Fassett's Locoweed Recovery Plan

Department of the Interior
U.S. Fish and Wildlife Service

Fassett's Locoweed
(*Oxytropis campestris* var. *chartacea*)
Recovery Plan

Prepared by:

June M. Dobberpuhl
Bureau of Endangered Resources
Wisconsin Department of Natural Resources
Box 7921
Madison, WI 53707

for
Region 3
U.S. Fish and Wildlife Service
Twin Cities, MN 55111

Approved: _____
Regional Director, U.S. Fish & Wildlife Service

Date: 3/27/91

DISCLAIMER

This is the completed Fassett's Locoweed Recovery Plan. It has been approved by the U.S. Fish and Wildlife Service. Recovery objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. They represent the official position of the U.S. Fish and Wildlife Service **only** after they have been signed by the Regional Director or Director as **approved**. Approved recovery plans are subject to modifications 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. Fassett's Locoweed Recovery Plan. Twin Cities, Minnesota. 57 pp.

Additional copies may be purchased from:

Fish and Wildlife Reference Service:

5430 Grosvenor Lane, Suite 118
Bethesda, Maryland 20814
301/492-6403
or
1-800-582-3421

The fee for the Plan varies depending on the number of pages of the Plan.

ACKNOWLEDGEMENTS

Sincere appreciation is extended to Thomas A. Meyer, Bureau of Endangered Resources, Wisconsin Department of Natural Resources, for his many contributions in the course of fieldwork, report preparation, and computer assistance.

The cover design and sketch of Fassett's locoweed were prepared by Jim McEvoy of the Wisconsin Department of Natural Resources.

EXECUTIVE SUMMARY

Current Status: The species is listed as threatened. During 1988, 1989, and 1990, Fassett's locoweed was relocated at five of eight historical stations. In 1990, a population was located at a previously unknown site. It was not found at other sites with potential habitat.

Habitat Requirements and Limiting Factors: Fassett's locoweed occurs on sandy shorelines of land-locked seepage lakes. Its persistence appears to be dependent upon periodic fluctuations in lake levels and maintenance of the shoreline habitat. The species is vulnerable to disturbances of the local hydrological regime, in addition to human impacts on the lake shorelines, including development, motor vehicle use, and trampling.

Recovery Objective: Protect and maintain existing populations for the foreseeable future.

Recovery Criteria: Protect the lake shorelines with Fassett's locoweed at 5 of the currently known sites in the first 3 years of the recovery period. Population protection should also be the goal at new locations yet to be found. Protection will best be accomplished through fee simple purchase. Where this is not possible, other methods should be pursued, including conservation easement and registry.

Protected populations will be monitored and the sites managed to maintain Fassett's locoweed for the following 7 years of the recovery period. Management needs may include removal of nonnative plant species and other measures necessary to sustain the shoreline habitat.

Actions Needed:

1. Protect lake shorelines where Fassett's locoweed occurs, in all cases pursuing the strongest, appropriate method.
2. Develop and initiate management activities which are necessary to population maintenance.
3. Monitor the population at 1 site on an annual basis and at other sites every 3 years.
4. Survey suitable habitat for additional populations.
5. Develop and distribute educational materials and give presentations to interested groups concerning Fassett's locoweed and its conservation.
6. Conduct research on selected aspects of the biology and ecology of Fassett's locoweed in order to determine the best protection and management strategies necessary for long-term population survival.

~~Total Estimated Cost of Recovery:~~ The following budget is the estimated cost of recovery to the Service and all participating agencies.

Costs (000's)

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Need 6	Total
1991	100.0	10.0	2.5	0.5	5.0	----	118.0
1992	125.0	20.0	1.5	0.5	2.5	5.0	154.5
1993	75.0	10.0	1.0	---	2.5	20.0	108.5
1994+	----	10.0	5.0	2.0	2.0	25.0	44.0
Total cost of recovery:	300.0	50.0	10.0	3.0	12.0	50.0	425.0

Date of Recovery: Delisting should be initiated in 2005, if recovery criteria are met.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PART I
INTRODUCTION

BRIEF OVERVIEW

Fassett's locoweed (*Oxytropis campestris* var. *chartacea*) is a perennial legume endemic to Wisconsin. It was assigned threatened status under the U.S. Endangered Species Act on September 28, 1988 (U.S. Fish and Wildlife Service 1988). Fassett's locoweed is presently known from six sites in two counties in central Wisconsin. Its habitat, shoreline areas of seepage lakes, is threatened by current land-use patterns and vegetation changes.

DESCRIPTION OF THE TAXON

Fassett's locoweed is a herbaceous perennial and member of the legume family (Fabaceae). The plants are cespitose, acaulescent, and arise from a branching caudex (Figure 1). Numerous pinnately compound leaves are clustered at the base of the plant and flowers develop on scapose racemes. The dense, white, silky hairs covering the leaves and most other parts give the plant a silvery-grey appearance (Barneby 1952, Welsh 1960).

The leaves, 8-21 cm long, are composed of 21-27 leaflets, which are 5-20 mm in length. The leaflets are rounded at the base and have an acute tip and somewhat inrolled margins. The connate stipules are densely pilose dorsally with ciliate margins, although the short free blades (4.5-12 mm long) are glabrous (Barneby 1952, Fassett 1939). The flower scapes, 1-20 per plant, are 10-30 cm tall and covered with spreading pilose hairs. An average of 15 (range 10-20) pea-like flowers develop on each raceme. The silky-villous calyx is 6-9 mm long with the 4-6.5 mm tube ending in lanceolate teeth 1.5-2.5 mm long. Initially violet to purple in color, the corolla becomes increasingly red in hue as it senesces. It is 1.5-2 cm long, with a total keel length (including the appendage) of 10-12 mm. Individual pale yellowish pods, 1 cm long, develop from each flower. Their papery walls are covered with fine silky white or black hairs. The legumes contain numerous black, reniform seeds 1-1.2 mm wide (Barneby 1952; Fassett 1936, 1939; Fernald 1952).

Figure 1. Fassett's locoweed (*Oxytropis campestris* var. *chartacea*). Illustration by Jim McEvoy.

TAXONOMY

The genus *Oxytropis* is circumboreal in distribution with its best representation in Asia and Europe. Of the approximately 200 species in the genus, only 22 occur in North America (Welsh (1960).

The species *Oxytropis campestris* has been described as a "polymorphic, circumboreal species, which ranges across North America, Asia, and Europe (Barneby 1952, p. 249). In North America, its range extends from eastern Canada and adjacent Maine west to northern Alaska and south to northern Oregon, Colorado, South Dakota, and Wisconsin. Barneby (1952) assigns eight varieties to this taxon, most of these restricted to the Rocky Mountains or Pacific Northwest of North America.

Elisens and Packer (1980) concluded that *O. campestris* denotes a polyploid complex which "has undergone cycles of polyploidization and periods of diversification and differentiation " (p. 1830). There are no known diploids in the complex, which is suggestive of its relative antiquity. However, chromosome counts have yet to be published for all taxa, including *O. c.* var. *chartacea.* The distribution of those species with the lowest ploidy levels indicates that they survived south of the glacial margin or in unglaciated refugia. This was followed by relatively rapid diversification and spread in the Recent Epoch of the Quaternary Period, from the Present to 5,000 years ago (Elisens and Packer 1980, Paull and Paull 1977).

Plants ascribed to the genus *Oxytropis* were first collected in Wisconsin in 1928 by L. Griscom (specimen at the Herbarium of the University of Wisconsin-Madison, WIS). Fassett (1936) described this specimen and his own later collections as belonging to a new species, *O. chartacea* Fassett. However, in his treatment of the genus *Oxytropis* in North America, Barneby (1952) assigned the Wisconsin material varietal status, *O. campestris* var. *chartacea* (Fassett) Barneby. He noted that the specimens were poorly defined and suggested that they might better be referred to *O. campestris* var. *johannensis* Fern. Barneby's conclusion was upheld by Welsh (1960) in his study of the legumes of the north-central United States.

The variety *johannensis* is known from Maine, Quebec, Nova Scotia, New Brunswick,

and Newfoundland. Its nearest occurrence is nearly 1600 km northeast of the Wisconsin sites. According to Barneby (1952), *O. c.* var. *johannensis* is similar to *O. c.* var. *chartacea* in every way except for the following characteristics. The pod in the latter is 8-15 mm long as opposed to 14-27 mm in *O. c.* var. *johannensis*. In addition, the stipules of *O. c.* var. *chartacea* are permanently pilose with free glabrous blades 3-9 mm long while in *O. c.* var. *johannensis*, the stipules become glabrate and the blades are 0.6-1.8 mm long. Plants from Wisconsin are also more copiously covered with a dense, pilose pubescence (Barneby 1952, Fernald 1950).

Regardless of its correct taxonomic disposition, the Wisconsin colonies are very isolated geographically from other populations of *Oxytropis campestris*. The nearest station of the species is that of *O. c.* var. *dispar* (A. Nels.) Barneby in North Dakota, over 800 km to the west (Barneby 1952).

HABITAT

Fassett's locoweed grows along the shorelines of landlocked, hardwater lakes where the Cambrian sandstone bedrock is overlain by sandy glacial drift. Nearly all lakes with historical populations of the species are less than 15 ha in size and occur at approximately 350 m elevation. Dependent upon groundwater seepage for their water supply, most are shallow (maximum depth of a few meters) and subject to frequent, large fluctuations in water level. (Fassbender et al. 1970, Fassbender and Nelson 1971, Johannes et al. 1970, Paull and Paull 1977).

Fassett's locoweed is found along the lakes on open shoreline and, to a lesser extent, on higher ground under the partial shade of adjacent vegetation. It grows on gentle, sand-gravel slopes and is absent from flat, low, mucky shorelines. The latter are colonized by aquatic emergent species, such as common cattail (*Typha latifolia*), hard-stemmed bulrush (*Scirpus acutus*), and knotweed (*Polygonum* spp.). Because of periodic fluctuations in lake levels, the amount of exposed, open shoreline varies, from being virtually nonexistent during times of high water, to about 30 m wide when the water level is low (Dobberpuhl

1988).

Above the open shoreline, the herbaceous vegetation is distributed in well-defined, concentric bands of sedges, grasses, and forbs. These bands and the stands of dead and living trees growing in concentric zones farther inland are further evidence of dramatic fluctuations in water levels (Welling et al. 1988). At Pickerel Lake, where Fassett's locoweed occurs, a 3-4 m wide zone of shrubs stood in about a meter of water in 1988. A fringe of live trees, approximately 50 cm dbh, occurred 5 to 15 m inland of the waterline. The most common species in the first fringe of trees are cottonwood (*Populus deltoides*), white birch (*Betula papyrifera*), and willows (*Salix* spp.). The fringe has a depth of only one or two trees and is adjacent to an open zone 1-2 m wide continuing away from the lake. Fassett's locoweed may occur in this area, under the partial shade of the surrounding vegetation. Next to it and continuing away from the lake, the vegetation is characterized as dry sandy woods dominated by oak (*Quercus velutina, Q. alba*) and pine (*Pinus banksiana, P. resinosa, P. strobus*). Fassett's locoweed has not been found in these more heavily wooded areas (Dobberpuhl 1988).

Along recently exposed shorelines, Fassett's locoweed is found in large numbers as dense, pure stands and as scattered individuals in areas which are also colonized by rushes (*Juncus* spp.) and sedges (*Carex* spp. and Eleocharis spp.) or grasses (*Panicum capillare, Poa compressa*). Herbaceous forbs are important associates above this zone and include smooth bank cress (*Arabis laevigata*), beach wormwood (*Artemsia caudata*), wild strawberry (*Fragaria virginiana*), spotted St. John's Wort (*Hypericum punctatum*), common boneset (*Eupatorium perfoliatum*), and woundwort (*Stachys palustris*) (Dobberpuhl 1988).

In all cases, Fassett's locoweed occurs in areas which are completely exposed to sunlight or receive only partial shade from other species. Particularly along the open shorelines but also throughout the sandy lakeside habitat, the soil surface is subjected to extreme temperature fluctuations, high solar radiation, strong winds, and soil moisture stress. However, it is in these areas, where competition from other plant species appears to be very low, that Fassett's locoweed occurs in the densest colonies.

Fluctuating lake levels are necessary to maintain the open habitat which apparently is most favorable for the taxon. Aggressive competitors may be destroyed during high water levels and never gain the foothold necessary to crowd out Fassett's locoweed during the relatively short periods of lake recession (Alverson and Solheim 1983).

DISTRIBUTION

The distribution of Fassett's locoweed may be related to the glacial history of Wisconsin. All but one historical station of the species (Pigeon Lake in northwestern Wisconsin) occur in the Central Plains region of the state just east of the eastern edge of extinct Glacial Lake Wisconsin. In the broad, flat sandplain of this region, streams deposited sandy outwash at the edge of the glacial lobe. Of the eight extant or historical stations of Fassett's locoweed in the area, seven occur along lakes in a shallow valley which runs several miles to the southeast of the town of Plainfield. This valley was a "tunnel channel" at the edge of the outermost glacial moraine. Such areas occurred in places where water, under tremendous pressure beneath the glacier, burst out and formed a stream course. Ice blocks which broke off from this channel were deposited and later melted to form the shallow, landlocked lakes typical of the area (Attig 1988, Paull and Paull 1977).

Central Wisconsin was a treeless tundra 14,000 - 26,000 years ago. Tundra polygons can be detected on aerial photographs taken in the exact region with current Fassett's locoweed populations. The periglacial environment was probably quite similar to the arctic and alpine habitats where other members of the genus exist today. Although Fassett's locoweed was perhaps once common on the treeless tundra, it may have been unable to survive later climatic change and consequently persists as a glacial relict along a few lakes with appropriate habitat (Attig 1988, Barneby 1952).

This hypothesis, that Fassett's locoweed may have once ranged widely on the shorelines of Glacial Lake Wisconsin, was first proposed by Fassett (1939). He also speculated that the species occurred in a similar situation along Glacial Lake Grantsburg in northwestern Wisconsin, thus explaining the occurrence of Fassett's locoweed along the

shore of Pigeon Lake in Bayfield County. However, according to Attig (1988), Lake Grantsburg was located too far west of present Pigeon Lake for the shoreline distribution to have been possible. Pigeon Lake occurs where the land was covered by the Late Wisconsinan glacial advance in an area of pitted morainal outwash. Lakes were formed when ice blocks buried in the landscape melted as a result of climatic warming.

A second theory has been proposed to explain the origin of Fassett's locoweed in Wisconsin. According to this view, the species was a post-glacial migrant into the region. Seeds were transported from other parts of the species' range, perhaps by receding glacial meltwaters or via long-distance dispersal by birds or mammals. Fassett's locoweed took advantage of the open shorelines frequently found along certain lakes. In the subsequent isolation of this habitat, characters distinctive to Fassett's locoweed evolved (Alverson and Solheim 1983, Iltis 1988).

The reason for the taxon's apparent inability to disperse more widely to other lakes in the vicinity is unknown. If long-distance dispersal allowed it to be a post-glacial migrant, perhaps an alteration in the mode or method which permitted this caused Fassett's locoweed to become rare and isolated. On the other hand, dispersal and subsequent persistence at a site may have always been a chance, rare occurrence, and the present distribution is similar to the previous post-glacial pattern.

The idea that Fassett's locoweed is a glacial relict is alluring and seems quite plausible in the case of the central Wisconsin stations. However, attributing the distant Pigeon Lake site to this origin is more problematic. Perhaps a distribution caused by glacial characteristics, in addition to a low rate of dispersal, change in dispersal mechanisms, or unknown limitations explain the taxon's current rarity and its confinement to a handful of sites. Although a conclusive answer to this question seems unlikely to be forthcoming, a genetic study to assess the relationship of Fassett's locoweed to closely related taxa may provide some answers.

Regardless of its origin, collection records indicate that Fassett's locoweed has never been common in modern times. After Griscom's initial visit in 1928, N.C. Fassett made a

second collection in 1934 (Fassett 1936).

In the 1930's, Dr. Fassett also located the taxon at several lakes in central Wisconsin, more than 240 km south of Pigeon Lake. He reported populations at Lake Huron (TYPE), Plainfield Lake, and nearby Fox and Mud lakes, all in Waushara County (Fassett 1939).

Decades passed during which no new sites of Fassett's locoweed were located. Then in 1963, K.D. Rill found plants growing on a sandy beach of Pickerel Lake in Portage County, about 24 km north of Plainfield. Additional stations were found in Waushara County. L.M. Nelson collected plants at Smith (Shumway) Lake in 1969, and in 1978, W.A. Smith reported seeing a few plants, but collected no specimen, from Weymouth Lake. Both Shumway and Weymouth lakes occur less than 1 km from Lake Huron.

Extensive searches for Fassett's locoweed have been conducted by botanists over the years since the Pigeon Lake discovery. However, Fassett's locoweed has not been found beyond Bayfield, Portage, and Waushara counties and is considered endemic to Wisconsin. Figure 2 shows the historical distribution of Fassett's locoweed in Wisconsin.

LIFE HISTORY

The life span of Fassett's locoweed is of unknown duration.
The species appears to reproduce entirely by seed as there is no evidence of vegetative reproduction. Flowering begins in the second or third week of May. The inflorescence is indeterminate with flowers blooming in progression from the bottom to the top of the raceme. When the uppermost flowers are in bloom in mid-June, legumes are already developing on the lower part. Seed dispersal from the mature pod begins by mid-July (Alverson 1981, Dobberpuhl 1988). A few plants with remontant flowers were seen by Wisconsin Department of Natural Resources (WDNR) staff in late September 1989.

The size or age a plant must be before it will develop a flower scape is unknown. However, although no quantitative data were recorded, it was observed that some of the plants which had germinated in the 1988 growing season produced flower stalks during the summer of 1989.

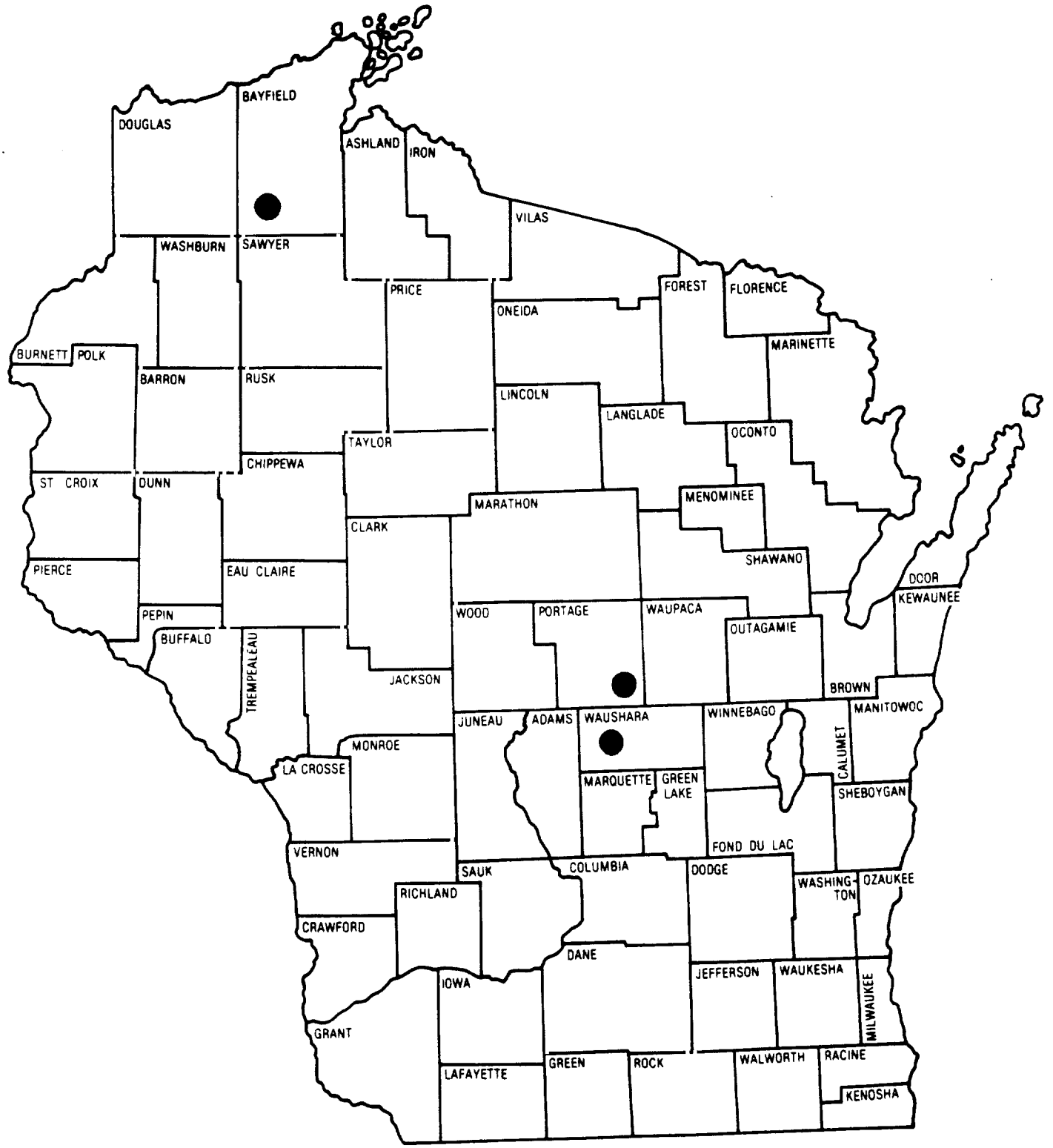

Figure 2. Historical distribution of Fassett's locoweed (*Oxytropis campestris* var. *chartacea*). Represented are one site each in Bayfield and Portage counties and seven sites in Waushara County.

In 1988, the rosette diameter of plants at Plainfield Lake was measured to determine the average sizes of flowering and nonflowering plants. It was found that the average diameter of flowering plants was significantly larger (p=.05) than that of nonflowering individuals, indicating that there is a lower size threshold below which plants will not initiate flowering. Of 263 plants sampled, 58% developed flower scapes, with an average of 1.5 (range 1-9) scapes per plant (Dobberpuhl, 1988).

The pollinator(s) of Fassett's locoweed is unknown although W.S. Alverson collected a small, leafcutting bee which was seen foraging on the flowers. The specimen was later identified to be *Megachile* sp. nr. *melanophoea* Smith (female, Megachildae). In addition, larger bees (*Bombus* sp.) have also been observed visiting flowers. The change in petal color from purple to red as an individual flower ages may signal the level of receptivity to a potential pollinator (Alverson 1981).

The mature fruits release numerous, small black seeds which have no evident adaptation for dispersal. As in many other plant species (Harper 1977, Johnson and Anderson 1986), the seeds of Fassett's locoweed probably tend to disperse in a clumped pattern around the parent plant. However, they may be moved short distances by wind, rain, or lake water during periods of inundation.

The normal reproductive cycle of Fassett's locoweed appears to have been severely disrupted in 1988 due to a prolonged drought. By early June, leaves on living plants had dried and were crumbling, and entire flower heads had aborted. In the study of plant size described above, 20% of all scapes had aborted their flowers by mid-June. Those that did survive produced legumes with few or no seeds. The impact of drought on long-term population survival is unknown (Dobberpuhl 1988).

Seed germination and dormancy requirements and viability of Fassett's locoweed are just beginning to be understood. In 1983, B.A. Cochrane collected seeds from several capsules at Lake Huron. These were placed in a small pot and left outdoors over the winter. Approximately one-third of the seeds germinated the following spring but all died shortly thereafter. A similar situation occurred with another batch of seeds the following

year. However, in the third year, the seedlings which germinated survived and, since then, have been transplanted to an outdoor garden (Cochrane 1988).

The Holden Arboretum of Mentor, Ohio, is currently conducting germination experiments under the guidance of the Center for Plant Conservation (CPC) of Jamaica Plains, Massachusetts. Seeds of Fassett's locoweed were collected from Plainfield Lake in August 1986. Germination has been sporadic with the highest rates (20%) achieved after first scarifying the seeds in hot water and allowing them to soak for 24 hours followed by a period of warm/cold temperature alterations. Germination under other regimes with or without pretreatment has ranged from 2-16%. That the seed may remain viable for a long period of time is indicated by the observation that seeds were still germinating in January 1989, 2 1/2 years after they were collected (Parsons 1989).

As with Cochrane's work, survivability of seedlings at the Holden Arboretum has been low. Potted individuals are apparently very sensitive to high moisture levels and frequently succumbed to fungal contamination. In 1987, seven propagated plants were transferred to sandy soil in an outside garden but had not flowered as of 1988 (Parsons 1989).

Both Cochrane and Parsons have suggested that the low survivability of seedlings may be linked to the absence of necessary rhizobial bacteria. Specimens occurring in their natural habitat have not been examined for the presence of nodulation. Future experiments at the Holden Arboretum will include the introduction of legume rhizobium inoculants (Parsons 1989).

The time-spaced pattern of germination seen in these studies has been observed elsewhere with locoweed seed. Ralphs and Cronin (1987) found two western North American species of the genus *Oxytropis* to have low rates of germination (3-21%) under optimal conditions. However, small percentages of buried seed germinated each year throughout the five year experiment. Rates of germination were higher for seed on the soil surface than for seed which was buried 1 cm deep in the soil.

Although other dormancy mechanisms may be involved, Robert and Boddrell (1988) concluded that it is primarily the hard seed coat which prevents germination in legumes. Exposure to the environment at the soil surface results in natural scarification which tends to weaken the seed coat. Several other factors, including light, moisture, temperature alterations, or a combination of these, may act to break embryo dormancy.

The astounding longevity of some leguminous seed is well-known. Porsild et al. (1967) grew healthy plants from seeds of *Lupinus arcticus* which were at least 10,000 years old. More recently, Ralphs and Cronin (1987) found that over 50% of buried locoweed seed remained viable after six years.

The initial seed germination studies with Fassett's locoweed indicate characters similar to other legume species. They have interesting implications for the particular mechanisms of population maintenance observed in this taxon in its natural habitat.

Populations of Fassett's locoweed appear to persist indefinitely in a zone above the high water line along landlocked lakes. Since the water level in these lakes may fluctuate greatly from one year to the next, Fassett's locoweed is present above ground only in this upper zone during times of high water. However, as the lake recedes and new shoreline is exposed, hundreds of seedlings of Fassett's locoweed germinate on the open beach sand and gravel. There are two likely sources for the seeds from which the seedlings are derived: 1) rain wash downslope from mature plants located above the high waterline and 2) germination from an *in situ* buried seed bank.

Although some seeds may simply wash down towards the lake via gravity, it seems unlikely that they would distribute as evenly and as densely as the seedlings occur along the shoreline. In addition, although substantial numbers of seed-bearing plants, which might serve as a seed source, occur above the shoreline at Plainfield Lake, this is not the case at other sites. At Second Lake, a few flowering plants are located above the tree line but in an area several hundred meters north of where the seedlings are found along the shore. No seedlings have been found near the mature plants. At Pickerel Lake, Fassett's locoweed was not found above the shoreline where germinants occur; in 1990, several

hundred seedlings were seen in an area of previously inundated beach (WDNR files).

Without studying the pathways of seed dispersal, it is impossible to make a conclusive determination as to their origin. However, the evidence suggests that the buried seed bank is of great importance to species survival. Even if some seed does make its way down the shoreline at Plainfield Lake, it still must be stored in the seed bank, because the thousands of germinants in 1988 and 1989 appeared before the seed pods of each year's flowering plants had opened. That the shoreline may have the appropriate combination of submersed and emersed periods for seeds to accumulate has been proposed by Keddy and Reznicek (1986) for freshwater lakes in Ontario. This also appears to be the situation at lakes where Fassett's locoweed occurs.

A study of several photographs (WDNR files) taken in previous years is illuminating. In 1986, during a period of high water, Fassett's locoweed was not seen along the northeastern shore of Plainfield Lake. Then in 1988, during the second of 2 dry summers, thousands of seedlings were found on newly exposed beach on this shore. By 1989, some of these seedlings produced flowers while new germinants continued to appear throughout the growing season. This shore was thought to be a completely new zone of colonization until previous photographic prints and slides of Fassett's locoweed at Plainfield Lake were examined. They showed that in 1984, the northeastern shoreline was covered with hundreds of flowering plants. In addition, photos taken in 1980 and in the 1940's at the same location also showed many flowering plants. This suggests that, at least in the 1980's, the average cycle of lake level fluctuations has been two to four years in length.

Similarly, Fassett's locoweed was flowering abundantly on the southern shore of Pickerel Lake when a photo was taken there in 1980. However, when that location was visited in 1988, the shoreline was under about a meter of water to the level of the high waterline, and Fassett's locoweed was not seen. The lake level had receded by 1989, and, as stated above, several hundred plants were found in 1990.

These observations indicate that Fassett's locoweed persists in the buried seed bank of the lake bottom but rapidly reoccupies periodically exposed zones. Keddy and Reznicek (1982) found a similar pattern in rare coastal plain plant species which inhabit the shore of a large lake with fluctuating water levels in Ontario. These species survive in the seed bank and quickly recolonize the exposed lake bed whenever the water levels recede. Van der Valk and Davis (1978) found that revegetation following drawdown of freshwater wetlands was also primarily derived from the seed bank.

The population of Fassett's locoweed seen above ground fluctuates greatly with lake level changes. Such variability in population sizes has also been reported for western North American locoweed species (Ralphs and Cronin 1987). Most of the species studied were annuals or short-lived perennials which were shown to depend on soil seed reserves for species persistence and as the source of population outbreaks during times of favorable environmental conditions. Although Fassett's locoweed may have a long life span in the areas above the high-water line, it probably functions as a short-lived perennial along the shoreline where it must complete its life cycle in the few years before water levels rise and inundate its habitat.

An important advantage to a species having a large seed bank is the ability to rapidly colonize newly exposed shore zones. Thus, Fassett's locoweed can establish colonies more quickly than potential competitive species which rely upon the dispersal of seeds or vegetative propagules. Low germination rates at a specific time but scattered over a long period, prevent the entire seed reserve from being depleted during a single period of favorable conditions which may not last long enough to produce another seed crop. Exogenous factors leading to seed crop failure may include a rapid return to high water levels, severe drought (as in 1988), disease, and predation.

According to Pavone and Reader (1982), a persistent seed bank is a strategy frequently employed by a species growing in an unpredictable environment because it offers protection against extinction during unfavorable years when seed production is curtailed. Conversely, the seed bank provides an advantage in the ecological exploitation

of preferred environmental conditions. Thus, species characterized by seed longevity and a large seed bank reserve exhibit a time-dependent survival strategy in an environment where there is a high probability that suitable habitat will be available periodically (Ralphs and Cronin 1987).

STATUS AND LAND OWNERSHIP

Field surveys to relocate historical stations of Fassett's locoweed were conducted in 1979-80 (Alverson 1981), in 1988 (Dobberpuhl 1988), and in 1989-90 by WDNR staff.

Fassett's locoweed has been relocated at five of the eight historical sites: Plainfield Lake, Second Lake (probably the same site as "Fox Lake" reported by Fassett), Weymouth Lake, and Lake Huron in Waushara County and Pickerel Lake in Portage County. It has also been found at a new site, Sherman (Marks) Lake, at a distance of several hundred meters from Second Lake in Waushara County. Information on all sites, including current landownership, is summarized in Table 1. Searches at other historical localities have been unsuccessful.

Fassett's locoweed has not been seen at Pigeon Lake since it was last collected there in 1934. The Mud Lake station (Fassett 1939) appears to have been extirpated. The land surrounding this small waterbody (<5 ha) is heavily grazed and was searched unsuccessfully in 1980, 1988, and 1990. Alverson (1981) observed grazing around Shumway Lake as well and could not find Fassett's locoweed. Although the landowner no longer leases his property for that purpose, no plants were found in 1988 or 1990, despite what appears to be excellent habitat (Dobberpuhl 1988).

Table 1. Records of extant and historical stations of Fassett's locoweed (*Oxytropis campestris* var. *chartacea*). All known sites are in Wisconsin.

Site Name/ County	Collection/ Observation Data*	Ownership Comments
Pigeon Lake Bayfield	First observed: 1928 Source: Specimen, Griscom, WIS Last observed: 1934 Source: Specimen, Fassett, WIS	Private and Public (Chequamegon Nat'l Forest, UW Board of Regents). Repeated searches over many years have been unsuccessful.
Pickerel Lake Portage	First observed: 1963 Source: Specimen, Rill, WIS Last Observed: 1990 Source: WDNR	Private portion of lakeshore with most of *Oxytropis* population acquired by WDNR in 1990.
Lake Huron Waushara	First observed: 1934 Source: Specimen, Fassett, WIS Last Observed: 1990 Source: WDNR	Multiple private owners. Extensive cottage and recreational development along lakeshore. *Ca.* 100 plants located below cottages in 1990.
Mud Lake Waushara	First observed: 1930's Source: Fassett (1939)	Private. Unsuccessful searches in 1980, 1988, and 1990. Lakeshore heavily grazed.
Plainfield Lake Waushara	First observed: 1934 Source: Specimen, Fassett, WIS Last observed: 1990 Source: WDNR	Private and Waushara County. Largest population known. WDNR working with private landowners to protect shoreline Vehicle abuse of area via county boat landing.
Second Lake Waushara	First observed: 1935 Source: Specimen, Fassett & Wadmond, WIS Last observed: 1990 Source: WDNR	Private property with majority of plants acquired by WDNR in 1990 and designated a State Natural Area. Contact made with secondary landowner.
Shumway Lake Waushara	First observed: 1969 Source: Specimen, Nelson, OS	Private. Unsuccessful searches in 1980, 1988, and 1990. Lakeshore grazed in 1980.
Weymouth Lake Waushara	First observed: 1978 Source: WDNR Last observed: 1989 Source: WDNR	Private. Excellent site. Landowners contacted in late 1989.
Sherman (Marks) Lake Waushara	First observed: 1990 Source: WDNR	Small population, portion acquired by WDNR in 1990, other portion on private land.

* Codes
OS = University of Wisconsin-Oshkosh
WDNR = Wisconsin Department of Natural Resources
WIS = University of Wisconsin-Madison

Following is a description of the six sites where extant populations of Fassett's locoweed have been located. The combined areal extent of these populations occupies about three hectares along lake shorelines.

Plainfield Lake. The largest known population of Fassett's locoweed occurs at Plainfield Lake. In 1988, over 1500 plants were estimated in a 700 sq m area located above the high waterline. As lake levels declined during 1988 and 1989, a population explosion with thousands of seedlings occurred in an area of previously inundated lakebed. Some seedlings present in 1989 germinated next to those which appeared in 1988 while many others were found on newly exposed shoreline.

Except for a small county-owned boat landing, the property surrounding Plainfield Lake is in private ownership by at least four different parties. Several houses and outbuildings are located 20 to 100 m from the shoreline.

Two of the landowners registered their property with The Nature Conservancy (TNC) in the 1970s. (Registry implies voluntary protection of the site with no legal obligations. The agreement is not transferred to subsequent owners.) The WDNR is involved with landowner contacts and has begun negotiating protection agreements.

Plainfield Lake is very accessible to the public; a state highway which receives moderate use extends along its eastern end. A township-owned boat landing is reached from this road and essentially bisects the population of Fassett's locoweed. Human use of the shoreline is heaviest in this area; the landing serves to make the lake accessible not only for boat launching but also for vehicle use of the shoreline. In winter, the lake is used by area hockey team members who drive along the shoreline to reach the game court located on the frozen lake. The area is marked by deep tire ruts which extend through dense plant populations. The original boat landing site has been enlarged as people use the area as a turn-around for their vehicles. Trampling by people and dogs is most intense here as well.

Fassett's locoweed occurs only sporadically within a few meters of the boat landing although large populations are found in nearby areas. A conspicuous infestation of sweet

clover (*Melilotus alba*) has expanded beyond the landing to less disturbed zones along the shore. This nonnative species can be very invasive in open areas. It is considered a threat to recovering prairies, because it may compete with native species for resources or otherwise alter the edaphic conditions of the plant community (Eckardt 1987). Although the effects of sweet clover on the lakeshore community where Fassett's locoweed grows are unknown, evidence from other areas indicates a possible serious threat.

The invasive orange hawkweed (*Hieracium aurantiacum*) is quite abundant a few meters above the high waterline and grows in association with Fassett's locoweed in that zone. This species is of concern because of its possible allelopathic properties and the potential impact on Fassett's locoweed (Waller 1989).

A Wisconsin Department of Transportation (WDOT) proposal to construct a storm sewer along Plainfield Lake poses a threat to the shoreline environment. According to the plan, the area drained would include the adjacent State Highway 73 as well as the city of Plainfield and the surrounding agricultural lands north of the lake. The resultant input to the lake could have not only a detrimental effect on water quality but may significantly alter natural lake levels. Since the persistence of Fassett's locoweed on the shoreline appears to be highly dependent upon lake level fluctuations, the addition of a storm sewer is a significant cause for concern. However, as of this writing, it appears that the presence of Fassett's locoweed as well as fiscal constraints have dampened enthusiasm for the project (Engle 1990, Fassbender 1990).

Second Lake. The population of Fassett's locoweed at Second Lake was estimated at 1,000 plants by Thomas A. Meyer, of the WDNR, in 1989. This number compares favorably with that reported by Alverson (1981).

The amount of available habitat at Second Lake is much smaller than at Plainfield Lake. A portion of Second Lake fronts along the state highway which runs between it and Plainfield Lake. Because of its proximity to the road, run-off of road salt and vehicle fuel probably occurs but whether or not this has an impact on Fassett's locoweed is unknown.

There are two residences along Second Lake, neither of which is in the immediate area of the plants. Most of the lakeshore is surrounded by a narrow band of oak-pine woods and the surrounding land is planted each year with row crops. The shoreline with Fassett's locoweed remains largely undisturbed.

The area with nearly all of the plants and a surrounding buffer zone are to be purchased by the WDNR and designated as a State Natural Area in 1990. The landowner of adjacent property containing a small group of plants has been contacted concerning protection of that area, and negotiations are expected to continue.

Lake Huron. Lake Huron is lined with cottages and other shoreline development, including boat houses, storage buildings, and lake piers. Human use of the lakeside is extensive. Lawns have been planted as close to the lake as the sandy soil will allow. Invasion by bluegrass (*Poa* spp.), sweet clover, orange hawkweed, and other nonnative species is widespread.

In 1980, 110 plants were found along the shoreline of Lake Huron (Alverson 1981). In May 1988, only four plants were located on a grassy slope below a cottage, and on a return visit in November of that year, these had been buried under brush piles. It seemed unlikely that any more than a few plants would be found.

However, in response to the drought, the lake level receded so that by 1989 more than two meters of shoreline were newly exposed. About 150 seedlings were located by WDNR staff in two areas below cottage developments. In 1990, a few large plants were found as well, including some which had flowered. No attempt has been made to contact the landowners.

Weymouth Lake. This small lake is isolated, inaccessible by public road, and supports excellent habitat for Fassett's locoweed. In 1989, hundreds of germinants were found along exposed shoreline, and several dozen large plants grew farther up the shore close to the first trees.

The property along the lake is owned by two families, one of whom has built a home in the woods above the lakeshore. Both landowners have been contacted by the WDNR concerning the Fassett's locoweed.

Pickerel Lake. A zone of hardwood forest several hundred meters wide surrounds Pickerel Lake. Beyond that are extensive irrigated farmlands.

Alverson (1981) estimated a population of more than 750 plants growing on a sandy, gravel beach of Pickerel Lake. In 1988, this habitat was under about a meter of water up to the permanent tree line, although a few plants were found along an upper shore on a different portion of the lake. In the intervening year, the lake responded to the drought so that by late summer 1989, 1-2 m of shoreline was exposed. Several dozen germinants of Fassett's locoweed were found in the same area where they had been seen by Alverson. In 1990, several hundred seedlings and a few dozen flowering plants were seen.

A private religious organization formerly owned the land along most of the lakeshore and operated a church camp there. Dormitories and other buildings had been erected on the north side of the lake. Impacts to the shoreline included intensive foot traffic, boat launching, and partial clearing of the adjacent woods.

The church group decided to sell their holdings along Pickerel Lake, and in 1990, the WDNR acquired approximately three-fourths of the shoreline to preserve Fassett's locoweed.

All locations with plant populations were included except those which occur along the lake below the camp buildings. That portion of the property remains for sale.

A county boat landing at the east end of the lake is popular for recreation and receives heavy use as a fishing and swimming spot. It is also an access point for day hiking. Management to re-route hiking and fishing trails is being evaluated on portions of the shoreline where Fassett's locoweed might be in jeopardy.

Sherman (Marks) Lake. In 1990, Fassett's locoweed was found along a portion of the shoreline of this shallow lake. Sherman Lake is located immediately south of Second Lake, with a low ridge of trees between them. Forty-eight plants of Fassett's locoweed were found along the former lake, within 8 m of the treeline.

Part of the shoreline along Sherman Lake, which includes a portion of the plant population, is included in the WDNR purchase at Second Lake. That area will be protected. The remainder of the population, however, is on private land. The appropriate property owner needs to be contacted and conservation measures pursued. There are currently no dwellings or other development on Sherman Lake; no immediate threat to Fassett's locoweed is known.

GENERAL THREATS

Because all sites known to have Fassett's locoweed populations occur in close proximity to one another, as a group they are subject to certain general threats. Perhaps the greatest immediate threat at nearly all sites is development, an issue that was discussed for each individual lake. Less obvious are several other potential threats.

The dominant land use beyond the fringe of woods surrounding each lake is agricultural. Because of the porous nature of the sandy soil, it must be irrigated all summer in order to grow crops. According to Furbish (1988), if the cone of depression from a high capacity well includes the groundwater zone associated with a seepage lake, the water levels in the lake may decline. The effects of continuously low water levels on Fassett's locoweed could be disastrous as the taxon apparently depends upon the open habitat provided by fluctuating water levels, with periodic inundation, for long-term maintenance. At the present time, the only restriction placed on the location of high capacity wells in Wisconsin is that they cannot interfere with a municipal water supply (Cain 1989).

Herbicide and pesticide use is heavy in the agricultural areas. In addition, many of the lakes with Fassett's locoweed are lined with residential properties and lawns. Possible

problems of spray drift or run-off onto Fassett's locoweed habitat have not been examined. Any decrease in the protective wooded buffer around each lake could result in increased overland flow of sediment-laden run-off into the water. Enrichment of the shoreline may permit the establishment of plant species which would compete with Fassett's locoweed but are currently unable to survive in the apparently nutrient-poor conditions typical of such areas.

(For further discussion of this issue, see the comments by the U.S. Environmental Protection Agency in Appendix 2.)

SUMMARY

Fassett's locoweed has been found extant at five of eight known historical stations and at one new location. All sites are seepage lakes in central Wisconsin; these are becoming increasingly popular as recreational and residential areas. Most of the lake shorelines where Fassett's locoweed occurs are in multiple private ownership.

Protection efforts by the WDNR are ongoing at several sites. Land acquisition has been accomplished for portions of Second Lake, Sherman Lake, and Pickerel Lake. Several of the landowners at Plainfield Lake and Weymouth Lake have been told about Fassett's locoweed. No contacts have been made with owners at the extensively developed Lake Huron.

PART II
RECOVERY

OBJECTIVE

The primary goals of recovery are to assure long-term protection and management of Fassett's locoweed at all sites with naturally-occurring populations. This includes the six extant populations as well as any new occurrences which might be found. Adequate protection will be accomplished not only through legal agreements with landowners but by increasing public awareness on the high-use lake shorelines. Education must be seen as integral to protection. Management to maintain appropriate habitat, including such activities as fencing populations in certain areas or removing invading, nonnative species, will be necessary at some sites. It is essential to conduct research which will contribute to recovery. Included here are seed bank research and genetic studies. Introduction of the species may become a future priority if protection of extant populations cannot be achieved. Removal of Fassett's locoweed from the list of U.S. Endangered and Threatened Species will be considered when six populations are permanently protected and managed, and monitoring indicates the populations to be self-sustaining.

STEPDOWN OUTLINE

1. Protect lake shorelines with populations of Fassett's locoweed, in all cases pursuing the strongest, appropriate method.
2. Develop and initiate management activities which are necessary to population maintenance.
3. Monitor existing populations.
4. Re-survey lakeshores with historical populations and those with potential habitat during years of low lake levels.

5. Develop and distribute educational materials and give presentations to interested groups concerning Fassett's locoweed and its conservation.

6. Conduct research on selected aspects of the biology and ecology of Fassett's locoweed in order to determine protection and management strategies necessary for long-term population survival.

    61. Examine the role of the seed bank in population maintenance.

        611. Conduct greenhouse experiments to determine the size and distribution of the buried seedbank.

        612. Study seed characteristics to determine dispersal mechanisms, longevity, and dormancy and germination requirements.

    62. Conduct genetic research to determine the number and distribution of genotypes in extant populations.

    63. Determine the taxon's breeding system.

    64. Investigate the effects of competition from nonnative species.

    65. Determine the locations of high capacity wells in relation to lake groundwater basin.

7. Consider introducing propagules of Fassett's locoweed at locations without extant populations but appropriate habitat, if adequate conservation cannot be achieved through protection of naturally-occurring populations.

NARRATIVE

1. **Protect lake shorelines with populations of Fassett's locoweed, in all cases pursuing the strongest, appropriate method.**

Since populations of Fassett's locoweed are known from only six sites, it is imperative that these areas be given the highest level of protection possible. This is the first priority in the recovery effort. All owners of property with, or adjacent to, extant populations must be identified and contacted to inform them of the rare plant taxon's presence and its significance. Each landowner should be encouraged to participate in

habitat protection.

A site cannot be considered adequately protected until a conservation-oriented organization holds fee title to the property. However, outright purchase may be difficult or not recommended at some sites, especially where the owner lives on the property. In those cases, a conservation easement is the preferred alternative over land registry which can be used as an interim measure. Dedication by the WDNR allows private land to be protected in perpetuity and should be pursued at all sites.

A conservation easement purchased by the WDNR would provide protection along a lakeshore by prohibiting all non-compatible land uses and allow for legal access for population monitoring and management.

Although the State of Wisconsin owns the lakebed where much of the Fassett's locoweed grows and the State Endangered Species Law applies on such property, the exclusive rights of the adjacent landowner are so extensive that profound disturbance of the plant population and habitat is possible. The area covered by an easement should include any plants located above the high waterline and an adequate buffer zone on the adjacent private property.

Land registry is a voluntary agreement with no legal requirements on the part of the property owner. It has already been employed by TNC with several landowners along Plainfield and Second Lakes. However, the inadequacy of the agreements has become evident since one major parcel with Fassett's locoweed was sold without the owner contacting TNC (part of a registry agreement is that the owner consents to contact TNC of his or her intent to place the property on the market). Another tract with the species had been for sale for at least a year before an inquiry during a registry list update brought the situation to TNC's attention.

Because of diverse ownership of the land surrounding each lake, a combination of protection methods will probably be required at each site. Following is a brief discussion on current and needed protection measures for each lake.

Plainfield, Second, and Sherman Lakes. These lakes occur very close together although a state highway runs between Plainfield Lake and the other two. All three lakes should be incorporated into one large preserve, delineating protected areas in established primary habitat surrounded by secondary buffer zones.

The lakebed and land above the high watermark with Fassett's locoweed make up the primary zones for protection and should include the full extent of the known or suspected seed bank. The wooded property inland from each plant population should be protected via fee acquisition or conservation easement. The slope above the lakeshore and a 60 m buffer zone beyond need to be included so as to prevent destructive land use practices which may cause erosion or otherwise alter the habitat of Fassett's locoweed. The remaining shoreline outside of the known population boundaries should receive some protection, probably through additional conservation easement or land registry agreements.

Most of the population at Second Lake and a portion of that at Sherman Lake (including an adequate buffer zone) will be protected through fee purchase by the WDNR in 1990. The owner of the remaining area has been contacted by WDNR staff and appears willing to protect the property. The method to do this has yet to be determined although protection should be relatively simple as there is no conflicting activity and use of both Second and Sherman lakes seems minimal.

At Plainfield Lake, at least five owners have property along the lakeshore with Fassett's locoweed. One of those is the local township which maintains an unimproved public boat landing on the lake.

Protection of the shoreline will probably involve different agreements. Some landowners maintain their residence on the lake while others live elsewhere. WDNR contact with the landowners is in its early stages so it is unknown what interests they have in their property and if they would be willing to sell it. Two of the owners have registered their property with TNC. This was an ineffective technique, because, as stated above, TNC was not contacted after the death of one owner. The land was placed on the market and sold in 1988 before WDNR staff became aware of the situation. This is unlikely to happen

again since WDNR staff intends to inform all landowners of the presence of Fassett's locoweed on their property and maintain continued contact with them.

The town boat landing has been the source of the most significant disturbance at Plainfield Lake. Vehicle operation on the beach at the landing is extensive and has ranged widely on either side as well. This is evidenced by deep tire ruts which cover the lower beach through the main population of Fassett's locoweed. Although plants occur on both sides of the landing, their density decreases dramatically in the proximity of this area. No plants are found in the landing itself. Presumably they are not there because they cannot survive the heavy traffic. In addition, the boat landing seems to be the entry point for invasion by weedy, nonnative species, particularly sweet clover (*Melilotus alba*). Between 1988 and 1990, the area occupied by sweet clover greatly increased in the vicinity of the landing.

Protection of Fassett's locoweed at Plainfield Lake depends on a solution to these problems. Local officials need to be contacted and a protection agreement negotiated. Management concerns should be addressed so that the WDNR will have the right to construct fences, remove sweet clover, and conduct other necessary activities.

Plainfield, Second, and Sherman lakes should be protected with the ultimate goal of dedication as a State Natural Area and as a memorial to N.C. Fassett. The primary objectives to be accomplished are the protection and preservation of Fassett's locoweed. The WDNR would take the lead on the protection efforts, with administration by the Bureau of Endangered Resources.

Lake Huron. Protection of Fassett's locoweed will be difficult because of the extensive development along the shoreline. The cooperation of adjacent landowners will be essential. Fee acquisition is probably an unrealistic goal while conservation easements and land registry might be more appropriate. These may be employed in areas where plants occur above ground and where records of former populations indicate a seed bank may still be present. In either case, education to develop awareness of landowners will be essential.

Pickerel Lake. Protection of the Fassett's locoweed population at this site is ongoing. The WDNR purchased the property with most of the plant population in 1990 and plans to pursue a conservation easement on the northeast shoreline where there is a small colony of plants.

Pickerel Lake has an improved boat landing owned and maintained by the county on its eastern shore. While this designated public use area does not occur near the Fassett's locoweed population, as it does at Plainfield Lake, it does serve as the main access point to other shoreline areas. The lake is heavily used for fishing and is also a popular swimming spot. Adequate protection of the plant population will require management of foot traffic so that trampling of Fassett's locoweed is prevented.

Weymouth Lake. Because of its isolated location and the conservation interests of the two adjacent landowners who own all the property along this lake, the Fassett's locoweed population does not appear to be immediately threatened. Initial contacts with both owners have been favorable. Fee purchase may be suitable in one instance while a conservation easement should be pursued for the other.

2. **Develop and initiate management activities for each site which are necessary to population maintenance.**

As sites are protected for Fassett's locoweed, management needs will be identified through monitoring (Task 3) and research activities (Task 6). Appropriate management programs should be implemented for the purpose of maintaining the habitat necessary to sustain Fassett's locoweed populations.

It will be necessary to prevent vehicle use of the shoreline and restrict excessive foot traffic in areas with plants. This can best be accomplished by a combination of fencing and posting signs as well as user education. The most appropriate measures will vary depending upon the lake and the type of disturbance it receives. For instance, at Pickerel Lake which is a popular fishing spot, routing trails to fishing points while

avoiding Fassett's locoweed may provide a satisfactory solution to the trampling problem.

Invading nonnative species are a concern at more than one site and should be surveyed for at all. Sweet clover can probably be controlled by hand-pulling and cutting plants at ground level, with care taken to avoid damage to plants of Fassett's locoweed. The establishment of this and other weedy species should be monitored on a regular basis and corrective action taken as necessary. Experiments to study the potential effects of orange hawkweed are discussed Task 64. If necessary, management must be undertaken to remove this species.

3. **Monitor existing populations.**

In order to detect responses to fluctuating lake levels and other habitat changes, populations of Fassett's locoweed should be monitored on a regular basis. Since the taxon is known extant at only six sites, the loss of any of these would be significant for meeting recovery goals. The status of the population at each site should be re-examined every third year until protection goals are met at each site and the population appears stable. Thereafter, more infrequent monitoring may be appropriate. In addition, baseline data on lake and shoreline environments should be collected.

At each site, the distribution of the Fassett's locoweed population should be outlined on a large-scale base map with reference to permanent marker points. Where the number of plants is relatively small (<300 individuals), it should be possible to make an accurate colony count. For larger groups, the size of the entire population can be estimated based on small samples (0.5 sq m works well). The age structure of the population should be examined and plants tallied in different categories including numbers of germinants, juveniles, and flowering and fruiting individuals.

It is recommended that at least one population be examined in more detail. Permanent plots or transect lines should be set up to record life history information which should answer questions concerning seedling survival, age to flowering, reproductive success, seed production, and individual life span.

In addition to collecting data on the plant population, the shoreline environment should be characterized according to substrate, aspect, and slope. Nearby topographical and cultural features should be noted. Permanent markers should be installed to measure fluctuations in lake levels over time. The frequency of exposure of submerged, buried seed banks can then be determined.

Associated plant species should be listed along with an estimate of percentage cover. Of particular interest are those species which establish themselves alongside Fassett's locoweed on newly exposed shorelines.

4. Resurvey lakeshores with historical populations and those with potential habitat during years of low lake levels.

Fassett's locoweed was not seen at four of eight historical stations or at any other sites during extensive surveys by WDNR staff in 1988. However, drought conditions persisted through 1989 leading to a further recession of lake levels and exposure of more shoreline habitat. Few surveys were conducted during that year, but a historical population was relocated at Weymouth Lake, increasing the known sites to five.

During 1990, historical stations and 12 lakes with potential habitat were surveyed. Fassett's locoweed was found at one new site, Sherman Lake, which lies adjacent to Second Lake.

It seems unlikely that other new stations will be found in Central Wisconsin, since intensive searches to date have been largely unsuccessful. An exception is Shumway Lake, which is the site of a historical collection and has what appears to be excellent habitat; it should be searched periodically in the future. In addition, the areal extent of populations at known sites may increase, especially under drought conditions. This was seen during 1990 when population extensions were seen at all sites. Therefore, the entire lakeshore at known sites needs to be examined periodically.

Pigeon Lake, in northwestern Wisconsin, was surveyed by staff of both the WDNR and Chequamegon National Forest in 1990. Fassett's locoweed was not found although

much seemingly appropriate habitat exists there. However, this lake had not receded as much as those farther south. If water levels at Pigeon Lake continue to fall, the shoreline should be searched again. If the species is found, it may be useful to survey several other lakes in the area as well.

In summary, except for those lakes discussed above, further field surveys for Fassett's locoweed are not recommended. Greenhouse seed bank studies utilizing soil from historical localities may be worthwhile to pursue as a final measure to determine if naturally-occurring populations still exist. (See Subtask #611 for a discussion of this method.)

5. Develop and distribute educational materials and give presentations to interested groups concerning Fassett's locoweed and its conservation.

Local awareness and education will be important considerations for recovery of Fassett's locoweed since its habitat is one which is generally highly valued for its recreational potential. It will be necessary to work with adjacent landowners to ensure that their activities are not harmful to the plant populations. Personal meetings with the goal of reaching land protection objectives should be done at each site. An informational brochure describing protection of rare plant species could be helpful to accomplish this.

Other efforts will need to be made to inform lake users of the presence of Fassett's locoweed at public boat landings and beaches. This may include posting informational signs at crucial locations at those sites and giving slide presentations at local township and garden club meetings.

Statewide organizations such as TNC, the Botanical Club of Wisconsin, and local conservation groups should be kept abreast of recovery efforts. There are a number of ways that those organizations could participate: creating educational materials, working on management activities, and monitoring plant populations, for example. They might spearhead a campaign to have Plainfield Lake designated as a special, local preserve with statewide significance.

6. Conduct research on selected aspects of the biology and ecology of Fassett's locoweed in order to determine protection and management strategies necessary for long-term population survival.

61. Examine the role of the seed bank in population maintenance.

611. Conduct greenhouse experiments to determine the size and distribution of the buried seed bank.

The seed bank appears to be critical for the long-term survival of Fassett's locoweed. Seed bank studies should be conducted at one or more sites with extant populations. It may also be possible to determine the taxon's presence in the seed bank at sites with historical collections through selective soil sample procedures. Determining the most likely habitat along a lake where Fassett's locoweed grew at one time will be difficult. However, this should be aided by the habitat characterization conducted for extant populations (see Task 3) which would increase the probability of choosing the most likely places where seeds lie buried.

It will be important to avoid destructive sampling to minimize impact to the population and its habitat. A survey of recent literature will help determine the minimum volume of soil needed to conduct valid studies (Bigwood and Inouye 1988, for example).

Soil samples should be collected and transferred to a greenhouse. Seedlings which emerge should be recorded over several seasons because of the differential germination observed in the field. The soil samples should reflect the vertical as well as horizontal distribution of buried seed. At the conclusion of the experiment, ungerminated seeds of Fassett's locoweed should be extracted from the samples and tested for their viability.

612. Study seed characteristics to determine dispersal mechanisms, longevity, and dormancy and germination requirements.

The role of the seed bank in Fassett's locoweed survival is clearly dependent upon the biology of the component seeds. The efficacy of dispersal mechanisms determines the relationship of seedlings to parent plants at a site as well as the ability of the taxon to

disseminate to new sites. Poor seed dispersal may account for the localized distribution of Fassett's locoweed.

The biological or environmental factors which lead to seed dormancy are unknown. This character is related to seed longevity for it is believed that seeds of Fassett's locoweed survive in a dormant state underwater until the correct germination conditions occur. How long seeds remain viable and capable of future germination is unknown.

Seed germination studies are currently being conducted by the Holden Arboretum, under the guidance of the CPC. The goal of this work is to develop techniques of artificial propagation and, at this time, does not involve studies of the other seed characters described above.

62. Conduct genetic research to determine the number and distribution of genotypes in extant populations.

The amount of genetic variation both within and between populations of Fassett's locoweed should be determined using electrophoretic isozyme techniques. This information may have implications for conservation of extant populations as well as introductions at historical and new sites. If populations at different sites are found to be genetically distinct and diverse, it will be important to maintain that variability. On the other hand, that might not be the case in genetically depauperate populations and their long-term sustainability may be in doubt. The approach taken in the matter of introductions will differ for the two situations; it will be important to record the success of establishment and persistence of colonies from different parent populations.

63. Determine the breeding system of Fassett's locoweed.

No evidence of vegetative reproduction has been observed in Fassett's locoweed which is therefore believed to rely completely upon sexual means for propagation. However, the type of breeding system employed is unknown, e.g., whether the plants have some degree of self-compatibility or are obligate outcrossers. The complex response of the

seed bank to fluctuating lake levels as evidenced by differential seed germination suggests a genetically variable seed pool, and at least some reliance upon outcrossing. The success of outplanted populations (Task 7) may ultimately depend upon the presence of appropriate pollinators. The identification of pollinators and determination of their distribution are necessary to this effort.

64. Investigate the effects of competition from nonnative as well as native species.

While certain aggressive nonnative species, such as sweet clover, should be eliminated from sites with Fassett's locoweed, the situation with orange hawkweed is not so clear.

This species grows extensively with Fassett's locoweed at several sites. Potential allelopathic or other effects of competition are unknown. It is recommended that replicate plots containing both taxa be set up with orange hawkweed removed from one-half of the replicates but left undisturbed in the other. Growth and reproduction of Fassett's locoweed should be monitored in both plots in order to document effects of competitive exclusion by orange hawkweed. If results indicate that the presence of the latter is harmful, corrective management will be necessary.

The effect of shading from the canopy needs to be examined for colonies of Fassett's locoweed which occur above the high-waterline. At every site, colonies are located under the partial shade of trees such as cottonwood, oak, and jack pine. Mature plants of Fassett's locoweed which flower and produce seed persist in this habitat when the remaining shoreline is underwater.

65. Determine the locations of high capacity wells and their relationship to groundwater basins for lakes with populations of Fassett's locoweed.

In order to determine if drawdown caused by operation of high capacity wells is affecting the groundwater supply, a long-term hydrology study is necessary. While this

would be a prohibitively expensive project for Fassett's locoweed recovery, a more modest study may adequately address the concerns (Craft, 1990).

According to George Craft of the Central Wisconsin Groundwater Center, located in Stevens Point, the groundwater basin associated with a lake can be delineated based on existing WDNR files. High capacity wells are indicated on aerial photographs. With this information, it is possible to measure the distance of wells from a lake and to determine if any exist within the associated groundwater basin. Potential effects of the location of wells within a basin can be evaluated in the event of a prolonged lake drawdown.

Given the complexities of groundwater flow and recharge, a more elaborate study may be necessary to fully address the groundwater drawdown concerns. A regional groundwater study, perhaps to be conducted in the near future, may provide definitive answers (Craft, 1990).

7. **Consider introducing propagules of Fassett's locoweed at locations, without extant populations but appropriate habitat, if adequate conservation cannot be achieved through protection of naturally-occurring populations.**

The first priority in this recovery plan is to maintain extant populations through protection and management. However, if upon evaluation these measures are found to be inadequate for conservation, introduction at other sites may be recommended.

Introductions should be done at historical sites where populations no longer occur or at sites with habitat of high potential success. The habitat characterization outlined in Task 3 should help identify suitable introduction sites.

Artificially propagated plant material should be used for introductions. Methods of artificial propagation are currently being developed by the Holden Arboretum, under the guidance of the CPC. However, a local source of plants will be needed to produce quantities of plants if introductions are to be done. A local private or state-owned nursery may be able to provide the facilities and personnel.

Introduced populations will need to be monitored. Successful establishment will be measured by several criteria. Plants should be permanently marked and counted on an annual basis. In addition, data pertaining to reproductive success and plant longevity, should be collected.

Criteria for determining successful establishment should include that a second generation of seedlings is produced. These must be observed to flower, set seed, and subsequently produce a new population of reproductive individuals. The introduced population must be shown to persist through at least one lake cycle with inundation followed by shoreline exposure. Individuals should be planted in several locations at each site, including the periodically inundated lakebed and the shore located above the high waterline. Survival should be recorded at all locations.

Finally, the land on which introduced populations are established should be protected. Procedures will follow the same guidelines outlined in Task 1.

PART III
IMPLEMENTATION

The Implementation Schedule that follows outlines actions and costs for the Fassett's locoweed recovery program. It is a guide for meeting the objectives presented in Part II of this plan. This schedule includes the general category for implementations, recovery plan tasks, corresponding task outline numbers, task priorities, task duration ("ongoing" denotes a task which has already begun and should continue as indicated in the recovery plan), agencies responsible to perform the tasks, and estimated costs for each task. Completion of these activities should bring about the recovery of Fassett's locoweed.

Table 2. Implementation schedule for Fassett's Locoweed recovery.

GENERAL CATEGORY	PLAN TASK	TASK #	PRIORITY #	TASK DURATION (YEARS)	FWS REGION	FWS PROGRAM	OTHER AGENCIES	FY-1	FY-2	FY-3	FY4-10	COMMENTS
A-1, 2 3, 6	Pursue highest level of land protection	1	1	Ongoing	3	OES	WI	100,000	125,000	75,000		Est. project cost for years 1-3 of recovery is $381,000
M-3	Develop and initiate management programs at each site.	2	2	3+	3	OES	WI	10,000	20,000	10,000	10,000	
I-1, 2, 6	Monitor existing populations.	3	2	Ongoing	3	OES	WI	2,500	1,500	1,000	5,000	Est. project cost for years 4-10 of recovery is $44,000.
I-1	Survey suitable habitat for additional populations.	4	3	Ongoing	3	OES	WI	500	500		2,000	
O-1	Develop & distribute educational materials	5	3	3+	3	OES	WI	5,000	2,500	2,500	2,000	Total project cost est. at $425,000 & may require additional time.
R-3, 7	Conduct research on selected aspects of the biology & ecology of Fassett's locoweed.	611, 612 62, 63 64, 65	2	3	3	OES	WI		5,000	20,000	25,000	

KEY TO IMPLEMENTATION SCHEDULE (TABLE 2)

General category (column 1)

Information Gathering & Research - **I, R**

1. Population status
2. Habitat status
3. Habitat requirements
4. Management techniques
5. Taxonomic studies
6. Demographic studies
7. Propagation
8. Migration
9. Predation
10. Competition
11. Disease
12. Environmental contaminant
13. Reintroduction
14. Other information

Acquisition - **A**

1. Lease
2. Easement
3. Management agreement
4. Exchange
5. Withdrawal
6. Fee title
7. Other

Other - **O**

1. Information and education
2. Law enforcement
3. Regulations
4. Administration

Management - **M**

1. Propagation
2. Reintroduction
3. Habitat maintenance and manipulation
4. Predator and competitor control
5. Depredation control
6. Disease control
7. Other management

Priority (column 4)

1 = an action that must be taken to prevent extinction or to prevent the species from declining irreversibly.
2 = an action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.
3 = all other actions necessary to provide for full recovery of the species.

Other codes

Continuous - Tasks that will continue once they are initiated
Ongoing - Tasks now being implemented
WI - Wisconsin Department of Natural Resources
FWS - Fish and Wildlife Service
OES - Office of Endangered Species
HA - Holden Arboretum

LITERATURE CITED

Alverson, W. S. 1981. Status report on *Oxytropis campestris* var. *chartacea* in Wisconsin. Unpublished report for the U.S. Fish and Wildlife Service. 17 pp.

Alverson, W. S. and S. Solheim. 1983. Wisconsin critical plant species - part III. Bull. Bot. Club of Wis. 15:3-10.

Attig, J. 1988. Wisconsin Geological and Natural History Survey, Madison, WI. Telephone conservation with J.M. Dobberpuhl, WDNR. December 15, 1988.

Barneby, R. C. 1952. A revision of the North American species of *Oxytropis* DC. Proc. Cal. Acad. Sci. 17:177-312.

Bigwood, D. W. and D. W. Inouye. 1988. Spatial pattern analysis of seed banks: an improved method and optimized sampling. Ecology 69:497-507.

Cain, M. 1989. Bureau of Legal Services, WDNR. Personal communication with J.M. Dobberpuhl, WDNR. January 5, 1989.

Cochrane, B. A. 1988. Madison, WI. Telephone conversations with J.M. Dobberpuhl. November, December 1988.

Craft, G. 1990. Telephone conversation with J.M. Dobberpuhl. November 1990.

Dobberpuhl, J. M. 1988. *Oxytropis campestris* var. *chartacea*: population and habitat survey. Unpublished report for the U.S. Fish and Wildlife Service. 17 pp.

Eckardt, N. 1987. Element Stewardship Abstract for *Melilotus alba* and *Melilotus officinalis*. Unpublished report for The Nature Conservancy, Minneapolis, Minnesota.

Elisons, W. J. and J. G. Packer. 1980. A contribution to the taxonomy of the *Oxytropis campestris* complex in northwestern North America. Canad. J. Bot. 58:1820-1831.

Engel, E. J. 1990. Telephone conversation with J.M. Dobberpuhl. May 1990.

Fassbender, R. L. 1990. Telephone conversation with J.M. Dobberpuhl. October 1990.

Fassbender, R. L. and L. M. Nelson. 1971. Surface Water Resources of Portage County. WDNR, Madison, WI. 78 pp.

Fassbender, R. L., J. Weber, and C. W. Threinen. 1970. Surface Water Resources of Waushara County. WDNR, Madison, WI. 97 pp.

Fassett, N. C. 1936. Notes from the Herbarium of the University of Wisconsin, No. 13. Rhodora 38:77-100.

Fassett, N. C. 1939. The Leguminous Plants of Wisconsin. Univ. of Wis. Press, Madison, WI. 157 pp.

Fernald, M. L. 1950. Gray's Manual of Botany, 8th Edition. D. Van Norstrand Co., NY. 1632 pp.

Furbish, W. 1988. Bureau of Water Supply, WDNR. Telephone conversation with J. M. Dobberpuhl, WDNR. December 23, 1988.

Harper, J. L. 1977. Population Biology of Plants. Academic Press, London. 892 pp.

Iltis, H. H. 1988. Department of Botany, University of Wisconsin, Madison, WI. Telephone conversation with J. M. Dobberpuhl, WDNR. October 19, 1988.

Johannes, S. I., L. M. Sather, and C. W. Threinen. 1970. Surface Water Resources of Bayfield County, WDNR, Madison, WI. 372 pp.

Johnson, R. G. and R. C. Anderson. 1986. The seed bank of a tallgrass prairie in Illinois. Amer. Midl. Nat. 115:123-130.

Keddy, P. A. and A. A. Reznicek. 1982. The role of seed banks in the persistence of Ontario's coastal plain flora. Amer. J. Bot. 69:13-22.

Keddy, P. A. and A. A. Reznicek. 1986. Great Lakes vegetation dynamics: the role of fluctuating water levels and buried seeds. J. Great Lakes Res. 12:25-36.

Parsons, B. A. 1989. Preliminary results on the germination of *Oxytropis campestris* var. *chartacea*. The Holden Arboretum, Mentor, OH. Unpub. data.

Paull, R. K. and R. A. Paull. 1977. Geology of Wisconsin and Upper Michigan. Kendall/Hunt Publ. Co., Dubuque, IA.

Pavone, L. V. and R. J. Reader. 1982. The dynamics of seed bank size and seed state of *Medicago lupulina*. J. Ecol. 70:537-547.

Porsild, A. E., C. R. Harrington, and G. A. Mulligan. 1967. *Lupinus articus* Wats. grown from seeds of Pleistocene Age. Science 158:113-114.

Ralphs, M. H. and E. H. Cronin. 1987. Locoweed seed in soil: density, longevity, germination, and viability. Weed Sci. 35:792-795.

Roberts, H. A. and J. E. Boddrell. 1985. Seed survival and seasonal pattern of seedling emergence in some Leguminosae. Ann. Appl. Biol 106:125-132.

van der Valk, A. G. and C. B. Davis. 1978. The role of seed banks in the vegetation dynamics of prairie glacial marshes. Ecology 59:322-335.

U. S. Fish and Wildlife Service. 1988. Determination of threatened status for *Oxytropis campestris* var. *chartacea* (Fassett's locoweed). Federal Register 53:37970-37972.

Waller, D. 1989. Department of Botany, University of Wisconsin, Madison, WI. Telephone conversation with J. M. Dobberpuhl, WDNR. February 2, 1989.

Welling, C. H., R. L. Pederson, and A. G. van der Valk. 1988. Recruitment from the seed bank and the development of zonation of emergent vegetation during a drawdown in a prairie wetland. J. Ecol. 76:483-496.

Welsh, S. L. 1960. Legumes of the North Central States: Galegeae. Iowa State J. Sci. 35:111-250.

APPENDIX 1

PUBLIC NOTICE OF RECOVERY PLAN DEVELOPMENT AND REVIEWERS

The Federal Register published a notice of the availability of the draft recovery plan for public review and comment on August 23, 1990. In addition, a public notice of the availability of the draft recovery plan was placed in the following newspapers on August 21 and August 22, 1990:

Stevens Point Journal
Stevens Point, Wisconsin

Waushara Argus
Wautoma, Wisconsin

The USFWS did not receive any response as a result of these newspaper notices.

In addition, the following individuals and organizations received copies of the draft recovery plan for review and comment:

Dr. William Alverson
Dept. of Botany
Room 245, Birge Hall
University of Wis.- Madison
Madison, WI 53706

Mr. Theodore Cochrane
Dept. of Botany
Room 251, Birge Hall
University of Wis.- Madison
Madison, WI 53706

Dr. Bob Cook
The Cornell Plantations
One Plantation Road
Ithaca, NY 14850

Dr. Thomas Gibson
Department of Botany
Birge Hall
University of Wis.- Madison
Madison, WI 53706

Dr. Hugh Iltis
Department of Botany
Room 154, Birge Hall
University of Wis.- Madison
Madison, WI 53706

Mr. Thomas Meyer
Bureau of Endangered Resources
Dept.of Natural Resources
101 S. Webster St.
Madison, WI 53707

Mr. Ronald Nicotera
Bureau of Endangered Resources
Dept. of Natural Resources
101 S. Webster St.
Madison, WI 53707

Mr. Robert Read
Bureau of Env. Anal. & Review
Department of Natural Resources
101 S. Webster St.
Madison, WI 53707

Mr. Welby Smith
MN Natural Heritage Program
Dept. of Natural Resources
500 Lafayette Road
St. Paul, MN 55155

Mr. Stephen Solheim
Dept. of Botany
Rm 245, Birge Hall
University of Wis.- Madison
Madison, WI 53706

Dr. Forrest Stearns
Dept. of Botany
3203 N. Downer
University of Wis.- Milwaukee
Milwaukee, WI 53201

Dr. Donald Waller
Dept. of Botany
Rm 232B, Birge Hall
University of Wis.- Madison
Madison, WI 53706

Dr. James Zimmerman
Dept. of Landscape Arch.
Rm 25, Agr. Hall
University of Wis.- Madison
Madison, WI 53706

District Manager
Milwaukee District Office
Bureau of Land Management
P.O. Box 631
Milwaukee, WI 53201-0631

Env. Protection Agency
Hazard Evaluation Division
EEB (TS769C)
401 M Street, S.W.
Washington, D.C. 20460

U.S. Forest Service
310 W. Wisconsin Ave.
Milwaukee, WI 53203

USFWS Offices:

Green Bay Field Office
1825 S. Webster Ave.
Bldg. #2
Green Bay, WI 54301

Division of Endangered Species & Habitat
Cons. (EHC)
Washington, D.C.
(400 ARLSQ)

Division of Refuges(RF)
Washington, D.C.
(670 ARLSQ)

Office of Public Affairs (PA)
Washington, D.C.
(3240 MIB)

Office of Research Support (ORS)
Washington, D.C.
(725 ARLSQ)

APPENDIX 2

U.S. Environmental Protection Agency Comments

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

SEP 5 1990

OFFICE OF
PESTICIDES AND TOXIC SUBSTANCES

Attn: Bill Harrison
U.S. Department Of Interior
Fish And Wildlife Service
Region 3 Division of Endangered Species
Federal Building, Fort Snelling
Twin Cities, Minnesota
55111

Dear Mr. Harrison,

Thank you for the opportunity to comment on the recovery plan for Fassett's Locoweed (Oxytropis campestris var. chartacea). Agronomist Richard Petrie of our Branch provides the following comments on the merits of this draft plan.

Mention is made of Fassett's Locoweed in proximity to agricultural areas that receive routine pesticide treatments. In addition, the potential for pesticide runoff is increased because the crops are irrigated and are located on sandy soils. In addition to potential adverse effects from pesticide use on agricultural land, pesticide runoff or drift may also occur from applications to lawns and non-crop areas by property owners (Plainfield, Huron, Weymouth lakes) and by county personnel (Parkland areas around Lake Huron). Many recently introduced herbicides are highly active on certain plant species at very low rates per acre, increasing their potential for off-target plant injury. As spray volumes and rates per acre are reduced, the potential for drift off-target during aerial application increases as well.

When demographic and habitat monitoring efforts occur, useful information such as the following might also be gathered:

1.) Determine the distance populations are located from agricultural areas, property owners, and parks.
2.) Determine if adequate drift control measures are being taken such as limiting the use of aircraft and mist blowers, maximizing droplet size by use of drift control agents and proper nozzle selection, etc.
3.) Determine the types of pesticides used near populations.
4.) Determine the number of applications of each pesticide.
5.) Evaluate topographic features and drainage systems to determine if they might facilitate the movement of pesticide residues from treated areas to adjacent areas where populations exist.

Any information obtained regarding pesticide use near populations of Fassett's Locoweed would be of interest to this office in our development of brochures and pesticide restrictions.

Sincerely,

Raymond Matheny

Raymond Matheny
Environmental Protection Agency
Office of Pesticide Programs
Environmental Fate And Effects Division
Ecological Effects Branch (H7507C)
401 M St., S.W.
Washington, D.C. 20460