

Leedy's Roseroot
(Rhodiola integrifolia ssp. leedyi)

**5-Year Review:
Summary and Evaluation**



Photo by Dr. Joel Olfelt

**U.S. Fish and Wildlife Service
Twin Cities Ecological Services Field Office
Bloomington, MN**

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5-YEAR REVIEW

Species reviewed: Leedy's roseroot (*Rhodiola integrifolia* ssp. *leedyi*)

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5-YEAR REVIEW
Leedy's roseroot/*Rhodiola integrifolia* ssp. *leedyi*

1.0 GENERAL INFORMATION

1.1 Reviewers

| | |
|--|---|
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1.2 Methodology used to complete the review:

Information obtained since the species' listing in 1992, and particularly since the recovery plan was approved in 1998, is discussed below. The discussion is supplemented where necessary with information obtained prior to listing. To conduct this review, all information in the files of the Twin Cities (Minnesota) Ecological Services Field Office, U.S. Fish and Wildlife Service, was reviewed in detail back to the date of the species listing (U.S. Fish and Wildlife Service 1992). In addition, a literature search was conducted to ensure that there was no other significant published information on the taxon that was not already in the Service's files. Significant input was also provided by Dr. Joel Olfelt (Northeastern Illinois University), John Wiley (U.S. Fish and Wildlife Service, New York Ecological Services Field Office), and Steve Young (New York Natural Heritage Program).

1.3 Background:

1.3.1 FR Notice citation announcing initiation of this review:

The Service notified the public of the initiation of the 5-year review in the Federal Register on April 22, 2008 (73 FR 21643-21645).

1.3.2 Listing history

Original Listing

FR notice: 57 FR 14649-14653
Date listed: April 22, 1992
Entity listed: subspecies
Classification: threatened

Technical Correction

FR notice: 75 FR 55686-55689
Date: September 14, 2010
Revised Scientific Name: *Rhodiola integrifolia* ssp. *leedyi*

1.3.3 Associated rulemakings: n/a

1.3.4 Review History: No status assessment or 5-year review has been conducted for this species since its 1992 listing.

1.3.5 Species' Recovery Priority Number at start of 5-year review: 9 – indicates that the subspecies faces a moderate degree of threat, its recovery potential is high, and that it is a subspecies.

1.3.6 Recovery Plan or Outline

Name of plan or outline: *Sedum integrifolium* ssp. *leedyi* (Leedy's roseroot) Recovery Plan.
Date issued: September 1998

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1 Is the species under review a vertebrate?

Yes, go to section 2.1.2.
 No, go to section 2.2.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan¹ containing objective, measurable criteria?

Yes

No

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?

Yes
 No

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)?

Yes
 No

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:

The recovery criteria for Leedy's roseroot are (U.S. Fish and Wildlife Service 1998, p. iv and 10):

Sedum integrifolium ssp. *leedyi* may be considered for delisting when:

(1) All three privately owned Minnesota populations are protected by conservation easements or fee acquisition by a public agency or private conservation organization;

(2) The Whitewater Wildlife Management Area, Minnesota, population is protected from or removed from any confirmed contamination threat and has been demonstrated to be self-maintaining for five years;

¹ Although the guidance generally directs the reviewer to consider criteria from final approved recovery plans, criteria in published draft recovery plans may be considered at the reviewer's discretion.

- (3) The Glenora Falls, New York, population is protected; and,
- (4) Habitat for 4,000 plants in multiple sites, evenly distributed along a 2-mile stretch of Glenora Cliff, New York, is protected. The two most-distant subpopulations protected at Glenora Cliff must be at least 1.5 miles apart; protected populations must be geographically distinct, self-sustaining, and have been protected for five consecutive years by measures that will remain effective following delisting.

In the recovery plan, the Service further elaborated on the recovery criteria (U.S. Fish and Wildlife Service 1998, p. 5):

The protected sites must represent the taxon's full range of genetic variability and may be protected by a combination of, but not limited to, the following conservation actions: Enrollment in permanent conservation easements, private land trusts, or landowner associations with effective land management plans to minimize impacts on *S. integrifolium* ssp. *leedyi* populations; fee acquisition; accompanied by tax relief or other compensation.

The status of progress made towards meeting each criterion is summarized below:

- (1) Criterion 1 has not been met. None of the three privately owned Minnesota populations has been protected by conservation easements or fee acquisition by a public agency or private conservation organization. We are not aware of any imminent threats of a high magnitude to these populations.
- (2) Criterion 2 has been met. There is no confirmed contamination threat to Leedy's roseroot at Whitewater Wildlife Management Area and the population has been self-maintaining since the approval of the recovery plan in September 1998. The number of plants at WWMA has fluctuated from year to year, but through 2014 was not significantly different than in 1998 (Fig. 2, Olfelt 2014).
- (3) Criterion 3 does not include a clear description of acceptable mechanisms of protection, but we assume that the mechanisms described as part of criterion 1 – “conservation easements or fee acquisition by a public agency or private conservation organization” – also apply to this criterion. There is no formal protection of the Glenora Falls population although it is currently “not likely to be developed” and inaccessible to the public (S. Young, NY Natural Heritage Program, Albany, NY, pers. comm. 30 May 2013).

(4) Criterion 4 – The number of plants at Glenora Cliffs may have declined between 1994 and 2010, but the 2010 count remained above 4,000 plants at 4,220 (New York Natural Heritage Program, unpubl. data). In addition, the 1994 survey was ‘not as rigorous’ as the later counts (S. Young, pers. comm. 2014); therefore, the apparent trend should be interpreted with caution. One small parcel with relatively few individuals has been protected by the Finger Lakes Land Trust, but habitat for 4,000 plants has not yet been protected. Leedy’s roseroot habitat is divided among numerous land parcels at Glenora Cliffs, but most of the population may be concentrated on relatively few tracts with about 24 different landowners; six of the entities own land that contains about 65% of the area inhabited by Leedy’s roseroot (U.S. Fish and Wildlife Service, *in litt.* 2014). If the 2010 census was within 14% of the actual number of plants – the size of the 95% confidence interval estimated for censuses of Minnesota population (Olfelt 2014, p. 2) – then the actual population size in 2010 was about 4,811. Therefore, to protect 4,000 plants, about 83% of the cliff frontage would have to be protected. If Leedy’s roseroot is evenly distributed across the cliff at Glenora Falls, this level of protection could involve a minimum of about 10 landowners. After formal protection is secured, funds for control of invasive plant species may be needed in perpetuity (S. Young, pers. comm. 30 May 2013).

Recovery criteria must be objective and measurable. The Leedy’s roseroot recovery criteria are objective and measurable with the following exceptions:

- 1) the word, “self-sustaining” in Criterion 4 should be defined; and,
- 2) the Service should clarify how to determine whether or not the protected sites “represent the taxon’s full range of genetic variability.”

Below we summarize each threat as described in the listing rule (U.S. Fish and Wildlife Service 1992) and describe whether it is adequately addressed by the recovery criteria. For each threat that is not addressed by the recovery criteria, we recommend a specific revision to the criteria later in this review (see, 4.0 RECOMMENDATIONS FOR FUTURE ACTIONS).

Minnesota – All Populations

“Road building and quarrying within karst formations” in Minnesota that would affect subsurface water flow and seepage patterns in Leedy’s roseroot cliff side habitats –The recovery criteria are clear that

certain sites must be protected, but they should further clarify that road building or quarrying are either precluded or unlikely to occur where they would affect water flow and seepage patterns in Leedy's roseroot's cliff side habitats.

Minnesota – Whitewater Wildlife Management Area

Contamination and changes to Whitewater Wildlife Management Area due to “filling or dumping in sink holes adjacent to the cliffs” – The recovery criteria are clear that Leedy's roseroot sites must be protected, but the criteria would have to be modified to ensure that Leedy's roseroot populations are protected from the effects of dumping material into sinkholes.

The use of pesticides that “may directly affect the quality of the Whitewater Wildlife Management Area” to which Leedy's roseroot plants are exposed – The recovery criteria do not clearly address this threat and should be revised to clarify that protections preclude the use of pesticides or herbicides that would harm Leedy's roseroot.

New York – Glenora Cliffs

Construction of stairs, vegetation clearing, and dropping felled trees on the Glenora Cliff site in New York – The recovery criteria should be further clarified to ensure that these activities would no longer pose a significant threat to Leedy's roseroot upon delisting.

“Residential development and alteration of the cliff-face and cliff-top habitat around Seneca Lake” that could affect ground water quality and flow – The recovery criteria do not clearly address this threat and would need to be revised to clarify that the populations around Seneca Lake must be protected from residential development and cliff-face alteration that could affect groundwater quality and flow and could destroy Leedy's roseroot plants.

Minnesota and New York

Erosion of the cliffs due to their inherent instability, heavy rains, and gullyng due to poor soil conservation practices above the cliffs –The criteria do not address threats that may be posed by erosion or inherent instability of the cliffs inhabited by Leedy's roseroot or by heavy rains. Cliff instability likely affects at least the Minnesota and Glenora Cliffs populations (Fig. 1; K. Mattingly, State University of New York – College of Environmental Science and Forestry, Syracuse, NY, pers. comm., 2014). The recovery criteria should be revised to address factors related to these threats, if still appropriate. In addition, the recovery criteria should be

revised to ensure that sites are protected from effects of gully formation that would threaten any Leedy's roseroot population if it is reasonably certain to occur in the foreseeable future.



Figure 1. Example of an apparently unstable cliff section at a Leedy's roseroot site in Minnesota. Photo by Phil Delphey, U.S. Fish and Wildlife Service.

Grazing where Leedy's roseroot is present on moderate slopes – The recovery criteria do not clearly address this threat and should be revised to ensure that no Leedy's roseroot population is considered to be protected unless grazing is not a threat or is precluded where it may pose a threat.

The low numbers of populations and their isolation – The recovery criteria address this threat by requiring the protection of all Leedy's roseroot populations that were known to occur when the recovery plan was approved. It may still be unclear, however, whether the taxon may be conserved by relying only on the protection of the seven extant populations. The seven populations include four in Minnesota; two in New York; and, one in South Dakota.

Logging where it might lead to erosion above the cliffs – This was cited in the listing rule as a potential threat. The recovery criteria should be revised to ensure that this is precluded by measures taken to protect each population.

In the recovery plan the Service also describe the following threats to Leedy's roseroot:

Stochastic events that would severely impact the species' genetic diversity due to the low number and isolation of remaining populations (U.S. Fish and Wildlife Service 1998, p. 6) – This overlaps with the threat in the listing rule of low numbers of populations and their isolation. It is addressed in the recovery plan by requiring the protection of populations. We may not be able to prevent all of the stochastic events that may have significant adverse effects on Leedy's roseroot populations and may need to determine whether the taxon may be recovered by relying only on the extant populations.

The laying of pipes from cliff-top homes onto the cliffs in New York (U.S. Fish and Wildlife Service 1998, p. 6) – As with construction of stairs, vegetation clearing, and dropping felled trees, the recovery criteria should be revised to consider sites as protected only if any harmful laying of pipes is precluded.

2.3 Updated Information and Current Species Status

In this section, we discuss information obtained since the species' listing in 1992 and particularly since the recovery plan was approved in 1998.

2.3.1 Biology and Habitat

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

Olfelt (1998, p. 16) found a seed germination rate for Leedy's roseroot of 77% and described this as high for a rare plant, but lower than that of related subspecies.

Olfelt also found some evidence for inbreeding in Minnesota populations and concluded that they were isolated genetically due to geographic separation that is greater than the presumed distance that pollen is likely transported by animal vectors (Olfelt 1998, p. 43). The two nearest Minnesota populations are separated by about 3,000 meters. Olfelt (1998, p. 43) assumed that Leedy's roseroot's likely pollen vectors could transport pollen no more than 1,000 meters.

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

Minnesota Populations

Olfelt (2014, p. 6-7) documented the fluctuations that Minnesota’s Leedy’s roseroot populations have experienced since 1997, but despite periods of drought and unusual heat none of the populations have declined over the entire period of monitoring (Fig. 2). Leedy’s roseroot populations increased at Whitewater Wildlife Management Area (WWMA) and Simpson Cliffs from 1997 to 2003, but decreased from 2006 to 2010 (Olfelt 2014, p. 2). Census sizes of all four populations increased between 2010 and 2011, but since then populations have been stable except for a moderate decrease at Simpson Cliffs (Fig. 2). Censuses for all populations were higher in 2014 than in 1997, the first year of monitoring.

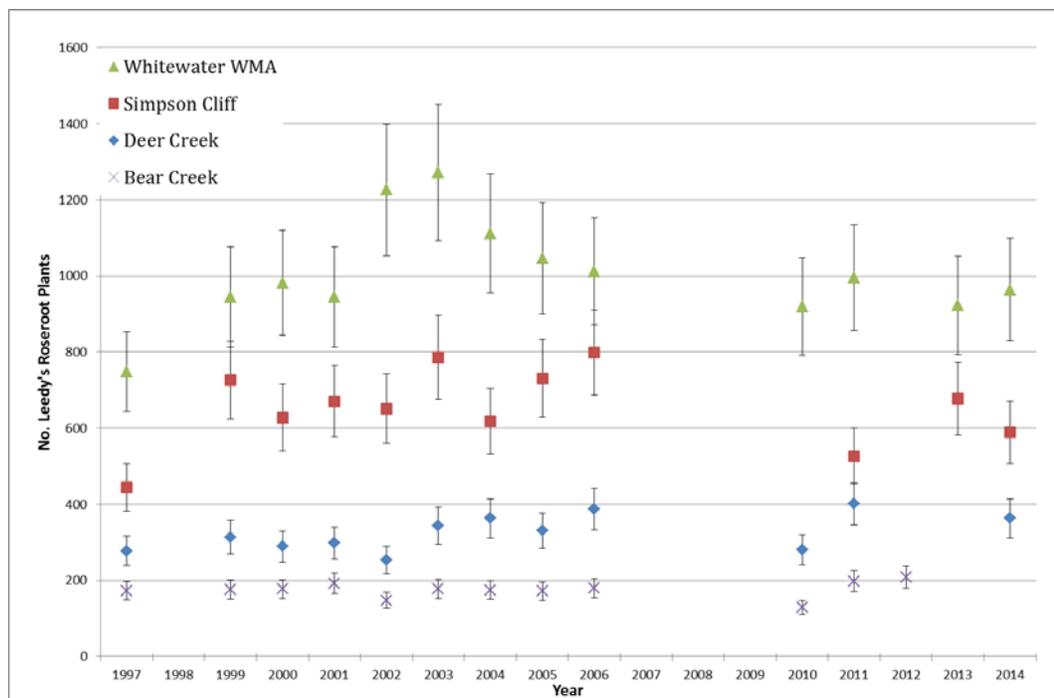


Figure 2. Census data for the four Minnesota populations of Leedy’s roseroot (Olfelt 2014). Error bars depict the 95% confidence intervals (+/-14% of counts).

The proportion of all plants that reproduce – the effective population size – has fluctuated markedly in at least two of the four Minnesota populations (Olfelt 2013, p. 3; 2014, p. 7). Low numbers of flowering plants and female flowers with filled seeds in the early years of Olfelt’s work suggested a pending decline in the WWMA population. In 2003,

however, numbers of plants increased their highest level (Fig. 2, Olfelt 2013, p. 2). Census numbers have since declined at WWMA, but not below the numbers counted in 1997 – the first year of counts (Fig. 2, Olfelt 2013, p. 2; 2014, p. 3). Levels of reproduction have also fluctuated at Deer Creek, but have remained relatively stable at Simpson Cliffs (Olfelt 2014, p. 2). The fluctuations in total plant counts relative to levels of reproduction demonstrate that our understanding of Leedy's roseroot population dynamics is still imprecise and that we are not yet able to predict population trends with much confidence (Olfelt 2013, p. 3; 2014, p. 4).

The factors that may drive fluctuations in plant numbers are beginning to be understood. Among the six demographic stages identified by Olfelt et al. (2007), the proportion of seeds that germinate and become seedlings may have the greatest impact on population fluctuations. Rock slides often associated with heavy precipitation events also appear to have a role in population fluctuations. In 2004, for example, a ten-meter-wide rock slide that originated from the top of the cliff likely removed "several tens of plants" (J. Olfelt, pers. comm. 2004).

New York Populations

At Glenora Cliffs in New York plant counts suggest a decline since 1994, although this may be an artifact of inconsistent census methods (Fig. 3; S. Young, pers. comm. 2014). In 1994, the number of plants was estimated at 6,193 whereas the most recent count in 2010 was only 4,220 (S. Young, New York Natural Heritage Program, pers. comm. 2010). Count methods and observers have not been consistent over the period and the 1994 may not have been as rigorous as later counts (S. Young, pers. comm. 2014). Between 1994 and 2010, counts were also conducted in 2003 (n = 4,073) and 2005 (4,901) (New York Natural Heritage Program, unpubl. data). The Leedy's roseroot population at Glenora Cliffs is counted every five years and a census is planned for 2015.

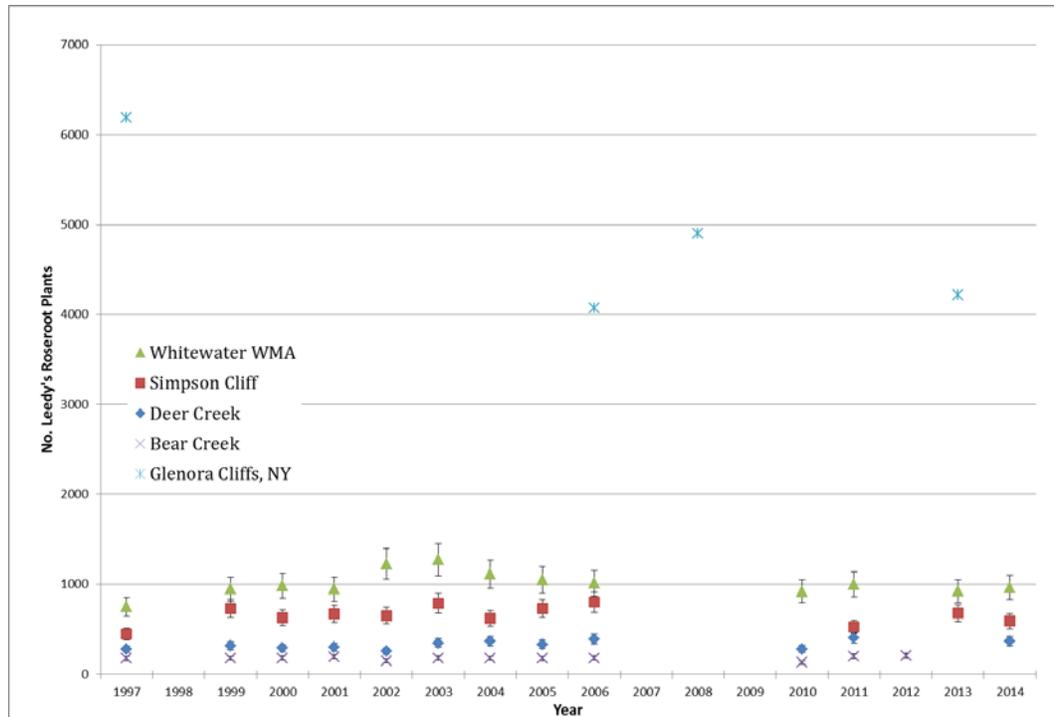


Figure 3. Plant counts at the Glenora Cliffs site in New York, with the Minnesota plant counts included to show the relative sizes of the populations. Note that count methods and observers have varied somewhat for the Glenora Cliffs population during the period shown.

If the Glenora Cliffs population did experience a 32 percent decline between 1994 and 2010, it would resemble some of the declines experienced by the three monitored Minnesota populations between 1997 and 2014. During that period, each of the three Minnesota populations experienced declines of 28-34% during specific intervals. Over the entire period between 1997-2014, however, none of the populations in Minnesota declined (Fig. 2). Although the decline in numbers of plants counted at Glenora Cliffs may be part of a long-term fluctuation or an artifact of inconsistent count methodology, it is cause for concern if the number of plants falls below 4,000 (see recovery criterion 4).

The much smaller Glenora Falls population was also last counted in 2010 when 60 plants were recorded (New York Natural Heritage Program, unpubl. data). In 1994, 40 plants were recorded, suggesting that the population at Glenora Falls has not likely declined in since then.

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):

Olfelt et al. (Olfelt et al. 2001; Olfelt and Freyman 2014) have completed extensive work on the genetics of Leedy's roseroot and its close relatives that has helped to resolve the subspecies' distinctiveness and distribution.

First, studies conducted by Olfelt et al. (2001, p. 406) distinguished Leedy's roseroot from other taxa with which they were formerly grouped as part of the *Sedum integrifolium* species complex. Recent work now also indicates that *Rhodiola integrifolia* that at Harney Peak in the Black Hills of South Dakota are closely related to the Minnesota and New York populations and are ssp. *leedyi* – Leedy's roseroot. Therefore, there now appear to be seven discrete populations of Leedy's roseroot – four in Minnesota; two in New York; and, one in South Dakota.

The populations in Minnesota may be effectively isolated from one another and the South Dakota population is clearly isolated. The Minnesota populations possess genetic differences from one another that are typical of animal-pollinated plant species (Olfelt 1998, p. 42). Olfelt (1998, p. 43) suggested that Leedy's roseroots animal pollen vectors likely do not transport pollen greater than 1000 m. None of the Minnesota populations are within 1000 m of one another and, therefore, may be on "separate evolutionary trajectories" (Olfelt 1998, p. 43). The two New York populations are discrete geographically, but separated by only 300-400 meters (J. Wiley, pers. comm. 2014). Analyses to determine whether there is gene flow between the two New York populations has not been conducted.

2.3.1.4 Taxonomic classification or changes in nomenclature:

On September 14, 2010 the Service published in the Federal Register (75 Federal Register 55686-55689) a notice that the scientific name of Leedy's roseroot had changed from *Sedum integrifolium* ssp. *leedyi* to *Rhodiola integrifolia* ssp. *leedyi*. Formerly a subgenus of *Sedum*, new genetic information has lead taxonomists to recognize *Rhodiola* as a distinct genus that includes Leedy's roseroot. The new combination is *Rhodiola integrifolia* Rafinesque subsp. *leedyi* (Rosendahl & J. W. Moore) H. Ohba (Ohba 2003, p. 218).

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):

In Minnesota and New York where Leedy's roseroot was known to occur at the time of listing, its distribution has not changed. We now know, however, that Leedy's roseroot occurs at Harney Peak in South Dakota (Olfelt and Freyman 2014, p. 908). This represents a significant expansion in the known range of Leedy's roseroot relative to what was known at the time of listing and when the recovery plan was approved.

In addition to genetic similarities, the determination that the plants at Harney Peak are Leedy's roseroot was based on multiple lines of evidence. They occupy similar moist north-facing cliff habitats; they have a similar trailing growth habit; and, they "cluster in rock fissures that are moist with seep water" (Olfelt and Freyman 2014, p. 908). The August 2000 field notes from the site indicate that the plants were 'hanging from seeping cracks on a steep north-northeast facing granite wall' (U.S. Forest Service, *in litt.* 2000).

The South Dakota population of Leedy's roseroot occurs on Black Hills National Forest on a cliff at approximately 7,000 feet above sea level. White spruce (*Picea glauca*) is the dominant overstory species on the north-northeast facing slope directly below the cliff; and ponderosa pine (*Pinus ponderosa*) is the dominant tree species in the general vicinity (U.S. Forest Service, *in litt.*). About seven patches of Leedy's roseroot may inhabit only a total of 10-50 square meters of the cliff face (Fig. 4; U.S. Forest Service, *in litt.* 2001; 2011). There has been significant recent mortality of ponderosa pine caused by mountain pine beetle (*Dendroctonus ponderosae*) in the vicinity of the Leedy's roseroot occurrence (C. Monks, U.S. Forest Service, Custer, SD, pers. comm. 2014).



Figure 4. Photo of Leedy's roseroot in Black Hills National Forest, South Dakota (Photo by Cheryl Mayer, U.S. Forest Service).

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

[Some information also relevant to this section is discussed in the context of recovery criteria and threats above (see section 2.2.3).]

Biologists in New York have noted recent changes in the plant community at the Glenora Cliffs site in New York, where Japanese knotweed (*Polygonum cuspidatum*) and European swallow-wort (*Cynanchum rossicum*) have invaded Leedy's roseroot habitat (J. Wiley, U.S. Fish and Wildlife Service, Cortland, NY, pers. comm. 29 July 2011). Steve Young noticed in 2010 that Japanese knotweed seemed "to have gotten worse in the center section of the population at Glenora Cliffs" and there is now an ongoing study to evaluate its potential effects on Leedy's roseroot (J. Wiley, pers. comm. 3 August 2013). Results after the study's first year do not support an inference that Japanese knotweed is adversely affecting Leedy's roseroot (Leopold 2014, p. 2-3). Eastern poison ivy (*Toxicodendron radicans*) may have also recently expanded in part of the site (S. Smolen, pers. comm. 7 June 2011).

In addition to plant invasions, the hemlock woolly adelgid, an insect that attacks eastern hemlock (*Tsuga canadensis*), has invaded the area inhabited by Leedy's roseroot in New York. Eastern hemlocks "are often damaged and killed within a few years of becoming infested" by the insect ("Northeastern Area." Hemlock Woolly Adelgid, Forest Health Protection, USDA Forest Service. U.S. Forest Service. Web. 18 Jan. 2013. <<http://www.na.fs.fed.us/fhp/hwa/>>.). Loss of eastern hemlock could lead to alterations in the cool microclimate at the site (R. Wesley, Cornell Plantations, Ithaca, NY, pers. comm. 7 June 2011). Leedy's roseroot does not associate with hemlocks directly, however, and hemlocks may only affect a small area of Leedy's roseroot habitat at the New York sites (J. Wiley, pers. comm. 2013; K. Mattingly, pers. comm. 2014).

2.3.1.7 Other:

Observations of plants that have been eroded from cliffs and of storm damage in Leedy's roseroot habitats has further confirmed the potential for storms and cliff top erosion to affect populations. Storm damage in Minnesota in 2014 knocked numerous Leedy's roseroot plants to the base of cliffs, where they will likely die (Olfelt 2014, p. 2, 4). It is not clear, however, whether the level of resulting mortality has affected growth of any of the Minnesota populations.

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

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

Changes in the plant community at the Glenora Cliffs site in New York may represent new threats to Leedy's roseroot; a study is ongoing to determine the effects of Japanese knotweed, although it is not yet clear whether and to what degree this invasive species may threaten the Leedy's roseroot at Glenora Cliffs (Leopold 2014). See section 2.3.1.6, above.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

No new information.

2.3.2.3 Disease or predation:

No new information.

2.3.2.4 Inadequacy of existing regulatory mechanisms:

Not relevant to Leedy's roseroot.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

Exposure to potentially harmful compounds in groundwater may be a threat to Leedy's roseroot that deserves further investigation. In the hydrogeologic assessment prepared shortly after completion of the Leedy's roseroot recovery plan, Spetzman and Cremers (1999) described how sinkholes can become sources of groundwater contamination if surface water carries agricultural chemicals into them from nearby farmland. This threat was not clearly addressed in the recovery plan, which mentioned only 'dumping into' or 'filling of' sinkholes as a threat to Leedy's roseroot. In addition to the potential threat posed by agricultural chemicals, smaller-scale herbicide applications should also be considered. At Glenora Cliffs, New York, for example, landowners sometimes apply herbicides to improve lake views (K. Mattingly, pers. comm. 2014).

At the Whitewater Wildlife Management Area site in Minnesota an eroded township road may be contributing to significant erosion along the cliff top (J. Olfelt, pers. comm. 2007). Wildlife managers are aware of this issue and have been investigating potential solutions with local jurisdictions for several years.

There is some question with regard to the potential for hydraulic fracturing (fracking) to affect Leedy's roseroot in New York because potentially affected bedrock formations outcrop along Seneca Lake cliffs that are inhabited by the species (J. Wiley, pers. comm. 2013). There is significant uncertainty regarding the potential for 'fracking' fluids to reach Leedy's roseroot habitats. Specifics of the bedrock structure; effects of fracking on the bedrock; and, the location of fracking operations would each influence the likelihood that Leedy's roseroot would be exposed to substances contained in fracking fluids (J. Wiley, pers. comm. 2013).

The Harney Peak, South Dakota population may be threatened by climate change and catastrophic wildfire (C. Monks, pers. comm. 2014). Leedy's roseroot already inhabits the highest elevation habitat available in the ecoregion and would not be able to move to higher – and presumably cooler and moister – habitats if climate change rendered its current habitat unsuitable. In addition, as ponderosa pines succumb to mountain pine beetle, drop needles, and fall the risk of a wildfire in forest around the Leedy's roseroot population is likely to increase (C. Monks, pers. comm. 2014).

The potential threat to Leedy's roseroot posed by Japanese knotweed and efforts to control it at Glenora Cliffs, New York are summarized above (section 2.3.1.6), but bears further discussion here. Research is underway to determine whether Japanese knotweed at Glenora Cliffs is likely to affect the viability of Leedy's roseroot there; results after one-year do not support an inference that this invasive species poses a direct threat to Leedy's roseroot, but the study is ongoing (Leopold 2014). There are agency efforts to control this invasive species, but individual landowners may also be using herbicides to control it with potential adverse effects to Leedy's roseroot (J. Wiley, pers. comm. 2014; K. Mattingly, pers. comm. 2014).

2.4 Synthesis

The size and distribution of Leedy's roseroot populations in Minnesota has not significantly changed since censuses began in 1997. The New York population at Glenora Cliffs may have declined, but differences between the 1994 count and later counts suggest that this should be interpreted with caution (Fig. 3). Each of the four Minnesota populations has undergone marked fluctuations over the last 17 years, but the most recent counts of plants are not significantly different than when counts began in 1997 (Fig 2.). The most recent count of plants at Glenora Cliffs in New York was above the minimum size needed for recovery, but smaller than previous counts. No clear causes for a decline at Glenora Cliffs have been ascertained, but investigations are underway to determine how invasive species may be affecting Leedy's roseroot there. The second – and much smaller – New York population at Glenora Falls remains little changed since 1998 and faces no clear and significant threats.

The determination that members of the *Rhodiola integrifolia* complex in South Dakota are Leedy's roseroot is a significant change that should now be addressed by the recovery plan for this species.

Formal protection of Leedy's roseroot populations by acquisition or conservation easement has made little headway since the species was listed. In Minnesota, landowners have been uninterested in selling their land or conservation easements. At Glenora Cliffs in New York, Leedy's roseroot habitat is divided among numerous land parcels, but most of the population may be concentrated on relatively few tracts with about 24 different landowners; land owned by six entities may contain about 65% of the population (U.S. Fish and Wildlife Service, *in litt.* 2014). Although it may not be feasible to protect every plant in the population, significant progress may be made by focusing on the few owners with most of the species' habitat on their lands. Therefore, the Service is working with its partners to prioritize lands for protection.

The recovery criteria for Leedy's roseroot should be revised to ensure that they address all of the threats to the taxon and take into account the discovery of a new population in South Dakota. Suggested revisions are described below in the section, **RECOMMENDATIONS FOR FUTURE ACTIONS**. In addition to protection and acquisition of habitats, the recovery criteria focus on impacts to groundwater that discharges into Leedy's roseroot's cliff side habitats. To ensure that any indirect threats associated with groundwater are adequately addressed, the recovery criteria should be reviewed to ensure that they contain enough specificity about the variety of activities that may affect Leedy's roseroot as a result of their exposure to harmful substances in groundwater or significant alterations of groundwater flows.

One recovery criterion is devoted entirely to Minnesota's largest population at Whitewater Wildlife Management Area. An eroding township road near this population has posed a potential threat to Leedy's roseroot for years, but the population has evidently not declined since approval of the recovery plan. The number of plants and the proportion of plants that reproduce has fluctuated markedly over the years, but counts were not significantly different in 2014 compared to the first counts conducted in 1997 (Fig. 2). Nevertheless, the condition of this road and its potential effects to Leedy's roseroot should continue to be monitored and evaluated.

3.0 RESULTS

3.1 Recommended Classification:

- Downlist to Threatened**
- Uplist to Endangered**
- Delist** (*Indicate reasons for delisting per 50 CFR 424.11*):
 - Extinction*
 - Recovery*
 - Original data for classification in error*
- No change is needed**

3.2 Recovery Priority Number: 9

Brief Rationale:

The survival of Leedy's roseroot remains dependent on seven populations that are mostly small and isolated. The largest population at Glenora Cliffs, New York, may still include more than 4,000 plants, but the remaining populations are each comprised of 1,000 or fewer plants. A population in South Dakota was only confirmed recently to be Leedy's roseroot. The discovery of this population improves the conservation status of Leedy's roseroot to some degree, but the population is small and faces a moderate degree of threat from wildfire. Each of the other populations faces moderate threats, but none are clearly near extirpation. Leedy's roseroot is still threatened. Populations generally appear to be stable and able to withstand relevant threats for the foreseeable future.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

1. Review threats to the species, beginning with the information in this review, to ensure that recovery criteria are revised appropriately to address all significant threats to the species. Prepare a list of threats based on this assessment and have it reviewed by species' experts to ensure that it is complete and accurate. Finally, revise the recovery criteria, as appropriate.
 - 1.1. Determine whether and to what degree any Leedy's roseroot populations are threatened by the instability of their cliff side habitats and whether heavy rains are likely to pose a threat any population. Use this information to determine whether the recovery criteria should be revised to address specific related threats and revise the criteria, if appropriate.
 - 1.2. Determine whether and to what degree any Leedy's roseroot populations are threatened by gully formation or by poor soil conservation practices. Revise the recovery criteria to address this factor if it poses a threat. This potential threat may currently be most relevant to the population at Whitewater Wildlife Management Area in Minnesota.
 - 1.3. Determine whether grazing or logging poses a direct or indirect threat to any Leedy's roseroot population. If they do, revise the recovery criteria to ensure that no site is considered to be protected unless the threats are adequately minimized.
 - 1.4. Consider revising the recovery criteria to clarify that the protections required for each Leedy's roseroot population must preclude the following:
 - 1.4.1. Filling or dumping material into any sink holes where that activity could result in exposure of Leedy's roseroot to harmful contaminants or alteration of groundwater flows to cliffs where Leedy's roseroot occurs;
 - 1.4.2. The use of any pesticides or herbicides where it would result in the exposure of Leedy's roseroot to harmful compounds; and,
 - 1.4.3. Road building or quarrying that would affect groundwater flows in any Leedy's roseroot cliff side habitats.
 - 1.5. Consider revising the recovery criteria to require that protection of Leedy's roseroot habitat at the Glenora Cliff site in New York would preclude the construction of stairs, vegetation clearing (except for invasive species), laying of pipes, and dropping felled trees where these activities would likely cause adverse effects to Leedy's roseroot.
 - 1.6. Consider revising the recovery criteria to further clarify that the populations around Seneca Lake must be protected from residential development, cliff-face alteration, and hydraulic fracturing (fracking) that could affect ground water quality and flow.
 - 1.7. Review the preliminary hydrogeological assessment prepared for Leedy's roseroot in Minnesota (Spetzman and Cremers 1999) and develop a plan to assess the risk of groundwater contamination for each of the four Minnesota populations and measures that would protect the taxon from this threat. Consider engaging the appropriate regional hydrologist with the Minnesota Department of Natural Resources, Division of Ecological and Water Resources to help develop this plan. Ensure that the plan is sufficient to determine the following:

- 1.7.1. The extent to which transport of agricultural chemicals into sinkholes poses a risk of exposing Leedy's roseroot to contaminated groundwater.
- 1.7.2. The locations of sinkholes – or the areas in which they may occur – that should be protected to ensure that each Leedy's roseroot population is safe from effects to groundwater flows or groundwater contamination.
- 1.7.3. The area in which road building or quarrying may expose Leedy's roseroot to the effects of any changes in groundwater discharge.
- 1.7.4. The specific practices that would need to be implemented to mitigate any specific threats of exposing Leedy's roseroot to changes in groundwater discharge or to contaminated groundwater and to alleviate any ongoing exposure.

It may also be prudent to carry out similar actions in New York.

2. Revise the recovery plan to address the Leedy's roseroot population that is now confirmed in South Dakota.
3. It may still be unclear whether the taxon may be conserved by relying only on the protection of the seven known extant populations. The seven populations include four in Minnesota; two in New York; and, one in South Dakota. Consider developing a range wide viability assessment that assesses the species' recovery criteria and determines whether extant populations would ensure sufficient redundancy and representation for the subspecies; and to develop criteria that may be used to determine whether or not the populations that are essential to recovery are sufficiently resilient.
4. Define "self-sustaining" per the recovery criteria or eliminate it from revised criteria.
5. Ensure that an adequate seed banking program is established for Leedy's roseroot.

5.0 REFERENCES

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Rhodiola integrifolia* ssp. *leedyi*

Current Classification: Threatened

Recommendation resulting from the 5-Year Review:

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

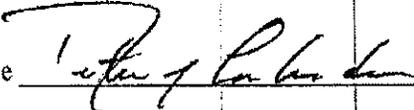
Appropriate Recovery Priority Number, if applicable: 9

Review Conducted By: Phil Delphey

FIELD OFFICE APPROVAL:

Lead Field Supervisor, U.S. Fish and Wildlife Service, Twin Cities Ecological Services Field Office

Approve



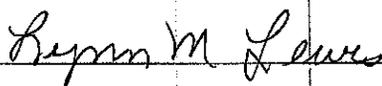
Date

29 April 2015

REGIONAL OFFICE APPROVAL:

Lead Assistant Regional Director, Ecological Services, U.S. Fish and Wildlife Service, Midwest Region

Approve

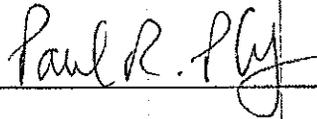


Date

5/4/15

Cooperating Assistant Regional Director, Ecological Services, U.S. Fish and Wildlife Service, Northeast Region

Signature



Date

5/26/15

Cooperating Assistant Regional Director, Ecological Services, U.S. Fish and Wildlife Service, Mountain-Prairie Region

Signature



Date

6/1/15