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TAXONOMIC AND DEMOGRAPHIC STUDIES
OF Cirsium longistylum
IN THE LITTLE BELT MOUNTAINS, MONTANA

U.S.D.A. FOREST SERVICE - REGION 1
LEWIS AND CLARK NATIONAL FOREST
MONTANA

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Challenge Cost-share Project

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SUMMARY

Cirsium longistylum is a perennial thistle that is endemic to central Montana. It is primarily known from Little Belt Mountains, where it is nearly ubiquitous within mesic to moist meadow and stream terrace sites. A summary of the status of this species can be found in Schassberger and Achuff (1991) and Schassberger (1991).

In 1991, Cirsium longistylum was removed from the Watch List of sensitive species for Region 1 of the U.S. Forest Service due to abundance. However, because it is a state endemic known from a limited area (albeit common in that area), and may be threatened by a weevil introduced as a biological control agent (used in an effort to limit the spread of the introduced Carduus nutans), it continues to be categorized by the U.S. Fish and Wildlife Service as C2 (U.S. Department of the Interior 1990). Cirsium longistylum is also ranked by the Montana Natural Heritage Program (Achuff 1991) as an S3 species; "rare in Montana (21+ occurrences)."

Morphological variation in some populations has led to questions about possible hybridization with other Cirsium species, and about the systematic status of C. longistylum. Numerous collections were made during the 1991 field season, and sent to Dr. A. Cronquist (Botanist, New York Botanical Garden) for review. Based on this material, Dr. Cronquist (1992) stated that he now felt that "C. longistylum was a "good" species of limited distribution in Montana." He also felt that "it probably hybridizes with C. hookerianum and possibly C. scariosum Nutt.", and that "hybrids were best identified in the field." Dr. Cronquist annotated the specimens from the population at Neihart as C. hookerianum Nutt., and they will be considered as such in the demographic studies. In light of the results of the morphological overview, it would be appropriate to use techniques of electrophoresis to support the hybridization hypotheses.

Permanent plots were set up at three sites (Russian Creek, Kings Hill, Neihart) in 1990 to study life history characteristics of C. longistylum. As stated above, the population at Neihart will now be considered as C. hookerianum. Changes in population numbers from 1990 to 1991 within study plots were found to be a result of: loss of plants which had flowered in the previous year, loss of plants at the rosette stage, and recruitment rates. Over this short period, population sizes and number of plants flowering fluctuated, but only further study will determine if this is normal for the species.

At Kings Hill in 1991, disturbance of the soil by rodents eliminated previously established rosettes, but appeared to aid in the germination of seeds as evidenced by the numerous seedlings present. At Neihart, many plants (31%) were grazed, either lightly or heavily. How grazing ultimately affects the ability of these rosettes to reach maturity will be revealed through continued monitoring.

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STATUS

SCIENTIFIC NAME: Cirsium longistylum Moore & Frankton.

COMMON NAME: long-styled thistle.

FEDERAL STATUS: C2

FOREST SERVICE STATUS: None. In 1991, Cirsium longistylum was removed from the Watch List of sensitive species for Region 1 of the U.S. Forest Service due to abundance.

FIELD SURVEY

While making collections of C. longistylum for the taxonomic study in 1991, a brief survey of the Highwood Mountains was completed. The introduced species Cirsium arvense and C. vulgare were both present here, but C. longistylum was not observed. It is possible that C. longistylum is associated with the calcareous soils of the Little Belt, Big Belt and Castle Mountains. The Highwood Mountains on the other hand, are volcanic centers that erupted shonkinite (similar to basalt, but greatly enriched in potassium) and other rocks about 50 million years ago (Alt and Hyndman 1986).

TAXONOMIC STUDIES

INTRODUCTION: Several Cirsium collections from the Little Belt Mountains and the Sawtooth Range were sent to Dr. Arthur Cronquist (a specialist in the Asteraceae=Sunflower Family) for verification in the winter of 1990-1991. The Sawtooth Range collection, Schassberger (402), NY, was verified as C. hookerianum. However, of the two sent from the Little Belt Mountains (Schassberger (403), NY, Belt Park; Schassberger (397), NY, Thornquist Gulch), Dr. Cronquist (1991) felt that the Thornquist Gulch collection "would seem to be C. longistylum," whereas the collection from Belt Park "looks to me like C. hookerianum." He went on to state that "I included C. longistylum, with some reluctance, in the single-volume flora for the Pacific Northwest, but I was uneasy about it then and I remain so now." Close examination by professional botanists of plants from the same population had often revealed a great deal of variability in the expansion of the involucre bract, a key character used in the identification of C. longistylum.

In the hopes that a more definitive conclusion might be reached, it was determined that a large number of specimens (preferably with duplicates) from sites across the range of the species should be sent to Dr. Cronquist for careful examination.

METHODS: Collections of C. longistylum were made by the author from twelve locations in the Little Belt and Big Belt mountains, and one collection of C. hookerianum from the Sawtooth Range in 1991. Duplicates were taken at most sites, however, slow drying caused molding in some cases so that only five locations had one (or two) duplicate specimens. These specimens, along with three collected in 1990, and four (one Cirsium hookerianum from the Sawtooth Range, and three Cirsium longistylum from the Little Belt and Castle mountains) collected by Dana Field and Wayne Phillips (Lewis & Clark National Forest) were sent to Dr. Arthur Cronquist for verification in December of 1991.

RESULTS AND CONCLUSIONS: Based on this material, Dr. Cronquist (1992) stated that he now felt that "C. longistylum was a "good" species of limited distribution in Montana." He also felt that "it probably hybridizes with C. hookerianum and possibly C. scariosum Nutt.," and that "hybrids are best identified in the field." Collections and subsequent annotations are as follows:

Submitted as Cirsium hookerianum Nutt.

Roe, Lisa, S. (464) 1991., NW side of Flesher Pass

Field, D. (14) 1991., Sawtooth Range, Slide Rock Point

Submitted as Cirsium longistylum Moore & Frankton

Schassberger, Lisa A. (403) 1990. Little Belt Mtns. Belt Park
Annotated JAN 1992 by A. Cronquist as C. hookerianum Nutt.

Schassberger, Lisa A. (409) 1990. Little Belt Mtns., Hay Coulee

Roe, Lisa, S. (465) 1991. Little Belt Mtns., Neihart Cemetery

Roe, Lisa, S. (466) 1991. Little Belt Mtns., Harley Creek
Possible hybrid (Cronquist 1992)

Roe, Lisa, S. (467) 1991. Little Belt Mtns., Kings Hill Pass
Possible hybrid (Cronquist 1992)

Roe, Lisa, S. (468) 1991. Little Belt Mtns., Deadman Creek

Roe, Lisa, S. (469) 1991. Little Belt Mtns., Birch Creek

Roe, Lisa, S. (470) 1991. Big Belt Mtns., Duck Creek Pass

Roe, Lisa, S. (472) 1991. Little Belt Mtns., Hay Canyon

- Roe, Lisa, S. (473) 1991. Little Belt Mtns., Onion Park
Annotated JAN 1992 by A. Cronquist as C. hookerianum Nutt.
- Roe, Lisa, S. (474) 1991. Little Belt Mtns., O'Brien Park
- Schassberger, Lisa A. (401) 1990. Little Belt Mtns., O'Brien Park
- Field, D. (13) 1991. Little Belt Mtns., Lamb Creek
- Field D. (16) 1991. Castle Mtns., Pasture Gulch
- Phillips H.W. 9910808-3) 1991. Little Belt Mtns.

It is of interest to note that in general, the specimens determined as C. hookerianum came from habitats that were moist to wet, whereas the rest of the specimens were collected from more mesic sites. The exception to this rule is the collection from Kings Hill (a mesic site) that was determined as a potential hybrid. However, this site has been extensively disturbed by road improvement activities.

In light of the results of the morphological overview, it would be appropriate to use techniques of electrophoresis to support the hybridization hypotheses and delimit the range of the species.

The collections denoted "Belt Park" in the list above were from the plot referred to as Neihart in the demographic monitoring studies.

DEMOGRAPHIC MONITORING TRANSECTS

During 1990, three permanent monitoring transects were established in what were thought to be populations of C. longistylum on the Lewis and Clark National Forest. As stated above in the taxonomic discussion, Dr. Cronquist (1992) annotated the Neihart population as C. hookerianum, and it will be referenced as such throughout the rest of the report.

The purpose of these transects is to provide more detailed data on the life history and population dynamics of C. longistylum. Data on survivorship and reproduction are important for understanding the biology of plants with limited distributions, especially when attempting to ensure their long-term preservation (Palmer 1987, Massey and Whitson 1980).

METHODS: The locations and the geographic details and methods used to establish the three plots are contained in a report by Schassberger and Achuff (1991). As in 1990, individuals were placed in size classes that appeared to

best relate to age. Additional categories were added as necessary in 1991. These included:

? - Rosettes or plants that had been recorded in the previous year but were not relocated in the current year. When present, possible causes of disappearance are noted.

Gone - Plants that were recorded as dead in the previous year, and which had decomposed or disappeared by the current year. (For example: Plants that had flowered in 1989, were recorded as dead in 1990 (dead flowering stalks were still visible), and as gone in 1991 (when stalks and leaves had disappeared).

Grazed - Many of the rosettes, especially at the Belt Park site, had been grazed. It was thought that this might have an effect on the ability of the plant to produce and store enough energy to eventually flower. Information on grazing was recorded as follows.

Grazed heavily - Plant was significantly reduced in size, at least two leaves had been removed.

Grazed - Plants that had a leaf or portion of a leaf removed.

Finally, general observations about the site and plants were noted where possible. As before rosette=individual that has only whorl(s) of leaves, flowering plants=individuals that are reproductive.

Raw data (1990-1991) recorded for each site are provided in Section VI., Demographic Monitoring Data, pp. 14-23.

RESULTS AND CONCLUSIONS: Plot data for the three sites are summarized in Table 1, p. 5 (Russian Creek), Table 2, p. 7 (Kings Hill), and Table 3, p. 9 (Neihart). Portions of this information are also represented graphically in Figures 1, 2, and 3, pp. 6, 8 and 10, respectively. In the tables, population growth rate (negative or positive) was calculated as the change (\pm) in the number of individuals from year 1 to year 2, divided by the number of individuals present in the plot in year 1, times 100.

Population sizes decreased at Neihart and Russian Creek from 1990 to 1991, and increased substantially at Kings Hill. The total number of individuals within the plots was reduced at Neihart by 26 percent and at Russian Creek by 33 percent between 1990 and 1991, while the number of individuals increased at Kings Hill by 54 percent during the same time period. In 1991, the density of plants varied from 0.18

TABLE 1. Summary of life history monitoring data for Cirsium longistylum at Russian Creek, Little Belt Mountains, Lewis and Clark National Forest, 1990-1991. (Percentages are rounded up or down to the nearest whole number.)

	<u>RUSSIAN CREEK</u> (elevation 6520 ft)		Plot radius 37 ft (11.3 m)
Observation Date	1990/07/27	1991/08/01	
Total # plants (dead or alive) observed		106	
Total # live rosettes and plants of current year	107	72	
Percentage change from the previous year		-33%	
New recruits (as a percent of all plants)		23 (32%)	
Density of live (plants/m ²)	0.24	0.18	
# small rosette plants (percent of small rosettes)	26 (24%)	24 (33%)	
# medium rosette plants (percent of medium rosettes)	23 (21%)	25 (35%)	
# large rosette plants; (percent of large rosettes)	20 (19%)	19 (26%)	
total # plants at rosette stage; (percent of plants at rosette stage)	69 (64%)	68 (94%)	
# plants flowering; (percent of plants flowering)	37 (35%)	4 (6%)	
mean # of heads open or unopened per flowering plant ± SD, n	16.4 ± 8.4 n = 37	13 ± 16.1 n = 4	
Total # rosettes observed to be dead		1	
Total # of rosettes not relocated presumed dead		19	
Total # dead or not relocated rosettes; (as a percentage of all live plants present in the previous year)		20 (19%)	
Total # of plants that had flowered in the previous year and are now dead		33	
Total # of plants not relocated that had flowered the previous year and are presumed dead		4	
Total number of dead or not relocated (flowering and rosette) plants; (as a percentage of all live plants present in the previous year)		57 (53%)	

RUSSIAN CREEK DEMOGRAPHIC DATA

CIRSIUM LONGISTYLUM

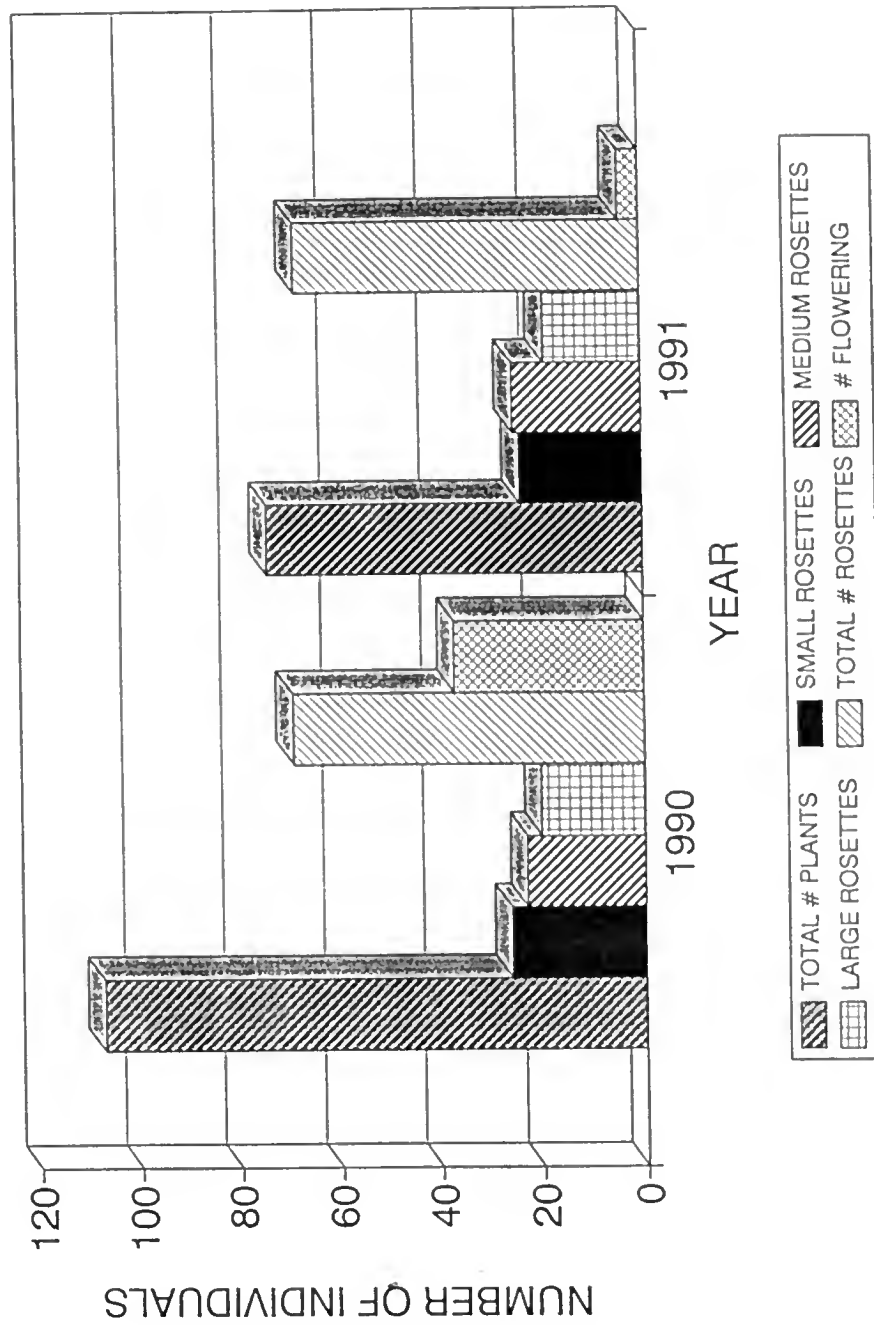


TABLE 2. Summary of life history monitoring data for Cirsium longistylum at Kings Hill, Little Belt Mountains, Lewis and Clark National Forest, 1990-1991. (Percentages are rounded up or down to the nearest whole number.)

Observation Date	<u>KINGS HILL</u> (Elevation 7880 ft)		Plot radius 15 ft (4.6 m)
	1990/07/30	1991/08/02	
Total # of plants (dead or alive) observed			205
Total # plants of current year plants recorded	113		174
Percentage change from the previous year			54%
New recruits; (as a percent of all plants)			133 (76%)
Density of live (plants/m ²)	1.7		2.6
# small rosette plants; (percent of small rosettes)	31 (27%)		141 (81%)
# medium rosette plants; (percent of medium rosettes)	37 (33%)		24 (14%)
# large rosette plants; (percent of large rosettes)	13 (12%)		9 (5%)
total # plants at rosette stage; (% of plants at rosette stage)	81 (71%)		174 (100%)
# plants flowering; (percent of plants flowering)	32 (28%)		0 (0%)
mean # of heads open or unopened per flowering plant ± SD, n	10.5 ± 7.7 n = 37		0
Total # rosettes observed to be dead			5
Total # of rosettes not relocated and presumed dead			35
Total # dead and not relocated rosettes; (as a percentage of all live plants present in the previous year)			40 (35%)
Total # of plants that had flowered in the previous year and are now dead			26
Total # of plants not relocated that had flowered the previous year and are presumed dead			6
Total number of dead or not relocated (flowering & rosette) plants; (as a percentage of all live plants present in the previous year)			72 (64%)

KINGS HILL DEMOGRAPHIC DATA

CIRSIUM LONGISTYLUM

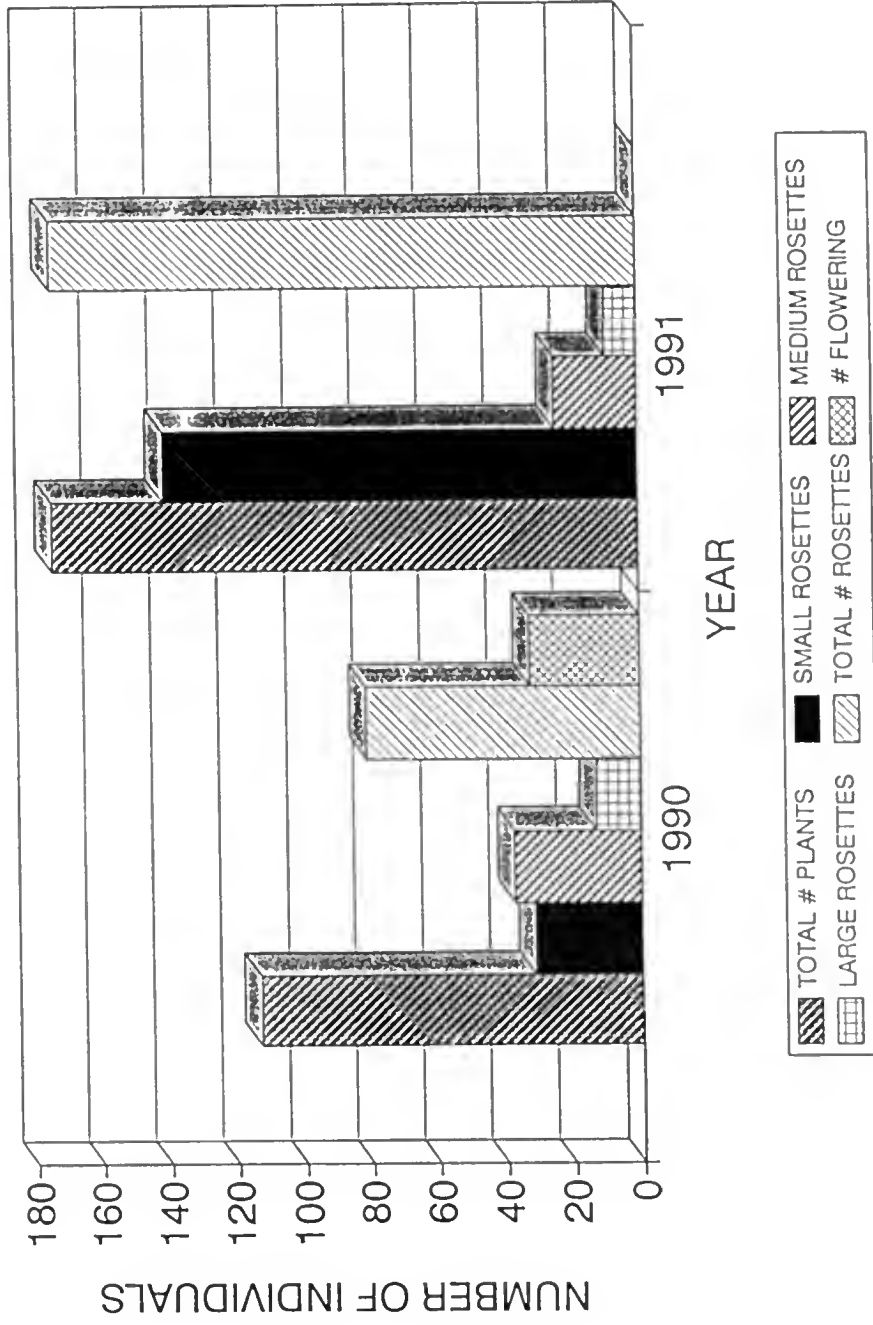
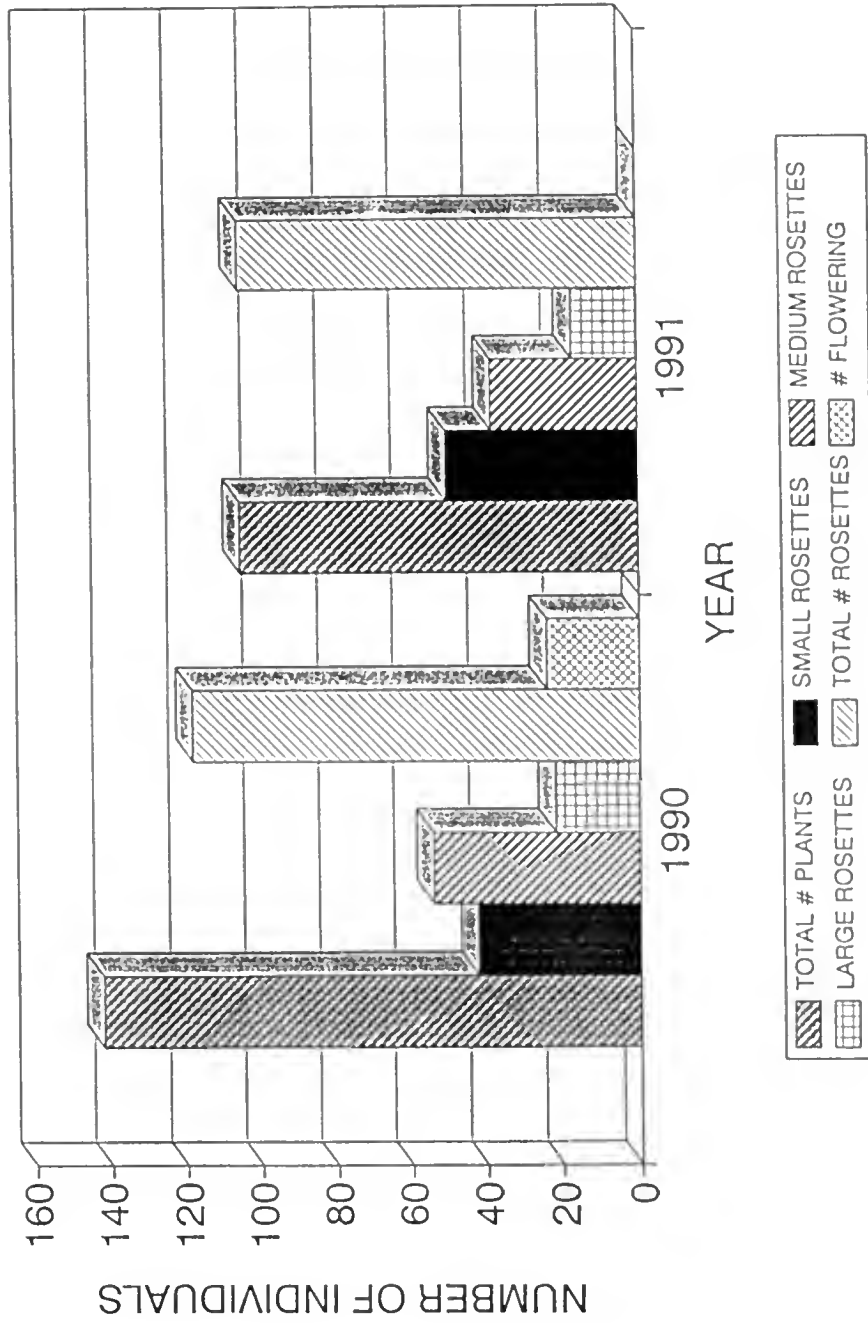


TABLE 3. Summary of life history monitoring data for Cirsium hookerianum at Neihart, Little Belt Mountains, Lewis and Clark National Forest, 1990-1991. (Percentages are rounded up or down to the nearest whole number.)

Observation Date	<u>NEIHARI</u> (Elevation 6960 ft)	
	1990/07/30	1991/08/01
Total # of current year rosettes and plants	142	105
Percentage change from the previous year		-26%
New recruits (as a percent of all plants)		44 (42%)
Density (plants/m ²)	2.2	1.6
# small rosette plants (as a % of all plants)	42 (30%)	50 (47%)
# medium rosette plants (as a % of all plants)	54 (38%)	38 (36%)
# large rosette plants (as a % of all plants)	22 (16%)	17 (16%)
# plants at rosette stage (% of plants at rosette stage)	118 (83%)	105 (100%)
# plants flowering (percent of plants flowering)	24 (17%)	0 (0%)
mean # of heads (open or unopened) per flowering plant (\pm SD, n)	14.6 \pm 5.8 n=24	0
Total # rosettes observed to be dead in 1991		3
Total # of rosettes not relocated and presumed dead		54
Total # dead or not relocated rosettes; (as a percentage of all live plants present in the previous year)		57 (40%)
Total # of plants that had flowered in the previous year and are now dead		17
Total # of plants not relocated that had flowered in the previous year and are presumed dead		7
Total number of dead or not relocated (flowering and rosette) plants present; (as a percentage of all live plants present in the previous year)		81 (57%)

NEIHART DEMOGRAPHIC DATA

CIRSIUM HOOKERIANUM



plants/m² at Russian Creek to 2.6 plants/m² at Kings Hill. Much of the increase at Kings Hill was due to high seedling establishment in areas where rodent activity had substantially disturbed the plot. However, this same activity eliminated several of the larger rosettes that were present in this same section of the plot. Disturbance is beneficial to seedling establishment, but may eliminate rosettes before they mature to the flowering stage.

Although the highest number of large and medium rosettes was observed at Neihart in 1990, only Russian Creek had flowering plants in the plot in 1991. At Russian Creek, flowering was reduced from 35 percent in 1990 to 6 percent in 1991. All of the plants that did flower in 1991 were recorded as large rosettes in 1990. The percentage of medium and large rosette plants increased in 1991 at Russian Creek, decreased at Kings Hill, and remained at nearly the same levels at Neihart in 1991. Casual observations by the author of sites across the Little Belt Mountains confirmed that there were fewer Cirsium plants flowering in 1991. This reduction in flowering could have been the result of climatic influences (May and June of 1991 were very wet and cold, or cyclical patterns of flowering).

In 1991, observations on grazing and other impacts to plants were made at all three sites. At Russian Creek, none of the rosettes had been grazed, although three had dead leaves at the base and the vegetative portion of one was moldy. At Kings Hill, two of the rosettes were grazed lightly, while twelve had disappeared due to rodent activity. The highest amount of herbivory occurred at Neihart, due in part to its proximity to a seep used by cattle located approximately 0.1 mile south of the plot (pers. obs.). Here, 31% of the rosettes had been grazed, and the canopy cover of other plant species had been significantly reduced. How grazing ultimately affects the ability of these rosettes to reach maturity should be uncovered through continued monitoring.

At Neihart, the negative growth rate was mainly due to the high loss of small, medium or large rosettes (54%), and a 40 percent recruitment rate. Whereas at Russian Creek, the negative growth rate was mainly due to the loss of plants that had flowered in 1990 (35%), and a 31 percent recruitment rate. Alternatively at Kings Hill, where 31 percent of the small, medium or large rosettes were lost between 1990 and 1991, and another 33 percent loss came from plants that had flowered in 1990, the recruitment rate (76%) was significant enough to offset these losses, resulting in a positive change in population size.

Population size fluctuations may be common for these species. Only further monitoring will yield information on population fluctuations.

RECOMMENDATIONS

It is recommended that demographic monitoring be continued for at least two more years to better understand the life history characteristics of these species. In light of the results of the morphological overview, it would be appropriate to use techniques of electrophoresis to support the hybridization hypotheses, and delimit the range of the species. Although abundant locally, C. longistylum has a very limited distribution, and is still considered a C2 species by the U.S. Fish & Wildlife Service (U.S. Department of the Interior 1990). Land managers should be aware of this species presence with respect to any planning activities.

III. LITERATURE CITED

- Achuff, P.L. 1991. Plant species of special concern in Montana. Montana Natural Heritage Program, 1515 E. 6th Ave., Helena, MT. 20 pp. mimeo.
- Alt, D., and D.W. Hyndman. 1986. Roadside Geology of Montana. Mountain Press Publishing Company, Missoula, Montana. 427 pp.
- Cronquist, A. 1991. Letter of 11 March to Lisa Schassberger, Montana Natural Heritage Program, Helena, Montana, concerning annotation of Cirsium specimens from the Little Belt Mountains, Montana.
- Cronquist, A. 1992. Letter of 13 January to Lisa Schassberger Roe, Montana Natural Heritage Program, Helena, Montana, concerning annotation of Cirsium specimens from the Little Belt, Castle, and Sawtooth Mountains of Montana.
- Massey, J.R., and P.D. Whitson. 1980. Species biology, the key to plant preservation. *Rhodora* 82:97-103.
- Palmer, M. 1987. A critical look at rare plant monitoring in the United States. *Biological Conservation* 39:113-127.
- Schassberger, L.A. 1991. Report on the conservation status of Cirsium longistylum, a candidate threatened species. Montana Natural Heritage Program, Helena, Montana. 92 pp.
- Schassberger, L.A., and P.L. Achuff. 1991. Status review of Cirsium longistylum, U.S.D.A. Forest Service, Region 1, Lewis and Clark National Forest. Montana Natural Heritage Program, Helena, Montana. 78 pp.
- U.S. Department of the Interior. 1990. Endangered and threatened wildlife and plants; review of plant taxa for listing as endangered or threatened species; notice of review. *Federal Register* 50 CFR Part 17: 6184-6229.

DEMOGRAPHIC MONITORING DATA

CATEGORIES

R = Rosette

Rs = small rosette, 1 whorl of basal leaves

Rm = medium rosette, 2 whorls of basal leaves

Rl = large rosette, > 2 whorls of basal leaves

P = Plant that has bolted.

Ph(x) = Plant with (x) number of open, flowering heads

Pb(x) = Plant with (x) number of closed heads (involucral bracts completely enclosed flowers)

Dead - a dead stem from the previous year

* Ph(x)b(x)h(x)b(x) indicates a plant with more than one flowering stem per rosette

Additional categories were added as necessary in 1991. These included:

? - Plants that had been recorded in the previous year but were not relocated in the current year. When present, possible causes of disappearance are noted.

Gone - Plants that were recorded as dead in the previous year, and which had decomposed or disappeared by the current year. For example: Plants that had flowered in 1989, were recorded as dead in 1990 (dead flowering stalks were still visible), and as gone in 1991 (when stalks and leaves had disappeared).

Grazed - Many of the rosettes, especially at the Belt Park site, had been grazed. It was thought that this might have an effect on the ability of the plant to produce and store enough energy to eventually flower. Information was recorded as follows.

Grazed heavily - Plant was significantly reduced in size, at least two leaves had been removed.

Grazed - Plants that had a leaf or portion of a leaf removed.

Finally, general observations about the site and plants were noted where possible.

i.e. moldy - mold was obviously present on leaves
rodent mound - recent rodent nests, or tunnels were present

For new recruits (or plants that were missed in 1990 but observed in 1991) direction and distance from stake and plant category are marked in **bold type** in the tables below.

Russian Creek (plot radius = 37')

1990/07/24

1991/08/01

Direction from center stake (in degrees)	Distance from stake (in feet in inches)		Plant	Plant
357	18'	5.5"	Rs	?
350	14'	0.5"	Rm	?
345	5'	8.0"		RI
339	14'	10"	Ph4b2	Dead
339	7'	10.5"	RI	RI dead leaves at base
338	29'	6"	Rm	Rm
336	17'	3"	Ph9b6	Dead
336	12'	4.5"	Rm	Rm
328	24'	10"	RI	Ph2b2
312	25'	9"	Rm	Rm
312	7'		Rm	Rm
311	22'	4.5"		Rs
311	19'	4.5"		Dead
311	8'	10.5"	Ph5b5	Dead
307	35'	9.5"	RI	Ph2b10
289	14'	7.5"	Rm	Rm
288	6'	3.5"	RI	RI
285	3'	11.5"	Rm	RI
285	29'	3"	RI	Ph7b5
281	29'	5.5"	RI	?
279	6'	11"		Rm
279	5'	4"		Rs
272	22'	6.5"	Dead	Gone
272	30'	3.5"	Rs	Rm
264	36'		Ph15b30	Dead
264	18'	4"	Ph8b12	Dead
264	17'	5"	Ph9b9	Dead
263	24'	0.5"	Rs	?
259	13'	5"		Rs
259	11'	10"		Rs
258	15'	9.5"		RI
256	22'	8.5"	Ph16b15	?
256	13'	11"	Rm	Rm
256	13'	9"	Ph5b4	Dead
256	11'	11"	Rs	RI
256	11'	3"	Rm	?
255	16'	5"	Rm	Rm
255	13'	1.5"	Rs	?
254	20'		Rs	?
253	23'	4.5"	Ph2b3	?
253	22'	2.5"		RI
253	19'	10"	Rs	?
253	19'	7"	Rs	?
252	12'	1"	Ph7b5	Dead
251	11'	3"	RI	Dead
248	18'	8"	Rs	Rm
248	11'	8"		Rm
246	19'	6"	Rs	Rm
246	19'	2"	Rs	Rm
246	12'	3"		RI
245	17'			Rm
244	17'	1.5"		Rs
243	18'	1.5"	Rs	RI
242	29'		Ph9b3h1b4	?
242	21'	5"	Rm	Rm
242	19'	0.5"	Rs	Rs
238	28'	4"	Ph5b10	Dead
238	17'	6"	Rs	?
238	16'	6.5"	Ph7b4	Dead
238	3'		Ph9b16	Dead
236	21'	8"	Rs	Rm
233	16'	9.5"	Rm	RI moldy
232	16'	4.5"	Dead	Gone
231	8'	1"	RI	RI
223	11'	5.5"	RI	?
222	11'	8"		Rs
220	11'	3"		Rs
220	11'	2"		Rs
210	8'	6"	Rm	?
210	12'	9"	Ph6b4	Dead

207	22'		Ph9b8	?
207	10'	7"	RL	?
192	16"	1"	Ph5b2	Dead
189	17'	8.5"	Rs	Rm
186	28'	7"	Rs	Rm
185	36'	8"	Rs	?
185	29'	4"	Rm	RL
177	21'	10.5"		Rs
174	28'	1"	Rm	?
172	37'		Rs	Rs
172	32'	10"	Rm	Rm
170	11'	8"	Ph8b9	Dead
169	15'		Dead	Gone
167	34'	4.5"	Rs	Rs
167	17'	5"	Rm	Rs
166	35'	8.5"	Rm	?
165	23'	9"	RL	Ph14b10 ants, aphids present
162	35'	9.5"	Rs	Rs
162	25'	11"		Rs
160	30'	6.5"	Rs	Rs
158	33'	9"	Rs	Rs
151	37'		Rs	?
151	29'		Ph12b5	Dead
150	32'	7"	Ph8b5	Dead
150	18'	9.5"	RL	RL
145	34'	8"		Rs
144	19'	10"		Rs
143	20'	9"	Rs	?
143	17'	5.5"	RL	RL
143	25'	5"	Ph9b4h5b2	Dead
141	24'	7.5"	Rm	Rm
140	29'	7"	Ph11b12	Dead
140	32'	1"	RL	RL mold
139	17'	10"	Ph7b5	Dead
130		11"		Rs
129	14'	3"	Rm	Rm
119	15'	7"	Ph7b6	?
116	31'	2"	Ph15b7	Dead
113	13'	5"	RL	RL
97	35'		Dead	?
72	7'	1"	Ph7b13	Dead
70	27'	4"		Dead plant
67	29'		Ph23b11	Dead
63	31'	6"	RL	RL
62	22'	10"	RL	Rm dead leaves at base
60	18'	4.5'	Ph6b6	Dead
60	4'	10.5"	Rm	RL
53	33'	5"	Ph11b6	Dead
52	25'	4"	Rm	Rm
52	24'	6"	Ph16b6	Dead
52	17'	8"	RL	?
51	30'	11"	RL	Rm or RL
50	15'	11"		Rs
47	36'	9"	Ph6b6	Dead
45	36'	5.5"	Ph9b7	Dead
45	34'	10"	Ph9b7	Dead
45	33'	5.5"	RL	Rm dead leaves at base
45	31'	3"	Ph4b5	Dead
36	8'	3"	Rs	Rs
32	36'	10"	Ph12b5	Dead
32	29'	3"	Ph4b1h1b2h3b2h4b3h4b2	Dead
23	33'	7.5"		Rs
23	33'	5.5		Rs
18	28'	2.5"	Rm	Rm
17	27'	2"	Ph6b3	?

Kings Hill (plot radius = 15')

* The new (in 1991) small rosettes recorded between 250° and 200° were in areas that had been disturbed by rodent activity.

Direction from center stake (in degrees)	Distance from stake (in feet in inches)		1990/07/30	1991/08/02
			Plant	Plant
359	10'	10"	Rm	Rm grazed
357	7'		Pb9	Dead
345	8'		Ph1b5	Dead
337	10'	10"	Ph1b9	Dead
306	8'	10"		Rm
306	5'	9"	Rs	Rm
306	4'	2"	Ph2b3h3b1h2b2	Dead
296	7'	2"	Ph7b5	Dead
286	3'	5.5"		Rs
275	13'	11"	Rs	Rm
274	14'	2.5"		Rs
272	13'	9"	RL	RL
270	13'	8"	Ph1b5b1	Dead
269	12'		Rm	Rm
267	13'	1"	Rm	Rm
265	11'	11"	Rm	Rm
265	12'	7"	Rm	Rm
264	12'	2"		Rs
263	12'	10.5"		Rs
260	9'	6"	Rm	Rm
260	13'	10"	Rs	Rs
260	13'	10"		Rs
260	13'	10"		Rs
260	12'	10"	Rm	Rm
260	13'	3"	Ph1b2	Dead
257	8'	9"	RL	RL
256	8'	10.5"		Rs
255	11'	2"	RL	RL
255	8'	6"	Ph1b14b10	Dead
255	8'	3"		Rs
255	8'	1"		Rs
253	7'	9"		Rs
253	7'	9"		Rs
253	7'	9"		Rs
251	7'	8"		Rs
251	7'	7"		Rs
251	7'	5.5"		Rs
251	7'	4"		Rs
251	7'	4"		Rs
250	7'	9"		Rs
249	8'	3"		Rs
249	8'	2.5		Rs
249	8'			Rs
249	7'	8"	Ph7b15	Dead
248	8'	2"	Rs	Rs
248	8'	2"		Rs
248	8'	1.5"		Rs
248	8'	0.5"		Rs
248	8'	0.5"		Rs
248	7'	11.5"		Rs
248	7'	11"		Rs
248	7'	10"		Rs
248	7'	10"		Rs
248	7'	10"		Rs
248	7'	10"		Rs
248	7'	10"		Rs
248	7'	10"		Rs
248	7'	10"		Rs
248	7'	7"		Rs
248	7'	7"		Rs
248	7'	6.5"		Rs
248	7'	4"		Rs
248	7'	4"		Rs
248	7'	3"		Rs
247	7'	11.5"		Rs
247	7'	11.5"		Rs

247	7'	11.5"		Rs
247	7'	11.5"		Rs
247	7'	10"		Rs
247	7'	8"		Rs
247	7'	8"		Rs
247	7'	6"		Rs
247	7'	4.5"		Rs
246	7'	9"		Rs
246	7'	8.5"		Rs
246	7'	8.5"		Rs
246	7'	8.5"		Rs
246	7'	7.5"		Rs
246	7'	7.5"		Rs
246	7'	7.5"		Rs
246	7'	7"		Rs
246	7'	5"		Rs
246	7'	2"		Rs
246	7'	2"		Rs
246	7'	1"		Rs
245	14'	7"	Rs	Rm grazed
245	13'	10"	Rs	Rm
245	13'	10"	Rs	Dead
245	11'	4"	Rs	?
244	13'	4"		Rs
242	7'	2"		Rs
242	7'	1"		Rs
242	6'	7.5"		Rs
242	6'	5"		Rs
239	8'	10"	Rm	?
239	7'	11"	Rm	?
239	7'	1"	Rm	?
239	3'	10"	Rm	?
237	10'	6"		Rs
236	14'	3"	Rs	? rodent nest?
235	14'	3"	Rs	? "
235	13'	8"	Rs	? "
235	12'	11"	Rs	? rodent mound
235	11'		Rs	? "
235	9'	6"	Rm	? "
234	8'	4"		Rs
233	11'	0.5"		Rs
233	9'	9"		Rs
233	9'	4"		Rs
233	9'	1"		Rs
230	9'	1.5"		Rs
230	9'	0.5"		Rs
227	12'	10"	Ph10b26	Dead
226	14'	6"	Ph1b7	?
226	8'	7"	Rs	?
222	13'	2"	Ph3b9	Dead
222	12'	11"	Ph1b3	Dead
222	11'	9"	Ph1b8	Dead
222	11'	9"	Rs	?
222	10'	8"	Ph1b5	?
222	8'	5"		Rs
222	7'	11"		Rs
221	12'	2"		Rs
221	12'	2"		Rs
221	12'	2"		Rs
221	11'	4.5"		Rs
221	6'	6"		Rs
221	9'	5"	Rs	?
221	8'	8"	Rs	Rs
221	7'	11"		Rs
220	8'			Rs
219	12'	3"	Ph1b4	Dead
219	11'	8"	Rm	?
219	11'	1"	Rm	?
219	3'	8"	Ph1b5	?
218	14'	4"		Rs
218	13'	8"		RL
216	10'	6"	Rs	Rs
212	11'	8"		Rm
211	12'	9"	Rm	RL
211	12'	6"	Rm	Rm
211	12'		Ph1b8	Dead
210	13'	8"	Ph5b24	Dead

210	12'	3"	Rl	Rl
209	9'	5"		Rs
209	9'	5"		Rs
209	9'	2"		Rs
208	13'		Rs	Rm
208	12'	4"	Rl	Rl
208	11'	2"		Rs
208	10'	10.5"		Rs
208	10'	9"	Rl	?
208	10'	9"	Rl	?
208	10'	6"		Rs
208	10'	6"		Rs
208	10'	6"		Rs
208	10'	5"		Rs
208	10'	2"		Rs
208	9'	9"	Rs	Rs
208	9'	8"	Rs	Rs
208	9'	6.5"		Rs
208	9'	4"		Rs
208	9'	3"		Rs
208	9'	2"		Rs
208	9'	2"		Rs
208	9'	2"		Rs
208	9'	2"		Rs
208	9'	2"		Rs
208	9'	1"		Rs
208	9'	1"		Rs
208	9'	1"		Rs
208	8'	11"	Rs	Rs rodent mounds
208	8'	11"		Rs
208	8'	6"	Ph1b4	Dead
207	13'	5"	Ph1b7	Dead
207	12'	7"	Rm	?
207	8'	7"	Ph1b2	?
204	13'	9"	Rm	?
204	13'	4"	Rl	Rl
204	12'		Pb4	Dead
204	9'	10"	Rm	?
204	6'	1"	Rm	?
203	14'	5"	Rm	Rs
203	11'	11"	Ph1b8	Dead
203	6'	7"	Rs	Rm
203	3'	8"	Rm	Dead
201	12'	11"		Rs
201	12'	10"		Rs
200	12'	10"	Rm	Rl
197	7'	2"	Rs	Rm
195	14'	10"		Rs
195	14'	10"		Rs
195	14'	10"		Rs
195	14'	9"		Rs
195	14'	7"	Rm	? rodent mounds
195	14'	6"	Rs	? " "
195	14'	2"	Rm	? " "
195	13'	6"	Rm	? " "
194	13'	11"		Rs
193	14'	4"	Rl	?
193	9'	10"	Rs	Rs
185	5'	10"		Rs
184	14'	8"	Ph4b12	Dead
182	12'	8"		Rs
182	11'	3"		Rs
181	12'	7.5"		Rs
181	12'	5.5"		Rs
177	10'		Ph5b4	?
175	13'		Rm	Rm
167	7'	10"	Rl	?
165	13'	7.5"		Rs
163	11'	7"		Rs
162	12'	5"	Ph3b3h4b2	Dead
162	11'	10"	Rm	Rm
159	14'	8"		Rs
159	13'	10"		Rs
159	11'	5"		Rs
155	14'	7"	Rl	Dead
155	13'	8"	Rm	Rm

155	12'	4"	Rm	?
150	3'	2"	Rs	Rs
150	3'	1"		Rs
150	3'	1"		Rs
150	3'		Rs	Rs
142	5'	8"	Ph5b4	Dead
139	8'	7"	RL	Dead
130	12'	5"		Rs
128	13'	10"	Ph6b10	Dead
104	6'	1"	Ph1b17	Dead
98	5'	3"	Rm	?
66	13'	2"		Rs
45	12'	5"	Ph1b5	?
40	5'	5"	RL	Dead
21	14'	4"	Rm	Rm
10	11'	10"		Rs
8	11'	10"		Rs
7	12'			Rs
5	14'	11"	RL	?
5	13'	8"	Pb5	Dead
5	13'	6"	Rs	Rm
5	11'	11"	Rm	?
3	13'	8"	Rs	Rm
3	9'	7"	Rm	? rodent hole
3	9'	7"	Rm	?
2	12'	2"	Rm	Rm
2	12'	2"	Rm	?

Neihart (plot radius = 15')

Direction from center stake (in degrees)	Distance from stake (in feet in inches)		1990/07/31 Plant	1991/08/01 Plant
360	10'	10"	Rs	?
360	8'	8"		Rs
360	8'	7"		Rm grazed
359	14'	8"	Rs	?
359	11'	6"		RL
359	6'	1"	Rm	?
354	9'	5"		RL
352	12'	9"		Rs
352	10'	0.5"		Rs
351	12'	10"		Rs
350	9'	10"		Rs
349	10'	11.5"		Rs
349	10'	0.5"		Rs
346	13'	4.5"		Rs
342	7'	4"	Ph8	Dead
342	6'	6"	Rs	Rs
341	15'		Ph10b3	Dead
341	6'	10"	Rs	?
340	11'	3"	Rm	Rm
340	11'	2"	Rm	?
340	7'	6"	Rs	?
339	10'	8"	RL	RL
339	5'	8"	Ph5b2	Dead
339	5'	7"	Rs	?
335	14'	6"	RL	Rm
335	11'	2"	Ph19b3	Dead
335	8'		Rs	?
335	7'	8"	Rm	Rm grazed
335	7'		Rm	Rm "
335	6'	11"	Rm	Rm "
335	6'	11"		Rs "
335	6'	11"		Rs "
330	14'	4"	Ph14b2	Dead
330	8'		Dead	Gone
330	5'	9"	RL	RL grazed
329	12'	3"	RL	RL
320	14'	8"	Rm	Rm grazed
318	14'	7"	Rm	?
314	10'	5"		Rs
290	4'	7"	Pb4b2	Dead
285	13'	5"	Rm	Dead died in 91'
284	13'	2"	Ph10	Dead
284	11'	7"	Ph2b4h15b2h3b3	Dead
279	11'	6"	Rm	Rm grazed to 2 leaves
279	10'	10"	Rm	Rm grazed
268	14'	4"		Rs
264	12'	9"	Rm	Rm grazed
264	11'	1"	Rs	Rm grazed
260	13'	3"	Rm	Dead
260	10'	1"	Rs	Rs
255	13'	2"	Rm	?
255	11'	4"	Rm	Rm grazed
252	13'	9"	RL	RL
252	13'	7"	Ph7b2	?
252	12'	7"	RL	?
252	11'	6"	Ph9b3	?
251	1'	9.5"		Rs
250	12'	7"	Rm	?
250	12'	5"	RL	?
250	12'	2"	Rm	?
247	12'	2"	Rm	?
246	11'	4"	Rs	Rm grazed
232	13'	7"		Rs
220	10'	10"	Rs	?
219	13'	9"		Rm
219	13'	7"	Rm	RL
218	11'	7"		Rm
210	10'	1"	Rm	Rm grazed

210	9'	9"	Rs	Rm "
210	9'	6"	Rs	Rm "
210	2'	9"	Rl	?
210	2'	9"		Rs
207	9'	4"	Rm	Rs grazed
203	2'	9"	Rl	?
201	7'	5"	Rm	?
201	5'	7"	Rm	?
201	5'	7"	Rm	?
201	4'	7"	Rm	Rl grazed
201	2'	5"	Rl	?
193	9'	7"	Ph12b2	Dead
193	4'	5"	Rm	Rm
188	15'		Rs	Rs grazed heavily
188	14'	11"	Rs	?
188	14'	5"		Rs
181	12'		Ph8b4	Dead
176	7'	6"		Rs
175	14'	11"	Rm	Rm grazed heavily
175	14'	3"	Rs	?
175	14'			Rm grazed
174	13'	11"	Rm	?
168	12'	3"	Rs	?
168	12'	3"	Rs	?
163	14'	5"		Rs
163	11'	9"		Rs
163	11'	7.5"		Rs
162	14'	9"	Rs	?
162	14'	11"	Rs	Rs
162	14'	4.5"		Rs
157	11'	6"	Rs	Rs grazed
157	11'	6"		Rs "
152	5'	6"		Rs
151	6'	4"		Rs
151	6'	4"		Rs
150	14'	2"		Rs
142	13'	8"	Rl	Rl
142	10'	9"	Ph13b3	?
142	10'	8"	Rs	Rm grazed
139	14'	3"	Rm	Rm
124	12'	10"	Ph17b5	?
124	7'	2"	Rm	Rm
124	3'	7"	Rl	Rl
115	14'	10"	Ph8b3	Dead
115	12'	4"	Rl	Rm grazed heavily
115	7'	1"	Rm	?
110	15'		Rl	Rm grazed heavily
107	14'	7.5"		Rs
107	4'	3"	Rl	?
107	2'	4"	Rl	Rl
102	8'	6"	Rl	Rl
92	6'	4"	Ph9b1	Dead
91	4'	5"		Rs
90	4'		Ph8b2	Dead
90	3'	9"	Ph5b1h5b4	Dead
79	7'		Rs	Rs
70	4'	10"	Ph1h1h1h1h1	?
69	10'			Rs
69	7'	1"		Rs
69	7'	1"		Rs
55	14'	2"	Rs	Rs
55	6'	9"	Rm	?
51	13'	8"	Rl	Rm dead leaves present
51	11'	1"		Rs
51	10'	6"	Rs	?
50	10'	5"	Rl	?
48	13'	8"	Ph14b6	Dead
48	11'	4"	Ph6b6	?
47	13'	9"	Ph3b2	Dead
47	5'	4"	Dead	Gone
44	12'	6"	Rs	?
43	13'	2"	Rs	?
43	12'	11"	Rs	?
43	6'	11"	Rs	Rs
41	6'	9.5"		Rs
32	12'	4"	Rs	Rm grazed
32	12'	4"	Rs	Rm "

32	11'	10"	Rs	Rs
30	12'	3"	Rm	?
31	12'	1"	Rm	Rl
31	5'	5"	Rm	?
28	12'	5"		Rs
27	12'	9"	Rm	Rm
27	12'	7"	Rm	?
23	14'	9"	Rs	Rm grazed heavily
23	14'	9"	Rs	Rm " "
20	11'	4"	Rl	?
19	12'	3"	Rs	?
19	6'	6"	Rm	?
16	7'		Ph11b1	?
16	10'	1"	Rm	Dead
11	12'	10"		Rs
8	8'	6"		Rs
8	8'		Rm	Rs
8	7'		Rs	?
8	7'		Rs	?
8	6'	9"	Rs	Rs
8	6'	7"	Rm	Rl
8	6'	3"	Rm	Rm
8	5'	11"	Rs	?
6	9'	6"	Rm	Rm grazed
6	8'	2"	Rm	Rm
5	9'	9"	Rm	?
5	9'	4"	Dead	Gone
5	8'	6"	Rl	Rl grazed heavily
5	8'	2"	Rm	?
5	13'	9"	Rm	Rm grazed heavily
3	11'	3"	Rl	Rl
3	11'	6"	Rm	?
3	10'	8"	Rm	?
2	11'	7"	Rm	?
2	10'	11"	Ph15b3	Dead
2	9'	5"	Rm	?
2	6'	11"	Rm	?
2	6'	11"	Rm	?
2	6'	5"	Rm	?
1	12'	7"		Rm
1	10'	10"	Rs	Rm
1	9'	8.5"		Rs
1	9'	8"		Rs
1	9'	4"	Rl	Rl

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