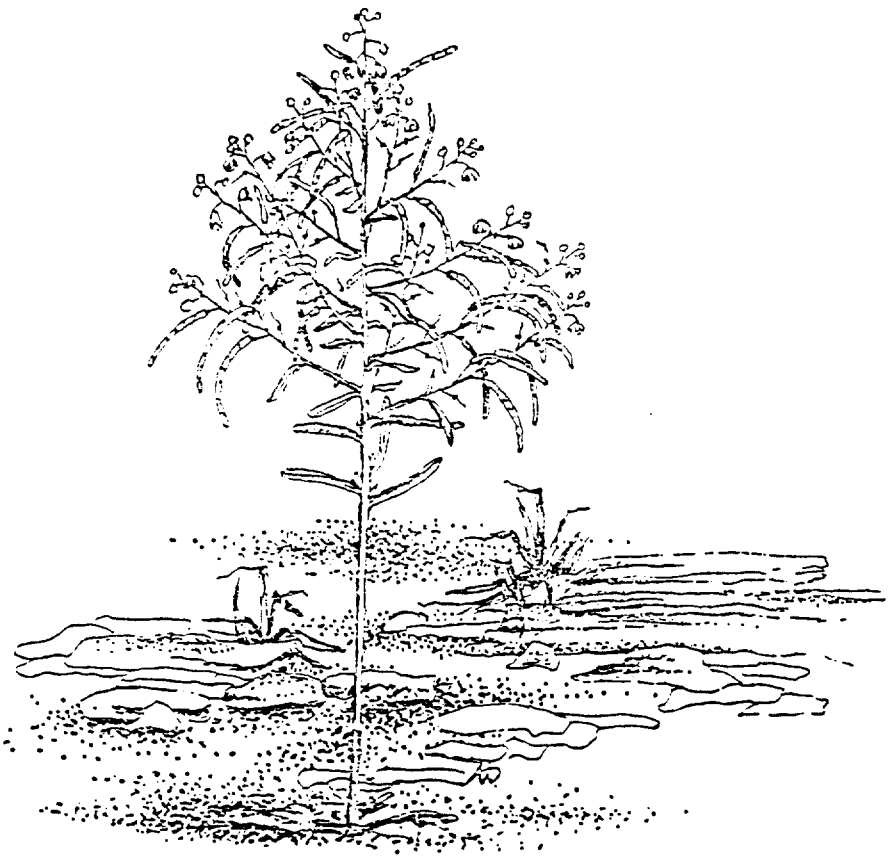
SHALE BARREN ROCK CRESS

(Arabis serotina)

RECOVERY PLAN



Northeast Region
U.S. Fish and Wildlife Service
Newton Corner, Massachusetts

SHALE BARREN ROCK CRESS

(*Arabis serotina* Steele)

RECOVERY PLAN

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Date: JUL 15

EXECUTIVE SUMMARY
SHALE BARREN ROCK CRESS RECOVERY PLAN

Current Status: Thirty-four extant populations and one historical population are known for this species, which was listed as endangered in August 1989. The extant populations are located in six Virginia and three West Virginia counties; the historical population was located in an additional Virginia county. Nineteen populations occur within the Monongahela and George Washington National Forests; of these, 13 have been proposed for further administrative protection. One Virginia population is owned and protected by the Commonwealth, and the protection needs of a West Virginia population on U.S. Navy land are being studied under a 5-year cooperative agreement. No protection has been initiated for the populations on private land. In addition to its Federal listing, the species is listed as endangered in Virginia.

Limiting Factors: Arabis serotina is jeopardized by drought, habitat degradation, stochastic events, herbivory, and other biotic factors. Since most of the extant populations have under 100 plants and many have fewer than ten individuals, the species may be vulnerable to local extirpation.

Recovery Objective: To remove Arabis serotina from the list of endangered and threatened species.

Recovery Criteria: This species will be reclassified to threatened when: (1) Twenty demonstrably self-maintaining populations are distributed throughout the species' range. (2) The habitat of these 20 populations is permanently protected. (3) Seeds are stored to prevent extinction in case of catastrophic loss of natural populations. Delisting will be initiated when, in addition to the above conditions having been met: (4) Fifteen additional self-maintaining populations and their habitat are permanently protected.

Actions Needed:

1. Seek protection of all extant populations, and secure permanent protection for self-maintaining populations and their habitat.
2. Monitor extant populations and their habitat on a regular basis.
3. Search for additional populations.
4. Study life history, ecological, and population parameters and establish guidelines for determining what constitutes a self-maintaining population.
5. Store seeds off-site in case of loss of extant populations.
6. As needed, manage populations for the maintenance of each population and its habitat.

Projected Costs ($000):

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Need 6	Total
FY 1	9.0	5.0	3.0	14.0	1.0	2.0	34.0
FY 2	8.0	3.0	3.0	13.0	1.0	2.0	30.0
FY 3	8.0	3.0	3.0	13.0		2.0	29.0
FY 4	8.0	3.0	3.0	11.0		2.0	27.0
FY 5	8.0	3.0	3.0	11.0		2.0	27.0
FY 6	8.0	3.0		3.0		2.0	16.0
FY 7	8.0	3.0		3.0		2.0	16.0
FY 8	8.0	3.0		3.0		2.0	16.0
FY 9	8.0	3.0		3.0		2.0	16.0
FY 10	8.0	3.0		3.0		2.0	16.0
Total	81.0	32.0	15.0	77.0	2.0	20.0	227.0

Projected Time Frame for Recovery: It should be possible to initiate delisting of Arabis serotina in 2002, if individual recovery tasks proceed on schedule.

* * *

The Shale Barren Rock Cress Recovery Plan delineates reasonable actions needed to recover and/or protect this endangered species. Recovery objectives will be attained and funds expended contingent upon appropriations, priorities, and other budgetary constraints.

The plan does not necessarily represent the views or official position of any individuals or agencies other than the U.S. Fish and Wildlife Service. The proposals in this recovery plan are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

Literature citations should read as follows:

U.S. Fish and Wildlife Service. 1991. Shale Barren Rock Cress (Arabis serotina) Recovery Plan. Newton Corner, Massachusetts. 40 pp.

Additional copies may be purchased from:

Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814
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1-800-582-3421

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Cover illustration by Ali Wieboldt

PART I: INTRODUCTION

The shale barren rock cress, Arabis serotina, a member of the mustard family, Brassicaceae, is one of several endemic species restricted to a unique natural community known as mid-Appalachian shale barren (Keener 1983). Within the band of shale barrens that occurs from southern Pennsylvania through Maryland into Virginia and West Virginia, A. serotina is restricted to a small region of western Virginia and eastern West Virginia. Within this area, 34 populations have been observed recently, making shale barren rock cress one of the most restricted of the shale barren endemic plants. Many of these populations are extremely small, consisting of fewer than ten plants when surveyed in the late 1980s. Due to the low numbers of plants, the restricted population area, and the small number of extant populations, A. serotina was listed as endangered by the U.S. Fish and Wildlife Service on August 8, 1989.

On December 4, 1989, representatives of the U.S. Fish and Wildlife Service, U.S. Forest Service, the Maryland, Virginia and West Virginia Natural Heritage Programs, Virginia Department of Agriculture and Consumer Services, and Virginia Polytechnic Institute and State University, met to discuss the recovery needs of Arabis serotina. The results of that discussion were used to formulate this plan.

DESCRIPTION AND TAXONOMY

Arabis serotina is a facultative biennial herb characterized in its nonreproductive stage by an inconspicuous basal rosette of lobed leaves. Average rosette size measured by G. Rouse (pers. comm.) over six sites ranged from 1.6-3.5 cm. In its reproductive stage, the basal leaves shrivel as the slender stem grows, or "bolts," and the inflorescence develops.

Wieboldt (1987) provides the best description of the plant's reproductive or bolting phase, although the data are based on limited sample sizes. The inflorescence of A. serotina, composed of three to 41 branches, measures 22.0 to 40.0 cm wide and is paniculate in appearance. Mature plants are 41 to 97 cm tall. Small whitish flowers, with calyxes from less than 2.0 to 3.3 mm long, bear fruits (siliques) that range from 4.30 to 7.94 cm. Seeds are usually yellowish brown and have a narrowly elliptic body, 1.5 to 2.0 times longer than broad with a narrow wing measuring from 0.1 to 0.2 mm.

A. serotina was first described by E.S. Steele in 1911 from specimens collected near Millboro in Bath County, Virginia (Steele 1911), and has been noted in other papers describing shale barren vegetation (e.g., Artz 1935, Core 1940, Platt 1951, Keener 1983). Since its description, there has been some debate over the taxonomy of the species: A. serotina is not mentioned in some floras (Fernald 1950, Gleason 1952) and is treated as synonymous with Arabis laevigata var. burkii in others (Hopkins 1937, Strausbaugh and Core 1977, Kartesz and Kartesz 1980).

To separate A. serotina from A. laevigata var. burkii, Wieboldt (1987) studied characteristics of habitat preference, phenology, and morphology for the two taxa. Comparing the

habitat, Wieboldt (1987) found that A. serotina was restricted to shale barrens, while A. laevigata var. burkii had a broader range of xeric habitats. Bartgis (1985) reported only two sites in West Virginia where both occurred together.

Wieboldt provided further evidence to separate the two taxa by examining their phenology. While A. laevigata var. burkii flowered in April and May, A. serotina flowered from mid-July through September. Implicit in this eight- to ten-week hiatus is an inability for these two taxa to cross-pollinate.

Wieboldt (1987) found several morphological characters that distinguish the two taxa, summarized in Table 1. Figure 1 also compares A. serotina and A. laevigata var. burkii. A. serotina is the taller of the two taxa, and its panicle-like inflorescence is wider and has more branches than the generally simple raceme of A. laevigata var. burkii. The seeds of A. laevigata var. burkii contrast with those of A. serotina in having a smaller, more broadly elliptic body with wider wings, from 0.25 to 0.50 mm. In addition, Wieboldt found generally shorter siliques in A. serotina, but there was overlap between the two taxa.

Table 1. Morphological distinctions between Arabis serotina and Arabis laevigata var. burkii (Wieboldt 1987).

MORPHOLOGICAL CHARACTER	*A. serotina*	*A. laevigata* var. *burkii*
Average calyx length	2.55 mm	3.83 mm
Inflorescence form	paniculate	simple raceme
Average inflorescence width	28.19 cm	12.17 cm
Average number of inflorescence branches	19.2	2.1
Average mature plant height	52.81 cm	41.07 cm
Average silique length	5.76 cm	7.62 cm

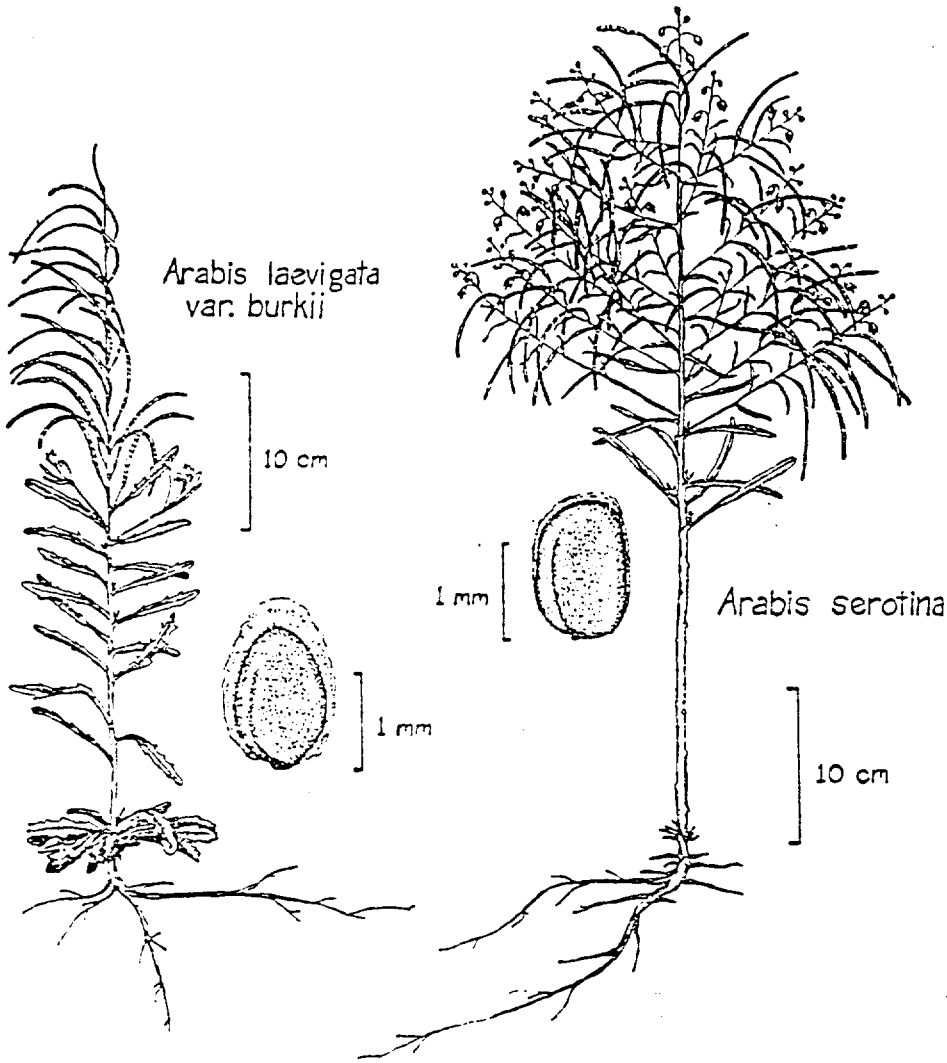

Figure 1. Average mature Arabis serotina plant compared with Arabis laevigata var. burkii and details of seeds (from Wieboldt 1987).

Illustration by Ali Wieboldt.

ECOLOGY AND LIFE HISTORY

Arabis serotina is endemic to mid-Appalachian shale barrens of the Ridge and Valley Province of the Appalachian Highlands; an understanding of this habitat, therefore, is essential to the recovery of the species. Mid-Appalachian shale barren is a designation for a shale slope of the region with an open, scrubby growth of pine, oak, red cedar, and other woody species adapted to the xeric conditions. Amidst the woody growth, which may form a canopy cover of less than 10%, an open herbaceous cover is found with species also adapted to the harsh conditions. Shale barrens were first described by Steele (1911) and extensively treated by Platt (1951) and Keener (1983). Additional research into shale barrens and their flora includes Allard and Leonard (1946), Artz (1935, 1937, 1948), Core (1940, 1952), Henry (1954), Morse (1983), Silberhorn (1968), and Wherry (1925, 1929, 1930, 1933, 1935, 1953, 1964).

Shale barren vegetation occurs on eroding shale formations, which are generally steeper than 20° (Platt 1951) and have southern aspects. The age of the shale in mid-Appalachian barrens is generally Upper Devonian, although Ordivician- and Silurian-age shale barrens are documented. Mid-Appalachian shale barrens are found most frequently on eroding slopes undercut by a stream flowing directly below the shale barren. Keener (1983) noted that shale barrens cover from 0.2 to 20 or more hectares.

Platt (1951) analyzed the temperature and moisture of shale barren soils. At the surface, where weather-resistant shale fragments replaced the duff and humus of the A horizon, conditions were extremely dry and warm. A maximum temperature of 63° C was noted, and during the warmest 4-5 hours of summer days temperatures of 55-60° C were very common. While the B

horizon (illuvial zone) was characteristically lacking, Platt noted that the C horizon's depth, moisture content, and nutrient content were similar to the C horizon of nearby slopes that were more heavily vegetated.

Platt hypothesized that the harsh surface conditions are an important controlling factor in germination and seedling establishment in the shale barrens. This may be an important factor to consider in relation to the recovery of A. serotina.

Another important ecological factor is the distribution of A. serotina in its shale barren habitat. Field workers frequently have noted that A. serotina grows in shale woodlands adjacent to the shale barrens in addition to growing in the open scree. Field workers also frequently observe that the habitat available to A. serotina, while apparently extensive, is unoccupied by the species. This suggests reproductive bottlenecks or dispersal problems.

Disturbance also may be a significant factor in the distribution of A. serotina within the shale barren habitat. Facultative biennials are opportunistic species that exploit disturbed areas that provide opportunities for seedling establishment. It may be that some disturbance event creates important habitat for germination and establishment of A. serotina.

Inventories have provided at least one year of population data for the 34 recently observed populations. Although findings indicate that most of the populations probably have from ten to 100 individuals, 20 populations have had fewer than ten individuals detected in at least one year (the lowest count is zero). Nine populations have had over 100 individuals observed during at least one inventory (the highest count is 434).

The number of A. serotina individuals within a population may fluctuate widely from year to year (P.J. Harmon pers. comm., Rouse 1990). While this fluctuation may represent a real difference in numbers of individuals between years, it may also be the result of differences in field workers' ability to detect plants or inconsistencies in the area, time of year, or life stages counted. For example, several West Virginia populations with initial counts of six or more individuals had no plants counted on the next visit, followed by 30 or more plants counted in the next year.

Little detailed work has been completed on the life history of A. serotina, but it is known that the plant's first life history stage is a non-reproductive basal rosette of leaves. This rosette shrivels when a flowering stem bolts. Flowering occurs from July until the first killing frost, at which time the plant dies. Until recently, the species was considered a strict biennial; however, evidence now indicates that A. serotina is a facultative biennial, as the basal rosette stage may persist for a number of growing seasons before the flowering scape is produced (West Virginia Department of Natural Resources 1989). There has been no research on the pollinators or pollination of A. serotina, although a dipteran of the family Syrphidae (flower flies) was observed to visit flowers (Lipford 1987).

The seed bank constitutes a third component of A. serotina's life history. Limited data indicate that seed production among A. serotina plants is of widely varying capacity. G. Rouse (pers. comm.), studying A. serotina at six sites in Virginia and West Virginia, estimated average seed output per bolting individual to range from 12-730 seeds. This can be compared with seed production for a plant with 455 siliques at a West Virginia site, which was estimated at 13,000-14,000 seeds (WVDNR 1989). Seed production appears to be affected by factors such as drought and herbivory. The

role of the seed bank and related questions of its distribution and longevity have not been investigated.

Preliminary data suggest that A. serotina also has a rhizomatous habit (Rouse, 1990 and pers. comm.). In plants in two different clusters of rosettes, Rouse followed a tiny rhizome to a connection with another plant. Further research is needed to establish the significance of this aspect of the species' life history, which has not been documented previously.

A. serotina individuals often die in the rosette or bolting stage before reproduction is initiated. Although herbivory frequently is noted as the cause of death, the identity of the herbivores and other possible causes of mortality are not understood. Further information on mortality is provided in the Threats section.

HISTORICAL AND CURRENT DISTRIBUTION

The range of Arabis serotina covers ten counties in Virginia and West Virginia. Table 1 lists the location and ownership status of all known sites, which are mapped in Figure 2. Of the 35 known populations, 34 have been seen since 1984 and are believed to be extant. The distinctive hook-shaped distribution of populations west of Shenandoah County conforms to the Upper Devonian shales of the region, a pattern similar to other endemic species of the central mid-Appalachian shale barren region (R. Bartgis pers. comm.).

Two populations have been observed in the Massanutten Mountains outside the species' primary range. A population reported by Lena Artz in 1935 in Shenandoah County near the Page County line at New Market Gap was last seen by Keener in

Table 2. Known locations of Arabis serotina

Virginia:

	County	Site Name	Owner	Last Seen
1	Alleghany	Johnson Creek	VDCR	1990
2	Augusta	Reubens Draft	GWNF	1990
3	Bath	Thompson Creek	Private	1991
4	Bath	Blackies Hollow	GWNF	1987
5	Bath	Indian Draft	Private	1987
6	Bath	Lick Run	GWNF	1987
7	Bath	Millboro Springs	Private	1987
8	Bath	Millboro Tunnel	GWNF	1984
9	Bath	Rough Mountain	GWNF	1987
10	Bath	South Sister Knob North	GWNF	1987
11	Bath	South Sister Knob South	GWNF	1990
12	Bath	Stuart Run	Private	1987
13	Bath	Big Cedar	Private	1991
14	Highland	Headwaters	GWNF	1990
15	Page	Browns Hollow	GWNF	1991
16	Rockbridge	Brattons Run	GWNF	1987
17	Shenandoah	New Market Gap	Unknown	1957

West Virginia:

18	Greenbrier	Blue Bend	MNF	1989
19	Greenbrier	Humphreys Draft	MNF	1989
20	Greenbrier	Lower Whites Draft	MNF	1989
21	Greenbrier	Meadow Creek	MNF	1989
22	Greenbrier	Middle Mountain	MNF	1990
23	Greenbrier	Turkey Pen	MNF	1989
24	Greenbrier	Upper Whites Draft	Private	1989
25	Greenbrier	Waids Draft	Private	1989
26	Greenbrier	Whitmans Draft	MNF	1989
27	Hardy	Rohrbaugh Run	MNF	1989
28	Pendleton	Brandywine	GWNF/ Private	1990
29	Pendleton	Broad Run	Private	1989
30	Pendleton	Dam #10	Private	1989
31	Pendleton	Heavener Run East	Private	1990
32	Pendleton	Heavener Run West	Private	1989
33	Pendleton	Little Fork	US Navy	1990
34	Pendleton	Temple	Private	1989
35	Pendleton	Thompson	Private	1989

VDCR = Virginia Department of Conservation and Recreation
GWNF = George Washington National Forest
MNF = Monongahela National Forest

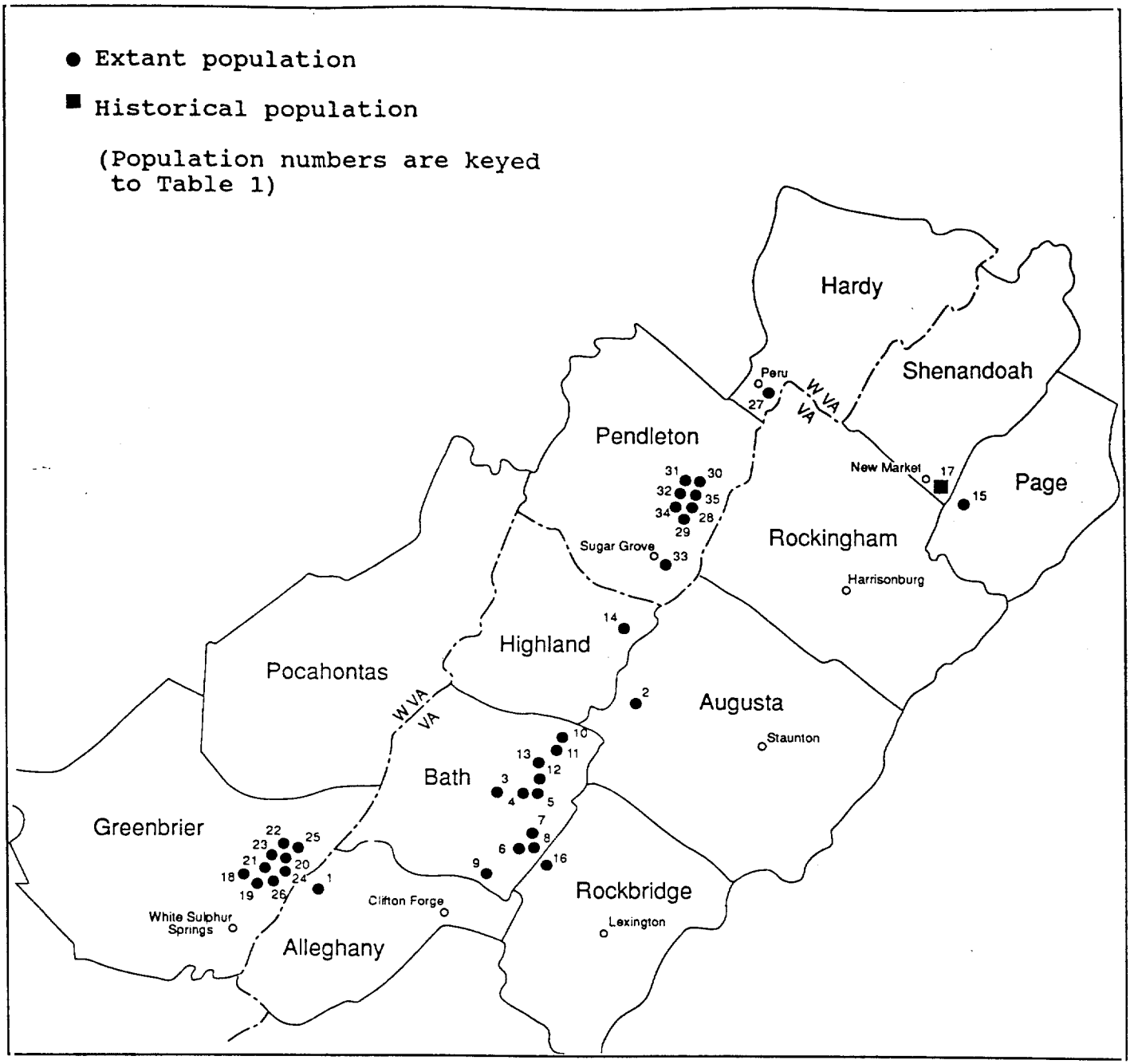

Figure 2. Distribution of Arabis serotina

Sources: VDCR Division of Natural Heritage
West Virginia Wildlife/Heritage Database

1957 (S. Morgan pers. comm.). A second population in Page County at Browns Hollow was discovered in 1991, at least three km from the Artz sighting. Shale barrens of the Massanutten Mountains are Ordivician-age Martinsburg shale and contain a number of other shale barren endemic plants.

THREATS AND LIMITING FACTORS

Arabis serotina is threatened by drought, anthropogenic habitat degradation, stochastic events causing reproductive failure, herbivory, and other biotic factors.

Since most of the 34 extant populations consist of less than 100 plants (many with fewer than ten individuals), this rare species may be particularly vulnerable to local extirpation. In general, herbivory, drought, or any other threat that acts on the species is more likely to destroy a small population than a large one. These small populations may also be susceptible to catastrophic loss by a stochastic event causing reproductive failure such as a tree falling or seed dispersal into an unsuitable habitat.

Herbivory by deer has been suggested by some investigators as a significant threat to A. serotina, although the data are mainly circumstantial. Bartgis (1987) reported that 15% to 70% of the inflorescences in each of the West Virginia populations were partially or completely destroyed by deer. Other observers in West Virginia have noted numerous deer tracks on the shale barrens, including tracks specifically associated with browsed A. serotina (WVDNR 1989). Many Virginia populations also have been reported to have evidence of deer browse (Lipford 1987, VDCR Division of Natural Heritage 1988).

These data cite evidence of grazing on the bolted stem and inflorescence (i.e., the terminal bud), rather than destruction of the rosette. Although plants pulled up by the roots also have been reported (WVDNR 1989), this cannot be directly attributed to deer. Most grazing activity appears to occur in spring, when (if a plant is not otherwise stressed) loss of the terminal bud could increase branching and, possibly, flower and seed production; this makes it difficult to ascertain the degree of threat grazing represents.

Further, G. Rouse (pers. comm. 1990) observed browsed A. serotina plants growing within deer exclosures constructed at Brandywine shale barren, possibly indicating that other biotic factors may be more serious threats than deer grazing. Rouse noted that other herbivores (perhaps lepidoptera) or agents such as fungi may be contributing to a large percentage of the damage, if not mortality, of A. serotina plants. He reported that a Pieris sp., a lepidopteran of the White and Sulfur family, was a predator on the young leaves and shoots of bolters, and another unidentified lepidopteran species was seen eating stem leaves and fruit. Larvae of the Olympic marble butterfly, Euchloe olympia, also were seen feeding on A. serotina in 1988 at one site in West Virginia (WVDNR 1989). In addition, Rouse documented high mortality rates (50%) among rosettes; this mortality appeared to be associated with observations of tiny holes on both the interior and edges of leaves prior to rosette death (Rouse, 1990 and pers. comm.). The cause of this mortality and the significance of larvae herbivory need to be determined.

While surveying two West Virginia sites located on barrens with past grazing by goats and sheep, Bartgis (1987) noted that none of the known A. serotina populations are on actively-grazed shale barrens. In West Virginia, goats and sheep have been the source of the most destructive grazing on A. serotina (Harmon 1991).

Drought may be a more significant threat to A. serotina populations than herbivory. Increased reproductive failure was observed among populations in one West Virginia valley that suffered a severe drought in 1987 (Bartgis 1987). Additional West Virginia data from 1988 and 1989 -- years of drought and normal rainfall, respectively -- suggested significant negative effects from drought on reproduction in the A. serotina populations studied, including dead terminal and lateral shoot tips and decreased fruit production (WVDNR 1989, WV Natural Heritage Program 1990).

There may also be some threat to A. serotina populations from human-caused habitat degradation. Road construction has resulted in the partial destruction and disturbance of five WestVirginia and three Virginia shale barrens containing A. serotina (Bartgis 1987, T. Wieboldt pers. comm. to S. Morgan 1987). Dam construction has damaged one site in West Virginia (Bartgis 1987). In Virginia, two sites have been damaged by railroad construction, and one site is crossed by a hiking trail (Lipford 1987, T. Wieboldt pers. comm. to S. Morgan 1987).

There has been some concern about possible impacts on A. serotina from gypsy moth (Lymantria dispar) infestation. Escaping in New England, the gypsy moth has moved south, defoliating large forest tracts and causing substantial mortality of trees in some forest types. The moth has entered the northern portion of A. serotina's range and may cover the entire range in the next one to four years.

Over time, tree mortality on and near the barrens could cause changes in the shale barren community structure. However, in the absence of any monitoring to date, many botanists speculate that such changes would be minor due to the low density of trees preferred by the gypsy moth.

Of more immediate concern are the possible effects on A. serotina caused by treatments to control gypsy moths. Spraying of Dimilin, a widely available pesticide, may cause high mortality in certain non-target organisms. These organisms include pollinators of A. serotina such as two rare butterflies (Pyrgus wyandot and Euchloe olympia), which inhabit shale barrens and adjacent woodlands. Researchers and manufacturers report that the bacterial insecticide Bacillus thuringiensis (Bt) is more specific, but still may cause high mortality in some lepidopteran species which play an essential role in pollination (Schweitzer 1989).

Overcollection of this species by botanists may also pose a threat to some populations of A. serotina, particularly at the more accessible shale barrens.

CONSERVATION MEASURES

Arabis serotina was assigned Federal Category 2 candidate status on November 11, 1983 (USFWS 1983) and was proposed for listing on November 17, 1988 (USFWS 1988). The plant was listed as a Federally endangered species (USFWS 1989) and as a state endangered species in Virginia by VDACS on the same date, August 14, 1989. West Virginia has no state endangered species regulation, so listing in that state is not possible. Arabis serotina is the only shale barren endemic species listed either as endangered or threatened in Virginia or on the Federal level.

In addition to regulatory protection, land protection efforts have begun for 21 of the 34 recently verified A. serotina populations. Johnson Creek, in Alleghany County, Virginia, is now owned by the Commonwealth and managed by the Virginia Department of Conservation and Recreation. VDCR's Division of

Natural Heritage in cooperation with The Nature Conservancy is drafting a management plan to protect A. serotina and other rare species found at the site, an exemplary shale barren. Johnson Creek also is dedicated formally under the Virginia Natural Areas Preserves Act (Section 10.1-209 through 217, Code of Virginia) as a State Natural Area Preserve to be managed in perpetuity for the protection of the shale barren and its component species.

Ten Virginia populations and one West Virginia population of A. serotina have been identified in George Washington National Forest. A National Forest Land and Resource Management Plan is being prepared for GWNF; this plan is required by the Forest and Rangeland Renewable Resources Planning Act as amended by the National Forest Management Act and directs management of all resources within GWNF. The Forest Plan is reviewed and updated (if necessary) every five years, and revised every ten years. Through the forest planning process, the VDCR Division of Natural Heritage has provided the Forest Service with information on the location and attributes of the ten A. serotina populations in Virginia. Natural Heritage scientists now are preparing a technical report outlining protection and management recommendations (Smith in prep.). The GWNF populations in Virginia are proposed for protection as Research Natural Areas (Forest Service Manual 4063.1-4063.41). This Federal administrative designation would afford these populations a high degree of protection and allow sites to be managed strictly for research, education, and biodiversity protection.

The A. serotina population at the Brandywine Shale Barren in West Virginia lies within GWNF boundaries and on private land. The Forest Service has been working with the WV Natural Heritage Program to protect the resources within their boundaries at Brandywine.

Eight populations of A. serotina are located within the Monongahela National Forest. Forest Service personnel, including district rangers, have been notified of the plant's locations and are directing management to avoid damage to A. serotina and the shale barren habitat. The Forest's Land and Resource Management Plan of 1985 designated two (Lower Whites Draft and Meadow Creek) of the eight shale barrens known from the MNF as botanical areas (a special area designation). In addition, both of these areas are also recommended for designation as Research Natural Areas, although approval is pending. Several of the other six A. serotina locations/shale barrens were unknown at the time the 1985 plan was prepared. Future revisions/amendments to the plan could designate other shale barrens as botanical areas or propose them for RNA designation.

The Little Fork A. serotina population, located on a U.S. Naval Base in Pendleton County, West Virginia, is afforded planning and conservation consideration through the Navy's Natural Resources Program. A five-year cooperative agreement between the U.S. Navy and West Virginia Natural Heritage Program was initiated in 1990 to further document the occurrence, distribution, and life cycle of the species on the base. The results from the cooperative agreement will be incorporated into the Navy's planning process and used to assess the need for establishing and maintaining the Little Fork site as an ecological reserve or research natural area.

Preliminary data from recent observations have produced questions regarding A. serotina's life history and ecology. Three studies have been initiated to address various aspects of the plant's biology.

The first study, begun in 1990, is examining the life history of A. serotina by monitoring individual plants over several years at six sites covering the known range of the

species. This work is designed to study life history characteristics, population size, and mortality.

The second study, also a multi-year project begun in 1990, is a grid study that involves mapping and analyzing one large population. Questions of life history, germination and seedling establishment, rhizomatous habit, distribution within the shale barren habitat, dispersal ability, the role of disturbance, population fluctuation, the role of seed bank, and mortality are being investigated. The initial results of these two multi-year studies will be available in late 1991.

In the third study, seed germination requirements are being examined. Preliminary data from laboratory greenhouse experiments conducted at the University of Kentucky indicate that winter cold treatment is important in breaking physiological dormancy in seeds of A. serotina (pers. comm. between C. Caljouw and C. Baskin).

A fourth study is being designed by the VDCR Division of Natural Heritage. This effort will examine the distribution of the species within the shale barren habitat, dispersal ability, and the role of disturbance. Also included in the study will be monitoring the condition of the community and documenting long-term successional trends of the habitat.

PART II: RECOVERY

RECOVERY OBJECTIVE

To remove Arabis serotina from the Federal list of endangered and threatened wildlife and plants.

Downlisting from endangered to threatened will be possible when the following conditions are met:

1. Twenty demonstrably self-maintaining populations are distributed throughout the species' range.

   Guidelines for determining what constitutes a self-maintaining population will be developed as part of the recovery program.

2. The habitat of these 20 populations is permanently protected.

   Habitat will be considered to be permanently protected if it is:

   a. in Federal ownership and protected through special designation such as an ecological reserve or research natural area,

   b. in ownership by a state agency or private conservation

organization that considers maintenance of the A. serotina population to be the predominating management objective for the site, or

c. in private ownership and safeguarded through a long-term cooperative agreement, deeded conservation easement, or covenant that effectively commits present and future landowners to protecting the site.

3. Seeds are stored to prevent extinction in case of disastrous loss of natural populations.

Delisting will be considered when, in addition to the above conditions having been met:

4. Fifteen additional self-maintaining populations and their habitat are permanently protected.

RECOVERY TASKS

1.0 Seek protection of all extant populations, and secure permanent protection for demonstrably self-maintaining populations and their habitat.

The recovery of Arabis serotina depends upon the perpetuation of extant populations and protection of their habitat. This task will involve efforts to provide permanent habitat protection for those populations that are demonstrated to be self-maintaining based upon current assessments of a given population's viability and, ultimately, the guidelines that will be developed in Task 4.3. Continuing protection of all extant populations will be sought through landowner cooperation (both formal and informal) and regulatory means.

1.1 Determine essential habitat for extant populations. Boundary determination will take into account the population biology and potential threats to each extant population. This should lead to protection of adequate habitat for the growth and self-maintenance of any given population.

1.2 Use land protection measures to preserve Arabis serotina habitat on public lands. Protective land designations and management prescriptions should be used to safeguard essential habitat (as determined in Task 1.1) in George Washington and Monongahela National Forests and on the U.S. Naval Base. Current proposals and recommendations to designate shale barrens containing A. serotina as Research Natural Areas, ecological reserves, or special botanical areas should proceed.

1.3 Seek landowner cooperation to preserve Arabis serotina habitat on private lands. Thirteen populations are entirely on private land and are not currently protected. Private landowners in Virginia were notified by VDACS of known A. serotina occurrences on their property when the species was listed. Subsequent discussions regarding protection planning and preservation of these sites have not occurred but should be initiated. All eight sites in private ownership in West Virginia warrant landowner notification and protection. Where feasible, an array of land protection procedures including registry, easements, management agreements, and acquisition will be considered as means to protect A. serotina habitat on private lands. Land acquisition activities would take place on a "willing seller" basis only.

1.4 Implement regulations to protect populations and their habitat. Federal, state, and local laws and regulations that govern endangered and threatened species will be carried out to the fullest extent possible. In addition, existing regulations should be strengthened where possible, and non-traditional avenues for endangered plant protection that may benefit A. serotina (e.g., erosion control requirements) should be considered. Section 7 Endangered Species Act responsibilities, particularly consultation, will be carried out to avoid indirect and secondary impacts to the species or its essential habitat (as defined in Task 1.1). Section 7(a)(1) of the Endangered Species Act, which directs Federal agencies to utilize their authorities in furtherance of the purposes of the Act by carrying out programs for the conservation and recovery of listed species, also will be implemented.

2.0 Monitor extant populations.
This task will entail monitoring of known populations to determine demographic trends, to identify and define threats, and to assess progress towards recovery.

2.1 Develop a standardized monitoring plan. In order to obtain reliable long-term data from all A. serotina populations, a monitoring plan will be developed that is standard, objective, and workable for all populations in all years. Information on number of individuals, numbers of bolting individuals, fruit set, and gross changes to habitat will be obtained. The monitoring plan should address recent findings by Rouse which suggest that the species may be rhizomatous.

2.2 Implement and evaluate the monitoring program on an annual basis. Monitoring activities for all known populations will be conducted each year. Based on initial monitoring results and on data gathered through life history and ecological studies (Tasks 4.1-4.5), the monitoring program will be refined as needed. Data derived from monitoring will be used to assess the continuing adequacy of protection efforts, to assess the ability of the population to be self-maintaining without management intervention, and to determine management needs on a site-specific basis.

3.0 Search for additional populations.

Additional A. serotina populations should be sought on Upper Devonian shale barrens within and adjacent to the known range and Ordivician shale barrens near New Market Gap in the Massanutten Mountains. There is a high likelihood that additional populations may be found. If and when found, the habitat of these populations should be protected as described under Task 1.0.

4.0 Conduct ecological and life history studies.

Conditions for recovery of A. serotina are based upon the protection of self-maintaining populations and their habitat. In order to establish guidelines to determine what constitutes a self-maintaining population, a number of important factors regarding the biology and ecology of the species must be studied, including (1) life history, (2) germination and seedling requirements, (3) distribution within habitat, (4) dispersal ability, (5) the role of disturbance, (6) population levels and fluctuations, (7) seed production and seed bank, and (8) mortality causes.

4.1 Conduct life history studies.

4.11 Study the species' life history through range-wide investigation of populations. Individual plants will be tagged to study life history attributes, population levels and fluctuations, and causes of mortality. To consider regional and climatological effects, populations in different regions will be monitored. To determine the effects of population size, plants from populations of differing sizes will be monitored.

4.12 Study the species' ecology and life history through an intensive examination of an extant population. The habitat of an extant population will be gridded to study life history, germination and seedling requirements, density and distribution within habitat, population size and fluctuation, seed production and seed bank, and mortality. Through gridding the population area, an intensive study of one population will seek to answer many important questions dealing with these factors and may suggest other problems.

4.13 Study the species' life history through a series of greenhouse and field experiments. Greenhouse experiments will be employed to study conditions required for germination and seedling establishment and to initiate long-term studies on seed viability. Field experiments will follow greenhouse experiments to test germination and seedling establishment under field conditions.

4.2 Monitor the condition of the community and document long-term successional trends of extant sites. For a selected group of extant sites, permanent vegetation monitoring plans will be designed to assess long-term changes in community structure and the distribution of Arabis serotina. This monitoring will help explain distribution within the barren habitat, species dispersal ability, seed bank, and the role of disturbance. This study will also document the effects of gypsy moth predation on the community structure of the shale barren habitat.

4.3 Develop guidelines as to what constitutes a self-maintaining population. After the results of the studies in Tasks 4.1-4.2 are in, much more data will be available on the factors that have been outlined as important to the maintenance of Arabis serotina. With this data, a set of guidelines will be developed to define a self-maintaining population.

4.4 Study species' genetic variability within and between populations. Electrophoretic analyses will be used to examine genetic flow across populations and to identify whether genetic bottlenecks might exist within a population.

5.0 Store seeds.

A seed storage facility should keep an adequate reserve of seeds to ensure preservation of species and maintenance of genetic diversity in case of a loss of extant sites. The USDA National Seed Bank in Colorado would be a suitable storage facility. Seeds collected from all known populations and a sampling of individuals within each population will provide the maximum genetic diversity.

6.0 Develop and implement management plans for extant populations as needed.

Although little information is currently available to suggest a need for active management of Arabis serotina populations, data collected under Tasks 2 and 4 will indicate if and where active management should be applied. For example, if deer herbivory is found to be detrimental, deer exclosures may be required to protect certain populations. This task will also involve assessment of gypsy moth control procedures in and around Arabis serotina populations.

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PART III: IMPLEMENTATION

The Implementation Schedule lists and ranks tasks that should be undertaken within the next three years in order to implement recovery of Arabis serotina. This schedule will be reviewed annually until the recovery objective is met, and priorities and tasks will be subject to revision. Tasks are presented in general order of priority.

Key to Priorities in Column 1

Task priorities are set according to the following standards:

Priority 1: Those actions that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2: Those actions that must be taken to prevent a significant decline in species population, or some other significant impact short of extinction.

Priority 3: All other actions necessary to provide for full recovery of the species.

Key to Agency Designations in Column 5

USFWS = U.S. Fish and Wildlife Service
R5 FWE = Region 5, Division of Fish and Wildlife Enhancement, U.S. Fish and Wildlife Service
USFS = U.S. Fish and Wildlife Service
GWNF = George Washington National Forest
MNF = Monongahela National Forest
NAVY = U.S. Navy
VDACS = Virginia Department of Agriculture and Consumer Services
VADNH = Virginia Department of Conservation and Recreation, Division of Natural Heritage
WVNHP = West Virginia Natural Heritage Program
TNC = The Nature Conservancy

IMPLEMENTATION SCHEDULE
Shale Barren Rock Cress

April 1991

Priority	Task Description	Task Number	Duration	Responsible Agency		Cost Estimates, $000			Comments
				USFWS	Other	FY1	FY2	FY3	
1	Determine essential habitat.	1.1	Ongoing	R5 FWE	VADNH* WVNHP	1	1	1	
1	Preserve habitat on public lands.	1.2	Ongoing	R5 FWE	USFS VADNH* WVNHP*	3	2	2	
1	Seek landowner cooperation to preserve habitat on private lands.	1.3	Ongoing	R5 FWE	TNC*	2	2	2	
1	Implement regulations to protect populations/habitat.	1.4	Ongoing	R5 FWE*	USFS*	3	3	3	
2	Develop a standardized monitoring plan.	2.1	1 year		VADNH* VDACS WVNHP	2			
2	Implement and evaluate the monitoring program.	2.2	Ongoing	R5 FWE	GWNF VADNH* VDACS WVNHP	3	3	3	Evaluation to be conducted in 1996 or 1997.
2	Search for additional populations.	3.0	5 years		VADNH* WVNHP	3	3	3	
2	Study life history characteristics on populations range-wide.	4.11	5 years		VDACS*	5	5	5	Study has been initiated for six populations.
2	Study ecology and life history through intensive examination of one population.	4.12	5 years		NAVY WVNHP*	3	3	3	Study has been initiated.
2	Study life history through greenhouse and field experiments.	4.13	3 years		VDACS*	2	2	2	Study has been initiated.

Shale Barren Rock Cress Implementation Schedule, Page 2

Priority	Task Description	Task Number	Duration	Responsible Agency		Cost Estimates, $000			Comments
				USFWS	Other	FY1	FY2	FY3	
2	Monitor long-term successional trends of extant sites.	4.2	Ongoing		VADNH*	4	3	3	Study design is underway.
2	Develop guidelines for defining what constitutes a self-maintaining population.	4.3	1 year	R5 FWE	MNF VADNH* VDACS WVNHP				To be developed in 1996 or 1997.
2	Store seeds.	5.0	2 years	R5 FWE*		1	1		
2	Develop and implement site-specific management plans as needed.	6.0	Ongoing		MNF VADNH* VDACS WVNHP	2	2	2	
3	Study genetic variability.	4.4	3 years	R5 FWE*					Study to be conducted at a later date.

* = lead agency

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