U.S. Fish & Wildlife Service

Recovery Plan for Kneeland Prairie Penny-cress *(Thlaspi californicum)*

RECOVERY PLAN
FOR
KNEELAND PRAIRIE PENNY-CRESS
(THLASPI CALIFORNICUM)

Region 1
U.S. Fish and Wildlife Service
Portland, Oregon

Approved: _____
Manager, California/Nevada Operations Office,
Region 1, U.S. Fish and Wildlife Service

Date: JUL 7 2003

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EXECUTIVE SUMMARY

Current Status: *Thlaspi californicum* (Kneeland Prairie penny-cress) is federally listed as endangered (65 FR 6332; February 9, 2000) and is known from a single population located in Kneeland Prairie, Humboldt County, California. Over 99 percent of the population is located on private land, with the remainder located on land owned by the California Department of Forestry and Fire Protection.

Habitat Requirements and Limiting Factors: *Thlaspi californicum* occurs at approximately 900 meters (2,800 feet) above mean sea level, on serpentine soils rich in heavy metals and poor in calcium, nitrogen, potassium, and phosphorus. Kneeland Prairie is located approximately 19 kilometers (12 miles) from the Pacific Ocean. The climate is marine-influenced, with average annual precipitation estimated at 150 centimeters (59 inches), and frequent summer fog. Dominant plant species in the area typically include *Festuca rubra* (red fescue), *Eriophyllum lanatum* (common woolly sunflower), *Koeleria macrantha* (junegrass), *Lomatium macrocarpum* (large-fruited lomatium), and *Elymus glaucus* (blue wildrye). No shrubs or trees are present.

A significant portion of the habitat historically occupied by *Thlaspi californicum* was eliminated by construction of Mountain View Road, Kneeland Airport, and a helicopter landing (helitack) base. The remaining habitat is potentially threatened by airport expansion, realignment of the road, and road maintenance. The majority of habitat is also subject to unrestricted cattle grazing, with unknown impacts. Due to its very limited population and distribution, this species is also highly vulnerable to chance events, either anthropogenic or natural in origin, and inbreeding depression.

Recovery Priority: The recovery priority for *Thlaspi californicum* is 2C on a scale of 1 to l8, reflecting conflict with construction or other development projects, a high degree of threat, a high potential for recovery, and a taxonomic rank of full species, which has a higher priority than a subspecies. Recovery priority numbers are based on criteria published by Federal Register Notice (48 FR 43098; September 21, 1983).

Recovery Objective: The primary objectives of this recovery plan are to protect the existing population of *Thlaspi californicum* and establish new, viable colonies, resulting in recovery of the species to the point where delisting is warranted. Conservation measures described for the species and its habitat are designed to ensure that at least five self-sustaining colonies will exist, distributed throughout its extant and historic range.

Recovery Criteria:

1. Reclassification to threatened status will be evaluated when all of the following conditions have been met:

    A. The population as a whole, and all three extant colonies, are protected and stable. Protected sites are defined as either: i) sites owned and/or managed by a government agency or private conservation organization that identifies maintenance of the species as the primary management objective for the site, or ii) sites protected by a permanent conservation easement or covenant that commits present and future landowners to the conservation of the species. To be deemed stable, the present largest population must maintain a running average population size (mean of annual mean population estimates) of at least 7,000 individuals, and the 2 other extant colonies must maintain a running average population size of at least 500 individuals each. Running averages will be determined over the most recent 10 years, or an appropriate period justified on the basis of population research.

    B. Reliable seed germination and propagation techniques for the species are understood and demonstrated.

    C. Genetic material, in the form of seeds adequately representing the genetic diversity within the species, is stored in a facility approved by the Center for Plant Conservation.

2. Delisting will be considered when, in addition to the criteria for downlisting, all of the following conditions have been met:

A. The running average for the entire population is 10,000 or more individuals over a period of 10 years, or an appropriate period justified on the basis of population research. The period may run concurrently with the downlisting period in 1.A above if this goal for the size of the entire population is met.

B. At least five protected and stable colonies (populations on distinct serpentine outcrops) are distributed throughout the current and historic range of the species. For a site to be considered protected, it must be either owned by a government agency or private conservation organization that identifies maintenance of the species as the primary management objective for the site, or the site must be protected by a permanent conservation easement or covenant that commits present and future landowners to the conservation of the species. To be deemed stable, the largest presently extant colony must maintain a running average population size of at least 7,000 individuals, and colonies on 4 additional outcrops must be shown to be naturally reproducing and maintain a running average population size of at least 500 individuals each for a period of 10 years, or an appropriate period justified on the basis of population research.

C. Monitoring of population size, trends, other pertinent characteristics, and habitat quality has begun and will continue for the post-delisting monitoring period.

Actions Needed:

1. Protection of the current population of *Thlaspi californicum* and its habitat, including land acquisition or legal restrictions placed on land use leading to long-term conservation of the species, continued annual monitoring, commitment by the California Department of Forestry and Fire Protection for long-term protection and management of the species on their property, continued outreach among stakeholders, and construction of a fence to discourage casual pedestrian use of the habitat.

2. Research necessary to enable maintenance and expansion of the existing population and establishment of new colonies. Critical aspects of the biology of

Thlaspi californicum need to be studied, including genetic diversity within the species, seed viability, propagation methods, and specifics of the species' habitat requirements.

3. Development and implementation of a repatriation/introduction plan.

4. Collection of seed adequately representing the genetic diversity within the species (based on the results of genetics investigation), and storage at a facility approved by the Center for Plant Conservation.

5. Inventories for new populations of *Thlaspi californicum* in suitable habitat.

6. Restoration or creation of additional suitable habitat for *Thlaspi californicum* as opportunities become available.

Estimated Costs for Recovery: Approximately $22,000 have already been spent on recovery of this species; we anticipate additional expenses of approximately $296,000 will be necessary over the next 10 years to recover this species.

Estimated Date of Recovery: Downlisting or delisting could potentially be considered by 2013 if the appropriate recovery criteria have been met.

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A. Overview

The final rule designating endangered status for *Thlaspi californicum* (Kneeland Prairie penny-cress) was published on February 9, 2000 (U.S. Fish and Wildlife Service 2000*a*). The final rule designating critical habitat for *Thlaspi californicum* was published on October 9, 2002 (U.S. Fish and Wildlife Service 2002).

We prioritize recovery actions by directing resources first to species facing a high threat, with a high potential for recovery, and to species with a high level of taxonomic distinctiveness. Recovery priority numbers range from 1 to 18 and are based on criteria published by Federal Register Notice (U.S. Fish and Wildlife Service 1983). The recovery priority number for *Thlaspi californicum* is 2C. This number indicates a species in a genus consisting of more than one species, with a high degree of threat and a high potential for recovery. The "C" denotes a species that is, or may be, in conflict with construction or other development projects.

B. Species Description

Thlaspi californicum is a perennial member of the mustard family (Brassicaceae) (Holmgren 1971; Hickman 1993). *Thlaspi californicum* grows from 9.5 to 12.5 centimeters (3.7 to 4.9 inches) tall, with a basal cluster of leaves 2 to 4 centimeters (0.8 to 1.6 inches) in length that develop prior to the flowering stage (Figure 1). The margins of the basal leaves range from entire (smooth) to dentate (toothed). The entire to dentate cauline (stem) leaves clasp the stem, and range from 1 to 1.5 centimeters (0.4 to 0.6 inches) long. The leaves overall are green to purplish. The inflorescence (floral display) is 5 to 10 centimeters (2.0 to 4.0 inches) long, with strongly ascending pedicels (flower stalks). Flowers consist of green to purplish sepals, 2.5 to 4 millimeters (0.1 to 0.2 inches) long, and white spoon-shaped petals. The fruit is a sharply pointed silicle (a short fruit typically no more than 2 to 3 times longer than wide), 7 to 10 millimeters (0.3 to 0.4 inches) long, elliptic to obovate, wingless and with an acute tip (Rollins 1993).

Thlaspi californicum, plant and microhabitat.

Basal foliage.

Fruit and inflorescence.

Kneeland Airport and the entire global distribution.

Figure 1. Photographs of *Thlaspi californicum* and its habitat.

Thlaspi californicum is distinguished within the genus by its long slender silicles, acute at the apex even when quite mature, and by the strongly ascending pedicels and silicles. The plant flowers between late March and May. The primary features that separate *T. californicum* from the closely related *T. montanum* var. *montanum* (mountain penny-cress) include the orientation of the pedicel, shape and notching of the fruit, and length/width ratio of the fruit. *Thlaspi m*. var. *montanum* has pedicels perpendicular to the stem, not strongly ascending, and the silicles are either truncate or shallowly notched, but not as acute at the apex as they are in *T. californicum* (Holmgren 1971). Holmgren (1971) cited Humboldt County collections of *T. m.* var. *montanum* both at much lower elevation (130 to 190 meters [400 to 600 feet]) and higher elevation (1,610 meters [5,000 feet]) than Kneeland Prairie (approximately 800 meters [2,500 feet]). In collections made at lower elevation, *T. m.*. var. *montanum* tended to be much larger than *T. californicum*.

C. Historic and Current Range

Kneeland Prairie is notable in botanical literature as the type locality for *Thlaspi californicum* (Figure 2). Botanists were aware of this population of the species as early as 1882, when specimens from which the species was described were likely collected from the vicinity of Mountain View Road (Holmgren 1971). Collections of *T. californicum* available in herbaria, all from Kneeland Prairie, were subsequently made in 1888, 1913, 1921, 1926, 1951, and 1962.

Prior to human alteration, the majority of serpentine outcrops within Kneeland Prairie were associated with a semi-continuous ridgetop exposure covering more than 2.4 hectares (6 acres) along Ashfield Ridge. Construction of Mountain View Road (presumably in the late 1800's), the Kneeland Airport in 1964, and more recently a helicopter landing (helitack) base by the California Department of Forestry and Fire Protection in 1980, eliminated a large portion of the serpentine exposure, and an estimated 50 percent of the suitable habitat for *Thlaspi californicum* (SHN Consulting Engineers & Geologists 1997; Figure 1). Doris Kildale Niles, longtime Humboldt County botanist, recalled observing the penny-cress during the 1920's and 1930's growing in habitat subsequently eliminated by the Kneeland Airport and helitack base (personal communication, 1990).

Figure 2. Location map for Thlaspi californicum (Kneeland Prairie penny-cress).

- ■ Approximate location

In addition to the Kneeland Prairie site, two other occurrences have been reported for *Thlaspi californicum*: 1) specimens housed at the Humboldt State University herbarium, collected by Constance and Rollins on May 11, 1942, 130 meters (400 feet) elevation, approximately 8 kilometers (5 miles) south of Hoopa, Humboldt County; and 2) a reference to *T. californicum* growing near Blue Banks on the Mendocino National Forest, cited in the Flora of the Vascular Plants of Mendocino County (Smith and Wheeler 1992). An assessment of the validity of the two outlying occurrences, and an inventory for *T. californicum* in suitable habitat elsewhere in Kneeland Prairie and to the south were conducted in 1997 (SHN Consulting Engineers & Geologists 1997). No other occurrences of *T. californicum* were located, and the vouchers collected by Constance and Rollins and by Smith and Wheeler were reassigned to *T. montanum.*

The Six Rivers National Forest, located approximately 11 kilometers (7 miles) east of Kneeland Prairie, has no documented occurrences of *Thlaspi californicum*. In 2001, a focused survey for *T. californicum* was conducted in the majority of suitable habitat located on Six Rivers National Forest within 16 kilometers (10 miles) north and south of the Kneeland Prairie site. No new sites were located (Six Rivers National Forest 2001). Additional suitable, but unsurveyed habitat occurs on that national forest.

Beyond Kneeland Prairie, the nearest known exposure of serpentine substrate is located west of Iaqua Buttes, approximately 5 kilometers (3 miles) south-southeast of the Kneeland Prairie site. That habitat, which is vegetationally distinct from the Kneeland serpentine habitat, supports the related *Thlaspi montanum* var. *montanum*. No evidence of intergradation between *T. californicum* and *T. m.* var. *montanum* was observed at the Iaqua Buttes site (SHN Consulting Engineers & Geologists 2001). Moreover, *T. m.* var. *montanum* has been repeatedly documented in the vicinity of Horse Mountain, some 24 kilometers (15 miles) northeast of Kneeland Prairie. The historic range of *T. californicum* probably never extended beyond Kneeland Prairie. Three factors support this conclusion: *T. californicum* has not been historically documented outside Kneeland Prairie; *T. m.* var. *montanum* occurs between 5 and 16 kilometers (3 and 10 miles) from Kneeland Prairie, both to the south and northeast; and no serpentine exposures are known to occur between Kneeland

Prairie and the coast (approximately 19 kilometers [12 miles]). However, potentially suitable, unsurveyed habitat is located on private lands both to the north and south of Kneeland Prairie, and on Six Rivers National Forest to the east. Although it is unlikely, *T. californicum* could conceivably occur outside Kneeland Prairie, in habitat isolated from the Kneeland site by populations of *T. montanum* var. *montanum*.

D. Population Status

Currently, the known global distribution of *Thlaspi californicum* is restricted to five semi-isolated concentrations of plants located on three small patches of serpentine outcrop (total 2.4 hectares [6 acres]) in the immediate vicinity of the Kneeland Airport, Kneeland Prairie, Humboldt County, California. Each plant concentration was referred to as an individual colony in the final rule designating critical habitat (U.S. Fish and Wildlife Service 2002), based on our uncertainty if the individual concentrations are reproductively isolated. However, for the purpose of this recovery plan, all plants within an individual serpentine outcrop are considered to be one colony, resulting in a total of three colonies. The largest colony occupies approximately 1,710 square meters (19,000 square feet) of serpentine outcrop on the west side of Mountain View Road. This colony contained about 9,920 plants in 1997, about 5,140 plants in 2001 (95 percent confidence interval of 3,884 to 6,400) (SHN Consulting Engineers & Geologists 2001), and about 8,850 plants in 2002 (95 percent confidence interval of 6,823 to 10,880) (Imper 2002). A second colony was discovered nearby in 1999 on California Department of Forestry and Fire Protection property. Sixteen plants were scattered over 54 square meters (600 square feet) of habitat at the site in 2001; 23 plants were observed in 2002. The third colony, presently including three concentrations of plants, was discovered in 1990 on the east side of the Kneeland Airport runway. In 2001, this colony contained a total of 135 plants occupying approximately 414 square meters (4,600 square feet) of habitat; 180 plants were observed in 2002. These population estimates are subject to error caused by the rhizomatous growth pattern of the species. For past sampling efforts, rosettes separated by less than about 10 centimeters (4 inches) were generally assumed to be the same individual. Further research is needed to develop a more accurate method of identifying individuals, for the purpose of standardizing population estimation.

Comparison of the only census data available for the species suggests a large annual turnover in the population; there was approximately a 48 percent decline in the overall population between 1997 and 2001, followed by a 69 percent increase between 2001 and 2002 (SHN Consulting Engineers & Geologists 1997, 2001; Imper 2002). Overall, 87 percent of the plants flowered in 1997 and 86 percent in 2001, with the remainder either in a vegetative stage or having been grazed (SHN Consulting Engineers & Geologists 2001). In 2002, 49 percent of the plants flowered; the 2002 population increase was predominantly in vegetative individuals.

With the exception of the California Department of Forestry and Fire Protection site, all habitat occupied by *Thlaspi californicum* occurs on private property.

E. Habitat/Ecosystem Description

Thlaspi californicum occurs on relatively undisturbed serpentine soils, with no well-defined soil profile and containing a high percentage of gravel and larger rock fragments. Ultramafic rocks, which include serpentinite, dunite, and peridotite, are found in discontinuous outcrops in the Sierra Nevada and Coast Ranges of California from Santa Barbara County to Humboldt County. The chief constituent of the parent rock is a variant of iron-magnesium silicate. Most serpentine soils are shallow, rocky, and highly erodible, and exhibit low productivity. As a result of the parent material, serpentine soils tend to be rich in magnesium, iron, and silicates, and poor in calcium, nitrogen, potassium, and phosphorus (Kruckeberg 1984).

The serpentine soils surrounding the Kneeland Airport were investigated in 2001 (SHN Consulting Engineers & Geologists 2001). In addition to the 3 occupied serpentine outcrops, 14 unoccupied outcrops occur on Ashfield Ridge. A total of 10 soil samples were collected from the 3 occupied outcrops and 3 of the unoccupied serpentine outcrops, and analyzed for various properties. Soil texture ranged from gravelly loam to very gravelly sandy loam, with the clay fraction ranging from 13 to 24 percent, and coarse fragments (greater than 2 millimeters [0.08 inches] in diameter) ranging from 19 to 51 percent by volume.

With one exception, all soils were mildly basic (pH range 6.9 to 7.6). Organic matter ranged from 1.4 to 3.7 percent by dry weight. Macronutrient levels were as follows: total nitrogen (N) (0.03 to 0.10 percent); NO3-N (0.6 to 1.4 parts per million); NH4-N (1.0 to 2.1 parts per million); total phosphorus (115 to 428 parts per million); extractable phosphorus (6 to 9 parts per million); total potassium (14 to 96 parts per million); total calcium (0.2 to 0.9 equivalents per 100 grams [3.5 ounces] soil); total magnesium (4.2 to 8.6 equivalents per 100 grams [3.5 ounces] soil). Average soil temperatures recorded at 12 centimeters (5 inches) beneath the surface at nine locations on the serpentine outcrops ranged from 7.2 degrees Celsius (45 degrees Fahrenheit) in March to 26.6 degrees Celsius (80 degrees Fahrenheit) in late July (SHN Consulting Engineers & Geologists 2001).

The same investigation found little difference between serpentine soils occupied by *Thlaspi californicum* and those not occupied. No obvious differences were seen with respect to the majority of macro- and micronutrients analyzed, soil water holding capacity, or particle size distribution. However, soils sampled within occupied habitat consistently contained higher levels of NO_3-N (1.1 to 1.4 parts per million), and there was a strong relationship between occurrence of *T. californicum* and cooler soil temperatures during the growing season.

However, among the serpentine outcrops in Kneeland Prairie, *Thlaspi californicum* appears to grow best in soils that are intermediate in fertility, but relatively free of exotic plants compared to the surrounding prairie. Possible factors related to the lower incidence of exotic species in optimum *T. californicum* habitat include: 1) lower calcium/magnesium ratio, 2) slightly higher pH (7.1 compared to 6.9), and 3) generally lower levels of macronutrients. The results also indicated high arsenic levels in soil could also be a factor limiting exotic species. Further research is necessary to determine whether differences in soil moisture regime or microclimate exist between the occupied and unoccupied serpentine outcrops.

Habitat occupied by *Thlaspi californicum* includes the full range of aspects, and exhibits both convex and concave microrelief. Slope angle generally ranges between

20 and 70 percent; elevation ranges between 870 and 900 meters (2,700 and 2,800 feet) above mean sea level.

The Kneeland Prairie serpentine deposit is located approximately 24 kilometers (15 miles) from the Pacific Ocean, the closest to the coast of any known deposit in Humboldt County (SHN Consulting Engineers & Geologists 1997). Distribution maps for *Thlaspi montanum* var. *montanum* (a taxon which included *T. californicum* at that time) prepared by Holmgren (1971) showed Kneeland Prairie to be at the western edge of the distribution, which covers most of the western United States. With an unimpeded exposure to the coast, the climate in Kneeland Prairie is undoubtedly more maritime than that of the more inland serpentine deposits located near Iaqua Buttes and Horse Mountain, Humboldt County (which support *T. m.* var. *montanum*). Average annual precipitation recorded approximately 8 kilometers (5 miles) south of the prairie was 150 centimeters (59 inches) for the period 1939 to 1969 (California Department of Water Resources 1975). Summer fog is a common feature in the prairie. As a result, the serpentine flora there exhibits more coastal species than do the more inland deposits.

Typically, vegetation on serpentine soils is sparse and stunted, referred to as "serpentine barrens". The causes of this syndrome have been traced to heavy metal toxicity and nitrogen deficiency (Kruckeberg 1984). These specialized conditions have given rise to a high degree of endemism. *Thlaspi californicum* and the related *T. montanum* var. *montanum* are both serpentine endemic species within California.

The botanically rich serpentine flora in Kneeland Prairie includes the following species (in descending order of percent cover), all native to northern California: *Festuca rubra* (red fescue), *Eriophyllum lanatum* (common woolly sunflower), *Koeleria macrantha* (junegrass), *Lomatium macrocarpum* (large-fruited lomatium), *Elymus glaucus* (blue wildrye), *Plectritis brachystemon* (short-spurred plectritis), *Aspidotis densa* (cliffbrake), *Eriogonum nudum* (naked buckwheat), *Viola hallii* (Hall's violet), *Lotus humistratus* (hill lotus), *Minuartia douglasii* (Douglas' sandwort), *Zigadenus micranthus* (small-flowered death camas), *Dichelostemma capitatum* (blue dicks), and *Epilobium minutum* (small-flowered willow herb). No trees or shrubs are present (SHN Consulting

Engineers & Geologists 1997). Within Kneeland Prairie, the distribution of *Thlaspi californicum* generally coincides with *V. hallii*. Although not rare, *V. hallii* is endemic to serpentine habitat in northwestern California and southern Oregon, and may serve as an indicator species for suitable *T. californicum* habitat within the prairie (SHN Consulting Engineers & Geologists 1997).

Kneeland Prairie has been subject to unrestricted cattle grazing for at least a century. The current level of grazing within the prairie appears to be relatively low. The unique serpentine soils present within *Thlaspi californicum* habitat support low total plant cover (typically less than 40 percent) and do not support many of the desirable forage species available in the nearby pasture. Although no quantitative data are available, current impacts from cattle within the serpentine outcrops seem to be minimal. Little difference in species composition was noted between occupied *T. californicum* habitat excluded from cattle grazing since at least 1980 (California Department of Forestry and Fire Protection site), and habitat currently opened to grazing (SHN Consulting Engineers & Geologists 2001), suggesting the cattle are having minimal impacts.

No information was available indicating the importance of fire in maintaining *Thlaspi californicum*, or its habitat. Historically, fire played an important role in maintaining grassland and oak woodland habitats on the North Coast (Barbour and Major 1977), of which Kneeland Prairie is typical, and it is expected to have influenced the long-term character of the soils and vegetation associated with the serpentine outcrops located there. However, the presumed fire suppression on Ashfield Ridge over the past century or more suggests at least these serpentine outcrops do not require frequent fire to maintain their suitability for *T. californicum*.

F. Associated Candidate Species

No Federal candidate species are known to occur in Kneeland Prairie. Kneeland Prairie is the type locality for *Fritillaria purdyi* (Purdy's fritillary), a lily endemic to serpentine outcrops in northwestern California. *Astragalus rattanii* ssp. *rattanii* (Rattan's milk-vetch) is also endemic to northwest California. Both are considered species of limited distribution by the California

Native Plant Society (California Native Plant Society 2001), and both occur in several of the serpentine outcrops surrounding the Kneeland Airport (SHN Consulting Engineers & Geologists 1997).

G. Life History/Ecology

The biology and ecology of *Thlaspi californicum* are poorly understood. The three semi-isolated colonies are all separated from each other by Mountain View Road and/or the Kneeland Airport runway. We do not know if the colonies are reproductively isolated. *Thlaspi californicum* normally begins blooming in March, with seed set in April or May and dehiscence of fruits (release of seeds) beginning in June. Approximately 86 percent of the individual plants were reproductive in 1997 and 2001 (SHN Consulting Engineers & Geologists 2001). Absence of flowering was attributed to either grazing or immaturity.

Holmgren (1971) completed an extensive biosystematic study of the genus *Thlaspi.* Unfortunately, Holmgren's investigation of genetics and hybridization included only a single California population of *T. montanum* var. *montanum* (collected near Post Creek, Trinity County, California) and no collections of *T. californicum*. Most *T. m.* var. *montanum* is diploid (2N = 28), although tetraploid populations were occasionally encountered, some in close proximity to diploid populations. Although the floral characteristics (white, small, and inconspicuous petals; anthers pointed in) of the genus are consistent with self-pollination, field and greenhouse observations of *T. m.* var. *montanum* suggested it is primarily an outbreeder. *Thlaspi m.* var. *montanum* is also slightly odoriferous, a characteristic consistent with outcrossing. In contrast, congeners (members of the same genus) that appear to be inbreeding were not odoriferous. In the Medicine Bow Mountains of Wyoming, *T. m.* var. *montanum* was commonly visited by a variety of insect pollinators, including members of the Muscidae (common flies), Empididae (dance flies), Syrphidae (flower flies), Halictidae (mining bees), and Chrysomelidae (leaf beetles) (Holmgren 1971). The breeding system of *T. californicum* is likely similar to that of *T. m.* var. *montanum*, based on their close taxonomic relationship. Studies are needed to clarify the breeding system of *T. californicum*.

Seed germination and propagation requirements of *Thlaspi californicum* have not been studied. One attempt to germinate *T. californicum* seed in the 1990's failed completely; that attempt included no pretreatment of seed, suggesting dormancy may not have broken (personal communication, Dr. M. Messler, 2001). Given that *T. montanum* var. *montanum* occurs more inland and normally at higher elevation, it may be reasonable to expect *T. m.* var. *montanum*, and perhaps *T. californicum*, to require cold stratification (exposure to cold temperature for an extended period prior to germination at warm temperature) to germinate. This hypothesis needs to be tested.

H. Reasons for Decline and Current Threats

Available habitat for *Thlaspi californicum* in Kneeland Prairie has been significantly reduced over the past century, as a result of construction of Mountain View Road, Kneeland Airport, and the helitack base (Imper 1990). In the case of the helitack base, construction was completed after passage of the California Environmental Quality Act. The species is potentially threatened by future impacts related to proposed modifications to the airport and possible realignment of the road. Various types of random events also pose a future threat to the species. The discussion below is organized according to the five listing critera under section 4(a)(1) of the Endangered Species Act.

1) Present or threatened destruction, modification or curtailment if its habitat or range.

Evidence suggests *Thlaspi californicum* has always been restricted to Kneeland Prairie. Within Kneeland Prairie, habitat for *T. californicum* has been significantly reduced over the past 37 years. Prior to 1964, an estimated 2.4 hectares (6 acres) of contiguous serpentine outcrop habitat existed at the top of Ashfield Ridge (Imper 1990). Approximately 50 percent of the habitat was subsequently lost due to construction of the airport, realignment of Mountain View Road, and construction of the California Department of Forestry and Fire Protection helitack base (Meyers 1991). In addition to losing habitat that could otherwise be occupied, decreasing habitat size and increasing isolation can negatively affect reproductive success in some species (Wolf and Harrison 2001).

Humboldt County is in the planning stage for upgrading the Kneeland Airport. The initial consultant report (Hodges & Shutt 1993) recommended extending the length of the runway by nearly 390 meters (1,200 feet), and the width by 3 meters (10 feet), and construction of a new parking area to meet Federal Aviation Administration setback standards. The slopes adjacent to the airport are often steep and unstable, and severely constrain any modifications to the airfield configuration. The west side of the runway (within *Thlaspi californicum* unoccupied, potential habitat) and the east side of the runway (adjacent to the occupied habitat) are being considered as possible locations for the parking area. Due to site conditions, the runway can only be extended to the south, which would potentially affect unoccupied serpentine habitat.

In addition to the threat from a proposed expansion of the airport, the serpentine habitat and population of *Thlaspi californicum* are potentially threatened by realignment of Mountain View Road, which could be conducted concurrently with, or independent of, the runway expansion.

2) Overutilization for commercial, recreational, scientific, or educational purposes.

Thlaspi californicum habitat is not currently significantly affected by commercial or recreational activities. All of the occupied habitat is private or State-owned, and posted no trespassing. Occasional human visitation and use by those interested in the botanical resources occurs, but that use appears minor. There is no known threat from collection of the plants themselves.

3) Disease or predation.

Disease and grazing by native animals are not known to be significant threats. for *Thlaspi californicum*. Cattle are grazed throughout the prairie and surrounding the airport, and cattle trails penetrate the two largest colonies. The third colony located on State land is fenced to exclude grazing. The impacts of the ongoing cattle grazing are not quantified, but available evidence suggests they are minimal at the current (low) stocking level. At higher stocking levels, livestock are expected to affect the species with increased trampling or

consumption of plants. Damage to plants could hinder reproduction. Other potential direct impacts on the habitat with increased cattle grazing could include increased erosion and soil compaction, and effects on resident pollinators, particularly ground-nesting bees (Sugden 1985). A change in livestock grazing intensity may also influence community composition of the surrounding grasslands, which could have indirect impacts on *T. californicum* by influencing habitat for pollination or dispersal agents.

4) Inadequacy of existing regulatory mechanisms.

The majority of historical loss of *Thlaspi californicum* habitat occurred prior to passage of the California Environmental Quality Act in 1970, and Federal protection of the species under the Endangered Species Act in 2000. However, these regulations provide only limited protection on private land. When the California Department of Forestry and Fire Protection constructed the Kneeland helitack base in 1980 (eliminating a significant portion of the suitable habitat), the project was subject to the California Environmental Quality Act. A Negative Declaration was filed, which mistakenly omitted consideration of potential impacts on *T. californicum*. The Humboldt County Planning Department required an after-the-fact botanical assessment to issue a conditional use permit, which identified the impacts on *T. californicum* and appropriate mitigation (Imper 1990). No mitigation was required by Humboldt County. Since virtually the entire distribution of *T. californicum* is located on privately owned grazing land, many activities which might negatively affect the species are not regulated by the California Environmental Quality Act or the Endangered Species Act. *T. californicum* is not State listed.

5) Other natural or manmade factors affecting its continued existence.

Due to the highly restricted population, *Thlaspi californicum* is vulnerable to destruction of all or a significant portion of its range as a result of random events such as: a) contaminant, herbicide, pesticide spills emanating from the airport, helitack base, and Mountain View Road; b) soil erosion; c) drought; d) fire; and e) exotic species encroachment. Contaminant spills or fire are generally catastrophic in nature, with acute effects, while the effects of soil erosion and

drought may occur over longer periods. The spread and associated impacts of exotic species encroachment may occur over long periods, and be difficult to detect. In each case, periodic monitoring is necessary to identify threats early, so that compensatory action may be taken.

The combination of limited range, a single population, and restricted habitat makes *Thlaspi californicum* susceptible to extinction or extirpation due to random events, such as fire, disease, or other occurrences (Shaffer 1981, 1987; Primack 1993, Meffe and Carroll 1994). Such events are a concern when the number of populations or geographic distribution of a species are severely limited.

Habitat for *Thlaspi californicum* has become progressively fragmented since the original construction of Mountain View Road, presumably in the 1800's. As a result, what probably was one large population spread across Ashfield Ridge is now fragmented into three relatively small and disjunct colonies, which probably function largely independently. Of course, many species endemic to serpentine substrates could be described as naturally fragmented due to the often patchy distribution of that geology. The issue of fragmentation is considered important in this case due to the small size of the remaining serpentine patches. In general, smaller serpentine outcrops support a higher number of alien species (Harrison 1999). Smaller outcrops may also be more vulnerable to recreational impacts, trampling, and modification of the unique serpentine soil chemistry as a result of enrichment from the surrounding meadow system (SHN Consulting Engineers & Geologists 2001). In addition, habitat fragmentation increases external threats by bringing sources of disturbance closer, and increasing the amount of habitat near edges. Conserving several small, disjunct habitat fragments presents greater biological and operational difficulties than a single large habitat area (Ehrlich and Murphy 1987).

I. Conservation Measures

We have funded several projects for *Thlaspi californicum*, including development of a monitoring protocol, population monitoring, habitat characterization, population inventories of suitable habitat, and a genetics study involving *T. californicum* colonies and *T. montanum* var. *montanum*. The current

monitoring protocol (SHN Consulting Engineers & Geologists 2001), which we funded, provides a methodology for estimation of the total population and a basic description of the habitat associated with the principal colony.

The Pacific Lumber Company Habitat Conservation Plan (Pacific Lumber Company 1999) covers lands immediately east of the *Thlaspi californicum* population. However, *T. californicum* is not a covered species under this Habitat Conservation Plan. Although suitable habitat occurs on Pacific Lumber Company lands, *T. californicum* has not been documented there. The Habitat Conservation Plan requires surveys for rare plant species, such as *T. californicum*, which potentially occur on covered lands. When detected in areas potentially affected by a covered activity, Pacific Lumber Company shall implement feasible measures to avoid, minimize, and/or mitigate significant adverse effects (measures to be approved by us).

The California Department of Forestry and Fire Protection has prepared a draft Policies and Procedures Directive governing agency activities affecting the *Thlaspi californicum* habitat located on their property (CDFFP 2001). That directive requires delineation of the sensitive habitat, restricts the kinds of activities to be conducted within the habitat, and includes various means for ensuring agency personnel are aware of the policy.

No section 7 consultations addressing *Thlaspi californicum* have been completed to date. The proposed modification of the Kneeland Airport will trigger section 7 consultation since the project will receive Federal Aviation Administration funding.

One critical habitat unit for *Thlaspi californicum* has been designated (U.S. Fish and Wildlife Service 2002); it consists of 30 hectares (74 acres) immediately surrounding the Kneeland Airport, on Ashfield Ridge. Critical habitat is defined as habitat containing all of the physical and biological features essential to the species' conservation, and that may require special management considerations or protection. In this case, the critical habitat includes all serpentine outcrops within the critical habitat unit, and prairie grasslands and oak woodlands within 30 meters (100 feet) of the serpentine outcrop area on Ashfield Ridge.

J. Recovery Strategy

The ultimate goal of any recovery plan is to preserve species in their native habitats. At the same time, off-site preservation of plant propagules can provide insurance against catastrophic events and facilitate future reintroduction efforts.

Based on our current knowledge, *Thlaspi californicum* has always been restricted to Ashfield Ridge in the immediate vicinity of the Kneeland Airport. The closely related *T. montanum* var. *montanum* occurs in close proximity both to the south and northeast. Therefore, until evidence indicates otherwise, there appears to be no justification for extending recovery efforts beyond the serpentine habitat located on Ashfield Ridge.

The first step toward recovery of *Thlaspi californicum* is to protect the entire extant population and its habitat. Since virtually the entire population occurs on private land, successful recovery must necessarily involve habitat acquisition, conservation easements, or other mechanisms securing long-term protection. Protection of *T. californicum* habitat will also require maintaining the natural processes upon which the species depends, and developing responsive management to counter potentially detrimental processes, such as exotic species encroachment.

Establishment of new colonies is considered a necessary recovery element to compensate for the historical decline in the population, and provide additional protection from catastrophic factors. Although repatriation/introduction efforts will focus on the existing exposed serpentine habitat, potential opportunities may exist for restoration of serpentine habitat buried during past construction, or exposure of serpentine geology where it is (naturally) situated near the ground surface. The latter effort, in particular, would be experimental in nature and such plans should be approved by independent peer-review before proceeding; such restoration would be inappropriate for mitigation of project impacts. Augmentation of existing colonies may be necessary; propagules used will not be moved among existing colonies unless future research shows it is appropriate.

Since we know relatively little about *Thlaspi californicum* and its ecology, successful recovery will require more thorough knowledge of the natural fluctuations in population size, growth requirements, and threats to the species. For example, the plant currently occupies only a small portion of the serpentine habitat near the airport. Defining the underlying factors responsible for its present distribution should improve the likelihood of successful recovery in the future. Research on the genetic relationships between the existing colonies will help guide future repatriation/introduction efforts. The small extant population of *T. californicum* and limited amount of suitable habitat also make this species particularly vulnerable to chance events, either anthropogenic or natural in origin. Therefore, in addition to further research, routine monitoring is crucial for detecting potential threats before they jeopardize the population. The recovery effort should include additional inventories intended to locate new populations, although that likelihood appears low.

Finally, maintaining successful partnerships with the California Department of Forestry and Fire Protection, and the single private landowner on whose land the entire *Thlaspi californicum* population and its habitat occur, is crucial to the successful implementation of this recovery plan and conserving the extant population.

II. RECOVERY

A. Objectives

The primary objectives of this recovery plan are to protect the existing population of *Thlaspi californicum* and establish new, viable colonies resulting in removal of this species from the list of endangered species. Specific actions are proposed to reduce or eliminate the causes of endangerment identified in the final rule listing *T. californicum* as endangered (U.S. Fish and Wildlife Service 2000*a*) (Table 1). Subject to budgetary limitations, with aggressive effort *T. californicum* could potentially qualify for delisting in 10 to 15 years.

Table 1. Proposed actions to reduce or eliminate threats to *Thlaspi californicum*.

LISTING FACTOR†	THREAT	STILL A THREAT?	ACTION NUMBERS	RECOVERY CRITERIA
A	Threat of airport expansion and road realignment	Yes	1.1	1A
B	NA			
C	Potential overgrazing by cattle	Yes	1.1, 1.4, 6.2	1A
D	Inadequate regulatory protection	Yes	1.3, 1.4	1A, 2B
E	Chance events leading to extinction	Yes	1.2, 2.1, 2.2, 3.1, 3.2, 3.3, 4, 5, 6.1, 6.3, 7, 8	1A, 1B, 1C, 2A, 2B, 2C

† Listing factors, as identified in section 4(a)(1) of the Endangered Species Act, are: A) the present or threatened destruction, modification, or curtailment of its habitat or range; B) overutilization for commercial, recreational, scientific, or educational purposes; C) disease or predation; D) the inadequacy of existing regulatory mechanisms; E) other natural or manmade factors affecting its continuing existence.

The general categories of recovery and long-term conservation actions emphasized in this plan, irrespective of priority, include 1) protection of the extant population and its habitat, involving acquisition or other legal protective

mechanism, monitoring, and coordination with the landowners; 2) research on the species biology and habitat requirements; 3) augmentation of existing colonies and establishment of new colonies; and 4) *ex situ* (away from original location) conservation measures including artificial rearing and seed banking. A further explanation of the actions necessary to conserve this species, arranged according to priority, is given in the following stepdown narrative and the implementation schedule. Since various methods needed to implement the recovery plan are untested for this species, and the requirements of the species are not fully known at this time, future management must be "adaptive" or flexible based on new research and monitoring data. For example, control of invasive nonnative plants does not appear to be a high priority at this time, but could become an issue over time.

B. Recovery Criteria

1. Reclassification to Threatened Status

Reclassification to threatened status will be evaluated when all the following conditions have been met:

a) The three extant colonies are protected and stable. Protected sites are defined as either: i) sites owned by a government agency or private conservation organization that identifies maintenance of the species as the primary management objective for the site, or ii) sites protected by a permanent conservation easement or covenant that commits present and future landowners to the conservation of the species. To be deemed stable, the present largest population must maintain a running average population size (mean of annual mean population estimates) of at least 7,000 individuals, and the 2 other presently extant colonies must maintain a running average population size of at least 500 individuals each. Running averages will be determined over the most recent 10 years, or an appropriate period justified on the basis of population research.

b) Reliable seed germination and propagation techniques for the species are understood and demonstrated.

c) Genetic material, in the form of seeds adequately representing the genetic diversity within the species, is stored in a facility approved by the Center for Plant Conservation.

2. Removal from the Endangered Species List

In order to be considered for delisting, not only must the presently extant colonies be protected, but the population as a whole must be expanded to offset natural fluctuations (as yet unknown), augment reproductive capacity, and provide protection against random catastrophic events.

Repatriation or introduction efforts involving rare species, particularly on serpentine soils, are necessarily experimental due to the inherent complexity and high degree of uncertainty involved (Falk *et al.* 1996). Any attempts at repatriation or introduction must recognize that: a) determining an outcome takes time (years, and perhaps decades) and b) planning and long-term commitment are essential. As a result, repatriated and introduced populations should not be counted toward recovery goals until they have persisted without intervention through the natural range of climatic variation, which may require a decade or more. Guidelines for planning rare plant reintroductions are provided by Falk *et al.* (1996). The uncertainty associated with introduction efforts does not detract from their importance, since the long-term survival of some species is unlikely in the absence of repatriation/introduction efforts.

The delisting criteria primarily emphasize specific colony and population size thresholds, based on the assumption that the probability of population persistence is higher for larger populations. Larger populations are, in general, less susceptible to random genetic and demographic events that put smaller populations at greater risk (Barrett and Kohn 1991, Ellstrand and Elam 1993). To protect *Thlaspi californicum* from these and other potentially broad-scale impacts that could affect the existing colonies (for example, mass wasting [downslope soil movement], drought, fire, contaminant spill), the delisting criteria include the establishment of new colonies removed from the main concentration. Establishment of colonies in habitats subject to slightly different climatic

conditions (for example, moisture availability, temperature, wind exposure), will reduce the probability of extinction associated with climatic extremes.

The degree to which the *Thlaspi californicum* population can be expanded is unknown. The largest colony of the species, which in 1997 included approximately 9,920 plants scattered over 0.28 hectares (0.72 acres) (SHN Consulting Engineers & Geologists 1997), is assumed to represent close to full occupation. The two other extant colonies currently occupy only a small portion of the outcrops where they occur, and thus, in theory, have abundant room for expansion. However, because the factors currently limiting the plants' population in these areas are unknown, it is uncertain whether population expansion is possible. In addition, 14 unoccupied serpentine outcrops are located in the vicinity of Kneeland Airport. However, all but two of those outcrops are smaller than 0.08 hectares (0.2 acres), and seven are smaller than 0.04 hectares (0.1 acres), which limits their carrying capacity and perhaps their suitability for *T. californicum*.

It has not yet been determined which, if any, of the unoccupied serpentine outcrops will actually support *Thlaspi californicum*. Using a density equal to the fully occupied habitat (1997 estimate), the 2 outcrops exceeding 0.08 hectares (0.2 acres) theoretically could support more than 2,800 plants, while the 7 outcrops smaller than 0.04 hectares (0.1 acres) theoretically can support somewhat less than 1,400 plants. Based on the above analysis, and the uncertainty in habitat suitability, expansion of the 2 smallest extant colonies and establishment of 2 colonies on new outcrops, each to contain at least 500 plants, is our goal at this time. This goal ensures each colony will have a population large enough to be reasonably stable, yet allows for some flexibility in how the colonies should contribute to attaining the total population size of 10,000 plants necessary for delisting. However, further research (*e.g.*, genetics) is needed to determine the most appropriate approach for such efforts and any such efforts must be conducted in accordance with a peer-reviewed augmentation/introduction plan which will be developed during implementation of this recovery plan. The augmentation/introduction plan will comply with our controlled propagation policy (U.S. Fish and Wildlife Service 2000*b*).

Survey results from 1997 (10,100 plants), 2001 (5,300 plants), and 2002 (9,000 plants) indicate the total population may fluctuate substantially from year to year (SHN Consulting Engineers & Geologists 1997, 2001). However, based on the amount of potential habitat lost to development since 1960 (approximately 50 percent), the pre-1960 population is likely to have exceeded 10,000 plants, even during a relatively poor year. Therefore, our goal at this time is restoration of the population to the presumed pre-1960 condition, or a minimum size of 10,000 plants.

A monitoring program is necessary to determine if the recovery criteria for reclassification or delisting have been met. Post-delisting monitoring will also be required to ensure that any long-term factors not fully addressed in this recovery plan do not threaten the population in the foreseeable future once the species has been delisted.

Delisting will be considered when, in addition to the criteria for downlisting, all of the following conditions have been met:

a) The running average for the entire population is a minimum of 10,000 individuals for a period of 10 years, or an appropriate period justified on the basis of population research. The period may run concurrently with the downlisting period in II.B.1.a above if this goal for the size of the entire population is met.

b) At least five protected and stable colonies (populations on distinct serpentine outcrops) are distributed throughout the current and historic range of the species. For a site to be considered protected, it must be either owned by a government agency or private conservation organization that identifies maintenance of the species as the primary management objective for the site, or the site must be protected by a permanent conservation easement or covenant that commits present and future landowners to the conservation of the species. To be deemed stable, the largest presently extant colony must maintain a running average population size of at least 7,000 individuals, and colonies on four additional outcrops must be shown to be naturally reproducing and maintain a running average population size

of at least 500 individuals each for a period of 10 years, or an appropriate period justified on the basis of population research.

c) Monitoring of population size, trends, other pertinent characteristics, and habitat quality has begun and will continue for the post-delisting monitoring period.

C. Stepdown Narrative of Recovery Actions

The following list of actions are arranged in order of priority for conserving *Thlaspi californicum*. The seven primary actions include multiplel elements, such as habitat acquisition or management, monitoring, research, or outreach, that are necessary to complete the primary action.

1. Protect the current population and its habitat (Priority 1).

The single known *Thlaspi californicum* population consists of three colonies scattered on relatively small isolated fragments of serpentine habitat, totaling approximately 1.1 hectares (2.8 acres). Suitable unoccupied habitat is limited to a few other serpentine outcrops on Ashfield Ridge. The colonies are threatened by activities associated with Mountain View Road (traffic, maintenance, potential realignment); expansion and maintenance of the Kneeland Airport; activities conducted by the private landowner; and/or activities related to operation of the California Department of Forestry and Fire Protection helitack base. Since *Thlaspi californicum* is restricted to specific soils in Kneeland Prairie, maintaining the integrity of as much as possible of that very limited habitat is essential to future recovery efforts. Due to the imminent threat posed by the airport modifications and other factors, and the species' restricted range, this task is assigned a priority level of 1.

1.1. Secure and/or protect currently occupied and presumed suitable habitat.

All occupied serpentine outcrops and an amount of unoccupied but suitable habitat on Ashfield Ridge adequate to support recovery must be

secured and protected in a manner that will ensure future conservation of the species in perpetuity. Two alternatives are available: a) acquisition by a government agency or private conservation organization that identifies maintenance of the species as the primary management objective for the site, or b) protection and management in accordance with a permanent conservation easement or covenant that commits present and future landowners to the conservation of the species and allowing access for monitoring.

1.2. Continue to implement the current annual monitoring plan for *Thlaspi californicum*; expand its scope to include characterization of population characteristics and life history and periodic review of the California Department of Forestry and Fire Protection Policies and Procedures Directive pertaining to *T. californicum* (CDFFP 2001).

Long-term survival of this species will depend on our ability to detect long-term changes in the population or habitat and to respond accordingly. The current monitoring plan (SHN Consulting Engineers & Geologists 2001) includes annual population estimates and basic habitat information. Populations naturally fluctuate due to numerous environmental and intrinsic factors. A better understanding of the magnitude, frequency, duration, and causes of these fluctuations is necessary to ensure long-term survival and enable interpretation of the species' response to management activities. The current monitoring protocol should be amended to record demographic and individual life history information (*e.g.*, typical recruitment and mortality rates and causal factors, relationship between population fluctucation and habitat and climate), enabling more accurate analysis of population trends and viability. The monitoring should also include an assessment of the effectiveness of management under the California Department of Forestry and Fire Protection Policies and Procedures Directive regarding the penny-cress, when that document has been finalized.

1.3. Finalize and implement the 2001 draft California Department of Forestry and Fire Protection Policies and Procedures Directive pertaining to *Thlaspi californicum*.

The California Department of Forestry and Fire Protection has prepared a draft Policies and Procedures Directive (CDFFP 2001) briefly outlining their future management of the *Thlaspi californicum* colony and serpentine habitat located on the helitack base property. Conservation of this habitat, and expansion of the colony located on that property is considered crucial to successful recovery of the species. If monitoring indicates the directive is not effective in protecting *T. californicum* and its habitat, or the directive is not finalized, a more formal conservation strategy should be developed outlining protective measures in detail.

1.4. Provide educational opportunities and facilitate coordination among stakeholders.

Due to the very limited distribution of this species, and history of impacts, it is essential to this recovery plan that all stakeholders, including the private property owners, California Department of Forestry and Fire Protection, and Humboldt County, are given every opportunity to participate in implementation of this recovery plan. This includes a commitment from us to keep them informed about the results of research on the species and progress in the recovery effort. In particular, the landowners should be kept apprised of the results of research indicating the response of *Thlaspi californicum* to various land management activities. Continual coordination among stakeholders will help avoid or minimize impacts to the population as a result of road maintenance and airport expansion activities conducted by Humboldt County, and activities conducted by the California Department of Forestry and Fire Protection and the private landowner. Due to the large portion of the occupied habitat located on private property, it is absolutely essential that we maintain a working relationship with the landowner to facilitate recovery efforts and eventually secure delisting.

2. Conduct research on the species' biology (Priority 2).

A thorough understanding of the biology of *Thlaspi californicum* is necessary to select optimal habitat for repatriation/introduction efforts, and manage the habitat consistent with the requirements of the species. This task is considered necessary to prevent a significant decline in the species population and its habitat, and is therefore assigned a priority level of 2.

2.1. Characterize genetic variation within and between known colonies of the species.

The nature and distribution of genetic variation within the species should be characterized and understood prior to any seed collection for archival offsite storage, any movement of seed between colonies, and/or any repatriation or introduction projects. A preliminary investigation of genetic differences among the colonies, and between *Thlaspi californicum* and the closely related *T. montanum* var. *montanum* was recently completed. Research is also needed on the extent of clonal growth within the population, and development of a method to standardize identification of individuals for the purpose of population estimation.

2.2. Investigate reproductive biology.

Thlaspi californicum currently occupies small, isolated fragments of remnant habitat. Information on the breeding system of the plant is needed (for example, whether it is an obligate outbreeder and if not, whether inbreeding depression occurs). A better understanding of the pollination biology of the species and the habitat requirements of pollinators is needed to ensure that management activities are compatible with required pollinators and dispersal agents.

3. Augment existing colonies and establish new colonies within Kneeland Prairie (Priority 2).

Establishment of new colonies within Kneeland Prairie will provide the best protection available against random natural occurring events that might otherwise cause its extinction. To accomplish this, a carefully prepared peer-reviewed augmentation/repatriation/introduction plan is needed, along with research into the technical aspects of successfully growing the species. This task is considered necessary to prevent a significant decline in the population as a result of impaired reproductive effort or catastrophic impacts to the population, and is therefore assigned a priority level of 2.

3.1. Identify and clarify site characteristics that are necessary to sustain *Thlaspi californicum*.

The currently known extant sites and unoccupied serpentine habitat in Kneeland Prairie vary to some degree in physical characteristics and environmental processes. These characteristics need to be better defined to maximize the probability of long-term success for managing existing sites and for establishing new colonies.

3.2. Determine optimum methods for seed germination and propagation. Develop a seedling bank available for augmentation, repatriation, and introduction efforts.

A controlled greenhouse study is needed to determine the best methods for germinating and propagating *Thlaspi californicum*. At the same time, a seedling bank may be developed for use in the augmentation/repatriation/introduction efforts plan. Subsequently, field propagation techniques need to be defined. All propagation should be conducted in accordance with our policy (U.S. Fish and Wildlife Service 2000*b*) regarding controlled propagation of species listed under the Endangered Species Act.

3.3. Develop and implement a peer-reviewed plan to augment, reintroduce, introduce, and monitor *Thlaspi californicum* in serpentine habitat within Kneeland Prairie, in consultation with all appropriate parties.

As soon as adequate information regarding field propagation techniques, habitat requirements, and other aspects of *Thlaspi californicum* biology is available, a formal plan for augmentation, repatriation and introduction should be developed. The plan should, among other items, indicate appropriate outplanting sites within the designated critical habitat, outline any additional experiments necessary to improve the outplanting success, outline methods for preparing sites and setting out plants (or sowing seed), and identify potential threats to the selected habitat that must be addressed (for example, erosion caused by surface runoff from the airport runway). The plan must be peer-reviewed by at least three appropriate independent scientists. As soon as sufficient propagated seedlings are available, the greenhouse seedlings should be outplanted to suitable habitat, and a monitoring protocol established to determine the success of outplanting.

4. Collect seed adequately representing the genetic diversity within the species and store in a Center for Plant Conservation approved facility (Priority 2).

The very limited extent and size of the only known population makes this species especially vulnerable to random environmental and anthropogenic impacts. As a hedge against the loss of significant genetic material, seed representing the full diversity within the species should be collected and stored in a Center for Plant Conservation approved facility. The distribution of seed collected should be based on the results of the genetics investigation described in Action 2.1 above. The stored seed may be used in efforts to establish new populations. This action is considered necessary to prevent a significant decline in the species population, and is therefore assigned a priority level of 2.

5. Conduct research on *Thlaspi californicum* habitat requirements that will help guide successful management of the existing and newly established colonies into the future (Priority 2).

This action is necessary to prevent a significant decline in the species population and habitat quality, as a result of potential nonnative plant species encroachment, fire, cattle grazing or natural herbivory, and is therefore assigned a priority level of 2.

5.1. Clarify the role of fire in the ecology of this species.

Fire has likely played an important role in the past maintenance of prairies on the northern Caliifornia coast, and potentially affects the quality of vegetation occurring on the serpentine outcrops. No information is available indicating the role fire plays in maintaining *Thlaspi californicum*.

5.2. Clarify the threat posed by herbivory, cattle grazing, and encroachment of nonnative plants on *Thlaspi californicum* and its habitat.

Potential threats associated with herbivory include direct removal of foliage and inflorescences, potentially reducing the vigor of plants or number of viable seeds produced in a given year. No information is available on the impacts of natural herbivores.

Cattle may have a variety of impacts on *Thlaspi californicum* and its habitat, including direct removal and trampling, potential compaction and enrichment of the soils, and introduction of nonnative species into the serpentine habitat. We have no information indicating whether serpentine habitat in the prairie is being degraded by cattle or invaded by nonnative plants over time. The rates at which species more typical of the surrounding prairie (for example, *Cynosurus echinatus* [hedgehog dogtail]) are encroaching and the degree to which each species influences the presence of *T. californicum* need to be determined in order to plan a long-term management strategy.

6. **Conduct additional surveys for new populations of *Thlaspi californicum* (Priority 3).**

Although it appears unlikely, additional populations of *Thlaspi californicum* may occur outside Kneeland Prairie. The only other known significant exposure of serpentine geology known in Humboldt County, within close proximity to the coast, is located south of Myers Flat, approximately 30 kilometers (19 miles) from the ocean (Kruckeberg 1984). There is no evidence that a botanical survey has ever been conducted of this habitat, which appears to be located entirely on private property.

Additional outcrops of serpentine may occur in unsurveyed areas near Kneeland Prairie. Two small outcrops, for which the landowner denied access, are located approximately 4.8 kilometers (3 miles) southwest of the Kneeland Airport. In addition, several outcrops, located to the south toward Bridgeville, have not been surveyed due to private access restrictions. This habitat, the serpentine outcrop located near Goat Rock, and any additional suitable habitat discovered within 16 kilometers (10 miles) of the Kneeland Airport should be the focus of future inventories. This action is not considered necessary to prevent a significant decline in the species population or its habitat quality, but will assist in meeting the recovery objective, and is therefore assigned a priority level of 3.

7. **Construct a fence along the west side of Mountain View Road adjacent to *Thlaspi californicum* habitat to discourage casual pedestrian use (Priority 3).**

Although pedestrian impacts within *Thlaspi californicum* habitat appear insignificant, protection of the principal colony located west of Mountain View Road would be enhanced by installation of a fence along the road. A fence installed at the upper edge of the habitat, and posted "no trespassing" should serve to discourage some of the unauthorized entry to the area. The fence may also prevent unauthorized sidecast of waste by Humboldt County Roads maintenance personnel. This action is not considered necessary to

prevent a significant decline in the species population or its habitat quality, but will assist in meeting the recovery objective, and is therefore assigned a priority level of 3.

8. Pursue opportunities as they become available, to restore or create additional suitable habitat for *Thlaspi californicum* (Priority 3).

As a result of modifications to the airport, helitack base, or other developments near the Kneeland Airport, land may become available for restoration or creation of suitable *Thlaspi californicum* habitat. A small amount of former serpentine outcrop was buried in conjunction with construction of the airport and other facilities in the area. That habitat could be reexposed and incorporated into the plan for establishing new colonies. In addition, it is likely that much of the surrounding ridgetop contains a core of serpentine geology, which could be exposed in conjunction with future development or mitigation projects. With proper planning, such habitat might provide an opportunity to expand the population. Creation of *T. californicum* habitat by exposing the subsurface geology would entail a detailed recreation of suitable soils for the plant, and would be considered highly experimental; such a proposal should be approved by formal peer review before being initiated. This action is not considered necessary to prevent a significant decline in the species population or its habitat quality, but will assist in meeting the recovery objective, and is therefore assigned a priority level of 3.

III. IMPLEMENTATION SCHEDULE

The Implementation Schedule is a guide for meeting the objectives discussed in the Recovery Section of this plan. This schedule indicates action priorities, action numbers, brief action descriptions, duration of actions, responsible agencies, and estimated costs. These actions, when accomplished, should bring about the recovery of the species and protect its habitat. Priorities in the first column of the following implementation schedule are assigned as follows:

Priority 1:	An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.
Priority 2:	An action that must be taken to prevent a significant decline in the species' population/habitat quality or some other significant negative impact short of extinction.
Priority 3:	All other actions necessary to meet the recovery objective.

Key to Acronyms used in Implementation Schedule

USFWS	U.S. Fish and Wildlife Service (Arcata Field Office)
CDFFP	California Department of Forestry and Fire Protection
HUM CO.	Humboldt County
CDFG	California Department of Fish and Game
TBD	To be determined
Ongoing	To continue until the action is no longer necessary for recovery
*	Indicates partner likely to take the lead on, or play a major role in, implementing the action.

Implementation Schedule for Recovery of *Thlaspi californicum*											
ACTION PRIORITY	ACTION NUMBER	ACTION DESCRIPTION	ACTION DURATION (YEARS)	RESPONSIBLE PARTY	COST PROJECTIONS ($1,000's)						COMMENTS
					TOTAL	FY1	FY2	FY3	FY4	FY5	
1	1.1	Secure and protect occupied and suitable habitat	10	USFWS*, CDFG, CDFFP, HUM CO.,	80				80		Cost based on fair market value; actual cost may vary
1	1.2	Continue to implement annual monitoring of all colonies, expand scope of monitoring to include population characteristics and life history, and periodically review effectiveness of CDFFP Policies Directive	10	USFWS*	45	4	4	4	4	4	$5,000 spent to date
1	1.3	Finalize and implement CDFFP Policies and Procedures Directive	10	CDFFP*	5	0.5	0.5	0.5	0.5	0.5	
1	1.4	Provide educational opportunities and facilitate coordination among stakeholders	10	USFWS*, CDFFP, HUM CO., CDFG	10	1	1	1	1	1	

Implementation Schedule for Recovery of *Thlaspi californicum*											
ACTION PRIORITY	ACTION NUMBER	ACTION DESCRIPTION	ACTION DURATION (YEARS)	RESPONSIBLE PARTY	COST PROJECTIONS ($1,000's)						COMMENTS
					TOTAL	FY1	FY2	FY3	FY4	FY5	
2	2.1	Characterize genetic variation within and between colonies of *Thlaspi californicum* and compare to *T. montanum*	2	USFWS*	20	6	6				$8,000 spent to date
2	2.2	Investigate reproductive biology of *T. californicum*	3	USFWS*	30	10	10	10			
2	3.1	Identify and clarify site characteristics necessary to sustain *T. californicum*	3	USFWS*	20	5	5	5			$5,000 spent to date
2	3.2	Determine optimum seed germination and propagation methods. Develop a seedling bank	3	USFWS*	30		10	10	10		
2	3.3	Develop and implement a peer reviewed plan to augment, repatriate, introduce, and monitor *T. californicum*	8	USFWS*	30			9	3	3	

Implementation Schedule for Recovery of *Thlaspi californicum*											
ACTION PRIORITY	ACTION NUMBER	ACTION DESCRIPTION	ACTION DURATION (YEARS)	RESPONSIBLE PARTY	COST PROJECTIONS ($1,000's)						COMMENTS
					TOTAL	FY1	FY2	FY3	FY4	FY5	
2	4	Collect seed and secure storage at a Center for Plant Conservation approved facility	1	USFWS*	3	3					
2	5.1	Clarify the role of fire in ecology of *T. californicum*	1	USFWS*	3	3					
2	5.2	Clarify the threat posed by herbivory, cattle grazing, encroachment of non-native plants on *T. californicum* and its habitat	4	USFWS*	20	5	5	5	5		
3	6	Conduct surveys for new populations of *T. californicum*	2	USFWS*	20	8	8				$4,000 spent to date
3	7	Construct a fence along Mountain View Road adjacent to *T. californicum* habitat	1	USFWS*, HUM CO.	2		2				
3	8	Restore or create suitable habitat.	TBD	USFWS*, CDFFP, HUM CO., CDFG	TBD						Costs depend on site and method used.
					TOTAL	FY1	FY2	FY3	FY4	FY5	
Totals ($1,000's)					318+	45.5	51.5	44.5	103.5	8.5	$22,000 spent to date

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APPENDIX A. RESPONSE TO PUBLIC AND AGENCY COMMENTS ON THE DRAFT RECOVERY PLAN

Only three comments were received in response to the outreach for the draft recovery plan. The following issues summarize all comments that we received from technical reviewers, agencies, and the public, which were not otherwise responded to by directly incorporating changes into the text of the final recovery plan.

Issue: Proposed improvements at the Kneeland Airport include repair and stabilization of four slide areas. Three of these areas are of special concern because they include suitable habitat for penny-cress. Work on these slide areas may impact suitable, but unoccupied habitat. In this respect, required airport maintenance is in conflict with the draft recovery plan task of protecting suitable habitat.

Response: The recovery plan includes some flexibility on which areas of the remaining suitable habitat near the airport need to be protected. This decision will be based on ongoing research to determine the areas of suitable habitat most likely to support the plant, and contribute to attaining the numeric recovery goals as stated in this plan. Consultation under section 7 of the Act would determine whether impacts from the proposed airport improvements would jeopardize the species or result in adverse modification of critical habitat. Therefore, whether or not proposed improvements conflict with the recovery plan will depend on the nature and extent of impacts on the suitable habitat, and our assessment at that time, based on the best available science, as to whether the impacted habitat is essential to attainment of recovery for the species.

Issue: The recovery plan indicates that increased (cattle) grazing could represent a direct impact on habitat by a variety of factors including effects on resident pollinators, particularly ground nesting bees. Given the stated lack of information on pollinators for T. californicum*, the tie to the Sugden reference seems broad. Is there some information that suggests ground-nesting bees are important to* T. californicum*?*

Response: The only information available at this time is the assumption that generalist bees and/or flies likely serve as pollination agents. Of potential resident pollinators, which presumably would be affected by grazing more than non-resident pollinators, bees are expected to be the most likely agent. However, it is anticipated that non-resident pollinators are the principal pollination agent.

Issue: Who is conducting the ongoing investigation into the genetic differences among colonies, and between T. californicum *and* T. montanum *var.* montanum*?*

Response: That research is being conducted by Humboldt State University, Arcata, California.