population simulations

To extrapolate the probability of extinction to DLI as a species, extant DLI populations with populations estimates were simulated using the minimal population estimate of the most recent visit. For DLI populations in Michigan and Wisconsin, the populations estimates were retrieved from that states respective Natural Heritage Biotics Database including data collected for this project (WDNR 2023, MNFI 2024). For DLI populations in Canada, the populations estimates reported in *USFWS Dwarf Lake Iris (Iris lacustris): Recovery Plan* and *COSEWIC Assessment and Status Report on the Dwarf Lake Iris (*Iris lacustris*) in Canada* were used (COSEWIC 2010, USFWS 2013). Population estimates for 126 extant populations were used (Table 5).

To determine the probability of extinction of a DLI population the cumulative distribution function (CDF) was used (Dennis et al. 1991, Morris and Doak 2002, Elderd et al. 2003). Simulations were run using the minimal population estimate as a starting population, quasi-extinction-threshold (N_x) of 500 ramets, and the μ and σ^2 derived from the count viability analysis. Although there has been no evidence of density dependence in DLI, we used a carrying capacity (K) 10% more than the maximum population estimate used (K = 55,000,000), to prevent population sizes from becoming unrealistically large. One thousand simulations for each population ran from the year of the visit the population estimate was made until 2033 (10 years post 2023). Ten years was used, because the growth rate and variance from the count-based viability analysis had a 10-year reliability based on the number of count-intervals used in the analysis (Fieberg and Ellner 2000). An extinction probability was calculated from these simulations. Those populations with 50% or greater extinction probability were categorized as extinct. Analyses were conducted using R version 4.2.3.

Table 5. Probability of extinction in 10 years based on most recent population estimates. EO ID is a unique identifier for each element occurrence (EO) record a State/Provincial Natural Heritage Database. EO Rank is a qualitative assessment of estimated viability of species described in Table 2. Year of Population (Pop.) Estimate (Est.) is the year of the most recent population estimate by a surveyor. Minimum Pop. Est. is the most recent minimum population estimate. A site is bolded and marked as Extant if extinction probability is less than 50%.

State/ Province	County	EO ID	EO Rank	Year of Pop. Est.	Minimum Pop. Est.	Extinction Probability	Extant or Extinct
MI	**Alpena**	**256**	**A**	**2021**	**50,000**	**25%**	**Extant**
MI	Alpena	1625	C	1996	2,000	54%	Extinct
MI	**Alpena**	**2440**	**AB**	**2021**	**25,000**	**31%**	**Extant**
MI	**Alpena**	**3403**	**A**	**2023**	**1,000,000**	**8%**	**Extant**
MI	**Alpena**	**8385**	**B**	**2021**	**50,000**	**25%**	**Extant**
MI	Alpena	9817	CD	1981	20	100%	Extinct
MI	**Charlevoix**	**1369**	**B**	**2019**	**8,000**	**38%**	**Extant**
MI	Charlevoix	8033	C	1999	100	100%	Extinct
MI	Charlevoix	18917	D	2019	300	89%	Extinct
MI	Charlevoix	22194	D	2019	100	100%	Extinct
MI	**Cheboygan**	**8439**	**B**	**2023**	**14,000**	**31%**	**Extant**
MI	Cheboygan	10464	BC	2021	250	94%	Extinct
MI	**Cheboygan**	**22657**	**D**	**2020**	**1,000**	**48%**	**Extant**
MI	Chippewa	10288	B	1998	1,000	53%	Extinct
MI	**Delta**	**2811**	**A**	**2023**	**1,153,695**	**8%**	**Extant**
MI	Delta	3132	C	2017	1,000	51%	Extinct
MI	**Delta**	**4466**	**C**	**2023**	**5,000**	**37%**	**Extant**
MI	**Delta**	**5633**	**A**	**2023**	**329,982**	**13%**	**Extant**
MI	Delta	11928	CD	1995	5	100%	Extinct
MI	Delta	23701	D	2021	800	51%	Extinct
MI	**Emmet**	**3606**	**B**	**2021**	**2,150**	**47%**	**Extant**
MI	**Emmet**	**7130**	**C**	**2023**	**1,500**	**48%**	**Extant**
MI	**Emmet**	**10381**	**C**	**2023**	**3,000**	**39%**	**Extant**
MI	Emmet	13051	CD	1981	10	100%	Extinct

State/ Province	County	EO ID	EO Rank	Year of Pop. Est.	Minimum Pop. Est.	Extinction Probability	Extant or Extinct
MI	**Mackinac**	**834**	**C**	**2021**	**10,000**	**35%**	**Extant**
MI	**Mackinac**	**835**	**B**	**2020**	**100,000**	**23%**	**Extant**
MI	**Mackinac**	**3635**	**BC**	**2023**	**20,000**	**26%**	**Extant**
MI	**Mackinac**	**5377**	**AB**	**1994**	**10,000**	**49%**	**Extant**
MI	**Mackinac**	**5954**	**B**	**2020**	**8,000**	**37%**	**Extant**
MI	Mackinac	8201	C	2001	100	100%	Extinct
MI	Mackinac	8202	C	2001	100	100%	Extinct
MI	**Mackinac**	**8623**	**B**	**2020**	**500,000**	**17%**	**Extant**
MI	**Mackinac**	**8964**	**A**	**2023**	**200,000**	**11%**	**Extant**
MI	Mackinac	10153	C	2019	300	89%	Extinct
MI	**Mackinac**	**10154**	**BC**	**1993**	**25,000**	**46%**	**Extant**
MI	**Mackinac**	**12221**	**AB**	**2020**	**1,230,000**	**13%**	**Extant**
MI	**Mackinac**	**12376**	**AB**	**2023**	**15,000**	**29%**	**Extant**
MI	**Mackinac**	**12503**	**AB**	**1999**	**10,000**	**47%**	**Extant**
MI	Mackinac	12547	C	1993	1,000	54%	Extinct
MI	Mackinac	12548	B	2019	100	100%	Extinct
MI	**Mackinac**	**12862**	**A**	**2020**	**2,206,000**	**10%**	**Extant**
MI	Mackinac	15825	C	1993	300	89%	Extinct
MI	Mackinac	24196	E	2019	10	100%	Extinct
MI	Mackinac	24245	C	2023	500	53%	Extinct
MI	**Menominee**	**5149**	**BC**	**2021**	**11,000**	**34%**	**Extant**
MI	**Menominee**	**15125**	**BC**	**2023**	**2,500**	**39%**	**Extant**
MI	**Menominee**	**15176**	**C**	**2019**	**3,500**	**45%**	**Extant**
MI	**Menominee**	**16477**	**AB**	**2005**	**200,000**	**38%**	**Extant**
MI	Presque Isle	2058	C	2002	300	90%	Extinct
MI	Presque Isle	2235	D	2022	250	94%	Extinct
MI	Presque Isle	4553	C	1996	100	100%	Extinct
MI	**Presque Isle**	**5551**	**AB**	**2023**	**201,000**	**12%**	**Extant**
MI	**Presque Isle**	**8162**	**B**	**2023**	**1,000,000**	**8%**	**Extant**
MI	**Presque Isle**	**10080**	**A**	**2022**	**500,000**	**11%**	**Extant**
MI	**Presque Isle**	**10481**	**C**	**2019**	**5,300**	**40%**	**Extant**
MI	**Presque Isle**	**10888**	**B**	**2021**	**10,000**	**37%**	**Extant**
MI	**Presque Isle**	**10918**	**A**	**2022**	**5,100,000**	**2%**	**Extant**
MI	**Presque Isle**	**15944**	**B**	**2020**	**10,000**	**37%**	**Extant**
MI	Presque Isle	23795	C	2019	500	57%	Extinct
MI	Schoolcraft	973	C?	2000	100	100%	Extinct
MI	Schoolcraft	1788	C	2000	100	100%	Extinct
MI	**Schoolcraft**	**3589**	**BC**	**2021**	**791,690**	**12%**	**Extant**
MI	**Schoolcraft**	**4465**	**BC**	**2021**	**5,000**	**40%**	**Extant**
MI	**Schoolcraft**	**6351**	**C**	**2021**	**60,800**	**24%**	**Extant**
MI	**Schoolcraft**	**6809**	**B**	**2021**	**103,000**	**21%**	**Extant**
MI	**Schoolcraft**	**8015**	**BC**	**2021**	**106,600**	**20%**	**Extant**
MI	**Schoolcraft**	**8842**	**C**	**2000**	**10,000**	**48%**	**Extant**

State/ Province	County	EO ID	EO Rank	Year of Pop. Est.	Minimum Pop. Est.	Extinction Probability	Extant or Extinct
MI	Schoolcraft	9196	C	2000	100	100%	Extinct
MI	**Schoolcraft**	**12942**	**B**	**2021**	**600,000**	**15%**	**Extant**
ON	**Bruce**	[10]	**E**	**2006**	**5,000**	**48%**	**Extant**
ON	Bruce	3	E	1998	9,500	50%	Extinct
ON	Bruce	3134	E	2008	2,200	53%	Extinct
ON	**Bruce**	**3140**	**E**	**2008**	**300,000**	**35%**	**Extant**
ON	**Bruce**	**3142**	**E**	**2006**	**25,000**	**41%**	**Extant**
ON	Bruce	3144	E	2003	3,000	51%	Extinct
ON	**Bruce**	**3147**	**E**	**2007**	**26,836**	**42%**	**Extant**
ON	**Bruce**	**3148**	**E**	**2007**	**561,800**	**32%**	**Extant**
ON	**Bruce**	**3149**	**E**	**2007**	**11,000**	**47%**	**Extant**
ON	**Bruce**	**3150**	**F**	**2004**	**40,000**	**43%**	**Extant**
ON	**Bruce**	**3162**	**E**	**2006**	**12,000**	**45%**	**Extant**
ON	Bruce	3163	F	2004	100	100%	Extinct
ON	**Bruce**	**5930**	**E**	**2005**	**270,400**	**37%**	**Extant**
ON	**Bruce**	**5931**	**E**	**2005**	**145,461**	**43%**	**Extant**
ON	Bruce	5934	E	2006	1,500	53%	Extinct
ON	**Bruce**	**64287**	**E**	**2006**	**7,000**	**47%**	**Extant**
ON	**Bruce**	**64288**	**E**	**2003**	**10,400**	**47%**	**Extant**
ON	**Bruce**	**91764**	**E**	**2003**	**1,000**	**54%**	**Extant**
ON	**Bruce**	**91788**	**E**	**2007**	**45,280,430**	**21%**	**Extant**
ON	**Bruce**	**92779**	**F**	**2008**	**15,300**	**45%**	**Extant**
ON	Manitoulin	[10]	E	2008	1,000	53%	Extinct
ON	**Manitoulin**	[10]	**E**	**2007**	**75,000**	**38%**	**Extant**
ON	**Manitoulin**	[10]	**E**	**2007**	**1,000,000**	**32%**	**Extant**
ON	**Manitoulin**	[10]	**E**	**2007**	**30,000**	**40%**	**Extant**
ON	**Manitoulin**	**64**	**E**	**2006**	**1,000,000**	**32%**	**Extant**
ON	**Manitoulin**	**3156**	**E**	**2007**	**10,000**	**46%**	**Extant**
ON	**Manitoulin**	**3157**	**F**	**2006**	**10,000**	**47%**	**Extant**
ON	**Manitoulin**	**3158**	**E**	**2006**	**1,000,000**	**33%**	**Extant**
WI	**Brown**	**545**	**B**	**2021**	**25,000**	**30%**	**Extant**
WI	Brown	12720	C	1999	8,000	50%	Extinct
WI	Door	46	BC	2005	2,000	51%	Extinct
WI	**Door**	**47**	**C**	**1999**	**100,000**	**42%**	**Extant**
WI	Door	832	C	2017	1,053	53%	Extinct
WI	**Door**	**1294**	**H**	**1979**	**84,000**	**48%**	**Extant**
WI	Door	2253	C	2016	200	98%	Extinct
WI	Door	3026	C	2017	1,000	52%	Extinct
WI	**Door**	**3194**	**D**	**1998**	**60,000**	**46%**	**Extant**
WI	Door	3750	B	1981	2,000	53%	Extinct

[10] Listed as "new" without a EO identifier in USFWS *Dwarf Lake Iris (*Iris lacustris*): Recovery Plan* (2013) and in COSEWIC *Assessment and Status Report on Dwarf Lake Iris* (2010).

State/ Province	County	EO ID	EO Rank	Year of Pop. Est.	Minimum Pop. Est.	Extinction Probability	Extant or Extinct
WI	Door	4237	A	2007	200	99%	Extinct
WI	**Door**	**4999**	**A**	**2017**	**1,050,000**	**18%**	**Extant**
WI	Door	6415	D	2017	200	98%	Extinct
WI	Door	7737	D	1998	768	54%	Extinct
WI	Door	8106	D	2017	27	100%	Extinct
WI	Door	9835	D	1985	124	100%	Extinct
WI	**Door**	**11021**	**AB**	**2017**	**101,000**	**33%**	**Extant**
WI	Door	11433	D	2015	80	100%	Extinct
WI	**Door**	**11811**	**D**	**1998**	**7,000**	**47%**	**Extant**
WI	Door	12950	C	1992	2,000	53%	Extinct
WI	**Door**	**14382**	**C**	**2017**	**7,021,000**	**15%**	**Extant**
WI	**Door**	**14918**	**C**	**2017**	**47,000**	**33%**	**Extant**
WI	**Door**	**15783**	**B**	**2014**	**7,431**	**42%**	**Extant**
WI	**Door**	**16329**	**B**	**2017**	**10,000**	**41%**	**Extant**
WI	**Door**	**17672**	**C**	**2017**	**4,500**	**48%**	**Extant**
WI	**Door**	**21172**	**C**	**2017**	**120,000**	**29%**	**Extant**
WI	Door	21175	D	1999	1,000	50%	Extinct
WI	Door	24438	D	2017	1,500	53%	Extinct
WI	**Door**	**30001**	**C**	**2017**	**79,000**	**27%**	**Extant**

Demographic-based population viability analysis (Hackett et al. 2021)

Each year-to-year transition of a marked ramet was used to compute a life-stage transitional matrix (i.e., Leslie Matrix; Table 6). These results were pooled across all demographic quadrats. Marked individuals whose markers were lost or unreadable were not included in the calculation of the life-stage transitional matrix. Individuals that were not associated with a marker in subsequent years were marked as new growth and given a marker. For quadrats that were lost, all individuals marked in the previous year was presumed dead.

For each transitional period of each demographic quadrat, the constant rate of population growth (λ), instantaneous growth rate (r), number of markers documented in both years, number of markers missing in subsequent year, number of newly marked ramets in subsequent year, documented mortality of marked ramets, and survivorship of marked ramets were calculated.

To develop the life-stage transitional matrix, first the ramets marked in both years were counted in the appropriate life stage cell corresponding to a transition between life stages (Table 6; Figure 4). Since much of DLI growth is due to vegetative growth from rhizomes, the new growth can be generated from and to multiple life stages. To account for the new growth in the subsequent year, the new ramets at each stage was contributed proportionally to the survivors of each life stage in the previous year similar to DeWalt (2004). For example, 12 new growth of Sterile Adults would be divided between 3 surviving Juvenile, 20 surviving Sterile

Adults, and 1 Reproductive Adult, 13% (1.56 ramets) would be attributed to the Juvenile to Sterile Adult transition cell, 83% (9.96 ramets) would be attributed to the Sterile Adult to Sterile Adult transition cell, and 4% (0.48 ramets) would be attributed to the Reproductive Adult to Sterile Adult transition cell. The transitional rate for each stage was calculated by dividing the ramets attributed to each transitional stage by the total number of ramets in the first year, including the non-survivors.

Transitional matrices were calculated at the quadrat-transitional year level, and then life stage matrices pooled and then converted to transitional matrices at the location-year and survey-level. The overall growth rate (λ), sensitivity, and stable stage distributions were calculated from the survey-level transitional matrix.

To project DLI populations 50 years, we used the multiple matrices approach with 1000 iterations. At each time step, a transitional matrix pooled at location-year level derived from demographic surveys was randomly selected to calculate the population of each life stage for the following year. This approach can allow for the inclusion of real-life disturbances that may occur and is based on observed data. A limitation of this approach is that only disturbances that affected the population during the years it was observed could be included, thus restricting the possible combinations of vital rates the simulation can generate (Morris et al. 1999). If the total population reached 500,000,000 ramets (K) in an iteration, that iteration stopped, and a new one began. The quasi-extinction threshold was set at 500 ramets.

DLI populations were projected using the initial abundances per life-stage in Table 6. Each of the four initial abundances were means derived from the minimum population estimate data collected from the most recent Michigan DLI qualitative, count, and demographic surveys of populations of the corresponding ranks as described by NatureServe (Table 1, Table 2). EOs ranked A and AB were included in calculations for those ranked A; B and BC in B, C and CD in C, and D in D. To determine the proportion of the estimate allotted to Juvenile, overall mean across all life-stage matrices was used (7%). To determine the proportion of Reproductive Adults, the mode of the categorical density of flowers/fruits in the populations of the rank was used: frequent fruits/flowers were 25% of the total population, occasional were 10%, and rare were 2%. The remaining ramets were assigned Sterile Adults.

To determine the probability of extinction of a DLI population, the mean of 10 quasi-extinction runs of 1000 iterations each were calculated for each rank with different initial abundances (Morris and Doak 2022, Stubben et al. 2020). All constants for the simulation were reused in the quasi-extinction simulations. DLI populations of different ranks were used to illustrate the effects on populations of differing size and quality.

Analyses were conducted using R version 4.1.1 and R package “popbio” (Stubben et al. 2020).

Table 6. Example transitional matrix. Columns are life stage in the first year; rows are the life stage in the second year. Values are illustrated in Figure 4.

	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	$S_{1,1}$	$F_{1,2}$	$F_{1,3}$
Sterile Adult	$G_{2,3}$	$S_{2,2}$	$S_{2,3}$
Reproductive Adult	$G_{3,1}$	$G_{3,2}$	$S_{3,3}$

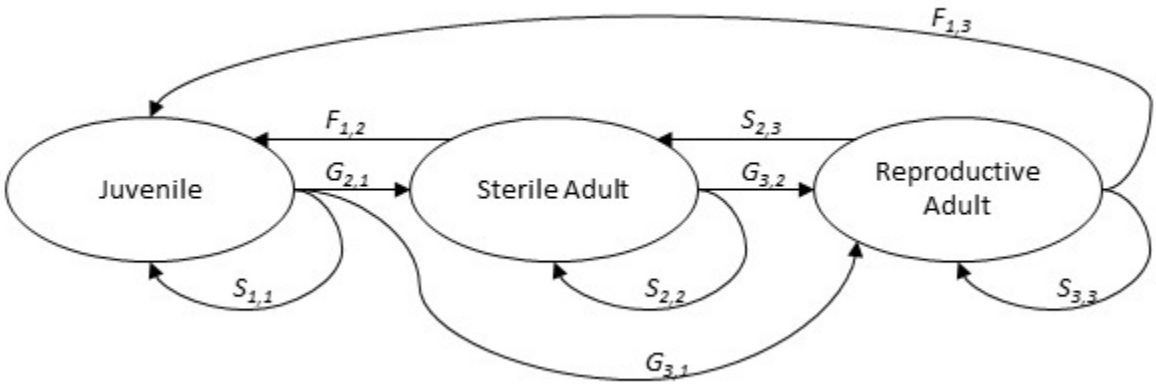

Figure 4. Generalized life-stage cycle model. Each arrow corresponds to the probability of a transition between stages during a transitional period. Variables correspond to those listed in the example of the transitional matrix (Table 6)

Table 7. Initial abundances per life stage used in 50-year projection of dwarf lake iris populations. Each initial abundance total relates to average population estimates for DLI populations ranked as A, B, C, and D using the NatureServe rubric (Table 2). The mean 7% of the total was assigned to Juvenile stage; the proportion assigned to Reproductive Adult depended on the mode categorical abundance of the Reproductive Adults in surveyed ranked populations; and the remainder was assigned as Sterile Adult.

Life Stages	Initial Abundance A	Initial Abundance B	Initial Abundance C	Initial Abundance D
Juvenile	24,833	3,532	189	125
Sterile Adult	294,442	34,311	1,836	1,624
Reproductive Adult	35,475	12,614	675	36
Total	354,750	50,457	2,700	1,785

RESULTS

From 2019 to 2023, 62 Michigan DLI EOs were visited across as a part of this project (Table 1). Spatial areas of DLI populations were adjusted or refined when needed in the Michigan Natural Heritage Database (MNFI 2024). Other survey data was recorded and summarized in the same database and a dataset shared with US Fish and Wildlife Service, Michigan Office (MNFI 2024). Fourteen Michigan populations underwent rank changes as a result of surveys. Site details can be found in APPENDIX B: .

Population genetic analysis

The James Cohen lab facilitated genetic testing and analysis interpretation of DLI samples. They used tunable Genotyping-by-Sequencing (tGBS) with 171 individuals across 24 populations. Analyses supported four geographic population clusters: West, Mid1, Mid2, and East (Figure 5). There is minimal genetic exchange among these four groups. Analyses (e.g., fastSTRUCTURE, PCA) indicated that there are nine adaptive units; evidence of local adaptation of DLI across its range. For more details, see APPENDIX C: Cohen and Turgman-Cohen 2023.

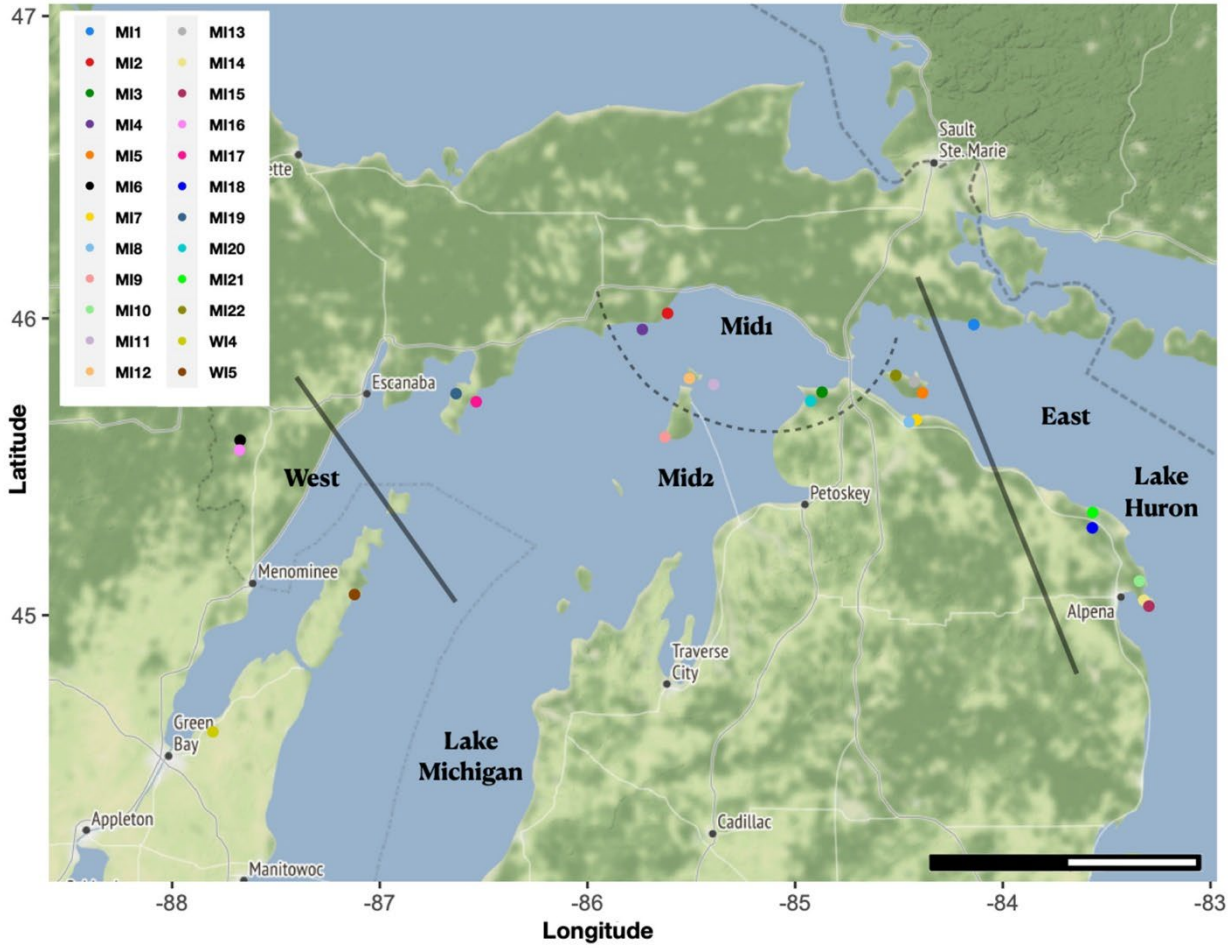

Figure 5. Four genetically distinct clusters of dwarf lake iris in USA: West, Mid1, Mid2, and East. Dark gray, dashed lines separate clusters geographically. Scale bar is 100 km. Each population sampled is represented by a colored dot and named for the source State and given a sequential number. Source: Cohen and Turgman-Cohen (2023).

Count-based population viability analysis

Seventeen DLI subpopulations across 10 EOs in Michigan had population data gathered in interoperable manners as to use in a count-based population viability assessment (Ewert and Scrimger 1989, Van Kley 1989, Ballard and Lauffer 1993, Ballard and Kowal 1997, Hackett et al. 2022). The combination of 2019 through 2023 count survey data and count data available in the literature produced 65 subpopulation change increments across 17 subpopulations (Table 8). Within one year time increment, growth was documented in DLI populations, but in any greater time increment between counts showed declines in the population. Using this data, μ was derived to be -0.0641 with σ^2 of 0.474 (Figure 6). The μ did not change much from that calculated using the 2019 through 2022 data (-0.0625), but the variance increased one tenth from 0.381 to 0.474 (Hackett et al. 2021, 2022). These estimates are reliable predictors for 7 to 13 years (Fieberg and Ellner 2000).

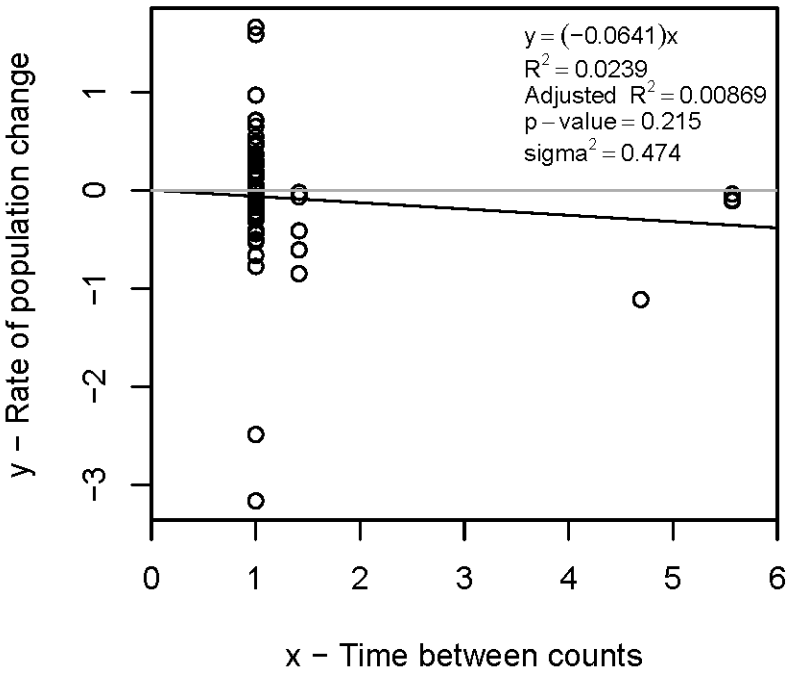

Figure 6. Linear regression of *y* on *x* for dwarf lake iris count data , where *y* is the natural log transformation of population change between two consecutive counts in a population or subpopulation, and *x* is a transformation of time between those two consecutive counts (equations in text).The slope is an estimate of μ, and the variance of the residuals (σ^2) are used for the population viability analysis. The grey horizontal line marks 0 or no change in population.

Population simulations

When we ran simulations using minimal population estimates, 63% populations will likely be extant in 10 years (i.e., 2033; *n* = 126; Table 5). Geographically, Wisconsin, USA, populations seemed disproportionately affected by likely extinction for 15 out of 29 populations (52%), while Michigan had 26 of 69 populations (38%), and Ontario had 6 of 28 (21%; Figure 7). In Michigan, Charlevoix County and Chippewa Counties had more than half of their populations predicted to be extinct.

Table 8. Mean density of dwarf lake iris (DLI) ramets in units of 1 m^2 by year of counts. Unless otherwise stated, data gathered from 2019 to 2023 surveys conducted by Michigan Natural Features Inventory (MNFI) and subpopulations derived from survey efforts and mapped in Michigan Natural Heritage Database (MNFI 2024). In Natural Heritage Database EO ID refers to unique identifier for a population record and SF ID refers to unique identifier of subpopulation shape mapped. See Table 1 for more information on DLI populations.

EO ID	SF ID	Area (m^2)	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	2019	2020	2021	2022	2023
1369	11815	6096[11]	472[11]	378[11]														
3403	66099	60,251												141	180	140	220	165
3403	66104	20,395												145	142	124	163	312
4466	66716	24,864												287		261	167	197
7130	66703	85,349		201[12]										162	98	199	117	101
8162	15674	1,399,573												287	267	270	392	328
8439	3211	64,355															164	123
8439	25454	71,279		275[12]										152	180	161	123	165
8439	25455	26,544												164	234	380	16	78
8439	66299	70,565												225	220	113	52	82
8964	27160	163,989												720		216	172	452
8964	27162	273,861												307		297	361	332
8964	27166	31,029												132		73	386	32
8964	66706	11,416												540		228	464	308
11321	25462	132[13]			55[13]	49[13]	46[13]	42[13]	54[13]	61[13]	45[13]	41[13]	35[13]	0.2				
12376	66711	137,500		292[12]										168	167	188	323	238
15125	66717	2359												315	367	281	296	176

[11] Count data and occupied area derived from Van Kley 1989
[12] Count data derived from Van Kley 1989
[13] Count data and occupied area derived from Ewert and Scrimger 1989, Ballard and Lauffer 1993, Ballard and Kowal 1997

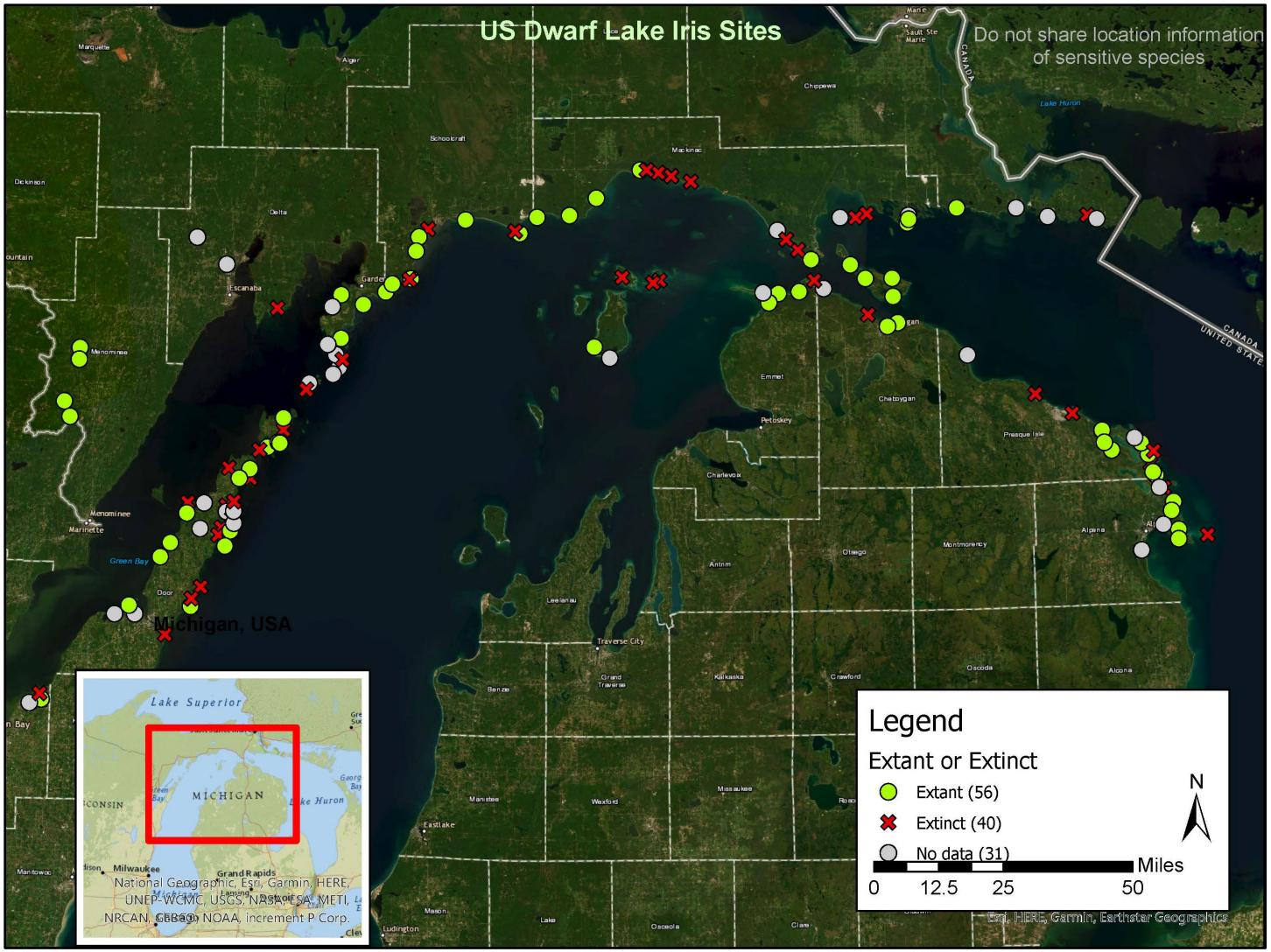

Figure 7. Map of the simulated population results in ten years given the growth rate (μ = -0.0641) and variance (σ^2 = 0.474). Predicted extant populations (green circles) had likelihood of extinction less than 50%; predicted extinct populations (red x's) had likelihood of 50% or greater; and no data populations (grey circles) were not included in the analysis due to lack of reliable data. Ontario sites are not mapped due to lack of centroid coordinates available for those populations.

Demographic-based population viability analysis (Hackett et al. 2021)

There were 29 year-to-year transitions of demographic quadrats across three DLI populations from 2019 to 2020. One demographic quadrat was documented only from 2020 to 2021. Four demographic quadrats were lost from 2019 to 2020 (Figure 8), and one quadrat was inundated in 2020 and unable to be properly recorded (Figure 3a).

The λ recorded at each location-year were almost all greater than 1 (Table 9). All except 7 transitions had more growth than mortality. The greatest number of missing or unreadable markers in the subsequent year was 71, with a mean of 14 (SD 19). The quadrat-transitions with the greatest missing or unreadable markers were those quadrats lost during a year of high-water level for the Great Lakes. The life-stage counts and life-stage transitional matrices for each quadrat-transition can be found in APPENDIX D: Demographic survey data.

When all quadrat-transitional matrices were pooled, the resulting life stage transitional matrix had positive overall growth (λ = 1.04), and the Sterile Adult stage was a relatively stable stage (Figure 9). The stable stage distribution for each life stage was 0.092, 0.83, and 0.076 for Juvenile, Sterile Adult, and Reproductive Adult, respectively, and. The species was most sensitive to disturbances or threats that cause decline of Sterile Adults. All life stages had approximately the same mean probability of mortality (0.44, 0.30, 0.39, respectively).

For the simulations based on transitional matrices at the location-year level, the mean populations of each rank increased overall (Figure 10). Confidence intervals ranged extensively after 10 years. The simulation using abundances derived from rank A/AB did not have any simulations that reached extinction or quasi-extinction (Figure 10, Figure 11a, Figure 11b); minimum population ever reached was 2447 ramets. Although no simulation of the rank B/BC, C/CD, or D populations reached 0 ramets, 0.1%, 13.6%, and 22.1% of simulations, respectively, reached below the set quasi-extinction threshold (500) before year 50 (Figure 10).

Table 9. Transition summary of marked DLI ramets. Element Occurrence (EO) ID is a unique number assigned to population in Michigan's Natural Heritage Database (Table 1). Marked ramets 'Missing 2nd year' were missing or unreadable markers. 'Survivorship' was the number of marked ramets not classified as "Dead" next year. New growth were ramets without a marker in the 2nd year. Mortality was the number of markers without a corresponding ramet in the 2nd year. Constant rate of population growth is λ. Instantaneous growth rate is *r*

EO ID	Quadrat	Years	Marked in both years	Missing 2nd year	Survi-vorship	New Growth	Mortality	λ	*r*
7130	1	2019-2020	43	2	38	22	5	1.44	0.36
7130	1	2020-2021	62	3	41	10	21	1.26	0.23
7130	3	2019-2020	26	1	23	10	3	1.33	0.29
7130	3	2020-2021	36	0	11	9	25	1.25	0.22
7130	4	2019-2020	19	1	17	13	2	1.65	0.50
7130	4	2020-2021	30	3	17	8	13	1.21	0.19
7130	5	2019-2020	17	7	15	32	2	2.08	0.73
7130	5	2020-2021	35	15	27	32	8	1.36	0.31
7130	6	2019-2020	-	17	0	0	17	0.00	0.00
7130	8	2019-2020	-	68	0	0	68	0.00	0.00
7130	10	2019-2020	-	71	0	0	71	0.00	0.00
7130	13	2020-2021	58	20	28	5	30	0.88	-0.13
12376	1	2019-2020	7	10	6	0	1	0.41	-0.89
12376	1	2020-2021	5	2	4	5	1	1.43	0.36
12376	2	2019-2020	-	38	0	0	38	0.00	0.00
12376	3	2019-2020	42	0	38	11	4	1.26	0.23
12376	3	2020-2021	52	1	40	13	12	1.23	0.21
12376	5	2019-2020	83	8	78	32	5	1.29	0.25
12376	5	2020-2021	68	49	39	8	29	1.08	0.08
12376	6	2019-2021	32	0	30	12	2	1.38	0.32
12376	6	2020-2021	44	0	35	10	9	1.25	0.22
15125	1	2019-2020	95	20	80	11	15	0.92	-0.08
15125	1	2020-2021	100	6	71	50	29	1.52	0.42
15125	4	2019-2020	15	4	14	7	1	1.16	0.15
15125	4	2020-2021	17	5	16	18	1	1.68	0.52
15125	5	2019-2020	46	7	40	15	6	1.15	0.14
15125	5	2020-2021	50	11	40	23	10	1.23	0.21
15125	7	2019-2020	30	18	29	46	1	1.58	0.46
15125	7	2020-2021	59	17	52	39	7	1.34	0.29

Figure 8. Photographs from selected lost quadrats in 2020: a) Flag from a quadrat in EO 12376, Mackinac County, MI, USA, while b) unmarked DLI ramets were found near GPS coordinates; c) - e) unmarked ramets near GPS coordinates for quadrats in EO 7130, Emmet County, MI, USA. In f) no ramets were found near GPS coordinates, so quadrat was likely lost. Photographs by Rachel Hackett

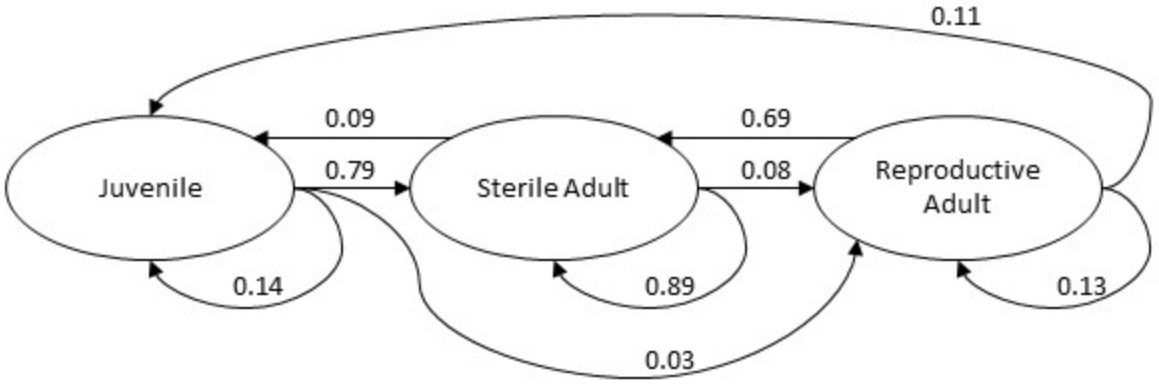

Figure 9. Illustrated life stage cycle of the pooled life stage transitional matrix. The numbers are the probability that a ramet will transition between life stages as indicated by the arrows.

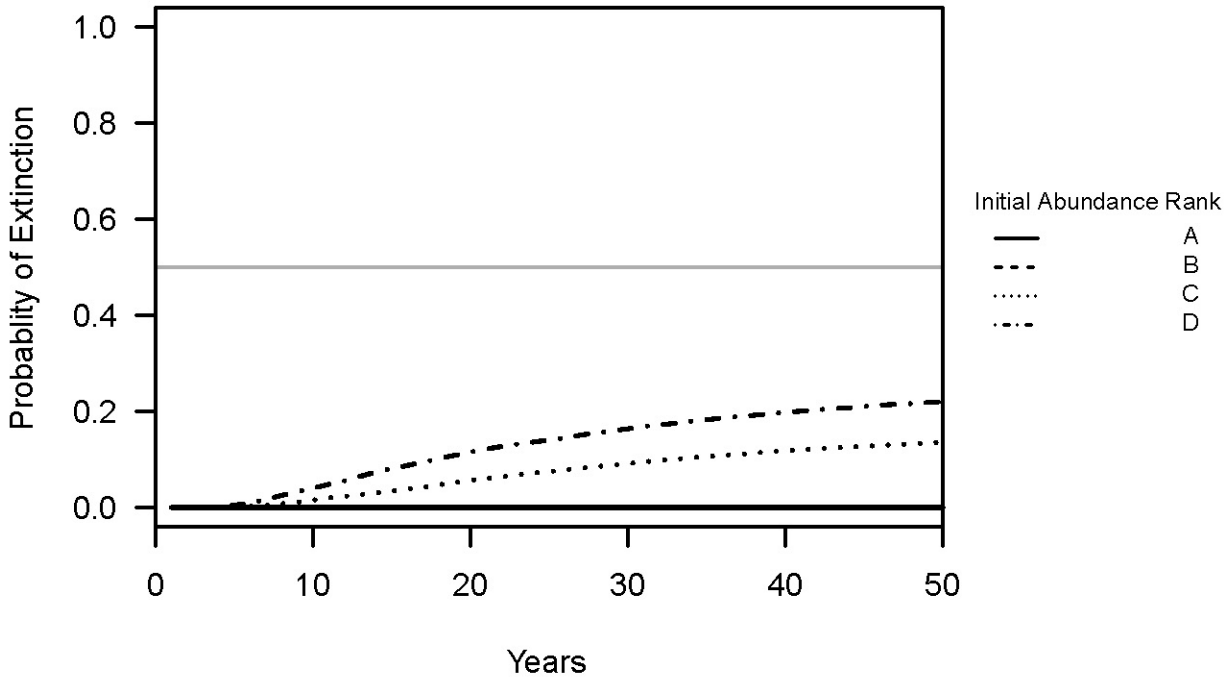

Figure 10. Extinction probabilities of populations with initial abundances based on Element Occurrence (EO) Rank. Each style of black line represents the probability of extinction for a population of initial abundances listed in the legend (Table 6). The 0.50 probability is marked with a grey line.

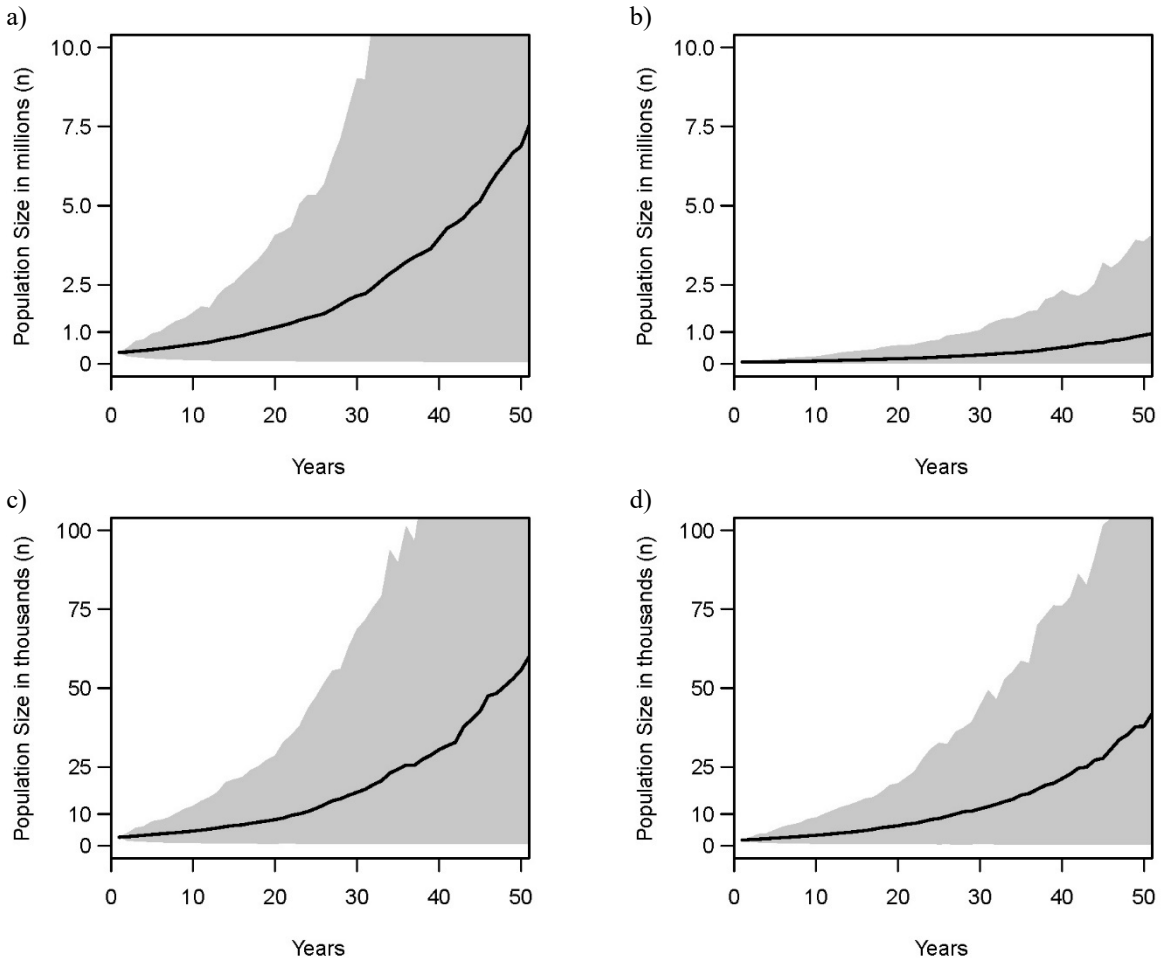

Figure 11. Population projections to 50 years using demographic life stage transitional data and different initial abundances based on rank with 1,000 iterations: a) initial abundance for populations of A rank, b) B rank, c) C rank, and d) D rank. Mean population (black line) and 95% confidence intervals (grey area). Note the change in magnitude of the units between a)/b) and c)/d) to improve visualization.

DISCUSSION

Representation among dwarf lake iris populations

Representation, in the conservation world, refers to a species ability to adapt over time to long-term changes in the environment. Representation is related to geographic, genetic, or life history variation across a species range (USFWS 2016). This project predicted population extinction across its USA range using available data and reexamined population genetics with methods not used previously.

Early explorations of DLI genetics in 1990's used isozymes and allozymes, and they found no to limited genetic variation within the species (Orick 1992, Simonich and Morgan 1994, Hannan and Orick 2000). With more advanced genetic analyses and taking into account the polyploid of the species, Cohen and Turgman-Cohen (2023) identified four distinct genetic and geographic population clusters across USA populations (Figure 5). Differences among the groups support the hypothesis that DLI migrated from west to east across its range, following retreating glaciers, with the Wisconsin and western Michigan populations with the greatest diversity. The greatest genetic diversity within a cluster was in the western cluster of Wisconsin and inland Michigan populations. Half of Wisconsin populations were also predicted to be extinct in ten years, given the current count-based viability analysis simulations (Table 5, Figure 7). With greater genetic diversity and threat of extinction, the preservation of the populations in the western cluster are a high priority for conservation to preserve the genetic variation within the species. Other methods of genetic preservation (e.g., specimen collection, assisted pollination) may need to be considered.

Factors of life history that should be taken into consideration when prioritizing conservation of DLI populations are the unique inland populations in the western genetic grouping and the populations with white flowered colonies.

Resiliency of the dwarf lake iris populations

Resiliency, in the conservation world, refers to a species ability to withstand extinction while facing natural and regular disturbances of its habitat, considering its abundance, growth rate, habitat quality, and meta-population dynamics (USFWS 2016). This project examined life stage transitions, population growth rates and variance, and examined local genetic adaptations related to a species resiliency. Genetic population analyses revealed nine groups of populations that had local adaptations (Cohen and Turgman-Cohen 2023). These local adaptations may play a part in a single populations ability to withstand natural disturbances.

From the demographic life cycle examination, disturbances or threats to the Sterile Adults life-stage would be most detrimental to the overall population. This stage had the highest growth probabilities both to and from this stage and accounted for the majority of the surviving ramets. Browsing was a common disturbance seen in this life stage, either by deer, rabbit, or slug, but our observations reported these threats affecting less than 50% of the population in

most instances. Increases in these threats or the introduction of new threats at this life stage could drastically change DLI population resilience.

The demographic and count-based population analyses differed relative to whether the growth rate of DLI was positive or negative. The count-based analysis is discussed further here, as the count-based analysis included more populations over a greater time span and has less errors in the data collecting stage as described below. From the count-based population analysis, the resiliency of DLI populations is highly variable with the current data as supported with the high variance (σ^2 = 0.474) relative to the slightly negative stochastic growth rate (μ = -0.0641). With the addition of 10 or more population count intervals per year since the 2021 report, the growth rate has decreased slightly and the variance has increased (Hackett et al. 2021, 2022). Based on the count data collected so far, DLI experiences short-term growth (i.e., one year between counts), but long-term declines (i.e., more than one year between counts).

There are different disturbances that DLI populations face based on their habitat. The greatest variations in a single subpopulation from 2019 to 2023 were seen in subpopulations growing in limestone cobble or sand dune habitats (EO ID 8439-SF 25455; EO ID 8964-SF 27160, SF 27166, SF 66706), although not all subpopulations growing in those habitats saw the same dramatic decreases. Surveys in 2023 saw an increase of population densities in subpopulations that had been declining (EO ID 3403, 4466, 8439, 8964). These were all shoreline subpopulations of limestone cobble shore or the first dunes of the sand dune and swale complex. The disturbances of these communities are strongly tied to the Great Lakes.

During the time of these most recent surveys has also been some of the highest Great Lakes water levels in over 20 years (Figure 12). The increases of the shoreline subpopulations in 2023 could be recovery from sand and cobble deposition after the high Great Lakes water levels from 2015 to 2023. Little is known about the ability of DLI to recover from deposition or long-term habitat flooding. DLI populations on the immediate shoreline may be at greater risk of extinction than populations found on secondary dunes, boral forests, fens, or glade habitats. With fluctuating Great Lakes water levels and increasing frequency of storms as a symptom of climate change, these disturbances may be happening at a frequency that does not allow for recovery of a population.

The resilience of DLI is promising given the current data analyses, but it is overall uncertain. The continued documentation of DLI population response throughout fluctuating water events and research into the effects of substrate deposition on DLI ramet growth and reproduction could lend itself to improved viability and extinction predictions of shoreline populations and the threat of greater, more frequency changes in the Great Lakes.

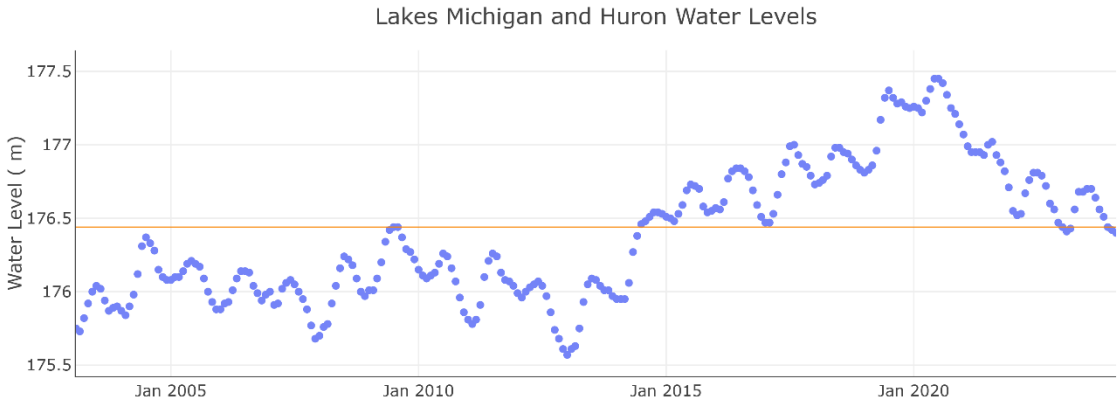

Figure 12. Average monthly water levels in meters for Lakes Michigan and Huron during 2003-2023 (blue dots, International Great Lakes Datum 1985). The red line indicates the average annual mean (1918-2023). Source: NOAA Great Lakes Environmental Research Laboratory.

Redundancy in dwarf lake iris populations

Redundancy, in the conservation world, refers to a species ability to withstand catastrophic events. Redundancy is related to the number, distribution, and resilience of populations (USFWS 2016). Dwarf lake iris has 177 documented populations, only 81% are considered currently extant (COSEWIC 2010, USFWS 2013, WDNR 2023, MNFI 2024), with 14% considered currently extinct, 5% of unknown status. With nearly 40% of the simulated populations likely to become extinct by 2033, the number of extant populations will likely dwindle. The simulations were based wholly on populations estimates, smaller populations more likely to be affected negatively, so it could be that a variable not yet able to be incorporated into the equation could influence the outcome. More population data is needed across more populations to improve the viability analysis and incorporate more variables into the model. The distribution of DLI likely to become extinct were disproportionately affecting Wisconsin populations given their overall number of occurrences (discussed above), but otherwise predicted DLI extinctions were spread across its range (Figure 7).

The key to the persistence of populations facing a catastrophic event may be in the breadth of different habitats which it grows. Each of those different habitats (e.g., dunes, glades, forest, fens, cobble shoreline), would have a different risk and response in light of most catastrophic events.

There are a few populations whose extent and local abundance play toward its ability to survive a catastrophic event by its shear numbers. Luckily these populations are already located in mostly protected areas, and efforts should be made to continue to protect their habitat.

Conservation of dwarf lake iris

The PVA conducted for this project indicated a decline in population growth for the species, but the variance of the growth rate throws uncertainty onto any sweeping statements about its

growth, stability, or decline (Figure 5). Most population viability analyses collect data over 4-5 years, but these short time periods may not capture the essence of a species demographic and environmental variation (Fiedler et al. 1998, Menges 2000). Collecting more count-based population data can not only contribute to being able to predict population viability further into the future, but also more data will allow for more variables to be included in the model. The variance within one-year increments could be due to the habitat it grows, presence of invasive species, animal impact, or some other symptom of climate change. This will allow researchers to better understand suspected vulnerable populations like those with small populations or directly influenced by the fluctuating Great Lakes water levels.

As more population data is collected, efforts should be made to protect, conserve, and manage populations with characteristics identified in the representation, resiliency, and redundancy:

- populations in the genetically diverse western group
- populations representing each genetic group
- populations in western Michigan that are further from the current lakeshore than all other populations
- populations with colonies of the white flowered form
- populations representing a variety of habitats
- large populations unlikely to be devastated by a catastrophic event

As mentioned in the resiliency discussion, representation across the breadth of natural communities where DLI is found is important for the species' persistence. These natural communities undergo different natural processes that affect rates of succession, and they have different levels of threats and disturbances. Efforts should be made to continue documenting DLI populations whose current status is unknown to better predict its persistence.

Errors

There are flaws with using DLI ramet estimates in the count-based analysis and simulations including 1) cognitive limitations for visualizing large numbers, 2) variation among surveyors, 3) hidden occupied areas of DLI not used when estimating total occupied area, and 4) overestimation without percent cover of occupied areas figured into estimates based on density. We attempted to preemptively counteract the first two items with standardized training including components to help with visualization. Michigan seasonal technicians in 2020 were trained together for population estimates, but Wisconsin and Ontario staff did not undergo the same training when their counts were made.

Within a count survey, the DLI occupied area could be underestimated, especially if a spatial survey was not required for an EO record. Only the most dense or obvious areas may have been considered when making the population estimates. This issue reinforces the importance of spatial surveys and accurate mapping of DLI populations.

There is also the possibility of overestimating of ramets because of the way we used DLI density and occupied area to estimate the total number of ramets in a population. Although varying DLI

densities are taken into consideration by using the mean density of quadrats within the same subpopulation, DLI rarely covered every meter of the mapped occupied area. One method of correction could be to measure or estimate a percent cover of occupied area with ramets, but this has its own faults with consistency, difficulty to visualize large populations, and time constraints.

Life-stage based demographic analysis is not without flaws including 1) not identifying the life stage the new growth likely originated from, and 2) the time range of the survey not adequately representing the long-life of the species. The assumption was made that the New Growth of a year could be attributed proportionally to having originated from any of the three life-stages, which it could have favored one over the other. More detailed examinations including unearthing of rhizomes and more frequent visits would be needed to determine the true proportion for the new vegetative growth. An earlier spring visit would be required to identify seedlings from other growth, which would be attributed only to the Reproductive Adults of the previous year. Our visits were too late to identify the seedlings with the 'hooked' leaf, which had wilted since emerging (Brotske, 2018). Since DLI is a perennial species, three years is unlikely long enough to observe a ramet for its entire life, which can pose complications to the projections of the information far into the future (Brigham and Thomson, 2003).

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APPENDIX A: KEY FOR ELEMENT OCCURRENCE IDENTIFIER (EO ID) TO SURVEY SITE NAME

[redacted]

The appendix is for funders, owners, and partners to reference Element Occurrence Identifiers (EO ID) to a survey site name that may be more familiar.

Table 10. List of dwarf lake iris (*Iris lacustris* Nutt.) Element Occurrence (EO) records from Michigan, Wisconsin, and Ontario (COSEWIC 2010, USFWS 2013, WDNR 2023, MNFI 2024). EO ID is a unique identifier for each EO record a State/Provincial Natural Heritage Database. Survey Site name is a colloquial name given the population that may reveal fine location information or for many Ontario sites, owner name. Rank is a qualitative assessment of estimated viability of species described in Table 2. Ownership are categories for owners of EO land: Federal (F), Municipal (M), Non-Governmental Organization (N), Private (P), State/Provincial (S), and Tribal/First Nation (T).

State/ Province	County	EO ID	Survey Site Name	Rank	Ownership
MI	Alpena	256	[redacted]	A	P, S
MI	Alpena	1625		C	P, S
MI	Alpena	2440		AB	N, P
MI	Alpena	2837		F	P, S
MI	Alpena	3403		A	N, P
MI	Alpena	6713		F	P, S
MI	Alpena	8385		B	P
MI	Alpena	8775		B?	P
MI	Alpena	9817		CD	F
MI	Charlevoix	1369		B	P, S
MI	Charlevoix	2472		BC (F)[14]	P
MI	Charlevoix	8033		C	S, T
MI	Charlevoix	18917		D	S, T
MI	Charlevoix	22194		D	S, T
MI	Cheboygan	6907		B	P, S
MI	Cheboygan	8439		B	N, S
MI	Cheboygan	10464		BC	P
MI	Cheboygan	22657		D	N
MI	Chippewa	743		F	P
MI	Chippewa	10263		F	P
MI	Chippewa	10288		B	P
MI	Chippewa	12375		F	P
MI	Delta	116		H	S
MI	Delta	2811		A	S
MI	Delta	3132		C	F
MI	Delta	3615		H	P
MI	Delta	4466		C	N
MI	Delta	4640		F	P
MI	Delta	5552		BC (F)[2]	P
MI	Delta	5633		A	S
MI	Delta	10711		X	S
MI	Delta	11586		F	F
MI	Delta	11928		CD	S
MI	Delta	22191		E	P, S
MI	Delta	23699		F	F, P
MI	Delta	23701		D	F

[14] Although surveyors failed to find in surveyed area, EO rank was not changed due to inability to survey portions of mapped area due to lack permission from landowner.

[redacted]

State/ Province	County	EO ID	[redacted]	Rank	Ownership
MI	Emmet	3606		B	M, P, S
MI	Emmet	7130		C	S
MI	Emmet	10381		C	S
MI	Emmet	11844		F	S
MI	Emmet	13051		CD	P, S
MI	Mackinac	834		C	P
MI	Mackinac	835		B	S
MI	Mackinac	1885		F	P
MI	Mackinac	3635		BC	P
MI	Mackinac	4458		F	F
MI	Mackinac	5377		AB	P
MI	Mackinac	5954		B	S
MI	Mackinac	8201		C	P
MI	Mackinac	8202		C	P
MI	Mackinac	8623		B	S
MI	Mackinac	8964		A	N, P, S
MI	Mackinac	10153		C	S
MI	Mackinac	10154		BC	F
MI	Mackinac	12221		AB	P, S
MI	Mackinac	12376		AB	P, S
MI	Mackinac	12503		AB	P
MI	Mackinac	12547		C[2]	P
MI	Mackinac	12548		B	P
MI	Mackinac	12862		A	N, P, S
MI	Mackinac	15825		C	P
MI	Mackinac	15826		C	P
MI	Mackinac	24196		E	S
MI	Mackinac	24245		C	F
MI	Menominee	5149		BC	P
MI	Menominee	15125		BC	S
MI	Menominee	15176		C	S
MI	Menominee	16477		AB	P
MI	Presque Isle	1854		C	P
MI	Presque Isle	2058		C	P
MI	Presque Isle	2235		D	P, S
MI	Presque Isle	4553		C	P
MI	Presque Isle	5551		AB	S
MI	Presque Isle	8162		B	P, S
MI	Presque Isle	10080		A	S
MI	Presque Isle	10481		C	P
MI	Presque Isle	10888		B	P
MI	Presque Isle	10918		A	P, S
MI	Presque Isle	11321		B	P
MI	Presque Isle	15944		B	S
MI	Presque Isle	23795		C	P
MI	Schoolcraft	973		C?	P
MI	Schoolcraft	1788		C	P
MI	Schoolcraft	3589		BC	P, S
MI	Schoolcraft	4465		BC	P
MI	Schoolcraft	6351		C	P
MI	Schoolcraft	6809		B	P
MI	Schoolcraft	8015		BC	P, S
MI	Schoolcraft	8842		C	P

[redacted]

State/ Province	County	EO ID	Survey Site Name	Rank	Ownership
MI	Schoolcraft	9196	[redacted]	C	P
MI	Schoolcraft	12942		B	P
ON	Bruce	UNK[15]		E	P
ON	Bruce	3[16]		E	P
ON	Bruce	3133		X	S
ON	Bruce	3134		E	N, P
ON	Bruce	3135		E	S
ON	Bruce	3136		E	S
ON	Bruce	3137		F	P
ON	Bruce	3138		E	T
ON	Bruce	3140		E	P
ON	Bruce	3142		E	N, P
ON	Bruce	3144		E	P
ON	Bruce	3145		X	P
ON	Bruce	3147		E	F, P
ON	Bruce	3148		E	F, T
ON	Bruce	3149		E	P
ON	Bruce	3150		E	N, P
ON	Bruce	3151		H	
ON	Bruce	3153		H	P, T
ON	Bruce	3155		F	F
ON	Bruce	3161		H	F
ON	Bruce	3162		E	P
ON	Bruce	3163		F	N
ON	Bruce	5930		E	S
ON	Bruce	5931		E	F, N
ON	Bruce	5932		F	S
ON	Bruce	5933		E	T
ON	Bruce	5934		E	N
ON	Bruce	18251		E	T
ON	Bruce	64287		E	S
ON	Bruce	64288		E	P
ON	Bruce	84791		F	P
ON	Bruce	91764		E	P
ON	Bruce	91788		E	N, P, S
ON	Bruce	92779		F	P
ON	Essex	3154		X	
ON	Manitoulin	[5]		E	M
ON	Manitoulin	[5]		E	T
ON	Manitoulin	[5]		E	T
ON	Manitoulin	[5]		E	T
ON	Manitoulin	64		E	M, P
ON	Manitoulin	3156		E	T
ON	Manitoulin	3157		F	M, P
ON	Manitoulin	3158		E	M, P
ON	Manitoulin	3159		X	M, P
ON	Manitoulin	3159		H	P
ON	Manitoulin	7834		E	S
WI	Brown	545		B	N, S, P
WI	Brown	4670		C	P

[15] Listed as "new" without a EO identifier in USFWS *Dwarf Lake Iris (*Iris lacustris*): Recovery Plan* (2013) and in COSEWIC *Assessment and Status Report on Dwarf Lake Iris* (2010).

[redacted]

State/ Province	County	EO ID	Survey Site Name	Rank	Ownership
WI	Brown	12720	[redacted]	C	P
WI	Door	46[16]		BC	M
WI	Door	393		CD	P
WI	Door	47[6]		C	P
WI	Door	832		C	S
WI	Door	1294		H	M, P
WI	Door	2253		C	S
WI	Door	3026		C	M, P, S
WI	Door	3194		D	P, S
WI	Door	3750		B	M, P
WI	Door	4237		A	M, N, P
WI	Door	4554		H	
WI	Door	4999		A	M, P, S
WI	Door	6415		D	P
WI	Door	7158		D	P
WI	Door	7490		C	M, P,
WI	Door	7737		D	F
WI	Door	8106		D	N
WI	Door	9835		D	P
WI	Door	11021		AB	S, P
WI	Door	11433		D	M, N, P
WI	Door	11811		D	P
WI	Door	12950		C	S
WI	Door	13459		E	S
WI	Door	14382		C	P
WI	Door	14918		C	P, S
WI	Door	15783		B	S
WI	Door	16329		B	M, P
WI	Door	17529		D	M, P
WI	Door	17672		C	S
WI	Door	20250		BC	P
WI	Door	21172		C	P
WI	Door	21175		D	M
WI	Door	21610		H	
WI	Door	24438		D	P
WI	Door	30001		C	N
WI	Milwaukee	6287		X	
WI	Milwaukee	17954		X	

[16] Instead of EO ID, the EO number is listed as an identifier. An EO report and ID for this site was not listed in the Wisconsin Natural Heritage Database (WDNR 2023), but population information was included in USFWS *Dwarf Lake Iris (*Iris lacustris*): Recovery Plan* (2013) with this EO number.

[redacted]

APPENDIX B: SITE DATA SUMMARY

[redacted]

This appendix contains detailed information about each site visited by Michigan Natural Features Inventory (MNFI) staff from 2019 to 2023. A full list of dwarf lake iris element occurrences (EO) can be found in Table 1 on page 3. Explanation of EO ranks is found in Table 2 on page 8. Methods of each survey type are described in *METHODS: Michigan field surveys* on page 10 and comparative summary of data gathered by survey type in Table 3 on page 11.

Table 11. List of Michigan dwarf lake iris (*Iris lacustris* Nutt.) Element Occurrence (EO) records surveyed from 2019-2023. EO ID is a unique identifier for each EO record a State/Provincial Natural Heritage Database. Rank is a qualitative assessment of estimated viability of species described in Table 2. Ownership are categories for owners of EO land: Federal (F), Municipal (M), Non-Governmental Organization (N), Private (P), State/Provincial (S), and Tribal/First Nation (T). Last Visit Date is the most recent visit, regardless of species presence. Michigan field surveys conducted from 2019 to 2023 were marked with a S for spatial survey, Q for qualitative survey, C for count survey, D for demographic survey, and G for genetic sampling.

County	EO ID	Survey Site Name	Rank	Ownership	Michigan Field Survey					Page
Alpena	256	[redacted]	A	P, S	S[17]	Q			G	43
Alpena	2440		AB	N, P	S[17]	Q				45
Alpena	2837		F	P, S		Q				47
Alpena	3403		A	N, P			C		G	48
Alpena	6713		F	P, S	S	Q				53
Alpena	8385		B	P	S	Q			G	54
Charlevoix	1369		B	P, S		Q			G	56
Charlevoix	2472		BC (F)[18]	P		Q				58
Charlevoix	18917		D	S, T		Q[19]			G	59
Charlevoix	22194		D	S, T	S	Q			G	61
Cheboygan	8439		B	N, S	S		C		G	63
Cheboygan	10464		BC	P	S[17]	Q				67
Cheboygan	22657		D	N	S	Q			G	68
Chippewa	743		F	P	S	Q				70
Chippewa	10263		F	P	S	Q				71
Chippewa	12375		F	P	S	Q				72
Delta	2811		A	S	S[17]	Q[19]				73
Delta	4466		C	N	S		C		G	75
Delta	4640		F	P		Q				79
Delta	5552		BC (F)[18]	P	S[17]	Q				80
Delta	5633		A	S	S	Q			G	81
Delta	11586		F	F	S					83
Delta	23699		F	F, P	S	Q				84
Delta	23701		D	F	S	Q				85
Emmet	3606		B	M, P, S	S[17]	Q				87
Emmet	7130		C	S	S		C	D	G	89
Emmet	10381		C	S	**S**	Q			G	94

[17] Visited subset of area of EO record depending on landowner permissions granted.
[18] Although surveyors failed to find in surveyed area, EO rank was not changed due to inability to survey portions of mapped area due to lack permission from land owner.
[19] Population in archeologically sensitive area, so qualitative survey was modified.

[redacted]

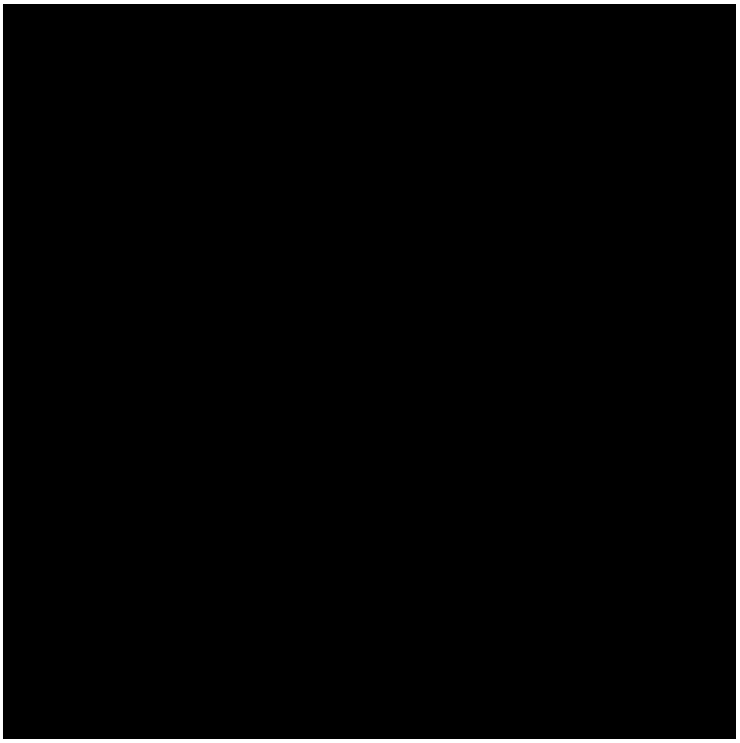
County	EO ID	Survey Site Name	Rank	Ownership	Michigan Field Survey				Page
Emmet	11844	[redacted]	F	S	S	Q			96
Mackinac	834		C	P	S[17]	Q			97
Mackinac	835		B	S		Q			99
Mackinac	1885		F	P	S				100
Mackinac	3635		BC	P	S	Q	C		101
Mackinac	4458		F	F		Q			103
Mackinac	5954		B	S	S	Q		G	104
Mackinac	8623		B	S	S[17]	Q		G	106
Mackinac	8964		A	N, P, S			C	G	108
Mackinac	10153		C	S	S	Q			112
Mackinac	12221		AB	P, S	S[17]	Q		G	113
Mackinac	12376		AB	P, S			C D	G	115
Mackinac	12547		C[2]	P	S[17]	Q			115
Mackinac	12548		B	P	S[17]				120
Mackinac	12862		A	N, P, S	S[17]	Q		G	121
Mackinac	24245		C	F	S	Q			123
Menominee	5149		BC	P	S[17]	Q			125
Menominee	15125		BC	S	S		C D	G	127
Menominee	15176		C	S	S	Q		G	131
Presque Isle	2235		D	P, S	S[20]	Q[19]			132
Presque Isle	5551		AB	S	S[20]	Q			133
Presque Isle	8162		B	P, S	S		C	G	134
Presque Isle	10080		A	S	S[20]	Q			138
Presque Isle	10481		C	P	S	Q			140
Presque Isle	10888		B	P	S[17]	Q			142
Presque Isle	10918		A	P, S	[17]	Q[19]		G	143
Presque Isle	11321		B	P	S[17]	Q			146
Presque Isle	15944		B	S		Q			147
Presque Isle	23795		C	P	S	Q			149
Schoolcraft	3589		BC	P, S	S[17]	Q			150
Schoolcraft	4465		BC	P		Q			153
Schoolcraft	6351		C	P	S	Q			155
Schoolcraft	6809		B	P		Q			157
Schoolcraft	8015		BC	P, S		Q			159
Schoolcraft	12942		B	P	S	Q			161

[20] With new survey, EO ID 2235, 5551 and 10080 no longer have sufficient separation distance and will be combined. [redacted]

Element Occurrence ID – 256

Alpena County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	A
Visit Dates	6/14/2020, 6/13/2020, 6/17/2020, 6/16/2020, 5/29/2019, 5/26/2021
Surveyors	Lynn Kirkpatrick, Rachel Hackett
Estimated Population Area (ac)	75.6
Number of Patches	21
Population estimate	50,000 – 200,000
10 year extinction probability	25%
Ownership Types	Private, State



[redacted] (EO ID 256) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, qualitative, and genetic were conducted between 2019 and 2023 with the last survey completed on 05/26/2021.

Survey Results

Spatial surveys resulted in an expansion of the estimated populated area from 15.5 to 75.6 acres. The number of mostly contiguous patches increased from 11 to 21. Flowers/fruits were of occasional abundance during survey(s). No white flowers were observed. Habitat data was collected at 10 points in the population (Table 256-1).

[redacted]

Table 256 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

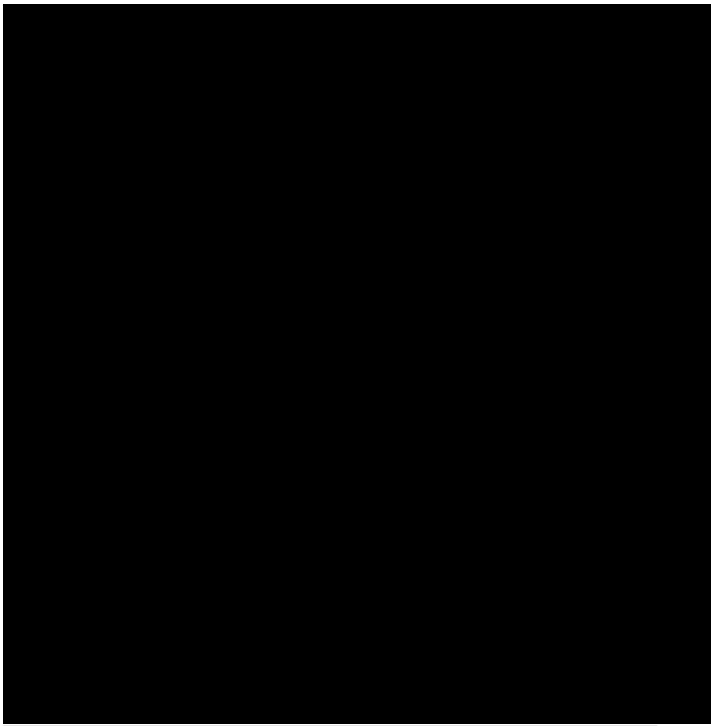
Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
256-20190529-2	66,271	sandy loam	moist	5.5	1.5	full sun		none
256-20190529-3	66,271	clay loam	moist	25.0	2.5	full sun		low
256-20200613-Qualitative_habitat-2	66,281	sandy loam	moist	6.5	1.5	full shade	10	low
256-20200613-Qualitative_habitat-3	66,281		moist	10.5	2.5	partial sun	50	low
256-20200613-Qualitative_habitat-4	66,281	clay loam	moist	11.0	1.2	full shade	30	low
256-20200613-Qualitative_habitat-5	18,178	clay loam	inundated	9.5	0.2	partial sun	60	low
256-20200614-Qualitative_habitat-1	66,292	loamy clay	moist	0.0	0.2	partial sun	75	low
256-20200616-Qualitative_habitat-73	66,270	sandy loam	moist	19.0	2.6	full shade	50	low
256-20200617-Qualitative_habitat-1	66,122	loamy clay	saturated	18.6	4.4	full shade	75	none
256-20200617-Qualitative_habitat-2	66,123	clay loam	moist	20.0	3.5	full shade	20	low

Leaf samples were collected for genetic analysis. Results from those efforts can be found in Cohen, J. I., and S. Turgman-Cohen. 2023. The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic. *Plants* 12: 1–17.

Element Occurrence ID – 2440

Alpena County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	AB
Visit Dates	6/15/2021, 10/14/2021
Surveyors	Rachel Hackett
Estimated Population Area (ac)	170.7
Number of Patches	6
Population estimate	25,000 - 40,000
10 year extinction probability	31%
Ownership Types	Non-Governmental Organization, Private



[redacted] (EO ID 2440) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 08/23/2023.

Survey Results

New areas were documented on NGO property. No other areas in this population were surveyed. Spatial surveys resulted in an expansion of the estimated populated area from 159.6 to 170.7 acres. The number of mostly contiguous patches increased from 4 to 6. Flowers/fruits were of occasional abundance during survey(s). No white flowers were observed. Habitat data was collected at 2 points in the population (Table 2440-1).

Table 2440 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
2440-20210615-Qualitative_habitat-19		sandy loam	moist	18.6	4.0	full sun	85	low
2440-20210615-Qualitative_habitat-20		sand	moist	2.2	1.2	partial sun	95	low

The following adventive species were observed as potential threats to the population:

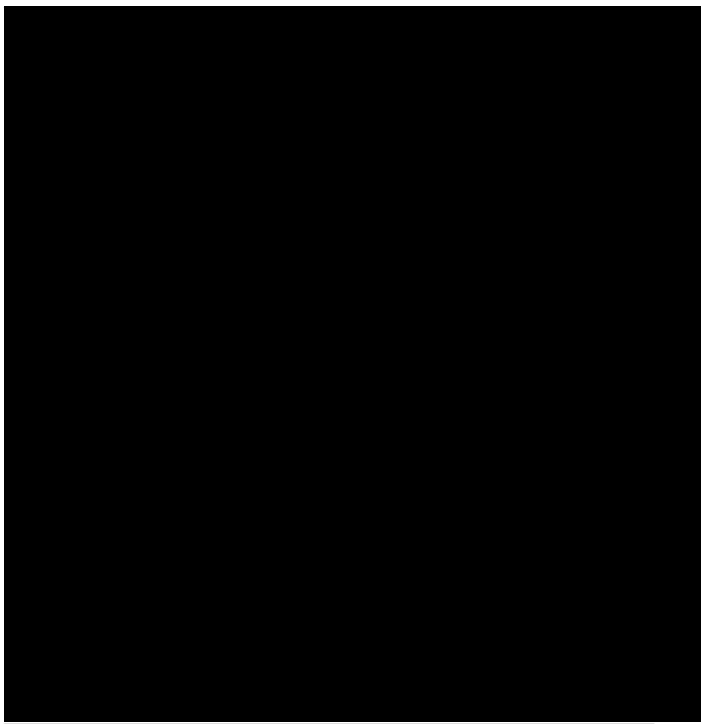
[redacted]

Scientific Name	Common Name	Abundance
Phalaris arundinacea	reed canary grass	occasional

Element Occurrence ID – 2837

Alpena County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	F
Visit Dates	6/11/2020
Surveyors	Lynn Kirkpatrick
Estimated Population Area (ac)	30.8
Number of Patches	1
Population estimate	0 - 100
10 year extinction probability	NA
Ownership Types	Private, State



[redacted] (EO ID 2837) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type qualitative were conducted between 2019 and 2023 with the last survey completed on 06/11/2020.

Survey Results

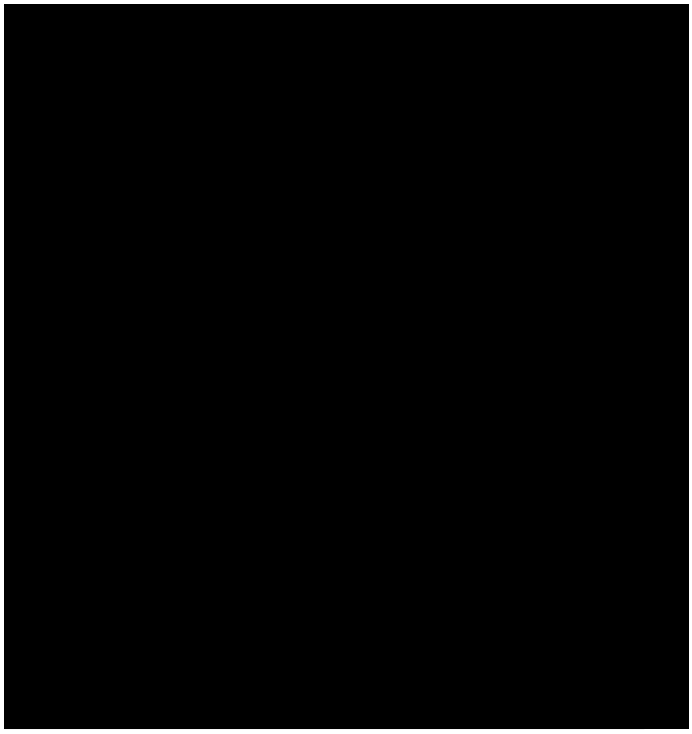
Surveyed entire area over two days. Failed to find. EO Rank changed from A to F as a result of the survey effort.

[redacted]

Element Occurrence ID – 3403

Alpena County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	A
Visit Dates	6/15/2020, 5/29/2019, 5/25/2021, 6/17/2022, 6/5/2023
Surveyors	Rachel Hackett, Mirabai Moseley, Marley Huijgen, Nicole Smith
Estimated Population Area (ac)	43.1
Number of Patches	3
Population estimate	1,000,000 - 2,000,000
10 year extinction probability	8%
Ownership Types	Non-Governmental Organization, Private



[redacted] (EO ID 3403) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type count, and genetic were conducted between 2019 and 2023 with the last survey completed on 06/05/2023.

Survey Results

Surveyed only NGO owned property. Private property mapped in population was not surveyed. Spatial surveys resulted in an expansion of the estimated populated area from 28.7 to 43.1 acres. The number of mostly contiguous patches increased from 1 to 3. Flowers/fruits were of occasional abundance during survey(s). No white flowers were observed. Habitat data was collected at 50 points in the population (Table 3403-1). Count data was collected in 50 plots (Table 3403-2).

Table 3403 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
3403-20190529-1	66,099	sand	inundated	3.5	0.50			none
3403-20190529-10	66,104	sandy loam	moist	10.0	0.25			
3403-20190529-2	66,099	sand	moist	2.0	0.50			low
3403-20190529-3	66,099	loamy sand	moist	11.0	1.00			low
3403-20190529-4	66,099	loamy sand	moist	6.0	1.00			low
3403-20190529-5	66,099	loamy sand	wet	2.0	0.75			none
3403-20190529-6	66,104	sandy loam	moist	4.5	0.00			low
3403-20190529-7	66,104	sand	moist	1.0	1.00			none
3403-20190529-8	66,104	sandy loam	moist	7.0	0.50			none
3403-20190529-9	66,104	sandy loam	moist	22.0	0.25			high
3403-20200615-11	66,099	sandy loam	moist	10.8	2.20	partial sun	20	low
3403-20200615-12	66,099	sandy loam	moist	8.8	1.00	partial sun	40	low
3403-20200615-13	66,099	sandy loam	moist	6.6	0.20	full sun	70	high
3403-20200615-14	66,099	sandy loam	moist	5.4	0.20	partial sun	35	high
3403-20200615-15	66,099	sandy loam	moist	16.4	2.20	full shade	25	high
3403-20200615-16	66,104	other	wet	5.0	0.20	partial sun	90	low
3403-20200615-17	66,104	sandy loam	inundated	10.6	2.00	partial sun	90	none
3403-20200615-18	66,104	loamy sand	dry	18.6	2.20	full sun	85	none
3403-20200615-19	66,104	loam	dry	7.4	2.80	partial sun	75	low
3403-20200615-20	66,104	sandy loam	moist	6.0	1.60	full shade	15	high
3403-20210525-21	66,099	loamy sand	dry	17.6	2.20	full shade	10	low
3403-20210525-22	66,099	other	dry	4.0	0.40	full shade	40	low
3403-20210525-23	66,099	loamy sand	moist	7.8	0.60	full sun	75	high
3403-20210525-24	66,099	loamy sand	moist	4.8	0.40	full sun	100	none
3403-20210525-25	66,099	sand	moist	0.0	0.20	full sun	95	none
3403-20210525-26	66,099	sand	moist	1.0	1.20	full sun	99	low
3403-20210525-27	66,104	sand	moist	8.5	2.40	full sun	95	low

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
3403-20210525-28	66,104	loamy sand	dry	5.6	0.50	full sun	90	none
3403-20210525-29	66,104	sandy loam	moist	4.5	1.80	partial sun	70	high
3403-20210525-30	66,104	sandy loam	dry	6.8	2.60	partial sun	50	low
3403-20220617-31	66,099	sand	dry	1.0	1.50	full shade	5	low
3403-20220617-32	66,099	loamy sand	dry	4.5	3.00	partial sun	100	none
3403-20220617-33	66,099	sand	dry	4.0	1.50	partial sun	5	low
3403-20220617-34	66,099	sand	dry	0.0	3.50	full sun	75	low
3403-20220617-35	66,104	sand	dry	1.5	3.00	full shade	5	low
3403-20220617-36	66,104	sand	dry	7.5	4.00	full sun	100	low
3403-20220617-37	66,104	sandy loam	dry	3.7	1.00	full shade	40	none
3403-20220617-38	66,104	sand	dry	0.0	2.50	full shade	5	low
3403-20220617-39	66,104	sandy loam	dry	6.0	1.80	full shade	5	low
3403-20220617-40	66,104	sand	dry	0.0	1.50	full shade	50	low
3403-20230605-41	66,099	sandy loam	dry	23.0	23.00	partial sun	25	low
3403-20230605-42	66,099	sandy loam	dry	4.2	1.20	full sun	100	none
3403-20230605-43	66,099	loamy sand	dry	18.0	2.50	full sun	95	low
3403-20230605-44	66,099	sandy loam	dry	35.0	2.00	partial sun	10	low
3403-20230605-45	66,099	sand	dry	0.0	1.50	full sun	95	low
3403-20230605-46	66,104	sand	dry	10.2	1.20	partial sun	90	low
3403-20230605-47	66,104	sand	dry	0.0	0.80	partial sun	75	low
3403-20230605-48	66,104	loamy sand	moist	15.0	2.00	partial sun	70	none
3403-20230605-49	66,104	sandy loam	dry	9.8	1.50	partial sun	60	low
3403-20230605-50	66,104	loamy sand	dry	32.0	2.00	full shade	15	low

[redacted]

Table 3403 -2. List of plots where population data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Juveniles	Sterile Adults	Reproductive Adults	Total Ramets
3403-20190529-1	66,099	52	27	1	80
3403-20190529-10	66,104	8	40	4	52
3403-20190529-2	66,099	3	11	3	17
3403-20190529-3	66,099	2	16	1	19
3403-20190529-4	66,099	28	11	2	41
3403-20190529-5	66,099	15	4	0	19
3403-20190529-6	66,104	6	4	0	10
3403-20190529-7	66,104	5	8	1	14
3403-20190529-8	66,104	17	20	0	37
3403-20190529-9	66,104	44	24	0	68
3403-20200615-11	66,099	4	55	1	60
3403-20200615-12	66,099	5	37	3	45
3403-20200615-13	66,099	16	50	2	68
3403-20200615-14	66,099	0	21	3	24
3403-20200615-15	66,099	4	22	2	28
3403-20200615-16	66,104	9	27	0	36
3403-20200615-17	66,104	8	18	0	26
3403-20200615-18	66,104	0	33	1	34
3403-20200615-19	66,104	5	59	4	68
3403-20200615-20	66,104	5	9	0	14
3403-20210525-21	66,099	13	102	0	115
3403-20210525-22	66,099	2	19	0	21
3403-20210525-23	66,099	4	42	0	46
3403-20210525-24	66,099	8	1	0	9
3403-20210525-25	66,099	2	6	0	8
3403-20210525-26	66,099	2	9	0	11
3403-20210525-27	66,104	1	49	6	56
3403-20210525-28	66,104	3	12	1	16
3403-20210525-29	66,104	2	27	0	29
3403-20210525-30	66,104	1	22	0	23
3403-20220617-31	66,099	0	42	3	45
3403-20220617-32	66,099	1	32	2	35
3403-20220617-33	66,099	0	103	1	104
3403-20220617-34	66,099	6	27	3	36
3403-20220617-35	66,104	2	42	2	46
3403-20220617-36	66,104	0	11	1	12
3403-20220617-37	66,104	4	88	6	98
3403-20220617-38	66,104	0	41	3	44
3403-20220617-39	66,104	1	11	0	12
3403-20220617-40	66,104	2	31	0	33
3403-20230605-41	66,099	0	43	6	49
3403-20230605-42	66,099	0	27	5	32
3403-20230605-43	66,099	3	64	6	73
3403-20230605-44	66,099	1	24	2	27
3403-20230605-45	66,099	4	19	2	25
3403-20230605-46	66,104	2	98	24	124
3403-20230605-47	66,104	5	19	3	27
3403-20230605-48	66,104	10	129	9	148
3403-20230605-49	66,104	4	63	9	76
3403-20230605-50	66,104	1	14	0	15

The following adventive species were observed as potential threats to the population:

Scientific Name	Common Name	Abundance
Centaurea stoebe; c. maculosa	spotted knapweed	frequent

[redacted]

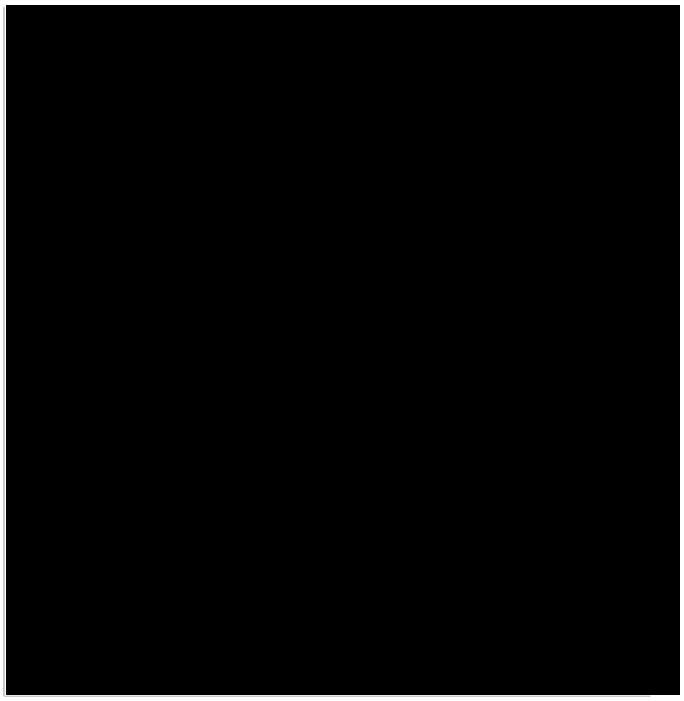
Scientific Name	Common Name	Abundance
Epipactis helleborine	helleborine	occasional
Hierachium sp.	hawkweed	frequent
Mycelis muralis; lactuca m.	wall lettuce	occasional

Leaf samples were collected for genetic analysis. Results from those efforts can be found in Cohen, J. I., and S. Turgman-Cohen. 2023. The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic. Plants 12: 1–17.

Element Occurrence ID – 6713

Alpena County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	F
Visit Dates	6/14/2021
Surveyors	Rachel Hackett
Estimated Population Area (ac)	7.7
Number of Patches	2
Population estimate	0 - 100
10 year extinction probability	NA
Ownership Types	Private, State



[redacted] (EO ID 6713) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 06/14/2021.

Survey Results

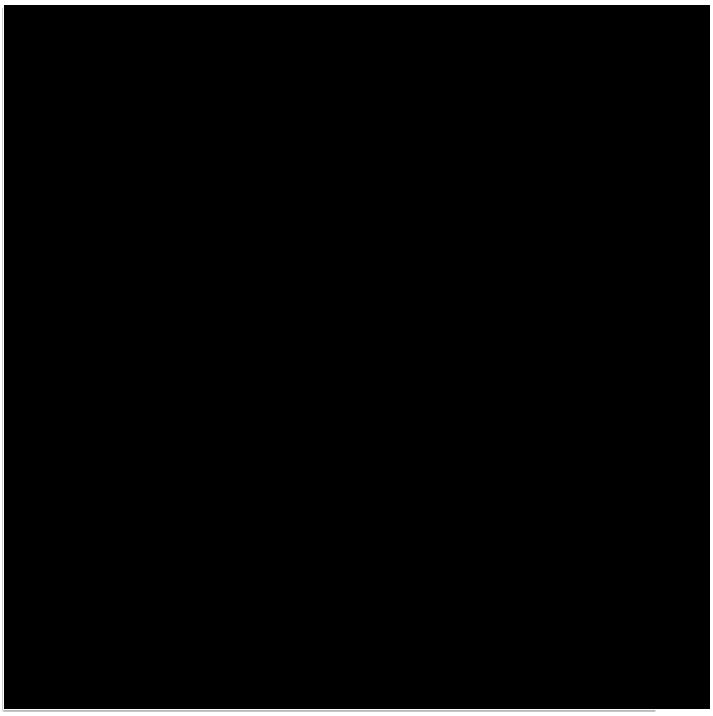
Little suitable habitat remaining. Failed to find in right-of-way, utility, and on State property. EO Rank changed from B to F as a result of the survey effort.

[redacted]

Element Occurrence ID – 8385

Alpena County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	B
Visit Dates	6/14/2020, 6/13/2020, 6/15/2021, 10/14/2021
Surveyors	Lynn Kirkpatrick, Rachel Hackett
Estimated Population Area (ac)	9.6
Number of Patches	7
Population estimate	50,000 - 115,000
10 year extinction probability	25%
Ownership Types	Non-Governmental Organization, Private



[redacted] (EO ID 8385) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, qualitative, and genetic were conducted between 2019 and 2023 with the last survey completed on 08/24/2023.

Survey Results

Survey was conducted on NGO property and easement only. Private property was not surveyed. EO Rank changed from BC to B as a result of the survey effort. Spatial surveys resulted in an expansion of the estimated populated area from 8.7 to 9.6 acres. The number of mostly contiguous patches increased from 3 to 7. Flowers/fruits were of occasional abundance during survey(s). No white flowers were observed. Habitat data was collected at 7 points in the population (Table 8385-1).

[redacted]

Table 8385 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
8385-20200613-Qualitative_habitat-2	66,294	sandy loam	moist	8.5	0.2	partial sun	75	low
8385-20200613-Qualitative_habitat-3	66,294	clay loam	moist	1.0	0.3	partial sun	40	low
8385-20200613-Qualitative_habitat-4	66,294	sandy loam	moist	5.3	0.4	partial sun	60	low
8385-20200613-Qualitative_habitat-5	66,293	loam	moist	2.5	0.2	partial sun	60	low
8385-20200614-Qualitative_habitat-1	68,392	sandy loam	moist	0.8	1.3	full shade	25	low
8385-20210615-Qualitative_habitat-25	68,392	sandy loam	dry	4.6	1.8	partial sun	60	none
8385-20210615-Qualitative_habitat-26	68,395	sandy loam	moist	7.9	1.2	partial sun	85	low

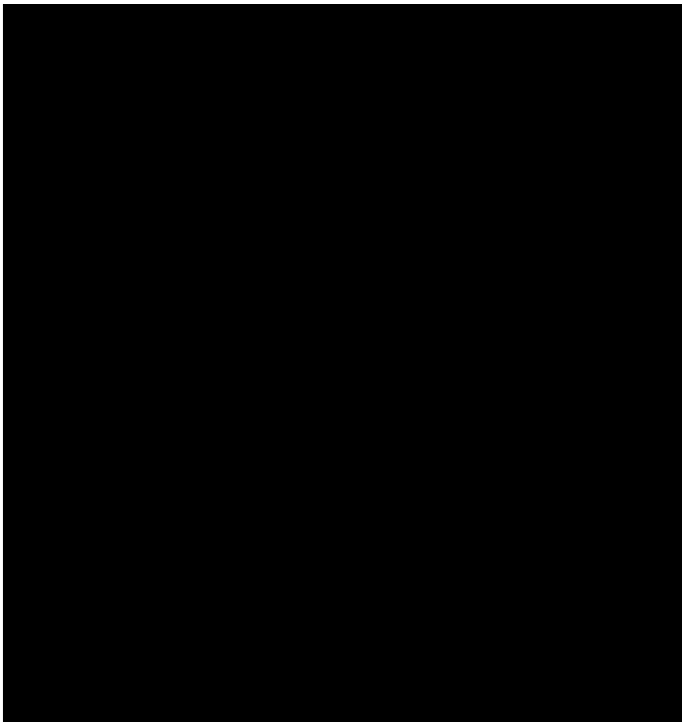
Leaf samples were collected for genetic analysis. Results from those efforts can be found in Cohen, J. I., and S. Turgman-Cohen. 2023. The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic. Plants 12: 1–17.

[redacted]

Element Occurrence ID – 1369

Charlevoix County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	B
Visit Dates	6/26/2019
Surveyors	Rachel Hackett
Estimated Population Area (ac)	13.8
Number of Patches	4
Population estimate	8,000 - 12,000
10 year extinction probability	38%
Ownership Types	Private, State



[redacted] (EO ID 1369) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type qualitative, and genetic were conducted between 2019 and 2023 with the last survey completed on 06/22/2022.

Survey Results

Spatial surveys resulted in a refining of the estimated populated area from 35.1 to 13.75 acres. Flowers/fruits were of frequent abundance during survey(s). No white flowers were observed. Habitat data was collected at 3 points in the population (Table 1369-1).

Table 1369 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Animal Impact
1369-20190626-1	66,705	loam	dry	13.4	2.8	none
1369-20190626-2	66,705	sand	dry	7.4	0.4	none
1369-20190626-3	66,704	loam	dry	3.4	1.2	none

The following adventive species were observed as potential threats to the population:

Scientific Name	Common Name	Abundance
Centaurea stoebe; c. maculosa	spotted knapweed	frequent

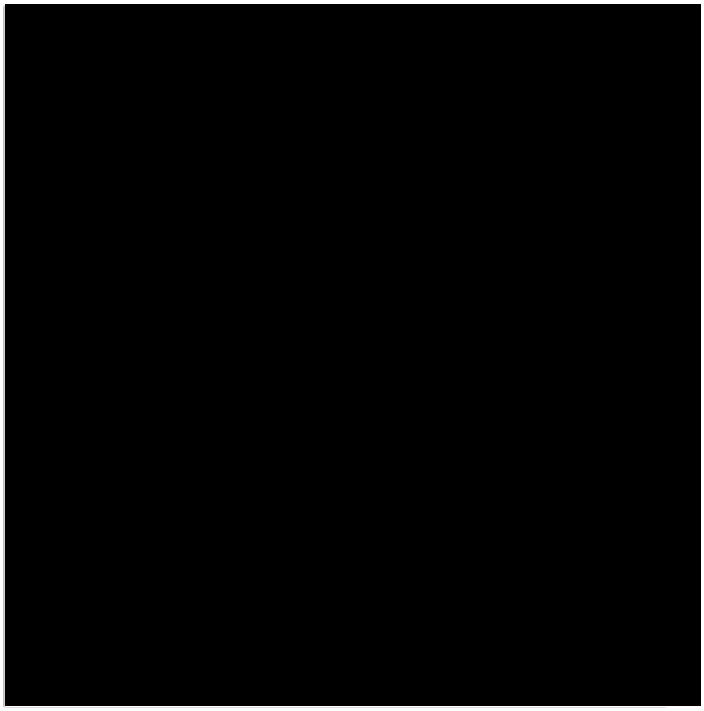
[redacted]

Leaf samples were collected for genetic analysis. Results from those efforts can be found in Cohen, J. I., and S. Turgman-Cohen. 2023. The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic. Plants 12: 1–17.

Element Occurrence ID – 2472

Charlevoix County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	BC
Visit Dates	6/25/2019
Surveyors	Rachel Hackett
Estimated Population Area (ac)	9
Number of Patches	2
Population estimate	0 - 10,000
10 year extinction probability	NA
Ownership Types	Private



[redacted] (EO ID 2472) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type qualitative were conducted between 2019 and 2023 with the last survey completed on 06/25/2019.

Survey Results

Although surveyors failed to find in surveyed area, EO rank was not changed due to inability to survey portions of mapped area due to lack permission from land owner. Population maximum reflects last extant survey maximum estimate (1999).

The following adventive species were observed as potential threats to the population:

Scientific Name	Common Name	Abundance
Centaurea stoebe; c. maculosa	spotted knapweed	frequent
Securigera varia; coronilla v.	crown-vetch	rare

[redacted]

Element Occurrence ID – 18917

Charlevoix County, [redacted]:

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	D
Visit Dates	6/26/2019
Surveyors	Rachel Hackett
Estimated Population Area (ac)	1.3
Number of Patches	4
Population estimate	300 - 800
10 year extinction probability	89%
Ownership Types	State, Tribal

[redacted]

[redacted] (EO ID 18917) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type qualitative, and genetic were conducted between 2019 and 2023 with the last survey completed on 06/26/2019.

Survey Results

EO Rank changed from CD to D as a result of the survey effort. Spatial surveys resulted in a refining of the estimated populated area from 1.5 to 1.3 acres. The number of mostly contiguous patches increased from 3 to 4. Flowers/fruits were of rare abundance during survey(s). No white flowers were observed. Habitat data was collected at 2 points in the population (Table 18917-1). Site was archeologically sensitive, so some measurements were not taken.

Table 18917 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Animal Impact
18917-20190626-1	68,336				3.00	low
18917-20190626-2	68,336				0.25	low

[redacted]

The following adventive species were observed as potential threats to the population:

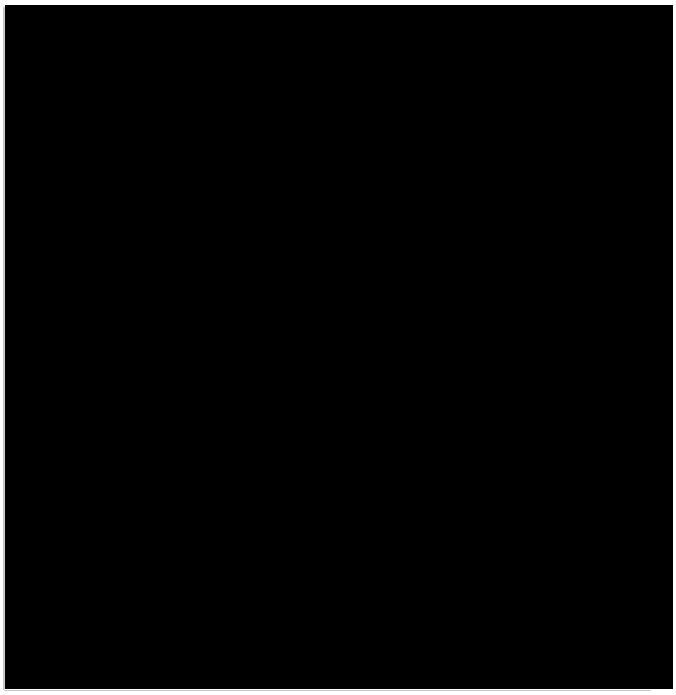
Scientific Name	Common Name	Abundance
Hieracium caespitosum	king devil	abundant

Leaf samples were collected for genetic analysis. Results from those efforts can be found in Cohen, J. I., and S. Turgman-Cohen. 2023. The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic. Plants 12: 1–17.

Element Occurrence ID – 22194

Charlevoix County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	D
Visit Dates	6/27/2019
Surveyors	Rachel Hackett
Estimated Population Area (ac)	18.1
Number of Patches	1
Population estimate	100 - 1,000
10 year extinction probability	100%
Ownership Types	State, Tribal



[redacted] (EO ID 22194) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, qualitative, and genetic were conducted between 2019 and 2023 with the last survey completed on 06/27/2019.

Survey Results

Documentation for this population was discovered as a result of a data mining effort funded by Great Lakes Restoration Initiative through US Fish and Wildlife Service (F18AC00566). EO Rank changed from E to D as a result of the survey effort. Spatial surveys resulted in an expansion of the estimated populated area from 0 to 18.1 acres. The number of mostly contiguous patches increased from 0 to 1. No flowers or fruits were observed. Habitat data was collected at 1 points in the population (Table 22194-1).

Table 22194 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Animal Impact
22194-20190627-1	61,422	sandy loam	saturated	13.1	2	none

[redacted]

The following adventive species were observed as potential threats to the population:

Scientific Name	Common Name	Abundance
Hieracium caespitosum	king devil	abundant

Leaf samples were collected for genetic analysis. Results from those efforts can be found in Cohen, J. I., and S. Turgman-Cohen. 2023. The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic. Plants 12: 1–17.

Element Occurrence ID – 8439

Cheboygan County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	B
Visit Dates	6/12/2020, 6/1/2019, 5/21/2021, 6/1/2021, 9/20/2021, 6/13/2022, 6/1/2023
Surveyors	Rachel Hackett, Lynn Kirkpatrick, Mirabai Moseley, Marley Huijgen, Liam Daniels
Estimated Population Area (ac)	172.1
Number of Patches	13
Population estimate	14,000 - 33,000
10 year extinction probability	31%
Ownership Types	Non-Governmental Organization, State

[redacted] (EO ID 8439) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, count, and genetic were conducted between 2019 and 2023 with the last survey completed on 06/01/2023.

Survey Results

Spatial surveys resulted in an expansion of the estimated populated area from 148.4 to 172.1 acres. The number of mostly contiguous patches increased from 7 to 13. Flowers/fruits were of occasional abundance during survey(s). No white flowers were observed. Habitat data was collected at 46 points in the population (Table 8439-1). Population count data was collected at 46 points (Table 8439-2).

[redacted]

Table 8439 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
8439-20190601-1	25,455	clay loam	saturated	6.50	2.50			none
8439-20190601-2	25,454	sand	moist	4.50	1.00			none
8439-20190601-3	25,454	sand	wet	3.40	0.25			low
8439-20190601-4	25,454	sand	wet	10.20	1.25			none
8439-20190601-5	66,299				2.50			low
8439-20190601-6	66,299				3.00			high
8439-20190601-7	66,299				1.00			low
8439-20190601-8	66,299				1.50			low
8439-20200612-11	25,455	clay loam	wet	11.80	0.50	partial sun	45	low
8439-20200612-12	25,455	loamy sand	wet	9.50	0.20	partial sun	70	low
8439-20200612-13	25,454	sand	moist	0.20	0.50	full shade	25	low
8439-20200612-14	25,454	sand	wet	0.00	0.50	full sun	90	low
8439-20200612-15	25,454	loamy sand	saturated	6.00	1.20	full shade	5	low
8439-20200612-16	66,299	loamy sand	wet	3.50	0.50	full shade	15	high
8439-20200612-17	66,299	loamy sand	moist	6.00	1.20	full shade	10	low
8439-20200612-18	66,299	sandy loam	wet	16.40	1.40	partial sun	75	low
8439-20200612-19	66,299	sandy loam	wet	18.60	2.20	full sun	100	none
8439-20210521-21	25,454	sand	wet	0.80	1.80	full sun	85	low
8439-20210521-22	25,454	sand	moist	0.20	0.50	full shade	25	none
8439-20210521-23	25,454	sand	moist	0.00	2.80	full sun	100	low
8439-20210521-24	25,454	sand	moist	0.41	1.40	full sun	100	low
8439-20210521-25	25,455	sandy loam	wet	9.40	3.90	full sun	75	none
8439-20210601-26	66,299	sandy loam	wet	16.20	4.50	full sun	100	low
8439-20210601-27	66,299	sandy loam	wet	13.50	5.80	partial sun	95	low
8439-20210601-28	66,299	sandy loam	moist	14.20	2.80	full shade	50	low
8439-20210601-29	66,299	sandy loam	wet	6.50	4.30	partial sun	40	low
8439-20220613-31	25,454	sand	dry	0.00	0.40	full shade	40	none
8439-20220613-32	25,454	sand	dry	0.00	2.50	full sun	95	none
8439-20220613-33	25,454	sand	moist	7.50	3.00	full sun	100	low
8439-20220613-34	25,455	sandy loam	moist	15.00	5.00	partial sun	40	low

[redacted]

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
8439-20220613-35	25,455	sandy loam	wet	7.60	4.80	partial sun	40	low
8439-20220613-36	66,299	loamy sand	wet	6.50	2.00	full sun	100	low
8439-20220613-37	66,299	sandy loam	wet	20.50	2.50	full sun	90	high
8439-20220613-38	66,299	sandy loam	wet	7.00	8.50	full sun	100	low
8439-20220613-39	3,211	sand	dry	0.00	0.50	partial sun	15	none
8439-20220613-40	3,211	sand	dry	2.00	8.00	partial sun	35	low
8439-20230601-41	25,455	loamy sand	wet	5.00	2.00	partial sun	25	low
8439-20230601-42	25,455	loamy sand	wet	7.00	2.00	partial sun	70	low
8439-20230601-43	25,454	sand	moist	0.00	0.50	partial sun	40	none
8439-20230601-44	25,454	sand	moist	4.00	3.50	partial sun	50	high
8439-20230601-45	25,454	sand	moist	0.00	3.00	full sun	65	high
8439-20230601-46	66,299	loamy sand	wet	7.50	0.20	partial sun	50	low
8439-20230601-47	66,299	sandy loam	wet	5.00	4.00	partial sun	80	low
8439-20230601-48	3,211	sand	wet	0.00	0.20	full shade	15	none
8439-20230601-49	3,211	sand	wet	0.00	0.80	full shade	75	low
8439-20230601-50	3,211	sand	moist	0.00	3.50	full shade	75	low

Table 8439 -2. List of plots where population data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Juveniles	Sterile Adults	Reproductive Adults	Total Ramets
8439-20190601-1	25,455	8	33	0	41
8439-20190601-2	25,454	18	41	0	59
8439-20190601-3	25,454	5	23	4	32
8439-20190601-4	25,454	5	17	1	23
8439-20190601-5	66,299	1	26	2	29
8439-20190601-6	66,299	0	9	0	9
8439-20190601-7	66,299	4	74	0	78
8439-20190601-8	66,299	9	97	3	109
8439-20200612-11	25,455	3	45	2	50
8439-20200612-12	25,455	4	59	4	67
8439-20200612-13	25,454	5	69	4	78
8439-20200612-14	25,454	0	3	0	3
8439-20200612-15	25,454	4	47	3	54
8439-20200612-16	66,299	0	3	0	3
8439-20200612-17	66,299	2	21	0	23
8439-20200612-18	66,299	6	86	8	100
8439-20200612-19	66,299	7	82	5	94
8439-20210521-21	25,454	8	129	10	147
8439-20210521-22	25,454	0	2	0	2

[redacted]

Event ID	Source Feature	Juveniles	Sterile Adults	Reproductive Adults	Total Ramets
8439-20210521-23	25,454	2	2	0	4
8439-20210521-24	25,454	1	7	0	8
8439-20210521-25	25,455	9	83	3	95
8439-20210601-26	66,299	2	40	1	43
8439-20210601-27	66,299	2	23	1	26
8439-20210601-28	66,299	2	26	1	29
8439-20210601-29	66,299	0	13	2	15
8439-20220613-31	25,454	0	4	0	4
8439-20220613-32	25,454	5	24	2	31
8439-20220613-33	25,454	5	52	0	57
8439-20220613-34	25,455	0	5	0	5
8439-20220613-35	25,455	1	2	0	3
8439-20220613-36	66,299	3	13	0	16
8439-20220613-37	66,299	0	9	1	10
8439-20220613-38	66,299	3	10	0	13
8439-20220613-39	3,211	1	20	0	21
8439-20220613-40	3,211	1	53	7	61
8439-20230601-41	25,455	3	19	0	22
8439-20230601-42	25,455	0	17	0	17
8439-20230601-43	25,454	0	81	26	107
8439-20230601-44	25,454	2	12	0	14
8439-20230601-45	25,454	1	2	0	3
8439-20230601-46	66,299	0	21	0	21
8439-20230601-47	66,299	2	17	1	20
8439-20230601-48	3,211	10	4	0	14
8439-20230601-49	3,211	0	39	0	39
8439-20230601-50	3,211	0	34	5	39

The following adventive species were observed as potential threats to the population:

Scientific Name	Common Name	Abundance
Centaurea stoebe; c. maculosa	spotted knapweed	occasional
Lonicera morrowii	morrow honeysuckle	rare

Leaf samples were collected for genetic analysis. Results from those efforts can be found in Cohen, J. I., and S. Turgman-Cohen. 2023. The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic. Plants 12: 1–17.

Element Occurrence ID - 10464

Cheboygan County, [redacted]:

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	BC
Visit Dates	6/16/2021
Surveyors	Rachel Hackett
Estimated Population Area (ac)	5.4
Number of Patches	4
Population estimate	250 - 800
10 year extinction probability	94%
Ownership Types	Private

[redacted] (EO ID 10464) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 06/16/2021.

Survey Results

Permission was acquired at only one area of this multi-polygon population, and estimates reflect that. Spatial surveys resulted in a refining of the estimated populated area from 13 to 5.4 acres. Flowers/fruits were of rare abundance during survey(s). No white flowers were observed.

Habitat data was collected at 1 point in the population (Table 10464-1).

Table 10464 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
10464-20210616-Qualitative_habitat-3	66,705	loamy sand	moist	12.8	2.8	full shade	10	low

The following adventive species were observed as potential threats to the population:

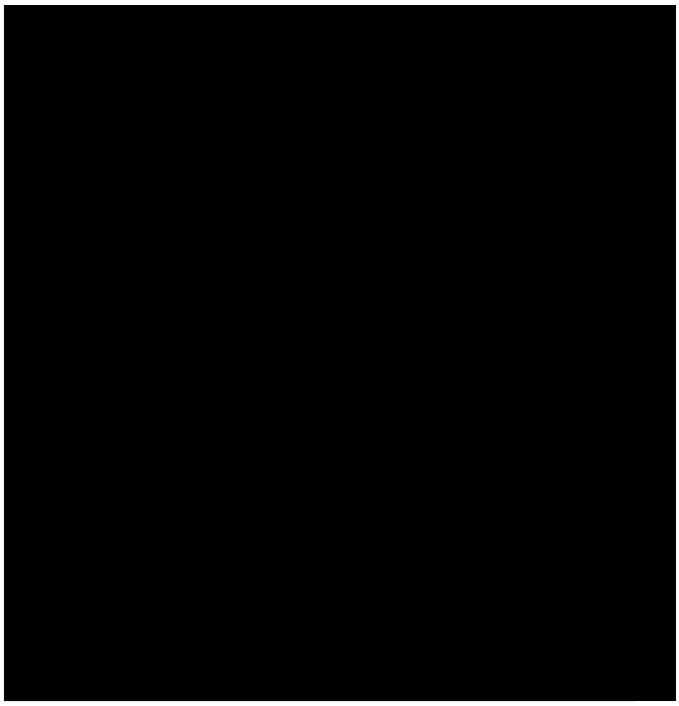
Scientific Name	Common Name	Abundance
Poa compressa	canada bluegrass	abundant

Element Occurrence ID - 22657

[redacted]

Cheboygan County, [redacted]:

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	D
Visit Dates	6/11/2020, 9/20/2021
Surveyors	Lynn Kirkpatrick, Rachel Hackett
Estimated Population Area (ac)	1.1
Number of Patches	3
Population estimate	1,000 - 2,000
10 year extinction probability	48%
Ownership Types	Non-Governmental Organization



[redacted] (EO ID 22657) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, qualitative, and genetic were conducted between 2019 and 2023 with the last survey completed on 08/21/2023.

Survey Results

Documentation for this population was discovered as a result of a data mining effort funded by Great Lakes Restoration Initiative through US Fish and Wildlife Service (F18AC00566). EO Rank changed from E to D as a result of the survey effort. Spatial surveys resulted in an expansion of the estimated populated area from 0 to 1.1 acres. The number of mostly contiguous patches increased from 0 to 3. Flowers/fruits were of occasional abundance during survey(s). No white flowers were observed. Habitat data was collected at 3 points in the population (Table 22657-1).

[redacted]

Table 22657 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
22657-20200611-Qualitative_habitat-1	66,279	loamy sand	moist	5.7	1.0	partial sun	60	low
22657-20200611-Qualitative_habitat-1	66,279	loamy sand	moist	5.7	1.0	partial sun	60	low
22657-20200611-Qualitative_habitat-2	66,279	sandy loam	saturated	9.0	1.4	full sun	95	high

The following adventive species were observed as potential threats to the population:

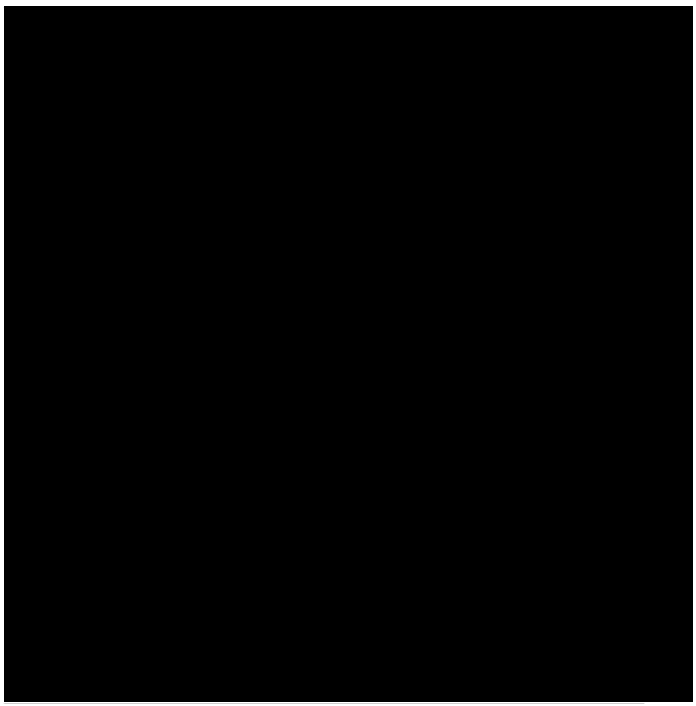
Scientific Name	Common Name	Abundance
Berberis thunbergii	japanese barberry	rare
Hypericum perforatum	common st. johns-wort	occasional
Rhamnus cathartica	common buckthorn	rare

Leaf samples were collected for genetic analysis. Results from those efforts can be found in Cohen, J. I., and S. Turgman-Cohen. 2023. The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic. Plants 12: 1–17.

Element Occurrence ID - 743

Chippewa County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	F
Visit Dates	7/10/2019
Surveyors	Jodi Spieles
Estimated Population Area (ac)	5.3
Number of Patches	1
Population estimate	0 - 100
10 year extinction probability	NA
Ownership Types	Private



[redacted] (EO ID 743) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 07/10/2019.

Survey Results

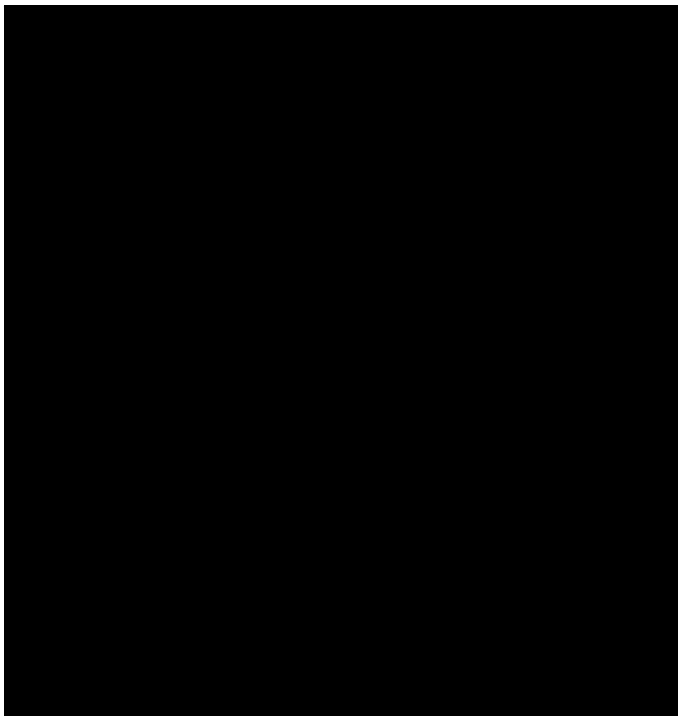
The majority of the area was thoroughly surveyed and no dwarf lake iris was found. The population max was estimated in case an area was overlooked. EO Rank changed from E to F as a result of the survey effort.

[redacted]

Element Occurrence ID - 10263

Chippewa County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	F
Visit Dates	6/16/2021
Surveyors	Rachel Hackett, Diana Diggs
Estimated Population Area (ac)	4.3
Number of Patches	1
Population estimate	0 - 100
10 year extinction probability	NA
Ownership Types	Private



[redacted](EO ID 10263) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 06/16/2021.

Survey Results

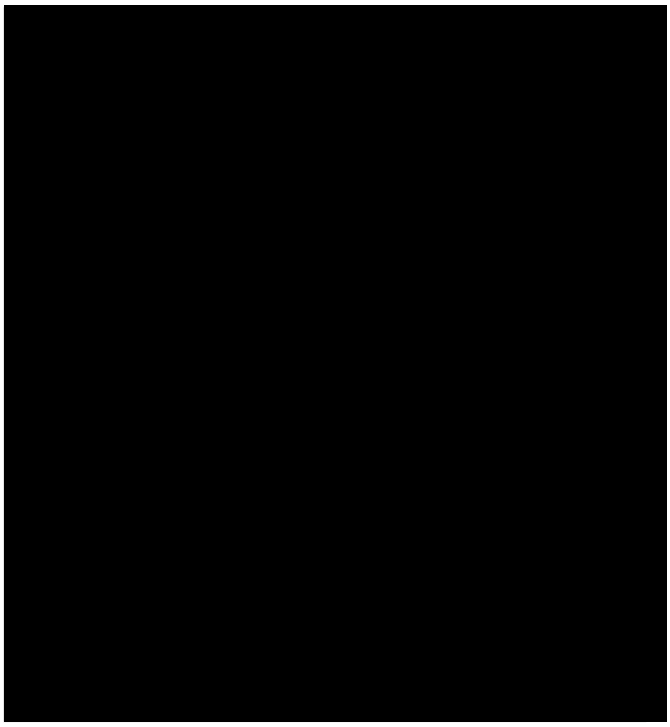
The entire documented area and nearby suitable habitat was searched. The population max was estimated in case an area was overlooked. EO Rank changed from C to F as a result of the survey effort.

[redacted]

Element Occurrence ID - 12375

Chippewa County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	F
Visit Dates	07/10/2019
Surveyors	Jodi Spieles
Estimated Population Area (ac)	4.1
Number of Patches	1
Population estimate	0 - 100
10 year extinction probability	NA
Ownership Types	Private



[redacted] (EO ID 12375) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 07/10/2019.

Survey Results

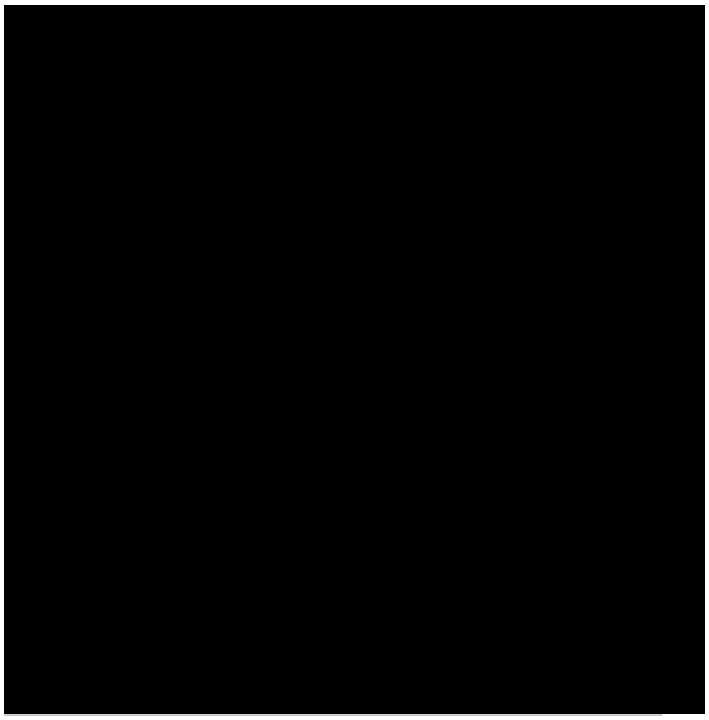
The majority of the area was thoroughly surveyed and no dwarf lake iris was found. The population max was estimated in case an area was overlooked. EO Rank changed from E to F as a result of the survey effort.

[redacted]

Element Occurrence ID - 2811

Delta County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	A
Visit Dates	6/7/2021, 6/9/2021, 6/18/2022, 5/24/2022, 8/1/2022, 6/3/2023
Surveyors	Rachel Hackett, Diana Diggs, William MacKinnon
Estimated Population Area (ac)	2435
Number of Patches	58
Population estimate	1,153,695 – 12,264,000
10 year extinction probability	8%
Ownership Types	State



[redacted] (EO ID 2811) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 06/03/2023.

Survey Results

Only State-owned land was surveyed and occupied area refined. The large vague source feature was retained in area calculations to represent potential patches on private lands. Spatial surveys resulted in an expansion of the estimated populated area from 1,989.9 to 2,435 acres. The number of mostly contiguous patches increased from 3 to 58. Flowers/fruits were of rare abundance during survey(s). White flowers were observed in one patch. Habitat data was collected at 9 points in the population (Table 2811-1).

[redacted]

Table 2811 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
2811-20210607-Qualitative_habitat-16		sandy loam	dry	6.5	2.0	full sun	100	low
2811-20210607-Qualitative_habitat-6		loam	dry	4.0	1.3	full sun	90	low
2811-20210607-Qualitative_habitat-8		loam	moist	17.0	1.0	partial sun	90	low
2811-20210609-Qualitative_habitat-19	68,382	loam	dry	8.0	3.0	partial sun	90	low
2811-20210609-Qualitative_habitat-20	68,388	sandy loam	moist	14.5	0.5	partial sun	40	low
2811-20220618-Qualitative_habitat-1	75,274	loam	moist	8.8	0.8	full sun	80	low
2811-20220618-Qualitative_habitat-1		loam	moist	4.8	4.8	full sun	80	low
2811-20220618-Qualitative_habitat-1		loam	moist	4.8	2.3	full sun	80	low
2811-20220618-Qualitative_habitat-141	75,253	loam	moist	5.0	1.0	full sun	90	low

The following adventive species were observed as potential threats to the population:

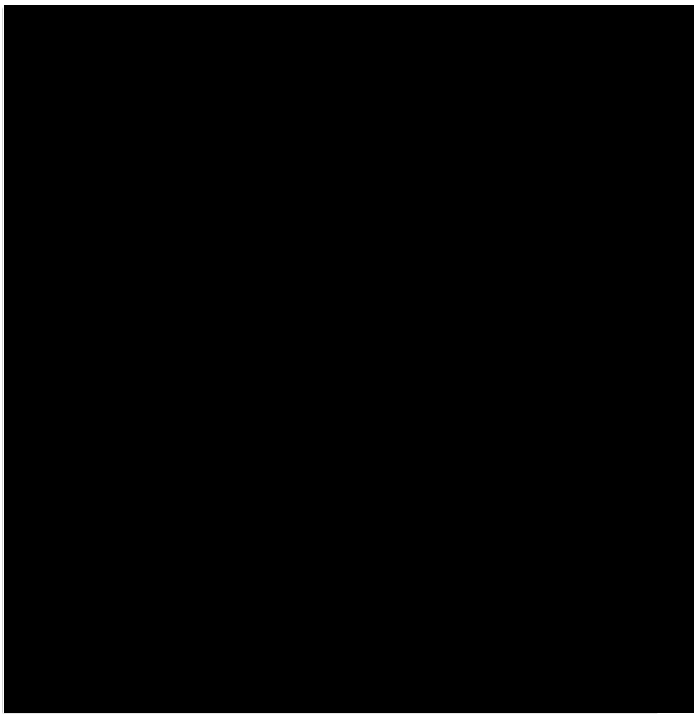
Scientific Name	Common Name	Abundance
Centaurea stoebe; c. maculosa	spotted knapweed	abundant
Hieracium piloselloides	king devil	abundant
Phalaris arundinacea	reed canary grass	abundant

[redacted]

Element Occurrence ID – 4466

Delta County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	C
Visit Dates	6/20/2019, 5/19/2021, 6/14/2022, 5/24/2023
Surveyors	Rachel Hackett, Zach Pitman, Mirabai Moseley, Marley Huijgen, Liam Daniels
Estimated Population Area (ac)	6.1
Number of Patches	1
Population estimate	5,000 – 8,000
10 year extinction probability	37%
Ownership Types	Non-Governmental Organization



[redacted] (EO ID 4466) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, count, and genetic were conducted between 2019 and 2023 with the last survey completed on 05/24/2023.

Survey Results

The reduction of acreage is not likely due to a reduction of population of refinement of vague spatial documentation. EO Rank changed from BC to C as a result of the survey effort. Spatial surveys resulted in a refining of the estimated populated area from 22.5 to 6.1 acres. Flowers/fruits were of occasional abundance during survey(s). No white flowers were observed. Habitat data was collected at 40 points in the population (Table 4466-1). Population count data was collected at 40 points (Table 4466-2).

[redacted]

Table 4466 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
4466-20190620-1	66,716	sandy loam	wet	16.4	1.8	full shade		none
4466-20190620-10	66,716	sand	wet	5.3	1.0	full shade		low
4466-20190620-2	66,716	loamy sand	moist	12.9	0.3	full shade		low
4466-20190620-3	66,716	sand	moist	4.3	1.6	full shade		none
4466-20190620-4	66,716	sandy loam	wet	17.5	0.8	full shade		low
4466-20190620-5	66,716	sand	saturated	4.5	2.3	full shade		low
4466-20190620-6	66,716	loam	saturated	3.8	2.9	full shade		none
4466-20190620-7	66,716	loam	saturated	13.1	2.2	full shade		low
4466-20190620-8	66,716	loam	moist	9.4	0.3	partial sun		low
4466-20190620-9	66,716	sand	wet	5.7	1.6	partial sun		low
4466-20210519-11	66,716	loamy clay	moist	18.6	0.5	partial sun	55	low
4466-20210519-12	66,716	sand	moist	0.0	2.5	partial sun	50	none
4466-20210519-13	66,716	loamy sand	moist	18.0	2.1	full sun	60	none
4466-20210519-14	66,716	sandy loam	moist	12.5	2.2	full shade	15	low
4466-20210519-15	66,716	sandy loam	moist	8.5	0.5	full shade	25	low
4466-20210519-16	66,716	sand	moist	1.5	1.2	full shade	20	low
4466-20210519-17	66,716	loamy sand	moist	3.5	0.8	partial sun	30	none
4466-20210519-18	66,716	sand	moist	0.0	4.0	full sun	50	none
4466-20210519-19	66,716	sand	wet	0.0	0.5	full sun	50	low
4466-20210519-20	66,716	loamy sand	moist	3.0	1.5	full sun	100	low
4466-20220614-31	66,716	sand	dry	0.0	18.0	full shade	20	none
4466-20220614-32	66,716	loamy sand	moist	6.4	10.0	full sun	70	high
4466-20220614-33	66,716	sand	dry	3.0	3.0	full sun	100	low
4466-20220614-34	66,716	loamy sand	dry	11.6	2.0	full shade	5	low
4466-20220614-35	66,716	loamy sand	moist	11.8	1.4	full shade	5	low
4466-20220614-36	66,716	loam	wet	19.0		partial sun	35	low
4466-20220614-37	66,716	other	dry	0.0	2.5	full sun	100	low
4466-20220614-38	66,716	other	dry	0.0	2.0	full sun	99	low
4466-20220614-39	66,716	sand	dry	0.0	12.0	partial sun	30	none

[redacted]

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
4466-20220614-40	66,716	sandy loam	wet	14.2	4.0	full shade	10	low
4466-20230524-41	66,716	loam	wet	8.0	1.5	full shade	55	low
4466-20230524-42	66,716	sand	dry	14.0	4.0	partial sun	15	low
4466-20230524-43	66,716	sand	moist	10.0	3.5	partial sun	75	high
4466-20230524-44	66,716	loam	wet	20.0	5.5	full shade	20	high
4466-20230524-45	66,716	sand	moist	9.0	1.5	full shade	5	low
4466-20230524-46	66,716	sandy loam	wet	6.0	1.0	partial sun	65	low
4466-20230524-47	66,716	loamy sand	wet	3.0	1.2	partial sun	40	high
4466-20230524-48	66,716	sand	dry	0.5	1.2	full sun	100	none
4466-20230524-49	66,716	other	dry	0.0	1.2	full sun	100	none
4466-20230524-50	66,716	sand	dry	0.0	0.8	full shade	15	none

Table 4466 -2. List of plots where population data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Juveniles	Sterile Adults	Reproductive Adults	Total Ramets
4466-20190620-1	66,716	3	10	0	13
4466-20190620-10	66,716	1	13	0	14
4466-20190620-2	66,716	1	45	0	46
4466-20190620-3	66,716	2	29	5	36
4466-20190620-4	66,716	3	56	1	60
4466-20190620-5	66,716	3	218	0	221
4466-20190620-6	66,716	3	98	3	104
4466-20190620-7	66,716	2	65	0	67
4466-20190620-8	66,716	2	77	0	79
4466-20190620-9	66,716	0	72	5	77
4466-20210519-11	66,716	6	31	10	47
4466-20210519-12	66,716	9	12	0	21
4466-20210519-13	66,716	9	123	18	150
4466-20210519-14	66,716	1	33	1	35
4466-20210519-15	66,716	14	93	1	108
4466-20210519-16	66,716	10	44	3	57
4466-20210519-17	66,716	8	91	5	104
4466-20210519-18	66,716	5	53	6	64
4466-20210519-19	66,716	9	29	0	38
4466-20210519-20	66,716	12	16	0	28
4466-20220614-31	66,716	1	35	0	36
4466-20220614-32	66,716	1	33	0	34
4466-20220614-33	66,716	2	66	10	78
4466-20220614-34	66,716	5	36	2	43
4466-20220614-35	66,716	0	57	4	61
4466-20220614-36	66,716	3	73	1	77
4466-20220614-37	66,716	0	4	0	4
4466-20220614-38	66,716	5	42	1	48

Event ID	Source Feature	Juveniles	Sterile Adults	Reproductive Adults	Total Ramets
4466-20220614-39	66,716	0	6	0	6
4466-20220614-40	66,716	2	29	0	31
4466-20230524-41	66,716	8	40	0	48
4466-20230524-42	66,716	8	37	3	48
4466-20230524-43	66,716	2	5	0	7
4466-20230524-44	66,716	8	9	0	17
4466-20230524-45	66,716	6	33	6	45
4466-20230524-46	66,716	13	91	18	122
4466-20230524-47	66,716	4	15	0	19
4466-20230524-48	66,716	10	59	2	71
4466-20230524-49	66,716	5	22	2	29
4466-20230524-50	66,716	2	63	21	86

The following adventive species were observed as potential threats to the population:

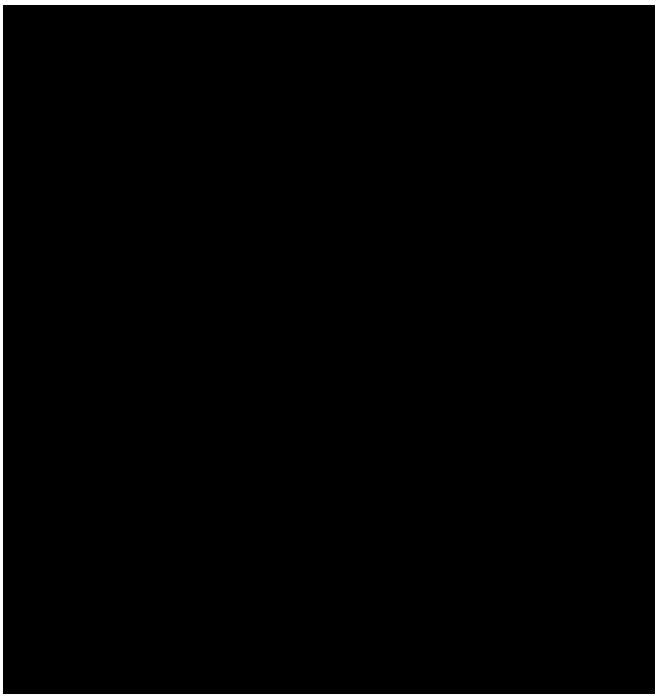
Scientific Name	Common Name	Abundance
Centaurea stoebe; c. maculosa	spotted knapweed	occasional
Cynoglossum officinale	hounds-tongue	frequent
Myosotis scorpioides	forget-me-not	occasional
Phalaris arundinacea	reed canary grass	occasional

Leaf samples were collected for genetic analysis. Results from those efforts can be found in Cohen, J. I., and S. Turgman-Cohen. 2023. The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic. Plants 12: 1–17.

Element Occurrence ID - 4640

Delta County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	F
Visit Dates	6/19/2019
Surveyors	Rachel Hackett, Zach Pitman
Estimated Population Area (ac)	32.9
Number of Patches	1
Population estimate	0 - 100
10 year extinction probability	NA
Ownership Types	Private



[redacted] (EO ID 4640) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type qualitative were conducted between 2019 and 2023 with the last survey completed on 06/19/2019.

Survey Results

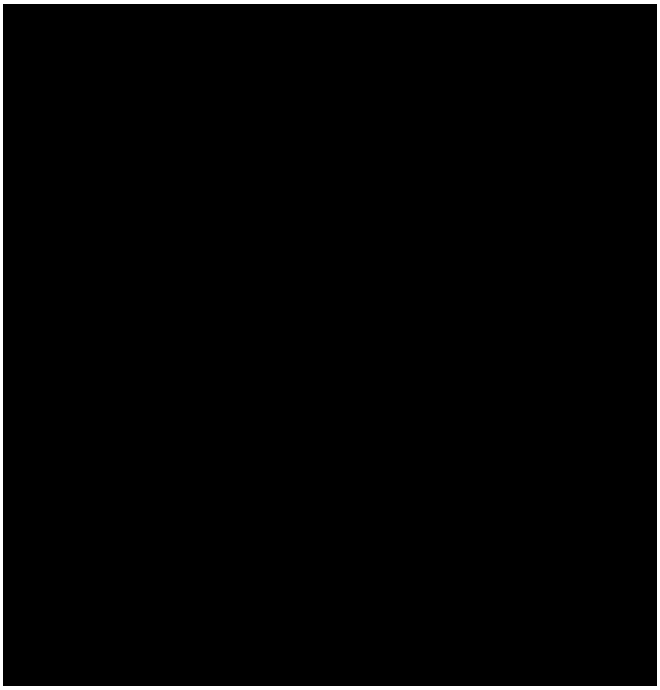
The majority of the area was thoroughly surveyed and no dwarf lake iris was found. The population max was estimated in case an area was overlooked. EO Rank changed from C to F as a result of the survey effort.

[redacted]

Element Occurrence ID – 5552

Delta County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	BC
Visit Dates	6/19/2019
Surveyors	Rachel Hackett, Zach Pitman
Estimated Population Area (ac)	4.3
Number of Patches	1
Population estimate	0 – 10,000
10 year extinction probability	NA
Ownership Types	Private



[redacted] (EO ID 5552) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 06/19/2019.

Survey Results

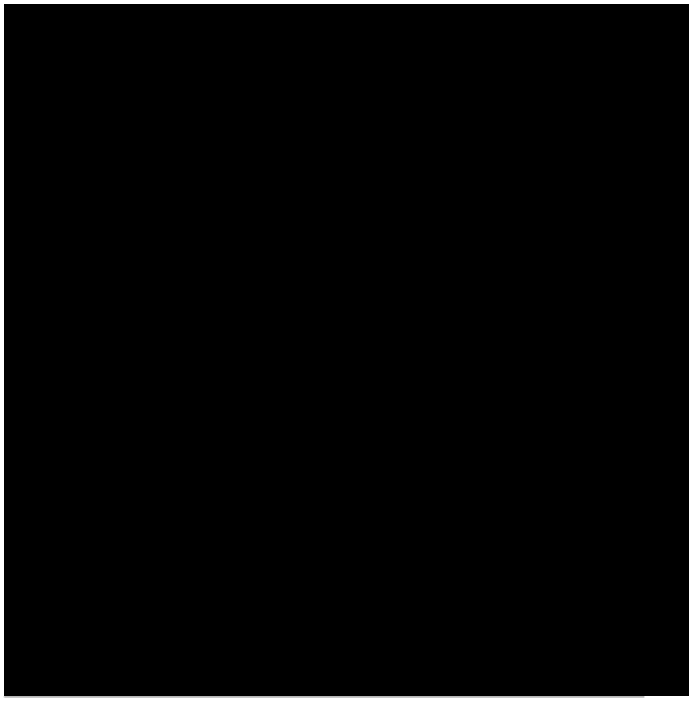
Although surveyors failed to find in surveyed area, EO rank was not changed due to inability to survey portions of mapped area due to lack permission from land owner.

[redacted]

Element Occurrence ID - 5633

Delta County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	A
Visit Dates	6/19/2019, 6/18/2022, 6/4/2023, 6/11/2023, 6/14/2023, 6/15/2023, 6/16/2023
Surveyors	Rachel Hackett, Zach Pitman, William MacKinnon
Estimated Population Area (ac)	269.3
Number of Patches	21
Population estimate	329,982 – 4,338,951
10 year extinction probability	13%
Ownership Types	State



[redacted] (EO ID 5633) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type qualitative, and genetic were conducted between 2019 and 2023 with the last survey completed on 06/15/2023.

Survey Results

Spatial surveys resulted in an expansion of the estimated populated area from 119.8 to 269.3 acres. The number of mostly contiguous patches increased from 2 to 21. Flowers/fruits were of occasional abundance during survey(s). No white flowers were observed. Habitat data was collected at 9 points in the population (Table 5633-1).

[redacted]

Table 5633 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
5633-20190619-10	66,715	loamy sand	moist	4.2	0.9	partial sun		none
5633-20190619-2	66,713	clay loam	moist	7.4	0.7	partial sun		low
5633-20190619-21	66,715	loamy clay	moist	6.8	1.7	partial sun		low
5633-20190619-25	66,715	clay loam	moist	12.6	2.1	full sun		low
5633-20190619-27	66,715	clay loam	moist	12.9	0.3	partial sun		none
5633-20190619-44	66,715	clay loam	moist	3.1	0.1	full shade		none
5633-20190619-61	66,715	clay loam	moist	6.5	1.7	partial sun		low
5633-20190619-7	66,713	loam	moist	5.8	1.2	full sun		
5633-20190619-92	66,715	loam	moist	14.8	1.4	partial sun		low

The following adventive species were observed as potential threats to the population:

Scientific Name	Common Name	Abundance
Borago officinalis	borage	occasional
Hieracium piloselloides	king devil	frequent

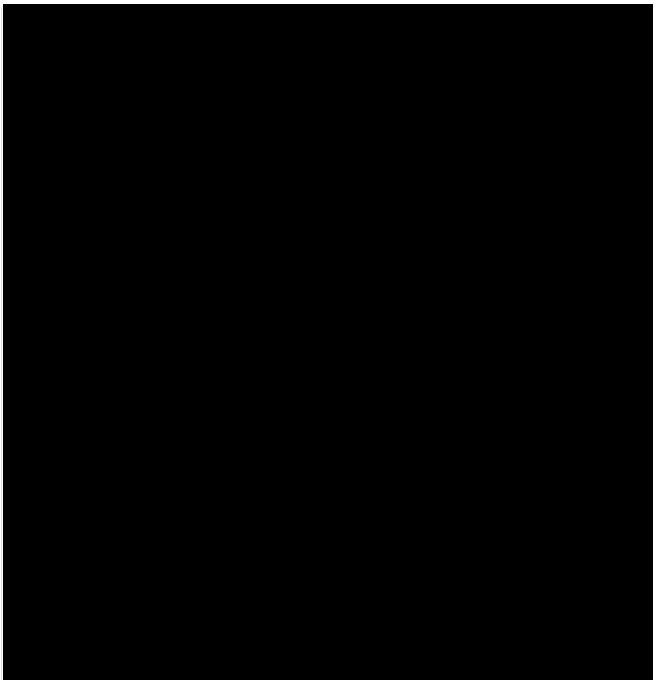
Leaf samples were collected for genetic analysis. Results from those efforts can be found in Cohen, J. I., and S. Turgman-Cohen. 2023. The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic. Plants 12: 1–17.

[redacted]

Element Occurrence ID – 11586

Delta County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	F
Visit Dates	07/28/2021
Surveyors	Tyler Bassett, Scott Warner
Estimated Population Area (ac)	182
Number of Patches	1
Population estimate	0 - 500
10 year extinction probability	NA
Ownership Types	Federal



[redacted] (EO ID 11586) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391) and additional support from the National Wildlife Refuge (F20AC11089), and with permission from landowners for those areas surveyed. Surveys of type spatial were conducted between 2019 and 2023 with the last survey completed on 07/28/2021.

Survey Results

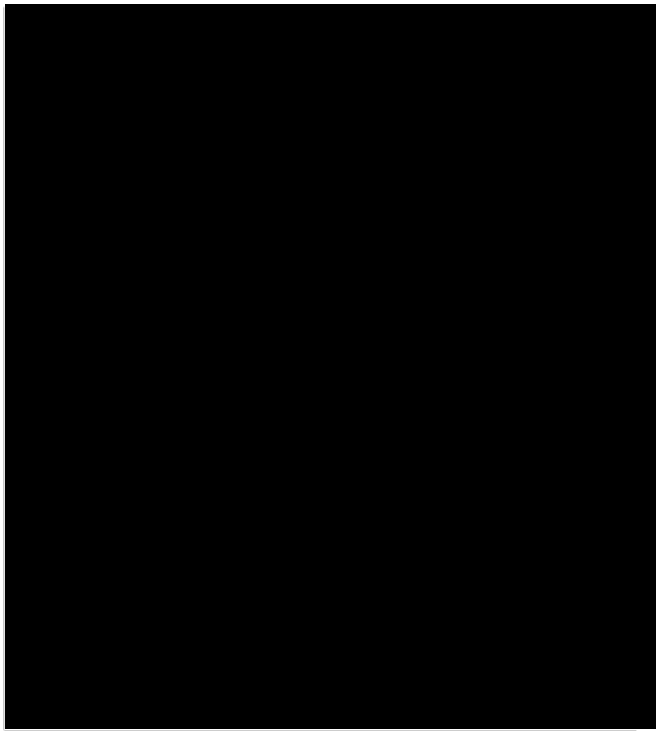
The majority of the area was thoroughly surveyed and no dwarf lake iris was found. The population max was estimated in case an area was overlooked. Population maximum reflects last extant survey maximum estimate (1995). EO Rank changed from C to F as a result of the survey effort.

[redacted]

Element Occurrence ID – 23699

Delta County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	F
Visit Dates	06/03/2021
Surveyors	Rachel Hackett, Tyler Bassett
Estimated Population Area (ac)	7.5
Number of Patches	1
Population estimate	0 - 100
10 year extinction probability	NA
Ownership Types	Federal, Private



[redacted] (EO ID 23699) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 06/03/2021.

Survey Results

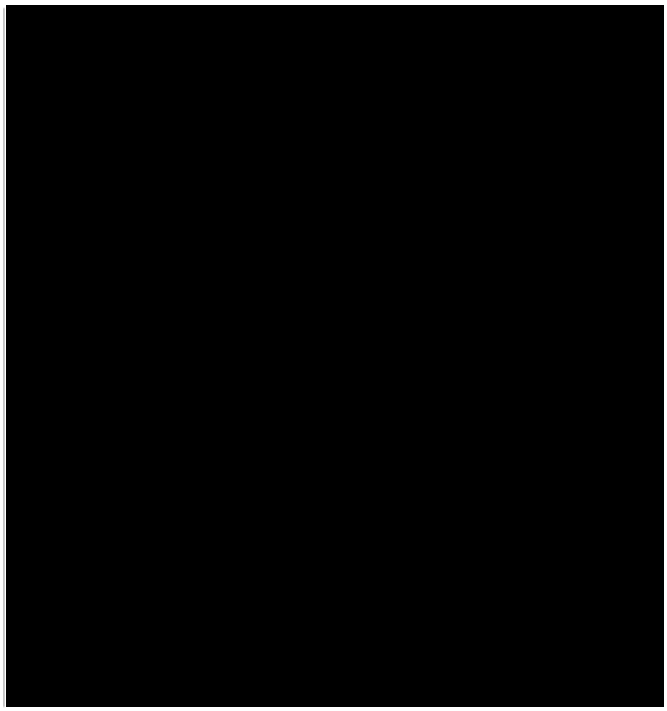
Documentation for this population was discovered as a result of a data mining effort funded by Great Lakes Restoration Initiative through US Fish and Wildlife Service (F18AC00566). EO Rank changed from H to F as a result of the survey effort. Spatial surveys resulted in an expansion of the estimated populated area from 0 to 7.5 acres. The number of mostly contiguous patches increased from 0 to 1.

[redacted]

Element Occurrence ID – 23701

Delta County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	D
Visit Dates	6/4/2021
Surveyors	Rachel Hackett
Estimated Population Area (ac)	2.1
Number of Patches	2
Population estimate	800 – 1,000
10 year extinction probability	51%
Ownership Types	Federal



[redacted] (EO ID 23701) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 06/04/2021.

Survey Results

Documentation for this population was discovered as a result of a data mining effort funded by Great Lakes Restoration Initiative through US Fish and Wildlife Service (F18AC00566). EO Rank changed from E to D as a result of the survey effort. Spatial surveys resulted in an expansion of the estimated populated area from 0 to 2.1 acres. The number of mostly contiguous patches increased from 0 to 2. Flowers/fruits were of rare abundance during survey(s). No white flowers were observed. Habitat data was collected at 4 points in the population (Table 23701-1).

[redacted]

Table 23701 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
23701-20210604-Qualitative_habitat-5	64,892	sand	dry	65	3.8		80	low
23701-20210604-Qualitative_habitat-6	64,892	loam	moist	66	9.4	full shade	25	high
23701-20210604-Qualitative_habitat-7	64,892	loam	dry	78	6.2	partial sun	45	high
23701-20210604-Qualitative_habitat-8	64,892	loam	dry	48	6.5	full shade	35	none

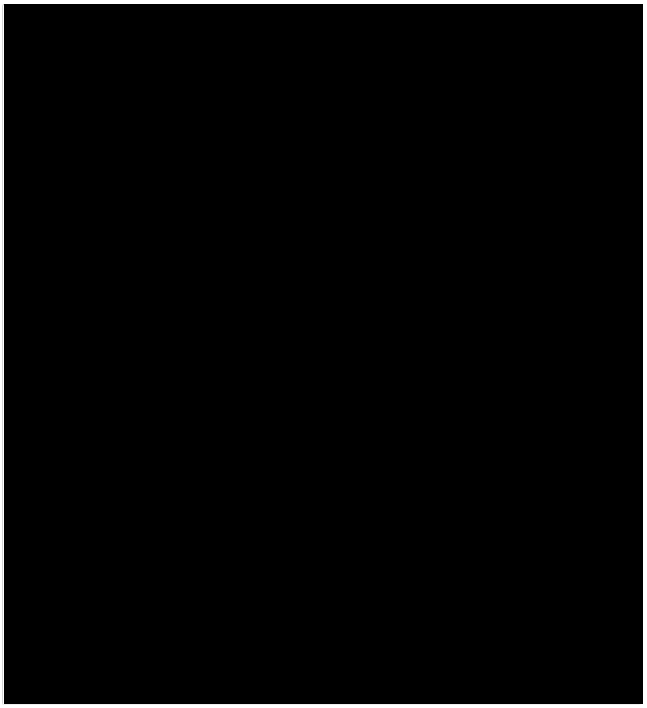
The following adventive species were observed as potential threats to the population:

Scientific Name	Common Name	Abundance
Hieracium lachenalii	european hawkweed	abundant

Element Occurrence ID - 3606

Emmet County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	B
Visit Dates	6/18/2021, 6/17/2021
Surveyors	Rachel Hackett, Diana Diggs
Estimated Population Area (ac)	181.2
Number of Patches	7
Population estimate	2,150 – 11,100
10 year extinction probability	47%
Ownership Types	Municipal, Private, State



[redacted](EO ID 3606) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 06/18/2021.

Survey Results

Access was granted on State, County, and select Private lands for survey. Large vague source features were retained to represent potential patches on private lands. Spatial surveys resulted in a refining of the estimated populated area from 181.3 to 181.2 acres. The number of mostly contiguous patches increased from 5 to 7. Flowers/fruits were of rare abundance during survey(s). No white flowers were observed. Habitat data was collected at 3 points in the population (Table 3606-1).

Table 3606 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
3606-20210617-Qualitative_habitat-22	68,429	sand	moist	7.6	2.2	partial sun	65	low
3606-20210617-Qualitative_habitat-23		loamy sand	moist	6.5	1.5	full shade	40	low
3606-20210617-Qualitative_habitat-24	68,425	loamy sand	moist	6.5	1.5	partial sun	80	low

The following adventive species were observed as potential threats to the population:

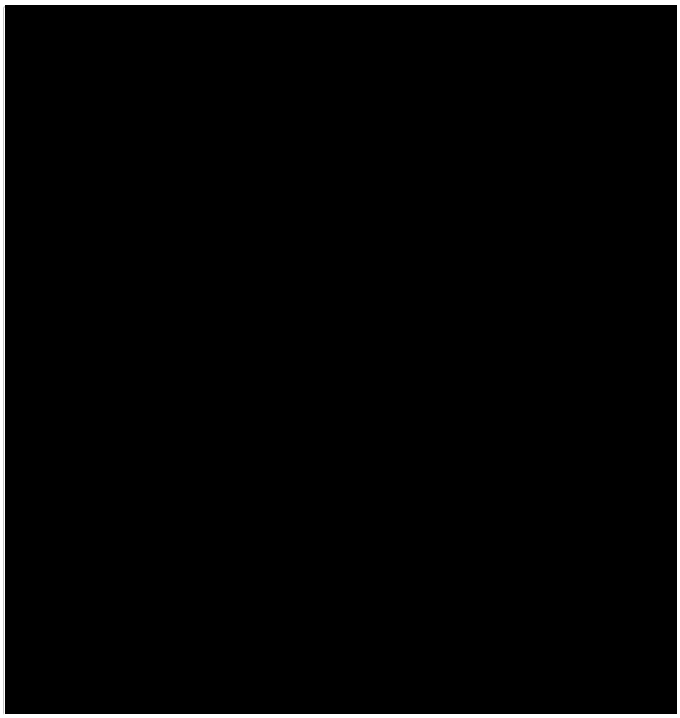
Scientific Name	Common Name	Abundance
Centaurea stoebe; c. maculosa	spotted knapweed	occasional
Hieracium pilosella	mouse-ear hawkweed	frequent
Mycelis muralis; lactuca m.	wall lettuce	frequent

[redacted]

Element Occurrence ID - 7130

Emmet County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	C
Visit Dates	6/8/2020, 5/14/2019, 5/15/2019, 6/17/2019, 6/11/2021, 5/31/2022, 5/30/2023
Surveyors	Rachel Hackett, Zach Pitman, Jim Cohen, Diana Diggs, Marta Springer, Liam Daniels
Estimated Population Area (ac)	21.1
Number of Patches	5
Population estimate	1,500 – 3,000
10 year extinction probability	48%
Ownership Types	State



[redacted] (EO ID 7130) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, count, demographic, and genetic were conducted between 2019 and 2023 with the last survey completed on 05/30/2023.

Survey Results

EO Rank changed from B to C as a result of the survey effort. Spatial surveys resulted in a refining of the estimated populated area from 23.1 to 21.1 acres. The number of mostly contiguous patches increased from 4 to 5. Flowers/fruits were of occasional abundance during survey(s). No white flowers were observed. Habitat data was collected at 51 points in the population (Table 7130-1). Population count data was collected at 52 plots with some demographic plots from 2019-2021 (Table 7130-2).

[redacted]

Table 7130 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
7130-20190617-1	66,703	loam	wet	6.00	1.00			low
7130-20190617-10	66,703	sandy loam	moist	6.50	1.25			none
7130-20190617-2	66,703	sand	wet	1.00	0.00			low
7130-20190617-3	66,703	loamy sand	wet	1.50	2.00			none
7130-20190617-4	66,703	sandy loam	moist	27.00	1.50			none
7130-20190617-5	66,703	loamy sand	wet	22.00	1.50			none
7130-20190617-6	66,703	sand	wet	3.20	1.20			none
7130-20190617-7	66,703	loamy sand	wet	8.25	1.25			none
7130-20190617-8	66,703	sandy loam	wet	9.00	2.00			none
7130-20190617-9	66,703	loamy sand	wet	4.50	1.25			none
7130-20200608-1	66,703	sandy loam	moist	5.50	2.20	full shade	25	low
7130-20200608-10	66,703	other	wet	0.00	0.00	partial sun	50	none
7130-20200608-11	66,703	sand	moist	1.50	1.00	full shade	10	low
7130-20200608-12	66,703	other	moist	1.50	0.50	full sun	95	none
7130-20200608-13	66,703	loamy sand	wet	3.50	0.80	full sun	95	none
7130-20200608-2	66,703	other	saturated	0.00	0.00	full shade	20	none
7130-20200608-3	66,703	loam	moist	6.50	3.20	full shade	10	low
7130-20200608-4	66,703	loamy sand	moist	11.20	0.50	partial sun	35	low
7130-20200608-5	66,703	loamy sand	moist	14.00	1.50	partial sun	25	low
7130-20200608-6	66,703	other	wet	0.00	0.00	partial sun	80	low
7130-20200608-7	66,703	other	inundated	0.00	0.00	full sun	100	none
7130-20200608-8	66,703	other	inundated	0.00	0.00	full sun	100	none
7130-20200608-9	66,703	other	inundated	0.00	0.00	partial sun	70	none
7130-20210611-1	66,703	sandy loam	moist	9.00	2.50	partial sun	60	low
7130-20210611-13	66,703	loamy sand	wet	4.00	1.50	full sun	95	none
7130-20210611-21	66,703	loamy sand	moist	5.00	0.50	full sun	95	low
7130-20210611-22	66,703	sandy loam	moist	4.00	0.50	partial sun	55	none
7130-20210611-23	66,703	loamy sand	moist	5.50	2.50	partial sun	75	low
7130-20210611-24	66,703	sandy loam	moist	5.00	5.00	full shade	15	low
7130-20210611-3	66,703	loam	moist	10.50	4.00	full shade	30	low
7130-20210611-4	66,703	sandy loam	moist	14.00	2.00	partial sun	50	low

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
7130-20210611-5	66,703	sandy loam	moist	10.00	2.50	partial sun	45	none
7130-20220531-31	66,703	loam	dry	10.00	7.00	partial sun	35	low
7130-20220531-32	66,703	loam	moist	6.20	5.00	partial sun	10	none
7130-20220531-33	66,703	sandy loam	moist	6.00	2.50	partial sun	20	none
7130-20220531-34	66,703	sandy loam	moist	13.80	3.25	partial sun	30	low
7130-20220531-35	66,703	sandy loam	moist	6.50	1.75	full shade	10	none
7130-20220531-36	66,703	sandy loam	moist	4.50	2.25	full shade	5	none
7130-20220531-37	66,703	sandy loam	dry	3.00	0.50	partial sun	60	none
7130-20220531-38	66,703	sandy loam	moist	7.25	0.50	partial sun	98	low
7130-20220531-39	66,703	sandy loam	moist	5.00	3.00	full shade	15	none
7130-20220531-40	66,703	sandy loam	moist	5.00	1.50	full shade	20	none
7130-20230530-41	66,703	loam	dry	20.00	1.50	full shade	15	none
7130-20230530-42	66,703					full shade		
7130-20230530-43	66,703	loam	dry	13.00	1.50	full shade	5	low
7130-20230530-44	66,703	loamy sand	dry	9.20	1.80	partial sun	35	low
7130-20230530-45	66,703	loamy sand	dry	35.00	1.50	partial sun	50	none
7130-20230530-46	66,703	sand	dry	2.00	0.50	full sun	95	none
7130-20230530-48	66,703	loamy sand	dry	2.50	0.50	full shade	60	none
7130-20230530-49	66,703	sand	dry	5.50	0.20	full shade	50	none
7130-20230530-50	66,703	loamy sand	dry	7.50	0.80	full shade	15	none

Table 7130 -2. List of plots where population data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Juveniles	Sterile Adults	Reproductive Adults	Dead (demographic only)	Total Ramets
7130-20190617-1	66,703	9	36	0	0	45
7130-20190617-10	66,703	15	42	14	0	71
7130-20190617-2	66,703	12	45	8	0	65
7130-20190617-3	66,703	5	21	1	0	27
7130-20190617-4	66,703	1	19	0	0	20
7130-20190617-5	66,703	3	20	1	0	24
7130-20190617-6	66,703	6	9	2	0	17
7130-20190617-7	66,703	0	4	1	0	5
7130-20190617-8	66,703	10	49	9	0	68

Event ID	Source Feature	Juveniles	Sterile Adults	Reproductive Adults	Dead (demographic only)	Total Ramets
7130-20190617-9	66,703	5	49	10	0	61
7130-20200608-1	66,703	5	55	0	5	65
7130-20200608-10	66,703	0	0	0	0	0
7130-20200608-11	66,703	2	43	5	1	50
7130-20200608-12	66,703	2	15	2	0	19
7130-20200608-13	66,703	10	60	8	0	78
7130-20200608-2	66,703	0	0	0	0	0
7130-20200608-3	66,703	2	30	1	3	36
7130-20200608-4	66,703	3	27	1	2	33
7130-20200608-5	66,703	5	37	6	2	50
7130-20200608-6	66,703	0	0	0	0	0
7130-20200608-7	66,703	0	0	0	0	0
7130-20200608-8	66,703	0	0	0	0	0
7130-20200608-9	66,703	0	0	0	0	0
7130-20210611-1	66,703	2	59	0	21	61
7130-20210611-13	66,703	5	34	0	30	39
7130-20210611-21	66,703	6	99	5	0	110
7130-20210611-22	66,703	7	21	0	0	28
7130-20210611-23	66,703	0	53	5	0	58
7130-20210611-24	66,703	3	38	0	0	41
7130-20210611-3	66,703	5	15	0	25	20
7130-20210611-4	66,703	5	21	1	13	27
7130-20210611-5	66,703	4	53	6	8	63
7130-20220531-31	66,703	9	36	0	0	45
7130-20220531-32	66,703	0	2	0	0	2
7130-20220531-33	66,703	8	25	0	0	33
7130-20220531-34	66,703	9	63	7	0	79
7130-20220531-35	66,703	3	6	0	0	9
7130-20220531-36	66,703	0	3	0	0	3
7130-20220531-37	66,703	21	3	1	1	25
7130-20220531-38	66,703	3	9	3	5	15
7130-20220531-39	66,703	9	44	0	0	53
7130-20220531-40	66,703	7	22	0	0	29
7130-20230530-41	66,703	0	2	2	0	4
7130-20230530-42	66,703	0	0	0	0	0
7130-20230530-43	66,703	3	4	0	0	7
7130-20230530-44	66,703	1	40	0	0	41
7130-20230530-45	66,703	6	75	11	0	92
7130-20230530-46	66,703	0	2	1	0	3
7130-20230530-47	66,703	0	0	0	0	0
7130-20230530-48	66,703	10	15	4	0	29
7130-20230530-49	66,703	3	39	0	0	42
7130-20230530-50	66,703	2	32	0	0	34

The following adventive species were observed as potential threats to the population:

Scientific Name	Common Name	Abundance
Centaurea stoebe; c. maculosa	spotted knapweed	occasional
Hieracium piloselloides	king devil	abundant
Hypericum perfoliatum	common St John's wort	occasional
Mycelis muralis; lactuca m.	wall lettuce	abundant
Rosa multiflora	multiflora rose	rare
Silene vulgaris	bladder campion	

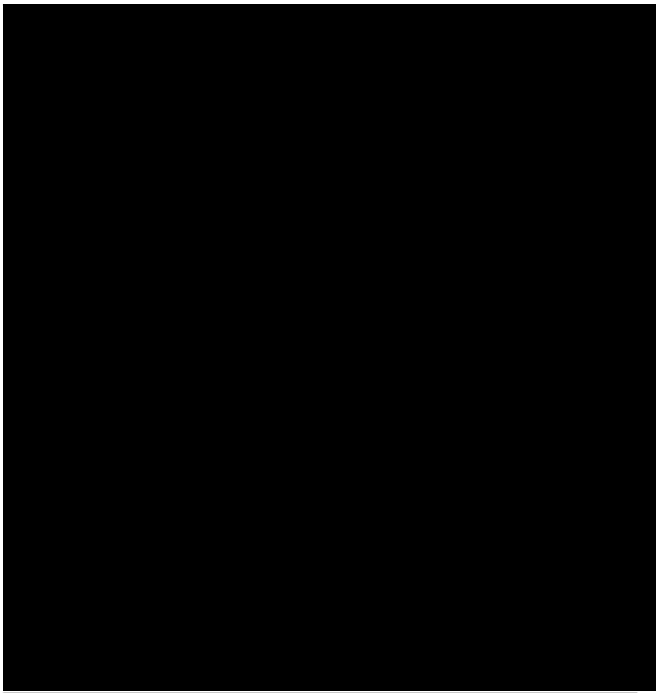
Leaf samples were collected for genetic analysis. Results from those efforts can be found in Cohen, J. I., and S. Turgman-Cohen. 2023. The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic. Plants 12: 1–17.

[redacted]

Element Occurrence ID – 10381

Emmet County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	C
Visit Dates	6/17/2019, 5/30/2023, 5/29/2024
Surveyors	Rachel Hackett, Zach Pitman, Jim Cohen, Liam Daniels
Estimated Population Area (ac)	2.2
Number of Patches	1
Population estimate	3,000 – 6,000
10 year extinction probability	39%
Ownership Types	State



[redacted] (EO ID 10381) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, qualitative, and genetic were conducted between 2019 and 2023 with the last survey completed on 05/30/2023.

Survey Results

The reduction of acreage is not likely due to a reduction of population of refinement of vague spatial documentation. Spatial surveys resulted in a refining of the estimated populated area from 7.7 to 2.2 acres. Flowers/fruits were of frequent abundance during survey(s). White flowers were of occasional abundance during survey(s). Habitat data was collected at 2 points in the population (Table 10381-1).

Table 10381 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
10381-20190617-6	66,301	sandy loam	moist	7.5	1.5			none
10381-20190617-14	66,301	loam	moist	9.0	3.0			

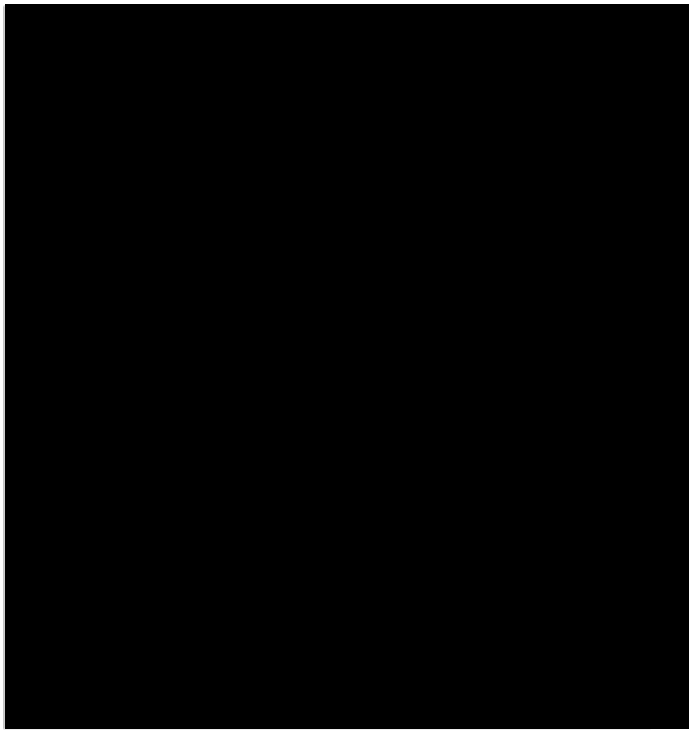
[redacted]

Leaf samples were collected for genetic analysis. Results from those efforts can be found in Cohen, J. I., and S. Turgman-Cohen. 2023. The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic. Plants 12: 1–17.

Element Occurrence ID - 11844

Emmet County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	F
Visit Dates	06/20/2020
Surveyors	Rachel Hackett
Estimated Population Area (ac)	413.8
Number of Patches	1
Population estimate	0 - 100
10 year extinction probability	NA
Ownership Types	State



[redacted] (EO ID 11844) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 06/20/2020.

Survey Results

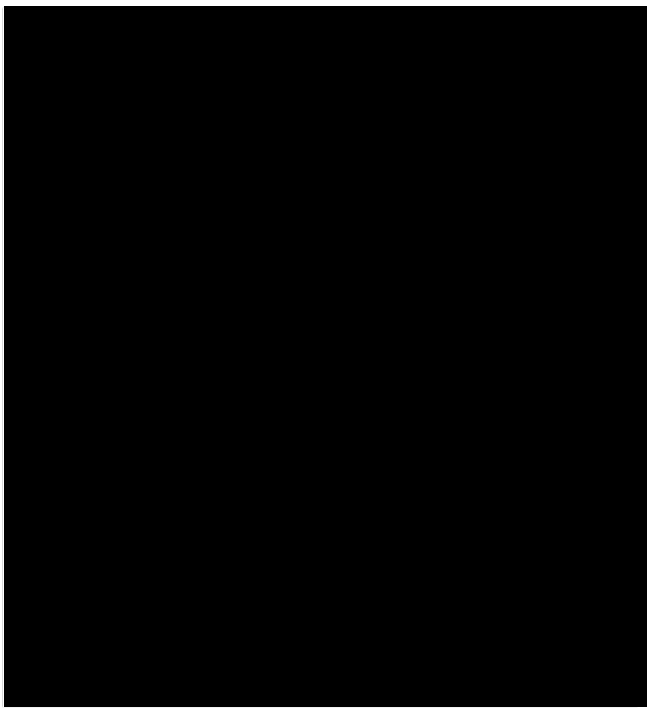
The majority of the area was thoroughly surveyed and no dwarf lake iris was found. The population max was estimated in case an area was overlooked. EO Rank changed from H to F as a result of the survey effort.

[redacted]

Element Occurrence ID – 834

Mackinac County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	C
Visit Dates	6/11/2021
Surveyors	William MacKinnon
Estimated Population Area (ac)	9.5
Number of Patches	4
Population estimate	10,000 – 26,000
10 year extinction probability	35%
Ownership Types	Private



[redacted] (EO ID 834) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 06/11/2021.

Survey Results

Access was granted on select Private lands for survey. Large vague source features were retained to represent potential patches on private lands. Spatial surveys resulted in an expansion of the estimated populated area from 9 to 9.5 acres. The number of mostly contiguous patches increased from 3 to 4. No flowers were observed during survey(s). Habitat data was collected at 11 points in the population (Table 834-1).

[redacted]

Table 834 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
834-20210611-Qualitative_habitat-1	69,155	sand	dry	1	1	full sun	75	low
834-20210611-Qualitative_habitat-2	69,155	other	dry	0	0	partial sun	50	none
834-20210611-Qualitative_habitat-3	69,155	other	dry	0	0	partial sun	40	low
834-20210611-Qualitative_habitat-4	69,155	sand	dry	0	1	partial sun	40	low
834-20210611-Qualitative_habitat-5	69,155	sand	dry	2	1	partial sun	40	low
834-20210611-Qualitative_habitat-6	69,155	loamy sand	moist	6	4	full shade	25	low
834-20210611-Qualitative_habitat-7	69,155	sand	dry	4	1	partial sun	20	low
834-20210611-Qualitative_habitat-8	69,155	loamy sand	moist	6	1	partial sun	40	low
834-20210611-Qualitative_habitat-9	69,155	sand	dry	4	1	partial sun	60	low
834-20210611-Qualitative_habitat-10	69,155	loamy sand	moist	6	2	partial sun	30	low
834-20210611-Qualitative_habitat-11	69,155	loamy sand	moist	6	2	partial sun	40	low

The following adventive species were observed as potential threats to the population:

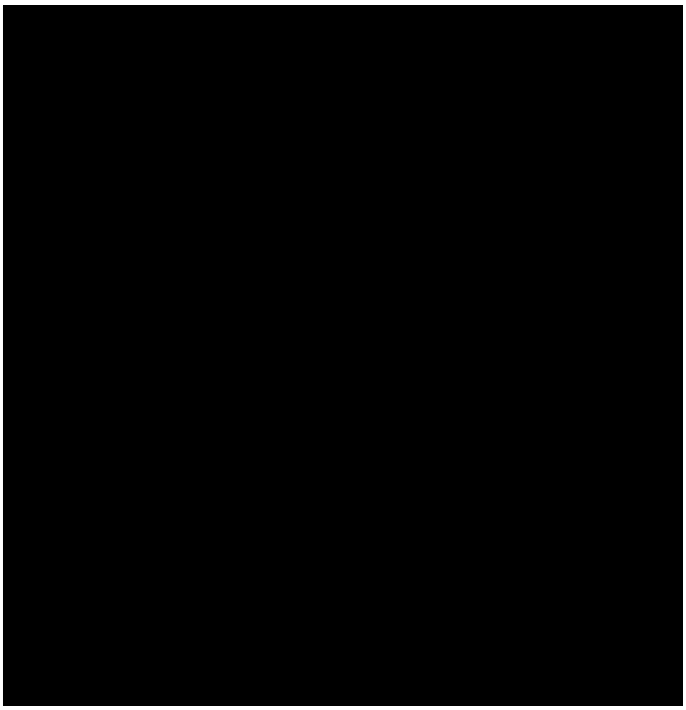
Scientific Name	Common Name	Abundance
Hieracium piloselloides	king devil	

[redacted]

Element Occurrence ID – 835

Mackinac County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	B
Visit Dates	6/18/2020
Surveyors	Jodi Spieles
Estimated Population Area (ac)	3.6
Number of Patches	1
Population estimate	100,000 – 300,000
10 year extinction probability	23%
Ownership Types	State



[redacted] (EO ID 835) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type qualitative were conducted between 2019 and 2023 with the last survey completed on 06/18/2020.

Survey Results

EO Rank changed from C to B as a result of the survey effort. Spatial surveys resulted in a refining of the estimated populated area from 23.8 to 3.6 acres. Flowers/fruits were of frequent abundance during survey(s). No white flowers were observed. Habitat data was collected at 3 points in the population (Table 835-1).

Table 835 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

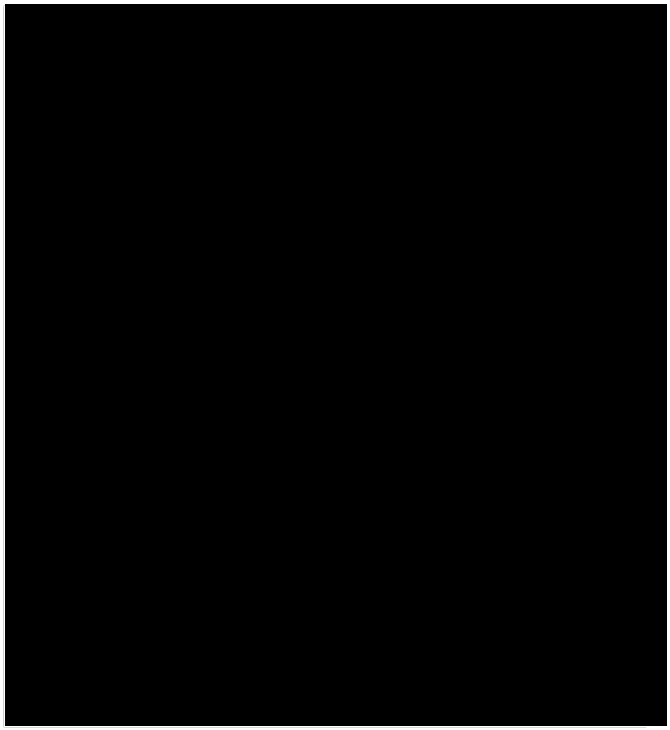
Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
835-20200618-Qualitative_habitat-2	66,712	loamy sand	dry	1.0	0.5	partial sun	70	low
835-20200618-Qualitative_habitat-3	66,712	loamy sand	dry	1.0	0.8	partial sun	50	low
835-20200618-Qualitative_habitat-4	66,712	loamy sand	wet	1.5	0.5	partial sun	50	low

[redacted]

Element Occurrence ID – 1885

Mackinac County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	F
Visit Dates	6/7/2023
Surveyors	Rachel Hackett, Nicole Smith
Estimated Population Area (ac)	1.7
Number of Patches	1
Population estimate	0 - 100
10 year extinction probability	NA
Ownership Types	Private



[redacted] (EO ID 1885) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial were conducted between 2019 and 2023 with the last survey completed on 06/07/2023.

Survey Results

EO Rank changed from BC to F as a result of the survey effort. The following adventive species were observed as potential threats to the population:

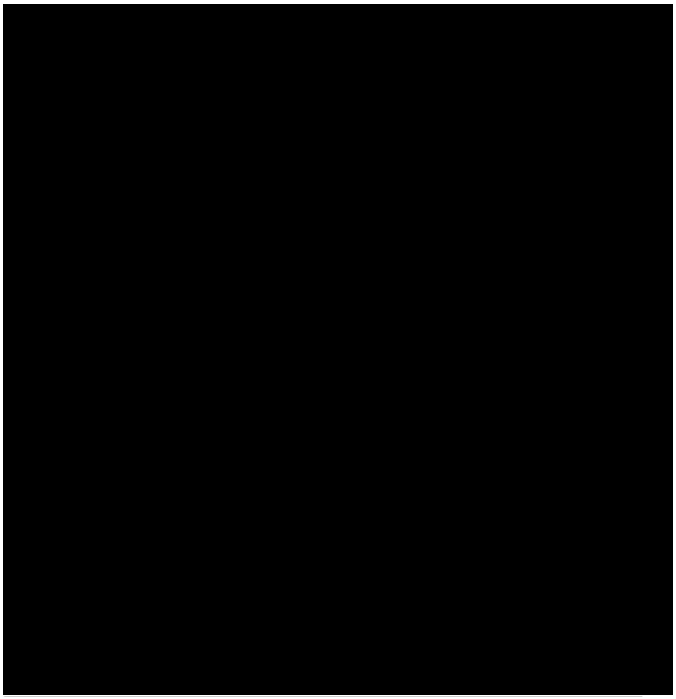
Scientific Name	Common Name	Abundance
Cynoglossum officinale	hounds-tongue	frequent
Hierachium sp.	hawkweed	frequent
Mycelis muralis; lactuca m.	wall lettuce	occasional
Myosotis scorpioides	forget-me-not	frequent

[redacted]

Element Occurrence ID – 3635

Mackinac County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	BC
Visit Dates	8/9/2023
Surveyors	Rachel Hackett, Diana Digges
Estimated Population Area (ac)	60.2
Number of Patches	6
Population estimate	20,000 – 2,000,000
10 year extinction probability	26%
Ownership Types	Private



[redacted] (EO ID 3635) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, qualitative, and count were conducted between 2019 and 2023 with the last survey completed on 08/09/2023.

Survey Results

Spatial surveys resulted in an expansion of the estimated populated area from 52.5 to 60.2 acres. Flowers/fruits were of rare abundance during survey(s). No white flowers were observed. Habitat data was collected at 10 points in the population (Table 3635-1). Population count data was collected at 10 points (Table 3635-2).

Table 3635 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
3635-20230809-	1,340	loamy sand	dry		0.2	full sun	100	none
3635-20230809-2	1,340	loamy sand	dry		0.2	full sun	100	low
3635-20230809-3	1,340	sandy loam	dry		0.5	full sun	100	none
3635-20230809-4	1,340	sandy loam	dry		1.5	full sun	100	low
3635-20230809-5	1,340	sandy loam	dry		2.5	partial sun	100	none
3635-20230809-5	1,340	sandy loam	moist		2.0	full shade	100	none
3635-20230809-7	1,340	sandy loam	dry		2.0	full sun	100	low
3635-20230809-8	1,340	other	dry		1.0	full sun	95	none
3635-20230809-9	1,340	other	dry		0.2	partial sun	85	low
3635-20230809-10	1,340	sandy loam	dry		2.0	partial sun	95	low

Table 3635 -2. List of plots where population data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Juveniles	Sterile Adults	Reproductive Adults	Total Ramets
3635-20230809-	1,340	1	9	0	10
3635-20230809-2	1,340	0	104	0	104
3635-20230809-3	1,340	0	74	0	74
3635-20230809-4	1,340	0	36	0	36
3635-20230809-5	1,340	1	22	0	23
3635-20230809-5	1,340	0	23	0	23
3635-20230809-7	1,340	0	22	0	22
3635-20230809-8	1,340	1	6	0	7
3635-20230809-9	1,340	0	27	0	27
3635-20230809-10	1,340	12	256	0	268

The following adventive species were observed as potential threats to the population:

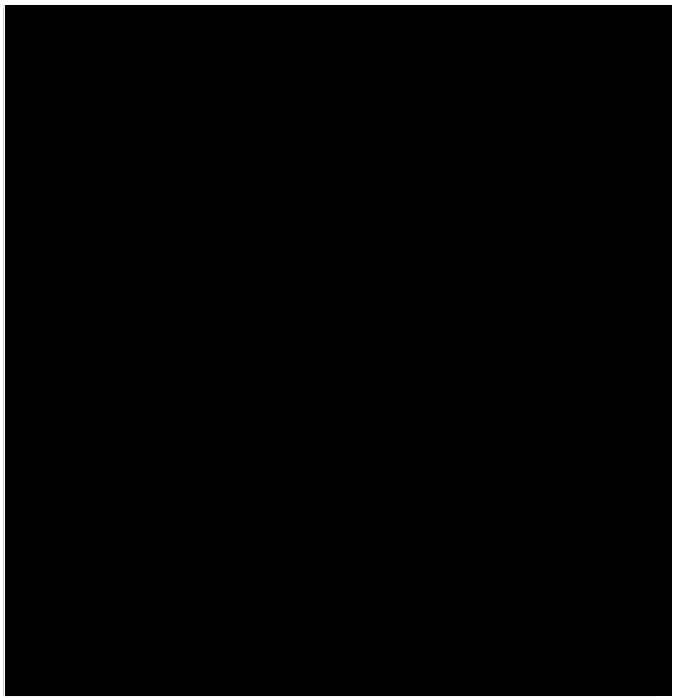
Scientific Name	Common Name	Abundance
Melilotus alba	white sweet clover	frequent
Centaurea montana	mountain knapweed	occasional
Centaurea stoebe; c. maculosa	spotted knapweed	occasional
Rhamnus cathartica	common buckthorn	rare
Lotus corniculatus	birdfoot trefoil	occasional

[redacted]

Element Occurrence ID – 4458

Mackinac County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	F
Visit Dates	6/10/2021
Surveyors	Rachel Hackett, Diana Diggs
Estimated Population Area (ac)	7.8
Number of Patches	1
Population estimate	0 - 100
10 year extinction probability	NA
Ownership Types	Federal



[redacted] (EO ID 4458) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type qualitative were conducted between 2019 and 2023 with the last survey completed on 06/10/2021.

Survey Results

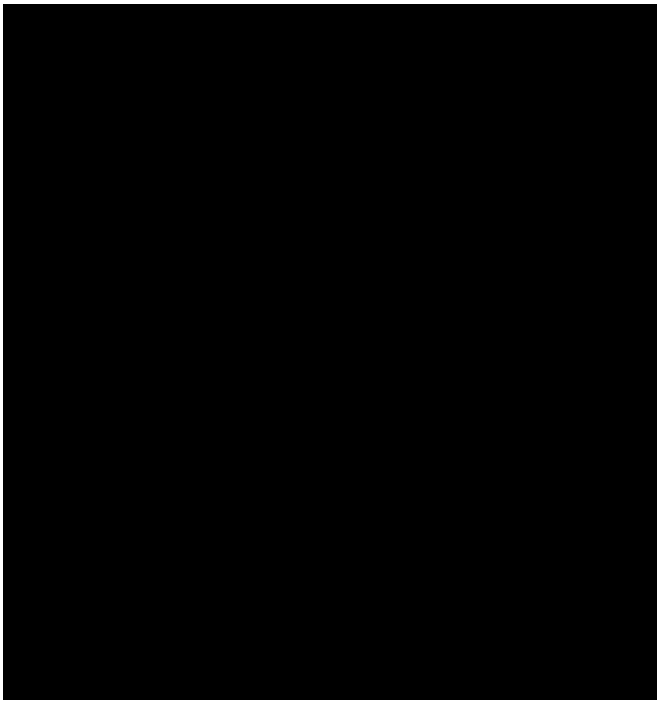
The majority of the area was thoroughly surveyed and no dwarf lake iris was found. The population max was estimated in case an area was overlooked.

[redacted]

Element Occurrence ID – 5954

Mackinac County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	B
Visit Dates	6/17/2020
Surveyors	Jodi Spieles
Estimated Population Area (ac)	56.2
Number of Patches	3
Population estimate	8,000 – 10,000
10 year extinction probability	37%
Ownership Types	State



[redacted] (EO ID 5954) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, qualitative, and genetic were conducted between 2019 and 2023 with the last survey completed on 06/17/2020.

Survey Results

Failed to find one mapped patch during surveys but found new patch. Spatial surveys resulted in an expansion of the estimated populated area from 49.1 to 56.2 acres. Flowers/fruits were of occasional abundance during survey(s). No white flowers were observed. Habitat data was collected at 2 points in the population (Table 5954-1).

Table 5954 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
5954-20200617-Qualitative_habitat-2	38	sandy loam	wet	18.5	1.5	full shade	5	
5954-20200617-Qualitative_habitat-3	38	loamy sand	dry	4.0	0.8	partial sun	80	low

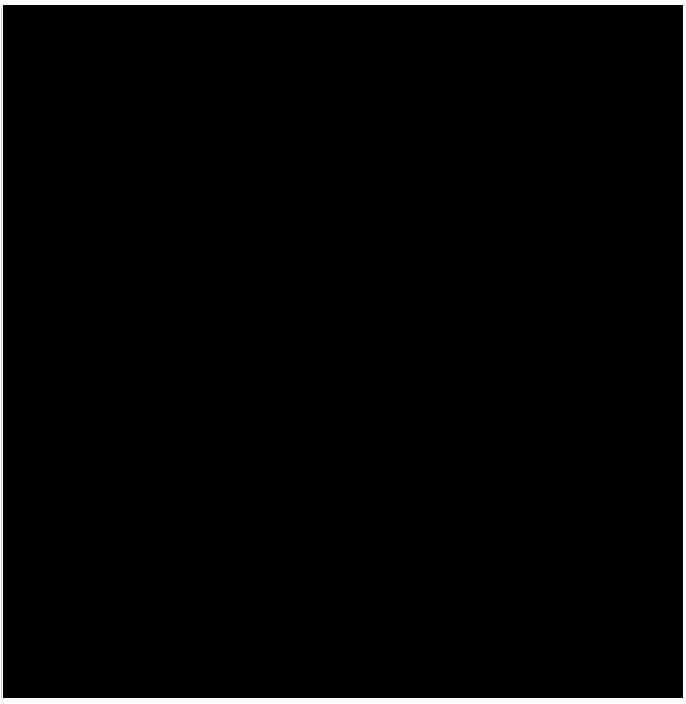
[redacted]

Leaf samples were collected for genetic analysis. Results from those efforts can be found in Cohen, J. I., and S. Turgman-Cohen. 2023. The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic. Plants 12: 1–17.

Element Occurrence ID – 8623

Mackinac County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	B
Visit Dates	6/17/2020
Surveyors	Lynn Kirkpatrick
Estimated Population Area (ac)	466.4
Number of Patches	3
Population estimate	500,000 – 1,000,000
10 year extinction probability	17%
Ownership Types	State



[redacted] (EO ID 8623) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, qualitative, and genetic were conducted between 2019 and 2023 with the last survey completed on 06/17/2020.

Survey Results

EO Rank changed from C to B as a result of the survey effort. Spatial surveys resulted in an expansion of the estimated populated area from 458.7 to 466.4 acres. The number of mostly contiguous patches increased from 2 to 3. Flowers/fruits were of frequent abundance during survey(s). No white flowers were observed. Habitat data was collected at 2 points in the population (Table 8623-1).

Table 8623 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
8623-20200617-Qualitative_habitat-2	66,748	other	moist	2.2	0.8	partial sun	70	low
8623-20200617-Qualitative_habitat-3	66,748	other	moist	8.4	0.7	full shade	15	low

Leaf samples were collected for genetic analysis. Results from those efforts can be found in Cohen, J. I., and S. Turgman-Cohen. 2023. The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic. Plants 12: 1–17.

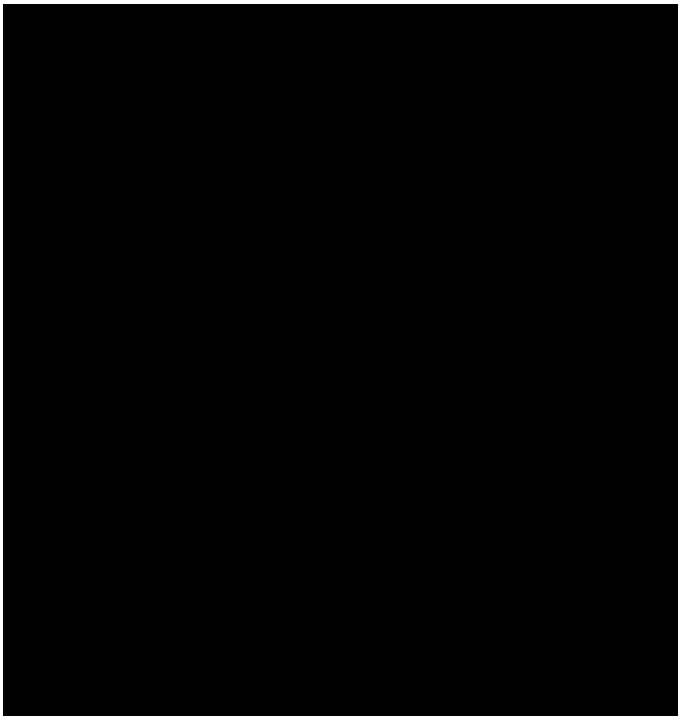
[redacted]

[redacted]

Element Occurrence ID – 8964

Mackinac County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	A
Visit Dates	6/28/2019, 5/20/2021, 6/15/2022, 5/31/2023
Surveyors	Rachel Hackett, Mirabai Moseley, Marley Huijgen, Liam Daniels
Estimated Population Area (ac)	146.5
Number of Patches	25
Population estimate	200,000 – 800,000
10 year extinction probability	11%
Ownership Types	Non-Governmental Organization, Private, State



[redacted] (EO ID 8964) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type count, and genetic were conducted between 2019 and 2023 with the last survey completed on 05/31/2023.

Survey Results

Spatial surveys resulted in an expansion of the estimated populated area from 143.3 to 146.5 acres. The number of mostly contiguous patches increased from 7 to 25. Flowers/fruits were of frequent abundance during survey(s). No white flowers were observed. Habitat data was collected at 40 points in the population (Table 8964-1). Population count data was collected at 40 points (Table 8964-2).

[redacted]

Table 8964 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
8964-20190628-1	27,166	clay loam	wet	13.4	0.00	full shade		low
8964-20190628-10	27,162	loamy clay	wet	8.8	2.00	partial sun		low
8964-20190628-2	27,166	other	inundated	0.0	0.00	partial sun		none
8964-20190628-3	66,706	loamy sand	saturated	12.6	2.50	full sun		low
8964-20190628-4	27,162	loam	dry	3.8	0.20	partial sun		low
8964-20190628-5	66,706	loamy sand	moist	4.4	0.20	full sun		low
8964-20190628-6	27,160	sandy loam	moist	14.5	0.50	full sun		low
8964-20190628-7	27,160	sand	moist	2.0	1.50	full sun		none
8964-20190628-8	27,162	loam	dry	11.3	1.25	full sun		high
8964-20190628-9	27,162	loamy clay	saturated	19.8	0.50	partial sun		low
8964-20210520-11	27,166	loam	moist	3.0	0.60	full sun	85	high
8964-20210520-12	27,166	loam	dry	4.7	1.50	full sun	85	high
8964-20210520-13	27,166	loamy sand	moist	1.8	0.80	partial sun	60	none
8964-20210520-14	66,706	loamy sand	moist	8.5	5.00	full sun	80	none
8964-20210520-15	66,706	loamy sand	dry	9.3	3.80	partial sun	40	low
8964-20210520-16	27,162	sandy loam	moist	8.8	0.50	full sun	100	low
8964-20210520-17	27,162	clay loam	moist	5.6	2.20	full sun	100	low
8964-20210520-18	27,162	sandy loam	moist	11.4	2.40	full sun	80	high
8964-20210520-19	27,162	clay loam	moist	7.5	3.00	full sun	90	low
8964-20210520-20	27,160	clay loam	moist	14.5	2.80	full shade	50	low
8964-20220615-31	27,160	sandy loam	moist	8.5	2.80	partial sun	80	low
8964-20220615-32	27,162	sandy loam	moist	7.9	3.30	partial sun	80	high
8964-20220615-33	27,162	sandy loam	moist	14.0	1.00	partial sun	99	high
8964-20220615-34	27,162	sandy loam	wet	18.5	2.50	partial sun	100	high
8964-20220615-35	27,162	sandy loam	dry	6.5	2.00	partial sun	30	low
8964-20220615-36	27,162	loamy sand	moist	9.0	12.00	full sun	100	low

[redacted]

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
8964-20220615-37	66,706	loamy sand	dry	21.5	5.00	full sun	100	low
8964-20220615-38	66,706	sand	dry	0.0	3.00	full sun	95	none
8964-20220615-39	27,166	other	other	0.0	1.00	partial sun	50	low
8964-20220615-40	27,166	other	dry	0.0	2.00	full sun	60	low
8964-20230531-41	27,160	clay loam	moist	15.0	3.50	full sun	90	low
8964-20230531-42	27,160	clay loam	moist	18.5	1.00	full sun	100	low
8964-20230531-43	27,166	loam	moist	6.0	1.20	full shade	55	none
8964-20230531-44	27,166	loamy sand	dry	4.5	0.80	partial sun	35	low
8964-20230531-45	66,706	sand	moist	5.0	2.00	full sun	100	none
8964-20230531-46	66,706	sand	dry	3.0	0.70	full sun	75	low
8964-20230531-47	27,162	loamy sand	dry	4.5	0.50	full sun	90	low
8964-20230531-48	27,162	loamy sand	dry	5.0	2.00	full sun	100	low
8964-20230531-49	27,162	sandy loam	moist	7.0	1.50	partial sun	80	low
8964-20230531-50	27,162	other	wet	5.5	1.50	full sun	95	low

[redacted]

Table 8964 -2. List of plots where population data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Juveniles	Sterile Adults	Reproductive Adults	Total Ramets
8964-20190628-1	27,166	9	35	2	46
8964-20190628-2	27,166	1	19	0	20
8964-20190628-3	66,706	4	180	1	185
8964-20190628-4	27,162	0	19	0	19
8964-20190628-5	66,706	1	81	3	85
8964-20190628-6	27,160	5	218	3	226
8964-20190628-7	27,160	8	117	9	134
8964-20190628-8	27,162	7	113	2	122
8964-20190628-9	27,162	44	69	0	113
8964-20190628-10	27,162	4	49	0	53
8964-20210520-11	27,166	16	1	0	17
8964-20210520-12	27,166	13	14	2	29
8964-20210520-13	27,166	9	0	0	9
8964-20210520-14	66,706	1	23	1	25
8964-20210520-15	66,706	11	76	2	89
8964-20210520-16	27,162	5	69	4	78
8964-20210520-17	27,162	1	56	3	60
8964-20210520-18	27,162	10	30	0	40
8964-20210520-19	27,162	12	103	4	119
8964-20210520-20	27,160	6	48	0	54
8964-20220615-31	27,160	0	41	2	43
8964-20220615-32	27,162	6	62	0	68
8964-20220615-33	27,162	5	49	2	56
8964-20220615-34	27,162	23	160	12	195
8964-20220615-35	27,162	3	46	2	51
8964-20220615-36	27,162	8	72	1	81
8964-20220615-37	66,706	1	183	5	189
8964-20220615-38	66,706	2	36	5	43
8964-20220615-39	27,166	1	145	2	148
8964-20220615-40	27,166	1	38	6	45
8964-20230531-41	27,160	5	93	13	111
8964-20230531-42	27,160	15	81	19	115
8964-20230531-43	27,166	0	2	0	2
8964-20230531-44	27,166	3	10	1	14
8964-20230531-45	66,706	0	28	2	30
8964-20230531-46	66,706	7	105	12	124
8964-20230531-47	27,162	2	154	52	208
8964-20230531-48	27,162	1	37	7	45
8964-20230531-49	27,162	9	63	0	72
8964-20230531-50	27,162	1	6	0	7

The following adventive species were observed as potential threats to the population:

Scientific Name	Common Name	Abundance
Phalaris arundinacea	reed canary grass	occasional
Cirsium vulgare	bull thistle	occasional
Hierachium sp.	hawkweed	frequent

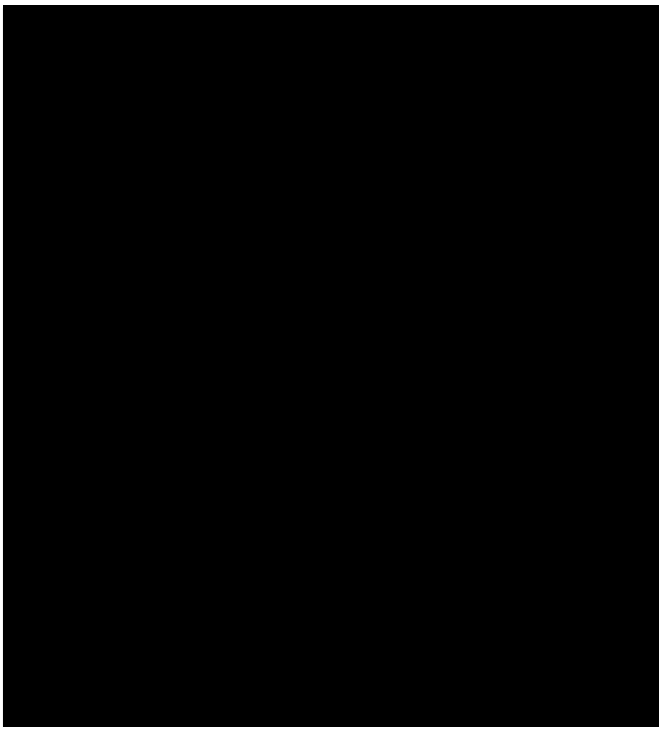
Leaf samples were collected for genetic analysis. Results from those efforts can be found in Cohen, J. I., and S. Turgman-Cohen. 2023. The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic. Plants 12: 1–17.

[redacted]

Element Occurrence ID - 10153

Mackinac County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	C
Visit Dates	6/21/2019
Surveyors	Rachel Hackett, Zach Pitman
Estimated Population Area (ac)	0.3
Number of Patches	1
Population estimate	300 - 500
10 year extinction probability	89%
Ownership Types	State



[redacted] (EO ID 10153) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 06/21/2019.

Survey Results

Spatial surveys resulted in a refining of the estimated populated area from 1.3 to 0.3 acres. Flowers/fruits were of frequent abundance during survey(s). No white flowers were observed. Habitat data was collected at 1 points in the population (Table 10153-1).

Table 10153 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

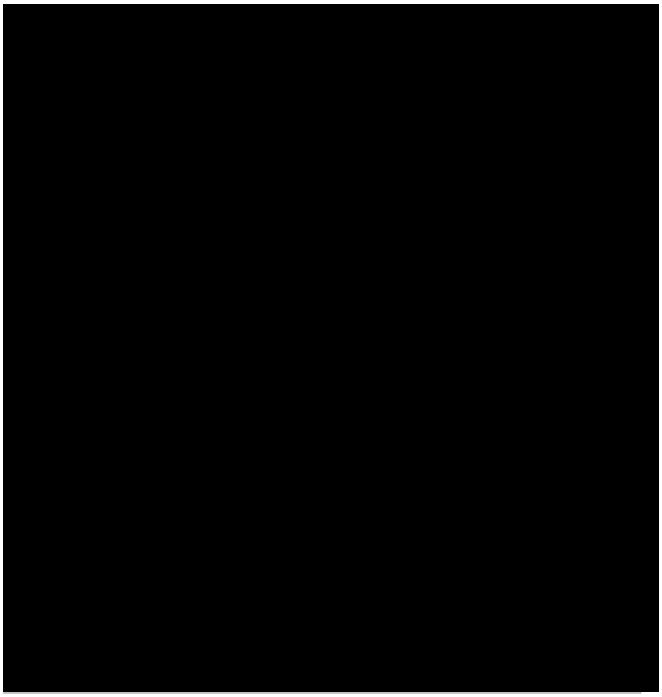
Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Animal Impact
10153-20190621-1	66,710	loam	wet	2.9	0.5	full sun	none

[redacted]

Element Occurrence ID – 12221

Mackinac County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	AB
Visit Dates	6/19/2020, 6/18/2020
Surveyors	Lynn Kirkpatrick
Estimated Population Area (ac)	4545.2
Number of Patches	14
Population estimate	1,230,000 – 4,500,000
10 year extinction probability	13%
Ownership Types	Private, State



[redacted] (EO ID 12221) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, qualitative, and genetic were conducted between 2019 and 2023 with the last survey completed on 06/19/2020.

Survey Results

Access was granted on State lands for survey. Large vague source features were retained to represent potential patches on private lands. Spatial surveys resulted in an expansion of the estimated populated area from 4543.1 to 4545.2 acres. The number of mostly contiguous patches increased from 4 to 14. Flowers/fruits were of frequent abundance during survey(s). No white flowers were observed. Habitat data was collected at 9 points in the population (Table 12224-1).

[redacted]

Table 12221 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

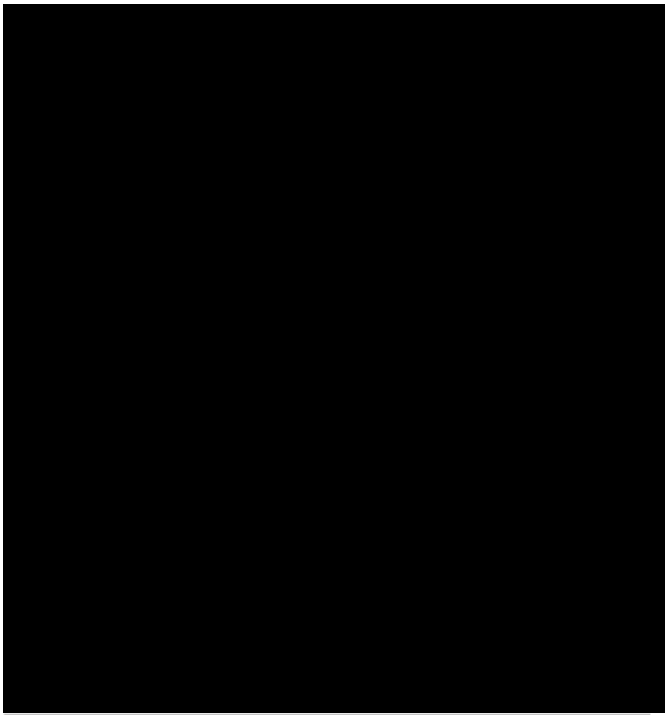
Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
12221-20200618-Qualitative_habitat-3	66,742	loamy sand	dry	1.0	0.3	full shade	40	low
12221-20200618-Qualitative_habitat-4	66,741	loamy sand	dry	1.0	0.5	full shade	40	low
12221-20200618-Qualitative_habitat-5	66,741	loamy sand	moist	3.5	0.5	full shade	50	low
12221-20200618-Qualitative_habitat-6	66,745	loamy sand	moist	1.5	1.0	partial sun	80	low
12221-20200618-Qualitative_habitat-7	66,745	loamy sand	saturated	1.0	0.2	full sun	70	
12221-20200618-Qualitative_habitat-8	66,746	other	saturated	11.0	0.5	full sun	75	low
12221-20200618-Qualitative_habitat-9	66,744	loamy sand	moist	9.0	0.5	partial sun	40	low
12221-20200619-Qualitative_habitat-1	66,736	loamy sand	saturated	3.0	0.5	full sun	10	low
12221-20200619-Qualitative_habitat-2	66,737	other	moist	9.0	1.5	partial sun	40	low

Leaf samples were collected for genetic analysis. Results from those efforts can be found in Cohen, J. I., and S. Turgman-Cohen. 2023. The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic. Plants 12: 1–17.

Element Occurrence ID - 12376

Mackinac County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	AB
Visit Dates	6/10/2020, 6/24/2019, 6/10/2021, 6/8/2021, 6/2/2022, 6/3/2022, 5/23/2023
Surveyors	Rachel Hackett, Diana Diggs, Marta Springer, Liam Daniels
Estimated Population Area (ac)	88
Number of Patches	11
Population estimate	15,000 – 25,000
10 year extinction probability	29%
Ownership Types	Private, State



[redacted] (EO ID 12376) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type count, demographic, and genetic were conducted between 2019 and 2023 with the last survey completed on 05/23/2023.

Survey Results

The reduction of acreage is not likely due to a reduction of population of refinement of vague spatial documentation. Spatial surveys resulted in a refining of the estimated populated area from 171.4 to 88 acres. The number of mostly contiguous patches increased from 6 to 11. Flowers/fruits were of frequent abundance during survey(s). No white flowers were observed. Habitat data was collected at 39 points in the population (Table 12376-1). Population count data was collected at xx plots with some demographic plots from 2019-2021 (Table 12376-2).

[redacted]

Table 12376 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
12376-20190624-1	66,711	loamy sand	moist	9.2	0.80			low
12376-20190624-2	66,711	sand	wet	2.5	0.25			low
12376-20190624-3	66,711	sand	wet	22.5	1.50			low
12376-20190624-4	66,711	sandy loam	saturated	9.9	0.50			
12376-20190624-5	66,711	sand	saturated	4.0	1.20			low
12376-20190624-6	66,711	loamy sand	wet	2.4	1.70			low
12376-20200610-1	66,711	sand	inundated	0.0	0.00	full sun	65	none
12376-20200610-2	66,711	sand	saturated	0.0	0.00	full shade	20	none
12376-20200610-3	66,711	sand	moist	5.5	1.60	full shade	5	low
12376-20200610-5	66,711	sand	wet	3.5	1.40	full sun	95	low
12376-20200610-6	66,711	sandy loam	wet	1.7	3.00	partial sun	25	low
12376-20210608-1	66,711	loamy sand	dry	7.0	0.40	full shade	15	none
12376-20210608-21	66,711	loamy sand	wet	9.0	0.40	full shade	25	none
12376-20210608-3	66,711	sand	moist	1.0	2.00	full shade	5	low
12376-20210608-4	66,711	loamy sand	wet	6.0	3.50	full sun	100	none
12376-20210608-5	66,711	sand	moist	1.0	2.00	partial sun	90	low
12376-20210608-6	66,711	loam	moist	4.0	1.00	full shade	35	high
12376-20210610-22	66,711	sand	dry	0.0	4.00	partial sun	60	low
12376-20210610-23	66,711	loamy sand	moist	10.0	1.00	full shade	15	none
12376-20220602-31	66,711	loam	moist	5.5	1.80	full shade	15	low
12376-20220602-32	66,711	sand	dry	0.0	0.10	full shade	10	low
12376-20220602-33	66,711	sand	dry	19.5	3.00	partial sun	5	low
12376-20220602-34	66,711	loamy sand	wet	18.0	1.80	full sun	75	low
12376-20220602-35	66,711	loamy sand	moist	2.5	7.00	partial sun	25	low
12376-20220602-36	66,711	sand	dry	35.0	0.75	full shade	5	none
12376-20220602-37	66,711	sand	dry	0.0	0.50	full sun	95	none

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
12376-20220602-38	66,711	sand	dry	3.5	1.75	partial sun	35	low
12376-20220602-39	66,711	loamy sand	dry	8.6	0.25	full shade	5	none
12376-20220602-40	66,711	loamy sand	dry	7.5	1.00	full shade	15	none
12376-20230523-41	66,711	loam	moist	6.3	2.00	full shade	15	low
12376-20230523-42	66,711	sand	dry	7.0	0.80	partial sun	15	none
12376-20230523-43	66,711	sand	moist	4.0	1.50	full shade	20	none
12376-20230523-44	66,711	sand	moist	0.0	0.50	full shade	10	none
12376-20230523-45	66,711	sand	moist	7.7	3.00	partial sun	40	none
12376-20230523-46	66,711	sand	moist	19.0	0.80	full shade	10	none
12376-20230523-47	66,711	sand	dry	0.0	0.50	partial sun	10	none
12376-20230523-48	66,711	sand	dry	10.0	2.00	full shade	50	none
12376-20230523-49	66,711	loamy sand	dry	3.3	0.20	partial sun	15	none
12376-20230523-50	66,711	sand	dry	4.5	0.80	full shade	15	none

Table 12376 -2. List of plots where population data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Juveniles	Sterile Adults	Reproductive Adults	Dead (demographic only)	Total Ramets
12376-20190624-1	66,711	0	12	5	0	17
12376-20190624-2	66,711	0	38	0	0	38
12376-20190624-3	66,711	0	35	7	0	42
12376-20190624-4	66,711	0	26	6	0	32
12376-20190624-5	66,711	0	69	22	0	91
12376-20190624-6	66,711	0	31	1	0	32
12376-20200610-1	66,711	0	6	0	1	7
12376-20200610-2	66,711	0	0	0	0	0
12376-20200610-3	66,711	5	41	3	4	53
12376-20200610-5	66,711	5	81	26	5	117
12376-20200610-6	66,711	1	35	6	2	44
12376-20210608-1	66,711	9	0	0	1	9
12376-20210608-21	66,711	31	4	0	0	35
12376-20210608-3	66,711	7	46	0	12	53
12376-20210608-4	66,711	9	1	0	19	10
12376-20210608-5	66,711	3	72	18	29	93
12376-20210608-6	66,711	4	36	5	9	45
12376-20210610-22	66,711	6	77	0	0	83
12376-20210610-23	66,711	44	4	0	0	48
12376-20220602-31	66,711	3	60	10	0	73
12376-20220602-32	66,711	24	84	4	0	112
12376-20220602-33	66,711	2	48	9	0	59
12376-20220602-34	66,711	32	69	5	0	106
12376-20220602-35	66,711	3	39	13	0	55
12376-20220602-36	66,711	8	39	0	0	47
12376-20220602-37	66,711	1	129	42	0	172
12376-20220602-38	66,711	18	85	4	0	107
12376-20220602-39	66,711	15	8	0	0	23
12376-20220602-40	66,711	17	37	0	0	54
12376-20230523-41	66,711	6	30	8	0	44
12376-20230523-42	66,711	6	55	2	0	63
12376-20230523-43	66,711	7	122	0	0	129
12376-20230523-44	66,711	21	36	0	0	57
12376-20230523-45	66,711	5	41	10	0	56
12376-20230523-46	66,711	7	36	0	0	43
12376-20230523-47	66,711	28	50	0	0	78
12376-20230523-48	66,711	17	45	0	0	62
12376-20230523-49	66,711	29	18	0	0	47
12376-20230523-50	66,711	11	5	0	0	16

The following adventive species were observed as potential threats to the population:

Scientific Name	Common Name	Abundance
Centaurea stoebe; c. maculosa	spotted knapweed	occasional
Hieracium piloselloides	king devil	frequent
Phragmites australis var. australis	reed	occasional
Silene vulgaris	bladder campion	occasional

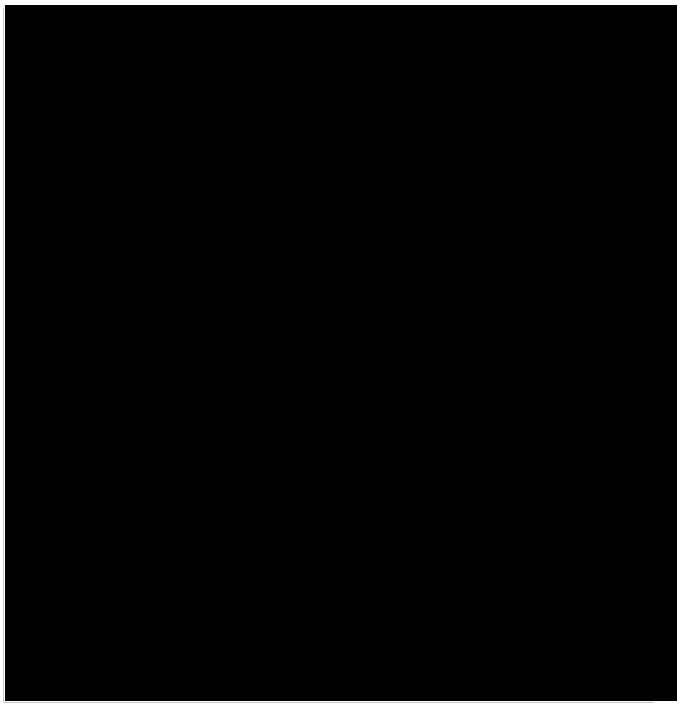
Leaf samples were collected for genetic analysis. Results from those efforts can be found in Cohen, J. I., and S. Turgman-Cohen. 2023. The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic. Plants 12: 1–17.

[redacted]

Element Occurrence ID - 12547

Mackinac County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	C
Visit Dates	06/12/2020
Surveyors	Jodi Spieles
Estimated Population Area (ac)	7.4
Number of Patches	3
Population estimate	0 – 10,000
10 year extinction probability	54%
Ownership Types	Private



[redacted] (EO ID 12547) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 06/12/2020.

Survey Results

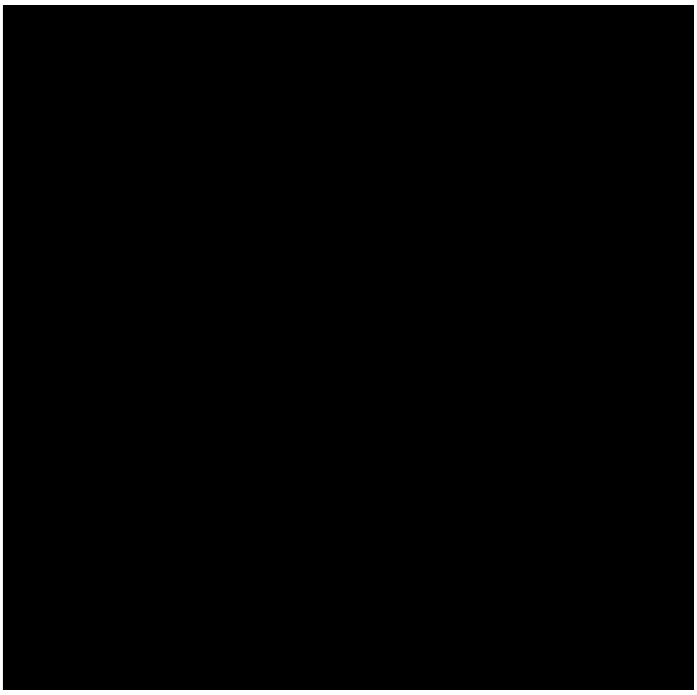
Although surveyors failed to find in surveyed area, EO rank was not changed due to inability to survey portions of mapped area due to lack permission from land owner. Maximum population was derived from last survey estimate (1993).

[redacted]

Element Occurrence ID - 12548

Mackinac County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	B
Visit Dates	06/10/2019
Surveyors	Jodi Spieles
Estimated Population Area (ac)	154.3
Number of Patches	6
Population estimate	100 – 1,000
10 year extinction probability	100%
Ownership Types	Private



[redacted] (EO ID 12548) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial were conducted between 2019 and 2023 with the last survey completed on 06/10/2019.

Survey Results

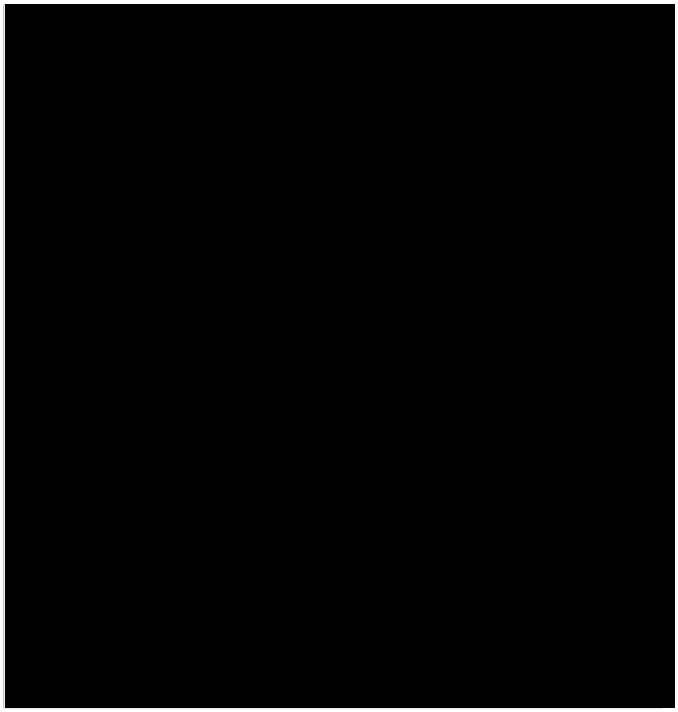
Access was granted on select Private lands for survey. Large vague source features were retained to represent potential patches on private lands. Spatial surveys resulted in an expansion of the estimated populated area from 144.2 to 154.3 acres. The number of mostly contiguous patches increased from 5 to 6.

[redacted]

Element Occurrence ID - 12862

Mackinac County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	A
Visit Dates	6/16/2020, 6/15/2020
Surveyors	Lynn Kirkpatrick
Estimated Population Area (ac)	2443.7
Number of Patches	20
Population estimate	2,206,000 – 5,420,000
10 year extinction probability	10%
Ownership Types	Non-Governmental Organization, Private, State



[redacted] (EO ID 12862) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, qualitative, and genetic were conducted between 2019 and 2023 with the last survey completed on 06/16/2020.

Survey Results

Access was granted on State and NGO lands for survey. Large vague source features were retained to represent potential patches on private lands. Spatial surveys resulted in an expansion of the estimated populated area from 2412.6 to 2443.7 acres. The number of mostly contiguous patches increased from 6 to 20. Flowers/fruits were of occasional abundance during survey(s). No white flowers were observed. Habitat data was collected at 7 points in the population (Table 12862-1).

[redacted]

Table 12862 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

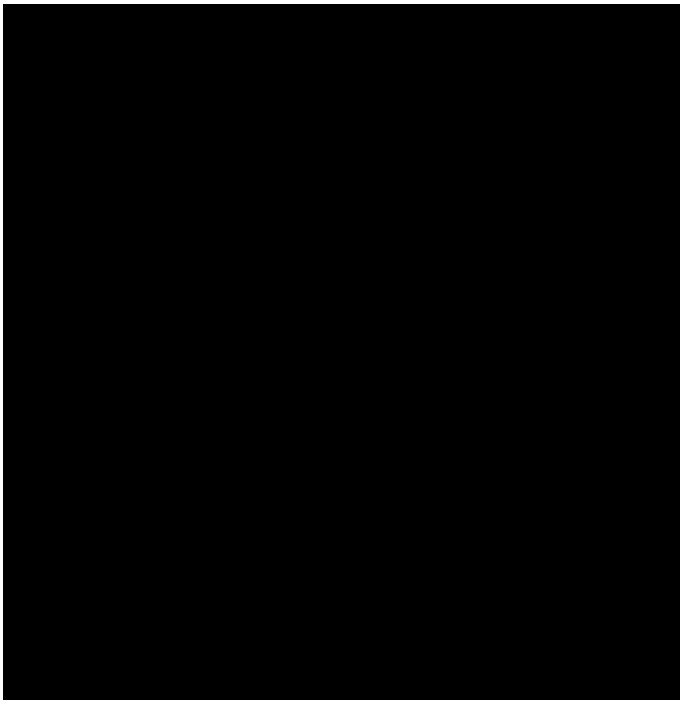
Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
12862-20200615-Qualitative_habitat-6	66,727	loamy sand	dry	1.0	0.8	full sun	80	low
12862-20200616-Qualitative_habitat-1	66,729	loamy sand	moist	5.3	1.8	full shade	30	low
12862-20200616-Qualitative_habitat-2	66,727	loamy sand	dry	3.5	0.2	full sun	90	none
12862-20200616-Qualitative_habitat-3	66,727	loamy sand	moist	2.5	0.5	partial sun	60	low
12862-20200616-Qualitative_habitat-4	66,722	loamy sand	moist	6.5	0.5	partial sun	60	low
12862-20200616-Qualitative_habitat-5	66,722	loamy sand	moist	7.2	1.0	partial sun	40	low
12862-20200616-Qualitative_habitat-7	66,729	sand	moist	5.2	2.4	partial sun	50	

Leaf samples were collected for genetic analysis. Results from those efforts can be found in Cohen, J. I., and S. Turgman-Cohen. 2023. The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic. Plants 12: 1–17.

Element Occurrence ID - 24245

Mackinac County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	C
Visit Dates	6/15/2020, 6/16/2023
Surveyors	Jodi Spieles, Rachel Hackett
Estimated Population Area (ac)	1.4
Number of Patches	3
Population estimate	500 - 850
10 year extinction probability	53%
Ownership Types	Federal



[redacted] (EO ID 24245) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 06/16/2023.

Survey Results

Documentation for this population was discovered as a result of a data mining effort funded by Great Lakes Restoration Initiative through US Fish and Wildlife Service (F18AC00566). EO Rank changed from E to C as a result of the survey effort. Spatial surveys resulted in an expansion of the estimated populated area from 0 to 1.4 acres. The number of mostly contiguous patches increased from 0 to 3. Flowers/fruits were of NA abundance during survey(s). No white flowers were observed. Habitat data was collected at 2 points in the population (Table 24245-1).

[redacted]

Table 24245 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
24245-20200615-Qualitative_habitat-1	66,719	loamy sand	moist	10	2	full sun	90	low
24245-20200615-Qualitative_habitat-2	66,720	sandy loam	wet	12	1	full sun	80	

The following adventive species were observed as potential threats to the population:

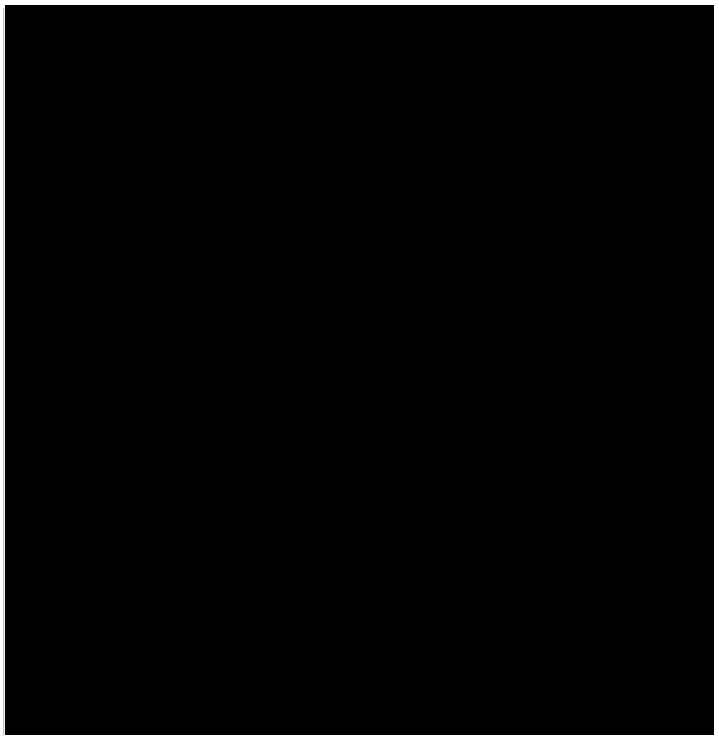
Scientific Name	Common Name	Abundance
Centaurea stoebe; c. maculosa	spotted knapweed	occasional
Mycelis muralis; lactuca m.	wall lettuce	frequent
Berberis thunbergii	Japanese barberry	rare
Cirsium palustris	marsh thistle	frequent
Euphorbia virgata	leafy spurge	occasional

[redacted]

Element Occurrence ID - 5149

Menominee County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	BC
Visit Dates	6/5/2021
Surveyors	Rachel Hackett
Estimated Population Area (ac)	16.9
Number of Patches	3
Population estimate	11,000 – 21,000
10 year extinction probability	34%
Ownership Types	Private



[redacted] (EO ID 5149) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 06/05/2021.

Survey Results

Access was granted on select Private lands for survey. Spatial surveys resulted in an expansion of the estimated populated area from 15.8 to 16.9 acres. The number of mostly contiguous patches increased from 2 to 3. Flowers/fruits were of occasional abundance during survey(s). No white flowers were observed. Habitat data was collected at 5 points in the population.

[redacted]

Table 5149 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
5149-20210605-Qualitative_habitat-6	31,807	loamy sand	moist	6.6	3.3	partial sun	50	none
5149-20210605-Qualitative_habitat-7	31,807	loam	dry	10.0	0.8	partial sun	80	low
5149-20210605-Qualitative_habitat-8	31,807	sandy loam	dry	10.3	1.3	partial sun	55	none
5149-20210605-Qualitative_habitat-16	68,355	other	dry	0.0	1.0	full sun	100	none
5149-20210605-Qualitative_habitat-17	68,355	other	dry		1.0	full sun		none

The following adventive species were observed as potential threats to the population:

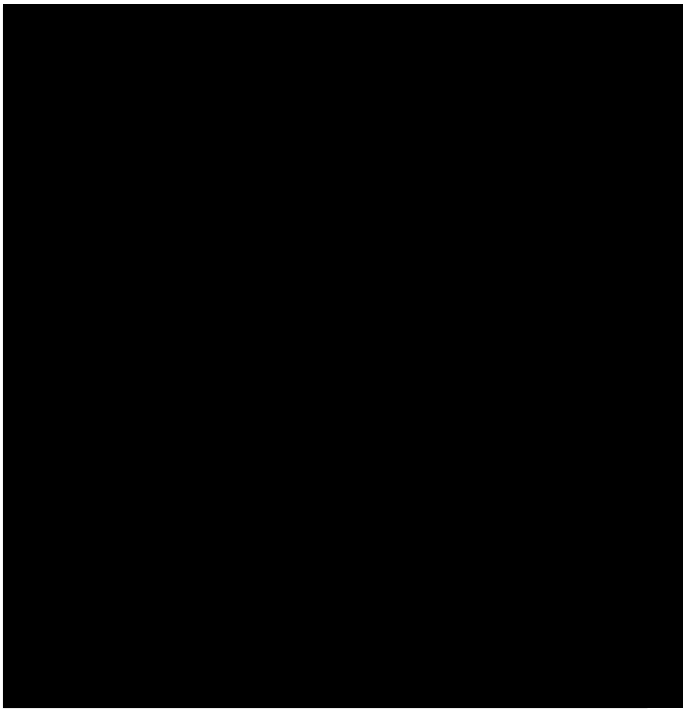
Scientific Name	Common Name	Abundance
Bromus inermis	smooth brome	occasional
Centaurea stoebe; c. maculosa	spotted knapweed	frequent
Elaeagnus umbellata	autumn-olive	frequent
Hypericum perforatum	common st. johns-wort	occasional

[redacted]

Element Occurrence ID – 15125

Menominee County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	BC
Visit Dates	6/9/2020, 6/18/2019, 6/5/2021, 6/1/2022, 5/22/2023
Surveyors	Rachel Hackett, Zach Pitman, Marta Springer, Liam Daniels
Estimated Population Area (ac)	0.6
Number of Patches	1
Population estimate	2,500 – 5,000
10 year extinction probability	39%
Ownership Types	State



[redacted] (EO ID 15125) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, count, demographic, and genetic were conducted between 2019 and 2023 with the last survey completed on 05/22/2023.

Survey Results

The reduction of acreage is not likely due to a reduction of population of refinement of vague spatial documentation. Spatial surveys resulted in a refining of the estimated populated area from 1.9 to 0.6 acres. Flowers/fruits were of frequent abundance during survey(s). No white flowers were observed. Habitat data was collected at 45 points in the population (Table 15125-1). Population count data was collected at 45 plots with some demographic plots from 2019-2021 (Table 15125-2).

[redacted]

Table 15125 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
15125-20190618-1	66,717	loamy sand	wet	3.00	1.50			low
15125-20190618-2	66,717	sandy loam	moist	6.00	0.50			low
15125-20190618-3	66,717	clay loam	moist	8.50	1.00			low
15125-20190618-4	66,717	loamy sand	moist	17.00	0.50			none
15125-20190618-5	66,717	loamy sand	moist	7.00	3.00			low
15125-20190618-6	66,717	loamy sand	moist	10.40	1.75			high
15125-20190618-7	66,717	sandy loam	moist	5.80	1.50			low
15125-20190618-8	66,717	sandy loam	moist	4.10	0.30			none
15125-20190618-9	66,717	clay loam	moist	1.40	2.00			none
15125-20200609-1	66,717	clay loam	moist	12.40	1.20	full sun	50	low
15125-20200609-11	66,717	clay loam	moist	7.60	0.50	partial sun	60	low
15125-20200609-12	66,717	sandy loam	moist	5.00	2.20	full sun	95	low
15125-20200609-4	66,717	sandy loam	dry	3.40	0.20	full sun	95	none
15125-20200609-5	66,717	sandy loam	moist	5.80	1.50	partial sun	25	
15125-20200609-7	66,717	sandy loam	moist	1.40	0.50	partial sun	80	low
15125-20210605-1	66,717	clay loam	moist	10.00	7.00	full sun	65	low
15125-20210605-21	66,717	loamy clay	moist	14.50	4.20	full sun	95	low
15125-20210605-22	66,717	clay loam	dry	5.50	4.50	full sun	100	none
15125-20210605-23	66,717	sandy loam	moist	5.20	2.00	full sun	100	low
15125-20210605-24	66,717	sandy loam	moist	5.50	2.00	full sun	95	low
15125-20210605-25	66,717	loamy sand	moist	3.00	1.00	full sun	100	none
15125-20210605-26	66,717	loamy sand	moist	5.80	4.80	full sun	100	none
15125-20210605-4	66,717	sandy loam	moist	5.20	3.20	full sun	100	low
15125-20210605-5	66,717	sandy loam	dry	7.40	2.80	full shade	50	high
15125-20210605-7	66,717	sandy loam	moist	5.50	2.20	partial sun	85	low
15125-20220601-31	66,717	loam	moist	6.80	1.50	full shade	75	low

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
15125-20220601-32	66,717	loam	dry	7.25	1.30	full sun	100	none
15125-20220601-33	66,717	sandy loam	dry	5.00	0.25	full sun	100	low
15125-20220601-34	66,717	sandy loam	dry	9.80	2.50	full sun	90	low
15125-20220601-35	66,717	sandy loam	dry	5.00	1.80	partial sun	60	high
15125-20220601-36	66,717	loamy sand	dry	5.50	0.50	partial sun	60	low
15125-20220601-37	66,717	sandy loam	dry	6.00	1.75	full sun	80	high
15125-20220601-38	66,717	sandy loam	dry	3.50	0.25	partial sun	95	high
15125-20220601-39	66,717	loamy sand	dry	2.20	0.50	full sun	100	low
15125-20220601-40	66,717	sandy loam	dry	5.50	1.50	full sun	100	low
15125-20230522-41	66,717	sandy loam	moist	7.80	1.70	full sun	90	low
15125-20230522-42	66,717	sandy loam	moist	2.70	0.90	full sun	90	none
15125-20230522-43	66,717	loamy sand	moist	5.00	2.50	partial sun	75	low
15125-20230522-44	66,717	sandy loam	moist	4.00	1.50	partial sun	60	low
15125-20230522-45	66,717	sandy loam	wet	2.50	5.00	full shade	10	low
15125-20230522-46	66,717	sandy loam	moist	5.10	2.20	full shade	35	low
15125-20230522-47	66,717	loamy sand	dry	1.60	0.50	full sun	100	none
15125-20230522-48	66,717	sandy loam	dry	5.50	0.80	full sun	95	none
15125-20230522-49	66,717	sandy loam	moist	8.00	2.00	full sun	95	none
15125-20230522-50	66,717	sandy loam	moist	4.80	1.80	full sun	90	none

Table 15125 -2. List of plots where population data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Juveniles	Sterile Adults	Reproductive Adults	Dead (demographic only)	Total Ramets
15125-20190618-1	66,717	0	111	4	0	115
15125-20190618-2	66,717	2	165	21	0	188
15125-20190618-3	66,717	14	187	10	0	211
15125-20190618-4	66,717	0	13	6	0	19
15125-20190618-5	66,717	0	52	1	0	53
15125-20190618-6	66,717	0	7	0	0	7
15125-20190618-7	66,717	3	39	6	0	48
15125-20190618-8	66,717	1	2	0	0	3
15125-20190618-9	66,717	3	54	8	0	65
15125-20200609-1	66,717	1	88	2	15	106
15125-20200609-11	66,717	6	68	1	0	75

[redacted]

Event ID	Source Feature	Juveniles	Sterile Adults	Reproductive Adults	Dead (demographic only)	Total Ramets
15125-20200609-12	66,717	12	207	13	0	232
15125-20200609-4	66,717	4	18	0	1	22
15125-20200609-5	66,717	1	53	1	6	61
15125-20200609-7	66,717	15	55	5	1	76
15125-20210605-1	66,717	5	117	10	29	132
15125-20210605-21	66,717	5	90	9	0	104
15125-20210605-22	66,717	4	25	1	0	30
15125-20210605-23	66,717	2	36	4	0	42
15125-20210605-24	66,717	5	16	2	0	23
15125-20210605-25	66,717	18	82	1	0	101
15125-20210605-26	66,717	1	70	7	0	78
15125-20210605-4	66,717	5	30	2	1	37
15125-20210605-5	66,717	7	53	2	10	62
15125-20210605-7	66,717	18	72	4	7	94
15125-20220601-31	66,717	18	67	0	0	85
15125-20220601-32	66,717	8	3	0	0	11
15125-20220601-33	66,717	1	11	2	0	14
15125-20220601-34	66,717	31	258	24	0	313
15125-20220601-35	66,717	26	32	0	0	58
15125-20220601-36	66,717	25	56	11	1	92
15125-20220601-37	66,717	7	33	6	0	46
15125-20220601-38	66,717	5	14	0	0	19
15125-20220601-39	66,717	14	63	9	0	86
15125-20220601-40	66,717	0	15	1	1	16
15125-20230522-41	66,717	2	4	0	0	6
15125-20230522-42	66,717	4	26	7	0	37
15125-20230522-43	66,717	8	46	12	0	66
15125-20230522-44	66,717	10	59	13	0	82
15125-20230522-45	66,717	26	9	0	0	35
15125-20230522-46	66,717	5	51	7	0	63
15125-20230522-47	66,717	2	17	0	0	19
15125-20230522-48	66,717	7	28	4	0	39
15125-20230522-49	66,717	2	25	7	0	34
15125-20230522-50	66,717	45	9	6	0	60

The following adventive species were observed as potential threats to the population:

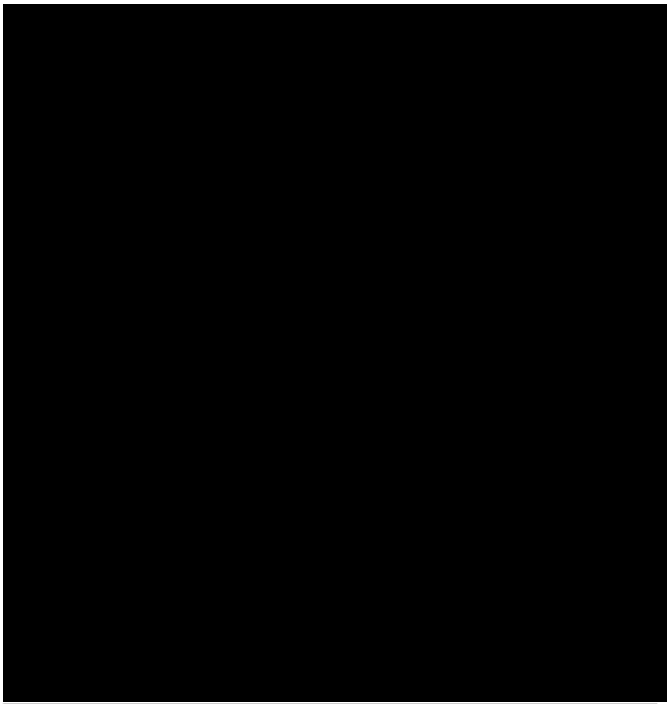
Scientific Name	Common Name	Abundance
Centaurea stoebe; c. maculosa	spotted knapweed	frequent
Hieracium piloselloides	king devil	frequent

Leaf samples were collected for genetic analysis. Results from those efforts can be found in Cohen, J. I., and S. Turgman-Cohen. 2023. The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic. Plants 12: 1–17.

Element Occurrence ID – 15176

Menominee County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	C
Visit Dates	6/18/2019
Surveyors	Rachel Hackett, Zach Pitman
Estimated Population Area (ac)	2.2
Number of Patches	1
Population estimate	35,00 – 12,000
10 year extinction probability	45%
Ownership Types	State



[redacted] (EO ID 15176) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, qualitative, and genetic were conducted between 2019 and 2023 with the last survey completed on 06/18/2019.

Survey Results

The reduction of acreage is not likely due to a reduction of population of refinement of vague spatial documentation. Spatial surveys resulted in an expansion of the estimated populated area from 1.9 to 2.2 acres. Flowers/fruits were of rare abundance during survey(s). No white flowers were observed. Habitat data was collected at 3 points in the population (Table 15176-1).

Table 15176 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Animal Impact
15176-20190618-3	66,718	clay loam	moist	10.4	4.6	low
15176-20190618-4	66,718	loamy clay	moist	12.4	3.1	low
15176-20190618-5	66,718	loamy sand	moist	9.7	2.8	none

Leaf samples were collected for genetic analysis. Results from those efforts can be found in Cohen, J. I., and S. Turgman-Cohen. 2023. The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic. Plants 12: 1–17.

[redacted]

Element Occurrence ID – 2235

Presque Isle County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	D
Visit Dates	5/26/2022
Surveyors	Rachel Hackett
Estimated Population Area (ac)	7.7
Number of Patches	1
Population estimate	250 - 500
10 year extinction probability	94%
Ownership Types	Private, State

[redacted]

[redacted] (EO ID 2235) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 05/27/2022.

Survey Results

After more precise spatial survey was conducted on this and nearby populations, the following element occurrences may be merged due to less than 1000 m of separation between patches: Besser Natural Area (EOID 2235), Rockport North (EOID 5551), and Stevenson's Fen (EOID 10080). EO Rank changed from B to D as a result of the survey effort. Flowers/fruits were of rare abundance during survey(s). No white flowers were observed.

[redacted]

Element Occurrence ID – 5551

Presque Isle County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	AB
Visit Dates	5/27/2022, 6/6/2023
Surveyors	Rachel Hackett, Nicole Smith
Estimated Population Area (ac)	109.2
Number of Patches	5
Population estimate	201,000 – 504,000
10 year extinction probability	12%
Ownership Types	State

[redacted]

[redacted] (EO ID 5551) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 06/06/2023.

Survey Results

After more precise spatial survey was conducted on this and nearby populations, the following element occurrences may be merged due to less than 1000 m of separation between patches: Besser Natural Area (EOID 2235), Rockport North (EOID 5551), and Stevenson's Fen (EOID 10080). EO Rank changed from C to AB as a result of the survey effort. Spatial surveys resulted in an expansion of the estimated populated area from 81.1 to 109.2 acres. The number of mostly contiguous patches increased from 2 to 5. Flowers/fruits were of occassional abundance during survey(s). White flowers were of rare abundance during survey(s).

The following adventive species were observed as potential threats to the population:

Scientific Name	Common Name	Abundance
Centaurea stoebe; c. maculosa	spotted knapweed	frequent
Mycelis muralis; lactuca m.	wall lettuce	rare

[redacted]

Element Occurrence ID – 8162

Presque Isle County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	B
Visit Dates	6/17/2020, 5/30/2019, 5/27/2021, 6/16/2022, 6/2/2023
Surveyors	Rachel Hackett, Mirabai Moseley, Marley Huijgen, Liam Daniels
Estimated Population Area (ac)	362.1
Number of Patches	5
Population estimate	1,000,000 – 5,000,000
10 year extinction probability	8%
Ownership Types	Private, State

[redacted]

[redacted] (EO ID 8162) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, count, and genetic were conducted between 2019 and 2023 with the last survey completed on 06/02/2023.

Survey Results

Spatial surveys resulted in an expansion of the estimated populated area from 361.2 to 362.1 acres. The number of mostly contiguous patches increased from 3 to 5. Flowers/fruits were of frequent abundance during survey(s). No white flowers were observed. Habitat data was collected at 49 points in the population (Table 8162-1). Population count data was collected at 49 plots (Table 8162-2).

[redacted]

Table 8162 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
8162-20190530-1	15,674	clay loam		4.5	2.50			low
8162-20190530-10	15,674	loamy clay	moist	5.0	3.00			low
8162-20190530-2	15,674	clay loam	moist	5.0	0.50			none
8162-20190530-3	15,674	loamy clay	moist	9.5	3.50			none
8162-20190530-4	15,674	loamy clay	dry	4.5	0.75			low
8162-20190530-5	15,674	clay	moist	6.5	1.00			low
8162-20190530-6	15,674	clay	moist	6.5	0.50			none
8162-20190530-7	15,674	loam	dry	2.0	1.00			low
8162-20190530-8	15,674	loamy clay	moist	3.5	1.50			none
8162-20190530-9	15,674	clay loam	dry	5.5	1.25			low
8162-20200617-11	15,674	loamy clay	moist	11.0	1.60	partial sun	20	none
8162-20200617-12	15,674	clay loam	dry	3.5	3.20	partial sun	70	low
8162-20200617-13	15,674	clay loam	moist	5.8	2.50	partial sun	40	none
8162-20200617-14	15,674	clay loam	dry	4.8	0.60	partial sun	70	none
8162-20200617-15	15,674	loamy clay	dry	10.6	0.40	partial sun	80	low
8162-20200617-16	15,674	clay loam	dry	4.8	0.60	full sun	95	low
8162-20200617-17	15,674	loamy clay	wet	5.6	4.50	full sun	100	none
8162-20200617-18	15,674	loamy clay	moist	5.8	1.80	partial sun	55	none
8162-20200617-19	15,674	clay loam	dry	3.0	0.40	full sun	100	none
8162-20200617-20	15,674	clay loam	dry	5.8	3.50	partial sun	65	low
8162-20210527-21	15,674	loam	dry	6.2	3.50	full shade	10	none
8162-20210527-22	15,674	loam	dry	2.0	2.10	partial sun	50	none
8162-20210527-23	15,674	clay loam	moist	3.4	1.80	partial sun	50	low
8162-20210527-24	15,674	loam	moist	3.4	5.80	full sun	95	none
8162-20210527-25	15,674	loamy clay	moist	6.0	2.50	full sun	100	none
8162-20210527-26	15,674	loamy clay	moist	4.1	2.10	full sun	100	none
8162-20210527-27	15,674	loamy clay	wet	4.0	4.20	full sun	100	none
8162-20210527-28	15,674	clay loam	moist	6.6	4.60	full shade	5	none
8162-20210527-29	15,674	loamy clay	moist	4.0	2.50	partial sun	70	low
8162-20210527-30	15,674	clay loam	dry	5.2	2.60	full sun	70	high
8162-20220616-31	15,674	clay	moist	8.8	3.00	full shade	70	low
8162-20220616-32	15,674	loamy clay	moist	12.9	1.50	full shade	10	low
8162-20220616-33	15,674	clay	moist	9.0	1.50	partial sun	50	low
8162-20220616-34	15,674	clay	dry	8.3	1.50	full shade	25	low
8162-20220616-35	15,674	clay	moist	4.0	1.00	partial sun	95	low
8162-20220616-36	15,674	clay	dry	3.0	1.50	partial sun	60	low
8162-20220616-37	15,674	clay	moist	7.6	1.80	partial sun	60	low
8162-20220616-38	15,674	loamy clay	dry	15.5	4.00	partial sun	60	low
8162-20220616-39	15,674	clay	moist	10.7	4.00	full shade	20	low
8162-20220616-40	15,674	loamy clay	dry	8.0	3.00	partial sun	10	low
8162-20230602-41	15,674	loam	dry	5.5	1.00	partial sun	60	low
8162-20230602-42	15,674	loam	dry	4.0	1.50	full shade	15	high
8162-20230602-43	15,674	clay loam	moist	5.0	0.50	partial sun	60	low
8162-20230602-44	15,674	loam	dry	6.0	3.00	full sun	100	low
8162-20230602-46	15,674	clay loam	dry	3.0	2.50	full sun	40	low
8162-20230602-47	15,674	clay loam	moist	13.0	3.50	full sun	80	low
8162-20230602-48	15,674	other	dry	0.0	3.00			high
8162-20230602-49	15,674	sandy loam	dry	2.0	0.50	full sun	65	low
8162-20230602-50	15,674	loam	dry	6.0	1.80	partial sun	70	none

Table 8162 -2. List of plots where population data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

[redacted]

Event ID	Source Feature	Juveniles	Sterile Adults	Reproductive Adults	Total Ramets
8162-20190530-1	15,674	11	66	0	77
8162-20190530-10	15,674	15	103	0	118
8162-20190530-2	15,674	3	57	8	68
8162-20190530-3	15,674	6	34	0	40
8162-20190530-4	15,674	2	25	0	27
8162-20190530-5	15,674	5	9	0	14
8162-20190530-6	15,674	2	8	0	10
8162-20190530-7	15,674	9	75	8	92
8162-20190530-8	15,674	36	110	58	204
8162-20190530-9	15,674	8	49	10	67
8162-20200617-11	15,674	11	65	5	81
8162-20200617-12	15,674	0	41	2	43
8162-20200617-13	15,674	0	35	3	38
8162-20200617-14	15,674	3	87	4	94
8162-20200617-15	15,674	2	20	1	23
8162-20200617-16	15,674	2	50	1	53
8162-20200617-17	15,674	5	83	1	89
8162-20200617-18	15,674	16	79	3	98
8162-20200617-19	15,674	12	50	0	62
8162-20200617-20	15,674	10	73	3	86
8162-20210527-21	15,674	2	40	0	42
8162-20210527-22	15,674	4	41	4	49
8162-20210527-23	15,674	4	39	2	45
8162-20210527-24	15,674	6	106	9	121
8162-20210527-25	15,674	15	113	6	134
8162-20210527-26	15,674	5	27	0	32
8162-20210527-27	15,674	2	30	0	32
8162-20210527-28	15,674	2	68	3	73
8162-20210527-29	15,674	3	111	1	115
8162-20210527-30	15,674	4	26	3	33
8162-20220616-31	15,674	0	32	0	32
8162-20220616-32	15,674	1	98	6	105
8162-20220616-33	15,674	3	99	0	102
8162-20220616-34	15,674	0	53	1	54
8162-20220616-35	15,674	4	184	11	199
8162-20220616-36	15,674	0	67	8	75
8162-20220616-37	15,674	8	107	4	119
8162-20220616-38	15,674	7	175	1	183
8162-20220616-39	15,674	4	29	7	40
8162-20220616-40	15,674	0	68	3	71
8162-20230602-41	15,674	1	59	2	62
8162-20230602-42	15,674	4	96	1	101
8162-20230602-43	15,674	2	55	8	65
8162-20230602-44	15,674	1	16	4	21
8162-20230602-46	15,674	0	185	33	218
8162-20230602-47	15,674	1	11	0	12
8162-20230602-48	15,674	3	25	0	28
8162-20230602-49	15,674	10	74	9	93
8162-20230602-50	15,674	11	118	9	138

The following adventive species were observed as potential threats to the population:

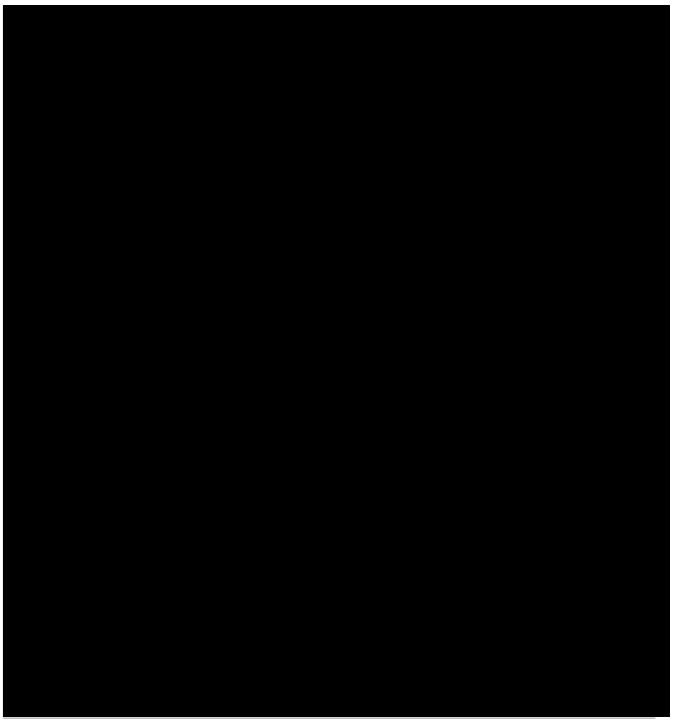
Scientific Name	Common Name	Abundance
Berberis vulgaris	common barberry	abundant
Centaurea stoebe; c. maculosa	spotted knapweed	occasional
Elaeagnus umbellata	autumn-olive	occasional
Mentha x piperita	peppermint	rare
Phalaris arundinacea	reed canary grass	occasional

Leaf samples were collected for genetic analysis. Results from those efforts can be found in Cohen, J. I., and S. Turgman-Cohen. 2023. The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic. Plants 12: 1–17.

Element Occurrence ID – 10080

Presque Isle County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	A
Visit Dates	5/28/2019, 5/28/2021, 5/26/2022
Surveyors	Rachel Hackett
Estimated Population Area (ac)	20.7
Number of Patches	11
Population estimate	510,000 – 5,100,000
10 year extinction probability	11%
Ownership Types	State



[redacted] (EO ID 10080) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 05/26/2022.

Survey Results

After more precise spatial survey was conducted on this and nearby populations, the following element occurrences may be merged due to less than 1000 m of separation between patches: Besser Natural Area (EOID 2235), Rockport North (EOID 5551), and Stevenson's Fen (EOID 10080). Spatial surveys resulted in a refining of the estimated populated area from 80.5 to 20.7 acres. The number of mostly contiguous patches increased from 1 to 11. Flowers/fruits were of frequent abundance during survey(s). White flowers were of abundance during survey(s). Habitat data was collected at 3 points in the population (Table 10080-1).

[redacted]

Table 10080 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
10080-20190528-3	66,073	loamy sand	wet		0.5	full sun		none
10080-20190528-10	66,072	clay	moist		1.5			none
10080-20210528-Qualitative_habitat-34	66,705	loamy clay	wet	11.5	2.9	full shade	40	low

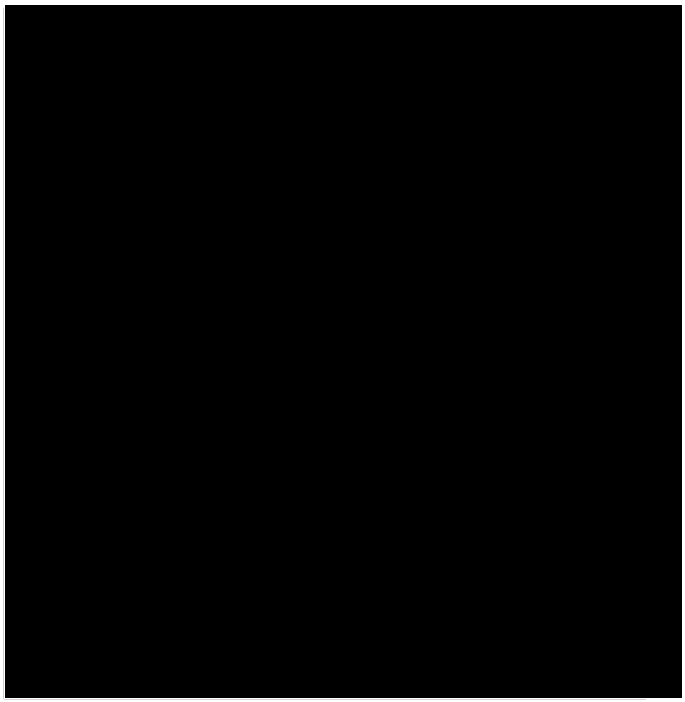
The following adventive species were observed as potential threats to the population:

Scientific Name	Common Name	Abundance
Centaurea stoebe; c. maculosa	spotted knapweed	frequent

Element Occurrence ID – 10481

Presque Isle County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	C
Visit Dates	5/28/2019
Surveyors	Rachel Hackett
Estimated Population Area (ac)	7.1
Number of Patches	2
Population estimate	5.300 – 11,000
10 year extinction probability	40%
Ownership Types	Private



[redacted] (EO ID 10481) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 05/28/2019.

Survey Results

Spatial surveys resulted in a refining of the estimated populated area from 7.7 to 7.1 acres. The number of mostly contiguous patches increased from 1 to 2. Flowers/fruits were of occasional abundance during survey(s). No white flowers were observed. Habitat data was collected at 5 points in the population (Table 10481-1).

[redacted]

Table 10481 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
10481-20190528-1	66,074	sandy loam	wet		3.0	partial sun		none
10481-20190528-2	66,074	loamy sand	wet		1.5	full shade		none
10481-20190528-3	66,074	sandy loam	moist		6.0	partial sun		
10481-20190528-4	66,074	sandy loam	moist		3.0	full shade		
10481-20190528-10	66,074	sandy loam	moist		1.0	full sun		

The following adventive species were observed as potential threats to the population:

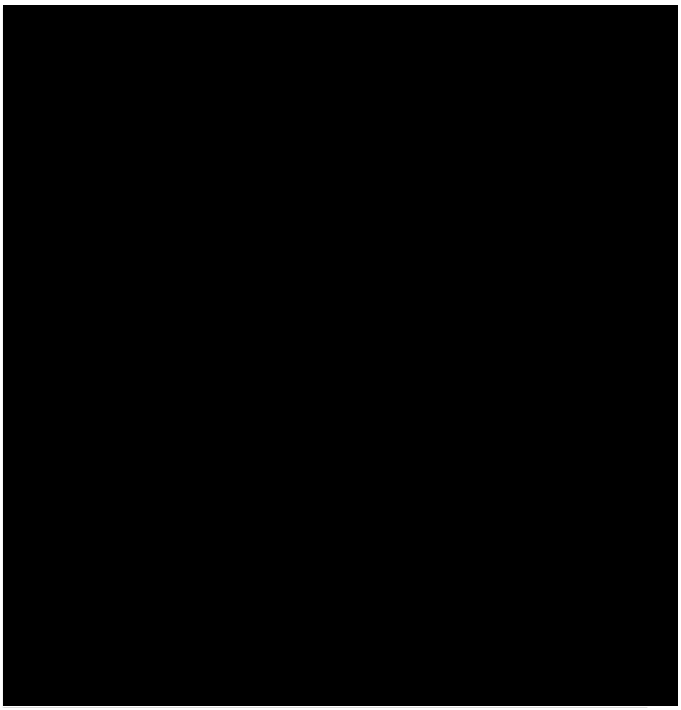
Scientific Name	Common Name	Abundance
Centaurea stoebe; c. maculosa	spotted knapweed	occasional

[redacted]

Element Occurrence ID - 10888

Presque Isle County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	B
Visit Dates	5/28/2019, 6/16/2021, 10/14/2021
Surveyors	Rachel Hackett
Estimated Population Area (ac)	194.4
Number of Patches	6
Population estimate	10,000 – 15,000
10 year extinction probability	37%
Ownership Types	Non-Governmental Organization, Private



[redacted] (EO ID 10888) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 08/22/2023.

Survey Results

Access was granted on NGO and select private lands only for survey. Large vague source features were retained to represent potential patches on private lands. Spatial surveys resulted in an expansion of the estimated populated area from 184.5 to 194.4 acres. The number of mostly contiguous patches increased from 4 to 6. Flowers/fruits were of occasional abundance during survey(s). No white flowers were observed. Habitat data was collected at 3 points in the population (Table 10888-1).

Table 10888 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

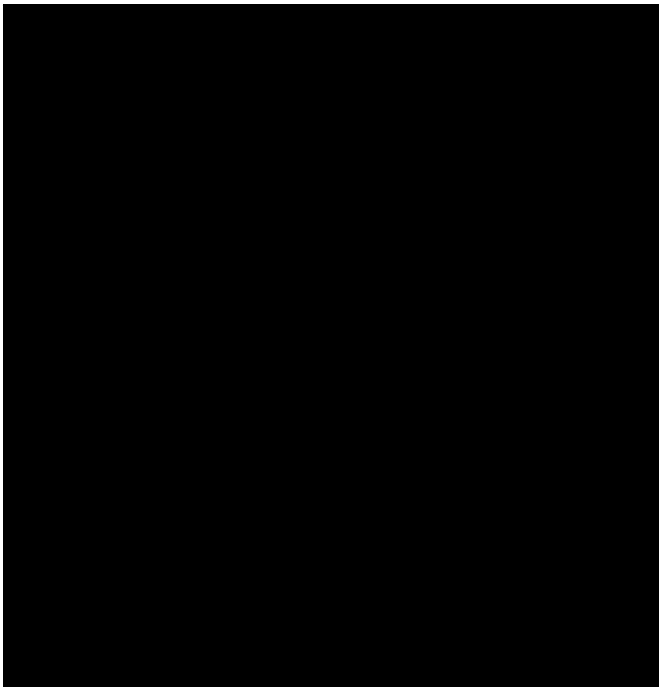
Event ID	Source Feature	Soil Type	Soil Moisture	Litter Depth (cm)	Sunlight Level	Animal Impact
10888-20190528-2	66,075	loamy sand	moist	1.0	full sun	none
10888-20190528-3	66,075	clay	moist	0.5	full sun	none
10888-20190528-8	66,075	sandy loam	moist	2.0	full shade	none

[redacted]

Element Occurrence ID – 10918

Presque Isle County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	A
Visit Dates	6/22/2020, 6/30/2020, 6/24/2020, 10/13/2021, 5/25/2022
Surveyors	Jodi Spieles, Rachel Hackett
Estimated Population Area (ac)	1096.4
Number of Patches	25
Population estimate	50,000,000 – 100,000,000
10 year extinction probability	2%
Ownership Types	Private, State



[redacted] (EO ID 10918) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, qualitative, and genetic were conducted between 2019 and 2023 with the last survey completed on 05/28/2022.

Survey Results

Spatial surveys resulted in an expansion of the estimated populated area from 942.9 to 1096.4 acres. The number of mostly contiguous patches increased from 12 to 25. Flowers/fruits were of occasional abundance during survey(s). No white flowers were observed. Habitat data was collected at 33 points in the population (Table 10918-1).

[redacted]

Table 10918 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
10918-20200622-Qualitative_habitat-1	66,297	sandy loam	dry	4.0	1.0	partial sun	60	low
10918-20200622-Qualitative_habitat-2	66,297	sandy loam	moist	3.0	0.3	full sun	95	low
10918-20200622-Qualitative_habitat-3	66,296	loamy sand	dry	1.0	1.0	full sun	95	low
10918-20200622-Qualitative_habitat-4	66,296	loamy sand	dry	1.0	0.5	full sun	100	low
10918-20200622-Qualitative_habitat-5	66,296	loamy sand	dry	3.0	1.0	partial sun	60	low
10918-20200622-Qualitative_habitat-6	66,296	loamy sand	dry	0.5	0.5	partial sun	50	high
10918-20200622-Qualitative_habitat-7	66,296	loamy sand	dry	1.0	1.0	partial sun	40	low
10918-20200622-Qualitative_habitat-8	66,296	loamy sand	dry	0.5	0.5	partial sun	50	low
10918-20200622-Qualitative_habitat-9	66,296	loamy sand	dry	10.0	1.0	full sun	70	low
10918-20200622-Qualitative_habitat-10	66,296	loamy sand	dry	1.5	1.0	partial sun	30	low
10918-20200622-Qualitative_habitat-11	66,296	loamy sand	moist	6.0	1.0	full sun	70	none
10918-20200622-Qualitative_habitat-12	66,296	loamy sand	dry	0.0	0.5	full sun	100	low
10918-20200630-Qualitative_habitat-13	66,751	loamy clay	moist	9.0	1.0	partial sun	75	none
10918-20200630-Qualitative_habitat-14	66,751	sandy loam	dry	4.0	1.0	full sun	80	low
10918-20200630-Qualitative_habitat-15	66,751	sandy loam	dry	9.5	0.5	partial sun	50	low
10918-20200630-Qualitative_habitat-16	66,751	sandy loam	dry	2.5	0.5	full sun	65	low
10918-20200630-Qualitative_habitat-17	66,295	sandy loam	dry	6.0	0.5	full sun	90	low
10918-20200630-Qualitative_habitat-18	66,295	loamy sand	dry	7.5	1.5	partial sun	60	low
10918-20200630-Qualitative_habitat-19	66,295	loamy sand	dry	6.5	0.5	partial sun	60	low
10918-20200630-Qualitative_habitat-20	66,295	clay loam	moist	10.0	1.0	full sun	90	low
10918-20200630-Qualitative_habitat-21	66,295	sandy loam	moist	14.0	1.5	full sun	80	low
10918-20200624-Qualitative_habitat-22	66,752	clay loam	moist	1.0	0.5	full sun	75	low
10918-20200624-Qualitative_habitat-23	66,752	clay loam	moist	0.0	1.0	full sun	95	low
10918-20200624-Qualitative_habitat-24	66,752	clay loam		4.0	0.5	full sun	95	low
10918-20200624-Qualitative_habitat-25	66,752	sandy loam	dry	7.5	1.0	full sun	90	low
10918-20200624-Qualitative_habitat-26	66,752	loamy clay	wet	13.5	0.5	full sun	100	low

[redacted]

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
10918-20200624-Qualitative_habitat-27	15,672	loamy sand	moist	3.5	0.5	partial sun	40	low
10918-20200624-Qualitative_habitat-28	15,662	clay loam	wet	12.0	0.5	full sun	70	low
10918-20200624-Qualitative_habitat-29	15,662	sandy loam		6.0	1.0	partial sun	40	low
10918-20200624-Qualitative_habitat-30	66,298	sandy loam	wet	7.0	2.0	full sun	95	low
10918-20200624-Qualitative_habitat-31	66,298	loamy sand	moist	4.0	1.0	partial sun	50	low
10918-20200622-Qualitative_habitat-32	15,667	loamy sand	dry	9.0	1.0	partial sun	40	low
10918-20200622-Qualitative_habitat-33	15,667	loamy sand	moist	6.0	1.0	partial sun	30	low

The following adventive species were observed as potential threats to the population:

Scientific Name	Common Name	Abundance
Centaurea stoebe; c. maculosa	spotted knapweed	frequent
Cirsium arvense	canada thistle	occasional
Euphorbia virgata; e. esula	leafy spurge	rare
Lonicera morrowii	morrow honeysuckle	rare

Leaf samples were collected for genetic analysis. Results from those efforts can be found in Cohen, J. I., and S. Turgman-Cohen. 2023. The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic. Plants 12: 1–17.

Element Occurrence ID – 11321

Presque Isle County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	B
Visit Dates	5/31/2019
Surveyors	Rachel Hackett
Estimated Population Area (ac)	737.7
Number of Patches	3
Population estimate	25 – 5,000
10 year extinction probability	NA
Ownership Types	Private

[redacted]

[redacted] (EO ID 11321) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 05/31/2019.

Survey Results

Permission was acquired at only one area of this multi-polygon population, and estimates reflect that. No fruits or flowers were observed. Habitat data was collected at 1 point in the population (Table 11321-1).

Table 11321 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

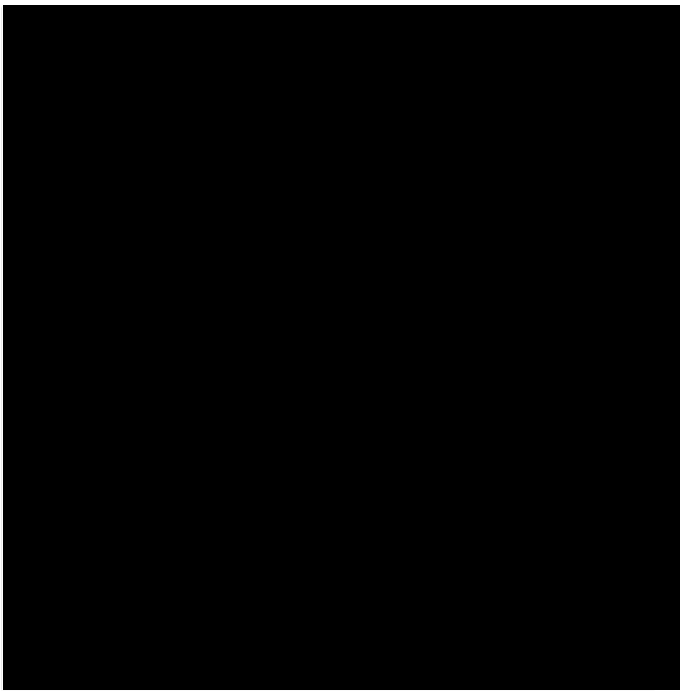
Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
11321-20190531-Qualitative_habitat-8	66,705	other	moist	0	0.5			low

[redacted]

Element Occurrence ID - 15944

Presque Isle County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	B
Visit Dates	6/30/2020
Surveyors	Jodi Spieles
Estimated Population Area (ac)	1.7
Number of Patches	1
Population estimate	10,000 – 15,000
10 year extinction probability	37%
Ownership Types	State



[redacted] (EO ID 15944) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type qualitative were conducted between 2019 and 2023 with the last survey completed on 06/30/2020.

Survey Results

Failed to find one mapped patch during surveys but found new patch. Spatial surveys resulted in a refining of the estimated populated area from 23.4 to 1.7 acres. Flowers/fruits were of rare abundance during survey(s). No white flowers were observed. Habitat data was collected at 3 points in the population (Table 15944-1).

Table 15944 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
15944-20200630-Qualitative_habitat-1	66,750	sandy loam	dry	9	2.0	partial sun	70	low
15944-20200630-Qualitative_habitat-2	66,750	clay loam	dry	1	0.5	full sun	90	low
15944-20200630-Qualitative_habitat-3	66,750	clay loam	dry	5	1.0	partial sun	50	low

The following adventive species were observed as potential threats to the population:

[redacted]

Scientific Name	Common Name	Abundance
Centaurea stoebe; c. maculosa	spotted knapweed	abundant

Element Occurrence ID – 23795

Presque Isle County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	C
Visit Dates	5/28/2019
Surveyors	Rachel Hackett
Estimated Population Area (ac)	5
Number of Patches	1
Population estimate	500 – 1,500
10 year extinction probability	57%
Ownership Types	Private

[redacted]

[redacted] (EO ID 23795) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 05/28/2019.

Survey Results

Documentation for this population was discovered as a result of a collaboration with LafargeHolcim/Presque Isle Quarry, property owner of another dwarf lake iris population. EO Rank changed from E to C as a result of the survey effort. Spatial surveys resulted in an expansion of the estimated populated area from 0 to 5 acres. The number of mostly contiguous patches increased from 0 to 1. Flowers/fruits were abundant during survey(s). No white flowers were observed. Habitat data was collected at 2 points in the population (Table 23795-1).

Table 23795 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

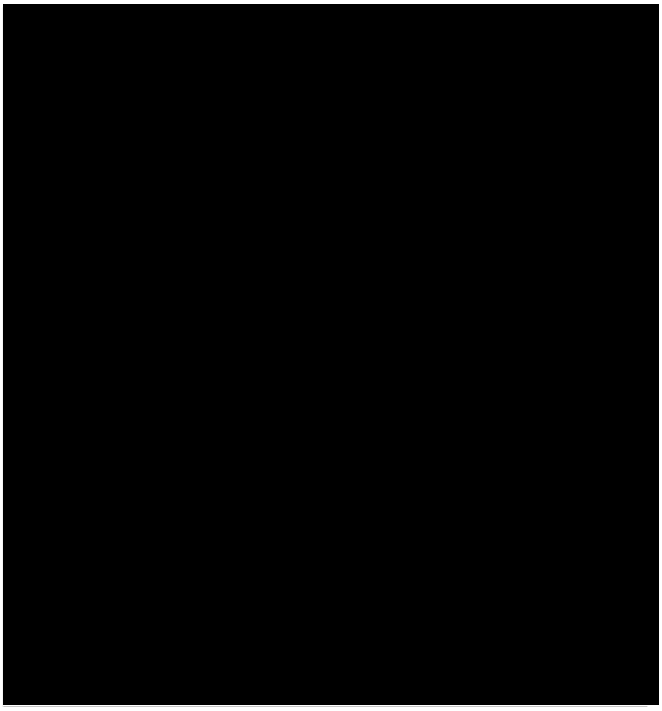
Event ID	Source Feature	Soil Type	Soil Moisture	Litter Depth (cm)	Sunlight Level	Animal Impact
23795-20190528-2	65,132	sandy loam	moist	1	full sun	
23795-20190528-5	65,132	loamy sand	wet	1	full sun	none

[redacted]

Element Occurrence ID – 3589

Schoolcraft County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	BC
Visit Dates	6/4/2021, 6/7/2021
Surveyors	William MacKinnon
Estimated Population Area (ac)	3101.9
Number of Patches	20
Population estimate	791,690 – 1,046,950
10 year extinction probability	12%
Ownership Types	Private, State



[redacted] (EO ID 3589) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 06/07/2021.

Survey Results

Access was granted on State and select private lands only for survey. Large vague source features were retained to represent potential patches on private lands. Spatial surveys resulted in a refining of the estimated populated area from 3141.6 to 3101.9 acres. The number of mostly contiguous patches increased from 2 to 20. Flowers/fruits were of occasional abundance during survey(s). No white flowers were observed. Habitat data was collected at 49 points in the population (Table 3589-1).

Table 3589 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
3589-20210604-Qualitative_habitat-1	69,202	loamy sand	dry	6.0	3.0	partial sun	45	low
3589-20210604-Qualitative_habitat-10	69,203	sand	dry	1.5	2.0	partial sun	50	low
3589-20210604-Qualitative_habitat-11	69,203	loamy sand	dry	6.0	4.0	full sun	70	none

[redacted]

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
3589-20210604-Qualitative_habitat-12	69,204	loamy sand	moist		1.5	partial sun	35	
3589-20210604-Qualitative_habitat-13	69,196		dry	3.0	1.0	partial sun	50	low
3589-20210604-Qualitative_habitat-14	69,196		dry	4.0	3.0	partial sun	50	low
3589-20210604-Qualitative_habitat-15	69,196		dry	2.0	1.0	partial sun	50	low
3589-20210604-Qualitative_habitat-2	69,202	loamy sand	dry	3.0	1.0	full sun	65	low
3589-20210604-Qualitative_habitat-3	69,202	loamy sand	dry	8.0	3.0	partial sun	40	low
3589-20210604-Qualitative_habitat-4	69,202	loamy sand	moist	10.0	8.0	partial sun	40	low
3589-20210604-Qualitative_habitat-5	69,202	loamy sand	dry	9.0	3.0	partial sun	40	low
3589-20210604-Qualitative_habitat-6	69,202	loamy sand	dry	4.0	1.0	partial sun	30	low
3589-20210604-Qualitative_habitat-7	69,202	loamy sand	dry	8.0	4.0	partial sun	30	low
3589-20210604-Qualitative_habitat-8	69,202	loamy sand	dry	8.0	4.0	partial sun	30	low
3589-20210604-Qualitative_habitat-9	69,203	loamy sand	dry	4.0	2.0	partial sun	50	none
3589-20210607-Qualitative_habitat-1	69,273	loamy sand	dry	3.0	2.0	partial sun	50	low
3589-20210607-Qualitative_habitat-10	69,274	sand	dry	2.0	2.0	full sun	70	low
3589-20210607-Qualitative_habitat-11	69,274	sand	dry	1.0	1.0	partial sun	60	low
3589-20210607-Qualitative_habitat-12		sand	dry	3.0	1.0	partial sun	40	none
3589-20210607-Qualitative_habitat-13		sand	dry	5.0	2.0	partial sun	35	low
3589-20210607-Qualitative_habitat-14		sand	dry	2.0	1.0	partial sun	30	low
3589-20210607-Qualitative_habitat-15		sand	dry	2.0	0.0	partial sun	50	low
3589-20210607-Qualitative_habitat-16		sand	dry	4.0	2.0	partial sun	55	low
3589-20210607-Qualitative_habitat-17		sand	dry	4.0	3.0	partial sun	35	low
3589-20210607-Qualitative_habitat-18	69,280	sand	dry	4.0	2.0	partial sun	50	low
3589-20210607-Qualitative_habitat-19	69,280	sand	dry	4.0	2.0	partial sun	50	low
3589-20210607-Qualitative_habitat-2	69,273	sand	dry	4.0	2.0	partial sun	50	low
3589-20210607-Qualitative_habitat-20	69,280	sand	dry	2.0	0.0	partial sun	50	low
3589-20210607-Qualitative_habitat-21	69,280	loamy sand	dry	6.0	2.0	partial sun	40	low
3589-20210607-Qualitative_habitat-22	69,289	sand	dry	0.0	0.0	partial sun	50	low
3589-20210607-Qualitative_habitat-23	69,289	sand	dry	1.0	0.0	partial sun	50	low

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
3589-20210607-Qualitative_habitat-25		sand	dry	1.0	0.0	partial sun	50	low
3589-20210607-Qualitative_habitat-26		sand	dry	3.0	1.0	partial sun	35	low
3589-20210607-Qualitative_habitat-27		sand	dry	3.0	2.0	partial sun	30	low
3589-20210607-Qualitative_habitat-28		sand	dry	1.0	0.0	partial sun	40	low
3589-20210607-Qualitative_habitat-29		sand	dry	4.0	2.0	full sun	60	low
3589-20210607-Qualitative_habitat-3	69,273	sand	dry	4.0	0.0	partial sun	35	none
3589-20210607-Qualitative_habitat-30		sand	moist	0.0	0.0	partial sun	45	low
3589-20210607-Qualitative_habitat-31		sand	dry	0.0	0.0	partial sun	45	low
3589-20210607-Qualitative_habitat-32	77,792	sand	moist	4.0	1.0	partial sun	30	low
3589-20210607-Qualitative_habitat-33		sand	dry	4.0	2.0	partial sun	30	low
3589-20210607-Qualitative_habitat-34		loamy sand	moist	8.0	3.0	partial sun	30	low
3589-20210607-Qualitative_habitat-35		sand	dry	6.0	2.0	partial sun	30	low
3589-20210607-Qualitative_habitat-4		sand	dry	0.0	0.0	full sun	60	low
3589-20210607-Qualitative_habitat-5		sand	dry	2.0	0.0	full sun	65	low
3589-20210607-Qualitative_habitat-6		sand	dry	0.0	0.0	full sun	50	low
3589-20210607-Qualitative_habitat-7		sand	dry	0.0	0.0	full sun	60	low
3589-20210607-Qualitative_habitat-8		sand	dry	0.0	0.0	full sun	60	low
3589-20210607-Qualitative_habitat-9	69,274	sand	dry	2.0	1.0	partial sun	40	low

The following adventive species were observed as potential threats to the population:

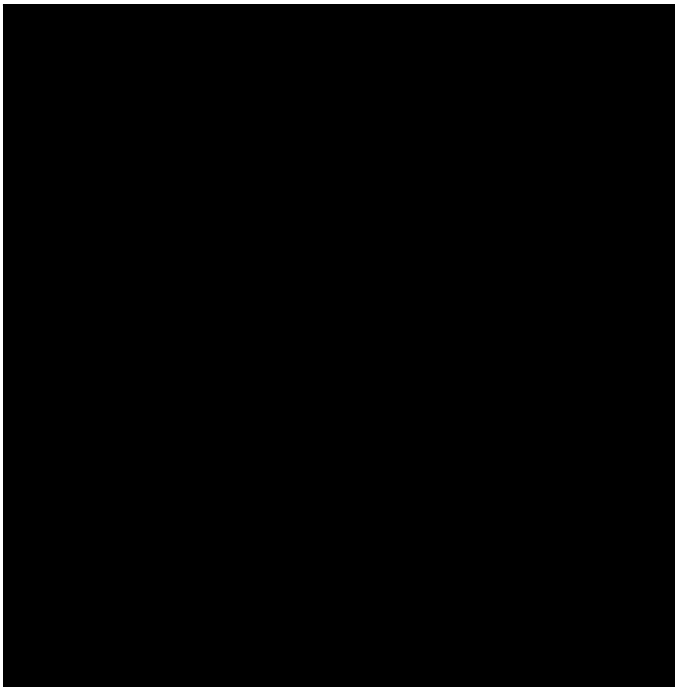
Scientific Name	Common Name	Abundance
Hieracium piloselloides	king devil	
Centaurea stoebe; c. maculosa	spotted knapweed	

[redacted]

Element Occurrence ID – 4465

Schoolcraft County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	BC
Visit Dates	6/9/2021
Surveyors	William MacKinnon
Estimated Population Area (ac)	21.3
Number of Patches	3
Population estimate	5,000 – 8,000
10 year extinction probability	40%
Ownership Types	Private



[redacted] (EO ID 4465) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type qualitative were conducted between 2019 and 2023 with the last survey completed on 06/09/2021.

Survey Results

Spatial surveys resulted in an expansion of the estimated populated area from 21.1 to 21.3 acres. The number of mostly contiguous patches increased from 1 to 3. Flowers/fruits were of occasional abundance during survey(s). No white flowers were observed. Habitat data was collected at 4 points in the population (Table 4465-1).

[redacted]

Table 4465 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
4465-20210609-Qualitative_habitat-1		sand	dry	2	2	partial sun	30	low
4465-20210609-Qualitative_habitat-2		sand	dry	4	2	partial sun	50	none
4465-20210609-Qualitative_habitat-3		sand	dry	0	0	partial sun	50	low
4465-20210609-Qualitative_habitat-4		other	dry	0	1	partial sun	30	none

The following adventive species were observed as potential threats to the population:

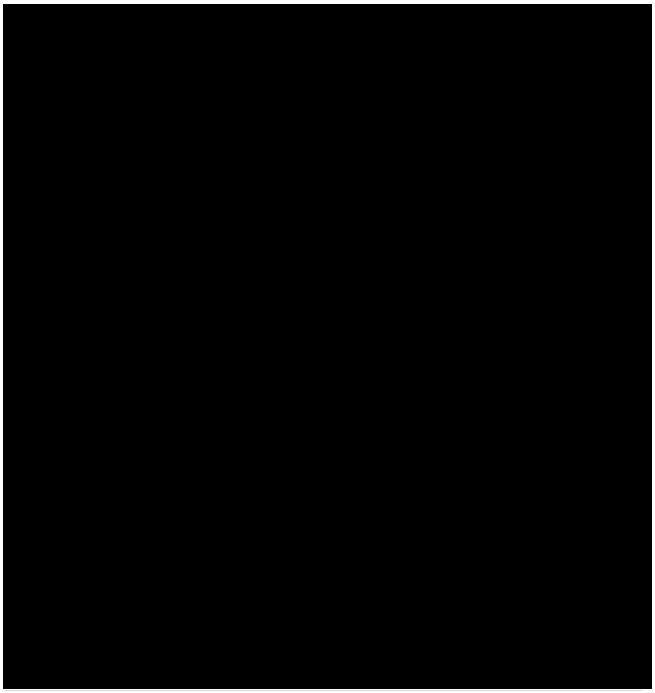
Scientific Name	Common Name	Abundance
Hieracium piloselloides	king devil	

[redacted]

Element Occurrence ID - 6351

Schoolcraft County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	C
Visit Dates	6/3/2021
Surveyors	William MacKinnon
Estimated Population Area (ac)	25.6
Number of Patches	8
Population estimate	60,800 – 101,200
10 year extinction probability	24%
Ownership Types	Municipal, Private



[redacted] (EO ID 6351) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 06/03/2021.

Survey Results

Access was granted on Municipal lands for survey. Large vague source features were retained to represent potential patches on private lands. Spatial surveys resulted in an expansion of the estimated populated area from 25.5 to 25.6 acres. The number of mostly contiguous patches increased from 6 to 8. Flowers/fruits were of occasional abundance during survey(s). No white flowers were observed. Habitat data was collected at 9 points in the population (Table 6351-1).

[redacted]

Table 6351 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
6351-20210603-Qualitative_habitat-1	69,071	sand	dry	0.05	1.0	partial sun	35	low
6351-20210603-Qualitative_habitat-2	69,071	loamy sand	dry	3.00	1.0	partial sun	65	low
6351-20210603-Qualitative_habitat-3	69,071	loamy sand	dry	5.00	2.0	full sun	80	low
6351-20210603-Qualitative_habitat-4		loamy sand	dry	1.50	0.5	partial sun	75	low
6351-20210603-Qualitative_habitat-5		sand	dry	0.50	0.5	full shade	85	none
6351-20210603-Qualitative_habitat-6		loamy sand	moist	2.00	1.0	partial sun	50	none
6351-20210603-Qualitative_habitat-7	69,071	loamy sand	dry	5.00	1.5	partial sun	50	low
6351-20210603-Qualitative_habitat-8	69,071	loamy sand	dry	6.00	1.5	partial sun	30	low
6351-20210603-Qualitative_habitat-9	69,071	sand	dry	0.50	0.5	full sun	70	low

The following adventive species were observed as potential threats to the population:

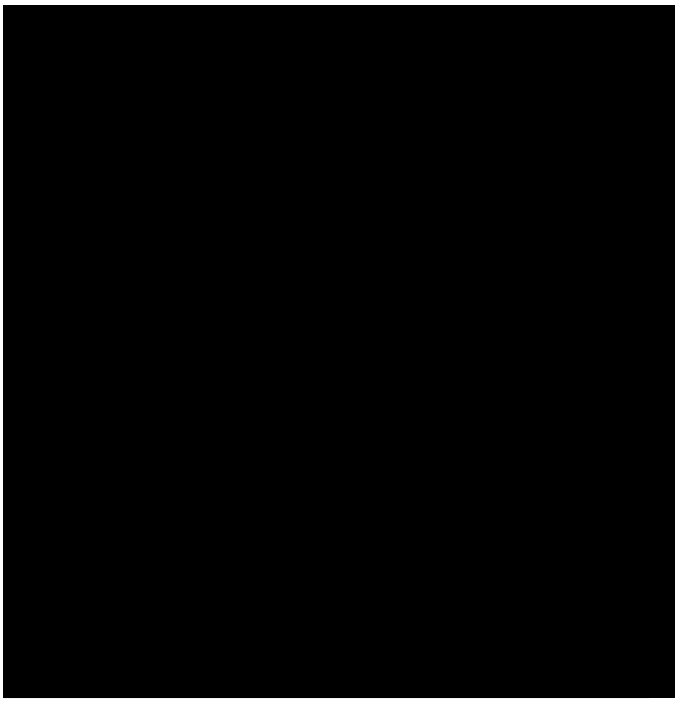
Scientific Name	Common Name	Abundance
Hieracium piloselloides	king devil	
Taraxcum officinale	common dandelion	

[redacted]

Element Occurrence ID - 6809

Schoolcraft County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	B
Visit Dates	6/3/2021, 6/8/2021
Surveyors	William MacKinnon
Estimated Population Area (ac)	22.4
Number of Patches	3
Population estimate	103,000 – 107,000
10 year extinction probability	21%
Ownership Types	Private



[redacted] (EO ID 6809) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type qualitative were conducted between 2019 and 2023 with the last survey completed on 06/03/2021.

Survey Results

Access was granted on State and select Private lands for survey. Spatial surveys resulted in an expansion of the estimated populated area from 22.2 to 22.4 acres. The number of mostly contiguous patches increased from 2 to 3. Flowers/fruits were of occasional abundance during survey(s). No white flowers were observed. Habitat data was collected at 8 points in the population (Table 6809-1).

[redacted]

Table 6809 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
6809-20210603-Qualitative_habitat-1	69,044	other	dry	0.00	0.0	partial sun	65	
6809-20210603-Qualitative_habitat-2	69,044	other	dry	0.00	0.0	partial sun	65	
6809-20210603-Qualitative_habitat-3	69,044	other	dry	0.00	0.0	partial sun	65	
6809-20210603-Qualitative_habitat-4	29,876	sand	dry	0.25	0.0	partial sun	30	none
6809-20210603-Qualitative_habitat-5	29,876	sand	moist	0.00	0.0	partial sun	30	
6809-20210608-Qualitative_habitat-1	69,044	sand	dry	2.00	2.5	partial sun	50	low
6809-20210608-Qualitative_habitat-2	69,044	sandy loam	moist	2.00	1.5	partial sun	70	low
6809-20210608-Qualitative_habitat-3	69,044	sandy loam	moist	2.50	1.5	partial sun	70	low

The following adventive species were observed as potential threats to the population:

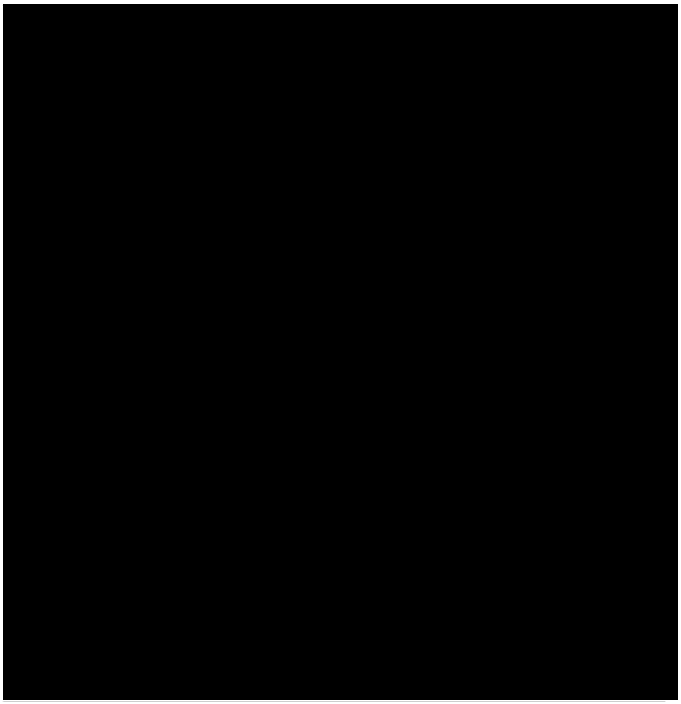
Scientific Name	Common Name	Abundance
Centaurea stoebe; c. maculosa	spotted knapweed	

[redacted]

Element Occurrence ID - 8015

Schoolcraft County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	BC
Visit Dates	6/2/2021
Surveyors	William MacKinnon
Estimated Population Area (ac)	31.3
Number of Patches	8
Population estimate	106,600 – 1,013,850
10 year extinction probability	20%
Ownership Types	Private, State



[redacted] (EO ID 8015) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type qualitative were conducted between 2019 and 2023 with the last survey completed on 06/02/2021.

Survey Results

Access was granted on State lands for survey. Private lands were not surveyed. Spatial surveys resulted in an expansion of the estimated populated area from 7.3 to 31.3 acres. The number of mostly contiguous patches increased from 5 to 8. Flowers/fruits were of occasional abundance during survey(s). No white flowers were observed. Habitat data was collected at 13 points in the population (Table 8015-1).

[redacted]

Table 8015 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
8015-20210602-Qualitative_habitat-1		loamy sand	dry	0.50	1.0	partial sun	40	low
8015-20210602-Qualitative_habitat-2		loamy sand	dry	0.50	1.0	partial sun	40	low
8015-20210602-Qualitative_habitat-5		sand	dry	1.50	1.0	full sun	73	none
8015-20210602-Qualitative_habitat-6		sand	dry	0.75	0.5	partial sun	63	low
8015-20210602-Qualitative_habitat-7		sand	dry	0.50	0.5	partial sun	65	none
8015-20210602-Qualitative_habitat-8		sand	dry	0.50	0.5	partial sun	65	none
8015-20210602-Qualitative_habitat-9		sand	dry	0.50	0.5	partial sun	65	none
8015-20210602-Qualitative_habitat-10		sand	dry	1.00	1.0	partial sun	70	low
8015-20210602-Qualitative_habitat-11		sand	dry	0.00	0.5	full sun	80	none
8015-20210602-Qualitative_habitat-12		sand	dry	1.00	0.5	full sun	90	
8015-20210602-Qualitative_habitat-13		sand	dry	1.00	0.5	full sun	90	
8015-20210602-Qualitative_habitat-3		loamy sand	moist	2.00	4.0	partial sun	80	low
8015-20210602-Qualitative_habitat-4		loamy sand	moist	2.00	4.0	partial sun	80	low

The following adventive species were observed as potential threats to the population:

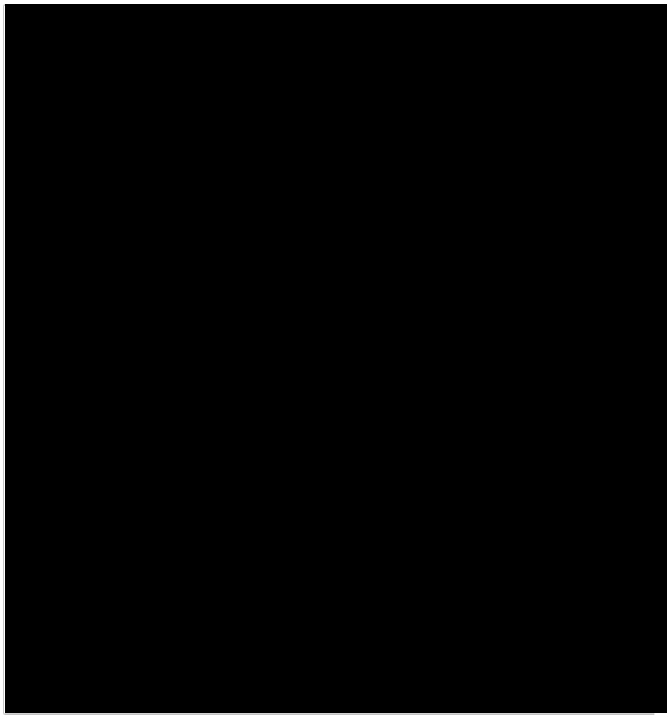
Scientific Name	Common Name	Abundance
Hieracium piloselloides	king devil	occasional
Taraxcum officinale	common dandelion	occasional
Centaurea stoebe; c. maculosa	spotted knapweed	rare

[redacted]

Element Occurrence ID - 12942

Schoolcraft County, [redacted]

Scientific Name	***Iris lacustris***
Common Name	dwarf lake iris
Rank	B
Visit Dates	6/4/2021
Surveyors	William MacKinnon
Estimated Population Area (ac)	60.8
Number of Patches	3
Population estimate	600,000
10 year extinction probability	15%
Ownership Types	Private



[redacted] (EO ID 12942) was surveyed as a part of a multiyear project coordinated by Michigan Natural Features Inventory (MNFI), Michigan State University Extension, funded by the Great Lakes Restoration Initiative through the US Fish and Wildlife Service (F18AC00566, F19AC00653, F20AC10391), and with permission from landowners for those areas surveyed. Surveys of type spatial, and qualitative were conducted between 2019 and 2023 with the last survey completed on 06/04/2021.

Survey Results

Access was granted on State and select private lands only for survey. Large vague source features were retained to represent potential patches on private lands. Flowers/fruits were of occasional abundance during survey(s). No white flowers were observed. Habitat data was collected at 8 points in the population (Table 12942-1).

Table 12942 -1. List of points where habitat data was collected. Schema of Event ID is [EO ID of population]-[date in format of YYYYMMDD]-[point type and/or number].

Event ID	Source Feature	Soil Type	Soil Moisture	Organic Soil Depth (cm)	Litter Depth (cm)	Sunlight Level	Canopy Openness (%)	Animal Impact
12942-20210604-Qualitative_habitat-1	12,860	loamy sand	moist	6.5	1	partial sun	30	none
12942-20210604-Qualitative_habitat-2	12,860	loamy sand	moist	7.5	1	partial sun	35	low
12942-20210604-Qualitative_habitat-3	12,860	loamy sand	dry	6.0	1	partial sun	60	low
12942-20210604-Qualitative_habitat-4	12,860	loamy sand	dry	9.0	2	partial sun	30	low
12942-20210604-Qualitative_habitat-5	12,860	sand	dry	3.0	1	partial sun	50	low
12942-20210604-Qualitative_habitat-6	12,860	sand	dry	2.5	0	partial sun	50	low
12942-20210604-Qualitative_habitat-7	12,860	sand	dry	5.0	2	partial sun	40	low
12942-20210604-Qualitative_habitat-8	12,860	loamy sand	dry	6.0	2	partial sun	40	low

The following adventive species were observed as potential threats to the population:

Scientific Name	Common Name	Abundance
Hieracium piloselloides	king devil	

[redacted]

APPENDIX C: COHEN AND TURGMAN-COHEN 2023

The following pages are the peer-reviewed article on population genetics of USA populations of DLI. These pages are numbered as they are in the published in the journal *Plants*:

Cohen, J. I., and S. Turgman-Cohen. 2023. The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic. Plants 12: 1–17, p.18.

plants

MDPI

Article

The Conservation Genetics of *Iris lacustris* (Dwarf Lake Iris), a Great Lakes Endemic

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Abstract: *Iris lacustris*, a northern Great Lakes endemic, is a rare species known from 165 occurrences across Lakes Michigan and Huron in the United States and Canada. Due to multiple factors, including habitat loss, lack of seed dispersal, patterns of reproduction, and forest succession, the species is threatened. Early population genetic studies using isozymes and allozymes recovered no to limited genetic variation within the species. To better explore genetic variation across the geographic range of *I. lacustris* and to identify units for conservation, we used tunable Genotyping-by-Sequencing (tGBS) with 171 individuals across 24 populations from Michigan and Wisconsin, and because the species is polyploid, we filtered the single nucleotide polymorphism (SNP) matrices using polyRAD to recognize diploid and tetraploid loci. Based on multiple population genetic approaches, we resolved three to four population clusters that are geographically structured across the range of the species. The species migrated from west to east across its geographic range, and minimal genetic exchange has occurred among populations. Four units for conservation are recognized, but nine adaptive units were identified, providing evidence for local adaptation across the geographic range of the species. Population genetic analyses with all, diploid, and tetraploid loci recovered similar results, which suggests that methods may be robust to variation in ploidy level.

Keywords: genotyping-by-sequencing; *Iris*; Lake Huron; Lake Michigan; polyploidy; polyRAD; rare plants; tGBS

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1. Introduction

In 1818, Thomas Nuttall described a new species of crested *Iris* L., *Iris lacustris* Nutt., "on the gravelly shores of calcareous islands of Lake Huron" [1]. Since then, the recognized geographic range of the species has expanded to include the northern regions of Lakes Huron and Michigan in the United States and Canada. Presently, the species is known from 165 occurrences, with more than half in Michigan (89) and the others split between Wisconsin (36) and Ontario (40) [2].

Plants of *I. lacustris* grow less than 15 cm in height [3], and this feature provides the species with its common name, Dwarf Lake Iris. The species bears self-compatible flowers, with purple sepals and purple petals with yellow and white markings, that are visited by various species of bees [4]. Across its geographic range, *I. lacustris* frequently inhabits the understory of coniferous forests along the shore, although a small number of inland populations are known (Figure 1) [2,5,6]. These habitats have thin entisols, and the dominant tree species primarily include *Thuja occidentalis* L., *Abies balsamea* (L.) Miller, and *Picea glauca* (Moench) Voss. The species has become a well-known endemic plant of the Great Lakes and is so characteristic of the region that it was recognized as the state wildflower of Michigan [7].

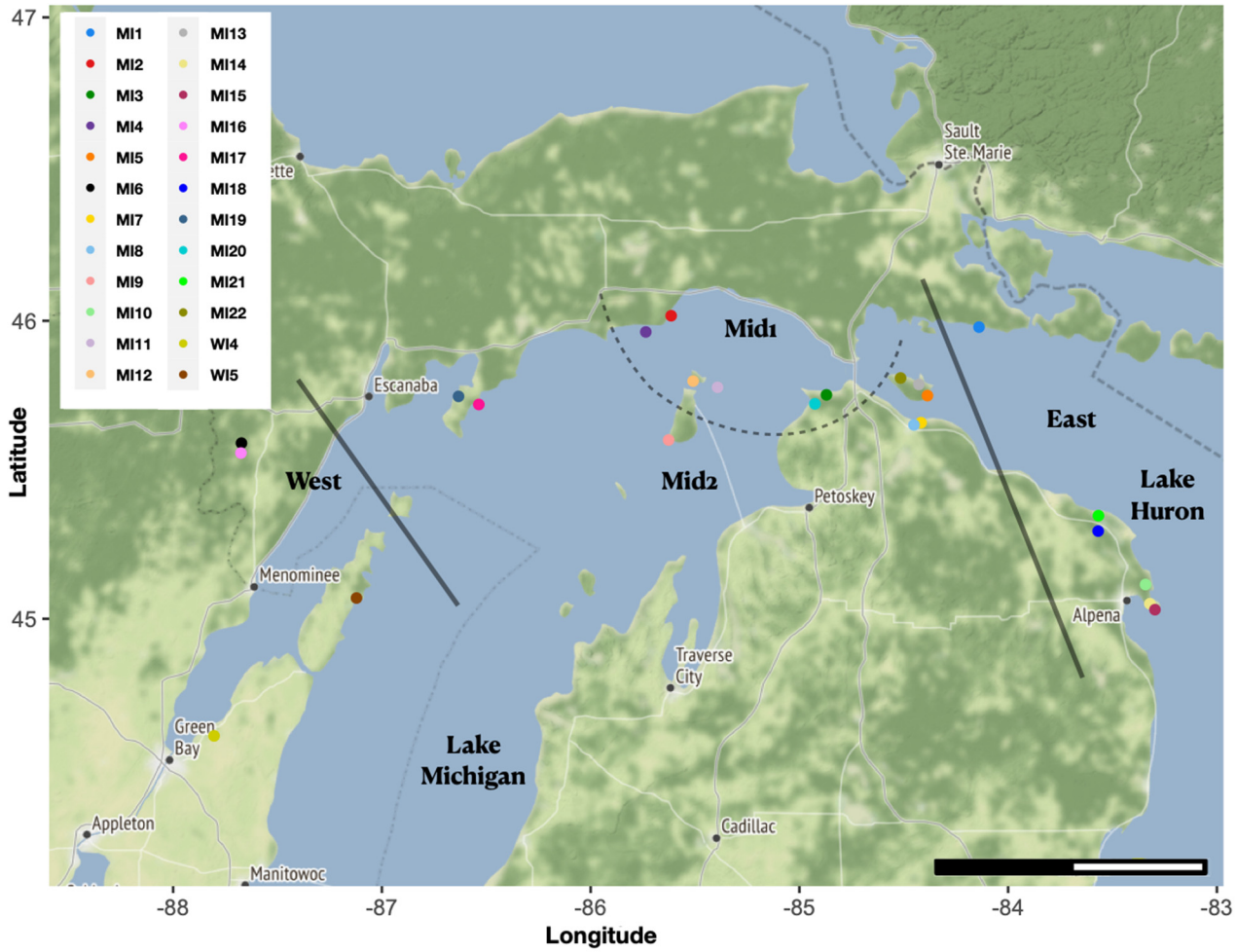

Figure 1. Map of locations sampled in present study. Dark gray entire lines denote division between East, Mid1, Mid2, and West clusters (also recognized as management units). The dashed gray line separates Mid1 and Mid2 populations, and Mid includes both groups of populations together. Light gray lines separate Wisconsin (USA), Michigan (USA), and Ontario (Canada). Scale bar is 100 km, with each section representing 50 km.

In 1988, 170 years after *I. lacustris* was initially described, the species was listed as federally threatened [5]. The small number of populations and individuals is due to multiple factors, including the loss of shoreline habitat, fungal infection of fruits, lack of seed dispersal, and overgrowth of the forest canopy that restricted plant growth, flower production, and sexual reproduction. Plants of the species currently reproduce more by vegetative growth than germination from the myrmecochorous seeds [5]. Despite this low germination rate, seeds can remain viable in the seedbank for at least 15 years [5], a factor that could influence long-term population growth and genetic diversity, although mass germination and recruitment are rare [4].

The ecology of *I. lacustris* has been examined to a greater extent than the genetic diversity of the species. To date, only three studies have explored this topic: Simonich and Morgan [8] examined nine populations in Wisconsin, using 22 allozyme markers, Orick [9] investigated nine populations in Michigan, using 24 isozymes, and Hannan and Orick [10] examined nine populations in Michigan, using 18 isozymes. In two studies, researchers identified genetic homogeneity across the populations; however, Orick [9] found overall heterozygosity to be 3.7%. Hannan and Orick [10] also note gene silencing may have been possible in four loci. In contrast to the genetic diversity recognized in *I. lacustris*, Hannan and Orick [10] found that the sister species, *I. cristata* Aiton [11], which has a wider geographic range across eastern North America, was variable at 11 of 15 loci. These studies

suggest that the genetic diversity of this rare species of *Iris* is quite limited. This genetic paucity is intriguing because *I. lacustris* and its sister are both putative tetraploids [10], and polyploid plant species tend to have greater genetic variation than diploid relatives, although selfing tends to be higher in polyploids [12–14]. Importantly, the genetic diversity of the *I. lacustris* may have implications for the ability of the species to respond to the changing environment across its geographic range and for various conservation efforts.

In order to investigate the population and conservation genetics of the species in a comprehensive manner, we examined multiple populations from across Michigan and Wisconsin, and we used tunable Genotyping-by-Sequencing (tGBS [15]), a method of reduced representation sequencing, to identify single nucleotide polymorphisms (SNPs) among the populations. The objectives of the present study are threefold: (1) identify genetic diversity and population structure and substructure across the range of *I. lacustris*, (2) explore patterns of migration, and (3) recognize population clusters for management of this rare species. Given the paucity of genetic diversity identified in previous studies, we hypothesized that there would be limited genetic variation across the species.

2. Results

2.1. DNA Sequencing and Polyploid Filtering

Among the 171 individuals of 24 populations across the geographic range of *I. lacustris* in Michigan and Wisconsin (Figure 1, Table 1), 726,786,603 paired-end reads were sequenced, with a mean of 4,225,503 reads per sample. The consensus sequence included 1,335,996 scaffolds with 196,139,854 bp (N50 = 644,994, L50 = 145). The mean per sample alignment and unique alignment to the consensus sequences are 93.9% and 74.4%, respectively. For the MCR90 dataset, 125 reads were interrogated per SNP across 2,341,730 bases, with 4.8% missing data for the final dataset. For the MCR50 dataset, 31 reads were interrogated per SNP across 23,904,409 bases, with 31.4% missing data for the final dataset. The numbers of SNPs in the diploid and tetraploid datasets identified through analysis in polyRAD are in Table 2.

Table 1. Population and sampling information and assignation of populations to clusters based on results of various population genomic analyses, including recognition of management and adaptive units, based on loci not under and under selection, respectively. Cluster, management unit, and adaptive unit assignation is based on population genetic analyses with fastStructure, discriminant analysis of principal components (DAPC), principal component analyses (PCA), and others described in the text.

Populations Sampled	Number of Individuals Sampled	Four Population Clusters in Analyses	Three Population Clusters in Analyses	Management Units (All Loci)	Management Units (Diploid and Tetraploid Loci)	Adaptive Units
MI1	10	East	East	1	1	1
MI2	3	Mid1	Mid	2	2	2
MI3	8	Mid1	Mid	2	2	3
MI4	7	Mid1	Mid	2	2	3
MI5	7	Mid2	Mid	3	3	4
MI6	14	West	West	4	4	5
MI7	8	Mid2	Mid	2	2	4
MI8	4	Mid2	Mid	3	3	4
MI9	3	Mid2	Mid	2	2	6
MI10	5	East	East	1	3	7
MI11	1	Mid1	Mid	2	2	3
MI12	2	Mid1	Mid	2	2	3
MI13	3	Mid2	Mid	3	3	4
MI14	13	East	East	1	3	7

Table 1. *Cont.*

Populations Sampled	Number of Individuals Sampled	Four Population Clusters in Analyses	Three Population Clusters in Analyses	Management Units (All Loci)	Management Units (Diploid and Tetraploid Loci)	Adaptive Units
MI15	8	East	East	1	1	7
MI16	3	West	West	4	2	5
MI17	10	Mid2	Mid	2	2	6
MI18	10	East	East	1	1	1
MI19	10	Mid2	Mid	2	2	6
MI20	3	Mid1	Mid	2	2	2
MI21	7	East	East	1	3	1
MI22	8	Mid2	Mid	3	3	4
WI4	12	West	West	4	2	8
WI5	12	West	West	4	2	9

Table 2. Information on six SNP (single nucleotide polymorphism) datasets examined including best K (cluster) value under various analyses. Dashes indicate analysis was not performed for dataset. StructureSelector results include MedMedK, MedMeanK, MaxMedK, and MaxMeanK, and, therefore, may have a range of best K values due to different results from these four metrics. DAPC is discriminant analysis of principal components, and for these analyses, best K value is determined via Bayesian Information Criterion. Additional information on identification of loci under selection and best K values in text.

Dataset	SNPs	Loci under Selection	All Loci		Loci under Selection		Loci Not under Selection	
			StructureSelector	DAPC	StructureSelector	DAPC	StructureSelector	DAPC
MCR90	5354	401	6	9	12–14	13	3–4	7
MCR90 diploid loci	2106	29	4–5	7	-	-	-	-
MCR90 tetraploid loci	1382	21	4–5	6	-	-	-	-
MCR50	344,509	65,075	5–7	4	11–13	10	3	1
MCR50 diploid loci	50,134	4311	3–4	2–3	9–10	7	2–3	1
MCR50 tetraploid loci	82,237	6939	3–4	2–3	8	9	3	1

2.2. Population Genomics

Across all datasets, observed heterozygosity slightly exceeds expected heterozygosity, and F_{IS} values are, in general, negative (Table 3). Pairwise F_{ST} values vary from 0.1–0.45, and results are similar among datasets (Table 4). Based on various AMOVA results, most of the variation is within samples, followed by between the populations, regardless of the datasets and partitioning of the populations (Supplemental Table S1). Mantel tests for isolation-by-distance analyses identify all datasets as having spatial structure (Supplemental Figure S1) with $p < 0.001$ for analyses of individuals, but only MCR90 datasets had spatial structure for populations ($p < 0.05$).

Results from analyses in fastSTRUCTURE, STRUCTURE, MavericK, and tess3r are similar. Based on the results from StructureSelector, the optimal K values were greater for all loci analyzed together than for either the diploid or tetraploid loci analyzed independently (Table 2, Supplemental Table S2). Similar clusters were recovered with the different datasets (Figure 2, Table 1), with a clear division between three groups—eastern, western, and central populations—and multiple analyses resulted in the central population being divided into two distinct groups at K = 4 and/or 5 (Figure 1, Supplemental Figures S2–S4), especially for all loci in fastSTRUCTURE and multiple datasets with STRUCTURE, MavericK, and tess3r. At K = 4–5, the two Wisconsin populations were often recovered with unique genomic signatures suggestive of admixture, and this is particularly the case with the MCR90 datasets. While the results of conStruct are similar to others, the three distinct groups identified are more opaque, with boundaries between the eastern and western populations overlapping to a larger extent than with the other analyses (Supplemental Figure S5); although, similar patterns can be recognized at K = 4 and 5 for the MCR90 all and diploid loci datasets. Among all

methods, the three populations on Bois Blanc Island in Michigan (MI5, MI13, and MI22), in the northwestern geographic range of the species, also include some individuals that show signals of admixture between the eastern and central populations (Figure 2). Graphs of K values for all analyses are included in Supplementary Materials (Figures S6–S16).

Table 3. Observed, expected, and total heterozygosity (H_O, H_S, H_T) and fixation index (F_{IS}) for the three MCR90 datasets for each population. Sample sizes are less than five for MI2, MI8, MI9, MI11, MI12, MI13, MI16, MI20, which could impact calculated statistics.

	MCR90 All Loci				MCR90 Diploid Loci				MCR90 Tetraploid Loci			
Population	**H_O**	**H_S**	**H_T**	**F_{IS}**	**H_O**	**H_S**	**H_T**	**F_{IS}**	**H_O**	**H_S**	**H_T**	**F_{IS}**
MI1	0.0586	0.0516	0.0516	−0.1365	0.064	0.0519	0.0519	−0.2325	0.0548	0.0462	0.0462	−0.1875
MI2	0.0503	0.0411	0.0411	−0.2224	0.0538	0.0417	0.0417	−0.2883	0.0532	0.0431	0.0431	−0.2329
MI3	0.0472	0.0307	0.0307	−0.5394	0.0521	0.0322	0.0322	−0.6191	0.0474	0.0301	0.0301	−0.5768
MI4	0.0581	0.0451	0.0451	−0.2873	0.0651	0.0479	0.0479	−0.3582	0.0628	0.0497	0.0497	−0.2624
MI5	0.0558	0.0532	0.0532	−0.047	0.052	0.0428	0.0428	−0.2161	0.051	0.041	0.041	−0.2444
MI6	0.0957	0.0704	0.0704	−0.3593	0.1043	0.0742	0.0742	−0.4064	0.0933	0.0675	0.0675	−0.3826
MI7	0.054	0.049	0.049	−0.1021	0.0519	0.042	0.042	−0.2372	0.0559	0.0449	0.0449	−0.2455
MI8	0.0655	0.0563	0.0563	−0.1631	0.0677	0.0573	0.0573	−0.1816	0.067	0.0555	0.0555	−0.2074
MI9	0.0594	0.0401	0.0401	−0.4814	0.0586	0.0373	0.0373	−0.5714	0.0673	0.0442	0.0442	−0.5217
MI10	0.0612	0.0477	0.0477	−0.2842	0.0554	0.043	0.043	−0.289	0.0515	0.0383	0.0383	−0.3455
MI11	0.0475	-	-	-	0.0527	-	-	-	0.0499	-	-	-
MI12	0.0522	0.0385	0.0385	−0.3578	0.0592	0.0411	0.0411	−0.4413	0.0551	0.0433	0.0433	−0.2749
MI13	0.0557	0.0447	0.0447	−0.2463	0.0508	0.0409	0.0409	−0.2434	0.0543	0.0401	0.0401	−0.3551
MI14	0.0535	0.0488	0.0488	−0.0981	0.0542	0.0448	0.0448	−0.2105	0.0497	0.0415	0.0415	−0.1989
MI15	0.0573	0.0551	0.0551	−0.0395	0.059	0.0516	0.0516	−0.1434	0.0589	0.0502	0.0502	−0.1724
MI16	0.0961	0.0694	0.0694	−0.384	0.0956	0.0661	0.0661	−0.4464	0.0795	0.0541	0.0541	−0.4686
MI17	0.0671	0.062	0.062	−0.0827	0.0609	0.0488	0.0488	−0.2478	0.0647	0.0524	0.0524	−0.2357
MI18	0.0639	0.0567	0.0567	−0.1277	0.0672	0.0542	0.0542	−0.2401	0.0643	0.0534	0.0534	−0.2054
MI19	0.0651	0.0575	0.0575	−0.1324	0.0645	0.0512	0.0512	−0.2604	0.0591	0.0487	0.0487	−0.215
MI20	0.0467	0.0343	0.0343	−0.3597	0.0481	0.0351	0.0351	−0.3711	0.0516	0.0365	0.0365	−0.4123
MI21	0.0624	0.054	0.054	−0.1557	0.0628	0.0497	0.0497	−0.262	0.0637	0.0512	0.0512	−0.2435
MI22	0.0543	0.0492	0.0492	−0.1035	0.0464	0.0382	0.0382	−0.2135	0.049	0.0397	0.0397	−0.2343
WI4	0.1081	0.0946	0.0946	−0.1424	0.1032	0.0848	0.0848	−0.2179	0.0895	0.0745	0.0745	−0.201
WI5	0.1033	0.085	0.085	−0.2157	0.1015	0.0775	0.0775	−0.3102	0.094	0.0734	0.0734	−0.2814

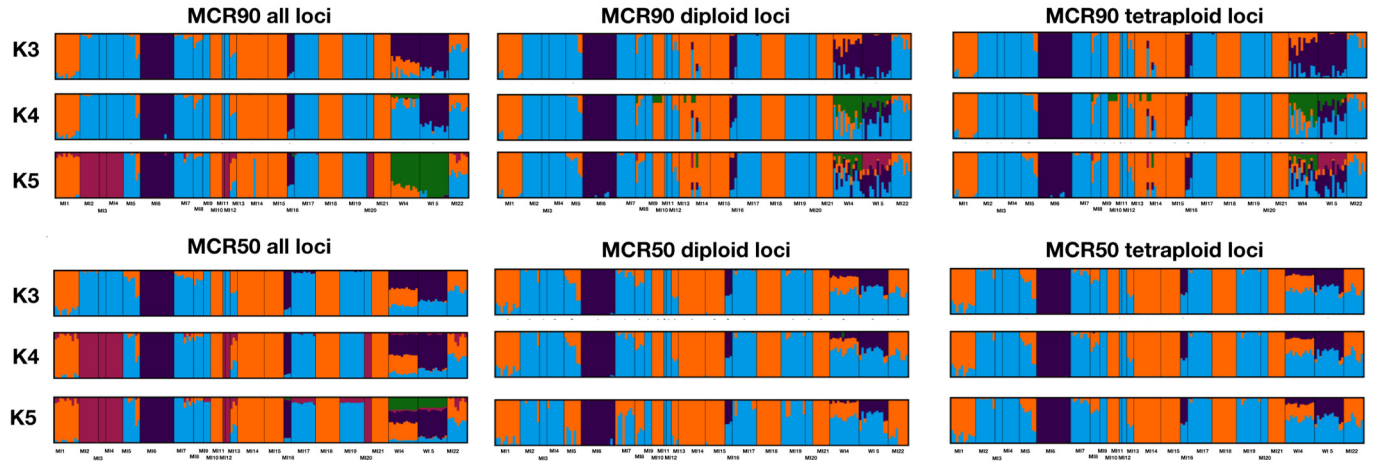

Figure 2. Structure bar graphs from fastSTRUCTURE for the six datasets analyzed in the present study for K = 3–5. Individual ancestry denoted by color.

Table 4. Pairwise F_{ST} values and heatmap for MCR90 all loci (below diagonal) and MCR90 diploid loci (above diagonal). Below the diagonal, red indicates lower values, and blue is for higher values. Above the diagonal, yellow is for lower values, and green is for higher values. Sample sizes are less than five for MI2, MI8, MI9, MI11, MI12, MI13, MI16, MI20, which could impact calculated statistics.

	MI1	MI2	MI3	MI4	MI5	MI6	MI7	MI8	MI9	MI10	MI11	MI12	MI13	MI14	MI15	MI16	MI17	MI18	MI19	MI20	MI21	MI22	WI4	WI5
MI1	-	0.17	0.20	0.21	0.16	0.25	0.18	0.16	0.22	0.14	0.12	0.17	0.13	0.11	0.09	0.26	0.18	0.05	0.20	0.16	0.05	0.15	0.15	0.19
MI2	0.29	-	0.12	0.12	0.16	0.24	0.16	0.18	0.24	0.20	0.07	0.11	0.13	0.16	0.15	0.27	0.16	0.19	0.17	0.00	0.19	0.11	0.16	0.20
MI3	0.36	0.26	-	−0.01	0.19	0.21	0.19	0.20	0.26	0.27	0.00	0.05	0.22	0.21	0.20	0.28	0.13	0.22	0.14	0.14	0.22	0.18	0.13	0.16
MI4	0.37	0.26	0.01	-	0.19	0.24	0.18	0.19	0.20	0.25	−0.08	0.03	0.19	0.22	0.20	0.26	0.14	0.23	0.15	0.10	0.23	0.18	0.16	0.19
MI5	0.26	0.29	0.30	0.31	-	0.20	0.08	0.04	0.20	0.12	0.12	0.18	0.08	0.12	0.12	0.23	0.12	0.17	0.14	0.16	0.16	0.06	0.14	0.15
MI6	0.41	0.39	0.37	0.39	0.31	-	0.23	0.19	0.22	0.24	0.14	0.19	0.20	0.24	0.23	0.13	0.20	0.25	0.20	0.21	0.24	0.22	0.19	0.20
MI7	0.32	0.35	0.37	0.37	0.12	0.35	-	0.08	0.19	0.19	0.11	0.18	0.16	0.15	0.15	0.25	0.12	0.20	0.14	0.14	0.18	0.11	0.15	0.18
MI8	0.31	0.38	0.41	0.40	0.07	0.34	0.14	-	0.18	0.15	0.04	0.14	0.10	0.14	0.12	0.20	0.11	0.17	0.13	0.16	0.16	0.09	0.12	0.15
MI9	0.42	0.43	0.44	0.38	0.32	0.40	0.34	0.39	-	0.29	0.18	0.25	0.28	0.24	0.21	0.25	0.10	0.24	0.12	0.25	0.25	0.24	0.13	0.14
MI10	0.20	0.34	0.44	0.42	0.23	0.38	0.32	0.29	0.45	-	0.19	0.25	0.13	0.03	0.06	0.28	0.20	0.13	0.21	0.21	0.09	0.12	0.14	0.19
MI11	0.30	0.24	0.05	−0.07	0.21	0.31	0.29	0.30	0.38	0.38	-	−0.03	0.12	0.14	0.10	0.13	0.05	0.14	0.06	0.07	0.14	0.12	0.02	0.07
MI12	0.33	0.25	0.07	0.03	0.26	0.35	0.34	0.36	0.41	0.41	0.01	-	0.17	0.19	0.15	0.21	0.13	0.18	0.13	0.14	0.20	0.18	0.09	0.13
MI13	0.21	0.26	0.37	0.33	0.16	0.33	0.27	0.23	0.44	0.22	0.28	0.31	-	0.09	0.09	0.25	0.15	0.14	0.16	0.15	0.14	0.02	0.12	0.15
MI14	0.15	0.31	0.38	0.39	0.24	0.40	0.30	0.28	0.42	0.04	0.33	0.36	0.18	-	0.03	0.26	0.18	0.10	0.19	0.15	0.07	0.09	0.14	0.19
MI15	0.17	0.32	0.38	0.39	0.24	0.39	0.29	0.26	0.41	0.09	0.30	0.34	0.19	0.04	-	0.23	0.16	0.09	0.18	0.13	0.08	0.11	0.12	0.17
MI16	0.43	0.44	0.44	0.43	0.32	0.19	0.37	0.34	0.42	0.43	0.30	0.37	0.39	0.42	0.39	-	0.20	0.25	0.20	0.26	0.26	0.27	0.14	0.14
MI17	0.28	0.25	0.22	0.25	0.17	0.32	0.21	0.22	0.18	0.27	0.13	0.20	0.21	0.27	0.26	0.28	-	0.20	0.07	0.14	0.18	0.13	0.13	0.16
MI18	0.12	0.33	0.38	0.40	0.29	0.41	0.33	0.32	0.42	0.17	0.32	0.35	0.23	0.14	0.15	0.41	0.29	-	0.21	0.18	0.04	0.16	0.15	0.21
MI19	0.33	0.30	0.28	0.31	0.22	0.35	0.25	0.25	0.27	0.32	0.21	0.26	0.26	0.31	0.30	0.34	0.11	0.33	-	0.15	0.20	0.15	0.15	0.17
MI20	0.29	−0.01	0.29	0.25	0.27	0.36	0.33	0.38	0.45	0.35	0.24	0.28	0.29	0.31	0.31	0.42	0.22	0.32	0.28	-	0.18	0.10	0.12	0.16
MI21	0.09	0.34	0.39	0.40	0.26	0.39	0.31	0.30	0.42	0.13	0.32	0.36	0.21	0.09	0.13	0.41	0.27	0.05	0.32	0.33	-	0.14	0.14	0.19
MI22	0.19	0.22	0.28	0.30	0.09	0.33	0.17	0.15	0.34	0.17	0.21	0.26	0.04	0.15	0.17	0.36	0.16	0.22	0.21	0.21	0.18	-	0.15	0.18
WI4	0.27	0.26	0.23	0.27	0.22	0.30	0.28	0.24	0.27	0.22	0.12	0.19	0.20	0.24	0.23	0.25	0.20	0.25	0.25	0.21	0.24	0.22	-	0.15
WI5	0.33	0.32	0.24	0.28	0.26	0.27	0.30	0.27	0.27	0.30	0.16	0.21	0.26	0.32	0.30	0.21	0.23	0.33	0.27	0.28	0.31	0.26	0.24	-

The results of principal components analysis (PCA) and discriminant analyses of principal components (DAPC) are similar to those that explicitly consider a priori population structure. With PCA, three to four clusters were recovered corresponding to the same ones from the population assignation analyses, and this was more evident with the MCR90 datasets compared to the MCR50 ones. In all analyses, three populations—MI6, MI16, and WI5—were recognized as most distinct from the other populations. Across DAPC analyses, individuals from populations tended to cluster together, and this is similar to results from other methods. In general, DAPC analyses recover MI6, MI16, and WI5 as distinct units or as a cluster together, with the results for MCR50 all loci being the only exception. In analyses with this dataset, WI5 was included in a cluster distinct from the other two populations, but with WI4 and populations from Michigan. In some analyses, such as MCR50 and MCR90 diploid loci, the divided cluster of central populations was identified. The number of loci under selection in each dataset is in Table 2.

Patterns of migration inferred from BA3-SNPs suggest that migration is minimal, regardless of the dataset analyzed, and that most individuals are from their original population (Figure 3). While this was certainly the case for all loci for MCR90, analyses with only the diploid loci for three or four population clusters (Table 1) provide evidence of greater rates of migration between adjacent populations (Figure 3). Migration directly between the eastern and western populations was negligible. The relationship among the four population clusters that was most supported by the results of DIYABC-RF and abcranger varies depending on the dataset analyzed. For all, diploid, and tetraploid loci, (West (Mid1 (Mid2, East))), (West (East (Mid1, Mid2))), and (West (Mid1 (Mid2, East))) are recovered as optimal, respectively, and (Mid2 (West (Mid2, East))) and (West (East (Mid1, Mid2))) are identified as close second choices for all and tetraploid datasets, respectively. The one constant among the three optimal trees is that the western population is recognized to have diverged prior to the mid and eastern populations, and this also is the case for one of the near-optimal trees (Supplemental Figure S17).

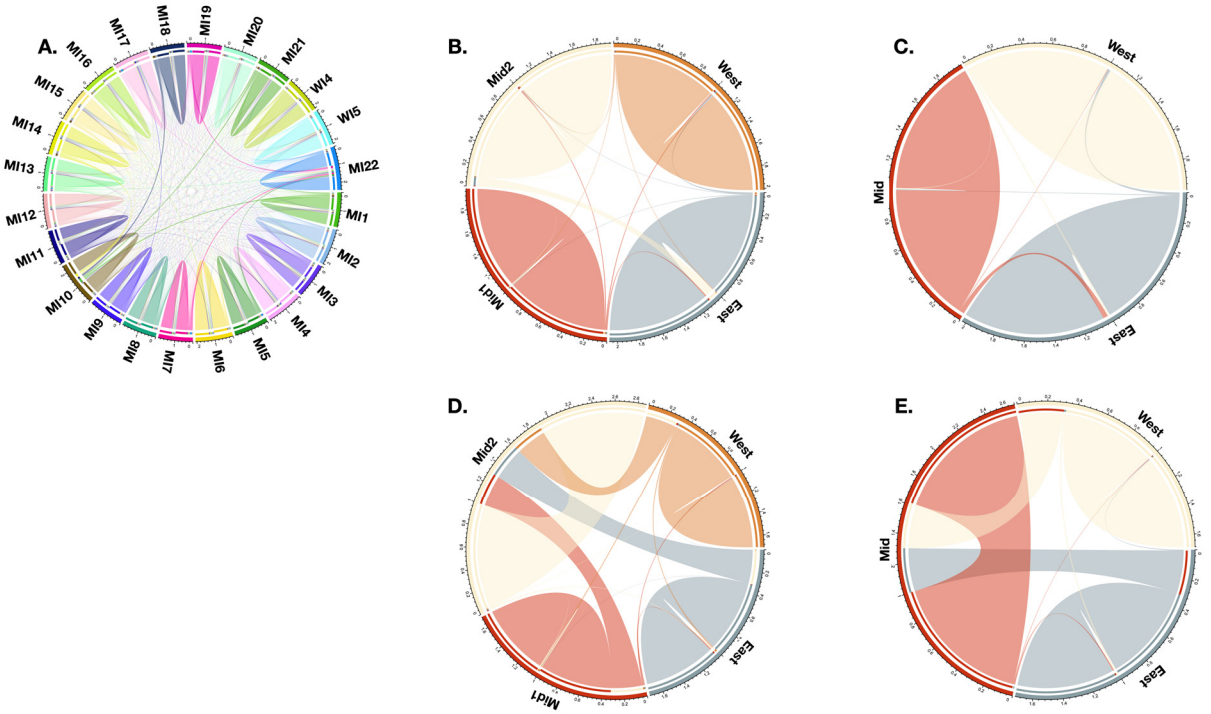

Figure 3. Patterns of migration based on MCR90 all loci (**A**–**C**) and MCR90 diploid loci (**D**,**E**) as resolved using BA3-SNPs. (**A**) All populations, (**B**,**D**) 4 populations, (**C**,**E**) 3 populations. Outermost circle denotes each population, and inner circle shows origin of migrants from each population. Lines connecting populations demonstrate patterns of migration.

2.3. Conservation Units

Based on the method of Funk et al. [16], evolutionarily significant units (ESUs) were identified using all loci, as described below, and the management units (MUs), which are based on fastSTRUCTURE, PCA, and DAPC analyses with loci not under selection, are quite similar. The largest difference between ESUs and MUs is that the two populations in Wisconsin may or may not be included with the other two western populations, MI6 and MI16, depending on the use of all loci or only diploid or tetraploid loci (Figure 4). The populations on Bois Blanc Island also have mixed ancestry based on these loci. The adaptive units, which are based on fastSTRUCTURE, PCA, and DAPC analyses with loci under selection, provide quite different results. Generally, among analyses, nine adaptive units are recognized, and these are structured based on geography (Figure 4, Supplemental Figure S18, Table 1).

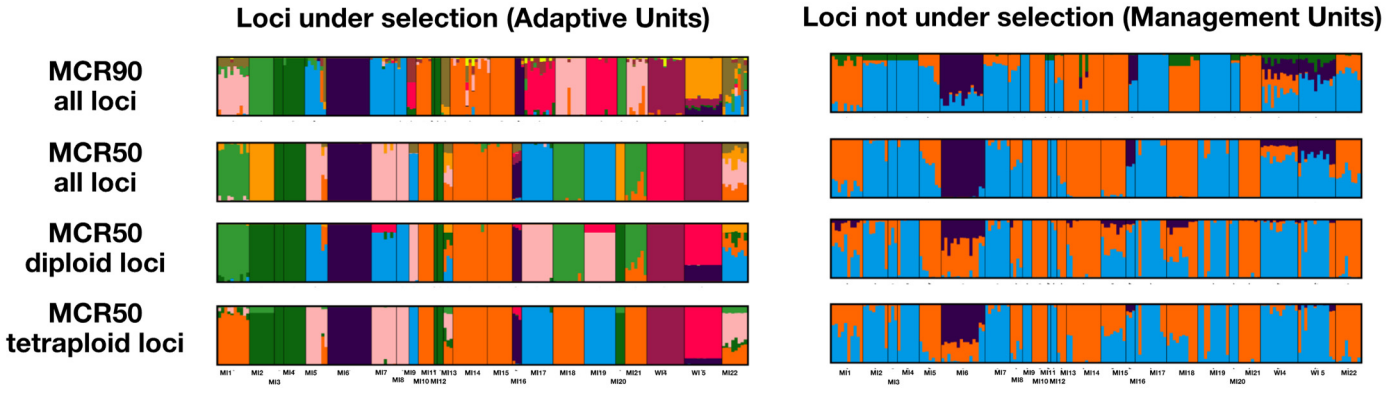

Figure 4. Structure bar graphs for MCR90 all loci and three MCR50 datasets for loci under and not under selection (adaptive units and management units, respectively). Individual ancestry denoted by color. Groups for each listed in Table 1, and best K values noted in Table 2.

The results of the fastSTRUCTURE, PCA, and DAPC are similar, with one exception. Unlike analyses with fastSTRUCTURE and PCA, where individuals of the same population cluster together, with DAPC, some individuals of the same population are members of different clusters. This is likely due to the large number of clusters identified as optimal, which is particularly the case for MCR90 and MCR50 datasets with all loci.

3. Discussion

3.1. Population Structure and Genetic Diversity

Based on the multiple datasets explored using various methodological approaches, three or four different population clusters were frequently recognized for *I. lacustris* across Michigan and Wisconsin. These clusters are structured geographically, with eastern, central, and western groups, and at higher K values, the central group is subdivided into two groups that are also geographically oriented (Figures 1 and 2). In the three prior studies that employed isozymes and allozymes to examine the population genetics of *I. lacustris* [8–10], no to limited genetic diversity was identified in the populations. Each study only investigated the genetic diversity of populations within one state, using markers available at the time, which likely led to the paucity of genetic diversity. In the present study, many more loci were examined, and individuals from across most of the geographic range of the species were analyzed together, which provides a more holistic approach to elucidating the genetic diversity of the species. These results demonstrate that our hypothesis—a lack of genetic diversity among the species—was incorrect.

Across all studied populations, statistically significant isolation-by-distance is noted, and much of the genetic variation occurs within samples and among populations, with little variation within each population. These results are, on some level, unsurprising for a species that is not only clonal but also includes minimal sexual reproduction. Sampling issues, such as small numbers of individuals studied for some populations and potential

collection of ramets, could also have contributed to limited within-population genetic diversity. Additionally, almost all populations have negative F_{IS} values, a finding frequently occurring with clonal plants [17]. A similar result was recovered by Edgeloe et al. [18] for another clonal, polyploid species, *Posidonia australis* Hook.f. Despite the clonal growth in these polyploid species, the multiple gene copies may provide sufficient genetic diversity and potential so that rare species, such as *I. lacustris*, do not suffer the negative long-term impacts of vegetative reproduction and inbreeding. The changing climate will certainly be a test as to whether the genetic diversity harbored in each population will be appropriate to adapt to new conditions [19].

Among the identified clusters of populations, there are two notable areas: Bois Blanc Island in the eastern part of the sampled range and the four western populations. In Bois Blanc Island, the populations display mixed ancestry between the eastern and central populations, and these were results recovered with multiple datasets and analyses. This mixed ancestry could occur because of hybridization on the island itself with ancestors from both populations colonizing and interbreeding there. Alternatively, hybridization could have taken place on the mainland of the lower peninsula of Michigan, such as at MI7 or MI8, followed by colonization of the island. While the signature of mixed ancestry identified in the present study may suggest that hybridization is recent, given that the species reproduces clonally, the signature of (older) hybridization could remain for an extended period of time. It is useful to keep in mind that the island and nearby areas on the mainland are some of the more heavily sampled geographic regions in the present study. This greater sampling could hint at a similar pattern in other areas if individuals were sampled to a larger extent. It was not possible to include representatives from Ontario, Canada in the study, and future studies that add these will likely have greater context for the relationship of the central and eastern populations to those even farther east.

The four populations in the western cluster (MI6, MI16, WI4, and WI5) are notable. While these populations form a cluster in most analyses (Figure 2), the two Wisconsin populations (WI4 and 5) differ from those in Michigan, and, in some analyses, from each other. While WI4 and WI5 are geographically close together on the Door Peninsula and tend to cluster together in some analyses, WI4 is sometimes resolved as sharing ancestry with the eastern populations, which is not the case for WI5. This could be due to the retention of ancestral polymorphism or the fact that the establishment of each of these populations differs. However, in analyses that account for both genetic and geographic data (i.e., tess3r and conStruct), both Wisconsin populations are distinct clusters and/or are usually allied with the other western populations. This is particularly the case for the diploid dataset. In another, well-known Great Lakes shoreline endemic, *Cirsium pitcheri* Torr. & A.Gray, a similar pattern was recovered. The populations from the Door Peninsula are also quite distinct from others on Lake Michigan [20], and the northern populations on the peninsula share more alleles with the populations in the Upper Peninsula of Michigan than with some of the populations on the southern part of the peninsula.

MI6 and MI16 are intriguing populations of *I. lacustris* because they are situated inland, and this is not the case for the other sampled populations. While other populations can be found a short distance from the shoreline, these populations are ca. 30 km from the current boundary of Lake Michigan. These two populations are consistently recognized as genetically distinct from the other sampled populations, and these both likely became established during higher water level periods of Glacial Lake Algonquin ca. 12,500 years ago [21,22]. As water levels decreased during the time of Glacial Lake Chippewa and subsequently rose to current levels, these two populations became isolated in suitable habitat (e.g., conifer wetland) that allowed individuals of *I. lacustris* to persist, but without the opportunity to interbreed with other, coastal populations, resulting in their distinct genetic signature (Figure 2).

3.2. Migration and Demography

After deglaciation, *I. lacustris* migrated eastward from the western part of its range. This pattern provides evidence that MI6 and MI16 became established early in the colonization of the species during times of higher water levels and, therefore, are relicts rather than the result of inland dispersal. Additionally, the central and then eastern populations developed via migration across northern Lakes Michigan and Huron, and these populations may have retained some of the ancestral polymorphisms in the more western populations, such as WI4 and WI5. This west-to-east pattern suggests that the populations in Ontario are the most recently established, a hypothesis that can be tested during a future study. The pattern noted here for *I. lacustris* differs from that of *C. pitcheri*, which is hypothesized to have migrated from east to west [20].

Overall, rates of migration, as inferred with BA3-SNPs, among populations are minimal, a result recovered in other species of *Iris* on the Korean Peninsula [23] and a pattern that is not uncommon for narrow endemics [20]. This minimal migration is the case for all 24 populations studied as well as with three and four population clusters inferred (Figure 3). Although the species presently reproduces within populations, migration occurred and may have provided an infusion of new alleles, even if this was not a common occurrence.

In *C. pitcheri*, Fant et al. [20] note that the changes in the water level of the Great Lakes shaped the geographic distribution of this endemic species, with lower water levels allowing for increased connection among populations. Lake level changes could also have impacted the geographic distribution of *I. lacustris*. This is particularly the case for the more inland populations, which could have become established ca. 4500 years ago during the most recent high water levels for the lake. Lower lake levels may have influenced colonization of the islands as well as migration across the northern regions of Lake Michigan and allowed for the exchange of individuals that currently would be more challenging.

An alternative hypothesis for the present geographic distribution of the species also exists. Van Kley and Wujek [6] and Brotske [4] provide evidence that *I. lacustris* can inhabit a diversity of ecosystems and that changes in patterns of disturbance and forest succession following European colonization of the area reduced the suitable habitat for the species (e.g., more forests with more closed canopies). This has resulted in populations primarily being restricted to shorelines where habitat was appropriate. If this is the case, the inland populations, such as MI6, would still represent relicts of a prior time, but this would be due to remnant habitat availability based on adequate disturbance regimes and/or seral stages, not prior establishment during higher water levels of the Great Lakes and subsequent serendipitous survival.

3.3. Subsetting Diploid and Tetraploid Loci

In the present study, polyRAD [24] was used to create datasets of diploid and tetraploid loci, and these were analyzed alongside a dataset of all loci for the MCR90 and MCR50 datasets. In general, analyses of all six datasets produced fairly similar results (Figure 2, Tables 3 and 4). fastSTRUCTURE analyses of MCR90 and MCR50 datasets of all loci resulted in the identification of a cluster of six populations in the central part of the sampled population of *I. lacustris* (MI2, MI3, MI4, MI11, MI12, and MI20) that was not recovered with the diploid or tetraploid datasets, although hints of this cluster can be seen in the MCR90 2N dataset at K = 5. This cluster is identified in all of the datasets with loci under selection as either one or two clusters (Figure 2) and with the MCR90 datasets analyzed with STRUCTURE [25] and MavericK [26].

The similar results among the datasets, regardless of ploidy, may provide some evidence that not disentangling diploid and tetraploid loci from all loci may not lead to spurious results using SNP data for population genomics [27]. This statement should be treated with skepticism because it is based only on one, empirical, study. Others who have used polyRAD to subset their datasets and identify diploid loci to use for population genomics [28,29], which is a practice aligned with assumptions of common methods [28], have not explored the use of all loci and/or tetraploid loci in comparison to only ones that

segregate as diploids. It would be useful for additional studies on the population genomics of polyploid species to examine data employing all, diploid, and tetraploid (and higher) loci to determine if similar or divergent results are recovered. At the same time, the results presented herein may provide some level of confidence for researchers investigating the population genomics of species of unknown ploidy that use all loci identified via tGBS, and similar reduced-representation methods may not yield incongruent results.

3.4. Conservation Genetics of I. lacustris

The evolutionarily significant units (ESUs) were described above with all loci used for population genomic analyses, and the management units (MUs), which were determined using only loci not under selection, are similar, but not identical to the ESUs; however, the differences are minor (Figure 4). Given the similar ESUs and MUs, the management of the populations of *I. lacustris* could be geographically clustered into three to four units. However, the results of the use of the loci under selection to resolve adaptive units (AUs) differ from those of ESUs and MUs (Supplemental Figure S18). The AUs provide evidence of local adaptation, so managing only three or four MUs would not necessarily ensure that all of the genetic diversity of the species is appropriately protected. A total of nine AUs are recognized (Table 1), and while these are also geographically clustered, the AUs are much smaller than are the ESUs and MUs (Figure 4).

This local adaptation is, on some level, unsurprising, because even though the species is generally restricted to the same type of habitat presently (i.e., shorelines), climatic, soil, and vegetation differences occur across the geographic range of the species. Indeed, *I. lacustris* inhabits three of the landscape ecology regions of Michigan and multiple districts and subdistricts within each region [30,31]. Van Kley and Wujek [6] also recognized four soil types, four vegetation types, and pH variation across the species' range. Given that the species primarily reproduces asexually, this can lead to a loss of genetic variation over time as a limited number of successful genotypes dominates each particular climate–soil–vegetation combination. Consequently, the seemingly same type of habitat in a geographically distinct area may result in local adaptations to the specific region and ecosystem and contribute to outbreeding depression, limiting successful offspring from infrequent interpopulation crosses.

4. Materials and Methods

4.1. Plant Material

During the summers of 2019 and 2020, leaf material of 171 individuals of *I. lacustris* was collected from 24 locations in Michigan and Wisconsin (Figure 1) and dried in silica gel. The number of individuals per population ranged from 1 to 12, depending on the suitability of the population for collection. Most individual plants were collected at least 3 m from each other to maximize the possibility of sampling genets, not ramets. Latitude and longitude were recorded for each specimen.

4.2. DNA Sequencing

Leaf material was sent to data2bio (www.data2bio.com, accessed on 1 May 2023) for DNA isolation and tunable Genotyping-by-Sequencing (tGBS) to recognize single nucleotide polymorphisms (SNPs) across the populations. Using the restriction enzyme Bsp1286I, paired-end tGBS libraries were created [15] and subsequently sequenced with an Illumina HiSeq X (Illumina Inc., San Diego, CA, USA). Based on all sequence data, consensus reference sequences were generated with CD-HIT-454 [32] after sequencing depth was normalized to 50×, and sequencing errors were corrected using Fiona [33]. Low-quality reads were discarded (PHRED quality < 15 and error rates ≥ 3%) and trimmed, and GSNAP [34] was employed to map reads to the reference sequences based on the following parameters: ≤2 mismatches per 36 bp and less than five total per 75 bp for tails. SNPs were identified based on the following criteria: two most common alleles supported by at least 30% of the aligned bases, at least five unique reads, the sum of the one or two most

common alleles covering at least 80% of the aligned reads, and no polymorphisms in the first or last three base pairs of each read. From the SNPs, two datasets were created: MCR90 with up to 10% missing data and MCR50 with up to 50% missing data.

4.3. Polyploidy Filtering

Because I. lacustris is a putative polyploid and many population genetic methods assume that species are (at most) diploid, polyRAD [24] was used to identify and filter loci that are diploid and tetraploid. The MCR90 and MCR50 datasets were filtered using the IteratePopStruct command to identify genotypes, and then the H_{ind}/H_E statistic [24,35] was employed to recognize diploid loci with $H_{ind}/H_E < 0.5$ and tetraploid loci with $H_{ind}/H_E > 0.75$. Datasets were created for each set of loci (Table 2). The number of SNPs in the diploid and tetraploid datasets does not equal the value in the initial datasets because of filtering with polyRAD.

4.4. Population Genomics

Observed and expected heterozygosity measurements and *F*-statistics were calculated with hierfstat [36,37], and AMOVA was conducted with poppr [38]. All 24 populations were examined, as were the populations divided into three and four geographic clusters, which are based on the optimal K values from preliminary analyses in fastSTRUCTURE (Table 2) and patterns of population structure from STRUCTURE and MavericK. fastSTRUCTURE [39] was employed to identify population structure, including the optimal number of clusters (K), and for these analyses, K = 1–24 were analyzed for the six SNP datasets, using Structure_threader [40], on the Kettering University High-Performance Computing Cluster (KUHPC). Ten replicates were run for each K, with a convergence criterion of 0.000001, a simple prior, and 100 test sets for cross-validation. The CLUMPAK main pipeline, which includes CLUMPP [41] and DISTRUCT [42], was employed to organize, cluster, and visualize the results of independent fastSTRUCTURE analyses, via 10,000 permutations of the LargeKGreedy algorithm [43]. To identify the optimal K value(s), the marginal likelihood that maximizes model complexity from fastSTRUCTURE and the MedMedK, MedMeanK, MaxMedK, and MaxMeanK values determined by StructureSelector [44,45] were examined. These latter four metrics are useful for uneven sampling and are based on recognizing the number of clusters that include, at minimum, one subpopulation. Differences among these metrics are the result of the arithmetic mean or median used and the median or maximum number of clusters identified [45].

For comparison, and given potential variation in ploidy at loci [27], STRUCTURE [25] and MavericK [26] were also used, with Structure_threader, for analyses with the three MCR90 datasets. With STRUCTURE, the following parameters were used with K = 1–24: 1,000,000 steps and 500,000 burnin, with alpha and lambda of 1, and with or without admixture. Ten replicates were run for each K. CLUMPAK and StructureSelector were also used for STRUCTURE analyses, with the best K also determined via the method of Evanno et al. [46] and Ln Pr (X | K). MavericK analyses were run for K = 1–12 with five replicates per K, without admixture, using the following parameters for each replicate: 50,000 steps and 5000 burnin for Markov Chain Monte Carlo (MCMC) sampling and an alpha of 1500 steps and 5000 burnin, with 50 rungs, for thermodynamic integration (TI) sampling, and 100 expectation-maximization repeats. With MavericK, graphs were visualized with R [47], and the optimal K value was determined using TI.

To explicitly include geographical data along with SNPs to investigate patterns of population genetics, tess3r [48] and conStruct [49] were used, and all datasets were analyzed with the former, but only the three MCR90 datasets with the latter. For tess3r, the alternating projected least squares method was undertaken for K = 1–24 for MCR90 and K = 1–12 for MCR50 datasets. Results for each K were visualized with bar graphs and maps in R [47], and the optimal K value was identified using the cross-validation plot for each dataset. For conStruct cross-validation, analyses were conducted with five replicates, for K = 1–8, using 10,000 MCMC iterations sampled every 1000 iterations and a training proportion of 0.5–0.8,

depending on the dataset. Subsequently, analyses with K = 3–5 were conducted, with five replicates, using one chain run for 100,000 MCMC iterations sampled every 1000 iterations and with the spatial model.

In addition to analyses for explicit population structure, all datasets were analyzed with principal component analyses (PCA), correspondence analyses (CA), and discriminant analyses of principal components (DAPC) in adegenet [50], principal coordinate analyses (PCoA) in hierfstat [36,37], and isolation-by-distance (IBD) analyses in adegenet using separate Mantel tests for population and individuals, with 999 simulations for the Mantel test. For DAPC for each dataset, the Bayesian Information Criterion (BIC) was used to identify the optimal number of clusters, and cross-validation was employed to explore the most appropriate number of PCs to retain for analysis.

Loci under selection were determined with BayeScan [51] using 100,000 iterations, a burnin of 50,000 iterations, a thinning interval of 10, and a sample size of 5000, and for each analysis, 20 pilot runs were conducted, each with 5000 steps. Loci under selection were visualized in R using F_{ST} values and a false discovery rate of 0.05.

Demographic history and patterns of migration were explored using BA3-SNPs [52,53], DIYABC Random Forest (DIYABC-RF) [54], and abcranger [55], and only the three MCR90 datasets were used for these analyses, with the three and four aforementioned population clusters used (apart from all 24 populations investigated with MCR90 with BA3-SNPs). For BA3-SNPs, the datasets were each run for 50 million Markov Chain Monte Carlo (MCMC) iterations, with 20 million MCMC burnin iterations, and a sampling interval of 2500 iterations, and the initial parameters for allele frequencies, inbreeding coefficient, and migration rates were tuned to vary between 0.2–0.6. For DIYABC-RF, the optimal scenario for patterns of diversification were examined among all 15 arrangements of four bifurcating populations. For each scenario, population size was modelled to vary after populations split and one and two other times for when the second and first populations diverge (Supplemental Figure S17). For analyses, all genetic diversity, F_{ST} distances, Nei's distances, and admixture estimates were selected, and the analyses were run for 15 million simulations with a batch size of 1000. Using the results of the training, a random forest analysis was conducted with abcranger [55] using 1000 trees to identify the number of trees supporting each model and to estimate the parameters of the model, with and without linear discriminant analysis, for partial least squares (PLS) estimation on the optimal model for each dataset.

4.5. Conservation Units

Conservation and management units were identified following the three-step method of Funk et al. [16], in which (1) evolutionarily significant units (ESUs) are recognized using all loci, (2) management units (MUs) are delimited with non-outlier loci, and (3) adaptive groups are determined using outlier loci. For the three steps, fastSTRUCTURE [39], PCA, and DAPC were used [50]. The first step was described above for datasets with all loci, and the other two steps were conducted using the same parameters for the three analyses and were based on two datasets (loci under and not under selection as determined via BayeScan [51]) for each MCR50 dataset and the all loci dataset of MCR90 (Table 2). The optimal K value was identified using StructureSelector [44], the marginal likelihood that maximizes model complexity from fastSTRUCTURE [39], and the BIC for DAPC with adegenet [50]. Based on the results of these analyses, ESUs, MUs, and adaptive groups were identified (Supplemental Figure S18).

5. Conclusions

The present study provides evidence of genomic variation and local adaptation across the geographic range of the species, which is novel given the negligible genetic diversity previously recovered for *I. lacustris* [8–10]. However, as Van Kley and Wujek [6] stated thirty years ago, "Despite a preference for a somewhat disturbed habitat, *Iris lacustris* will not grow where the habitat has been destroyed by residential, resort, or industrial development".

Therefore, the conservation genetic results are of limited value if management steps are not taken to ensure that individuals of *I. lacustris* have the opportunity to be successful in situ. This includes not only ensuring intermediate light conditions and limited litter [5,6], but also that as much genetic diversity across the entire geographic range of the species is conserved and managed appropriately. Indeed, given the local genetic diversity recognized among the nine adaptive units, it would be prudent to strive to conserve representatives from these areas. This is particularly important because the populations that are best able to adapt to the changing climate in the Great Lakes region is presently unknown [56]. Therefore, to ensure the longevity of this charismatic species, appropriate long-term management is necessary. Future work that includes the populations of *I. lacustris* from Ontario can extend the presented results to investigate the ways in which these populations relate to those in the United States. Given the international geographic range of the species, conservation efforts that are binational would be particularly useful.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/plants12132557/s1, Figure S1. Results for Isolation-by-Distance (IBD) for the six datasets. The x-axis is geographic distance, and the y-axis is genetic distance. Figure S2. Structure bar graphs from STRUCTURE for the six datasets analyzed in the present study for K (clusters) = 3–5. Individual ancestry denoted by color. Populations are denoted below each graph. Figure S3. Structure bar graphs from MavericK, without admixture, for the three MCR90 datasets analyzed in the present study for K (clusters) = 3–5. Individual ancestry denoted by color. Populations are denoted below each graph. Figure S4. tess3r maps of population assignation for the six datasets analyzed in the present study for K (clusters) = 3–5. Individual ancestry denoted by color. Figure S5. Maps and bar graphs of population assignation for the three MCR90 datasets analyzed in the present study for K (clusters) = 3–5. Individual ancestry denoted by color. Figure S6. Results for best K from StructureSelector for analyses with fastStructure for (A) MCR90 all loci, (B) MCR90 diploid loci, and (C) MCR90 tetraploid loci. Figure S7. Results for best K from StructureSelector for analyses with fastStructure for (A) MCR50 all loci, (B) MCR50 diploid loci, and (C) MCR50 tetraploid loci. Figure S8. Results for best K from StructureSelector for analyses with Structure without admixture for (A) MCR90 all loci, (B) MCR90 diploid loci, and (C) MCR90 tetraploid loci. Figure S9. Results for best K from StructureSelector for analyses with Structure with admixture for (A) MCR90 all loci, (B) MCR90 diploid loci, and (C) MCR90 tetraploid loci. Figure S10. Results for best K from MavericK, based on thermodynamic integration (TI), for analyses without admixture (A) MCR90 all loci, (B) MCR90 diploid loci, and (C) MCR90 tetraploid loci. Figure S11. Results for cross-validation scores for tess3r analyses for (A) MCR90 all loci, (B) MCR90 diploid loci, (C) MCR90 tetraploid loci, (D), MCR50 all loci, (E) MCR50 diploid loci, and (F) MCR50 tetraploid loci. Figure S12. Results for cross-validation scores for conStruct validation analyses for (A) MCR90 all loci, (B) MCR90 diploid loci, and (C) MCR90 tetraploid loci to identify best K (clusters). Graphs with blue and green dots are for spatial and non-spatial models, respectively, and graph with only blue dots displays predictive accuracy for spatial model with confidence intervals. Figure S13. Results for Bayesian Information Criterion (BIC), to identify best K (clusters), from discriminant analysis of principal components (DAPC) for (A) MCR90 all loci, (B) MCR90 diploid loci, (C) MCR90 tetraploid loci, (D), MCR50 all loci, (E) MCR50 diploid loci, and (F) MCR50 tetraploid loci. Figure S14. Results from StructureSelector for best K (clusters) fastStructure analyses for loci under selection for (A) MCR90 all loci, (B) MCR50 all loci, (C) MCR50 diploid loci, and (D) MCR50 tetraploid loci. Figure S15. Results from StructureSelector for best K (clusters) fastStructure analyses for loci not under selection for (A) MCR90 all loci, (B) MCR50 all loci, (C) MCR50 diploid loci, and (D) MCR50 tetraploid loci. Figure S16. Results for Bayesian Information Criterion (BIC), to identify best K (clusters), from discriminant analysis of principal components (DAPC) analyses for (A) MCR90 all loci under selection, (B) MCR50 all loci under selection, (C) MCR50 diploid loci under selection, (D), MCR50 tetraploid loci under selection, (E) MCR90 all loci not under selection, (F) MCR50 all loci not under selection, (G) MCR50 diploid loci not under selection, (H), MCR50 tetraploid loci not under selection. Figure S17. 15 branching scenarios evaluated in DIYABC. Pop 1 is East, Pop 2 is Mid 1, Pop 3 is Mid 2, Pop 4 is West. See Table 1 for population assignation to each population. Change in color represents potential change in population size. Scenario 3 is optimal for all and tetraploid loci, and scenario 7 is optimal for diploid loci. Figure S18. Nine Adaptive Units recognized from population genetic

analyses using loci under selection. Map of locations sampled in present study. Dark gray entire lines denote division between East, Mid1, Mid2, and West clusters (also recognized as Management Units). The dashed gray line separates Mid1 and Mid2 populations, and Mid includes both groups of populations together. Light gray lines separate Wisconsin (USA), Michigan (USA), and Ontario (Canada). Scale bar, in red, represents 50 kilometers. Table S1. AMOVA results for all datasets. Table S2. K values for the MCR90 datasets for STRUCTURE and Maverick.

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APPENDIX D: DEMOGRAPHIC SURVEY DATA

Demographic survey data at the quadrat-transition year level.

Table 12. Life stage counts to develop transitional matrices at the quadrat-transitional year level. Columns are life stage in the first year; rows are the life stage in the second year.

EO 7130 - quadrat 1, 2019-2020	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	4	1	0	0
Sterile Adult	18	6	31	0
Reproductive Adult	0	0	0	0
Dead	0	1	4	0

EO 7130 - quadrat 1, 2020-2021	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0	0	1	0
Sterile Adult	10	2	38	0
Reproductive Adult	0	0	0	0
Dead	0	3	14	0

EO 7130 - quadrat 3, 2019-2020	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	2	0	0	0
Sterile Adult	8	4	17	1
Reproductive Adult	0	0	1	0
Dead	0	0	3	0

EO 7130 - quadrat 3, 2020-2021	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	2	0	3	0
Sterile Adult	7	1	7	0
Reproductive Adult	0	0	0	0
Dead	0	1	20	1

EO 7130 - quadrat 4, 2019-2020	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	3	0	0	0
Sterile Adult	10	1	15	0
Reproductive Adult	0	0	1	0
Dead	0	0	2	0

EO 7130 - quadrat 4, 2020-2021	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	2	0	2	0
Sterile Adult	6	1	12	1
Reproductive Adult	0	0	1	0
Dead	0	2	11	0

EO 7130 - quadrat 5, 2019-2020	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	5	0	0	0
Sterile Adult	25	2	8	1
Reproductive Adult	2	0	4	0
Dead	0	0	2	0

EO 7130 - quadrat 5, 2020-2021	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	3	0	0	0
Sterile Adult	24	4	21	1
Reproductive Adult	5	0	1	1
Dead	0	0	6	1

EO 7130 - quadrat 6, 2019-2020	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0	0	0	0
Sterile Adult	0	0	0	0
Reproductive Adult	0	0	0	0
Dead	0	6	9	2

EO 7130 - quadrat 8, 2019-2020	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0	0	0	0
Sterile Adult	0	0	0	0
Reproductive Adult	0	0	0	0
Dead	0	10	49	9

EO 7130 - quadrat 10, 2019-2020	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0	0	0	0
Sterile Adult	0	0	0	0
Reproductive Adult	0	0	0	0
Dead	0	15	42	14

EO 7130 - quadrat 13, 2020-2021	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	3	0	2	0
Sterile Adult	2	7	23	1
Reproductive Adult	0	0	0	0
Dead	0	1	18	6

EO 12376 - quadrat 1, 2019-2020	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0	0	0	0
Sterile Adult	0	0	6	0
Reproductive Adult	0	0	0	0
Dead	0	0	1	0

EO 12376 - quadrat 1, 2020-2021	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	5	0	4	0
Sterile Adult	0	0	0	0
Reproductive Adult	0	0	0	0
Dead	0	0	0	0

EO 12376 - quadrat 2, 2019-2020	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0	0	0	0
Sterile Adult	0	0	0	0
Reproductive Adult	0	0	0	0
Dead	0	0	38	0

EO 12376 - quadrat 3, 2019-2020	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	3	0	1	1
Sterile Adult	8	0	27	6
Reproductive Adult	0	0	3	0
Dead	0	0	4	0

EO 12376 - quadrat 3, 2020-2021	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0	0	5	1
Sterile Adult	13	3	29	1
Reproductive Adult	0	0	0	0
Dead	0	2	7	1

EO 12376 - quadrat 5, 2019-2020	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	5	0	0	0
Sterile Adult	26	0	41	13
Reproductive Adult	1	0	16	9
Dead	0	0	4	0

EO 12376 - quadrat 5, 2019-2020	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0	0	0	1
Sterile Adult	0	3	34	6
Reproductive Adult	8	0	4	2
Dead	0	2	10	3

EO 12376 - quadrat 6, 2019-2020	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0	0	0	1
Sterile Adult	12	0	23	0
Reproductive Adult	0	0	6	0
Dead	0	0	2	0

EO 12376 -quadrat 6, 2020-2021	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	3	0	1	0
Sterile Adult	7	1	24	4
Reproductive Adult	0	0	5	0
Dead	0	0	5	2

EO 15125 - quadrat 1, 2019-2020	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0	0	1	0
Sterile Adult	11	0	75	2
Reproductive Adult	0	0	2	0
Dead	0	0	15	0

EO 15125 - quadrat 1, 2020-2021	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	4	0	1	0
Sterile Adult	43	0	62	1
Reproductive Adult	3	0	6	0
Dead	0	1	19	1

EO 15125 - quadrat 4, 2019-2020	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	4	0	0	0
Sterile Adult	3	0	10	4
Reproductive Adult	0	0	0	0
Dead	0	0	0	1

EO 15125 - quadrat 4, 2020-2021	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	2	2	0	0
Sterile Adult	15	2	12	0
Reproductive Adult	1	0	1	0
Dead	0	0	0	0

EO 15125 - quadrat 5, 2019-2020	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	1	0	0	0
Sterile Adult	14	0	38	1
Reproductive Adult	0	0	1	0
Dead	0	0	6	0

EO 15125 - quadrat 5, 2020-2021	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	5	0	2	0
Sterile Adult	18	1	32	1
Reproductive Adult	0	0	5	0
Dead	0	0	7	0

EO 15125 - quadrat 7, 2019-2020	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	15	0	0	0
Sterile Adult	31	3	15	6
Reproductive Adult	0	0	5	0
Dead	0	0	1	0

EO 15125 - quadrat 7, 2020-2021	New Growth	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	9	3	6	0
Sterile Adult	30	9	29	1
Reproductive Adult	0	1	4	0
Dead	0	1	4	1

Table 13. Transitional matrices at the quadrat-transitional year level. Columns are life stage in the first year; rows are the life stage in the second year.

EO 7130 - quadrat 1, 2019-2020	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.22	0.09	0.00
Sterile Adult	1.17	1.31	0.00
Reproductive Adult	0.00	0.00	0.00

EO 7130 - quadrat 1, 2020-2021	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.00	0.02	0.00
Sterile Adult	0.50	0.90	0.00
Reproductive Adult	0.00	0.00	0.00

EO 7130 - quadrat 3, 2019-2020	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.09	0.07	0.09
Sterile Adult	1.35	1.11	1.35
Reproductive Adult	0.00	0.05	0.00

EO 7130 - quadrat 3, 2020-2021	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.09	0.16	0.00
Sterile Adult	0.82	0.45	0.00
Reproductive Adult	0.00	0.00	0.00

EO 7130 - quadrat 4, 2019-2020	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.18	0.16	0.00
Sterile Adult	1.59	1.36	0.00
Reproductive Adult	0.00	0.06	0.00

EO 7130 - quadrat 4, 2020-2021	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.04	0.14	0.12
Sterile Adult	0.45	0.66	1.35
Reproductive Adult	0.00	0.04	0.00

EO 7130 - quadrat 5, 2019-2020	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.34	0.29	0.33
Sterile Adult	2.66	2.00	2.67
Reproductive Adult	0.14	0.40	0.13

EO 7130 - quadrat 5, 2020-2021	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.11	0.09	0.07
Sterile Adult	1.89	1.45	0.93
Reproductive Adult	0.18	0.18	0.46

EO 7130 - quadrat 13, 2020-2021	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.09	0.11	0.02
Sterile Adult	0.94	0.58	0.15
Reproductive Adult	0.00	0.00	0.00

EO 12376 - quadrat 1, 2019-2020	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.00	0.00	0.00
Sterile Adult	0.00	0.86	0.00
Reproductive Adult	0.00	0.00	0.00

EO 12376 - quadrat 1, 2020-2021	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.00	2.25	0.00
Sterile Adult	0.00	0.00	0.00
Reproductive Adult	0.00	0.00	0.00

EO 12376 - quadrat 3, 2019-2020	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.00	0.10	0.22
Sterile Adult	0.00	0.96	1.07
Reproductive Adult	0.00	0.09	0.00

EO 12376 - quadrat 3, 2020-2021	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.00	0.12	0.33
Sterile Adult	0.80	0.98	0.55
Reproductive Adult	0.00	0.00	0.00

EO 12376 - quadrat 5, 2019-2020	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.00	0.06	0.06
Sterile Adult	0.00	0.98	0.92
Reproductive Adult	0.00	0.27	0.42

EO 12376 - quadrat 5, 2020-2021	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.00	0.00	0.08
Sterile Adult	0.60	0.71	0.50
Reproductive Adult	0.12	0.25	0.32

EO 12376 - quadrat 6, 2019-2020	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.00	0.00	1.00
Sterile Adult	0.00	1.12	0.40
Reproductive Adult	0.00	0.19	0.00

EO 12376 -quadrat 6, 2020-2021	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.09	0.10	0.06
Sterile Adult	1.20	0.86	0.80
Reproductive Adult	0.00	0.14	0.00

EO 15125 - quadrat 1, 2019-2020	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.00	0.01	0.00
Sterile Adult	0.00	0.92	1.14
Reproductive Adult	0.00	0.02	0.00

EO 15125 - quadrat 1, 2020-2021	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.00	0.06	0.03
Sterile Adult	0.00	1.18	0.80
Reproductive Adult	0.00	0.10	0.02

EO 15125 - quadrat 4, 2019-2020	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.00	0.29	0.23
Sterile Adult	0.00	1.21	0.97
Reproductive Adult	0.00	0.00	0.00

EO 15125 - quadrat 4, 2020-2021	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.62	0.12	0.00
Sterile Adult	1.44	1.86	0.00
Reproductive Adult	0.06	0.14	0.00

EO 15125 - quadrat 5, 2019-2020	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.00	0.02	0.03
Sterile Adult	0.00	1.15	1.35
Reproductive Adult	0.00	0.02	0.00

EO 15125 - quadrat 5, 2020-2021	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.12	0.15	0.12
Sterile Adult	1.45	1.08	1.45
Reproductive Adult	0.00	0.11	0.00

EO 15125 - quadrat 7, 2019-2020	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.52	0.49	0.52
Sterile Adult	2.07	1.73	2.07
Reproductive Adult	0.00	0.24	0.00

EO 15125 - quadrat 7, 2020-2021	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.38	0.30	0.09
Sterile Adult	1.18	1.20	0.79
Reproductive Adult	0.07	0.09	0.00

Table 14. Transitional matrices at the location-transitional year level. Columns are life stage in the first year; rows are the life stage in the second year.

EO 7130, 2019-2020	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.06	0.06	0.02
Sterile Adult	0.47	0.65	0.15
Reproductive Adult	0.01	0.04	0.00

EO 7130, 2020-2021	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.07	0.09	0.04
Sterile Adult	0.93	0.80	0.43
Reproductive Adult	0.03	0.03	0.11

EO 12376, 2019-2020	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.00	0.04	0.13
Sterile Adult	0.00	0.78	0.94
Reproductive Adult	0.00	0.15	0.31

EO 12376, 2020-2021	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.01	0.14	0.11
Sterile Adult	0.74	0.81	0.59
Reproductive Adult	0.06	0.13	0.18

EO 15125, 2019-2020	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.52	0.09	0.30
Sterile Adult	2.07	1.10	1.49
Reproductive Adult	0.00	0.05	0.00

EO 15125, 2020-2021	Juvenile	Sterile Adult	Reproductive Adult
Juvenile	0.39	0.14	0.07
Sterile Adult	1.19	1.21	0.93
Reproductive Adult	0.06	0.10	0.01