

UPDATE TO THE REPORT ON THE CONSERVATION STATUS OF  
Arabis fecunda, A CANDIDATE THREATENED SPECIES

Taxon name: Arabis fecunda Rollins  
Common name: Sapphire rockcress  
Family: Brassicaceae (Cruciferae)  
State where taxon occurs: U.S.A., Montana  
Current Federal status: USFWS Notice of Review,  
Category 2  
Recommended Federal status: USFWS Notice of Review,  
Category 2  
Author of update: Lisa Ann Schassberger  
Original date of report: November 15, 1985  
Date of most recent revision: January 29, 1990  
Individual to whom further  
information and comments should  
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V. New Information

21. **Record of revisions:** 29 January 1990; Lisa Ann Schassberger; Topics: I.1.D.; I.2.B.b.; I.5.A.; I.5.B.1.e.; I.6.A.; I.6.B.1.b.; I.6.B.1.c.; I.6.B.4.; I.6.C.1.; I.6.C.3.; I.6.C.4.; I.6.C.7.; I.7.A.; I.7.B.1.; I.7.B.2.m.; I.7.D.4.a.; I.8.C.2.b.; I.9.A.; I.9.B.; I.11.A.1.; II.12.; II.13.A.; II.13.B.; II.15.A.1.; II.15.A.2.; II.15.B.; II.16; III.17.C.1.; III.17.D.; III.18.  
Note: Within the text, numbers in parentheses following site names are the three-digit occurrence numbers of sites tracked by the Montana Natural Heritage Program.

**I.1.D. History of knowledge of taxon:** One additional population of Arabis fecunda was discovered at Cattle Gulch (013) in the Pioneer Mountains, Beaverhead County, Montana, during survey work in 1989. This brings the total number of known populations of A. fecunda to 13.

**I.2.B. National.**

**b. Other current formal status recommendations:** Arabis fecunda is currently included on the Watch list in Region 1 (Northern Region) of the U.S. Forest Service. Watch plants include those species, subspecies or varieties that are not currently known to occur on National Forest land, but which are suspected to occur on such lands owing to the presence of suitable habitat. Also, these are plants for which there is concern for population viability within a given state. If found on National Forest lands, these taxa would be designated as sensitive (U.S. Department of Agriculture 1988). Since the establishment of list, A. fecunda was confirmed from five locations on the Beaverhead National Forest. Thus, the status should be changed to sensitive on the U.S. Forest Service list.

**I.5.A. Geographical range:** The newly discovered population of A. fecunda at Cattle Gulch (013) is just southwest of Divide in the Pioneer Mountains, Beaverhead County, Montana. This population is approximately 2.5 miles east of the population at Canyon

Creek (011). Arabis fecunda is known only from southwestern Montana. The global distribution for this species is shown on Map 1, p. 3.

**I.5.B.1.**

**Populations currently known extant:**

- e. Montana:** Information on the newly discovered Cattle Gulch population (013) is found on p. 4; the exact location is provided on a map, p. 5. Additional information was gained on the Quartz Hill (005) and Canyon Creek (011) sites. Updated occurrence records and maps for these sites are included on pp. 6-8. Information on the other 12 known populations of A. fecunda may be found in Lesica (1985) and Schassberger (1988).

**I.6.A.**

**Concise statement of general environment and habitat.** The Cattle Gulch population occurs in dry, gravelly calcareous soil, on steep southwest-facing slopes, at 6,200 feet in elevation.

**I.6.B.1.b.**

**Regional macroclimate:** The long-term weather station nearest to the newly discovered population in the Pioneer Mountains is at Divide, approximately 3.5 miles northeast of the site, at 5,395 ft. in elevation. For the period from 1951-1980, the July mean temperature was 63.3 °F, the January mean was 19.1 °F, and the average annual precipitation was 12.39 in. (U.S. Department of Commerce 1982).

**I.6.B.1.c.**

**Local microclimate.** The climate at Cattle Gulch is probably similar to that of Divide. However, this site is probably somewhat cooler and may receive more precipitation, as it is 1,000 ft. higher in elevation.

**I.6.B.4.**

**Physiographic and topographic characteristics:** The Cattle Gulch (013) population occurs on soils derived from the Madison Limestone Formation, comprised of metamorphosed limestone and sandstones, and the Threeforks Formation, comprised of grayish-brown argillaceous limestone (Richards and Pardee 1925). This A. fecunda population is on steep, southwest-facing

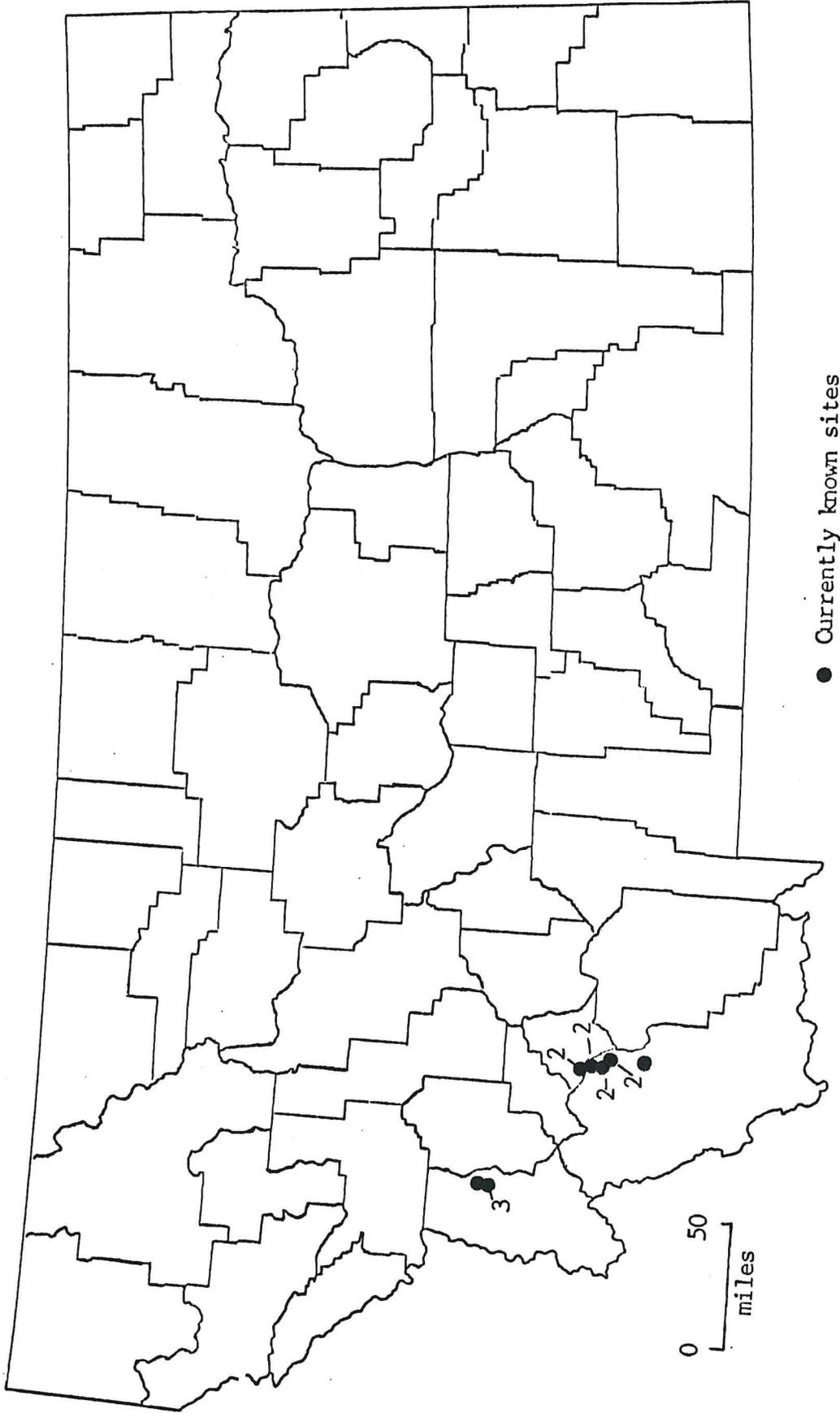


Figure 1. Global distribution of Arabis fecunda, Montana.

ARABIS FECUNDA  
SAPPHIRE ROCKCRESS

Global rank: G2      Forest Service status: WATCH LIST  
State rank: S2      Federal Status: C2

Element occurrence code: PDBRA06290.013

Survey site name: CATTLE GULCH  
County: Beaverhead

Latitude: 454133  
Longitude: 1124712

USGS quadrangle: CATTLE GULCH

Township-range: 002S010W    Section: 01  
Township-range comments: NW4, NE4SW4, Section 2, NE4; T1SR10W:  
Section 36, SW4

Survey date: 1989-06-07	Elevation: 6200
First observation: 1989	Slope/aspect: 15-35% / S,SW
Last observation: 1989-06-07	Size (acres): 160

Location:

PIONEER MOUNTAINS, CATTLE GULCH, 1.0-1.65 AIR MILES  
NORTHWEST OF CONFLUENCE OF CATTLE GULCH AND CANYON CREEK,  
CA. 7 AIR MILES NORTHWEST OF MELROSE, MT.

Element occurrence data:

127 PLANTS COUNTED (84 FLOWERING, 43 STERILE); FOUR  
SUBPOPULATIONS; SLOPES LARGELY UNDISTURBED, ALTHOUGH THERE  
HAS BEEN SOME PAST GRAZING IN THE BOTTOM OF CATTLE GULCH.

General site description:

IN DRY, GRAVELLY CALCAREOUS SOILS ON STEEP SLOPES;  
CERCOCARPUS LEDIFOLIUS/AGROPYRON SPICATUM TYPE, WITH  
ARTEMISIA FRIGIDA, PHYSARIA GEYERI, LINUM PERENNE, SENECIO  
CANUS, GUTIERREZIA SAROTHRÆ, CYMPTERUS BIPINNATUS, OPUNTIA  
POLYACANTHA.

Land owner/manager:

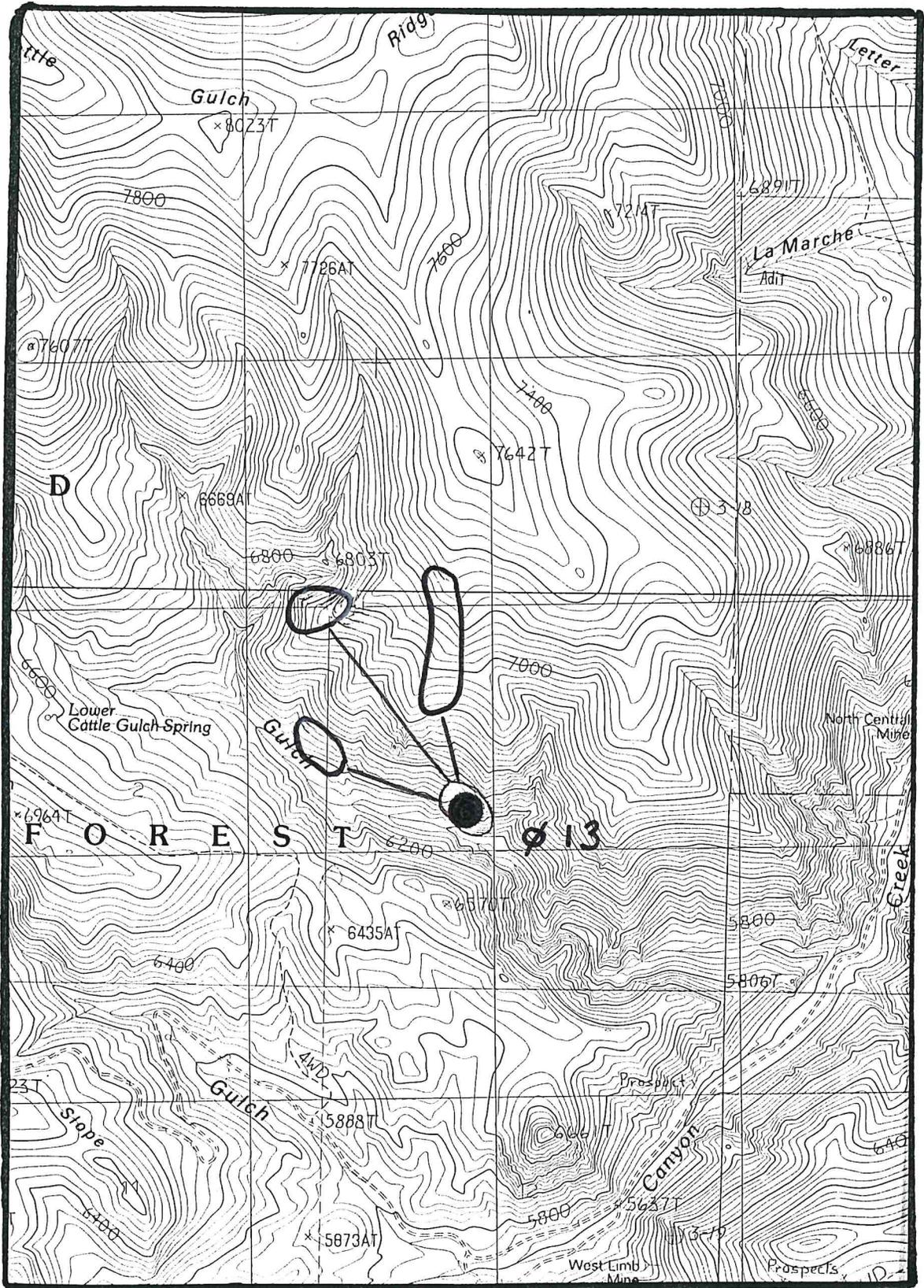
BEAVERHEAD NATIONAL FOREST, WISE RIVER RANGER DISTRICT

Comments:

VOUCHER - SHELLY, J.S. (1512), 1989, (MONTU); SITE SURVEYED  
WITH DR. FRANK SCHITOSKEY, USFWS.

Information source:

SHELLY, J.S. 1989. FIELD SURVEYS IN BEAVERHEAD COUNTY, 5-9  
JUNE.



USGS Cattle Gulch (7.5') quadrangle.

Cattle Gulch (013)

ARABIS FECUNDA  
SAPPHIRE ROCKCRESS

Element occurrence code: PDBRA06290.005

Global rank: G2 Forest Service status: WATCH LIST  
State rank: S2

Survey site name: QUARTZ HILL  
County: Beaverhead

USGS quadrangle: VIPOND PARK

Township-range: 001S011W Section: 36  
Township-range comments: CENTER

Survey date:	1989-06-06	Elevation:	7960
First observation:	1986	Slope/aspect:	8-35%/ SW
Last observation:	1989-06-06	Size (acres):	5

Location:

PIONEER MOUNTAINS, ECHO GULCH, SOUTHWEST BASE OF QUARTZ  
HILL, CA.5 AIR MILES SSW OF DEWEY, MT.

Element occurrence data:

CA. 375-500 PLANTS, MOST STERILE IN 1989; SOME LIGHT GRAZING  
IN PAST, MINING IN NEARBY AREAS.

General site description:

ON OPEN, GRAVELLY CALCAREOUS SLOPE, IN PINUS CONTORTA ZONE,  
WITH DRABA OLIGOSPERMA, TOWNSENDIA PARRYI, ERIGERON  
COMPOSITUS, AND IVESIA GORDONII.

Land owner/manager:

BEAVERHEAD NATIONAL FOREST, WISE RIVER RANGER DISTRICT

Information source:

SHELLY, J.S. 1989. FIELD SURVEYS IN BEAVERHEAD COUNTY, 5-9  
JUNE.

ARABIS FECUNDA  
SAPPHIRE ROCKCRESS

Element occurrence code: PDBRA06290.011

Global rank: G2 Forest Service status: WATCH LIST  
State rank: S2

Survey site name: CANYON CREEK  
County: Beaverhead

USGS quadrangle: CATTLE GULCH  
VIPOND PARK

Township-range: 002S010W Section: 08 N2  
Township-range comments: Sec 5 S2, Sec 6 SE4, Sec 7 NE4

Survey date:	1988-06-13	Elevation:	7000
First observation:	1988	Slope/aspect:	3-35%+ S,SW,SE
Last observation:	1989-06-16	Size (acres):	200

Location:

PIONEER MOUNTAINS, CANYON CREEK AND VIPOND CREEK DRAINAGES,  
CA. 12 MILES WEST OF MELROSE, MT, ALONG CANYON CREEK ROAD  
(BEAVERHEAD N.F. RD. #187); ON SLOPES ABOVE OLD KILNS, AND  
ABOVE VIPOND CREEK.

Element occurrence data:

CA. 10,000+ FLOWERING PLANTS IN 3 SUBPOPULATIONS; FLOWERING  
AND FRUITING OVER A LARGE AREA.

General site description:

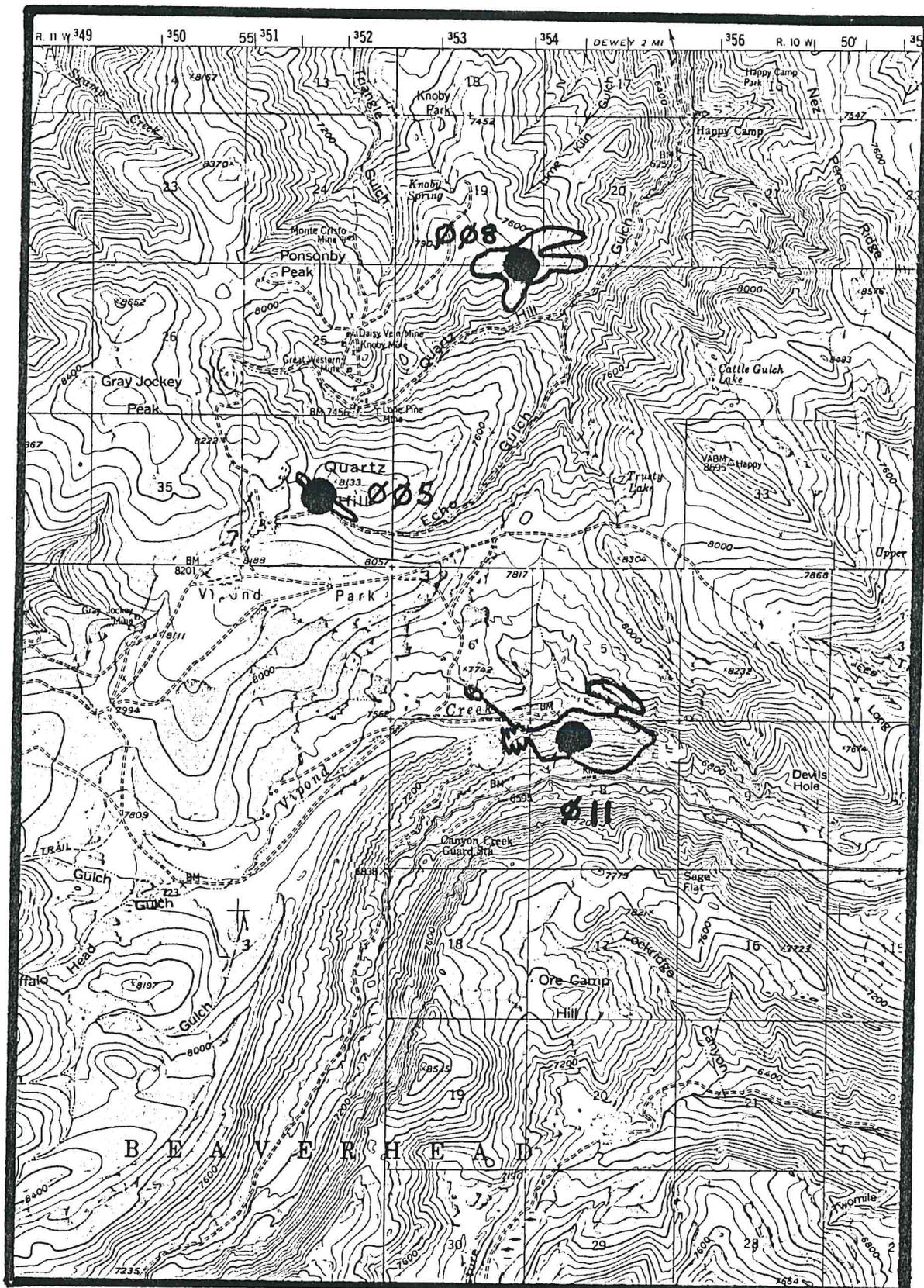
ON ROCKY CALC-SILICATE SLOPES, BENEATH PINUS FLEXILIS AND  
PSEUDOTSUGA MENZIESII, WITH ARTEMISIA TRIDENTATA, A.  
FRIGIDA, ERIGERON COMPOSITUS, CERCOCARPUS LEDIFOLIUS,  
AGROPYRON SPICATUM, PINUS CONTORTA AND POTENTILLA FRUTICOSA.

Land owner/manager:

BEAVERHEAD NATIONAL FOREST, WISE RIVER RANGER DISTRICT

Information source:

SCHASSBERGER, L.A. 1988 FIELD SURVEY, SOUTHWEST MONTANA,  
1-3, 6-7 AND 13-15 JUNE.



USGS Vipond Park (15') Quadrangle.  
Quartz Hill (005)  
Upper Quartz Hill Gulch (008)  
Canyon Creek (011)

slopes, at 6,200 ft. in elevation.

- I.6.C.1. Vegetation, physiognomy and community structure:** The vegetation associated with A. fecunda at the Cattle Gulch (013) site would be classified as a Cercocarpus ledifolius (curly-leaf mountain mahogany) / Agropyron spicatum (bluebunch wheatgrass) habitat type as described by Mueggler and Stewart (1980).
- I.6.C.3.** Species associated with Arabis fecunda at Cattle Gulch (013) include Artemisia frigida (fringed sagewort), Gutierrezia sarothrae (broom snakeweed), Physaria geyeri (Geyer's twinpod), Linum perenne (blue flax), Senecio canus (wooly groundsel), Cymopterus bipinnatus (fernleaf spring parsley) and Opuntia polyacantha (plains pricklypear).
- I.6.C.4. Dominance and frequency of this taxon in the community type:** The canopy cover of A. fecunda at Cattle Gulch (013) is quite low (less than 1%), which is somewhat lower than other known populations.
- I.6.C.7. Other endangered, threatened, rare, or vulnerable species occurring in the habitat of this taxon:** Mimulus suksdorfii and Astragalus platytropis, two plants of limited distribution in Montana occur with Arabis fecunda at Cattle Gulch. Mimulus suksdorfii is currently known from only one other location in southwestern Montana. Astragalus platytropis is known from six other locations, also in southwestern Montana.
- I.7.A. General summary of population biology of the taxon:** There are about 127 A. fecunda plants in the Cattle Gulch (013) population, in an area covering 60 acres.
- I.7.B.1. Known Populations:** One new population of A. fecunda was discovered during the 1989 field season. This brings the total number of known populations to 13, all of which occur in Montana. Nine of these populations occur along the north and east flanks of the Pioneer Mountains, Beaverhead and Silver Bow counties, while the other four populations are found along the western foothills of the Sapphire Range in Ravalli County.

**I.7.B.2. General demographic details of each population.**

**m. Cattle Gulch**

1. **Area:** Four subpopulations covering 60 acres.
2. **Number and size of plants:** 127 plants counted, ca. 65 % in flower (1989).
3. **Density:** Sparse.
4. **Presence of dispersed seed:** Unknown.
5. **Evidence of reproduction:** Presence of flowers and fruit.
6. **Evidence of expansion/contraction:** None.

**I.7.D.4. Seed biology.**

- a. Amount and variation of seed production:** Information from permanent transects at Birch Creek (004) and Charleys Gulch (001) indicate that fruit production is strongly related to climatic trends and, perhaps to a lesser extent, interspecific competition. See Appendix B in Schassberger (1988), and Appendix A of this report (p. 16). The effects of Centaurea maculosa invasion on the fecundity of A. fecunda are also discussed in Hamilton and Mitchell-Olds (1989).

In 1989, transects were established at two sites (Lime Gulch (012) and Canyon Creek (011)) in the Pioneer Mountains, in order gain more information on the life history of this species in areas not invaded by spotted knapweed, Centaurea maculosa (Appendix B, p. 17). This study is designed to compliment research on two populations (Birch Creek (004) and Charleys Gulch (001)) located on the western flanks of the Sapphire Mountains.

The data collected in 1989 from the Pioneer Mountains indicate that fecundity was higher at Canyon Creek (011) than at Lime Gulch (012). The number and percent of plants fruiting, and the number of fruits per plant and

per inflorescence, were higher at Canyon Creek. The number of seeds per fruit was quite similar for each site (Appendix B, p. 17).

Although the differences in fecundity are interesting, no conclusions can be drawn yet. The Lime Gulch (012) population is approximately 1,000 feet lower in elevation than Canyon Creek (011), and is located on the lower eastern flanks of the Pioneer Mountains in the rain shadow of some of the highest peaks of the range. Thus, it is likely to receive substantially less precipitation and have warmer temperatures than the Canyon Creek population. These site differences influence the phenology of the populations. The data indicates that there needs to be at least a one to two week delay in reading the Canyon Creek transects, in order to obtain data comparable to Lime Gulch (Appendix B, p. 17).

- I.8.C.2. b. Interspecific:** Density and fecundity of Arabis fecunda populations may be influenced by the presence and abundance of Centaurea maculosa (spotted knapweed). Reports from an ongoing study of the interactions between these two species from sites in Ravalli County is contained in Appendix B of Schassberger (1988), and in Appendix A of this report (p. 16). See also Hamilton and Mitchell-Olds (1989).
- I.9.A. General nature of ownership:** The Cattle Gulch (013) site is on U.S. Forest Service lands.
- I.9.B. Specific landowners:**
1. USDA Forest Service  
Beaverhead National Forest  
610 N. Montana Street  
Dillon, MT 59725
- I.11.A.1. Present or threatened destruction, modification, or curtailment of habitat or range:** The A. fecunda population at Cattle

Gulch is in largely undisturbed habitat. Although some grazing does occur in the area, it appears to be restricted to the lower, more gently sloping hillsides, below the population.

- II.12. General assessment of vigor, trends and status:** All 13 A. fecunda populations occur within a radius of ca. 47 miles. Centaurea maculosa (spotted knapweed) is currently not a threat to populations along the flanks of the Pioneer Range, but appears to be impacting the sites along the foothills of the Sapphire Range. See Appendix B Schassberger (1988), and Appendix A of this report (p. 16). Reproductive output of the A. fecunda population at Cattle Gulch appears to be normal, but has fewer individuals than other populations nearby.
- II.13.A. Recommendation to U.S. Fish and Wildlife Service:** It is recommended that Arabis fecunda be retained as a Category 2 species, until threats to populations can be more fully evaluated.
- II.13.B. U.S. Forest Service:** Arabis fecunda is now known to occur on lands administered by the U.S. Forest Service. Thus, it should be placed on the list of sensitive species in Region 1 for Montana.
- II.15.A. 1. Recommendations regarding present or anticipated activities:** The effects of mining or increased grazing in areas supporting populations of Arabis fecunda should be assessed before any new management actions are implemented. Although spotted knapweed (Centaurea maculosa) is not currently a problem in the Pioneer Mountains, its eventual dispersal into the area should be monitored, as this species appears to have a negative impact on many plant species, including Arabis fecunda.
- 2. Areas recommended for protection:**
- Canyon Creek (011): Large representative population of Arabis fecunda located at a higher elevation site on U.S. Forest Service lands in the East Pioneer Mountains.

Recommendation: Site should be proposed for special designation.

Lime Gulch (012): Large representative population at a lower elevation, on very distinctive soils, located on the lower eastern flanks of the East Pioneer Mountains. This population is on Forest Service lands, and a close equivalent to sites in the foothills of the Sapphire Range (which are threatened by spotted knapweed invasion). Recommendation: Site should be proposed for special designation.

Quartz Hill (005): This site supports a good population of A. fecunda, and populations of Penstemon lemhiensis (Lemhi penstemon) and Claytonia lanceolata var. flava (yellow springbeauty) occur nearby. Both of these plants are also USFWS Category 2 taxa, and are included on the U.S. Forest Service Region 1 list of sensitive species. Recommendation: Site should be proposed for special designation.

**I.15.B. Monitoring activities:** Monitoring should be continued at all four current study sites, to gain valuable long-term life history information.

**III.17.C. 1. Surveys:**

J. Stephen Shelly, Montana Natural Heritage Program:

8 May 1986 (001; Charleys Gulch)  
19-20 May 1987  
19-20 May 1988  
1-3 June 1988  
24-25 May 1989  
6-9 June 1989

Peter Lesica, The Nature Conservancy:

8 May 1986 (001; Charleys Gulch)  
27-30 May 1986  
19-20 May 1987  
19-20 May 1988  
24-25 May 1989

Lisa A. Schassberger, Montana Natural  
Heritage Program:

1-3 June 1988  
6-7 June 1988  
13-15 June 1988  
6-9 June 1989

**III.17.D**

**Knowledgeable individuals:**

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Montana Natural Heritage Program  
State Library Building  
1515 E. 6th Ave.  
Helena, MT 59620

Peter Lesica  
Division of Biological Sciences  
University of Montana  
Missoula, MT 59812

**III.18.**

**Summary of materials on file:** All detailed field forms, maps and color slides are on file at the office of the Montana Natural Heritage Program, Helena, MT. Herbarium vouchers for Montana populations are deposited at the University of Montana Herbarium (MONTU) Missoula.

## Literature Cited

- Hamilton, M.B., and T. Mitchell-Olds. 1989. Population biology of Arabis fecunda, a rare endemic. 1. Directional selection and interspecific competition. *Evolution* (In review).
- Lesica, P. 1985. Report on the conservation status of Arabis fecunda, a potential candidate species. Unpublished report to the U.S. Fish and Wildlife Service, Denver, Colorado. 18 pp.
- Mueggler, W.F., and W.L. Stewart. 1980. Grassland and shrubland habitat types of Western Montana. Intermountain Forest and Range Experiment Station, Ogden, Utah. 154 pp.
- Richards, R.W., and J.T. Pardee. 1925. The Melrose Phosphate Field, Montana. U.S.G.S. Bull. 780: 1-32.
- Schassberger, L.A. 1988. Update to the report on the conservation status of Arabis fecunda, a candidate threatened species. Unpublished report to the U.S. Fish and Wildlife Service, Denver, Colorado. 36 pp.
- U.S. Department of Agriculture, Forest Service. 1988. Sensitive Plant Field Guide to Montana. U.S. Forest Service, Northern Region, Range, Air, Watershed, and Ecology Unit, Missoula, Montana.
- U.S. Department of Commerce. 1982. Monthly Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1951-80. National Oceanic and Atmospheric Administration, Climatology of the United States No. 81. 23 pp.

**Appendix A**

THE ECOLOGY OF ARABIS FECUNDA:  
LONG-TERM MONITORING AND SPOTTED KNAPWEED REMOVAL STUDIES.  
1989 PROGRESS REPORT

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September 1989

## INTRODUCTION

In order to adequately protect populations of an organism, it is necessary to understand its life history and population dynamics (Massey and Whitson 1980, Sutter 1986, Palmer 1987). In addition, many rare species are threatened by interactions with non-native species that have been introduced into their habitat (Drake 1988). It is important to understand the nature of these interactions in order to protect populations of rare species from extinction.

Sapphire rockcress (Arabis fecunda Rollins) is a rosette-forming perennial in the Mustard Family (Brassicaceae). This recently described species (Rollins 1984) is endemic to highly calcareous, azonal soils in the foothills of the Sapphire Range in Ravalli County and in the Pioneer Range in Beaverhead and Silver Bow counties, Montana (Lesica 1985, Schassberger 1988). Arabis fecunda occurs on eroding slopes with low vascular plant density. Often these sites have a relatively high cover of cryptogamic soil crust. In Ravalli County, populations of Arabis fecunda are thought to be threatened by livestock grazing and encroachment by an aggressive exotic weed, spotted knapweed (Centaurea maculosa) (Lesica 1985).

This paper is a progress report on two studies being conducted on populations of Arabis fecunda in Ravalli County. The studies and their purposes are:

- |       |  |
|-------|--|
| Study | 1. Long-term monitoring of <u>Arabis fecunda</u> populations. Purpose: Determine important life history attributes, and determine trends in overall recruitment and mortality. |
| Study | 2. Spotted knapweed removal study. Purpose: Determine the effects of spotted knapweed competition on the reproductive performance and survivorship of <u>Arabis fecunda</u> .  |

## METHODS

### Study Areas

We conducted our studies at two sites in Ravalli County, Montana: Charleys Gulch and Birch Creek. The Charleys Gulch site is on a steep, eroding, southwest-facing slope along the gulch at an elevation of ca. 5,000 ft. (T6N R19W S29, NW1/4). The Birch Creek site is on a steep, eroding, southeast-facing slope above the creek at an elevation of ca. 4,700 ft. (T7N R19W S16, NW1/4). More complete descriptions of the study sites can be found in Lesica (1985) and Schassberger (1988).

### Long-term Monitoring Study

In May, 1987, we established permanent belt transects of 12 adjacent m<sup>2</sup> plots at each site following the methods outlined in Lesica (1987). Individual Arabis fecunda plants were mapped and recorded using the following system:

- S - Seedling
- R - indicates the number of rosettes per plant
- I - indicates the total number of inflorescences (stems) per plant
- F - indicates the total number of fruits produced by the plant

Thus, a plant with two rosettes, three stems and a total of nine fruits would be recorded as R1-I3-F9. Seedlings were recognized by their small size (< 15 mm diameter). Many single or multiple rosette plants may also be first-year plants. In addition, we noted the presence of recently disturbed soil and evidence of livestock trampling. We did not record seedling-size plants at the Birch Creek site in 1987. In 1989 we collected 50 randomly selected fruits from different individual at Charleys Gulch, and 25 fruits at Birch Creek. Each fruit was hand-dissected, and the number of seeds in each was recorded. We read the transects on May 19-20, 1987 and 1988 and May 24-25, 1989. Population density and fecundity data are presented in Table 1.

### Spotted Knapweed Removal Study

In May, 1987, we established two permanent belt transects consisting of 10 adjacent m<sup>2</sup> plots at each of the study sites following the methods of Lesica (1987). Transects were placed in areas with relatively heavy spotted knapweed infestations. Individual Arabis fecunda plants were mapped and recorded as in the long-term monitoring study. For each transect, we removed the spotted knapweed from five randomly selected plots by carefully cutting the plants below the root crown with a sharp knife. Spotted knapweed was removed from plots 2,4,5,8, and 9 at Birch Creek and from plots 1,4,5,8, and 9 at Charleys Gulch. We did not record seedlings at the Birch Creek site in 1987. Ocular estimates of percent canopy cover of spotted knapweed were made for treatment and control plots each year. We read the transects on May 19-20, 1987 and 1988 and May 24-25, 1989. Data on percent canopy cover of spotted knapweed are presented in Table 2; performance parameters for A. fecunda are shown in Table 3.

### Data Analysis

Population growth rate was calculated for each long-term monitoring study site in 1988 and 1989 by taking the increase in individuals over the previous year and dividing by the number of

individuals present in the plot the previous year. Negative growth rates reflect a decreasing population size.

## Discussion

### I. Long-term monitoring studies

1. The severe drought that occurred in 1988 appears to have influenced total fruit production at both Charleys Gulch and Birch Creek (Table 1). During that year, the percentages of fruiting plants reached the lowest recorded levels. However, over the three study years, at both sites, there has been an increase in the fecundity (# fruits/fruiting plant) of the reproductive individuals.
2. The slight negative population growth rate at the Charleys Gulch site may be due, in part, to the impacts of cattle trampling, which was very evident at this site in both 1988 and 1989.

### II. Spotted knapweed removal studies

1. Yearly removal of spotted knapweed from randomly selected plots in the study transects has resulted in a decrease (but not eradication) in the mean percent canopy cover of spotted knapweed in those plots, at both Charleys Gulch and Birch Creek (Table 2).
2. At Charleys Gulch, an increase in plant densities occurred in the spotted knapweed removal plots over the three-year study period (Table 3). At Birch Creek, a drastic increase was detected in 1988, followed by a decrease in 1989 (Table 4). In the control plots, densities remained fairly constant at Charleys Gulch, and decreased slightly in 1989 at Birch Creek. These data suggest that reduction of interspecific competition from spotted knapweed may allow increased establishment of A. fecunda plants. The population growth statistics reflect these changes.
3. The fecundity parameters were apparently heavily influenced by the drastic climatic fluctuations during the three-year study period. To fully assess the potential influence of spotted knapweed competition on fecundity, additional transect readings over several more years are needed.

Table 1. Population density and fecundity data for Arabis  
fecunda in long-term monitoring transects, 1987-1988.

		<u>Birch Creek</u>	<u>Charleys Gulch</u>
Density (plants/m <sup>2</sup> )	1987	4.8	6.5
	1988	4.6	6.0
	1989	4.9	5.5
Population growth	1988	0.14	-0.08
	1989	0.05	-0.08
# plants fruiting	1987	20	33
	1988	7	11
	1989	32	24
% plants fruiting	1987	35%	42%
	1988	11%	15%
	1989	47%	36%
# fruits per fruiting plant	1987	3.8	5.1
	1988	14.0	8.8
	1989	22.0	15.8
# fruits per inflorescence	1987	2.2	2.1
	1988	5.2	3.0
	1989	6.8	3.9
% plants with more than one rosette	1987	9%	27%
	1988	8%	38%
	1989	9%	30%
% one-rosette plants with fruit	1987	29%	37%
	1988	12%	22%
	1989	45%	35%
% multi-rosette plants with fruit	1987	83%	57%
	1988	0%	4%
	1989	67%	40%

Table 2. Percent canopy cover of spotted knapweed (*Centaurea maculosa*) in removal transects in 1987 (before spotted knapweed removal), 1988 and 1989. An asterisk (\*) indicates plots from which spotted knapweed was removed; remaining plots are controls.

Charleys Gulch #2												
Year	*			*	*			*	*		Control Mean	Removal Mean
	1	2	3	4	5	6	7	8	9	10		
1987	20	25	20	25	28	23	20	23	30	25	23	25
1988	5	20	28	15	18	30	25	23	18	35	28	16
1989	2	25	33	5	10	28	30	8	5	30	29	6

Birch Creek #2												
Year		*		*	*			*	*		Control Mean	Removal Mean
	1	2	3	4	5	6	7	8	9	10		
1987	30	35	35	30	33	38	28	23	23	28	32	29
1988	30	20	30	30	20	30	15	30	30	20	25	26
1989	28	10	40	15	15	23	15	5	5	20	25	10

Table 3. Performance parameters for *Arabis fecunda* in spotted knapweed removal (n=5) and control (n=5) plots at Charleys Gulch (mean=SD).

	<u>1987</u>		<u>1988</u>		<u>1989</u>	
	Removal	Control	Removal	Control	Removal	Control
Density (plants/plot)	12.8+3.9	14.2+3.6	14.4+3.3	14.0+4.2	19.4+5.8	13.4+3.7
Fruiting plants/plot	5.8+2.7	4.6+2.6	0.4+0.5	0.4+0.9	6.4+4.2	5.4+2.5
% plants fruiting	39.3+13.0	32.5+17.6	2.4+3.2	4.0+8.9	30.6+16.6	39.9+13.0
New plants	---	---	4.2+2.6	3.0+2.9	7.0+3.2	2.6+1.3
Dead plants	---	---	2.6+3.6	3.2+2.0	2.0+2.0	3.2+1.5
Population growth	---	---	0.15	-0.02	0.41	-0.08
# fruits/plot	26.8+17.0	18.6+6.7	4.6+6.8	3.4+7.6	104.8+61.9	82.0+38.1
# inflorescences/plot	12.2+6.7	8.4+3.8	1.0+1.4	1.0+2.2	27.6+17.7	21.2+9.7
Fruits/inflorescence	2.2+0.3	2.4+0.5	4.5+0.7	3.4+0.0	3.9+0.4	3.8+0.3
Inflorescence/fruiting plant	2.1+0.5	2.1+1.1	2.5+0.7	2.5+0.0	4.4+1.1	4.4+2.2

Table 4. Performance parameters for *Arabis fecunda* in spotted knapweed removal (n=5) and control (n=5) plots at Birch Creek (mean+SD).

	<u>1987</u>		<u>1988</u>		<u>1989</u>	
	Removal	Control	Removal	Control	Removal	Control
Density (plants/plot)	16.0+3.9	21.2+6.5	58.0+59.2	24.0+3.7	32.6+12.9	17.2+10.3
Fruiting plants/plot	8.8+2.9	8.0+4.5	1.2+1.3	1.4+2.1	11.2+5.3	5.4+4.7
% plants fruiting	54.7+12.1	35.7+12.3	4.6+6.2	5.5+7.9	33.7+9.7	36.2+17.9
New plants	---	---	50.4+60.3	13.6+8.6	16.8+6.3	7.8+5.4
Dead plants	---	---	11.4+5.2	10.8+5.8	42.2+50.4	14.6+5.9
Population growth	---	---	2.67	0.27	-0.12	-0.28
# fruits/plot	55.6+26.4	39.2+16.9	18.2+18.6	8.0+10.7	348+169	139+168
# inflorescences/plot	22.2+6.6	18.8+9.2	3.6+4.6	1.8+2.9	41.6+18.4	22.0+23.2
Fruits/inflorescence	2.4+0.6	2.4+1.1	6.5+3.1	5.9+2.2	8.6+2.9	5.7+1.9
Inflorescence/fruiting plant	2.2+0.6	2.6+1.0	2.7+0.9	1.1+0.2	3.8+0.6	3.5+1.5

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- Drake, J. A. 1988. Biological invasions into nature reserves. *Trends in Ecology and Evolution* 3: 186-187.
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- Sutter, R. D. 1986. Monitoring rare plant species and natural areas - ensuring the protection of our investment. *Natural Areas Journal* 6: 3-5.

**Appendix B**

DEMOGRAPHIC MONITORING OF ARABIS FECUNDA  
IN THE PIONEER RANGE

1989 ESTABLISHMENT REPORT

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December 1989

## INTRODUCTION

In order to adequately protect populations of an organism, it is necessary to understand its life history and population dynamics (Massey and Whitson 1980, Sutter 1986, Palmer 1987). In addition, many rare species are threatened by interactions with non-native species that have been introduced into their habitat (Drake 1988). It is important to understand the nature of these interactions in order to protect populations of rare species from extinction.

Sapphire rockcress (Arabis fecunda Rollins) is a rosette-forming perennial in the Mustard Family (Brassicaceae). This recently described species (Rollins 1984) is endemic to highly calcareous, azonal soils in the foothills of the Sapphire Range in Ravalli County, and in the Pioneer Range in Beaverhead and Silver Bow counties, Montana (Lesica 1985, Schassberger 1988). Arabis fecunda generally occurs on steep, often eroding slopes with low vascular plant density. In Ravalli County, populations of A. fecunda are thought to be threatened by livestock grazing and encroachment by an aggressive exotic weed, spotted knapweed (Centaurea maculosa) (Lesica 1985, Schassberger 1988). In Silver Bow and Beaverhead counties, populations may be threatened by mining activity and livestock grazing.

This report documents the establishment of demographic monitoring transects for Arabis fecunda at two sites in the Pioneer Range, on Beaverhead National Forest lands.

## STUDY SITES

### I. Lime Gulch

Location: Five miles west of Interstate Highway 15, on the north side of Birch Creek Road, approximately 1/4 mile up Lime Gulch from the road; T5S R10W Sec 14; ca. 6,200 ft elevation.

#### a. South Transect

Location: East-facing slope on the west side of the gulch, ca. 20 m up from the bottom. 98 degrees from the start pin to the summit of Limestone Mountain; 204 degrees to the summit of the grassy mountain south of Birch Creek Road. The start pin is next to an old juniper stump.

Line bearing: 21 degrees

Slope: 16 degrees

Aspect: 165 degrees

Instructions: Read transect south to north.

b. North Transect

Location: West-facing slope on the east side of the gulch, ca. 5 m above the bottom. 209 degrees from start pin to the summit of the bald hill with patches of trees; 17 degrees to the base of the Douglas fir snag near the bottom of the gulch.

Line bearing: 178 degrees

Slope: 22 degrees

Aspect: 274 degrees

Instructions: Read transect north to south.

II. Canyon Creek

Location: Approximately 12.5 miles west of Melrose on the Canyon Creek Road, at the corner of the road overlooking the kilns; T2S 10W Sec 8; 7,200 ft elevation.

a. West Transect

Location: Moderate, south-facing slope. 162 degrees from the start pin to the southwest-most kiln; 227 degrees to the junction of the guard station road.

Line bearing: 110 degrees

Slope: 31 degrees

Aspect: 205 degrees

Instructions: Read transect west to east.

b. East Transect

Location: Moderate, south-facing slope. 178 degrees from the start pin to southwest-most kiln; 48 degrees to wooden platform.

Line bearing: 96 degrees

Slope: 30 degrees

Aspect: 180 degrees

Instructions: Read transect west to east.

### METHODS

On June 15 (Lime Gulch) and 16 (Canyon Creek), we established two permanent belt transects of 12 adjacent m<sup>2</sup> plots at each site, following the methods outlined in Lesica (1987). The start and end points of each transect were marked by a section of reinforcing bar driven into the ground and painted orange. Individual *A. fecunda* plants were mapped and recorded using the following system:

- S - Seedling (rosette less than 15 mm diameter)
- R - indicates the number of rosettes (> 15 mm diameter) per plant
- I - indicates the total number of inflorescences (stems) per plant
- F - indicates the total number of fruits produced by the plant

Thus, a plant with two rosettes, three stems and a total of nine fruits would be recorded as R1-I3-F9. In cases where plants had not finished blooming, two flowers or flower buds were recorded as one fruit. Since a first year plant can bloom and set fruit (Lesica and Shelly, personal observation), the above system describes size rather than age classes.

At each site, we located 25 randomly-chosen plants outside of the transects, and picked one fruit from each. We dissected each fruit, and recorded the number of viable-appearing seeds in each.

Many of the plants at Canyon Creek were still flowering when we read the transects; thus we recommend that this transect be read in late June or early July.

### RESULTS AND DISCUSSION

A summary of the data collected in 1989 is presented in Table 1. All plants were mapped and scored to size class within each of the four transects. Fecundity was much greater in the Canyon Creek population than the Lime Gulch population. Also, the Canyon Creek population had a higher percentage of plants with more than one rosette. The Lime Gulch population is ca. 1,000 ft lower in elevation and in the rain shadow of the Pioneer Mountains. The differences in fecundity could be an artifact of

sampling on consecutive days at sites which have very different microclimates, i.e., the phenology of the two populations may not be the same. The reason(s) for the difference in rosette number is unknown.

Table 1. Population density and fecundity data for Arabis  
fecunda in long-term monitoring transects, Beaverhead  
National Forest, 1989.

	<u>Canyon Creek</u>	<u>Lime Gulch</u>
Density (plants/m <sup>2</sup> )	15.8	15.4
# plants fruiting	95	6
% plants fruiting	25.1%	1.6%
# fruits per fruiting plant	10.8	3.2
# fruits per inflorescence	5.5	1.7
% plants with more than one rosette	20.3%	12.2%
% one-rosette plants with fruit	23.8%	0.9%
% multi-rosette plants with fruit	29.9%	6.7%
Seeds per fruit	34.2+10.5	31.1+5.6

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- Drake, J. A. 1988. Biological invasions into nature reserves. *Trends in Ecology and Evolution* 3: 186-187.
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- Sutter, R. D. 1986. Monitoring rare plant species and natural areas - ensuring the protection of our investment. *Natural Areas Journal* 6: 3-5.

6/1988  
Arabis fecunda  
Vipond Park (011)  
Lisa A. Schussberger

6/1988  
Arabis fecunda  
Month of Jerry Creek (007)  
Lisa A. Schussberger

Arabis fecunda  
Lime Gulch (012)  
2  
Lisa A. Schussberger

Arabis fecunda 6/1988  
Habitat  
Month of Quartz Hill Gulch (006)  
Lisa A. Schussberger

Arabis fecunda 6/1988  
Habitat  
Month of Jerry Creek (007)  
Lisa A. Schussberger

Arabis fecunda 6/1988  
Habitat  
Lime Gulch (012)  
Lisa A. Schussberger

Arabis fecunda 6/1988  
Habitat  
Month of Quartz Hill Gulch (006)  
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Arabis fecunda 6/1988  
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