

Arabis macdonaldiana
(McDonald's rock-cress)
5-Year Review:
Summary and Evaluation



Arabis macdonaldiana: Red Mountain, Mendocino County, California
Photograph used courtesy of David Imper

U.S. Fish and Wildlife Service
Arcata Fish and Wildlife Office
Arcata, California

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5-YEAR REVIEW

Arabis macdonaldiana (McDonald's rock-cress)

I. GENERAL INFORMATION

Purpose of 5-Year Reviews:

The U.S. Fish and Wildlife Service (Service) is required by section 4(c)(2) of the Endangered Species Act (ESA) to conduct a status review of each listed species at least once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. Our original listing of a species as endangered or threatened is based on the existence of threats attributable to one or more of the five threat factors described in section 4(a)(1) of the ESA, and we must consider these same five factors in any subsequent consideration of reclassification or delisting of a species. In the 5-year review, we consider the best available scientific and commercial data on the species, and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process defined in the ESA that includes public review and comment.

Species Overview:

Arabis macdonaldiana (McDonald's rock-cress), a perennial herbaceous member of the Brassicaceae (mustard family), was one of the first plant species to be listed as endangered under the ESA. The species was listed in 1978. McDonald's rock-cress is characterized by lavender or crimson-purple flowers and a deep green rosette of broadly spatulate (spoon-shaped) leaves from which the short flowering stems arise. It is particularly striking when observed amidst the often barren, steep, serpentine rock slopes on which it occurs. The species is distinguished from other rock-cress species by its toothed, generally hairless basal leaves (leaves at the base) less than one inch long. *Arabis macdonaldiana* occurs in soils derived from ultramafic parent material, containing high levels of heavy metals and low levels of nutrients. Its habitat ranges from barren gravel slopes to open scrub and pine woodlands. The majority of the distribution occurs within a designated wilderness area.

At the time it was listed, *Arabis macdonaldiana* was considered to be restricted to a single population at Red Mountain, Mendocino County. However, in 1993, the taxonomic treatment of the species was revised to include populations of purple-flowered rock-cress located near the Oregon border. Since 1993, the species was thought to occur in Mendocino, Del Norte, and the very western portion of Siskiyou counties in California, and the very southern portion of Curry County in Oregon. However, recent genetic work indicates that *Arabis macdonaldiana* is confined to Red Mountain, Mendocino County, California (see the Taxonomy and Genetics section below).

Methodology Used to Complete the Review:

This review was conducted by the Arcata Fish and Wildlife Office (AFWO) following March 2008 guidance issued by Region 8 of the Service. We used information from the *Arabis macdonaldiana* recovery plan (Service 1984), data/records contained in Service files, relevant information provided by other agencies and experts, and data from the California Natural Diversity Database (CNDDDB) maintained by the California Department of Fish and Wildlife (CDFW). The recovery plan, information contained in Service files, and unpublished monitoring and research reports were the primary sources of information used to update the species' status and threats. This 5-year review contains updated information on the species' biology and threats, and an assessment of that information compared to that known at the time of listing. No other 5-year reviews have been conducted since listing. We focus on current threats to the species that are attributable to the ESA's five listing factors. The review synthesizes all this information to evaluate the listing status of the species and provide an indication of its progress towards recovery. Finally, based on this synthesis and the threats identified in the five-factor analysis, conservation actions are recommended for future initiation within the next 5 years.

Contact Information:

Lead Regional Office: Larry Rabin, Deputy Division Chief for Listing, Recovery, and Environmental Contaminants; and Lisa Ellis, Fish and Wildlife Biologist, Region 8, California and Nevada; (916) 414-6464.

Lead Field Office: Kathleen Brubaker, Arcata Fish and Wildlife Office; (707) 822-7201.

Federal Register (FR) Notice Citation Announcing Initiation of This Review: A notice announcing initiation of the 5-year review of this taxon and the opening of a 60-day period to receive information from the public was published in the Federal Register on March 25, 2009 (74 Federal Register 12878). No comments were received in response to the notice.

Listing History:

Original Listing (Service 1978)

FR Notice: 43 Federal Register 44810

Date of Final Listing Rule: September 28, 1978

Entity Listed: *Arabis macdonaldiana* (species)

Classification: Endangered

State Listing: *Arabis macdonaldiana* (McDonald's rock-cress) was listed by the State of California as endangered in 1979.

Associated Rulemakings: None

Review History: No status reviews or other documents that contain a five-factor analysis and conclusion have been conducted since the taxon was listed.

Species' Recovery Priority Number at Start of 5-Year Review: The recovery priority number for *Arabis macdonaldiana* is 14c according to the Service's 2009 Recovery Data Call for the AFWO. Recovery priority numbers are based on a 1-18 ranking system, where 1 is the highest-ranked recovery priority and 18 is the lowest (Endangered and Threatened Species Listing and Recovery Priority Guidelines, 48 FR 43098, September 21, 1983). This number indicates that this taxon faces a low degree of threat, has a high potential for recovery, and is in potential conflict with construction or development (surface mining).

Recovery Plan or Outline:

Name of Plan or Outline: McDonald's Rock-cress Recovery Plan (*Arabis macdonaldiana* Eastwood)

Date Issued: February 28, 1984

II. REVIEW ANALYSIS

Application of the 1996 Distinct Population Segment (DPS) Policy:

The ESA defines "species" as including any subspecies of fish or wildlife or plants, and any distinct population segment (DPS) of any species of vertebrate wildlife. This definition of species under the ESA limits listing of distinct population segments to species of vertebrate fish or wildlife. Because the species under review is a plant, the DPS policy is not applicable, and the application of the DPS policy to the species' listing is not addressed further in this review.

Information on the Species and its Status:

In her original description of *Arabis macdonaldiana* (McDonald's rock-cress), Alice Eastwood (1903) employed the spelling *Arabis mcdonaldiana* in honor of Captain James M. McDonald. Critchfield (1977) changed the spelling of the specific epithet to "*macdonaldiana*," believing the original spelling to be in error. The original spelling "*mcdonaldiana*" was used in the species recovery plan (Service 1984). However, to be consistent with the original listing rule, the spelling "*macdonaldiana*" is used in this document.

Species Biology and Life History:

Arabis macdonaldiana is a showy perennial herb in the Brassicaceae (mustard family). The species was first discovered in northern Mendocino County, California in 1902, and described the following year by Alice Eastwood, a prominent early California botanist (Eastwood 1903). The species has a branched caudex (short, vertical, often woody stem at or just beneath the ground surface) and several simple stems ranging from 2 to 10 inches in height (Hickman 1993). The lower leaves are in rosettes (a cluster of leaves in a circle), spatulate (rounded above and narrowed to the base), and range between 0.4 and 0.8 inch long and 0.2 to 0.3 inch wide. The leaves are toothed, and essentially smooth. Plants often do not flower and fruit every year. The petals are rose or purple in color and measure 0.35 to 0.43 inch long. Flowering typically occurs between April and May. As many as 12 siliques (elongate fruits, dry, and open at maturity) up to 1.6 inches long may be produced, from which very small, slightly winged seed are

discharged. This species is distinguished from other rock-cress species by being almost glabrous (without hairs or glands) and having comparatively short, spatulate basal leaves.

Arabis macdonaldiana is endemic (restricted to a well-defined condition) to serpentine soils. The term serpentine is used here in the vernacular sense, referring to soils derived from ultramafic parent materials that have been altered through a process called serpentinization. The factors accounting for serpentine endemism, and plant responses to serpentine soils have been well studied (Kruckeberg 1984). The major factor responsible for the restriction of certain plant species to serpentine soils seems to be the lower degree of inter-specific competition, compared to non-serpentine soils. Serpentine endemics have evolved means of coping with the harsh growing conditions presented by serpentine (e.g., low amounts of essential nutrients, especially calcium, and high concentrations of potentially toxic minerals such as nickel, chromium, and magnesium), while most other plant species are either unable to grow, or are less vigorous on serpentine. The net result is that serpentine soils generally have lower plant density, and lower inter-specific competition.

Baad (1987) observed a high rate of small mammal herbivory on *Arabis macdonaldiana* at Red Mountain following artificial propagation (on nursery soil) and outplanting to the Red Mountain site. He suspected *Peromyscus boylea* (brush mouse), a generalist herbivore, was one of the primary foragers. Following up on this observation, Griffiths (2007) analyzed plant tissues of *Arabis macdonaldiana* grown on soil containing a gradient in heavy metal soil concentrations (collected at Red Mountain), then planted a portion of the plants back to Red Mountain, and compared the incidence of small mammal herbivory after 3 weeks, both on foliage and reproductive structures.

The naturally occurring plants appeared to be immune to significant herbivory; however, the plants that had been artificially propagated on nursery soil were subject to intense herbivory, suggesting *Arabis macdonaldiana* acquires some level of protection from herbivory due to the uptake of heavy metals present in the soil. *Arabis macdonaldiana* was found to accumulate low levels of chromium and cobalt in its tissues, and nickel was accumulated at levels suggesting the species may be considered a nickel accumulator (concentration of nickel exceeding 100 parts per million). Griffith's conclusions were limited by small sample sizes, but his results did suggest a significant reduction in small mammal herbivory for plants grown on soils containing higher concentrations of heavy metals. The association between reduced herbivory and heavy metal accumulation has been suggested for a variety of species growing on serpentine, including some species of insect and fungi (Griffiths 2007). According to Griffiths (2007), Baad conducted a lab test that determined that snails preferred plants grown on potting soil compared to plants grown on serpentine soil.

Spatial Distribution:

Based on current research and the original listing rule for the species, the distribution of *Arabis macdonaldiana* is confined to Red Mountain, near Leggett, Mendocino County (Figure 1). In October 2006, all lands owned by the Bureau of Land Management (BLM) in the immediate vicinity of Red Mountain were designated as the Red Mountain Unit of the South Fork Eel River



Figure 1. Range map for *Arabis macdonaldiana*, Red Mountain, Mendocino County, California.

Wilderness Area; hereafter, referred to as the Red Mountain Wilderness. Since 2006, the BLM has acquired additional land supporting *Arabis macdonaldiana* that has been incorporated into the Red Mountain Wilderness. An estimated 85 percent of *Arabis macdonaldiana* occurs within the Red Mountain Wilderness (J. Wheeler, pers. comm. 2012a). The remaining approximately 15 percent occurs on private land.

The documented distribution of *Arabis macdonaldiana* at Red Mountain is based on a compilation of multiple surveys by Sutherland (R. Sutherland, pers. comm. 1979), Goforth (1980a), Baad (1987), and Jennings (2003) (Table 1). Goforth (1980a) estimated the occurrence of *Arabis macdonaldiana* at Red Mountain contained between 10 and 20 colonies scattered over a 5-square-mile area on the summit plateau, with the total number of individuals estimated at between 1,000 and 10,000. Jennings (2003) mapped *Arabis macdonaldiana* over the majority of public lands supporting the species at Red Mountain in 2003. He mapped 43 polygons encompassing 79 acres, including 3 percent of the serpentine soils at Red Mountain, scattered over a 1.6 mile by 2.6 mile area (4.2 square miles). At least 10 additional sites were recorded in previous surveys, primarily on private lands. Private lands encompass some 25 percent of the soils suitable for *Arabis macdonaldiana* in the area. Additional habitat suspected to support *Arabis macdonaldiana* is located on the south slope of Red Mountain, but has not been mapped due to safety concerns (Jennings 2003). In 2003, a conservative estimate of the amount of habitat occupied by *Arabis macdonaldiana* at Red Mountain was in excess of 80 acres.

Table 1. Summary of reported locations of *Arabis macdonaldiana*, Red Mountain, Mendocino County, California.

EO No. ¹	Source Name	Location Detail	Population Estimate	TRS ²	OWNER ³
RED MOUNTAIN POPULATION					
001	Multiple 1902-1994	Mapped by CNDDDB as 31 polygons, southern end Red Mountain	"~10-20 colonies in 5 square mile area on summit"; 1,000-10,000 plants	24N/16W/S19	BLM
035	Anonymous 1998	0.3 mile southeast of Cedar Spring, Red Mountain	Approximately 50 plants	24N/16W/S7	BLM
039	Baad 1986-87; Jennings 2003	South end of Red Mountain; 2 colonies	Less than 50 plants in 1986 in the larger colony; in 2003, 6 plants in the western colony	24N/16W/S29	BLM
041	Jennings 2003	0.1-0.3 mile northwest of peak marked 3286 on topographic map, south end Red Mountain	6 plants observed in north colony and 3 plants in south colony in 2003	24N/16W/S29	BLM
042	Jennings 2003	0.3 mile southwest of peak marked 3286, south end Red Mountain	One plant 2003	24N/16W/S32	BLM

¹Element occurrence number from CNDDDB

²TRS = Township/Range/Section (Humboldt Meridian)

³BLM = Bureau of Land Management

Abundance:

Arabis macdonaldiana is highly rhizomatous and clonal, making the determination of an individual difficult. As a result, population estimates made by different surveyors may not be directly comparable.

The population was roughly estimated between 1,000 and 10,000 individuals when the species was listed (Service 1984). There still has been no accurate population estimate made. Jennings (2003) sampled plant density along a single transect in one of his mapped polygons.

Extrapolation of that figure to the approximate 80-acre area Jennings mapped in 2003 yields an estimate on the order of 10,000 plants. However, *Arabis macdonaldiana* can be very small, and complete surveys are difficult and time-consuming. Monitoring data collected from 1984-2002 in (22) 5-square meter permanent plots, representing 2 different habitats for the plant (Littlered, and Hiltebiden/Dann soils), contained an average of 26 plants per plot (Baad 2002).

Extrapolating that figure to an acre would equal 21,000 plants. Extrapolating further, to the approximate 80 acres of occupied habitat, would equal over a million plants. The average number of plants in Baad's sample plots declined to 6 in 2009, which still equates to over 4,800 plants per acre. However, Baad's study plots were subjectively located for purposes other than estimating the population, and do not represent the overall habitat (Baad 1987). His data do indicate the high spatial variability in plant density, and the difficulty in developing an accurate population estimate. Taken together, the data suggest the overall population size probably exceeds 10,000 plants.

Population Trends:

Available data indicating population trends in *Arabis macdonaldiana* were collected by Baad and others at Red Mountain between 1984 and 2009 (Baad 1987, 2002; D. Imper, Service, and J. Wheeler, BLM, unpubl. data, pers. comm. 2009). The monitoring focused on the plant life history and site-specific trends in populations at five study sites located within 1 square mile, representing a variety of microhabitats for *Arabis macdonaldiana* at Red Mountain. Permanent sample plots were read annually between 1984 and 1998, and again in 2002 and 2006. Individual plants were counted, mapped, measured, and classified as to reproductive class (Baad 2002). Also in 2006, the plots were mapped with a GPS unit for future reference. The plots were re-sampled in 2009 (Imper and Wheeler, unpubl. data 2009).

Data for the largest of the five study sites appear to show a peak in both cover and abundance of *Arabis macdonaldiana* around 1990, with a relatively consistent decline since then (Figure 2). Baad (2002) attributed the decline to progressive encroachment of *Pinus attenuata* (knobcone pine). However, though sample sizes were relatively smaller, data for the other study sites exhibit a similar slow steady decline in abundance and/or cover of the species, which in those cases was not attributable to *Pinus attenuata*. The data collected in 2009 (Imper and Wheeler, unpubl. data 2009) showed continued decline in the sample plots, with *Arabis macdonaldiana* completely absent in many cases. The cause of the progressive decline in *Arabis macdonaldiana* at Baad's Red Mountain study sites (Baad 2002; Imper and Wheeler, unpubl. data 2009) is not clear.

Climate and Geography:

Climate for the Red Mountain area can be characterized as Mediterranean, with hot dry summers, cool wet winters. The majority of precipitation occurs between November and April. Mean annual precipitation at Richardson Grove State Park, 9 miles northwest of Red Mountain (200 feet elevation), is 69 inches. Average daily minimum and maximum temperatures in July and August at Richardson Grove are 53 and 86 degrees Fahrenheit (F), respectively. In December, maximum and minimum temperatures in Richardson Grove are 37 and 49 degrees F., respectively. The elevation for *Arabis macdonaldiana* at Red Mountain is approximately 1,800 feet on the south slope of Red Mountain above Cedar Creek (Goforth 1980b).

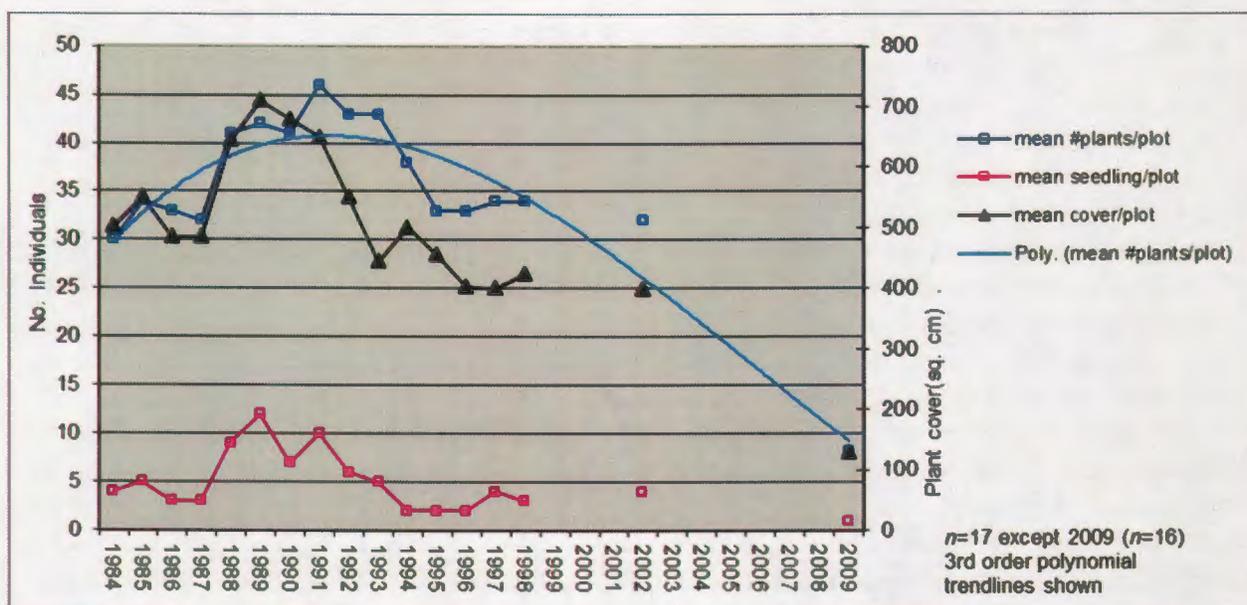


Figure 2. *Arabis macdonaldiana* sample plot summary and trends (1984-2009), Red Mountain Study Area 9, Mendocino County California.

Vegetation:

Arabis macdonaldiana generally occurs with an open overstory that may include *Pinus jeffreyi* (Jeffrey pine), *Pinus lambertiana* (sugar pine), and *Calocedrus decurrens* (incense cedar), and in a few cases, dense *Pinus attenuata* (Goforth 1980a). *Pinus attenuata* commonly invades following fire (Whittaker 1954). The shrub canopy may include *Garrya buxifolia*, *Quercus vaccinifolia*, *Arctostaphylos canescens*, and *Ceanothus pumilus*. Several rare plant taxa occur in association with *Arabis macdonaldiana*, including *Eriogonum kelloggii* (Kellogg's buckwheat) and *Sedum laxum* ssp. *eastwoodiae* (Red Mountain stonecrop), both candidates for Federal listing.

Soils:

Arabis macdonaldiana is restricted to ultramafic rocks, chiefly peridotite, and soils ranging from recently exposed serpentine to very old weathered lateritic (a red residual soil rich in iron and aluminum) soils. The parent ultramafic rocks are rich in magnesia, silica, and iron and contain amounts of nickel (Kruckeberg 1984). As a result of weathering over long periods, reddish soils

form in areas, such as the summit dome of Red Mountain, where iron has been oxidized, and the silica and magnesia leached out. Residual metals, including iron, nickel, and chromium, occur in high concentrations. Nickel concentrations, for example, may exceed 2 percent nickel oxide (Service 1984).

Three serpentine soils found nowhere else in the county are mapped on Red Mountain (Rittman and Thorson 1988), based on the proportion of the following soil series present:

- Dann clayey skeletal, oxidic, mesic Typic Xerochrept; well-drained moderately deep to bedrock, low water holding capacity
- Hiltabidel loamy-skeletal, oxidic, nonacid, mesic Lithic Xerorthent; very shallow, well-drained soils, low water-holding capacity
- Littlered clayey, ferritic, mesic Xeric Haplohumult; very deep well-drained; relatively high water-holding capacity and organic carbon

The Dann-Hiltabidel Complex, occurring on 30-50 percent slopes, and Dann-Littlered-Hiltabidel Complex, occurring on 5-30 percent slopes, together account for about 56 percent of the Red Mountain serpentines. The remainder of the area is mapped as the Hiltabidel-Dann complex, occurring on 5-75 percent slopes. All are less than 31 inches deep. A small area below the top of Red Mountain is mapped as Littlered clay loam, a deep lateritic soil found normally on mild slopes. The majority of the *Arabis macdonaldiana* appears to occur on the Hiltabidel/Dann Complex soil, which coincides with about 90 percent of Jennings (2003) mapped polygons for the species. A small portion of the *Arabis macdonaldiana* occurs on the Littlered clayey soils, including Baad's permanent study site referred to as "Area 9" (Baad 2002), which exhibited the highest density of *Arabis macdonaldiana* (Figure 2), and was his only site dominated by *Pinus attenuata*.

Fire:

Fire is an important factor affecting vegetation patterns in general across the Klamath Bioregion, including the Red Mountain area where *Arabis macdonaldiana* occurs, and appears particularly important in maintaining many open habitats (Skinner *et al.* 2006; U.S. Forest Service [USFS] 1995; Baad 2002). Pre-European settlement fire-return intervals for Jeffrey pine/grassland communities, while variable, ranged as little as 8 to 15 years (Skinner *et al.* 2006). A dramatic decline in fire frequency since then has allowed conifer encroachment or establishment of dense shrub stands in many areas.

Only two fires appear to have influenced the Red Mountain population over at least the past 90 years. The Red Mountain lightning fire of June 2008 burned approximately 3,000 acres within the Red Mountain Wilderness (BLM 2008). The fire burned some 1,000 acres at the top of Red Mountain, with reportedly 80 percent mortality of brush and 10 percent tree mortality (J. Wheeler, BLM, pers. comm. 2008). The fire boundary encompassed or touched on about 25 of the 40 habitat polygons for *Arabis macdonaldiana*, constituting less than 50 percent of the total occupied habitat area. The actual burn footprint was highly irregular, and post-fire inspection indicated that even where the fire burned close to Baad's permanent study plots in "Area 9," less

than 50 percent of the actual plot burned (Imper and Wheeler, unpubl. data 2009). The majority of the burned habitat appeared to have experienced a relatively low intensity ground fire, with little crowning. Plot data for *Arabis macdonaldiana* density and cover indicated no significant mortality occurred as a result of the fire.

Prior to the 2008 fire, the only fire included on the Fire and Resource Map Project's (FRAP) online historical fire database (California Department of Forestry and Fire Protection 2009) for the immediate area of Red Mountain since the 1920's, was the 1952 Lynch Fire. That fire came from the west, and based on the historical fire map, burned perhaps six *Arabis macdonaldiana* polygons on the west side of Red Mountain. However, evidence suggests the Lynch Fire may have burned farther west than reported, and may have stimulated germination and growth of *Pinus attenuata* that now dominates Baad's "Area 9" study area (Baad 2002). Baad (1987) had estimated the fire impacting "Area 9" occurred sometime between 1937 and 1947; based on tree stem cores sampled in 2009 (Imper and Wheeler, unpubl. data 2009), 1952 appeared to be a reasonable date for the fire.

Taxonomy and Genetics:

Arabis macdonaldiana is included in a group of five purple-flowered *Arabis* species distributed in the Coast Ranges of northwestern California and southwestern Oregon, distinguished within the genus by their relatively large, conspicuous lavender to purplish flowers and a rosette, usually flattened, obovate to broadly oblanceolate leaves from which the flowering stems arise (Rollins 1973). The group includes: *Arabis macdonaldiana*, *Arabis aculeolata*, *Arabis blepharophylla*, *Arabis oregana* and *Arabis modesta* (Hickman 1993). *Arabis macdonaldiana* is most closely related to *Arabis aculeolata* (Rollins 1941), which differs primarily in its larger stature, wings on its seeds, basal leaves and lower stems that are usually covered with dense trichomes (hairs) and narrower, usually truncate, petals.

The taxonomic relationship between the *Arabis macdonaldiana* on Red Mountain (in Mendocino County, California) and the more northern populations of *Arabis* group in the North Fork of the Smith River watershed (Del Norte County, California, and Curry County, Oregon) and the Siskiyou Mountains (Del Norte County and western Siskiyou County, California) has long been a source of confusion. Following her initial collection and description of *Arabis macdonaldiana*, Eastwood (1903) made a second collection of what she called *Arabis macdonaldiana* in 1907, in northern Del Norte County, California (Daniel 1997). The species was merged with *Arabis blepharophylla* by Jepson (1925) and treated as a variety of that species. However, Rollins (1941) elevated the taxon back to the rank of species, and annotated the 1907 specimen from Del Norte County to *Arabis aculeolata* (Daniel 1997). Goforth (1980a), after extensive field review, suggested the North Fork of the Smith River population, in Del Norte County, was in fact *Arabis macdonaldiana*.

To address the taxonomic uncertainty, in 1981, the USFS and BLM funded a taxonomic investigation by Goforth; this study involved collection of data from 49 of the 120 sites known at that time. Cytological, morphological, floristic, and environmental data were used to evaluate the relationships of the various *Arabis* taxa. Goforth (1983) determined the Red Mountain population to be distinct from the North Fork of the Smith River population in several respects. The Red Mountain plants were overall shorter, had smaller stem leaves and wider basal leaves,

and in general showed less morphological variability. Nevertheless, Goforth's (1983) taxonomic treatment would have lumped the purple-flowered *Arabis* from Red Mountain, Mendocino County, the North Fork of the Smith River distribution, and what was described at that time as *Arabis serpentinicola* from Preston Peak, Siskiyou County, into the same taxon, *Arabis macdonaldiana* ssp. *macdonaldiana*. *Arabis aculeolata* would have been changed to *Arabis macdonaldiana* ssp. *aculeolata*. However, Goforth's taxonomy was not formally peer-reviewed or ever published (Service 1984).

Linda Ann Vorobik, author of the treatment of purple-flowered *Arabis* for the Jepson Manual (Hickman 1993), while recognizing that ecological and morphological differences did exist within the group, did not believe those differences warranted recognition at the subspecies or variety level. Vorobik's treatment (Hickman 1993) differed from Goforth's (1983) in that *Arabis aculeolata* was retained, and *Arabis macdonaldiana* was redefined to include the Red Mountain, North Fork of the Smith River watershed, and High Siskiyou (Siskiyou Mountains) populations.

More recently, several individuals familiar with the purple-flowered *Arabis*, including Vorobik, author of the current taxonomic treatment, have expressed concern that the relationship between the Red Mountain and the northern populations should be further investigated, given their degree of isolation and observed differences. Specifically, they recommended a genetic analysis be conducted before any action was taken to change the status of *Arabis macdonaldiana* under the ESA (Hoover, pers. comm. 2009; D. Goforth, pers. comm. 2009; L. Vorobik, pers. comm. 2009).

Previous to 2012, the only genetics work that had been conducted relative to *Arabis macdonaldiana* was by Vorobik in 2008 (pers. comm. 2009), who conducted limited molecular research funded by the USFS and a University of California at Berkeley Heckard Grant. Vorobik determined that representatives of all five species included in the purple-flowered *Arabis* group were essentially identical with respect to the Internal Transcribed Spacer (a piece of non-functional ribonucleic acid) gene. However, in 2012, Harbaugh-Reynaud and Vorobik sampled 42 specimens within the purple-flowered *Arabis* group. Their results indicated that *Arabis macdonaldiana* is represented by two distinct lineages: (1) Red Mountain, Mendocino County, California; and (2) Siskiyou and Del Norte counties, California, and Curry and Josephine counties, Oregon.

In their summary report of the 2012 research, Harbaugh-Reynaud and Vorobik recommended that *Arabis macdonaldiana* specimens from Red Mountain retain the name *Arabis macdonaldiana*, while the other lineage be revised to be a distinct species (yet to be named), or a subspecies of *Arabis aculeolata*. Furthermore, Harbaugh-Reynaud and Vorobik determined that *Arabis macdonaldiana* on Red Mountain is clearly distinct from any other taxon (Harbaugh-Reynaud and Vorobik 2012). Therefore, although there has been much confusion and uncertainty related to the taxonomy genetics of the purple-flowered *Arabis* group, the most recent genetic work indicates that *Arabis macdonaldiana* on Red Mountain is distinct from any other taxon.

Species-specific Research and/or Grant-supported Activities:

Inventory:

- Population monitoring at Red Mountain Distribution, 1984-2009; funded by the BLM and the Service.
- Population inventory at Red Mountain, 2003; funded by the BLM and the Service.

Research:

- Baad, M. 1984-2002. Research at Red Mountain funded by the BLM and the Service.
- Griffiths, A. 2007. Heavy metal accumulation in McDonald's rock-cress (*Arabis macdonaldiana*) defends against herbivory: a field experiment. M.S. Thesis, California State University, Sacramento.
- Daniels, S. L. 1997. Landsat-derived serpentine barren classification for locating McDonald's rock-cress (*Arabis macdonaldiana*). M.S. Thesis Humboldt State University.
- Vorobik L. 2008. Preliminary molecular research on the purple-flowered *Arabis* complex; funded by the Service and UC Berkeley Heckard Grant.
- Harbaugh-Reynaud and Vorobik. 2012. Genetic study of Red Mountain rock-cress (*Arabis macdonaldiana*, Brassicaceae); partially funded by the BLM and the Service.

Other:

- *Arabis macdonaldiana* seed was collected at Red Mountain in the 1980's and is stored at the Berry Botanic Garden in Portland, Oregon. This collection included thousands of seed, representing more than 50 plants (S. Friedman, pers. comm. 2009).

Five-Factor Analysis:

The following analysis describes and evaluates the threats attributable to one or more of the five listing factors outlined in section 4(a)(1) of the ESA.

FACTOR A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range.

At the time of listing, the only threat identified under Factor A for *Arabis macdonaldiana* at Red Mountain was mining. Half the range for the species was believed to be privately owned by mining interests, with the remainder on public lands held under unpatented mining claims by the Coastal Mining Company. It was anticipated that the company would pursue mining of nickel-containing soils, which could affect the entire range of the species. In the late 1980's, Coastal

Mining Company sold all of their mining claims on Red Mountain to Coombs Tree Farms (K. Geer, Service, pers. comm. 1995). Mining continues to pose a threat to *Arabis macdonaldiana* at Red Mountain, because the entire distribution of *Arabis macdonaldiana* continues to be held under unpatented lode and/or placer mining claims. However, the degree of threat is less than when the species was listed, due to Red Mountain Wilderness designation, which has reduced the vulnerability of *Arabis macdonaldiana* to impacts from new mining claims.

Of the overall 2,700 acres of potential suitable soils on Red Mountain, including known-occupied habitat, 670 acres or 25 percent is privately held. Only a small portion of this privately held habitat has been inventoried for *Arabis macdonaldiana*. The remaining 2,030 acres of potential habitat, and approximately 85 percent of the *Arabis macdonaldiana* population, is located within the Red Mountain Wilderness, of which 100 percent is held under mining claims. No mining is currently conducted in the area, and no validity exams (see below) have been conducted on any of the mining claims.

Under the Northern California Coastal Wild Heritage Wilderness Act of 2006 (H.R. 233 [109th]) 6,500 acres on and around Red Mountain were designated wilderness and added to the existing South Fork Eel Wilderness Area. That legislation specifically retained valid land rights, such as mining claims, in existence on the date of enactment. However, the area was withdrawn from all new forms of (1) entry, appropriation, or disposal under the public land laws; (2) location, entry and patent under mining laws, and (3) disposition under all laws pertaining to mineral and geothermal leasing or mining of materials.

For the existing claims, before BLM may approve a mining plan of operations, the BLM minerals staff must conduct a validity examination to determine if the claim is valid (J. Willoughby, BLM, pers. comm. 2007). The validity exam involves a determination of whether a mining operation on the claim was economically viable at the time the claim was filed. Because there are different claimholders on Red Mountain that likely filed claims at different times, separate validity exams would need to be performed, raising the cost of conducting the examination.

Due to the high cost of the validity examinations, BLM typically only does them when a plan of operations is filed by a claimholder (Willoughby, pers. comm. 2007). The BLM has 60 days to determine if sufficient information was provided to conduct a validity examination, and then 2 years to complete the examination. If the validity examination fails, the claim is cancelled. If the claim is determined to be valid, the claimant may file patent to gain ownership to the land, although for short-lived mining operations a patent is often not filed. The BLM does not have the right to deny such a patent, and therefore, issuance of the patent is not a Federal action subject to section 7 of the ESA (Willoughby, pers. comm. 2007).

There appears to be some legal uncertainty as to whether a patent within designated wilderness area covers both the land and mineral rights, or just mineral rights. The majority of recently conducted validity examinations in California have failed (Willoughby, pers. comm. 2007). With regard to the potential for Red Mountain to be mined, a Bureau of Mines Preliminary Feasibility Study conducted at Red Mountain in 1978 concluded those deposits met the minimum tonnage grade test at the time; i.e., 35 million short tons of material containing an average 0.8 percent nickel (Geer, pers. comm. 1995). However, commercial mining at Red

Mountain was not considered economically feasible at the time due to the relatively low grade of the resource (low metal concentrations) and the high cost of mining it (Geer, pers. comm. 1995).

Any mining operation on Red Mountain would most likely be an open-face bench type that would involve removal and processing of the mineral-bearing ore containing nickel, chromium, and cobalt (Service 1984). All vegetation and habitat for *Arabis macdonaldiana* would be removed in the affected area. Although the operations plan would require restoration of the affected areas, plant species composition would undoubtedly be altered. There is no evidence in the literature indicating *Arabis macdonaldiana* is able to recolonize disturbed soils.

Regardless of existing mining claims, *Arabis macdonaldiana* habitat and serpentine soils in general contain an attractive source of heavy metals, particularly nickel, subject to technological improvements and market fluctuations. Therefore, future pressure to open these lands to mining is possible. However, the majority of the distribution of *Arabis macdonaldiana* at Red Mountain, while potentially covered under current mining claims, would be subject to environmental regulations applicable to wilderness.

In addition to mining, the recovery plan identified a moderate threat from road widening and maintenance. Factors such as fire and off-highway vehicles (OHV) were considered to have low threat potential. The majority of past disturbance at Red Mountain has been caused by mining exploration and road construction, both for mining access and fire control (Imper and Wheeler, unpubl. data 2009). The overall proportion of *Arabis macdonaldiana* habitat affected by those activities is considered relatively small (Service 1984; Imper and Wheeler, unpubl. data 2009).

Current OHV use at Red Mountain is largely related to illegal marijuana gardens. There is a proposal to enhance recreational use of the Red Mountain Wilderness with construction of a foot and/or horse trail, intended to encourage public use and discourage marijuana growing and illegal vehicle use (Wheeler, pers. comm. 2009). Annual visits are generally conducted by BLM staff to ensure that no new road construction or other impacts occur in the Red Mountain Wilderness (Wheeler, pers. comm. 2012b).

Fire as a factor modifying *Arabis macdonaldiana* habitat is discussed under Factor E.

Summary of Factor A Threats

Mining continues to be a threat, though less so than when the species was listed. Designation of wilderness status for an estimated 85 percent of the population on Red Mountain has precluded filing of any new mining claims, and reduced the vulnerability of *Arabis macdonaldiana* to future mining impacts. Recreational use, primarily OHV use, appears to pose relatively little threat.

FACTOR B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes.

Overutilization is generally not a threat to this species. While *Arabis macdonaldiana* is a showy plant, presumably with horticultural appeal, there is no evidence that commercial collection is a threat. The rugged terrain and difficult access probably minimizes its collection.

FACTOR C: Disease or Predation.

We have no information indicating that disease or predation is a significant factor affecting this species.

FACTOR D: Inadequacy of Existing Regulatory Mechanisms.

At the time of listing, the absence of State listing and the inadequacy of the recently passed California Native Plant Protection Act were identified as threats. *Arabis macdonaldiana* was subsequently listed as endangered by California in 1979.

State Protections in California:

(1) California Endangered Species Act (CESA) and Native Plant Protection Act (NPPA):

The provisions of CESA (California Fish and Game Code, section 2080 *et seq.*) in combination with the NPPA (Division 2, Chapter 10, section 1908) generally prohibit the unauthorized take of State-listed species, require State agencies to consult with the CDFW on activities that may affect a State-listed species, and restrict the import or export, possession, purchase, or sales of any species or part or product of any species listed as endangered or threatened. The State may authorize permits for scientific, educational, or management purposes, and allow take that is incidental to otherwise lawful activities. However, private landowners are exempt from the prohibitions on take of plants in the process of land use development, even if it results in habitat modification. Where landowners have been notified by the State that a rare or endangered plant is growing on their land, the landowners are required to notify the CDFW 10 days in advance of changing land use in order to allow salvage of listed plants. There is no evidence suggesting that *Arabis macdonaldiana* can be successfully transplanted, or suggesting the degree that salvage could be successful. Overall, these two laws offer little in the way of regulatory protection for the species.

(2) California Surface Mining and Reclamation Act of 1975 (SMARA):

All surface mining operations that disturb greater than 1 acre or move more than 1,000 cubic yards are required under SMARA to have an approved reclamation plan before the start of mining activity. SMARA also requires financial assurances be posted to cover the cost of final reclamation. Reclamation may extend to affected lands surrounding the mined lands, and may require backfilling, grading, resoiling, revegetation, soil stabilization or other measures.

In theory, adverse environmental effects are prevented or minimized and mined lands are reclaimed to a condition adaptable for alternate land uses. However, SMARA does not specifically protect endangered species habitat and does not appear adequate to offer much protection for *Arabis macdonaldiana*, particularly were the species to be delisted.

(3) California Environmental Quality Act (CEQA):

The CEQA requires review of any project that is undertaken, funded, or permitted by the State or a local governmental agency. If significant effects are identified, the lead agency has the option of requiring mitigation through changes in the project or to decide that overriding considerations make mitigation infeasible (CEQA section 21002). Therefore, protection of listed species through CEQA is dependent upon the discretion of the lead agency involved.

Federal Protections

(1) Endangered Species Act of 1973, as amended (ESA):

Section 7(a)(2) of the ESA requires Federal agencies to consult with the Service to ensure any project they fund, authorize, or carry out does not jeopardize a listed species. Section 9 of the ESA prohibits (1) the removal and reduction to possession (i.e., collection) of endangered plants from lands under Federal jurisdiction, and (2) the removal, cutting, digging, damage, or destruction of endangered plants on any other area in knowing violation of a state law or regulation or in the course of any violation of a state criminal trespass law. Consultation under section 7 could potentially be initiated at the approval stage for mining operations proposed within the Red Mountain Wilderness. Section 7 consultation may or not be applicable to mining operations proposed on private lands at Red Mountain, depending on whether a nexus exists in conjunction with issuance of other permits (e.g., Clean Water Act permit).

(2) National Environmental Policy Act (NEPA):

NEPA (42 U.S.C. 4371 *et seq.*) provides some protection for listed species that may be affected by activities undertaken, authorized, or funded by Federal agencies. Prior to implementation of such a project, NEPA requires the agency to analyze the potential impacts on the human environment, including natural resources. In cases where that analysis reveals significant environmental effects, the Federal agency must propose mitigation alternatives that would offset those effects (40 C.F.R. 1502.16). These mitigations usually provide some protection for listed species. However, NEPA does not require that adverse impacts be fully mitigated, only that impacts be assessed and the analysis disclosed to the public.

Summary of Factor B Threats

In summary, BLM policies governing mining on Federal lands (as described in Factor A), in combination with the withdrawal of the Red Mountain Wilderness from new mining claims, likely provide the greatest protection for *Arabis macdonaldiana* habitat located on public lands, if the species were to be delisted both at the State and Federal level. The ESA currently provides regulatory protection in conjunction with the section 9 prohibitions on plant collection and destruction specific to Federal lands, and the approval process for mining operation plans on public lands. However, mining on private lands would be covered under the ESA in cases where no Federal permit or other nexus exists. In addition, the mining patent process, as a nondiscretionary agency action, may not be subject to the provisions of the ESA. In California, the CEQA likely provides the greatest protection at the State level for private lands, but protection under that law is largely discretionary. The regulatory environment continues to be

inadequate to protect *Arabis macdonaldiana*, particularly where it grows on private property at Red Mountain.

FACTOR E: Other Natural or Manmade Factors Affecting its Continued Existence

Lack of Fire

A potential threat not identified when the species was listed, and not yet well characterized, is the progressive encroachment into *Arabis macdonaldiana* habitat by woody species in the absence of fire. Baad (2002) recognized the threat from vegetation encroachment to at least three rare plants known from Red Mountain serpentines, including *Arabis macdonaldiana* and two Federal candidate species, *S. eastwoodiae* and *E. kelloggii*.

Fire suppression efforts can cause adverse effects on *Arabis macdonaldiana* as a result of fire breaks constructed with heavy equipment or hand crews. Fire breaks are often placed along ridge lines, potential suitable habitat for *Arabis macdonaldiana*. The heavy equipment generally scrapes a layer of earth, eliminating all vegetation and permanently altering the soils.

In general, the overall manner in which any fire, including the 2008 Red Mountain Fire, may have affected *Arabis macdonaldiana* is difficult to predict. Positive impacts from setting back natural succession and restoring its habitat, and negative impacts from incinerating individuals and fire suppression efforts would both be involved. As an example, the Service recently consulted with the USFS regarding the effects of the nationwide program of fire retardant application, which included an assessment of the effects on *Arabis macdonaldiana* locally (Service 2012). The Service concurred that aerial retardant application, in the manner proposed, was likely to adversely affect the species, but would not jeopardize the species. The degree of effects would vary according to habitat treated. Forested habitat (*Pinus jeffreyi*/grassland) or dense shrubland, which was more likely to have accumulated fuels, were deemed most likely to be affected by direct retardant drops. Open scree slopes, where the plants are located, were considered unlikely to be affected.

Fire suppression would also maintain existing scrub and forested habitat, allowing progressive encroachment on the species. At the same time, fire control measures could be beneficial by reducing fire intensity in situations where *Arabis macdonaldiana* is vulnerable to incineration. Without fire to periodically restore early successional conditions and an open canopy, *Arabis macdonaldiana* would likely decline in a portion of its range. However, it is unclear how long it would take for encroachment to negatively affect the species in specific habitats.

Genetic impoverishment

The genetic implications of habitat fragmentation, genetic isolation and declining effective population size are threats common to rare species (Saunders *et al.* 1991; Meffe and Carroll 1997). At Red Mountain, small breeding populations and the potential loss of genetic diversity from inbreeding and/or random genetic drift could be a problem, given the limited population size and limited range of the species, particularly if the decline observed at Red Mountain continues in future years.

Climate Change

Global climate change likely constitutes a new threat for the species. Current climate change predictions for terrestrial areas in the Northern Hemisphere indicate warmer air temperatures, more intense precipitation events, and increased summer continental drying (Field *et al.* 1999; Cayan *et al.* 2005; IPCC 2007). However, predictions of climatic conditions for smaller sub-regions such as California remain uncertain. It is unknown at this time if climate change in California will result in a warmer trend with localized drying, higher precipitation events, or other effects. *Arabis macdonaldiana* at Red Mountain may not have access to environmental heterogeneity, due in part to its more limited extent. Casual observation suggests a majority of the population may grow under more uniform conditions, such as a tendency to occur in high flat areas or on south-southwest aspects, which may offer less refuge under drying or warming conditions.

Summary of Factor E Threats

Some evidence suggests fire and associated fire suppression activities may occasionally be fatal for *Arabis macdonaldiana*, but that the impact is relatively insignificant due to the low fuels accumulation in most of its habitat. At the same time, fire is likely an important factor in maintaining the portion of its habitat most susceptible to encroachment by woody species. The proportion of its habitat susceptible to rapid encroachment, and the rate at which its habitat becomes unsuitable is not well known. Because of the small population size and limited range of the species, genetic impoverishment may be a threat, especially if the number of plants continues to decline. Climate change may be a long-term threat, but the potential effects are uncertain. Maintaining a high level of genetic diversity, and habitat diversity, presumably is the best way to counter threats posed by lack of fire, genetic impoverishment, and climate change.

III. RECOVERY CRITERIA

The recovery plan for *Arabis macdonaldiana* was approved February 28, 1984. Recovery plans provide guidance to the Service, states, and other partners and interested parties on ways to minimize threats to listed species, and identify criteria to achieve species recovery goals. There are many paths to accomplishing the recovery of a species and recovery may be achieved without fully meeting all recovery plan criteria. For example, one or more criteria may have been exceeded while other criteria may not have been accomplished. In that instance, we may determine that, over all, the threats have been minimized sufficiently, and the species is robust enough, to downlist or delist the species. In other cases, new recovery approaches and/or opportunities unknown at the time the recovery plan was finalized may be more appropriate ways to achieve recovery. Likewise, new information may change the extent that criteria need to be met for recognizing recovery of the species. Overall, recovery is a dynamic process requiring adaptive management, and assessing a species' degree of recovery is likewise an adaptive process that may, or may not, fully follow the guidance provided in a recovery plan.

We focus our evaluation of species status in this 5-year review on progress that has been made toward recovery since the species was listed by eliminating or reducing the threats discussed in the five-factor analysis. In that context, progress towards fulfilling recovery criteria serves to indicate the extent to which threat factors have been reduced or eliminated.

Recovery Criteria:

Because *Arabis macdonaldiana* was one among the first plant species listed under the ESA, the policies governing the Service's preparation of recovery plans were still under development, particularly with respect to the definition of specific, quantitative recovery criteria. The primary objective of the recovery plan was to protect and maintain the only known population of *Arabis macdonaldiana* at Red Mountain, the eventual goal being reclassification of the species to threatened status. No quantified goals were defined other than an expectation that at least 5 square miles of occupied habitat should be protected to maintain the species. The determination of more specific goals was left as a task to be completed as part of the recovery plan. It was assumed that conservation of the existing population and habitat at Red Mountain would be adequate to ensure that *Arabis macdonaldiana* remained a viable component of the Red Mountain ecosystem. Nonetheless, the recovery plan concluded that the species would continue to occupy a very restricted range, as a result would always be threatened by stochastic extinction, and therefore, was unlikely to ever be delisted.

Delisting Criteria:

No criteria for delisting were included in the recovery plan.

IV. SYNTHESIS

Mining continues to be a threat, though less than when the species was listed. The portion of the population at Red Mountain covered under mining claims has not changed since it was listed; however, the wilderness designation in 2006 has precluded filing of new claims on the public-owned portion of the range. BLM policies governing mining on Federal lands, in combination with the withdrawal of the Red Mountain Wilderness from new mining claims, likely provide the greatest protection for *Arabis macdonaldiana* habitat located on public lands.

Overutilization is not a threat to the species, nor is there evidence that disease or predation are threats to the species. Although some evidence suggests fire and associated fire suppression activities may occasionally be fatal for *Arabis macdonaldiana*, the impact is relatively insignificant due to the low fuels accumulation in most of the species' habitat. At the same time, fire is likely an important factor in maintaining the portion of its habitat most susceptible to encroachment by woody species.

Because of the small population size and limited range of the species, genetic impoverishment may be a threat, especially if the number of plants continues to decline. Climate change may be a long-term threat, but the potential effects are uncertain. Maintaining a high level of genetic diversity, and habitat diversity, presumably is the best way to counter threats posed by lack of fire, genetic impoverishment, and climate change.

There is evidence suggesting the abundance, and potentially the distribution of *Arabis macdonaldiana* at Red Mountain has progressively declined since at least 1990. The largely unexplained decline in at least a portion of the Red Mountain population, and the unknown extent to which natural encroachment of vegetation into its habitat is affecting the species,

indicates that further research is needed with respect to population trends and natural threats to *Arabis macdonaldiana* habitat at Red Mountain.

Based on the results of this 5-year review, we conclude that *Arabis macdonaldiana* continues to meet the ESA definition of endangered. While the species appears to be at some risk, further research is needed before an informed decision may be made regarding any change in status. Therefore, no status change is recommended at this time.

V. RESULTS

Recommended Listing Action:

- Downlist to Threatened
 Uplist to Endangered
 Delist (indicate reason for delisting according to 50 CFR 424.11):
 Extinction
 Recovery
 Original data for classification in error
 No Change

New Recovery Priority Number and Brief Rationale: The current Recovery Priority Number is 14c, indicating a low degree of threat, a high recovery potential, and a potential conflict, in this case from mining. The Service recommends no change to this number.

VI. RECOMMENDATIONS FOR ACTIONS OVER THE NEXT 5 YEARS

Because there is some evidence to suggest that the population may have declined since listed, a field study of *Arabis macdonaldiana* should be conducted to determine:

- (1) the degree to which shrub and tree encroachment may be impacting the population;
- (2) the continued presence of *Arabis macdonaldiana* in previously mapped habitat polygons, or other locations at Red Mountain;
- (3) the cause for the observed decline in *Arabis macdonaldiana* in the vicinity of the study sites used by Baad (2002).

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**U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW**

Arabis macdonaldiana (McDonald's rock-cress)

Current Classification: Endangered

Recommendation Resulting from the 5-Year Review:

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change needed

Review Conducted By: Dave Imper and Kathleen Brubaker

FIELD OFFICE APPROVAL:

Lead Field Supervisor, U.S. Fish and Wildlife Service

Approve _____



Date _____

5/13/13