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:	Montana, U.S.A.
Recommended federal status:	USFWS Category 2 (C2)
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I. SPECIES INFORMATION

A. CLASSIFICATION

1. SCIENTIFIC NAME: Arabis fecunda Rollins (Rollins 1984)

2. SYNONYMS: None

3. COMMON NAME: Sapphire rockcress

4. FAMILY: Brassicaceae (Mustard Family)

5. GENUS: Arabis contains more than 100 species of the Northern Hemisphere from desert to alpine habitats (Hitchcock et al. 1964).

6. SPECIES: Arabis fecunda was first collected by Jaculyn Cory at the type locality south of Charleys Gulch in mid-May, 1975 (Cory 1416 MONTU). These specimens were in flower, and she returned on 13 June 1976 to collect the type specimen (Cory 1611 MONTU) in fruit. The identification of these specimens remained undetermined until 1983 when they were sent to Reed C. Rollins at the Gray Herbarium of Harvard University who described the plant as a new species (Rollins 1984).

   Type Specimen-- Ravalli County, Montana, on rocky terrain near sagebrush, big game range east of Corvallis, 13 June 1976, Jaculyn Cory 1611, MONTU. The type locality is one of the Charleys Gulch subpopulations, EO #001.

   Cory's collections were large bolting specimens even though axillary flowering plants are much more common at the site (Walsh 1992, Lesica and Shelly 1994). Thus, Rollins' description of a "congested" inflorescence does not apply to axillary flowering plants. Furthermore, the petals fade to a purplish color described by Rollins, but are actually white in the field.

   Rollins described A. fecunda as being closely related to A. fernaldiana (Rollins 1984).

B. PRESENT LEGAL OR FORMAL STATUS

1. FEDERAL STATUS

   a. U.S. FISH AND WILDLIFE SERVICE: C2; Arabis fecunda is a candidate for listing as a

threatened or endangered species, but currently there is insufficient information to make a decision on listing (USDI-FWS 1993).

b. U.S. FOREST SERVICE: Region One lists A. fecunda as sensitive. A sensitive plant species is one for which the Regional Forester has determined there is a concern for population viability, within a state, as evidenced by significant current or predicted downward trend in populations or habitat. All plants listed as sensitive are known to occur on national forest land (Lesica and Shelly 1991).

c. U.S. BUREAU OF LAND MANAGEMENT: The Interim Draft Policy Regarding Sensitive Plants and Sensitive Plant Communities on BLM Lands in Montana lists A. fecunda as Special Status, Priority One. BLM will take no conscious action that will cause a species of special status to be listed as threatened or endangered. Habitat of Priority 1 Species may, after proper evaluation, be considered for Areas of Critical Environmental Concern (ACEC) or Research Natural Areas (RNA).

2. STATE STATUS: Arabis fecunda is currently listed as globally imperiled (G2) and imperiled in Montana (S2) by the Montana Natural Heritage Program. Lesica and Shelly (1991) list A. fecunda as threatened in Montana. These state listings do not provide any direct legal protection for A. fecunda.

C. DESCRIPTION

1. GENERAL NONTECHNICAL DESCRIPTION: Arabis fecunda is a small perennial forb with one to many clusters of basal leaves and flower stalks 3-12 in high. The basal leaves generally have a smooth margin and are 0.5-1.0 in long and ca. 0.2 in wide. Leaves on the flowers stalks are smaller and clasp the stem. The leaves and stem are grayish-white with a dense cover of small branched hairs. Flowering occurs in one of two ways: (1) axillary flowering - one to many decumbent inflorescence stems develop from axillary buds among the tightly clustered leaves of the rosette or (2) bolting - a single inflorescence stem is produced from the terminal bud in the center of

the rosette. Bolting inflorescences are generally larger and leafier than axillary inflorescences. An individual rosette may produce axillary inflorescences for numerous years, while bolting rosettes always die. Some rosettes produce axillary inflorescences for one to many years before either dying or bolting and then dying. Others bolt once and die. Axillary flower stalks are unbranched, while bolting inflorescences are often branched. Each flower has four white petals 0.25-0.5 in long and ca. 0.2 in wide. The flowers are close together on the stalk but become further apart as they mature into fruits. Fruits are 1-2 in long and ca. 0.05 in wide and held nearly erect by the stalks that may be up to 0.5 in long. The fruits are densely hairy, and each side of the fruit contains a single row of round seeds ca. 0.05 in diameter.

2. TECHNICAL DESCRIPTION: Perennial with a simple or branched caudex, densely pubescent throughout with fine dendritically branched trichomes; stems erect to somewhat decumbent at base, simple or few branched, 1-3 dm high; leaves hoary, dimorphic; basal leaves petiolate, spatulate to linear oblanceolate, entire or with a few broad teeth in the blade area, 1-3 cm long, 2-4 mm wide; cauline leaves sessile, entire or the lower with a few teeth, oblong, acute, sparingly auriculate to nonauriculate, 7-20 mm long; inflorescences usually congested, sepals oblong, nonsaccate, densely pubescent, 6-7 mm long, ca. 2 mm wide; petals purplish, obovate, not unguiculate, narrowing gradually from blade to point of insertion, 9-13 mm long, 3-5 mm wide; fruiting pedicels erect to slightly divaricately ascending, straight, 6-10 mm long; siliques erect, congested, usually appressed to rachis, straight to slightly curved inward, 3-5 cm long, ca. 1.5 mm wide, valves densely pubescent, compressed between seeds; styles ca. 1 mm long; seeds in a single row, suborbicular to slightly longer than broad, narrowly winged-margined all around, ca. 1.2 mm in diameter, mucilaginous when wetted; cotyledons accumbent (Rollins 1984)

It should be remembered that the above description was based on a very limited amount of material. An additional, more recent technical description can be found in Rollins (1993).

3. FIELD CHARACTERS: Arabis is a very difficult genus, and a suite of characters is usually needed to distinguish a particular species from others. The very erect fruits and dense grayish covering of branched hairs on the foliage and fruit distinguish A. fecunda from all other Arabis in western Montana. The species occurs only in calcareous soil.

4. PHOTOGRAPHS AND LINE DRAWINGS: Photographs of Arabis fecunda are available from the Montana Natural Heritage Program. A line drawing is found on the cover of Lesica and Shelly (1991). A line drawing of a bolting plant can be found in Kelseya Vol. 2, No. 1 (1988).

D. GEOGRAPHICAL DISTRIBUTION

1. RANGE: Arabis fecunda occurs at elevations of 4,700-7,800 ft in the west foothills of the Sapphire Range of Ravalli County and the foothills and mountains of the East Pioneer Range and Highland Mountains of Beaverhead and Silver Bow counties (Lesica 1985, Schassberger 1988). The global distribution of the species is shown in Figure 1.

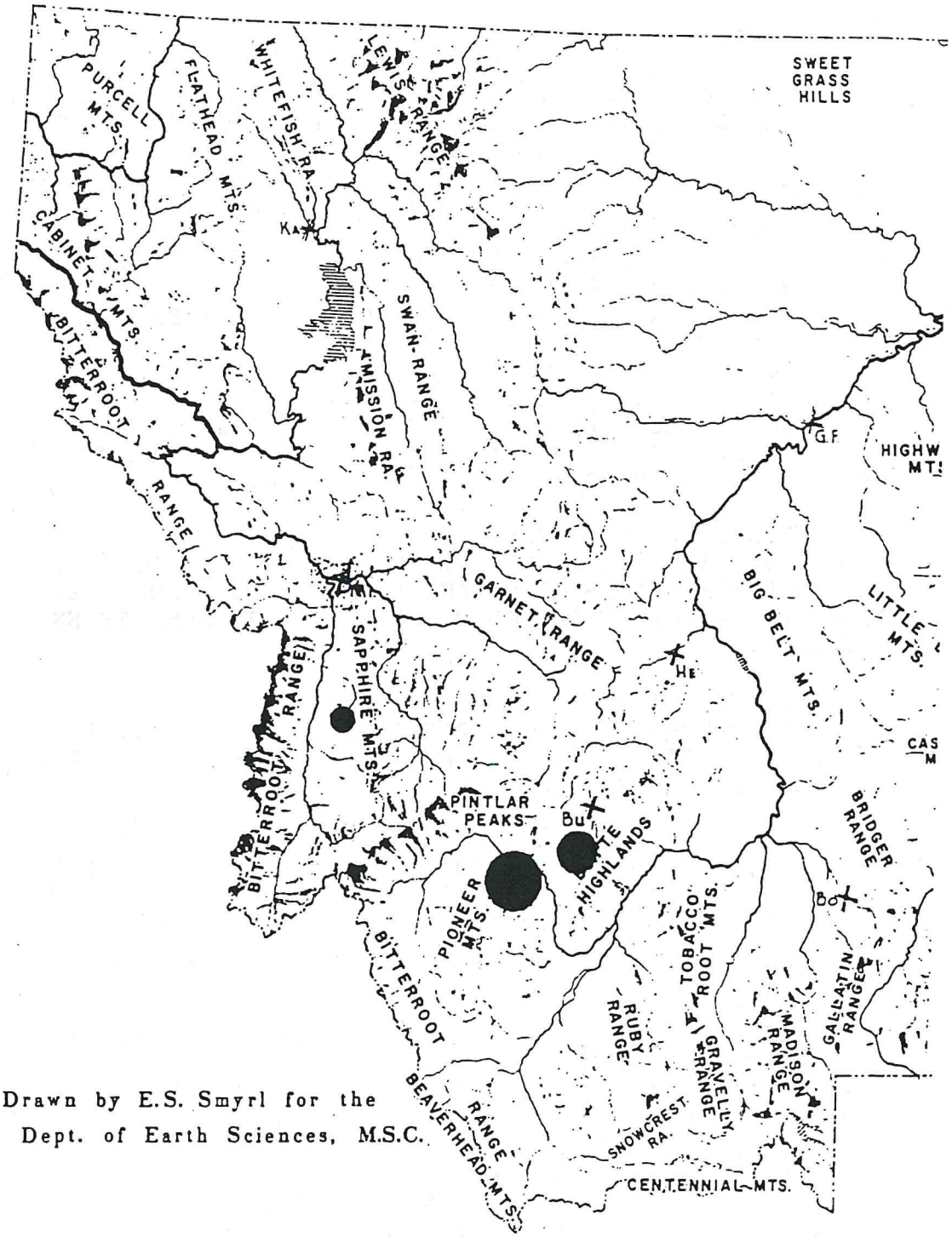
2. RECENTLY VERIFIED SITES: There are 18 known locations for Arabis fecunda; all have been verified in the past six years. Location, elevation and directions to these sites are provided in Table 1. More complete information can be found in the full element occurrence records given in Appendix A.

3. LOCATIONS NOT YET INVESTIGATED: Arabis fecunda has always been found in southwest Montana on soils derived from calc-silicate rocks that have come in contact with granitic intrusions. Similar geologic situations occur on the east flank of the Highland Mountains just west of the town of Silver Star and on the northwest end of the Tobacco Root Range ca. 6 miles south of Whitehall.

E. CULTIVATED MATERIAL: Arabis fecunda is currently being cultivated at the University of Montana under direction of Thomas Mitchell-Olds. In addition, a few individuals been planted in the outdoor garden around the Botany Greenhouse.

F. HABITAT

Figure 1. Location of Arabis fecunda populations.



Drawn by E.S. Smyrl for the
Dept. of Earth Sciences, M.S.C.

Table 1. Location of Arabis fecunda sites. Information includes (EO #), county, latitude-longitude, elevation, legal description and directions to the site.

001 CHARLEYS GULCH
Ravalli Co., 461531N 1140000W, 5000 ft, T6N R19W S20
CHARLEYS GULCH, WEST SLOPE OF SAPPHIRE RANGE, ALONG CHARLEYS GULCH ROAD CA. 1.1-2.1 MILES FROM JUNCTION WITH PAVED COUNTY ROAD; ALSO NORTH AND SOUTH OF GULCH.

002 SPRING GULCH Ravalli Co., 461452N 1140109W, 4740 ft, T6N T19W S30
SPRING GULCH, WEST SLOPE OF SAPPHIRE RANGE; AT JCT. OF HWYS. 269 & 380, 2.5 MI. E. TO WHERE 380 TURNS N.; E. 1.5 MI. TO CHARLEYS GULCH RD., 2 MI. TO CATTLEGUARD; SITES 1 MI. SW.

003 ROCK QUARRY GULCH
Ravalli Co., 461358N 1140137W, 4850 ft, T6N R19W S31
ROCK QUARRY GULCH; FROM JCT. OF HWYS. 269 & 380, GO 2.5 MI. E. TO CORNER WHERE 380 TURNS N.; GO E. 1.5 MI. TO CHARLEYS GULCH RD., & 2 MI. TO CATTLEGUARD; SITE IS 2 MILES SW.

004 BIRCH CREEK BLUFFS
Ravalli Co., 462201N 1135911W, 4700 ft, T7N R19W S16
WESTERN LOWER SLOPES OF SAPPHIRE MOUNTAINS, ALONG BIRCH CREEK AND TRIBUTARY NW. OF SCHOOLHOUSE BUTTE, CA. 7 AIRMILES ENE. OF CORVALLIS.

005 QUARTZ HILL
Beaverhead Co., 454224N 1125419W, 7960 ft, T1S R11W S36
PIONEER MOUNTAINS, ECHO GULCH, SOUTHWEST BASE OF QUARTZ HILL, CA.5 AIR MILES SSW OF DEWEY, MT.
^

006 MOUTH OF QUARTZ HILL GULCH
Beaverhead Co., 454608N 1125126W, 5780 ft, T1S T10W S8
TRAVEL 0.25 MILE WEST OF DEWEY, MT ON HIGHWAY 43, THEN SOUTH ON QUARTZ HILL GULCH ROAD, EAST AND WEST OF THE ROAD FOR 1.5 MILES.

007 JERRY CREEK
Silver Bow Co., 454718N 1125402W, 5700 ft, T1N R10W S31
T1N R11W S36
CA. 1.5 MILES EAST OF WISE RIVER, MT, ON HIGHWAY 43, NE ON JERRY CREEK ROAD 0.3 MILE; HILLSIDES AND OUTCROPS EAST OF ROAD.

008 UPPER QUARTZ HILL GULCH
Beaverhead Co., 454345N 1125242W, 7500 ft, T1S R10W S19
CA. 3.75 MILES SOUTH OF DEWEY, MT. ON QUARTZ HILL GULCH ROAD, CA. 0.2 MILE SW OF ROAD.

Table 1 (cont.)

009 SPRING GULCH II
Beaverhead Co., 454643N 1125354W, 5600 ft, T1S R11W S1
CA. 2.2 MILES EAST OF WISE RIVER, MT, ON HIGHWAY 43. AT BEND, 0.20 MILE SOUTH OF ROAD ATOP STEEP CLIFFS.

010 WISE RIVER
Silver Bow Co., 454708N 1125230W, 5600 ft, T1S R10W S5
T1N R10W S32
1.0 MILE WEST OF DEWEY, ON HIGHWAY 43; 0.33 MILE NORTH OF ROAD ON THE NORTH SIDE OF WISE RIVER.

011 CANYON CREEK
Beaverhead Co., 454101N 1125213W, 7000 ft, T2S R10W S8
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.

012 LIME GULCH
Beaverhead Co., 452352N 1124844W, 6200 ft, T5S R10W S14
5 MILES WEST OF INTERSTATE-15, UP BIRCH CREEK ROAD. NORTH OF ROAD, ON EAST AND WEST FACES OF LIME GULCH.

013 CATTLE GULCH
Beaverhead Co., 454133N 1124712W, 6200 ft, T2S R10W S1
T1S R10W S36
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.

014 FISH CREEK
Silver Bow Co., 454807N 1122852W, 7080 ft, T1N R7W S28
HIGHLAND MOUNTAINS SOUTH OF BUTTE; FROM CAMP CREEK ROAD (FS RD 8520) TAKE ROAD TO FISH CREEK. ONCE ON THE FISH CREEK ROAD, PROCEED WEST UNTIL ROAD CROSSES TO SOUTH SIDE OF CREEK. PROCEED ANOTHER 0.3 MILES. SITE IS ON NORTH SIDE OF CREEK.

015 LIMEKILN HILL
Silver Bow Co., 454837N 1122747W, 7320 ft, T1N R7W S27
HIGHLAND MOUNTAINS SOUTH OF BUTTE. FROM FISH CREEK ROAD (FS RD 668), TAKE ROAD TO LIMEKILN HILL (FS RD 8492). PROCEED 0.6 MILE; SITE IS ON RIDGE TO THE WEST.

016 TUCKER CREEK
Silver Bow Co., 454710N 1123951W, 6640ft, T1S R9W S1
T1N R9W S36
FROM DIVIDE (TOWN), TAKE FRONTAGE ROAD NORTH CA. 5 MILES. GO EAST UNDER I-15 TO RANCH, THEN TAKE ROAD TO RESERVOIR. SITE IS ON HILL NORTH OF RESERVOIR.

Table 1 (cont.)

017 SOUTH FORK TUCKER CREEK
Silver Bow Co., 454746N 1123830W, 6720 ft, T1N R8W S31
FROM DIVIDE (TOWN) TAKE FRONTAGE ROAD NORTH CA. 5 MILES. GO EAST UNDER I-15 TO RANCH. FOLLOW DIRT ROAD TO NORTHEAST CA. 4 MILES, KEEPING TO RIGHT AT FORKS, TO SITE ON EITHER SIDE OF SOUTH FORK TUCKER CREEK, CA. 1 MILE NORTHEAST OF RESERVOIR.

018 MOOSE TOWN
Silver Bow Co., 454620N 1123438W, 6700 ft, T1S R8W S3
T1N R8W S35
FROM HIGHLAND ROAD, TAKE MOOSE TOWN ROAD SOUTHWEST CA. 2 MILES TO MALONEY PARK. SITE IS ON BLUFFS NORTH OF MOOSE CREEK.

1. ASSOCIATED VEGETATION: Arabis fecunda generally occurs in relatively sparse vegetation. At three sites, bare soil varied from 40% to 80%, and basal vegetation varied from 20% to 50% (Lesica and Shelly 1994). Many of the sites occur on steep slopes with very sparse vegetation and periodic natural erosion. In some cases these steep slopes support cryptogamic soil crusts that have been shown to be beneficial to survival of A. fecunda plants (Lesica and Shelly 1992).

   In Ravalli County, zonal vegetation at A. fecunda sites is Artemisia tridentata-Festuca idahoensis-Agropyron spicatum steppe, sometimes with a sparse overstory of Pinus ponderosa. In Beaverhead and Silver Bow counties, associated vegetation is Cercocarpus ledifolius, Juniperus scopulorum or Pinus flexilis woodland, very open Pseudotsuga menziesii forest or sparse Agropyron spicatum grassland. Habitat descriptions and common associated species for the 18 sites are presented in Table 2.

2. PHYSIOGRAPHY: All known Arabis fecunda occur in the Northern Rocky Mountains of southwest Montana. Populations in the north part of the range are found in the west foothills of the Sapphire Range in the Willow Creek drainage, a tributary of the Bitterroot River. In the southern portion of the range A. fecunda occurs in the foothills and mountains at the north end of the East Pioneer Range and the Highland Mountains in the lower Big Hole River drainage. One population in the Highland Mountains is just across the divide in the drainage of the Jefferson River.

3. TOPOGRAPHY: Arabis fecunda usually occurs on moderate to steep slopes with a warm (SE, S, SW, W) aspect. Most sites are in lower slope positions, although populations do occur on mid and upper slopes. Elevations range from 4,700 ft to 7,800 ft; sites in Ravalli county are at or below 5,000 ft, while populations in the southern portion of the range are above 5,500 ft.

4. SOIL RELATIONSHIPS: Arabis fecunda occurs only on soils derived from calcareous sediments that have been metamorphosed to some extent by contact with granitic intrusions. Soils are generally sandy in texture with low organic matter content and a light albedo. Results of analysis of soil from the Charleys Gulch site in Ravalli county are

Table 2. Habitat descriptions for Arabis fecunda sites.

001 CHARLEYS GULCH
ON STEEP, WEST AND SOUTHWEST-FACING SLOPES, ON LIGHT-COLORED CALCAREOUS OUTCROPS, IN SAGEBRUSH GRASSLAND WITH CHRYSOPSIS VILLOSA, GILIA SPICATA, PHYSARIA GEYERI, ALYSSUM ALYSSOIDES.

002 SPRING GULCH
ON LIGHT-COLORED GRANITIC AND CALCAREOUS ROCK OUTCROPS, ON STEEP, S-FACING SLOPES; SAGEBRUSH GRASSLAND WITH PINUS PONDEROSA,HAPLOPAPPUS ARMERIOIDES,GILIA SPICATA, CRYPTANTHA.

003 ROCK QUARRY GULCH
ON LIGHT-COLORED ROCK OUTCROPS ON OPEN, S-FACING SLOPES; IN SAGEBRUSH GRASSLAND NEAR LOWER TREELINE, W/ SCATTERED PINUS PONDEROSA, AGROPYRON SPICATUM, HAPLOPAPPUS ARMERIOIDES.

004 BIRCH CREEK BLUFFS
WHITE, HIGHLY CALCAREOUS, ERODING SLOPES OF METAMORPHOSED CALC-SILICATES; WITH PINUS PONDEROSA, JUNIPERUS SCOPULORUM, HAPLOPAPPUS ARMERIOIDES, LESQUERELLA ALPINA, POA SECUNDA.

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

006 MOUTH OF QUARTZ HILL GULCH
CALC-SILICATE ROCKY OUTCROPS AND HILLSIDES; BENEATH JUNIPERUS SCOPULORUM AND PSEUDOTSUGA MENZIESII, WITH CERCOCARPUS LEDIFOLIUS AND DRABA NIVALIS.

007 JERRY CREEK
CALC-SILICATE OUTCROPS & HILLSIDES IN OPEN SOILS, BENEATH JUNIPERUS SCOPULORUM AND PSEUDOTSUGA MENZIESII, WITH CERCOCARPUS LEDIFOLIUS AND ERIGERON COMPOSITUS.

008 UPPER QUARTZ HILL GULCH
CALC-SILICATE ROCKY OUTCROPS AND HILLSIDES; BENEATH PSEUDOTSUGA MENZIESII, WITH CERCOCARPUS LEDIFOLIUS AND DRABA NIVALIS.

009 SPRING GULCH II
ON CALC-SILICATE ROCKY OUTCROPS BENEATH JUNIPERUS SCOPULORUM AND PSEUDOTSUGA MENZIESII, WITH CERCOCARPUS LEDIFOLIUS.

010 WISE RIVER
ON CALC-SILICATE ROCKY OUTCROPS AND SOILS, BENEATH JUNIPERUS SCOPULORUM AND PSEUDOTSUGA MENZIESII, WITH CERCOCARPUS LEDIFOLIUS.

Table 2 (cont.)

011 CANYON CREEK
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.

012 LIME GULCH
CALC-SILICATE ROCK OUTCROPS AND HILLSIDES, BENEATH JUNIPERUS SCOPULORUM, WITH CERCOCARPUS LEDIFOLIUS, SENECIO CANUS AND ERIGERON COMPOSITUS.

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

014 FISH CREEK
OPEN EXPOSURE ON STRAIGHT MIDSLOPE. DRY AREA, SANDY SOIL, CALCAREOUS METASEDIMENT. ASSOCIATED DOMINANT SPECIES: ARTEMISIA FRIGIDA, AGROPYRON SPICATUM. ADDITIONAL ASSOCIATED PLANT SPECIES: SENECIO CANUS, ERIGERON COMPOSITUS, CAMPANULA ROTUNDIFOLIA.

015 LIMEKILN HILL
OPEN EXPOSURE ON UNDULATING UPPER RESIDUAL MOUNTAIN SLOPE; DRY AREA, SILTY SOIL, CALCAREOUS METASEDIMENT PARENT MATERIAL. ASSOCIATED DOMINANT SPECIES: PINUS FLEXILIS, AGROPYRON SPICATUM, HAPLOPAPPUS ACAULIS. ADDITIONAL ASSOCIATED SPECIES: POTENTILLA FRUTICOSA, PENSTEMON ARIDUS.

016 TUCKER CREEK
OPEN EXPOSURE ON UNDULATING SLOPE, DRY AREA ON RESIDUAL MOUNTAIN MIDSLOPE. SANDY SOIL OF CALCAREOUS METASEDIMENT PARENT MATERIAL. ASSOCIATED DOMINANT SPECIES: CERCOCARPUS LEDIFOLIUS, AGROPYRON SPICATUM, HAPLOPAPPUS ACAULIS. ADDITIONAL ASSOCIATED SPECIES: ORYZOPSIS HYMENOIDES, CYMOPTERUS BIPINNATUS.

017 SOUTH FORK TUCKER CREEK
PARTIALLY SHADED EXPOSURE ON CONVEX SLOPE; DRY AREA ON RESIDUAL LOWER MOUNTAIN SLOPE. SANDY SOIL OF CALCAREOUS METASEDIMENT PARENT MATERIAL. ASSOCIATED DOMINANT SPECIES: CERCOCARPUS LEDIFOLIUS, JUNIPERUS SCOPULORUM, AGROPYRON SPICATUM. ADDITIONAL ASSOCIATED SPECIES: HAPLOPAPPUS ACAULIS, CYMOPTERUS BIPINNATUS. DEER SCAT PRESENT.

Table 2 (cont.)

018 MOOSE TOWN
OPEN TO PARTIALLY SHADED EXPOSURE ON UNDULATING AND CONVEX SLOPES. DRY AREAS LOWER TO MIDSLOPE; SANDY SOIL OF CALCAREOUS METASEDIMENT PARENT MATERIAL AND POSSIBLY DOLOMITE. ASSOCIATED DOMINANT SPECIES: AGROPYRON SPICATUM, PHLOX MUSCOIDES, HAPLOPAPPUS ACAULIS, POTENTILLA FRUTICOSA, PINUS FLEXILIS, JUNIPERUS COMMUNIS. ADDITIONAL ASSOCIATED SPECIES: ERIGERON COMPOSITUS, DOUGLASIA MONTANA, SENECIO CANUS, ARCTOSTAPHYLOS UVA-URSI, AND SEDUM LANCEOLATUM.

presented in Table 3. Sediments from Ravalli County belong to the Wallace Formation in the Precambrian Belt Series, while those from Beaverhead and Silver Bow counties are Paleozoic Madison limestone (Alt and Hyndman 1986).

5. REGIONAL CLIMATE: The closest weather recording station to the Ravalli County sites is at Hamilton, ca. 13 miles southwest and 1,000 ft lower. Mean temperatures for July and January are 67° and 25° F respectively, and mean annual precipitation is 13.1 in. The closest recording station to sites in Beaverhead County and most sites in Silver Bow County is Divide, at 5,406 ft along the Big Hole River. Mean temperatures for July and January are 63° and 19° F respectively, and mean annual precipitation is 12.4 in. Butte, at 5,540 ft, is ca. 13 miles north of three sites in Silver Bow County. Mean temperatures for July and January are 63° and 16° F respectively, and mean annual precipitation is 11.7 in (NOAA 1982). Many of the sites are appreciably higher than the recording stations, and thus likely experiences colder temperatures and greater precipitation.

6. DEPENDENCE ON ABIOTIC DYNAMICS: Periodic erosion and slumping of steep slope habitat may be partially responsible for maintaining the vegetation in a sparse condition, reducing competition for light, water and nutrients. These conditions may be important for the continued presence of A. fecunda at these sites. Many sites would be considered to be early successional or edaphic disclimaxes. Fire was relatively frequent in many of these areas, but the sparse vegetation present at the sites probably did not carry fire well.

   Lesica and Shelly (1993) found a strong positive correlation between winter precipitation and recruitment and survivorship. Thus, all else being equal, drier conditions are expected to result in population declines.

G. POPULATION DEMOGRAPHY AND BIOLOGY

1. PHENOLOGY: Seeds germinate readily without stratification (Lesica and Shelly 1994); thus, most seeds probably germinate in the fall. Observations of naturally occurring and garden plants suggest that vegetative growth occurs in early spring and perhaps again in fall if precipitation is adequate. At the Ravalli County

Table 3. Results of analysis of soil from the Charleys Gulch (EO#001) Arabis fecunda site. Percent organic matter determined by loss on ignition; textural analysis by the Bouyoucous hydrometer method; elemental analysis performed on a Jarrell-Ash 865 inductively coupled plasma spectrophotometer on 0.5 N ammonium acetate extracts.

pH	7.4
% organic matter	1.0
% sand	65.0
% silt	32.0
% clay	3.0
Al	5.1 ppm
B	0.6
Ca	12780.0
Cu	0.6
Fe	8.9
Mg	44.0
Mn	6.2
P	30.3
K	11.0
Si	26.4
Na	6.0

sites, Arabis fecunda begins flowering in early to mid-April, and mature fruit is present beginning in mid-May. Seed dispersal begins in late May. In Beaverhead and Silver Bow counties, flowering at the lower elevation sites occurs in mid-May through early June, and mature fruit can be found starting in early June. At sites near or above 7,000 ft, mature fruit can be found starting in mid-June. Flowering and fruit maturation depends on weather conditions in that year.

2. POPULATION SIZE AND CONDITION: Five of the known A. fecunda populations have fewer than 1,000 plants, seven populations have between 1,000 and 10,000 plants, and six have more than 10,000 plants. Population estimates for all known sites are given in Table 4. Most populations appear vigorous with plants of all sizes present.

3. REPRODUCTIVE BIOLOGY

   a. TYPE OF REPRODUCTION: Arabis fecunda reproduces from seed only. Seed is only produced following pollination (Walsh 1992), suggesting that agamospermy does not occur; however, pseudogamy cannot be ruled out.

   b. POLLINATION BIOLOGY: Walsh (1992) reports that Arabis fecunda is fully self-compatible. In nature, seed is probably a result of a combination of selfing and outcrossing. Results of an isozyme genetics study are consistent with a mixed mating system (Leeper et al., in press). It is not known what proportion of the seeds are the result of self-pollination.

      Pollinating agents of Arabis fecunda are not known. Plants flowers very early in the growing season; thus, the most likely pollinators are flies which are the only common vectors at that time of year. Mathew Hamilton (pers comm.) reported flies visiting A. fecunda flowers at Charleys Gulch in 1990.

   c. SEED BIOLOGY: In 1989-93 the number of seeds per fruit for Arabis fecunda at one site in Ravalli County and two sites in Beaverhead County varied between 5 and 56 with a five-year mean that varied between 31 and 34 (Lesica and Shelly 1994). Reproductive plants produced 0-96 fruits with a mean of 10.6-14.6 at the three sites (Lesica and Shelly 1994). Number of seeds and fruits

Table 4. Estimated size of *Arabis fecunda* populations.

001 CHARLEYS GULCH
CA. 8000-10000+ PLANTS, IN 13 SUBPOPULATIONS.

002 SPRING GULCH
CA. 1000-1500+ PLANTS, 4 SUBPOPULATIONS.

003 ROCK QUARRY GULCH
CA. 800-1000+ PLANTS, ONE POPULATION.

004 BIRCH CREEK BLUFFS
10,000+ INDIVIDUALS, CA. SIX SUBPOPULATIONS.

005 QUARTZ HILL
CA. 375-500 PLANTS.

006 MOUTH OF QUARTZ HILL GULCH
CA. 7,300 PLANTS IN 8 SUBPOPULATIONS.

007 JERRY CREEK
CA. 5,050 PLANTS IN 2 SUBPOPULATIONS.

008 UPPER QUARTZ HILL GULCH
CA. 75-100 PLANTS.

009 SPRING GULCH II
CA. 100-200 PLANTS; SPARSELY DISTRIBUTED.

010 WISE RIVER
CA. 100+ PLANTS.

011 CANYON CREEK
CA. 10,000+ FLOWERING PLANTS IN 3 SUBPOPULATIONS.

012 LIME GULCH
CA. 10,000+ PLANTS.

013 CATTLE GULCH
127 PLANTS COUNTED (84 FLOWERING, 43 STERILE); FOUR SUBPOPULATIONS.

014 FISH CREEK
2,000 TO 5,000 INDIVIDUALS.

015 LIMEKILN HILL
5,000-10,000 INDIVIDUALS

016 TUCKER CREEK
10,000+ INDIVIDUALS.

Table 4 (cont.)

017 SOUTH FORK TUCKER CREEK
10,000+ INDIVIDUALS

018 MOOSE TOWN
1000-5000 INDIVIDUALS, IN LARGEST SUBPOPULATION; ADDITIONAL SUBPOPULATION CA. 1.5 MILES NORTHWEST; 2000 PLANTS: THIRD SUBPOPULATION CA. 1 MILE NNW: 100-2000 STEMS.

varied among years and sites. At five sites mean number of fruits per plant varied from 9.4 to 22.0 in 1990-91 (Walsh 1992).

Seeds from both Charleys Gulch and Canyon Creek demonstrated 85-90% germination in warm/light conditions without stratification. Seeds from Charleys Gulch also germinated readily in cold/dark conditions, but these same conditions induced dormancy in seeds from Canyon Creek (Lesica and Shelly 1994). These results suggest that at some sites Arabis fecunda has only a transient seed bank, while at others there may be a long-term seed bank.

Seeds are small and are shed as the fruit splits open on the flower stem. They are probably projected from the parent plant by wind shaking the stems. Biological vectors are unknown.

d. DEMOGRAPHY: Arabis fecunda is a relatively short-lived perennial; only ca. half of the plants that establish live for more than two years, and only ca. one-third live for four years or more (Lesica and Shelly 1994). Annual recruitment is generally high; the ratio of new recruits to survivors varied from 0.09 to 2.06 with means for 1989-93 between 0.31 and 0.95. Mortality of new recruits is also high; in 1991-93, it varied from ca. 20-50% (Lesica and Shelly 1994). Fecundity is generally high; reproductive A. fecunda plants produced an average of 10-15 fruits, and the number of seeds per fruit averaged 31-34. Thus, reproductive plants produced an average of 340-500 seeds per year (Lesica and Shelly 1994). Plants that bolted produced ca. 2.5 times as many seeds per year as axillary flowering plants but have much higher mortality (Lesica and Shelly 1994).

There is great variation in life history traits among Arabis fecunda populations. The Arabis fecunda population at Charleys Gulch (EO#001) had a lower recruitment rate but higher overall as well as new recruit survivorship. On average, plants grew more slowly, were older at first reproduction, and had lower annual fecundity as a result of producing fewer seeds per fruit. The Canyon

Creek population (EO#008) had higher recruitment, faster growth, and higher mortality. Annual fecundity was higher and plants became fecund at an earlier age. Population size was more stable at Charleys Gulch than at Canyon Creek (Lesica and Shelly 1994). Walsh (1992) found that larger plants were more likely to survive and more likely to have higher reproductive rates.

The frequency of bolting was much higher at Canyon Creek, and this is likely the source of much of the difference between Arabis fecunda life histories at the two sites (Lesica and Shelly 1994). Bolting plants have higher annual fecundity and much higher mortality than axillary flowering plants. Axillary flowering plants are iteroparous (perennial or polycarpic), while bolting plants approach the semelparous (annual or monocarpic) life history (Lesica and Shelly 1994). Walsh (1992) also found that bolting plants are more likely to die.

e. POPULATION GENETICS: The differences in life history traits exhibited among the Arabis fecunda populations studied could be the result of genetic differentiation, phenotypic plasticity (one genotype that produces different phenotypes under different conditions) or both. Quantitative genetics studies are required to determine the basis of the variation. Leeper et al. (in press) used starch gel electrophoresis to investigate apportionment of genetic variation in Arabis fecunda populations. Of 18 putative loci scored, 17 were invariant; however, the one polymorphic locus had different frequencies among the populations, suggesting a degree of differentiation. Results of germination studies (Lesica and Shelly 1994) indicate that there is genetic differentiation between the Charleys Gulch and Canyon Creek populations. Furthermore, they suggest that there is a genetic difference between plants that bolt and those that do not. Together these results provide evidence that differences in life history traits between the two sites have a genetic basis (Lesica and Shelly 1994).

4. SUMMARY OF POPULATION BIOLOGY: Walsh (1992) found that five sample populations of Arabis fecunda declined in 1990-91, and three of these declined in 1991-92, while the other two became larger (Leeper et al., in press). Leeper et al. (in press) predicted that population of A. fecunda at Birch Creek would decline and eventually become extirpated based on three years of monitoring data. Lesica and Shelly (1994) found that in 1989-93 two sample populations of A. fecunda in Beaverhead County increased in size, while one in Ravalli County declined. Population survival is most often controlled by uncommon events, either beneficial or detrimental. Short-term studies such as those reported above are probably of little value for predicting extinction probabilities. Results of these studies do suggest that Ravalli County populations are more likely to be declining.

H. ECOLOGY

1. COMPETITION: Arabis fecunda occurs only in relatively sparse vegetation, suggesting that it is sensitive to competition from other species. Due to its diminutive stature, A. fecunda is probably sensitive to shading by taller plants.

Centaurea maculosa is an aggressive Eurasian weed present at all A. fecunda sites in Ravalli County. It is a taprooted perennial that is widely introduced in North America where it has become a serious pest of semi-arid grasslands in the Pacific Northwest and intermountain valleys of the Northern Rocky Mountains (Watson and Renney 1974, French and Lacey 1983). Its ability to invade and replace native plants is well-documented (Morris and Bedunah 1984, Harris and Cranston 1979, Tyser and Key 1988). In addition, leachates of Centaurea maculosa inhibit germination of grass and conifer seedlings (Kelsey and Locken 1987); however, Kelsey and Bedunah (1989) feel that concentrations high enough to inhibit germination are seldom found in natural environments. Centaurea maculosa was introduced into western Montana in the 1920's and has since come to dominate large areas of rangeland (French and Lacey 1983). Like A. fecunda, it is a rosette-forming, taprooted, iteroparous perennial with an average life-span of 3-5 years (Watson and Renney 1974, Boggs and Story 1987). The presence of C. maculosa significantly reduces the population

growth rate of A. fecunda, mainly by reducing recruitment (Lesica and Shelly, submitted). Hamilton and Mitchell-Olds (1990) found that the presence of C. maculosa reduced fecundity of A. fecunda at a Ravalli County site. Results of a study at Charleys Gulch and Birch Creek suggest that both species may be able to co-occur if the density of knapweed does not increase (Lesica and Shelly, submitted).

Competitive effects of other species on A. fecunda are not known.

2. FACILITATION: Cryptogamic soil crusts occur at some of the Arabis fecunda sites, and Lesica and Shelly (1992) demonstrated that soil crust benefits A. fecunda populations by increasing survival of adult plants.

   Although there is evidence that cattle have an adverse effect on A. fecunda populations (see below), under some conditions, they may be beneficial. Arabis fecunda establishes best when not in competition with other plants (Lesica and Shelly, submitted), so grazing of competitors may be advantageous. Exclosure studies at two sites near the Big Hole River suggest that grazing may sometimes have detrimental effects (Lesica 1993). At one site A. fecunda increased in the grazing exclosure, while at the other it decreased relative to controls. Furthermore. Some of the largest populations, such as Birch Creek and Jerry Creek, are in areas that are intensely grazed.

3. HERBIVORY: J. S. Shelly observed insect larvae in the fruits of Arabis fecunda at both Lime Gulch and Charleys Gulch in 1990. The identification of this insect is not known. Seed predation appears to be of limited extent.

   Scattered plants have been observed at Lime Gulch and Canyon Creek with the upper portion of one or two fruits bitten off (Lesica and Shelly, pers. observation). The source of this predation is not known.

4. PATHOGENS: A rust, Puccinia sp. was observed infecting a small number of plants at Charleys Gulch in 1985 (Lesica, pers. observation). Rust infections appear to be rare and local.

5. OTHER NEGATIVE INTERACTIONS: Cattle occur at nearly all A. fecunda sites. Although they probably do not graze the plants, they may have adverse effect in some areas by destroying established plants or the soil crust that supports them (Lesica and Shelly 1992). Exclosure studies at two sites near the Big Hole River suggest that grazing may sometimes have detrimental effects (Lesica 1993). At one site A. fecunda increased in the grazing exclosure, while at the other it decreased relative to controls. Livestock are important vectors for exotic weed infestations.

6. HYBRIDIZATION: Arabis fecunda is a distinctive member of the genus in Montana (Rollins 1984). Although A. holboellii does occur at some sites, there is no evidence of hybridization.

I. LAND OWNERSHIP

1. U.S. NATIONAL FORESTS

a. BEAVERHEAD NATIONAL FOREST: Six sites in the East Pioneer Range in Beaverhead and Silver Bow counties are entirely or partially on lands administered by Beaverhead N.F. A list of sites and ownership are given in Table 5.

b. DEERLODGE NATIONAL FOREST: Three sites in the Highland Mountains in Silver Bow County are entirely or partially on land administered by Deerlodge N.F. A list of sites and ownership are given in Table 5.

2. U.S. BUREAU OF LAND MANAGEMENT: Six sites in the East Pioneer and Highland ranges in Beaverhead and Silver Bow counties are on land administered by BLM's Butte District. Two of the sites are in the Humbug Spires proposed wilderness area. A list of sites and ownership are given in Table 5.

3. STATE OF MONTANA: Four sites in the Sapphire, East Pioneer and Highland ranges in Ravalli, Beaverhead and Deer Lodge counties are partially on state lands. A list of sites and ownership are given in Table 5.

4. PRIVATE: Six sites in the Sapphire, East Pioneer and Highland ranges in Ravalli, Beaverhead and Deer Lodge counties are partially on deeded land. A list of sites and ownership are given in Table 5.

Table 5. Management responsibility for sites supporting populations of Arabis fecunda.

001	CHARLEYS GULCH	PRIVATELY OWNED LAND (INDIVIDUAL OR CORPORATE); STATE LAND - UNDESIGNATED
002	SPRING GULCH	PRIVATELY OWNED LAND (INDIVIDUAL OR CORPORATE)
003	ROCK QUARRY GULCH	PRIVATELY OWNED LAND (INDIVIDUAL OR CORPORATE)
004	BIRCH CREEK BLUFFS	STATE LAND - UNDESIGNATED; PRIVATELY OWNED LAND (INDIVIDUAL OR CORPORATE)
005	QUARTZ HILL	BEAVERHEAD NATIONAL FOREST, WISE RIVER RANGER DISTRICT
006	MOUTH OF QUARTZ HILL GULCH	BLM: BUTTE DISTRICT, DILLON RESOURCE AREA; BEAVERHEAD NATIONAL FOREST, WISE
007	JERRY CREEK	BLM: BUTTE DISTRICT, HEADWATERS RESOURCE AREA; STATE LAND - UNDESIGNATED
008	UPPER QUARTZ HILL GULCH	BEAVERHEAD NATIONAL FOREST, WISE RIVER RANGER DISTRICT
009	SPRING GULCH II	BLM: BUTTE DISTRICT, DILLON RESOURCE AREA
010	WISE RIVER	BLM: BUTTE DISTRICT, HEADWATERS RESOURCE AREA; PRIVATELY OWNED LAND (INDIVIDUAL OR CORPORATE)
011	CANYON CREEK	BEAVERHEAD NATIONAL FOREST, WISE RIVER RANGER DISTRICT
012	LIME GULCH	BEAVERHEAD NATIONAL FOREST, WISE RIVER RANGER DISTRICT
013	CATTLE GULCH	BEAVERHEAD NATIONAL FOREST, WISE RIVER RANGER DISTRICT
014	FISH CREEK	DEERLODGE NATIONAL FOREST, JEFFERSON RANGER DISTRICT
015	LIMEKILN HILL	DEERLODGE NATIONAL FOREST, JEFFERSON RANGER DISTRICT

Table 5 (cont.)

016 TUCKER CREEK
BLM: BUTTE DISTRICT, HEADWATERS RESOURCE AREA; STATE LAND - UNDESIGNATED; H

017 SOUTH FORK TUCKER CREEK
BLM: BUTTE DISTRICT, HEADWATERS RESOURCE AREA; HUMBUG SPIRES PRIMITIVE AREA

018 MOOSE TOWN
PRIVATELY OWNED LAND (INDIVIDUAL OR CORPORATE); DEERLODGE NATIONAL FOREST,

J. MANAGEMENT PRACTICES

1. MINING: Contact zones between granitic intrusions and Madison limestone are often areas of commercial mineral deposits (Alt and Hyndman 1986). This is the same geologic situation that provides the habitat for Arabis fecunda. Nine of fourteen sites in the southern portion of the range are in close proximity to old mines. However, Fish Creek is the only site with an active mine nearby. It is not known how past or present activity has affected A. fecunda populations

2. LIVESTOCK GRAZING: All known populations of Arabis fecunda except Spring Gulch II are subject to cattle grazing. Grazing is light in some areas such as Lime Gulch, Cattle Gulch and Canyon Creek, but heavy in others such as Birch Creek and Jerry Creek. Livestock are important vectors for exotic weed infestations. Effects of livestock grazing are discussed under Facilitation (G.2) and Other Negative Interactions (G.5) above.

3. RECREATION: All sites on public land managed by federal agencies are open to hunting. Portions of the Tucker Creek and South Fork Tucker Creek sites are in or near the boundaries of the Humbug Spires wilderness study area. None of the sites show evidence of off-road vehicle use. The effects of recreation on A. fecunda populations are not known but are probably negligible.

K. EVIDENCE OF THREATS TO SURVIVAL

1. EXOTIC WEED ENCROACHMENT: Centaurea maculosa is present at all known Arabis fecunda sites in Ravalli County. At most sites the infestations are severe. This aggressive exotic has been shown to have adverse effects on many native species including A. fecunda (Lesica and Shelly, submitted). Currently C. maculosa does not occur at any of the Beaverhead or Silver Bow county A. fecunda sites, but it does occur in these counties and could become a problem in the near future.

2. LIVESTOCK GRAZING: Livestock grazing occurs at most Arabis fecunda sites, although heavy grazing is reported for fewer than half the sites. Evidence for negative effects of livestock on A. fecunda are equivocal. Direct herbivory has never been observed and is probably rare. However,

Lesica and Shelly (1992) found that soil crusts are beneficial to A. fecunda survivorship at some sites, and these crusts are often destroyed by livestock. Livestock also adversely affect survivorship by directly trampling plants, and this effect can be locally severe (Lesica and Shelly, pers. observation). However, many of the largest populations are also the most heavily grazed. It is possible that a small plant like A. fecunda that is not eaten would benefit from having larger neighbors grazed. After two years, exclosure studies at two sites near the Big Hole River have also yielded equivocal results. At one site A. fecunda density increased in the exclosure compared to controls, while in the other A. fecunda decreased. Lesica and Shelly (1994) found that A. fecunda populations can have different life histories; some populations are more dependent on adult survival for population growth. These populations would tend to be more adversely affected by livestock trampling.

Over the long term, livestock grazing will probably be detrimental to survival of A. fecunda populations because, in addition to trampling plants, livestock are also significant vectors for exotic weed encroachment. This double negative impact will probably outweigh increases in recruitment at most sites.

3. MINING: At this time there is only one A. fecunda site that is near an active mine, and there have been no adverse effects to date. Nonetheless, many A. fecunda populations are near mining claims or inactive mines that could become active in the event of improved extraction methods or increases in the value of minerals. Consequently, mining activity does pose a potential risk to A. fecunda populations.

4. HERBICIDE APPLICATION: Many Ravalli County Arabis fecunda sites are located in areas with severe infestations of Centaurea maculosa, a state listed noxious weed. Consequently, these populations may be subject to weed control measures such as herbicide application by government or private agents. The effects of various herbicides on A. fecunda are not known.

II. ASSESSMENT AND MANAGEMENT RECOMMENDATIONS

A. GENERAL ASSESSMENT OF VIGOR, TRENDS AND STATUS: The geographic range of Arabis fecunda consists of two disjunct areas: (1) the northern area along the west face of the Sapphire Range in Ravalli County and (2) the southern area in the East Pioneer and Highland ranges in Beaverhead and Silver Bow counties. The status and trends of Arabis fecunda in these two areas appears to be different.

There are 14 known populations in the southern area, and many of these are large and relatively undisturbed. Weed infestations have not yet become a problem. Mining activity is a potential but not a current threat. Livestock grazing does occur at most sites, but evidence that it is a serious threat is unconvincing at this time. Monitoring studies suggest that populations are stable or perhaps even growing. Consequently, Arabis fecunda appears to be secure in the southern portion of its range.

There are four known populations in Ravalli County, two of which are quite large. All sites have been historically overgrazed, and invasion and serious degradation of native habitats by Centaurea maculosa occurs throughout the entire area. The area is experiencing increasing pressure from human population growth, so introduced weeds will likely be an escalating problem. Livestock grazing will likely continue into the foreseeable future. Results of monitoring studies suggest that populations in Ravalli County may be declining and that increased density of C. maculosa could lead to extirpation of populations. It seems likely that A. fecunda population viability in this area is trending downward.

The two areas are separated by ca. 80 miles, and the habitats Arabis fecunda occupies are noticeably different. Thus, there are likely to be genetically distinct populations in the two areas, and the little evidence available is consistent with this hypothesis. Although the majority of known populations are not currently threatened or endangered, Arabis fecunda may be threatened in a potentially significant portion of its range.

B. RECOMMENDED STATUS:

1. U.S. FISH AND WILDLIFE SERVICE: The distribution and size of Arabis fecunda populations are reasonably well known. However, threats and the significance of potentially threatened populations to the viability of the species as a whole are not

yet well documented. Ongoing studies on the effects of livestock grazing being conducted for BLM and research being conducted by Mitchell-Olds et al. at the University of Montana will shed light on this problem

Plant species cannot be listed as threatened or endangered in just a portion of their range in the same manner as animals. In lieu of this option, I recommend that Arabis fecunda be retained as a candidate for listing as a threatened or endangered species (C2).

2. U.S. FOREST SERVICE: I recommend that Arabis fecunda be retained on the list of sensitive species, even though most populations on land administered by U.S.F.S. appear stable and unthreatened at this time.

3. U.S. BUREAU OF LAND MANAGEMENT: I recommend that Arabis fecunda be retained on the list of sensitive species, even though most populations on land administered by BLM appear stable and unthreatened at this time.

C. CONSERVATION RECOMMENDATIONS: The presence of livestock may be detrimental to Arabis fecunda populations due to both trampling and introduction of exotic weeds. Heavy livestock grazing should be reduced to moderate or light levels in pastures where A. fecunda is present.

Encroachment by exotic weeds is probably the most significant threat to A. fecunda populations. Roads are a major source of weed infestations (Sauer 1988, Tyser and Worley 1992). Road construction or any other major disturbances should be curtailed in areas supporting populations of A. fecunda.

Arabis fecunda and Centaurea maculosa may be able to coexist if densities of the latter do not become too great (Lesica and Shelly, submitted). Although current biological controls for C. maculosa will not eliminate infestations, they may be able to control them. Biological control agents for C. maculosa should be introduced at all A. fecunda sites in Ravalli County (Lesica and Shelly, submitted).

The sensitivity of A. fecunda to various herbicides is not known. Herbicide application should be curtailed in proximity to populations of A. fecunda. County and state officials should be informed of sensitive sites.

Disturbances from mining activities could be detrimental to A. fecunda populations. Any proposed mining activity in the area of populations should be reviewed and disturbances curtailed or mitigated.

In order to determine whether Arabis fecunda deserves status as a threatened or endangered species, it is essential to know the extent of genetic differentiation between threatened populations in Ravalli County and the unthreatened populations in Beaverhead and Silver Bow counties. This information is critical for developing a management plan for A. fecunda. Isozyme studies failed to answer this question (Leeper et al., in press). Genetic studies employing more powerful nuclear DNA methods should be used to determine the genetic distances among selected populations throughout the range of the species. Furthermore, quantitative genetics studies to determine the degree of differentiation for traits that may be under strong local selection should be conducted.

D. INTERESTED PARTIES

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III. INFORMATION SOURCES

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B. MUSEUM COLLECTIONS: The University of Montana herbarium MONTU has the largest collection of specimens of Arabis fecunda, including the type collection.

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