Determining preferred habitat conditions for genetically healthy populations of *Cirsium hillii*

Joslyn Mink[1] and Jeremie Fant[2]
[1]University of Wisconsin-Madison, and [2]Chicago Botanic Garden

Abstract: The small, fragmented populations of *Cirsium hillllii* are being threatened by declining habitat quality in the dry-mesic habitats. This study looked at the relationship between site characteristics, and demographic response in *Cirsium hillii* populations in Illinois and Wisconsin. Genetic data was used to distinguish genetic diverse and genetically depauperate populations and 5-10yrs of demographic data was used to determine resource allocation differences between populations. Correlation among the site characteristics, and demographic and genetic data indicated that genetic diverse populations with high flowering populations of C. *hillii* preferred sites with dry soil, low competition, and high native flora diversity.

Introduction

The native thistle *Cirsium hillii* (Hill's thistle) is a threatened species (Asteraceae) which is protected in both Illinois and Wisconsin. Hill's thistles are found in fragmented, upland, dry-mesic prairies. They are able to self pollinate, but it leads to inbreeding depression on the population.[1] Natasha de Vere (2009) examined how population size and habitat quality in the British Isles influenced the genetic diversity of *Cirsium dissectum* population, another rare asexually reproducing thistle. She concluded that populations with better habitat quality had higher genetic diversity. Habitat quality for this study included factors associated with increased survival of seedlings in the population.[2] In this study we are comparing *Cirsium hillii* populations from Illinois and Wisconsin which have been monitored for over 5 years, and for which we have genetic information. These populations vary in genetic diversity and how they allocate their resources for both growth and reproduction at each site. We hope to determine if there is a correlation between genetic and demographic fitness and site quality parameters, with the aim to help guide future restorations of these *Cirsium hillii* sites.

Figure 1. *Cirsium hillii* plant in bloom at Lake in the Hills Fen

Information could be used by prairie restoration site managers to determine whether *C. hillii* would survive at their sites.

Populations at sites with non-preferred conditions would have lower vital rates due to the energy they would have to allocate towards phenotypic plasticity needed to survive at the site.[3]

Three main objectives:

- Classify sites as genetically and demographically healthy.
- Measure various parameters of habitat "quality"
- Test for correlations between these parameters and genetically diverse and demographically healthy populations

Materials and methods

- Genetic and demographic information was completed in previous years, by Jeremie Fant and past interns
- Sites
- Data for this field season was collected at the following sites:
  - IL – Campton Hills Park, Dixie Fromm Briggs, Grant Creek Prairie, Lake in the Hills Fen, Lyman Woods, Vermont Cemetery.
  - WI – Bolz Prairie, Muralt Bluff, Rocky Run State Area, Walking Iron Natural Area
- Plant Size and Density
  - *Cirsium hillii* plant size and density. Flags were used to mark plant and tag locations (**fig. 3a**)
  - Plant diameter and longest leaf were recorded for 100 plants
- Vegetative Survey
  - A plot 20m x 20m was identified at each site, with *Cirsium hillii* plants centered in the middle of the plot
  - Five transects (0m, 5m, 10m, 15m & 20m) were run along the plot. A vegetative survey was conducted at every two meters using a ½m² quadrat. A total of 50 quadrats per site.
  - Species and cover class were determined for each quadrat (**fig. 3b**)

Figure 3a. *C. hillii plot* with flagged plants

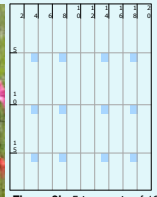

Figure 3b. 5 transects of 10 quadrats for vegetative survey and blue squares represent soil samples

- Soil Survey
  - Soil samples were also collected.
  - Four soil transects were taken half way between vegetative transects at 2.5m, 7.5m, 12.5m and 17.5m.
  - One soil core was taken at every 5 meters. A total of 12 soil cores.
  - Samples were prepared for analysis
  - Unfortunately analysis was not complete in time for poster.
- Analysis
  - Correlations were tested for all measured genetic, demographic, and community variables using JMP™

Results

Figure 2. Muralt bluff

Genetic and Demographic data

Site	GENETIC (Na,Ne,He)	SEXUAL % Flowering	SIZE (Leaf length and diameter)	ASEXUAL (% New rosettes)	Allocate Resources
Illinois					
Campton	L	L	M	H	**New**
Dixie	H	L	L	H	**New**
Grant	M	M	H	M	Size
LITH	H	H	H	M	Size/Flower
Lyman	L	M	M	H	**New**
Vermont	L	L	H	L	Size
Wisconsin					
Bolz	L	L	L	H	**New**
Hawkhill	H	L	M	L	Size
Iron	H	H	L	H	**Flower/New**
Muralt	M	H	L	L	Flower
Rocky	M	H	L	L	Flower

Table 1. Past demographic and genetic data. Using the following abbreviations: L=low, M=medium, and H=high. The red highlights the small values

Site Conditions

SITE	Bare Ground	Floral Index	Avg Soil Moisture (%)	Total Number of Species	Invasive (%)	Native (%)	Upland (%)	Avg # species / quadrat
Campton	3.4	27.17	12.7490732	50	18	82	40	7.2
Dixie	3.12	26.11	11.9870805	45	33.33	66.67	31.11	6.3
Grant	3	29.92	29.4545366	39	10.26	89.74	28.21	8.3
LITH	3.08	24.25	11.7158634	24	29.17	70.83	62.5	5.3
Lyman	2.42	19.61	21.5665268	36	38.89	61.11	33.33	8.8
Vermont	0	38.42	26.8730315	44	6.82	93.18	36.36	12
Bolz	1.81	31.21	21.6808736	43	20.93	79.07	53.49	8.4
Hawkhill	2.2	34.65	24.1390837	39	17.95	82.05	61.54	7.2
Iron	2.58	34.43	10.7327769	51	23.53	76.47	45.1	7.3
Murralt	2.92	32.38	17.6483522	41	19.51	80.49	41.46	9
Rocky	4.04	32.58	12.1788334	39	12.82	87.18	48.72	6.2

Table 3. The values calculated from the data collected in 2010 across all the sites

Correlations between site parameters

	Bare Ground	Floral Index	Average Soil Moisture (%)	Invasive (%)	Native (%)	Avg # species/ quadrat
Bare Ground			**-0.6034**			**-0.6911**
Avg Soil Moisture (%)	**-0.6034**					**0.0401**
Invasive (%)		**-0.7978**				-0.5742
Native (%)		**0.7978**				0.5742
Avg # species/quadrat	**-0.6911**		**0.6544**	-0.5742	0.5742	

Table 3a. Correlation between site characteristics. Bolded values are significant with r-values<0.05, non-bolded values show a trend with 0.05<r-value<0.1

Correlations between site, demographic and genetic parameters

	Size	% Flowers	% Died	Large (%)	Genetics	Seedlings (%)
Site Bare		0.4778	**0.7414**			
Floral Index			-0.571			
Average Soil Moisture (%)	0.5298					
Total Number of Species				**-0.5958**		
Avg # Species/quadrant					**-0.7779**	
Small (%)		0.5185				**0.625**
% New rosettes				0.5566		
Size						**-0.7547**

Table 3b. Again showing correlations between site characteristics, with the significant values bolded

Discussion

Site Characteristics by Demographic data (table 1 & 2)

- **Vegetative Growth** (large plants with few flowers)
  - Vermont and Grant
  - Low bare ground, high floral index, high soil moisture, high % native, low % upland, very high species per quadrat
- **Sexually Reproducing** (small plants and flower frequently)
  - Muralt, Rocky, Iron
  - Dry soil, high floral index, high average species per quadrat, high percentage of native and upland plants
- **Asexually Reproducing** (small plants and do not flower frequently)
  - Campton, Dixie, Lyman
  - Low floral index, high invasiveness

Site quality correlations

- **Death (Turnover/Asexual growth)**
  - Less flowering - as density of plants increase, the genetic diversity decreases
  - Less large plants with more species per quadrat and less genetic diversity (**table 3b**)
  - Death or turnover is greatest with high bare ground and low floral index, probably related to invasiveness (**table 3a & 3b**)
- **Greater flowering**
  - *Cirsium hillii* tolerates stress – and reproduces in stressful environments.
    - Less soil moisture producers smaller plants.
    - Small size associated with more flowers and increased seedling production (**table 2b**)

Conclusions

Being a poor competitor and good at tolerating stress suggests that competition is a main limiting factor for this species, and that it would do better at sites with more bare ground and less invasiveness. This holds true while looking at the demography data for genetically healthy populations that put their energy towards sexual reproduction. These sites characteristically have dry, and likely sandy, soil, and are species rich with high percentage of not only native species, but also upland specialized species. This information could be used to determine whether *Cirsium hillii* would flourish or merely persist at a dry-mesic, sandy soil prairie restoration site.

Literature cited

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