Jesup's milk-vetch
(*Astragalus robbinsii* var. *jesupii*)

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
New England Field Office
Concord, New Hampshire

Fall 2008

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Field Office:

New England Field Office, Susanna von Oettingen, (603) 223-2541, Susi_vonOettingen@fws.gov

Lead Regional Office:

Region 5, Mary Parkin, (617) 417-3331, Mary_Parkin@fws.gov

1.2 Methodology Used to Complete the Review

The Jesup's Milk-Vetch (JMV) 5-Year Review was conducted as an individual effort by Susanna von Oettingen, the recovery lead biologist for the JMV. State natural resource agency personnel responsible for the recovery of this species were contacted for the most current information on occurrences, threats, and recovery activities. Non-governmental organizations and other biologists conducting research on the JMV were also contacted. Relevant information from the 1989 recovery plan, information provided by state biologists, and a draft plan for JMV monitoring and recovery (Farnsworth 2008) comprise the principal basis for this review.

1.3 Background

1.3.1 Federal Register Notice citation announcing initiation of this review:

73 FR 3991 (January 23, 2008) Notice of Endangered and Threatened Wildlife and Plants; Initiation of a 5-Year Review of Ten Listed Northeastern Species

1.3.2 Listing history:

Federal Register notice: Determination of Astragalus robbinsii var. jesupii (JMV) to be an Endangered Species; 52 FR 21481-21484
Date listed: June 5, 1987
Entity listed: Species
Classification: Endangered

1.3.3 Associated rulemakings: None

1.3.4 Review history:

The JMV was included in a cursory 5-year review conducted for all species listed before 1991 (56 FR 56882). Although no other 5-year reviews have been completed for this species, an extensive status and literature review was

conducted in 2004 in the course of drafting a revised recovery plan (Farnsworth and Harvey 2004). Additional updates to the species' life history and threats were provided in a 2008 draft JMV rare plant monitoring and introduction plan (Farnsworth 2008) prepared for the New Hampshire Natural Heritage Bureau. The draft recovery plan revision has not yet been completed or released for public review and comment.

1.3.5 Species' Recovery Priority Number at start of 5-year review:

The recovery number for the JMV is 6, indicative of a subspecies with a high degree of threat and a low degree of recovery potential.

1.3.6 Recovery plan:

Name of plan or outline: Jesup's Milk-Vetch (*Astragalus robbinsii* var. *jesupii*) Recovery Plan
Date issued: November 21, 1989

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment Policy

2.1.1 Is the species under review a vertebrate? No.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?

Yes, there is a final, approved recovery plan for JMV with objective and measurable criteria. However, the criteria were developed 19 years ago and are outdated.

2.2.2 Adequacy of recovery criteria:

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?
The recovery criteria are not current and do not reflect the life history and threats information that has been documented since the recovery plan was released in 1989. Although a comprehensive review was initiated in 2004 and updated in 2008 as a revised draft recovery plan, the criteria were only generally addressed at that time. New life history information, additional threats, and potential management strategies have been identified that should be incorporated as components into revised and/or additional criteria. Criterion 2, focusing on establishing seven additional populations may be unreachable. Although potential

habitat has been identified, surveys indicate that there may only be sufficient habitat for a few additional sites. Criterion 3 may still be valid, but requires refining based on new life history information as well as the potential to manage threats.

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria?

No, not all of the five listing factors are sufficiently addressed in the recovery criteria, and the delisting standards for one or more criteria will need revision.

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:

1) Protect and maintain three known populations and their essential habitat to prevent extinction of the species.

Criterion 1 is partially met; landowner permission is consistently granted to monitor all populations, investigate the species' life history, develop and implement methodology for population augmentation, and implement invasive plant control measures.

JMV is a narrow endemic, restricted to three locations on the banks of the Connecticut River in central Vermont and New Hampshire. None of the extant populations is permanently protected, although management strategies have been developed and implemented to maintain essential JMV habitat. Revision of the criterion (or the addition of a fourth criterion) is needed to account for competition for available habitat from a number of invasive plant species, which were not considered to be a threat at the time the 1989 recovery plan was written. Exotic invasive plants have significantly affected Hartland Ledges, Vermont, and occur at the other two sites, Sumner Falls and Jarvis Hill, New Hampshire. Removal of invasive species by hand and the use of herbicides has been undertaken since 1998 at all locations, and these efforts are controlling the invasive plants to some extent (Brumback 2007). Nevertheless, long-term management strategies to control or eliminate invasive plants need to be developed and implemented. A revised criterion should require the successful long-term management of invasive plant species at all three JMV sites.

2) Increase size of total population to ensure long-term survival by locating or establishing seven additional occurrences of JMV with a range of 100 to 500 individuals.

This criterion should be revised.

Numerous surveys for potential JMV habitat were conducted on over 150 miles of the Connecticut River in Vermont and New Hampshire between 1985 and 2007. No additional sites were identified and limited suitable habitat was located. It may be impossible to establish seven additional sites given the limited suitable habitat. Moreover, population augmentation efforts have been minimally

successful (Brumback 2004, Brumback 2006, Brumback 2007). Techniques are still being reviewed to determine the optimal conditions and methodology for transplanting seedlings or sowing seeds for population augmentation or the establishment of new populations (Cairns 2008).

3) Based on minimum viable population and identification of available habitat, determine if JMV can be reclassified or determine that delisting or reclassification is not possible.

This criterion should be revised.
An attempt should be made to define objective, measurable delisting criteria in accordance with section 4(f) of the Endangered Species Act of 1973, as amended (ESA). Rarity alone is not sufficient grounds for listing; thus, delisting criteria should focus on abatement of threats to the three known JMV populations. Moreover, it is not sufficient to identify available habitat without the ability to successfully establish and maintain populations. Recovery criteria should take into consideration the limited suitable habitat available for establishment of new populations, as well as the threat to existing (and possible future) populations from exotic invasive plants.

2.3 Updated Information and Current Species Status

2.3.1 Biology and habitat:

Farnsworth and Harvey (2004) and Farnsworth (2008) provide detailed information on the species' life history and population status, as well as the threats facing the JMV. The following summaries are based in large part on these two documents.

2.3.1.1 New information on the species' biology and life history:

Recent life history investigations have focused on seed and seedling biology, inflorescence production, and population cycles (Farnsworth 2008).

Seed and seedling biology:
The New England Wildflower Society has conducted systematic seed germination trials since 1992 (Brumback 2002, 2006, 2007, 2008; Farnsworth 2008). The percent of seeds that successfully germinate ranges from 0% to 85% (average germination of 33.2%) with mean rates of 20% to 60% (Farnsworth 2008). Seeds may germinate upon collection (Dunlop 1994), may germinate after drying, and have been documented to germinate after one, three, five, or 14 years of cold storage (Farnsworth and Harvey 2004, Brumback 2006, Brumback 2007, Brumback 2008, Farnsworth 2008). Germination rates appear to peak after one year in cold storage (Farnsworth 2008).

There appears to be a difference in germination rates between the Jarvis Hill population and the Hartland Ledges and Sumner Falls populations. The Jarvis Hill population consistently demonstrates a lower germination rate than the other

two populations based on germination trials (Farnsworth 2008), i.e., the Jarvis Hill population is consistently larger and provides more seed (in general) than the other two populations, although fewer seedlings may germinate (proportionally) than in the Hartland Ledges or Sumner Falls populations. The difference in germination rates may have implications for future population augmentation or introduction efforts, and further research on this potential difference should be conducted.

JMV seedlings appear to be sensitive to mid-summer drought. Those seedlings growing in modest shade provided by adjacent vegetation appear to thrive better than those growing in more open conditions (Farnsworth and Harvey 2004). Observed or estimated seedling survival rates in the field are generally low. Less than 25% of total seed produced results in observed seedlings in subsequent years (New Hampshire Natural Heritage Inventory 2001, Farnsworth 2008). The percent of seedlings surviving more than one year is unknown at this time.

Inflorescence production also appears to cycle on a three-year rotation (Farnsworth 2008). Although reproductive output per plant varies annually, Farnsworth (2008) observed that the number of inflorescences produced per plant at Hartland Ledges and Jarvis Hill appears to have declined since 1997.

Investigations of the bedrock geology and soils of the three JMV sites and five comparable sites where JMV did not occur were undertaken in 2006 (Bailey 2007, Farnsworth 2008). Calcium carbonate was detected in soil samples from Sumner Falls and Hartland Ledges (Bailey 2007) and was reconfirmed by analyses of thin-sectioned bedrock material. Bailey (2007) also noted that active seeps occur at the three JMV sites but at only one of the sites without JMV. Qualitative analyses indicated that seeps at JMV sites appear to be higher in pH and lower in potassium than at non-JMV sites (Farnsworth 2008). These seeps also serve as important water sources for JMV during times of drought.

Research investigating microhabitat parameters was initiated in 2008 based on the supposition that knowledge of optimal soil temperature and humidity conditions will benefit future transplant efforts for population augmentation or introductions. Techniques to enhance transplant success including the use of drip irrigation demonstrated a modest level of success (Nothnagle and Brumback 2002), and further refinement of these techniques has been proposed.

2.3.1.2 Abundance, population trends, demographic features or trends: Farnsworth (2008) estimated effective population sizes for the three JMV subpopulations: Sumner Falls 40 plants, Hartland Ledges 77 plants, and Jarvis Hill 474 plants. The effective population size for the species is approximately 590 plants (median population is approximately 680 plants) (Farnsworth 2008). The overall population appears to be relatively stable, although there is great year-to-year variation in population numbers at the three sites.

Cairns (2008) states that JMV may exhibit a synchronized three-year cycle with one low-abundance year followed by two medium- or high-abundance years. The three-year cycle may be due to the following reasons: (1) JMV has a three-year life span, (2) most plants are of the same age class (e.g., abundant seedlings, fewer numbers of older plants), and (3) the age of the dominant plants is the same at all three sites (Cairns 2008).

Definitive life history information relative to the age and survival rate of JMV plants is lacking; however, observations indicate that JMV plants do not flower their first year, may flower the next two years, and die in the third or fourth year. Life history studies focusing on individual plants have been initiated, although this has proven to be very difficult due to flooding and ice scouring of the habitat that obliterates markers and marked individuals. Further investigation is recommended in order to obtain information on the life span and seed production relative to age and size of individual plants.

2.3.1.3 Genetics, genetic variation, or trends in genetic variation:
Farnsworth (2008) suggests that the three JMV populations show minimal genetic divergence based on similarities to other rare *Astragalus*. The genetic structure of the individual subpopulations is unknown. Farnsworth (2008) observes that small populations such as those of the JMV (in particular Hartland Ledges and Sumner Falls) are at risk of random extinction due to stochastic events and a reduction in genetic diversity due from inbreeding.

Additional genetics investigation, including a genetic analysis of each subpopulation or a common garden comparison of within-site versus between-site mixes may be necessary to determine the best seed source for future introductions (S. Cairns, New Hampshire Natural Heritage Bureau, pers. comm. 2008; K. Holsinger, University of Connecticut, pers. comm. 2008)

2.3.1.4 Taxonomic classification or changes in nomenclature:
There is no new information regarding JMV taxonomy, nor is there any change in taxonomic classification.

2.3.1.5 Spatial distribution, trends in spatial distribution, or historic range:
JMV is a narrow endemic plant once documented from five locations along a 25-km stretch of the Connecticut River of Vermont and New Hampshire. At the time the JMV was listed three extant sites remained: Hartland Ledges in Vermont and Sumner Falls and Jarvis Hill in New Hampshire. Although extensive surveys of potential and historic habitat along the Connecticut River were conducted between 1985 and 2007, no additional sites were found. The JMV range remains restricted to the three extant sites, all of which are very small (each less than an acre in size).

2.3.1.6 Habitat or ecosystem conditions:

Habitat suitability is being significantly altered by the invasion of native and non-native plant species. Black swallowwort (*Cynanchum louiseae*), shrubby honeysuckle (*Lonicera morrowii*), cypress spurge (*Euphorbia cyparissias*), and purple loosestrife (*Lythrum salicaria*) have been documented at one or more sites since 1997 (Cairns 2007, Farnsworth 2008). Invasive plants are annually monitored at all three sites; intensive management, including removal by hand and herbicide treatments, is ongoing at Hartland Ledges and Sumner Falls.

2.3.1.7 Other:

Recent perceived changes in weather patterns may be attributed to global climate change, and impact JMV reproduction or the ability to compete with other species for available habitat. Unusual flooding events (record flood levels reported during June and July of 2006)[1] and lack of ice-scour in recent years may be indicative of changing regional weather patterns. JMV plants, and especially seedlings, are also particularly vulnerable to drought (Farnsworth 2008). Although climate change and its effects on weather and ultimately hydrology are largely theoretical at this time, long-term investigations on the timing, duration and intensity of droughts, flood and ice-scour events and subsequent JMV productivity and population fluctuations should be initiated in order to ascertain whether there is a correlation between these weather events and population or individual-level response.

2.3.2 Five-factor analysis:

2.3.2.1 Factor A. Present or threatened destruction, modification or curtailment of its habitat or range:

Habitat maintenance depends on management access to control invasive species and monitor population, and on sufficient ice scour to maintain open conditions (see Factor E below). To date, no populations have been permanently protected, and there are no permanent management agreements in place to ensure that management will continue in the future. Although landowners have consistently allowed access to the populations for surveys, research, and invasive plant control activities, there are no guarantees that this level of cooperation will continue.

The 1989 JMV recovery plan did not recognize habitat alteration by invasive native and non-native plant species. Black swallowwort, purple loosestrife, cypress spurge, and shrubby honeysuckle were first documented as a looming threat to JMV habitat at Hartland Ledges and Sumner Falls in 1998 (Farnsworth and Harvey 2004). Poison ivy (*Rhus toxicodendron*), a native plant, appears to be forming dense patches at Hartland Ledges and threatens JMV seedling establishment. Efforts to develop the most successful methodology to remove

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[1] Data taken from the following USGS website: http://nwis.waterdata.usgs.gov/nh/nwis/monthly/?referred_module=sw&site_no=01154500&por_01154500_2=1268930,00060,2,1942-03,2007-09&start_dt=1990-05&end_dt=2007-08&format=html_table&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=parameter_selection_list

and/or contain the spread of these species and restore JMV habitat have been ongoing since 1998 (Brumback 2003, 2004; New Hampshire Natural Heritage Bureau 2003). Competition for habitat between these and possibly future invasive species and JMV is the most significant threat to the successful recovery of JMV.

2.3.2.2 Factor B. Overutilization for commercial, recreational, scientific, or educational purposes:
Although the 1989 recovery plan identified over-collection for botanical purposes as a threat to the species, collection of JMV has not occurred either legitimately or illegally since the species was listed. Overutilization as a potential threat should be re-assessed if removal or reduction of the protections of the ESA becomes a possibility.

2.3.2.3 Factor C. Disease or predation:
There is no evidence that predation or disease is a significant threat to the species. Although damage to individual plants by herbivorous mammals, including woodchucks, deer and unidentified rodents, has been observed, no long-term population-level effects of herbivory have been documented.

2.3.2.4 Factor D. Inadequacy of existing regulatory mechanisms:
This factor is assessed relative to pertinent non-ESA regulatory mechanisms. Given that the known threats to the species' long-term persistence are limited to invasive species, changes in ice scour, and small population effects, the only available non-ESA regulatory mechanism is the Federal Power Act of 1920, as amended; no regulatory interventions are currently available for invasive species and small population effects. Wilder Dam, the dam upriver of all three populations, is scheduled for relicensing around 2015. The relicensing process must give "equal consideration" to, among other things, environmental quality; conditions needed to sustain the JMV may or may not be included as a consideration in the absence of ESA protections.

2.3.2.5 Factor E. Other natural or manmade factors affecting its continued existence:
JMV habitat depends on ice scour, and possibly spring flooding to a lesser extent, to maintain an open area for seed germination and to eliminate other plants that may compete for available habitat. Changes in the ice-scour regime of the Connecticut River due to climate change may affect habitat suitability for JMV germination by a reduction in ice-scoured habitat. Moreover, seasonal changes in flooding events and increased flooding at times of the year when plants are flowering or setting seeds (i.e., June through August) may significantly degrade habitat or reduce productivity, further threatening the recovery of JMV.

Two of the three populations of JMV are extremely small and may be vulnerable to inbreeding depression and loss of heterozygosity (Farnsworth 2008). Farnsworth (2008) observed that inflorescences produced by JMV plants at Hartland Ledges declined over the last 10 years. This population may be

vulnerable to a genetic bottleneck as indicated by the apparent decline in reproduction.

2.4 Synthesis

Jesup's milk-vetch occurs at three locations within a 25-km range on the banks of the Connecticut River in central Vermont and New Hampshire. Extensive surveys of the Connecticut River have not located additional populations and have identified only limited potential habitat. No populations are permanently protected, although landowners have consistently allowed access to the populations for surveys, research, and invasive species management.

Extensive seed germination trials conducted by Brumback (2002, 2006, 2007, 2008) and Brumback and Nothnagle (2002) indicate that there is a wide range of germination rates (0 percent to 85 percent) with an average rate of germination of approximately 33 percent. Seeds may remain viable for many years, although viability appears to peak after the first year of cold storage (Farnsworth 2008). Observed or estimated seedling survival rates in the field are low, less than 25 percent on average[2].

Seedlings resulting from germination trials were used in transplant trials (Brumback 2004, 2006, 2007; Brumback and Nothnagle 2002). On average, 25 percent of the transplanted seedlings survive the first year. Following seedlings for one or more years has proven difficult, and new methods need to be developed to track individual plants.

Recovery actions to date have focused on: (1) Determining whether the populations are stable, declining or increasing; (2) identifying what appears to be a three-year population cycle; (3) determining seed viability and seed germination rates; and (4) developing initial techniques for successfully transplanting seedlings and to some extent, directly sowing seeds. The control of invasive plants has been successfully implemented, and a method of herbicide treatment that avoids adversely affecting JMV plants has been developed (Brumback 2002), although it is clearly understood that this is a long-term management commitment.

The potential for hydrological alterations that might affect the habitat continues to exist since dams upriver of the populations affect water flows and may affect the duration and intensity of ice-scour events. Global climate change may affect the hydrology of the Connecticut River over the long-term by causing changes in the timing, duration and intensity of flooding, droughts and ice-scour. Changes in hydrological events may affect the species' habitat or reproduction. The immediacy of this threat is unknown.

The significance of the small JMV populations and population-level genetic effects to the survival of the species is uncertain. Inbreeding depression, genetic bottlenecks and vulnerability to environmental stochasticity are potential threats to the species; without

[2] This figure is based on a comparison of total seed produced and numbers of plants observed in subsequent years (Farnsworth 2008).

additional genetic data (within population and between population genetic analyses), the level and immediacy of these threats are unknown.

The most significant and immediate threat to the continued existence of JMV stems from invasive plant species that outcompete JMV for nutrients, light and physical habitat. Management actions, including the physical removal of plants, as well as select herbicide treatments, appear to be controlling invasive species. However, there does not appear to be the potential to permanently control invasive plants due to seed sources that occur up-slope or upriver of the populations. Invasive plant control is a long-term management commitment, and should invasive plant control measures be discontinued, it is unlikely that JMV would survive.

The JMV remains a highly imperiled species due to the immediate threat of habitat encroachment by invasive plant species and the long-term commitment needed to control invasive plants. Two of the three JMV populations are small and may be subject to stochastic events that could hasten their decline or suddenly obliterate them, as happened to a fourth population in 1985 (Farnsworth and Harvey 2004). In summary, JMV continues to meet the ESA definition of endangered, i.e., the species remains in danger of extinction throughout its range.

3.0 RESULTS

3.1 **Recommended Classification:** Retain as endangered.

Rationale: The limited distribution and small population size of JMV make the species particularly vulnerable to invasive species and changes in hydrologic and ice-scour conditions. Both of these threats may become more difficult to manage over time in the face of climate change. Together, these considerations indicate that the JMV remains at risk of extinction throughout its range.

3.2 **New Recovery Priority Number:** Retain as 6.

Rationale: The JMV continues to experience a high degree of threat and a low degree of recovery potential. This priority number also reflects a subspecific taxonomic classification, which continues to be the case for the JMV.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

Recovery actions were identified in Farnsworth and Harvey (2004) and Farnsworth (2008) and reviewed by experts involved in the recovery of Jesup's milk-vetch, including federal, state and non-government biologists. The following comprehensive list of actions needed to recover the species is not prioritized; details are found in Farnsworth and Harvey (2004) and Farnsworth (2008):

- Revise the 1989 recovery plan. A draft recovery plan (Harvey and Farnsworth 2004) and a draft monitoring plan and recovery update (Farnsworth 2008) were produced for the New Hampshire Natural Heritage Bureau. These two documents would facilitate the completion of a revised recovery plan.

- Permanently protect the three JMV populations or, at a minimum, develop long-term management agreements if permanent protection is not possible.

- Develop site-specific management plans, including methods to enhance productivity and control invasive species.

- Research microhabitat parameters in order to select the most appropriate habitat for establishing new JMV populations.

- Continue seed bank and germination trials. Develop and implement a common garden experiment to determine if there are differences in seed germination rates and seedling survival between the three populations. Outcomes from this experiment may identify the best seed source for the establishment of future populations.

- Building on results of the microhabitat research, as well as the common garden experiment, identify potential introduction sites, obtain landowner permission and transplant seedlings. Develop methodology to enhance seedling survival.

- Augment existing populations using seedlings from germination trials.

- Continue surveys and monitoring of JMV plants and seedlings to evaluate the status of existing populations. Determine and compare intrinsic rates of population increase at all sites.

- Continue monitoring and managing invasive plants.

5.0 REFERENCES

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Principal Contacts (non-FWS) – provided information

William Brumback
New England Wild Flower Society
Garden in the Woods
Hemenway Road
Framingham, Massachusetts 01701
BBrumback@newfs.org

Sara Cairns
New Hampshire Natural Heritage Bureau
DRED Division of Forest and Lands
172 Pembroke Road
Concord, New Hampshire 03302
S_Cairns@dred.state.nh.us

Elizabeth Farnsworth
Royalston, Massachusetts 01368
efarnswo@mtholyoke.edu

Bob Popp
Vermont Department of Fish and Wildlife
5 Perry Street, Suite 40
Barre, Vermont 05641
Bob.Popp@state.vt.us

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Astragalus robbinsii* var. *jesupii*

Current classification: Endangered

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
__x__ No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: N/A

Review conducted by: Susanna von Oettingen, New England Field Office

FIELD OFFICE APPROVAL:

Approve _____ Date 02 Sept 2009
Supervisor, New England Field Office

REGIONAL OFFICE APPROVAL:

Approve _____ Date 9/11/09
Acting Regional Director, Northeast Region, U.S. Fish and Wildlife Service