Short-term response of dwarf lake iris to canopy manipulation

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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: A 'fell and remove' canopy manipulation plot at EO ID 10888. Dwarf lake iris can be seen to the left of the center stump. Photo by Alex Ellison.

EXECUTIVE SUMMARY

Dwarf lake iris (*Iris lacustris*) is a rare plant species found within several kilometers of the northern shores of Lake Michigan and Lake Huron of the Great Lakes of North America. One of the recovery objectives in the US Fish and Wildlife Services' Dwarf Lake Iris Recovery Plan was to "advance the understanding of dwarf lake iris ecology through research and experimental management practices". This project directly addresses management techniques suspected to improve growth of dwarf lake iris populations by opening canopy to allow greater amount of light to reach the plants. Three treatment and one control plot was surveyed in areas of at least 70% canopy at each of four dwarf lake iris populations in the Northern Lower Peninsula of Michigan, USA. Three treatment types were performed on trees in the plots: felling the trees, felling and removing the trees, and girdling the trees. Plots were surveyed for two full growing seasons post-treatment. Despite the immediate removal of canopy (i.e., fell and fell and remove treatments), the treatments did not result in noticeable differences in the area occupied by the species or the number of flowers produced, which is inconsistent with Van Kley's work (1989). In fact, across all plots, the amount of area covered by dwarf lake iris decreased regardless of treatment. There was a significant increase in number of ramets from pre-treatment ramet count to the last spring ramet count for dwarf lake iris in the fell and remove plots, indicating an increase in density given the occupied area did not increase. There could be longer-term effects of the treatments, especially fell and remove and possibly girdle that warrant continued monitoring.

ACKNOWLEDGEMENTS

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INTRODUCTION

Dwarf lake iris (*Iris lacustris* Nutt.; henceforth DLI) is a perennial iris found within 32 kilometers of the northern shores of Lake Michigan and Lake Huron of the Great Lakes of North America. The plant is small, less than 16 cm (6 in) tall, with blue or rarely white flower that usually blooms from mid-May to mid-June. Its ramet density, flowering abundance, and fruit set is greatly affected by light levels and litter depth (Van Kley 1989). DLI is pollinated mostly by small bees and other generalist species, and most sexual reproduction appears local within population clusters (Cohen and Turgman-Cohen 2023). Its seeds are distributed by ants (Brotske 2018). Most reproduction of DLI is conducted through asexual means of rhizomous growth (Makholm 1986, Orick 1992, Simonich and Morgan 1994).

This Great Lakes endemic species is listed as a threatened species throughout in the United States of America, Michigan, and Wisconsin and as a species of special concern in Canada and Ontario. For federal threatened and endangered species, species status and recovery plans are developed to identify and assess threats to a species, and then propose solutions to maintain and grow remnant populations (USFWS 2016, Smith et al. 2018). 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).

One of the recovery objectives in the Dwarf Lake Iris (*Iris lacustris*): Recovery Plan (2013) was to "advance the understanding of dwarf lake iris ecology through research and experimental management practices". This project directly addresses management techniques that have been suspected to improving growth of DLI colonies based heavily on research by Van Kley (1989, Van Kley and Wujek 1993) and other observations: opening canopy to allow more light to reach the plants.

Among different Michigan populations, Van Kley (1989) showed greater flowering abundance and fruit set in populations with greater light levels and less litter depth. Many short-term observations among populations support this association. These results and observations have led to the assumption that human-engineered canopy reduction for a population will increase the population size, density, and/or productivity. Although this assumption is logical, a colony's response to canopy manipulation has not been documented; other factors may influence the growth and preference of DLI population such as soil moisture.

To better understand the effects of canopy management on DLI populations, we designed an experiment where common canopy manipulation methods were tested and DLI populations monitored to detect responses in DLI growth, cover, and reproduction.

METHODS

Study Area

Most DLI 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 (Cohen et al. 2015, Hackett et al. 2021, Hackett et al. 2022, MNFI 2024).

Four sites were selected with DLI populations owned and managed by one of two non-governmental, non-profit organizations: Little Traverse Conservancy (element occurrence [EO] ID 22657) or Michigan Nature Association (EO ID 2440, 8385, 10888; MNFI 2024; APPENDIX A: Definitions and NatureServe Terminology, APPENDIX B: Site and Plot Keys). Sites were in the northern Lower Peninsula of Michigan, USA, in either Alpena, Cheboygan, or Presque Isle Counties. Plots within each site were located were in boreal forest or forested part of dune and swale complex with greater than 70% canopy density.

Experimental Design

At each study area, four plots 10 m x 10 m plots were marked containing DLI. One was a control plot and receive no canopy manipulation. The other three plots underwent one of three possible canopy treatments: 1) tree girdling, henceforth girdle, 2) tree felling, henceforth fell, 3) tree felling and removal, henceforth fell and remove. All trees greater than 10 cm (4 in) diameter at breast height (DBH) were treated. Prior to treatment the species, DBH, approximate height, and location in the plot of each tree were recorded.

At the plot-level, overstory canopy density was measured using a concave densiometer. The surveyor stood at the plot center facing in a cardinal direction and followed the methods of Lemmon 1956. This was repeated in all four cardinal directions and the mean was calculated. Soil type was be recorded at this level.

Monitoring DLI

Pre-treatment monitoring of DLI in each plot was conducted prior to canopy manipulation and five more sampling events were conducted post canopy manipulation. To more accurately measure the DLI population in a single plot, each 10 m x 10 m plot was divided into 25 subplots of 2 m x 2 m (Figure 1, Figure 2). Population and habitat measurements were taken only in subplots with DLI present: percent cover of DLI overall, number of flowers or fruits, estimate of number of ramets, percent of ramets at each life stage (Table 1), ranked animal impact, and photograph (APPENDIX C: Data Dictionary for Sampling). Percent cover of other herbaceous and woody vegetation, bare ground, debris, and other were be recorded at the DLI present subplot-level. At three randomly selected subplots with DLI present, soil moisture, soil pH, depth of vegetative litter, and depth of organic/top layer of soil was also measured. All measurements were pooled and averaged for analysis at the plot level.

Table 1. Description of DLI life stages at flowering time.

Stage	Description
Young ramet	Ramet less than 5.25 cm tall and lacks sexual reproductive organs (i.e., flower, fruit)
Sterile adult ramet	Ramet greater than 5.25 cm, but lacks sexual reproductive organs
Reproductive ramet	Ramet has sexual reproductive organs

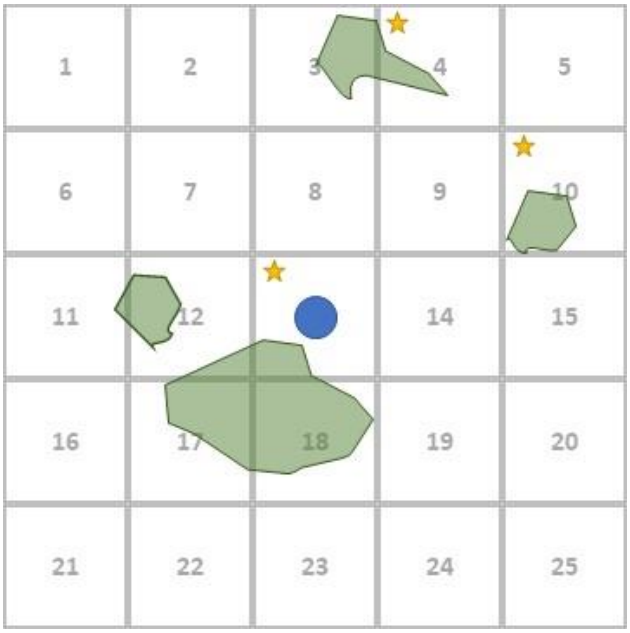

Figure 1. Diagram of plot with subplots. The subplot numbering is orientated to 1 in the NW corner. The blue circle in the center is the plot center; the green polygons represent DLI patches; the yellow stars mark the random subplots selected for additional habitat measurements.

Figure 2. Panoramic photograph of subplots marked out in June 2022. Nathan Hilbrands, Huron Pines AmeriCorps member, and Rachel Hackett, MNFI Conservation Associate – Botanist pictured. Photograph by Alex Ellison.

Statistical Analysis

Trends over time among treatments and sampling events for measurements of overstory density, soil moisture, soil pH, litter depth, and organic soil depth were compared with repeated measures analysis of variance (ANOVA) and Tukey's pairwise analysis.

Models were fit for the response variables 1) area of DLI (m^2), 2) total ramet estimate, and 3) number of reproductive ramets (spring periods only). The model that best fit the data (i.e., lowest AIC value) between a generalized liner model and generalized linear mixed model was selected for further examination. Mixed effects models were examined to see if plot had a random effect on the results seen and, if so, to account for that bias (e.g., the plots had different starting values among each other than between treatments). Gamma family distribution was used for the area of DLI due to the data being continuous non-negative variable with a skew. Poisson family distribution was used for variables for the target species ramet estimate and number of reproductive ramets due to the integer nature of the variable. Tukey-adjusted p-values were used for pairwise comparison.

Analysis of co-variance (ANCOVA) was run to detect differences between the pre-treatment sampling event of June 2022 and the last June sampling event in 2024 while accounting for the bias of starting values among plots at the same site for area covered by DLI, total ramet estimate, and number of reproductive ramets.

All data analyses were run using the statistical program R (version 4.2.3 or 4.4.2, R Foundation for Statistical Computing, Vienna, Austria) unless otherwise specified.

RESULTS

Pre-treatment monitoring of DLI in each plot was conducted in June 2022 and five more sampling events occurred post canopy manipulation: October 2022, June 2023, August 2023, June 2024, and August 2024. Among treatments, two groups were statistically different: Group 1 – control plots and girdle canopy treatment and Group 2 – fell and fell and remove trees (Figure 3). Group 2 had significantly less canopy cover than Group 1. No other habitat measurements were statistically significant between groups (APPENDIX D: Plot-Level Measurements).

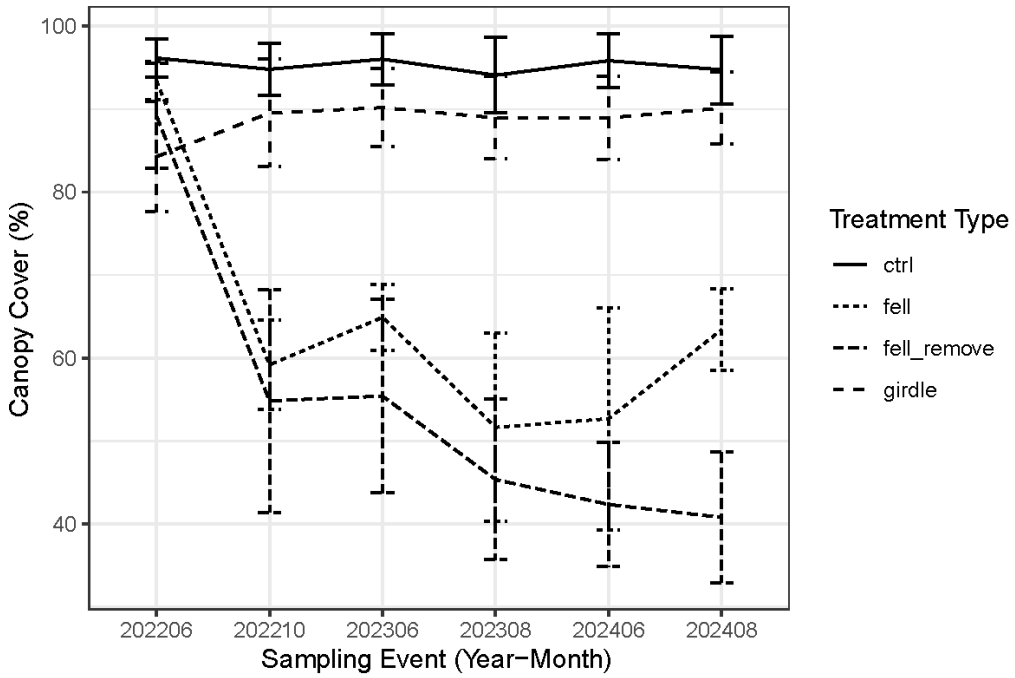

Figure 3. Line graph illustrating canopy cover measurements at each sampling event among treatment groups. At each sampling event the standard error is illustrated with perpendicular whiskers.

The difference in the plot area covered in a post-treatment sampling events from pre-treatment sampling event decreased for all treatment types (Figure 4).

The generalized linear mixed models all selected when compared to generalized linear models, indicating the bias of plot on the response variable. Residuals of mixed models were not normally distributed, but the robustness of the mixed model approach by accounting for the random effects with the use of poisson distribution for number of reproductive and total ramets produces less bias results than other analyses (Schielzeth et al. 2020, Knief and Forstmeier 2021).

The area occupied by DLI found that no treatment type was significantly different from another.

Total ramet estimate found some difference between fell and removed treatment and control, but it was not significant when examined pairwise ($p = 0.2$).

The number of reproductive ramets in fell and removed plots were significantly more than the control group but not different from the other groups ($p < 0.05$). Pairwise adjusted Tukey placed control and fell and remove treatments in two separate groups with fell and girdle mixed between them.

ANCOVA was run on the June 2022 and June 2024 data for the area covered by DLI and total estimated ramets while controlling for pre-treatment values (i.e., co-variate). Number of reproductive ramets did not pass the independence nor homogeneity assumptions, so ANCOVA was not run on that variable. For area covered by DLI, no significant difference was found among the treatments, only between the sampling events. Estimated total number of ramets did show significance (p-value < 0.1) for the fell and remove treatment from the control and girdle, but not from the fell group. The fell group was not significantly different from any group. The fell and remove group had total ramet increases among all four plots of that treatment type, while other groups were mixed (Figure 5).

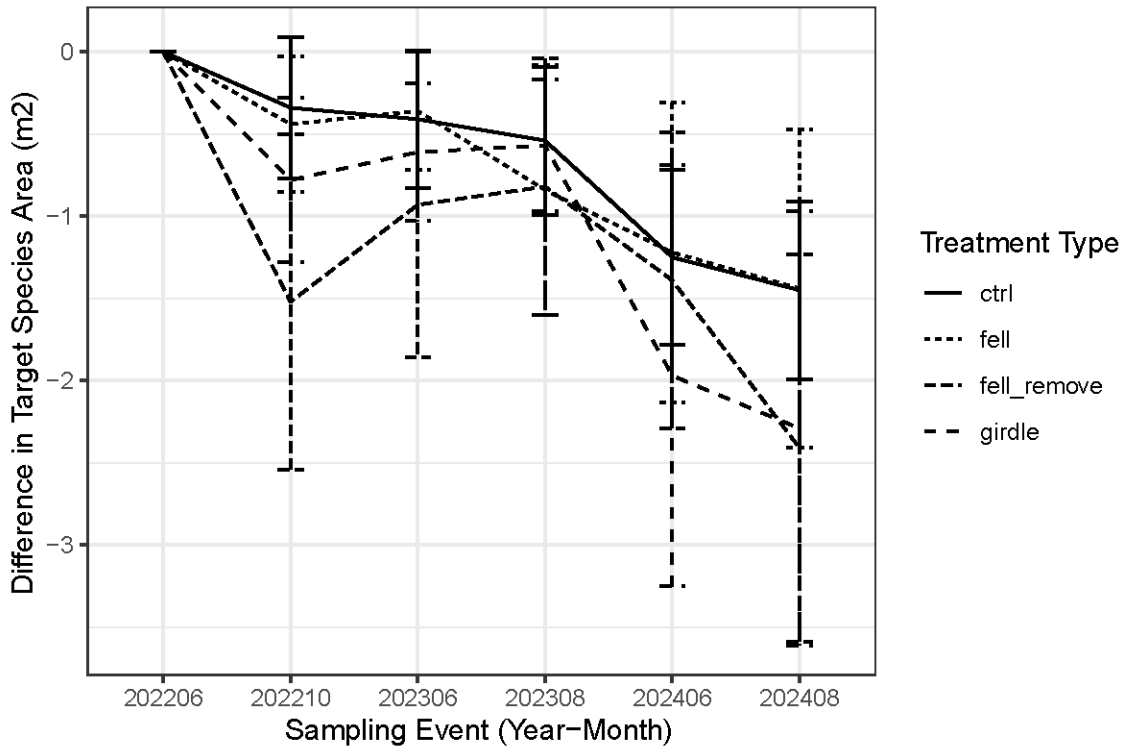

Figure 4. Difference in plot area occupied by DLI from pre-treatment area throughout sampling events. Different line types represent different treatments.

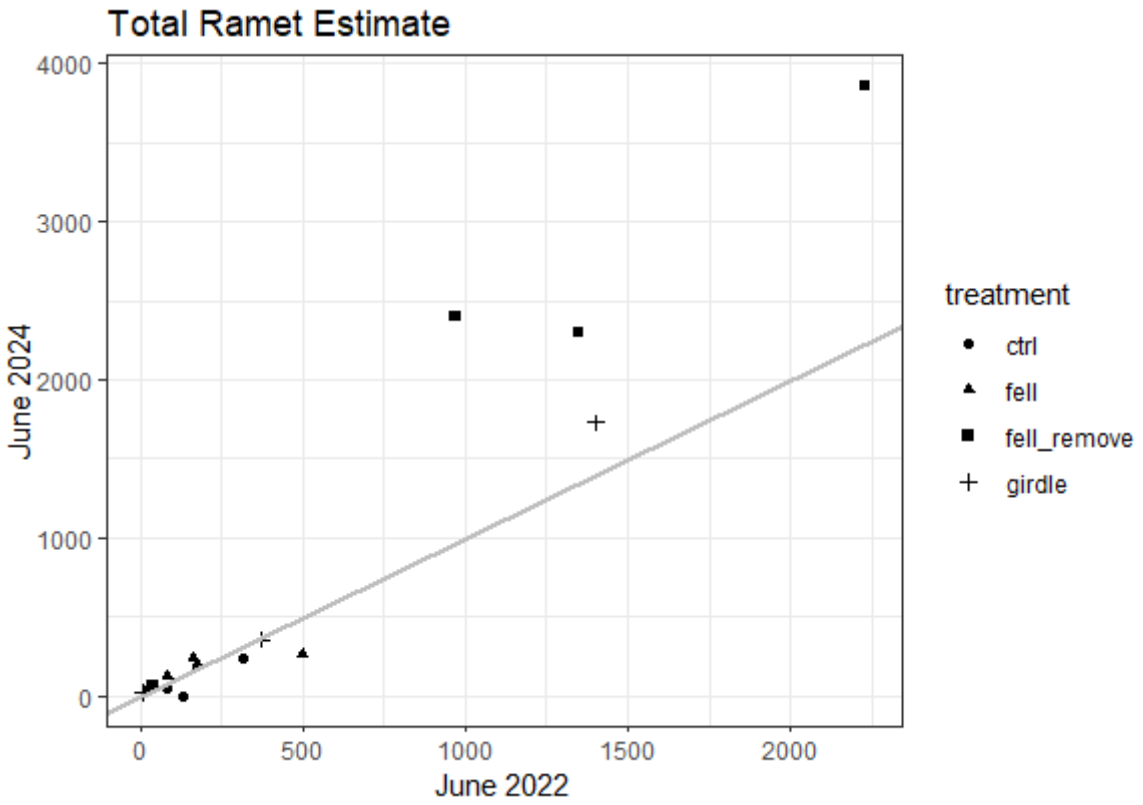

Figure 5. Change in total ramet estimates between June 2022 and June 2024 by treatment group. June 2022 sampling is along the x-axis and June 2024 sampling is along the y-axis. Solid grey line represents the 1:1 or no change in total number of ramets.

DISCUSSION

Across all plots, the amount of area covered by DLI decreased regardless of treatment. No treatment showed a significant difference in the amount decreased. No decrease of the same consistency or magnitude was observed across any of the habitat variables measured, so no correlation can be made with habitat measures that may have change. Other effects may be at play to impact the DLI patches in such a manner or more time may be needed for habitat measure(s) to emerge correlated with the trend. DLI are a perennial plant living several years and changes at the individual and population level are likely to have a lag time. A source of error could be difference among annual estimates, but the same surveyor was present and contributing to measurements for each sampling event.

Our results support a weak relationship with Van Kley (1989) showed that populations with greater sunlight produced more flowers than shaded populations, but we were unable to show any short-term increase in flowers produced when the canopy was removed (i.e., fell treatment, fell and removed treatment), allowing more sunlight penetration to the populations on the forest floor. A source of error could be the timing of the sampling events relative to peak blooming time of the DLI that year. Spring weather in the Great Lakes region has become more variable among years and timings. The first documented flowering dates based on observations on iNaturalist during sampling years were May 12, 2022, May 14, 2023, and April 29, 2024. June sampling events may have occurred during different times relative to peak bloom, which may alter representation at a site.

The fell and remove treatment showed weak differences between the control plots in total number of ramets and number of reproductive ramets, but there was not separation among all of the groups. Since there was not significant difference or increase in the area covered by DLI for this treatment, it seems likely that the population increased in density. Longer-term monitoring is needed to observe any greater or consistent benefit of this canopy treatment in other areas, or if effects to the habitat as a result of canopy manipulation change the population in other ways.

Observationally, the fell treatment only shifted cover from the canopy of the forest to the downed wood and branches on the ground. These plots were most difficult to maneuver. Assuming that light does play an important part in the vegetative or reproductive growth of DLI, this treatment is likely to have the least amount of benefit to the DLI populations.

The results of girdling treatment are lagging. The canopy cover has not yet significantly changed from the pre-treatment, thus the light levels, the hypothesized greatest influence on DLI population growth (Van Kley 1989), has not changed significantly. More years of monitoring are needed to determine the viability of this management method.

LITERATURE CITED

Albert, D. A. 1995. Regional Landscape Ecosystems of Michigan, Minnesota, and Wisconsin: A Working Map and Classification. Gen. Tech. Rep. NC-178. St. Paul, MN, USA. <https://doi.org/10.2737/NC-GTR-178>. Accessed November 2024.

Brotske, V. 2018. Pollination, Seed Dispersal and Seedling Establishment in the Federally Threatened Dwarf Lake Iris (*Iris lacustris*). University of Wisconsin-Green Bay, Green Bay, WI, USA.

Cohen, J. G., M. A. Kost, B. S. Slaughter, and D. A. Albert. 2015. A Field Guide to the Natural Communities of Michigan. Michigan State University Press, East Lansing, MI. 362 pp.

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.

Cole-Wick, AA, RA Hackett, HD Enander, CM Wilton, and JG Cohen. 2021. Invasive Species Management Plan for the Saginaw Chippewa Indian Tribe. Michigan Natural Features Inventory, Report No. 2021-03, Lansing, MI.

Hackett, RA, A Klain, J Spiels, L Kirkpatrick, PJ Higman. 2021. Dwarf Lake Iris Recovery and Population Monitoring. Michigan Natural Features Inventory, Report No. 2021-07, Lansing, MI.

Hackett, RA, A Klain, J Spieles, L Kirkpatrick, W MacKinnon, PJ Higman. 2022. Dwarf Lake Iris Recovery and Population Monitoring – Addendum 2022. Michigan Natural Features Inventory, Report No. 2022-19, Lansing, MI.

Knief, U., and W. Forstmeier. 2021. Violating the normality assumption may be the lesser of two evils. Behavior Research Methods 53:2576–2590.

Lemmon, PE. 1956. A Spherical Densiometer for Estimating Forest Overstory Density. Forest Science: 2(4) 314-320.

Makholm, M. M. 1986. Ecology and management of *Iris lacustris* in Wisconsin. University of Wisconsin-Madison.

Michigan Natural Features Inventory (MNFI). 2024. Michigan Natural Heritage Database, Lansing, MI.

NatureServe. 2021. Biotics 5 online help. Definitions of NatureServe Conservation Status Ranks. NatureServe, Arlington, Virginia, USA. Website <https://help.natureserve.org/biotics/>. Accessed 20 February 2021.

Orick, M. W. 1992. Enzyme polymorphism and genetic diversity in the Great Lakes endemic *Iris lacustris* Nutt. (dwarf lake iris). Eastern Michigan University, Ypsilanti, Michigan, USA.

Schielzeth, H., N. J. Dingemanse, S. Nakagawa, D. F. Westneat, H. Allegue, C. Teplitsky, D. Réale, N. A. Dochtermann, L. Z. Garamszegi, and Y. G. Araya-Ajoy. 2020. Robustness of linear mixed-effects models to violations of distributional assumptions. Methods in Ecology and Evolution 11:1141–1152.

Simonich, M. T. and M. D. Morgan. 1994. Allozymic uniformity in *Iris lacustris* (dwarf lake iris) in Wisconsin. Canandian Journal of Botany: 72, 1720–1722.

Smith, D. R., N. L. Allan, C. P. Mcgowan, J. A. Szymanski, S. R. Oetker, and H. M. Bell. 2018. Issues and Perspectives Development of a Species Status Assessment Process for Decisions under the U.S. Endangered Species Act. *Journal of Fish and Wildlife Management* 9: 302–320.

U.S. Fish and Wildlife Service (USFWS). 2013. Dwarf Lake Iris (*Iris lacustris*) Recovery Plan. Bloomington, Minnesota.

U.S. Fish and Wildlife Service (USFWS). 2016. USFWS Species Status Assessment Framework: an integrated analytical framework for conservation. Version 3.4 dated August 2016.

Van Kley, J. E. 1989. Habitat and ecology of *Iris lacustris* (the dwarf lake iris). Central Michigan University, Mount Pleasant, Michigan, USA.

Van Kley, J. E., and D. E. Wujek. 1993. Habitat and Ecology of *Iris lacustris* (the Dwarf Lake Iris). *The Michigan Botanist* 32: 209–222.

Wieczorek J, Bloom D, Guralnick R, Blum S, Döring M, et al. (2012) Darwin Core: An Evolving Community-Developed Biodiversity Data Standard. PLoS ONE 7(1): e29715. https://doi.org/10.1371/journal.pone.0029715

APPENDIX A: DEFINITIONS AND NATURESERVE TERMINOLOGY

This appendix contains definitions of terms used in the conservation community including NatureServe and Natural Heritage Program terminology and descriptions for global, state, and element occurrence ranks. Global and state ranks are assigned at a species- or natural community-level. Element occurrence ranks are assigned at a population- or stand-level.

Table A - 1. Additional definitions of terms and abbreviations used in report. Table modified from Cole-Wick et al. 2021.

Term	Description
Element Occurrence (EO)	A record of a listed species or natural community in a Natural Heritage Database that can contribute to the survival or persistence of that element
Natural Community	An assemblage of interacting plants, animals, and other organisms that repeatedly occur under similar environmental conditions across the landscape and is predominantly structured by natural processes rather than modern anthropogenic disturbances, such as timber harvest, alterations to hydrology, and fire suppression. Historically, indigenous peoples were an integral part of Michigan's natural communities with many natural community types being maintained by native management practices such as prescribed fire.
Natural Heritage Database	A repository of records documenting location, status, and characteristics of rare plant populations, animal populations, and natural communities in a designated region

Table A - 2. Explanation of status ranks for plant and animal species. Species with these ranks are tracked in state Natural Heritage Database.

Status	Description	Explanation
E	State endangered	State populations of species are considered endangered: in danger of extinction within the State of Michigan. The species has State protections under the Endangered Species Act of the State of Michigan (Part 365 of PA451, 1994 Michigan Natural Resources and Environmental Protection Act).
T	State threatened	State populations of species are considered threatened: likely to become endangered in the foreseeable future within the State of Michigan.. The species has State protections under the Endangered Species Act of the State of Michigan (Part 365 of PA451, 1994 Michigan Natural Resources and Environmental Protection Act).
SC	State special concern	State populations of species are declining but the species does not have State protections under the Endangered Species Act of the State of Michigan (Part 365 of PA451, 1994 Michigan Natural Resources and Environmental Protection Act). Protection of State special concern amphibian and reptiles are found under Michigan Department of Natural Resources Director's Order No. FO-224-13.
LE	Federally endangered	Populations of this species are considered endangered: in danger of extinction throughout all or a significant portion of its range in the USA. The species has protections under the federal Endangered Species Act of 1973..
LT	Federally threatened	Populations of this species are considered threatened: likely to become endangered within the foreseeable future. The species has protections under the federal Endangered Species Act of 1973.

Table A - 3. Explanation of state and global status ranks for natural communities. Abridged table developed by NatureServe (2021).

Status	Description	Explanation
S1	Critically Imperiled	At very high risk of extirpation in the jurisdiction due to very restricted range, very few populations or occurrences, very steep declines, severe threats, or other factors.
S2	Imperiled	At high risk of extirpation in the jurisdiction due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors.
S3	Vulnerable	At moderate risk of extirpation in the jurisdiction due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors.
S4	Apparently secure	At a fairly low risk of extirpation in the jurisdiction due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors.
S5	Secure	At very low or no risk of extirpation in the jurisdiction due to a very extensive range, abundant populations or occurrences, with little to no concern from declines or threats.
G1	Critically Imperiled	At very high risk of extinction or elimination due to very restricted range, very few populations or occurrences, very steep declines, very severe threats, or other factors.
G2	Imperiled	At high risk of extinction or elimination due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors.
G3	Vulnerable	At moderate risk of extinction or elimination due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors.
G4	Apparently secure	At fairly low risk of extinction or elimination due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors.
G5	Secure	At very low risk or extinction or elimination due to a very extensive range, abundant populations or occurrences, and little to no concern from declines or threats.
GU	Unrankable	Currently unrankable due to lack of information or due to substantially conflicting information about status or trends. NOTE: Whenever possible (when the range of uncertainty is three consecutive ranks or less), a range rank (e.g., G2G3) should be used to delineate the limits (range) of uncertainty.

APPENDIX B: SITE AND PLOT KEYS

[redacted]

This appendix contained detailed information about site with canopy manipulation plots. Plot-level measurements were found in APPENDIX D: Plot-Level Measurements.

Table B - 1. List of Michigan dwarf lake iris (*Iris lacustris* Nutt.) Element Occurrence (EO) populations where canopy manipulations took place. EO ID was a unique identifier for each EO record a State/Provincial Natural Heritage Database. Survey Site Name included both the name of the Sanctuary and the name recorded in the Natural Heritage Database. Rank was a qualitative assessment of estimated viability of species described in APPENDIX A: Definitions and NatureServe Terminology.

EO ID	Survey Site Name	County	Rank	Ownership
2440	[redacted]	Alpena	AB	[redacted]
8385	[redacted]	Alpena	B	[redacted]
10888	[redacted]	Presque Isle	B	[redacted]
22657	[redacted]	Cheboygan	D	[redacted]

Table B - 2. Plot location data at each site. EO ID was a unique identifier for each EO record a State/Provincial Natural Heritage Database. Plot identifier (Plot ID) was a unique identifier assigned to each plot. Plot treatment type was the type of canopy manipulation exercised in the plot.

EO ID:	Plot ID	Plot Treatment Type	Latitude	Longitude	Horizontal Accuracy (m)	Elevation (m)	Vertical Accuracy (m)
22657	A	ctrl	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
22657	B	girdle	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
22657	C	fell_remove	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
22657	D	fell	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
10888	E	girdle	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
10888	F	ctrl	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
10888	G	fell	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
10888	H	fell_remove	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
2440	J	girdle	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
2440	K	fell_remove	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
2440	L	fell	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
2440	M	ctrl	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
8385	N	fell	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
8385	O	ctrl	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
8385	P	girdle	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
8385	Q	fell_remove	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

APPENDIX C: DATA DICTIONARY FOR SAMPLING

Data was collected at each plot event, subplot (e.g., subevent), and organism occurrence levels for habitat sampling using a Esri Survey123 form. DarwinCore Terms were used as "Field Names" where applicable (Wieczorek et al. 2012).

Table C - 1. Descriptions of each field of data and meta-data to be collected. "Table" refers to the level of data collected and spreadsheet it is found on. "Display name" is the name used in surveys and most correspondence; "Field Name" is the true name used in tables and analyses. Italics indicate a "Field Name" whose data is repeated from the Event Table to help with organization and data analysis among different levels of data. "Data Type" is the class of data and "Length" is the length of characters set in the field of the spreadsheet generated by the Survey123 app.

Table	Display Name	Field Name	Definitions and Values	*Example*	Data Type	Length
Event	ObjectID	objectid	Record identifier unique to the table only. Automatically generated by ArcGIS Online.	*3*	Integer	-
Event	GlobalID	globalid	Unique global identifier. Automatically generated by ArcGIS Online. Used to link related records via ParentGlobalID	*ce204f44-7c56-43fc-aa82-856f1d7b11b0*	String	-
Event	Date	eventDateVerbatim	The day, month, year, and start time of survey	*08/17/2021 16:00*	DateTime	255
Event	eventDate	eventDate	The year, month, and day of survey without separating characters	*20210817*	Integer	8
Event	Surveyor name (s)	recordedBy	Name(s) of the surveyor(s) conducting the sampling. Separate by ";"	*Rachel Hackett; Alex Ellison*	String	255
Event	Location ID	locationID	Unique EO ID of site selected from site names Values: Preserve (22657), P Sanctuary (8385), M Sanctuary (2440), S Sanctuary (10888), Other (0)	*22657*	Integer	10
Event	locality	locality	Name of site selected	*Dwarf Lake Iris Bay Preserve*	String	100
Event	EO_rank	EO_rank	Letter ranking given to site by MNFI when last survey was conducted	*AB*	String	5
Event	county	county	Name of the county the site is located	*Cheboygan*	String	25
Event	Plot ID	locationID_plot	Unique identifier of plot at site location	*A*	String	10
Event	Plot Treatment Type	locationID_plotType	Identify the treatment type occurring at plot. Values: ctrl, girdle, fell, fell_remove, other	*girdle*	String	25

Table	Display Name	Field Name	Definitions and Values	*Example*	Data Type	Length
Event	Pre or Post	locationID_plotSuffix	Select whether or not survey is being conducted before or after treatment. Values: pre, post, other	*pre*	String	10
Event	sublocationID	sublocationID	Unique identifier created from concatenation of the fields: locationID + locationID_plot	*22657_A*	String	100
Event	eventID	eventID	Unique identifier created from concatenation of the fields: sublocationID + eventDate.	*22657_A_20210817*	String	109
Event	latitudeDecimalDegrees	latitudeDecimalDegrees	Latitude coordinate of the plot center location (datum: WGS84, units decimal degrees).	*42.5648913*	Double	25
Event	longitudeDecimalDegrees	longitudeDecimalDegrees	Longitude coordinate of the plot center location (datum: WGS84, units decimal degrees).	*-83.21687465*	Double	25
Event	horizontalAccuracy	horizontalAccuracy	The horizontal accuracy of the GPS-acquired x- and y-coordinates in meters.	*5.55*	Double	10
Event	elevationInMeters	elevationInMeters	The elevation (altitude, meters above sea level) as recorded by the GPS unit.	*318.1*	Double	10
Event	verticalAccuracy	verticalAccuracy	The vertical accuracy of the z-coordinate (if recorded by the GPS).	*10.5*	Double	10
Event	Plot area (m2)	sampleSizeValue	Area of the sampling plot.	*100*	Double	10
Event	Suplot area (m2)	sampleSizeValue_sub2	Area of one subplot within the plot	*4*	Double	10
Event	sampleSizeUnit	sampleSizeUnit	Measurement unit of plot area. Values: square_millimeter, square_centimeter, square_meter, square_kilometer, hectare, square_inch, square_foot, square_yard, square_mile, acre, other	*square_meter*	String	25
Event	Soil Texture:	m_soilTextureValue	The soil texture described using standard texture by feel analysis.	*clay*	String	25
Event	m_soilTextureUnit	m_soilTextureUnit	The categorization or measurement unit used to describe soil texture.	*Standard soil texture by feel analysis*	String	255

Table	Display Name	Field Name	Definitions and Values	*Example*	Data Type	Length
Event	m_soilTextureMethod	m_soilTextureMethod	Description or literature citation of the method used to determine soil texture	*Standard soil texture by feel analysis: S.J. Thien. 1979. A flow diagram for teaching texture by feel analysis. Journal of Agronomic Education. 8:54-55.*	String	255
Event	Sunlight Category	m_sunlightCategoryValue	Categorization of the approximate sunlight reaching the plot. Values: Full shade (< 20% of the day in the sun), Partly sunny (20 – 60% of the day in the sun), Full sun (> 60% of day in the sun), Other – explain in notes	*Full shade*	String	255
Event	Associated Species	m_species_yn	Yes/No indicating whether tree measurements (e.g., DBH, height) or data on other associated species will be taken at this event. Values: yes, no, other	*yes*	String	5
Event	Overstory Density Measurements	m_overstory_yn	Yes/No indicating whether overstory density measurement will be taken at this event. Values: yes, no, other	*yes*	String	5
Event	Mean Overstory Density (%)	m_overstoryDensityMeanValue	Mean of the m_overstoryDensityValues taken in 4 cardinal direction from the center of the plot.	*25*	Double	10
Event	m_overstoryDensityMeanUnit	m_overstoryDensityUnit	The unit used to estimate overstory density.	*Percent*	String	25

Table	Display Name	Field Name	Definitions and Values	*Example*	Data Type	Length
Event	m_overstoryDensityMeanMethod	m_overstoryDensityMethod	A description of or reference to the method or protocol used to determine the canopy area measurement.	*Forestry Densiometer (Lemmon, PE. 1956. A Spherical Desiometer for Estimating Forest Overstory Density. Forest Science: 2(4) 314-320.*	String	255
Event	Plant Name	nomenclaturalCode_target	Comprehensive Michigan plant species list using six letter acronyms for the scientific name for Michigan species as per Herman et al. 2001.	*Iris lacustris (IRILAC)*	String	10
Event	scientificName_target	scientificName_target	The scientific name of the target species.	*Iris lacustris*	String	100
Event	vernacularName_target	vernacularName_target	The common or vernacular name of the target species.	*dwarf lake iris*	String	100
Event	nomenclaturalCodeUSDA_target	nomenclaturalCodeUSDA_target	The USDA target species nomenclature code.	*IRLA*	String	10
Event	family_target	family_target	The family name for the target species.	*Iridaceae*	String	25
Event	genus_target	genus_target	The genus name for the target species.	*Iris*	String	25
Event	nativeNonNative_target	nativeNonNative_target	The target species' native/non-native status.	*native*	String	10
Event	physiognomy_target	physiognomy_target	The physiognomic class, or physical appearance and shape of the target species. Values: tree, shrub, vine, forb, grass, sedge, fern	*forb*	String	10
Event	coefficient_of_cons_target	coefficient_of_cons_target	Coefficients of conservatism (C values) are numeric values assigned to plant species to indicate their sensitivity to anthropogenic disturbance. Coefficients of conservatism range from 0 - 10 and represent an estimated probability that a plant is likely to occur in a landscape relatively unaltered from what is believed to be pre-European settlement condition.	*9*	Integer	2

Table	Display Name	Field Name	Definitions and Values	*Example*	Data Type	Length
Event	coefficient_wetness_target	coefficient_wetness_target	The coefficients of wetness (W) is the estimated probability for which a species occurs in wetlands. Positive signs (+) indicating a wet tendency and negative signs (-) indicating a dry tendency.	*0*	Integer	3
Event	lifeDuration_target	lifeDuration_target	The life duration or life span category of the target species. Values: annual, biennial, perennial	*perennial*	String	10
Event	Additional Notes Plot	eventRemarks	Remarks by the surveyor(s) on the plot location event.	*Cloudy, trash in plot.*	String	255
Overstory Density Measurement	eventDate_overstory	*eventDate_overstory*	The year, month, and day of survey without separating characters	*20210817*	Integer	8
Overstory Density Measurement	locationID_overstory	*locationID_overstory*	Unique EO ID of site. Values: 22657, 8385, 2440, 10888, 0	*22657*	Integer	10
Overstory Density Measurement	sublocationID	*sublocationID_overstory*	Unique identifier created from concatenation of the fields: locationID + locationID_plot	*22657_A*	String	100
Overstory Density Measurement	eventID	*eventID_overstory*	Unique identifier created from concatenation of the fields: sublocationID + eventDate.	*22657_A_20210817*	String	109
Overstory Density Measurement	Direction	m_overstoryDensityRemarks	Cardinal direction facing from center of plot. Values: N, NE, E, SE, S, SW, W, NW, Other	*E*	String	5
Overstory Density Measurement	Open Canopy Dots	m_canopyAreaDotsOpen	Count of the number of assumed dots in each corner of each square on the densiometer that are reflecting ¼ square openings..	*55*	Integer	3
Overstory Density Measurement	Overstory Density	m_overstoryDensityValue	Overstory density calculated by 100 – 1.04 * m_canopyAreaDotsOpen	*42.8*	Double	255
Overstory Density Measurement	m_overstoryDensityUnit	m_overstoryDensityUnit	The unit used to estimate overstory density.	*Percent*	String	25

Table	Display Name	Field Name	Definitions and Values	*Example*	Data Type	Length
Overstory Density Measurement	m_overstoryDensityMethod	m_overstoryDensityMethod	A description of or reference to the method or protocol used to determine the canopy area measurement.	*Forestry Densiometer (Lemmon, PE. 1956. A Spherical Desiometer for Estimating Forest Overstory Density. Forest Science: 2(4) 314-320.*	String	255
Subevent	eventDate_sub	*eventDate_sub*	The year, month, and day of survey without separating characters	*20210817*	Integer	8
Subevent	locationID_sub	*locationID_sub*	Unique EO ID of site. Values: 22657, 8385, 2440, 10888, 0	*22657*	Integer	10
Subevent	sublocationID	*sublocationID_sub*	Unique identifier created from concatenation of the fields: locationID + locationID_plot	*22657_A*	String	100
Subevent	eventID	*eventID_sub*	Unique identifier created from concatenation of the fields: sublocationID + eventDate.	*22657_A_20210817*	String	109
Subevent	locationID_plotType_sub	*locationID_plotType_sub*	Treatment type occurring at plot. Values: ctrl, girdle, fell, fell_remove, other	*girdle*	String	25
Subevent	Subplot:	subeventID_suffix	Unique identifier of the subplot within the plot	*11*	String	255
Subevent	sublocationID2_sub	sublocationID2_sub	Unique identifier created from concatenation of the fields: locationID + subeventID_suffix.	*22657_A_11*	String	120
Subevent	subeventID	subeventID	Unique identifier created from cont concatenation of the fields sublocationID2_sub + eventDate_sub	*22657_A_11_20210817*	String	120
Subevent	sampleSizeValue_sub	sampleSizeValue_sub	Area of the sampling subplot.	*4*	Double	10
Subevent	sampleSizeUnit_subplot	sampleSizeUnit_sub	Measurement unit of subplot area. Values: square_millimeter, square_centimeter, square_meter, square_kilometer, hectare, square_inch, square_foot, square_yard, square_mile, acre, other	*square_meter*	String	25
Subevent	Gather additional habitat data	m_extraHabitat_yn	Indicates whether or not additional habitat data was taken in the subplot. Values: Yes, No, Other	*Yes*	String	5

Table	Display Name	Field Name	Definitions and Values	*Example*	Data Type	Length
Subevent	-	image_sub	Photograph of subplot taken from above. Any additional photos.	-	Image	
Subevent	Percent Cover of Target Species	organismQuantity_target	Percent cover for target species in subplot.	*30*	Double	5
Subevent	organismQuantityType_target	organismQuantityType_target	The type of evaluation/classification for organismQuantity_target	*Percent*	String	255
Subevent	Target Species Estimate	m_populationEstimateValue	Estimate of the number of ramets in the subplot.	*550*	Integer	8
Subevent	m_populationEstimateUnit	m_populationEstimateUnit	Measurement unit of the m_populationEstimateValue	*amount*	String	25
Subevent	Number Reproductive	m_numberReproductiveValue	Number of flowers or fruits present in subplot.	*5*	Integer	5
Subevent	m_numberReproductive Unit	m_numberReproductiveUnit	Measurement unit of the m_numberReproductiveValue	*amount*	String	25
Subevent	Number Youngling	m_numberYounglingValue	Number of young ramets present in subplot (< 5.25 cm tall).	*5*	Integer	5
Subevent	m_numberYounglingUnit	m_numberYounglingUnit	Measurement unit of the m_numberYounglingValue	*amount*	String	25
Subevent	Number Sterile Adult	m_numberSterileValue	Number of sterile adults present in subplot. Calcuated in form by subtracking m_numberReproductiveValue and m_numberYounglingValue from m_populationEstimateValue.	*58*	Integer	5
Subevent	m_numberSterileUnit	m_numberSterileUnit	Measurement unit of the m_numberReproductiveValue	*amount*	String	25
Subevent	Young Ramets (%)	m_youngValue	Percent of ramets that are less than 5.25 cm tall in the subplot. Calculated from m_numberYounglingValue divided by m_populationEstimateValue.	*10*	Double	5
Subevent	m_youngUnit	m_youngUnit	Measurement unit of the m_youngValue.	*percent*	String	25
Subevent	Sterile Adult Ramets (%)	m_sterileAdultValue	Percent of ramets that are sterile adult, greater than 5.25 cm tall in the subplot. Calculated from m_numberSterileValue divided by m_populationEstimateValue	*85*	Double	5
Subevent	m_sterileAdultUnit	m_sterileAdultUnit	Measurement unit of the m_sterileAdultRametValue	*percent*	String	25

Table	Display Name	Field Name	Definitions and Values	*Example*	Data Type	Length
Subevent	Reproductive Ramets (%)	m_reproductiveAdultValue	Percent of ramets that are reproductive in the subplot. Calculated from m_numberReproductiveValue divided by m_populationEstimateValue	*5*	Double	5
Subevent	m_reproductiveAdultUnit	m_reproductiveAdultUnit	Measurement unit of the m_reproductiveAdultValue	*percent*	String	25
Subevent	Percent Cover Herbaceous Species	m_percentCoverHerbaceous	Percent cover of herbaceous plant species other than the target species.	*30*	Double	5
Subevent	Percent Cover Woody Species	m_percentCoverWoody	Percent cover of woody plant species other than the target species.	*30*	Double	5
Subevent	Percent Cover Bare Ground or Water	m_percentCoverBareGround	Percent cover of bare ground or water in subplot.	*10*	Double	5
Subevent	Percent Cover Debris	m_percentCoverDebris	Percent cover of debris in subplot.	*10*	Double	5
Subevent	Percent Cover Other	m_percentCoverOther	Percent cover of other items in subplot. Other is explained in additional notes.	*5*	Double	5
Subevent	Animal Impact	m_animalImpactValue	Categorical ranking of impact that reflects percent of target species affected by animal impact (e.g., herbivory) Values: no_impact, low_impact (less than 50% of individuals impacted), high_impact (50% or more individuals impacted)	*low_impact*	String	25
Subevent	m_animalImpactUnit	m_animalImpactUnit	Measurement unit of the m_animalImpactValue	*Categorical ranking of impact that reflects percent of target species affected by animal impact (e.g., herbivory)*	String	255
Subevent	Soil Moisture Description	m_soilMoistureQualValue	Qualitative description of soil moisture Values: dry, moist, wet, saturated, inundated, other	*Moist*	String	255
Subevent	Soil Moisture	m_soilMoistureValue	Measure of soil moisture in the subplot.	*5.5*	Double	5
Subevent	m_soilMoistureUnit	m_soilMoistureUnit	Measurement unit of the m_soilMoistureValue	*percent*	String	25
Subevent	m_soilMoistureMethod	m_soilMoistureMethod	A description of or reference to the method or protocol used to determine the soil moisture.	*Kelway Soil pH and Moisture Meter*	String	255
Subevent	Soil pH	m_soilpHValue	Measurement of soil pH	*7.2*	Double	5
Subevent	m_soilpHUnit	m_soilpHUnit	Measurement unit of the m_soilpHValue	*pH*	String	25

Table	Display Name	Field Name	Definitions and Values	*Example*	Data Type	Length
Subevent	m_soilpHMethod	m_soilpHMethod	A description of or reference to the method or protocol used to determine the soil pH.	*Kelway Soil pH and Moisture Meter*	String	255
Subevent	Litter Depth (cm)	m_litterDepthValue	Measure of litter depth in the subplot	*3.2*	Double	5
Subevent	m_litterDepthUnit	m_litterDepthUnit	Measurement unit of the m_litterDepthValue. Values: millimeter, centimeter, meter, kilometer, inch, foot, yard, mile, other	*centimeter*	String	25
Subevent	Organic Soil Depth (cm)	m_organicSoilDepthValue	Measure of organic soil depth in the subplot.	*4.8*	Double	5
Subevent	m_organicSoilDepthUnit	m_organicSoilDepthUnit	Measurement unit of the m_organicSoilDepthValue	*centimeter*	String	25
Subevent	Additional Notes Subplot	eventRemarks_sub	Remarks by the surveyor(s) on the subplot event.	*Cloudy, trash in plot.*	String	500
Occurrence	Date:	*eventDate_occ*	The year, month, and day of survey without separating characters	*20210817*	Integer	8
Occurrence	Location ID:	*locationID_occ*	Unique EO ID of site. Values: 22657, 8385, 2440, 10888, 0	*22657*	Integer	10
Occurrence	sublocationID	*sublocationID_occ*	Unique identifier created from concatenation of the fields: locationID + locationID_plot	*22657_A*	String	100
Occurrence	eventID	*eventID_occ*	Unique identifier created from concatenation of the fields: sublocationID + eventDate_occ.	*22657_A_20210817*	String	109
Occurrence	Subplot:	subeventID_suffix_occ	Unique identifier of the subplot within the plot	*11*	String	255
Occurrence	subplotID	subeventID_occ	Unique identifier created from cont concatenation of the fields sublocationID_occ + subeventID_suffix_occ + eventDate_occ	*22657_A_20210817_11*	String	120
Occurrence	Select target species by name	nomenclaturalCode	Comprehensive Michigan plant species list using six letter acronyms for the scientific name for Michigan species as per Herman et al. 2001. Drop down list displays scientific name, common name.	*THUOCC*	String	10
Occurrence	scientificName	scientificName	The scientific name of the plant.	*Thuja occidentalis*	String	100
Occurrence	vernacularName	vernacularName	The common or vernacular name of the plant.	*northern white cedar*	String	100

Table	Display Name	Field Name	Definitions and Values	*Example*	Data Type	Length
Occurrence	nomenclaturalCodeUSDA	nomenclaturalCodeUSDA	The USDA species nomenclature code.	*THOC2*	String	10
Occurrence	family	family	The family name for the species.	*Cupressaceae*	String	25
Occurrence	genus	genus	The genus name for the plant.	*Thuja*	String	25
Occurrence	nativeNonNative	nativeNonNative	The plant's native/non-native status.	*native*	String	10
Occurrence	physiognomy	physiognomy	The physiognomic class, or physical appearance and shape of the species. Values: tree, shrub, vine, forb, grass, sedge, fern	*tree*	String	10
Occurrence	coefficient_of_conservatism	coefficient_of_conservatism	Coefficients of conservatism (C values) are numeric values assigned to plant species to indicate their sensitivity to anthropogenic disturbance. Coefficients of conservatism range from 0 - 10 and represent an estimated probability that a plant is likely to occur in a landscape relatively unaltered from what is believed to be pre-European settlement condition.	*4*	Integer	2
Occurrence	coefficient_wetness	coefficient_wetness	The coefficients of wetness (W) is the estimated probability for which a species occurs in wetlands. Positive signs (+) indicating a wet tendency and negative signs (-) indicating a dry tendency.	*-3*	Integer	3
Occurrence	lifeDuration	lifeDuration	The life duration or life span category of the plant. Values: annual, biennial, perennial	*perennial*	String	10
Occurrence	Are you certain in your species identification?	scientificName_id_certain	The surveyor's certainty of the species identification. Values: yes, no, other	*yes*	String	5
Occurrence	Species Dominance Value:	organismQuantity	Record an overall dominance value for each species documented for each grouping of nested plots. Values: dominant, abundant, frequent, occasional, rare, locally dominant, locally abundant, locally common	*dominant*	String	25
Occurrence	Species Dominance Value Type:	organismQuantityType	The type of evaluation/classification for organismQuantity.	*modified DAFOR scale*	String	255

Table	Display Name	Field Name	Definitions and Values	*Example*	Data Type	Length
Occurrence	Tree DBH (in)	m_treeDBHValue	The diameter at breast height (DBH) to the nearest tenth of a unit using a diameter tape. DBH refers to the tree diameter measured at 4.5 feet above the ground.	*10.4*	Double	10
Occurrence	Tree DBH Units	m_treeDBHUnit	Unit of measurement for tree DBH. Values: centimeter, inch	*inch*	String	20
Occurrence	Tree Height (m)	m_treeHeightValue	The height of tree using a clinometer.	*45*	Double	10
Occurrence	Tree Height Unit	m_treeHeightUnit	The unit of measurement for snag height. Values: centimeter, meter, inch, foot, yard	*meter*	String	20
Occurrence	Tree Height Device/Method	m_treeHeightMethod	A description of or reference to the method or protocol used to determine the tree height.	*Suunto® Tandem Global Compass/Clinometer*	String	255
Occurrence	Additional Notes (Occurrence)	occurrenceRemarks	Remarks by the surveyor(s) on the individual occurrence.	*Unsure of species beyond genus. Fungus on leaves.*	String	255

APPENDIX D: PLOT-LEVEL MEASUREMENTS

Measurements taken at the plot-level or pooled from subplot to plot-level. Habitat related measurements are found in Table D - 1. Dwarf lake iris related measurements are found in Table D - 2. Descriptions of how each pooled measurement was pooled is found in Table D - 3.

Table D - 1. Habitat measurements at the plot-level. Element occurrence identifier (EO ID) is a unique identifier for each occurrence of a tracked species population in its subnational (e.g., State, Provincial) Natural Heritage Program (See APPENDIX A: Definitions and NatureServe Terminology). Plot identifier (Plot ID) was a unique identifier assigned to each plot. Plot treatment type was the type of canopy manipulation exercised in the plot. Sampling event date is the date the sampling occurred in the format of year-month-day.

EO ID	Plot ID	Plot Treatment Type	Sampling Event Date	Canopy Cover (%)	Soil Moisture (%)[1]	Litter Depth (cm)[1]	Organic Soil Depth (cm)[1]	Soil pH[1]	Soil Texture	Animal Impact[1]	Sunlight Category
22657	A	control	2022-06-06	96	38	0.6	14.0	7.0	sandy-loam	low_impact	full_shade
22657	A	control	2022-10-03	92	0	1.2	5.0	7.0	sandy-loam	low_impact	full_shade
22657	A	control	2023-06-12	97	10	1.3	2.5	6.9	loamy-sand	low_impact	partial_sun
22657	A	control	2023-08-21	96	0	0.3	4.0	6.8	sand	high_impact	full_shade
22657	A	control	2024-06-10	97	10	2.0	2.0	6.4	sand	high_impact	full_shade
22657	A	control	2024-08-26	97	5	0.5	4.0	6.9	loamy-sand	low_impact	full_shade
22657	B	girdle	2022-06-10	72	6	16.3	6.0	6.9	sandy-loam	low_impact	partial_sun
22657	B	girdle	2022-10-03	71	13	1.9	5.3	6.9	sandy-loam	low_impact	full_shade
22657	B	girdle	2023-06-12	76	12	1.7	4.8	6.9	sandy-loam	low_impact	partial_sun
22657	B	girdle	2023-08-21	75	10	2.2	12.7	6.8	sand	high_impact	partial_sun
22657	B	girdle	2024-06-10	75	25	4.0	12.5	6.6	loamy-sand	high_impact	partial_sun
22657	B	girdle	2024-08-26	78	5	1.0	4.5	6.9	loamy-sand	low_impact	partial_sun
22657	C	fell_remove	2022-06-10	72	0	6.2	7.6	6.9	loamy-sand	low_impact	partial_sun
22657	C	fell_remove	2022-10-03	31	20	1.3	6.0	7.0	sandy-loam	high_impact	partial_sun

[1] Measurement pooled from subplot. Function used for pooling measurement can be found in Table D - 3.

EO ID	Plot ID	Plot Treatment Type	Sampling Event Date	Canopy Cover (%)	Soil Moisture (%)[1]	Litter Depth (cm)[1]	Organic Soil Depth (cm) [1]	Soil pH[1]	Soil Texture	Animal Impact[1]	Sunlight Category
22657	C	fell_remove	2023-06-12	31	8	1.0	7.0	7.0	sand	high_impact	full_sun
22657	C	fell_remove	2023-08-21	31	10	2.0	2.0	7.0	sand	high_impact	full_sun
22657	C	fell_remove	2024-06-10	29	20	1.0	10.0	7.0	sand	high_impact	full_sun
22657	C	fell_remove	2024-08-26	21	2	0.5	1.0	7.0	sand	high_impact	full_sun
22657	D	fell	2022-06-10	96	62	1.2	13.0	6.8	loamy-sand	low_impact	partial_sun
22657	D	fell	2022-10-03	69	75	2.2	15.0	6.8	sandy-loam	low_impact	partial_sun
22657	D	fell	2023-06-12	77	100	1.0	9.0	6.6	loam	no_impact	full_sun
22657	D	fell	2023-08-21	56	55	2.0	25.0	6.6	loamy-sand	high_impact	full_sun
22657	D	fell	2024-06-10	70	100	1.0	0.0	6.4	loamy-sand	low_impact	partial_sun
22657	D	fell	2024-08-26	72	57	1.5	4.0	7.0	loamy-sand	high_impact	full_sun
10888	E	girdle	2022-06-08	95	100	1.5	0.0	6.6	loam	low_impact	full_shade
10888	E	girdle	2022-10-04	96	100	2.5	10.0	6.8	silty-loam	low_impact	partial_sun
10888	E	girdle	2023-06-13	94	100	1.0	15.0	6.4	silty-loam	low_impact	full_shade
10888	E	girdle	2023-08-22	96	100	1.0	20.0	6.3	loam	high_impact	partial_sun
10888	E	girdle	2024-06-11	97	100	2.0	25.0	6.5	silty-clay-loam	high_impact	full_shade
10888	E	girdle	2024-08-27	96	100	0.5	12.0	6.6		high_impact	partial_sun
10888	F	control	2022-06-08	99	77	1.5	5.3	6.4	sandy-loam	no_impact	full_shade
10888	F	control	2022-10-04	100	90	3.3	9.3	5.9	silty-loam	low_impact	full_shade
10888	F	control	2023-06-13	100	100	2.0	13.3	6.5	sandy-loam	low_impact	full_shade
10888	F	control	2023-08-22	100	100	2.2	20.0	6.3	loam	high_impact	full_shade
10888	F	control	2024-06-11	100	100	2.3	10.7	6.2	clay-loam	high_impact	full_shade
10888	F	control	2024-08-27	99	87	1.5	10.3	6.2	sandy-loam	high_impact	full_shade
10888	G	fell	2022-06-07	97	92	2.3	11.0	6.9	sandy-loam	no_impact	full_shade
10888	G	fell	2022-10-04	65	72	1.3	10.0	6.4	loam	low_impact	partial_sun
10888	G	fell	2023-06-13	60	93	0.7	14.0	6.3	loam	low_impact	full_sun
10888	G	fell	2023-08-22	58	100	1.3	17.3	6.2	loam	high_impact	full_sun
10888	G	fell	2024-06-11	55	100	1.3	17.0	6.8	loam	high_impact	partial_sun
10888	G	fell	2024-08-27	57	100	0.7	14.3	6.5	loamy-sand	high_impact	full_sun

EO ID	Plot ID	Plot Treatment Type	Sampling Event Date	Canopy Cover (%)	Soil Moisture (%)[1]	Litter Depth (cm)[1]	Organic Soil Depth (cm)[1]	Soil pH[1]	Soil Texture	Animal Impact[1]	Sunlight Category
10888	H	fell_remove	2022-06-07	86	22	2.8	9.1	7.0	loamy-sand	no_impact	partial_sun
10888	H	fell_remove	2022-10-04	57	23	5.8	5.8	6.9	loamy-sand	low_impact	partial_sun
10888	H	fell_remove	2023-06-13	41	18	2.2	5.0	6.8	loamy-sand	low_impact	full_sun
10888	H	fell_remove	2023-08-22	53	22	4.2	6.5	6.9	sandy-loam	low_impact	full_sun
10888	H	fell_remove	2024-06-11	47	40	5.3	10.7	6.4	sandy-loam	low_impact	full_sun
10888	H	fell_remove	2024-08-27	57	20	1.3	5.7	6.9	sand	high_impact	full_sun
2440	J	girdle	2022-06-21	74	23	2.1	12.0	6.7	loamy-sand	high_impact	full_shade
2440	J	girdle	2022-10-05	92	11	1.3	11.5	6.9	sandy-loam	low_impact	full_shade
2440	J	girdle	2023-06-14	94	8	0.7	12.0	6.8	sandy-loam	no_impact	full_shade
2440	J	girdle	2023-08-23	89	28	2.0	5.3	6.5	sandy-loam	no_impact	full_shade
2440	J	girdle	2024-06-12	90	53	1.3	13.7	6.3	sandy-loam	high_impact	full_shade
2440	J	girdle	2024-08-28	89	38	0.7	1.7	6.9	loamy-sand	high_impact	partial_sun
2440	K	fell_remove	2022-06-21	99	47	3.9	6.1	6.5	loamy-sand	low_impact	full_shade
2440	K	fell_remove	2022-10-05	92	6	1.8	5.3	6.8	sandy-loam	low_impact	partial_sun
2440	K	fell_remove	2023-06-14	81	37	1.4	11.7	6.6	loamy-sand	low_impact	full_sun
2440	K	fell_remove	2023-08-23	69	20	1.6	4.2	6.5	sandy-loam	low_impact	full_sun
2440	K	fell_remove	2024-06-12	61	23	0.7	6.7	6.5	sandy-loam	high_impact	full_shade
2440	K	fell_remove	2024-08-28	50	28	0.5	1.2	6.8	sandy-loam	high_impact	full_sun
2440	L	fell	2022-06-20	95	37	6.0	9.3	6.7	sand	high_impact	partial_sun
2440	L	fell	2022-10-05	58	53	1.6	9.0	6.8	loamy-sand	low_impact	partial_sun
2440	L	fell	2023-06-14	63	18	1.2	10.0	6.9	loamy-sand	low_impact	full_sun
2440	L	fell	2023-08-23	72	53	2.3	8.3	6.3	loam	high_impact	full_sun
2440	L	fell	2024-06-12	72	70	1.7	7.0	6.2	sandy-loam	high_impact	partial_sun
2440	L	fell	2024-08-28	72	33	0.7	3.7	6.8	loamy-sand	high_impact	full_sun
2440	M	control	2022-06-21	100	13	4.3	9.4	6.8	loamy-sand	low_impact	full_shade
2440	M	control	2022-10-05	100	7	1.6	2.5	7.0	sand	low_impact	full_shade
2440	M	control	2023-06-14	100	3	1.3	9.7	7.0	loamy-sand	high_impact	full_shade
2440	M	control	2023-08-23	100	8	2.5	8.0	6.6	sandy-loam	high_impact	full_shade

EO ID	Plot ID	Plot Treatment Type	Sampling Event Date	Canopy Cover (%)	Soil Moisture (%)[1]	Litter Depth (cm)[1]	Organic Soil Depth (cm) [1]	Soil pH[1]	Soil Texture	Animal Impact[1]	Sunlight Category
2440	M	control	2024-06-12	100	22	2.3	7.0	6.7	sandy-loam	high_impact	full_shade
2440	M	control	2024-08-28	100	8	1.2	1.5	6.9	sand	high_impact	full_shade
8385	N	fell	2022-06-08	87	67	1.6	0.0	6.2	silty-clay	no_impact	partial_sun
8385	N	fell	2022-10-06	45	73	1.0	4.2	6.6	silty-loam	low_impact	full_sun
8385	N	fell	2023-06-16	60	100	0.7	11.0	6.3	silty-loam	low_impact	full_sun
8385	N	fell	2023-08-24	19	95	2.3	8.0	6.1	silty-loam	low_impact	full_sun
8385	N	fell	2024-06-14	14	100	0.8	7.3	6.3	silty-clay-loam	high_impact	full_sun
8385	N	fell	2024-08-29	53	100	0.8	8.0	6.4	loam	high_impact	full_sun
8385	O	control	2022-06-09	90	73	1.7	6.3	6.7	sandy-loam	high_impact	partial_sun
8385	O	control	2022-10-07	87	50	0.8	6.3	6.9	loam	low_impact	full_shade
8385	O	control	2023-06-16	87	78	0.8	6.0	6.3	loam	low_impact	full_shade
8385	O	control	2023-08-24	81	88	1.8	9.7	6.1	sandy-loam	low_impact	full_shade
8385	O	control	2024-06-14	86	100	0.8	6.3	6.2	loam	no_impact	full_shade
8385	O	control	2024-08-29	83	95	1.5	7.0	6.5	loam	high_impact	full_shade
8385	P	girdle	2022-06-09	96	45	1.4	8.5	6.7	clay-loam	low_impact	partial_sun
8385	P	girdle	2022-10-06	99	67	2.4	6.7	6.5	loam	low_impact	full_shade
8385	P	girdle	2023-06-15	97	60	0.5	6.2	6.9	loam	low_impact	partial_sun
8385	P	girdle	2023-08-24	96	62	2.0	10.0	6.3	loam	low_impact	full_shade
8385	P	girdle	2024-06-13	94	50	1.2	8.7	6.7	silty-loam	low_impact	partial_sun
8385	P	girdle	2024-08-29	97	60	0.5	7.7	6.9	loam	high_impact	full_shade
8385	Q	fell_remove	2022-06-09	99	65	6.0	8.0	6.7	sandy-loam	low_impact	partial_sun
8385	Q	fell_remove	2022-10-06	39	72	1.5	10.0	6.8	silty-loam	low_impact	partial_sun
8385	Q	fell_remove	2023-06-15	69	75	1.2	7.7	6.7	silty-loam	low_impact	full_sun
8385	Q	fell_remove	2023-08-24	29	63	2.3	9.3	6.5	loam	low_impact	full_sun
8385	Q	fell_remove	2024-06-13	32	78	0.8	9.3	6.6	silty-loam	low_impact	partial_sun
8385	Q	fell_remove	2024-08-29	36	50	0.8	8.3	6.9	loam	low_impact	partial_sun

Table D - 2. Dwarf lake iris population measurements at the plot-level. Element occurrence identifier (EO ID) is a unique identifier for each occurrence of a tracked species population in its subnational (e.g., State, Provincial) Natural Heritage Program (See APPENDIX A: Definitions and NatureServe Terminology). Plot identifier (Plot ID) was a unique identifier assigned to each plot. Plot treatment type was the type of canopy manipulation exercised in the plot. Sampling event date is the date the sampling occurred in the format of year-month-day. Dwarf lake iris (DLI) Area is the estimated area occupied by DLI within the plot.

EO ID	Plot ID	Plot Treatment Type	Sampling Event Date	DLI Area (m^2) [1]	Total Ramet Estimate[1]	Number of Reproductive Ramets[1]	Number of Young Ramets[1]	Number of Sterile Adults[1]
22657	A	control	2022-06-06	0.36	135	4	0	131
22657	A	control	2022-10-03	0.40	45	0	0	45
22657	A	control	2023-06-12	0.52	51	2	1	48
22657	A	control	2023-08-21	0.60	43	0	0	43
22657	A	control	2024-06-10	0.20	3	0	2	1
22657	A	control	2024-08-26	0.08	19	0	4	15
22657	B	girdle	2022-06-10	8.40	375	8	8	359
22657	B	girdle	2022-10-03	6.94	624	0	14	610
22657	B	girdle	2023-06-12	7.68	668	30	23	615
22657	B	girdle	2023-08-21	7.80	1042	0	36	1006
22657	B	girdle	2024-06-10	3.04	358	0	10	348
22657	B	girdle	2024-08-26	3.12	569	0	17	552
22657	C	fell_remove	2022-06-10	0.12	40	2	1	37
22657	C	fell_remove	2022-10-03	0.20	15	0	0	15
22657	C	fell_remove	2023-06-12	0.32	46	3	0	43
22657	C	fell_remove	2023-08-21	0.40	55	0	0	55
22657	C	fell_remove	2024-06-10	0.40	70	0	4	66
22657	C	fell_remove	2024-08-26	0.40	48	0	2	46
22657	D	fell	2022-06-10	0.60	85	3	0	82
22657	D	fell	2022-10-03	0.80	40	0	1	39
22657	D	fell	2023-06-12	0.92	120	4	4	112
22657	D	fell	2023-08-21	0.92	135	0	3	132
22657	D	fell	2024-06-10	1.00	125	0	10	115

EO ID	Plot ID	Plot Treatment Type	Sampling Event Date	DLI Area (m^2) [1]	Total Ramet Estimate[1]	Number of Reproductive Ramets[1]	Number of Young Ramets[1]	Number of Sterile Adults[1]
22657	D	fell	2024-08-26	0.60	70	0	3	67
10888	E	girdle	2022-06-08	0.16	8	0	0	8
10888	E	girdle	2022-10-04	0.16	12	0	0	12
10888	E	girdle	2023-06-13	0.16	10	0	2	8
10888	E	girdle	2023-08-22	0.16	10	0	0	10
10888	E	girdle	2024-06-11	0.16	17	0	1	16
10888	E	girdle	2024-08-27	0.08	17	0	0	17
10888	F	control	2022-06-08	2.88	175	0	3	172
10888	F	control	2022-10-04	2.92	165	0	2	163
10888	F	control	2023-06-13	2.62	209	0	14	195
10888	F	control	2023-08-22	2.22	202	0	5	197
10888	F	control	2024-06-11	1.56	188	0	10	178
10888	F	control	2024-08-27	1.02	184	0	6	178
10888	G	fell	2022-06-07	0.32	19	0	2	17
10888	G	fell	2022-10-04	0.36	21	0	0	21
10888	G	fell	2023-06-13	0.36	25	0	2	23
10888	G	fell	2023-08-22	0.36	28	0	6	22
10888	G	fell	2024-06-11	0.20	34	0	2	32
10888	G	fell	2024-08-27	0.20	51	0	3	48
10888	H	fell_remove	2022-06-07	19.68	2231	65	28	2138
10888	H	fell_remove	2022-10-04	15.24	1245	0	12	1233
10888	H	fell_remove	2023-06-13	16.00	2709	12	57	2640
10888	H	fell_remove	2023-08-22	16.56	2970	0	134	2836
10888	H	fell_remove	2024-06-11	15.76	3856	53	114	3689
10888	H	fell_remove	2024-08-27	14.20	2173	0	25	2148
2440	J	girdle	2022-06-21	0.20	8	0	2	6
2440	J	girdle	2022-10-05	0.36	14	0	0	14
2440	J	girdle	2023-06-14	0.24	12	0	3	9
2440	J	girdle	2023-08-23	0.20	11	0	1	10

EO ID	Plot ID	Plot Treatment Type	Sampling Event Date	DLI Area (m^2) [1]	Total Ramet Estimate[1]	Number of Reproductive Ramets[1]	Number of Young Ramets[1]	Number of Sterile Adults[1]
2440	J	girdle	2024-06-12	0.20	26	0	0	26
2440	J	girdle	2024-08-28	0.14	21	0	0	21
2440	K	fell_remove	2022-06-21	9.80	970	13	22	935
2440	K	fell_remove	2022-10-05	8.48	479	0	4	475
2440	K	fell_remove	2023-06-14	9.28	1565	8	41	1516
2440	K	fell_remove	2023-08-23	9.60	2346	0	160	2186
2440	K	fell_remove	2024-06-12	8.48	2402	16	56	2330
2440	K	fell_remove	2024-08-28	7.46	2087	0	90	1997
2440	L	fell	2022-06-20	3.20	501	1	17	483
2440	L	fell	2022-10-05	2.80	192	0	0	192
2440	L	fell	2023-06-14	2.72	305	5	9	291
2440	L	fell	2023-08-23	2.52	436	0	17	419
2440	L	fell	2024-06-12	1.76	260	0	12	248
2440	L	fell	2024-08-28	1.72	202	0	7	195
2440	M	control	2022-06-21	1.96	314	0	11	303
2440	M	control	2022-10-05	2.16	361	0	4	357
2440	M	control	2023-06-14	2.06	340	4	11	325
2440	M	control	2023-08-23	1.98	239	0	17	222
2440	M	control	2024-06-12	1.12	235	0	2	233
2440	M	control	2024-08-28	1.06	273	0	3	270
8385	N	fell	2022-06-08	4.44	164	0	6	158
8385	N	fell	2022-10-06	2.84	118	0	0	118
8385	N	fell	2023-06-16	3.12	316	3	29	284
8385	N	fell	2023-08-24	1.40	117	0	6	111
8385	N	fell	2024-06-14	0.74	243	0	42	201
8385	N	fell	2024-08-29	0.28	90	0	4	86
8385	O	control	2022-06-09	3.00	84	0	3	81
8385	O	control	2022-10-07	1.36	68	0	1	67
8385	O	control	2023-06-16	1.36	92	0	7	85

EO ID	Plot ID	Plot Treatment Type	Sampling Event Date	DLI Area (m^2) [1]	Total Ramet Estimate[1]	Number of Reproductive Ramets[1]	Number of Young Ramets[1]	Number of Sterile Adults[1]
8385	O	control	2023-08-24	1.24	105	0	11	94
8385	O	control	2024-06-14	0.34	47	0	8	39
8385	O	control	2024-08-29	0.26	44	0	5	39
8385	P	girdle	2022-06-09	8.08	1402	1	59	1342
8385	P	girdle	2022-10-06	6.28	602	0	0	602
8385	P	girdle	2023-06-15	6.32	1021	25	27	969
8385	P	girdle	2023-08-24	6.40	1451	0	71	1380
8385	P	girdle	2024-06-13	5.56	1731	25	34	1672
8385	P	girdle	2024-08-29	4.36	812	0	22	790
8385	Q	fell_remove	2022-06-09	6.20	1350	62	30	1258
8385	Q	fell_remove	2022-10-06	5.80	345	0	0	345
8385	Q	fell_remove	2023-06-15	6.48	1595	49	94	1452
8385	Q	fell_remove	2023-08-24	5.96	1880	0	258	1622
8385	Q	fell_remove	2024-06-13	5.60	2300	53	109	2138
8385	Q	fell_remove	2024-08-29	4.12	1030	0	0	1030

Table D - 3. Functions used to pool subplot measurements into plot-level data.

Subplot Measurement	Pooled Function
DLI Area (m2)	sum
Total Ramet Estimate	sum
Number of Young Ramets	sum
Number of Sterile Adults	sum
Number of Reproductive Ramets	sum
Animal Impact	mode
Soil Moisture (%)	mean
Litter Depth (cm)	mean
Organic Soil Depth (cm)	mean
Soil pH	mean