DROSERA ROTUNDIFOLIA MONITORING PROTOCOL

Field Ecology Class
Conservation Biology Class
Rocky Mountain Biological Laboratory

INTRODUCTION

I. Location and Description of Mt. Emmons Iron Fen

Designated a Colorado State Natural Area in 1999, the three acre Mount Emmons Iron Fen in the West Elk Mountains is a unique wetland acidic fen. The Iron Fen was registered as a Colorado State Natural Area in 1980, and the formal Articles of Designation as a State Natural Area were signed in 1999. The Iron Fen is located on the south side of Mount Emmons, three and a half miles east of Crested Butte, situated within seventy-five acres of land administered by the U.S. Forest Service. This site is one of only three acidic fens in the state of Colorado, and one of only two locations of the plant *Drosera rotundifolia* in Colorado. (Environmental Assessment, U.S. Forest Service, 2000)

A fen is defined as a wetland that is primarily made up of organic soil material. Fens take thousands of years to develop, and so are essentially irreplaceable. Therefore, these wetlands cannot be considered a renewable resource because of their slow soil accumulation rates of 4.3-16.2 inches per thousand years. In addition, there is currently no known reliable method for creating a new fully functional fen, nor a method to restore a severely degraded one. Wetlands that are defined as "functioning fens" are those that either continue to support the fen's native plant communities, or have the potential to rapidly recover those functions with the removal or rectification of drainage, grazing, or other impacts. The Mt. Emmons fen was designated a functioning fen by the U.S. Fish and Wildlife Service in 1998. (EA 2000)

Currently, fens fall within the Resource Category 1 of the U.S. Forest Service's "Mitigation Policy" (Federal Register vol 46, no15, February 4, 1981). The definition of this categorization is a desire for "no loss of existing habitat value" (FWS Memo, "Regional Policy on the Protection of Fens" 1998). Specifically, the Mt. Emmons fen was listed in 1991 under the management area prescription from the Forest Land and Resource Management Plan (FLRMP) as 10c, a Special Interest Area. This area is therefore managed with the goals of protecting an area with unusual botanical, historical, scenic, geological, zoological, or paleontological

characteristics and the ultimate withdrawal from mineral entry (EA 2000). This type of classification was intended to protect the fen from the effects of future mine claims, mining action, mineral development, and mine claim speculation. However, the eleven existing mining claims that currently overly the fen are not affected by this type of protection. (EA 2000)

In order to gain a higher level of protection to the Mt. Emmons Iron Fen, the U.S. Forest Service has filed a pending proposal for mineral withdrawal that would be effective for a period of fifty years. A successful mineral withdrawal would be consistent with the agreement reached between the U.S. Forest Service and the Colorado Natural Areas Program in designating the fen as a Colorado Natural Area. This withdrawal would protect the fen from future mining claims, but would not override the claims that already exist. However, if existing claims are determined to be invalid under the General Mining Law of 1872, or if claims are released, potential mining could eventually be eliminated from the fen. (EA 2000)

The hydrologic processes of the Mt. Emmons fen are very sensitive to disturbance. The water that flows into the fen has a pH of between 2.6 and 4.4. This water is rich in iron from passage through layers of pyrite, and when it reaches the surface of the fen, it oxidizes to sulfuric acid and deposits limonite that lines the bottom of the fen and also forms the terraces on the edges of the pond. Extensive dry iron deposits found east of the pond and wetlands indicate that the wet portions of the fen were once 33% larger than they are today. Historic mining may have drained some of the fen (Lamm, 1998), as the tunnels of the old Keystone workings did drain some of the aquifers in the bedrock. Another impact on hydrologic processes includes a ditch dug by the Gunnison County Road and Bridge Department directs fen outflow to one culvert underneath the Kebler Road, which then drains into Coal Creek

Obviously, water use for mining would have a great impact on the hydrologic processes of the Mt. Emmons fen. Currently, the fen is supplied with water from groundwater springs, but it is very possible that mining activities could divert or stop this groundwater flow. In addition, the mining of molybdenum produces 99.6 percent waste rock, and would level the mountain and annihilate this irreplaceable ecosystem.

In addition to these sensitive hydrologic processes, several unusual species frequent and reside in the Iron Fen. These species include an aquatic midge, *Paroclus* sp., previously found only in South America; another midge, *Boreochlus* sp., which harbors an unusual symbiotic trichomycete gut fungus; a purple filamentous alga, *Zygogonium* sp., found only in acidic,

aquatic habitats; and two dragonflies (*Somatochlora semicircularis* and *Leucorrhinia hudsonica*), which are usually only found at higher altitudes and in Canada. The Iron Fen plant community is dominated by several wetland plants such as the cotton sedge, *Eriphorum angustifolium*, various sedges of the genus *Carex*, rushes of *Juncus* species, and four or more species of *Sphagnum* moss. The fen is one of only two sites in Colorado where the sundew *Drosera rotundifolia* exists. As a result of *Drosera rotundifolia*'s unique distribution, the Colorado Natural Heritage Program has listed the sundew as G5S2 (Globally: demonstrably secure; State: imperiled within the state, vulnerable to extinction) (EA 2000). This plant serves as an effective indicator species, as its sensitive relationship to the water table will help monitor the changes in the Iron Fen habitat.

2. *Natural History of* Drosera rotundifolia

The round-leaved sundew, *Drosera rotundifolia,* is a short-lived perennial forb. The upper surface of the leaf blades are covered with reddish, glandular hairs tipped with a sticky, glutinous secretion. Insects are caught with the sticky glandular leaf hairs, and trapped as the leaf folds around the prey. The hairs secrete proteolytic enzymes which digest the insect and enable the plant to absorb nutrients through its leaves. Insect capture is generally believed to enhance growth and reproduction of round-leaved sundew.

Round-leaved sundews reproduce vegetatively, or by seed. Vegetative reproduction takes place when leaf buds form plantlets, or when axillary buds below the rosette form a secondary rosette. As the stem decays, the two separate. Adventitious plants develop in the autumn. The inflorescence is a one-sided raceme with 2 to 15 flowers on a scape that is 5-25 cm long. There may be one to seven inflorescences per rosette. The fruits are capsules with numerous small seeds. When flowers are open during the day, they are cross-pollinated by wind or insects. Self-pollination may take place as flowers close in the evening. The fruits often persist unopened, and seeds are released when the fruit rots. Plants flower in their first summer and every year thereafter

Acidic soils with low nutrient concentrations (nitrogen, phosphorous, or calcium) are the most common substrate for *Drosera rotundifolia.* As a facultative seral species, round-leaved sundew is very shade intolerant; since the plant is so small, even graminoids and small shrubs may limit light availability. The sundew is generally associated with sphagnum mosses and

grows on floating sphagnum mats or sphagnum hummocks. It grows often at confluences of springheads, around seeps, or along streams rather than lake margins in the Rocky Mountains.

Round-leaved sundew is usually confined to sites with a high water table or high precipitation and humidity, requiring continually moist or wet situations. The plant grows in organic acid soils that are low in available nutrients (nitrogen and phosphorous, and calcium). The normal range of the water table on sites where round-leaved sundew grows is from 2cm above, to 40 cm below the soil surface. Flooding can be tolerated for several weeks, but dry periods can only be tolerated for a very short time (all *Drosera* natural history from www.fs.us).

Because the hydrologic processes of the fen are sensitive to changes in the water table, they would certainly be affected by mining within the core of the mountain. The very existence of this unique fen is dependant on undisturbed groundwater movement. Any nearby activities, whether mining, recreational, or development, must be carefully considered to guard and protect this unique habitat and plant population.

METHODS

Two groups from the Rocky Mountain Biological Lab (RMBL) set up monitoring systems for the *Drosera rotundifolia* populations at the Mt. Emmons Iron Fen. Each group, the RMBL Field Ecology class and Conservation Biology class, used slightly different methods in determining an appropriate monitoring program. However, their combined experience determined a method that is most suitable to the monitoring of this population.

Field Ecology class methods:

Two groups of three people each delineated transects that were ten meters long and fifty centimeters wide along the shoreline of the pond. Each group started its transects at the spring and moved in opposite directions around the fen. We defined the shoreline as the area surrounding the main body of water, and "shorelines" of inlets that were smaller than 1m wide were ignored. Transects were continuous around the entire main body of water, and were laid out so that we could examine twenty-five centimeters on either side of the transect.

Drosera rotundifolia occurrence was observed per 10cm increment of transect. That is, when a *Drosera* plant was noted, the observer moved 10cm farther along the transect and began

looking for another *Drosera* plant. If a *Drosera* plant was present, the person would then move another 10cm forward, and so forth. If no *Drosera* plants were present at that transect location, the transect-walker would continue along the transect until the next *Drosera* was encountered, then would move 10cm forward to search for another plant. This methodology was designed to monitor the occurrence of *Drosera* plants, not to census the *Drosera* populations. We photographed each transect to document the position of the water line and its spatial relationship to the transect.

In this study we did not include all of the islands that are present in the main body of water. *Drosera* plants exist on many of those islands, so we recorded where the islands containing *Drosera* plants were located. We also photographed these island sites to document the occurrence of plants on the islands.

Conservation Biology class methods:

A.) *Shoreline sites and perpendicular transects:*

On July 9, 2000, RMBL's Conservation Biology class designed a slightly different methodology to monitor *D. rotundifolia* occurrence at the Iron Fen. Survey efforts were concentrated on the northeast shoreline of the fen pond, because the Field Ecology class found the highest *Drosera* occurrence in this area. The survey began at the main spring and included nine contiguous transects in a north-to-west direction, each of which was 10 m long and 50 cm wide. The outer perimeter of the transects was set by making a 50-cm measurement perpendicular to the pond shoreline at every meter along the transect. The shorelne was defined as the boundary of the standing water level and the diagnostic presence of an emergent moss coated with a black deposit. As implemented by the Field Ecology class, upon encountering a *Drosera* plant along the transect, a count was tallied and 10 cm was skipped before another occurrence could be recorded. Along curved areas of shoreline, the 10cm was measured along the longer side of the curve. Due to the difficulty of standardizing measurements within the pond, islands above standing water level were disregarded.

To indicate the current position of the sampled shoreline, we recorded the distance and compass bearing at the beginning and end of each transect (every 10 meters starting with meter 0) to the small lodgepole pine (*Pinus contorta*) immediately adjacent to the spring. This tree may serve as a temporary landmark by future studies to ensure that transects and shoreline

locations are comparable. Future assessment of this *D. rotundifolia* population should establish the location of these transects as a permanent (i.e. GPS) file.

The Conservation Biology class also documented *D. rotundifolia* occurrence more distant from the shoreline. Usually, transects perpendicular to the shoreline were installed every 2 m of the water's edge transect. However, if the shoreline's direction would have caused a new perpendicular transect to pass over a previously surveyed perpendicular transect, that location was skipped to avoid double sampling. These perpendicular transects extended at least 5 m away from the shoreline transect and were 50 cm wide. The occurrence of *Drosera* was counted as stated above. If no *Drosera* plants were observed for three consecutive meters, that perpendicular transect was finished. Twenty-nine perpendicular transects were searched.

B.) Inlet Sites:

Aside from the main survey along the shoreline of the fen, we also documented the occurrence of *Drosera* along the edges of the inlets on the north side of the fen, into the fen pond. Our objective was to obtain information regarding how far from the main body of water *Drosera* could be observed. A formalized map was then created from the sketches made during this survey (Fig. 1). There were four inlets surveyed, along with the surrounding marsh areas. We began the survey at the inlet that was the farthest west, the main north-side inlet. We then proceeded east to the other three inlets.

We established a temporary transect marker by citing a relatively permanent object as a beginning point for our measurements, which is indicated on the map. These objects are located at or near the stream inlet, because the "edge" of the fen is variable and can be difficult to determine clearly. We used either fallen trees, living trees that were leaning over the stream, or small yet noticeable topographic drop-offs near the beginnings of the stream inlets. A compass reading was also recorded relative to a permanent white, wooden post on the north shore of the pond. This provided a reference point for the points where our surveys started. It is advisable that future surveys use a GPS device to mark and relocate these transects.

We followed the established beginning of each stream inlet until it reached a point of moss-covered land. Along each side of the stream we would search for patches of *Drosera*, which we would group into "plots" of several patches. Each plot was given a letter to represent it (A - P in Fig. 1). We determined the number of individual patches per plot, and which of these patches were "dense," those that were greater than 3 cm wide. For the patches that we

considered dense, we measured their widths at the widest point. We also recorded the distance from the edge of the inlet stream where the furthest occurrence of *Drosera* was observed.

The survey took ten people a total of three hours.

RESULTS

Field Ecology class results:

Group one of the Field Ecology class conducted fifty-three 10-m transects, with a count of 262 occurrences of *Drosera,* while group two conducted forty-five 10-m transects, with a count of 359 occurrences of *Drosera.* The distribution of these plants is documented in Table 1.

Table 1. Occurrence of *Drosera rotundifolia* along the edge of the fen for Groups One and Two. Each transect was 10 m long and 50 cm wide.

Group 1. Starting N. of spring	***Drosera* occurrences**	**Group 2. Starting S. of spring**	***Drosera* occurrences**
1	0	1	0
2	4	2	0
3	0	3	0
4	46	4	0
5	23	5	0
6	28	6	0
7	50	7	0
8	49	8	0
9	8	9	0
10	16	10	0
11	8	11	0
12	18	12	0
13	4	13	0
14	2	14	0
15	0	15	0
16	0	16	0
17	0	17	0
18	0	18	0
19	0	19	0
20	0	20	0
21	0	21	0
22	0	22	0
23	0	23	0
24	0	24	0
25	0	25	0

26	0	26	0
27	0	27	0
28	0	28	0
29	0	29	0
30	0	30	0
31	0	31	4
32	0	32	4
33	0	33	7
34	0	34	54
35	0	35	18
36	0	36	15
37	0	37	42
38	0	38	61
39	0	39	47
40	0	40	8
41	0	41	36
42	0	42	49
43	0	43	0
44	0	44	14
45	0	45	0
46	0		
47	0		
48	0		
49	0		
50	0		
51	0		
52	0		
53	0		
Total Drosera occurrences	**262**		**359**

Frequency distributions of *Drosera* occurrence indicate that a majority of the transects observed by both groups were free of *Drosera* (See Figures 2 & 3). For Group one, twelve of the transects contained *Drosera* and in group two, thirteen of the transects contained *Drosera.* In both cases, transects containing *Drosera* were contiguous along the northeastern shore of the fen pond. The transects that contained the most *Drosera* plants were located within zero to ten meters from the shoreline.

Figure 2

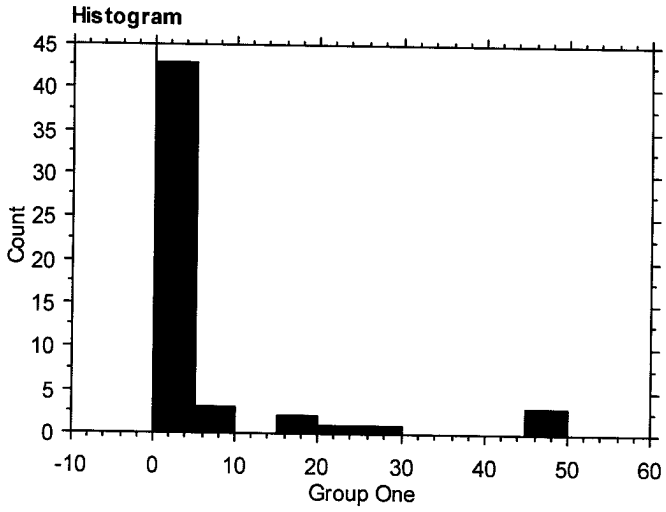
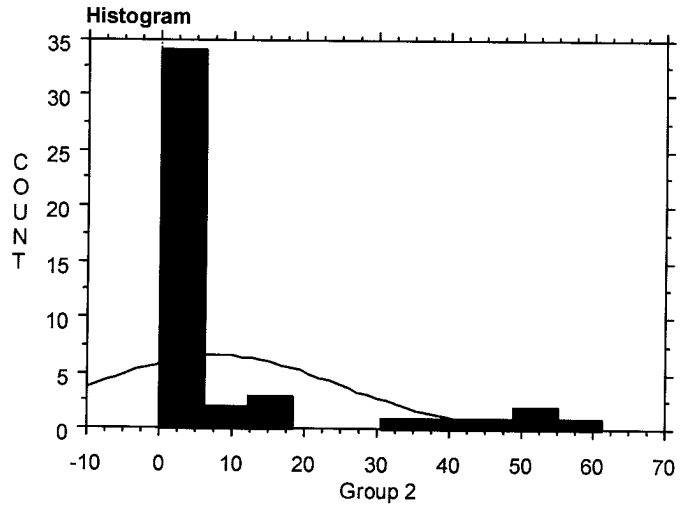


Figure 3



Conservation Biology class results:

The Conservation Biology class documented *Drosera* occurrence in nine continuous transects. Their results are presented in Table _.

Table 2. Occurrence of *Drosera rotundifolia* along the edge of the fen pond for 9 contiguous transects, each of which was 10 m long and 50 cm wide. The survey began at the main spring on the east end of the pond and moved in a northerly to northwesterly direction.

Transect	Meter	*Drosera* Occurrence
1	1	0
1	2	0
1	3	0
1	4	0
1	5	0
1	6	1
1	7	3
1	8	0
1	9	0
1	10	0
2	11	0
2	12	0
2	13	4
2	14	5

2	15	10
2	16	7
2	17	0
2	18	0
2	19	7
2	20	1
3	21	0
3	22	0
3	23	0
3	24	0
3	25	5
3	26	7
3	27	9
3	28	9
3	29	3
3	30	5
4	31	3
4	32	0
4	33	0
4	34	0
4	35	0
4	36	0
4	37	0
4	38	0
4	39	0
4	40	0
5	41	0
5	42	11
5	43	0
5	44	0
5	45	0
5	46	0
5	47	0
5	48	0
5	49	0
5	50	1
6	51	0
6	52	0
6	53	0
6	54	0
6	55	0
6	56	0
6	57	0
6	58	11
6	59	0
6	60	1

7	61	10
7	62	10
7	63	6
7	64	6
7	65	10
7	66	10
7	67	7
7	68	7
7	69	4
7	70	0
8	71	0
8	72	0
8	73	0
8	74	3
8	75	8
8	76	6
8	77	0
8	78	0
8	79	0
8	80	0
9	81	0
9	82	0
9	83	0
9	84	5
9	85	10
9	86	7
9	87	2
9	88	0
9	89	0
9	90	0

Table 3. Compass bearings and distances to the small lodgepole pine (*Pinus contorta*) immediately adjacent to (S of) the main spring, from the beginning and end of each 10-m transect (every 10 meters starting with meter 0).

Meter	Compass bearing	Distance (m)
0	S.21°E.	0
10	S.13°E.	7.6
20	S.3°E.	13.15
30	S.9°E.	18.4
40	S.41°E.	20.78
50	S.57°E.	19.2
60	S.79°E.	20.15
70	S.87°E.	25.6

80	N.81°E.	28.95
90	S.89°E.	34.95

We had a total of 29 transects perpendicular to the fen shoreline. Five of these transects had at least one occurrence of *Drosera*. *Drosera* occurrences were usually documented from one to five meters from the shoreline in all transects, except for transect number 28. Transect 28 had *Drosera* occurring up to six meters away from the shoreline.

Table 4. *Drosera rotundifolia* occurrences in transects perpendicular to shoreline.

Transect number	*M.S.T**	*Meter on transect*	Drosera *Occurrence*
1	0	1 to 5	0
2	2	1 to 5	0
3	4	1 to 5	0
4	6	1 to 5	0
5	8	1 to 5	0
6	10	1 to 5	0
7	26	1	7
		2	8
		3	2
		4	0
		5	1
8	28	1	7
		2	2
		3 to 5	0
9	30	1 to 5	0
10	32	1 to 5	0
11	34	1 to 5	0
12	36	1 to 5	0
13	38	1 to 5	0
14	40	1 to 5	0
15	42	1 to 5	0
16	44	1 to 5	0
17	46	1 to 5	0
18	48	1 to 5	0
19	SKIP	DUE TO	OVERLAP
20	52	1 to 5	0
21	54	1 to 5	0
22	56	1 to 5	0
23	58	1 to 5	0
24	60	1	4

		2	4
		3 to 5	0
25	62	1	2
		2	5
		3 to 5	0
26	SKIP	DUE TO	OVERLAP
27	SKIP	DUE TO	OVERLAP
28	68	1	0
		2	0
		3	3
		4	2
		5	5
		6	1
29	71	1 to 5	0

*M.S.T. = Meter mark in shore transect

DISCUSSION

Eric S. Menges and Doria R. Gordon define three levels of monitoring rare plant species in their 1996 paper. Level one monitoring consists of defining the spatial distribution of populations of plants. This type of data is useful in monitoring plants that have stable populations and in defining any major changes to those populations. From this type of data one may even be able to draw conclusions regarding the size of relevant populations, but not for the health of the population, nor for its ability to colonize nearby areas (Menges 1996). In addition, Level one focuses on multiple populations, while we were only monitoring one population.

Level two monitoring focuses on the quantitative monitoring of population size and condition. Results from this method generally include an estimate the entire number of individuals in the population. In addition, level two monitoring tracks these populations as permanent data points, returning to the same transects and the same populations annually (Menges 1996). The monitoring program that both the Field Ecology and the Conservation Biology class implemented fall between these two levels of monitoring, in that both collected abundance data and observed occurrence of Drosera plants.

Discussion of Field Ecology class results:

There was a difference in the number of transects counted by groups one and two. The shoreline of the southern shore was very hard to distinguish, and so applying our methodology

on that shore was more subjective and inconsistent between the groups. Future efforts should define a rule for determining the shoreline, as our lack of rule may account for the total number of 10-m transects being different. The northeastern shoreline of the fen was much easier to identify, so both groups were able to locate their transects similarly there.

The reasons for the observed distribution of *Drosera* are not fully understood. One potential explanation could be the amount of sunlight that the shore banks receive. The northeastern shore of the fen receives more constant and direct sunlight than does the southern shore (www.fs.us) proposes that carnivorous plant success was determined in great part by the amount of sunlight received.

Discussion of Conservation Biology class results:

The sampling program that RMBL's Conservation Biology class implemented also utilizes the methods of both levels one and two monitoring as described by Menges and Gordon (1996). The combination of these two methods provides useful information about the abundance as well as the local distribution of *Drosera*, and can be utilized in future monitoring efforts.

Our data indicated that *Drosera* plants occur most often in habitats with high sunlight availability. Because *D. rotundifolia* is shade intolerant (Fire Effects Information Systems), this species is likely most common in areas of abundant sunlight, such as the areas on the northern shoreline of the fen. Our study focused only on the northern shore of the fen, because the southern shore was entirely shaded, and no *D. rotundifolia* plants had been observed there by the Field Ecology class. Our data also indicated that *Drosera* plants most are likely to occupy shoreline habitats. At least one occurrence of *Drosera* was observed in each of the nine transects measured along the shoreline, while only five of the twenty-nine transects measured perpendicular to the shoreline contained *Drosera*. Shoreline habitat is more likely to provide ample moisture to sustain *Drosera* populations, whereas the habitats with lower moisture availability, such as those located further inland, are not as hospitable to *Drosera*.

As previously stated, a high water table is imperative for sustaining *Drosera* plants. *D. rotundifolia* derives its nutrients from the insects it consumer by absorbing those nutrients through the leaves with the aid of proteolytic enzymes. This process can only take place in the presence of ample water (Fire Effects Information Systems). Furthermore, *Drosera* seeds are

buoyant and are often carried by snowmelts and floods before they establish themselves in suitable habitats. Thus, water is essential both for the persistence of existing *Drosera* plants, as well as for propagation of future generations.

However, *Drosera* was observed in transects inland, perpendicular to the shoreline. Thefore, *D. rotundifolia* plants are capable of establishing inland, as long as that area is occasionally inundated by rising water levels of the fen, or are fed by seeps from the pond. While *Drosera* cannot withstand constant inundation, it is possible that the plants can survive occasional flooding. Substantial numbers of *Drosera* were also observed in inlet areas of the fen, removed even further from the shoreline. Most of these populations were located in shadier areas, in close proximity to a water source. We believe that *Drosera* may inhabit inland areas as long as they receive suitable water and sunlight to sustain them.

The small inland groups of plants that we observed may become an integral component of the fen, should there be a reduction in the fen's outflow. There may be a future effort to "restore" the fen by plugging the western drainage ditch, which would alter the fen's outflow (Scottie Willie, personal communication). Should this alteration take place, the current shoreline habitat might be flooded, and the present shoreline *Drosera* plants would likely be incapable of survival. Those *Drosera* plants now located inland would be important for sustaining the species at that site. Shallow-rooted *Drosera* plants are especially vulnerable to flooding and uprooting, and current populations would certainly be threatened by rising water levels (www.fs.fed.us). The monitoring program that we implemented allows for study of the impact that changes in land use may have on existing plant populations, as well as the health of the entire habitat. As impending land use changes in the area near the fen may cause changes in the fen's hydrologic status, information regarding the local distribution of *Drosera rotundifolia* will prove a useful tool to determine the best strategy to manage and monitor the fen ecosystem.

Recommendations for future monitoring efforts:

In future, ideally annual, assessments of the *Drosera rotundifolia* population at the Mt. Emmons Iron Fen, the methodology developed by the combined efforts of the RMBL Field Ecology class and the Conservation Biology class may be utilized. Efforts should be focused on the northeastern shoreline of the fen pond, as this was where both classes found the highest occurrences of *Drosera rotundifolia*. The data collected by these RMBL classes, as well as data

collected by future monitoring efforts, may be instrumental in assessing the impacts of land use changes on the ecosystem of the Iron Fen.

FIGURE CAPTIONS

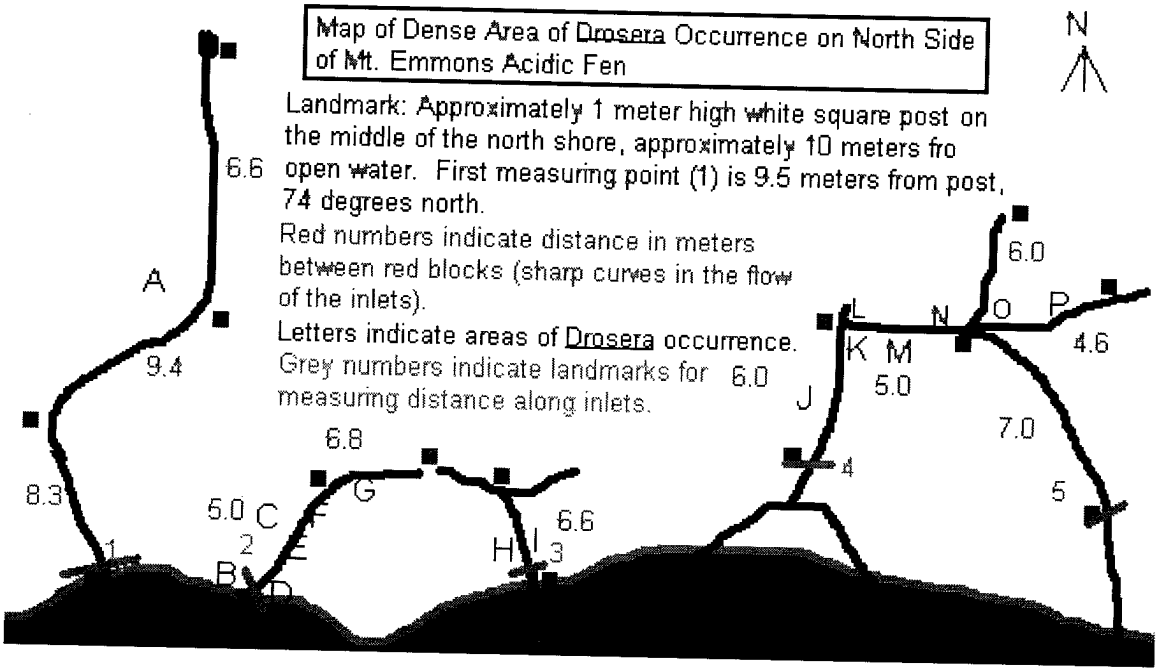
Figure 1: *Drosera rotundifolia* occurrence on tributaries of the north shore of Iron Fen. Information on landmarks and measuring techniques on map. Data for occurrence sites locate don map can be found in Table X. [Tributary Map Table]

Figure 2. Frequency distribution of the number of Drosera occurrences found in the fen by Group 1 of the Field Ecology class.

Figure 3. Frequency Distribution of the number of *Drosera* occurrences found in the fen by Group 2 of the Field Ecology class.

APPENDIX

Figure 1.



Measuring Landmarks Information:

1. Small diameter tree trunk, fallen across inlet.
2. Small diameter Pine, growing bent over the inlet.
3. Submerged log creating a 20cm drop in the inlet.
4. Noticeable drop.
5. Inlet narrows to 25 cm.

LITERATURE CITED

Fire Effects Information Systems website, http://www.fs.fed.us/database/feis/plants/forb/drorot/ FEIS is a division of the U.S. Department of Agriculture Forest Service. Information on *Drosera rotundifolia* was compiled by the FEIS office at the Rocky Mountain Research Station. Accessed July 20, 2000.

Menges, E.S. and Gordon, D.R. (1996) "Three levels of monitoring intensity for rare plant species." Natural Areas Journal 16: 227-237.

U.S. Forest Service website, http://www.fs.us. Accessed July 20, 2000.

U.S. Forest Service. Environmental Assessment: Mt. Emmons Iron Bog Proposed Mineral Withdrawl. 2000.

U.S. Forest Service. Regional Policy on the Protection of Fens. June 8, 1998.