

M.L. 2015 Project Abstract

For the Period Ending June 30, 2017

PROJECT TITLE: Habitat Mitigation for Goblin Fern Conservation

PROJECT MANAGER: Bobby Henderson

AFFILIATION: Leech Lake Band of Ojibwe

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FUNDING SOURCE: Environment and Natural Resources Trust Fund

LEGAL CITATION: M.L. 2015, Chp. 76, Sec. 2, Subd. 03s

APPROPRIATION AMOUNT: \$61,000

AMOUNT SPENT: \$39,276

AMOUNT REMAINING: \$21,724

Overall Project Outcome and Results

Goblin fern (*Botrychium mormo*) is a tiny, cryptic species of fern from the Great Lakes region of North America. The species once occurred throughout rich sugar maple and basswood forests of Minnesota, Michigan, and Wisconsin, but in recent times has become exceedingly rare and vulnerable throughout the entirety of its historic range. The primary goals of this project were to (1) evaluate habitat conditions and environmental factors influencing the decline of goblin fern populations; (2) quantify projected population extirpation rates for all recorded populations across Leech Lake Reservation, including Chippewa National Forest.

1) Habitat conditions were assessed by the degree of worm damage at each location and assigned an IERAT rank of 1-5 (1 = non-wormed, 5 = extremely wormed). Each site was also assigned a habitat ranking of 1-5 (1 = prime, 5 = non-extant); which directly correlates with the probability of goblin fern presence/absence at each location.

2) Our estimates of Minnesota goblin fern extirpation are consistent with previous publications; in fact our estimates indicate a significant increase in extirpation rates when compared to older publications addressing habitat issues and concerns.

Though startling, our study provides current published information about the loss of critical habitat, and subsequent decrease in occurrence and abundance of this state threatened species across its native range within Minnesota. With exception to the driftless area in southeastern Minnesota, there are no earthworm species native to the state, especially the rich maple and basswood forests of northern Minnesota. Contrary to long held belief, earthworms, especially those known as "crawlers", cause irreparable damage to the forest floor and soil. As a result, much of the vital habitat required for the survival of goblin fern has become seriously degraded and fragmented across the north woods of Minnesota.

Project Results Use and Dissemination

Our abstract was submitted for peer review in June 2018. Upon receiving comment, review and revisions were made to the abstract, which was submitted in July 2018, and ultimately accepted for publication. The published article has been disseminated amongst select individuals within Minnesota Department of Natural Resources, Chippewa National Forest, Superior National Forest, and Ottawa National Forest for the purpose of developing and implementing improved habitat conservation

measures. Additionally, all data collected from the project were shared with the USFS, Chippewa National Forest for the purposes of updating database records.



Environment and Natural Resources Trust Fund (ENRTF) M.L. 2015 Work Plan Final Report

M.L. 2015, Chp. 76, Sec. 2, Subd. 03s Project Abstract
For the Period Ending June 30, 2017

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PROJECT MANAGER: Bobby Henderson
AFFILIATION: Leech Lake Band of Ojibwe
MAILING ADDRESS: 115, 6th St. NW, Suite E
CITY/STATE/ZIP: Cass Lake, MN 56633
PHONE: (218) 784-8620
E-MAIL: bwh1940355@gmail.com
WEBSITE: [If applicable]
FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2015, Chp. 76, Sec. 2, Subd. 03s

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- 1)** Zlonis, K.J., Henderson, B.W., 2018. Invasive earthworm damage predicts occupancy of a threatened forest fern: Implications for conservation and management. *Forest Ecology and Management* 430, 291-298



Environment and Natural Resources Trust Fund (ENRTF) M.L. 2015 Work Plan Final Report

Date of Report: December 18, 2018 (Final Report)

Final Report

Date of Work Plan Approval: June 11, 2015

Project Completion Date: June 30, 2018

PROJECT TITLE: Habitat Mitigation for Goblin Fern Conservation

Project Manager: Bobby Henderson

Organization: Leech Lake Band of Ojibwe

Mailing Address: 115, 6th St. NW, Suite E

City/State/Zip Code: Cass Lake, MN 56633

Telephone Number: Cell (218) 784-8620

Email Address: bwh1940355@gmail.com

Web Address:

Location: Beltrami, Cass, Itasca (Leech Lake Reservation/Chippewa National Forest)

Total ENRTF Project Budget:

ENRTF Appropriation: \$61,000

Amount Spent: \$39,276

Balance: \$21,724

Legal Citation: M.L. 2015, Chp. 76, Sec. 2, Subd. 03s

Appropriation Language:

\$61,000 the first year is from the trust fund to the commissioner of natural resources for an agreement with the Leech Lake Band of Ojibwe to examine goblin fern populations, a threatened species in Minnesota, in relation to habitat degradation and to develop long term habitat mitigation and species conservation strategies. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

I. PROJECT TITLE: Habitat Mitigation for Goblin Fern Conservation

II. PROJECT STATEMENT:

In 2013 Minnesota made updates to the Endangered and Threatened Species list, Statement of Need and Reasonableness (SONAR). As a result the status for Goblin fern (*Botrychium mormo*) was raised from a species of Special Concern to a Threatened species in Minnesota. This rare fern commonly referred to as a moonwort or Goblin fern, is a small discreet fern endemic to the rich Northern Hardwood forests of Minnesota, Wisconsin, Michigan, with a single historic record from Ontario, Canada. Currently this species is threatened in Minnesota (total records unknown), threatened in Michigan (13 records), endangered in Wisconsin (89 records), and receives a Global rank of G3 (vulnerable). Within this restricted range it occurs only within specific habitats defined by forest community type and soils. These communities in Minnesota are often dominated by *Acer saccharum*, *Tilia americana*, *Fraxinus nigra*, *Betula alleghaniensis*, with occasional upland *Thuja occidentalis* and *Ulmus spp...* The soils tend to be sandy loams – loam, with an intact thick organic layer (O and A soil horizons) Outside Minnesota the habitats and canopy composition slightly differ, but *Acer* and *Tilia* continue to be a dominant associate species.

Since 1975 there have been over 600 Goblin fern observations on Leech Lake Reservation/Chippewa NF; which makes this area the heart of Goblin fern distribution. But it is highly suspected many of the populations prior to 2000 have been extirpated as a result of severe habitat degradation. The scourge most responsible for Goblin fern extirpation throughout its range has been the introduction of non-native earthworms. All earthworms found in Minnesota are non-native; with the majority being European species of the family *Lumbricidae*. The initial arrival of earthworms came with European settlers around the mid-1800s, but since that time their spread has been expedited through human activities such as the dumping of unused fishing bait, forest management activities, recreation, development, and potentially anything that moves soil from a contaminated area to areas unaffected by earthworms. As a result the continual rapid loss of habitat is extirpating Goblin fern populations at an alarming rate.

This is a multifaceted project with multiple goals. The **overall goal** is to review historic record locations to examine populations in order to quantify Goblin fern abundance, decline, and possible extirpations at the local scale. These crucial steps in the project will be accomplished through surveying and monitoring a random sampling of sample units (EO records).

The **second goal** is to collect earthworm data utilizing the Invasive Earthworm Rapid Assessment Tool (IERAT) and assign each specific location a ranking as defined by IERAT. This exercise will also give us the opportunity to assess and document the adverse effects earthworms cause to Goblin fern habitat. Ultimately the earthworm data will be submitted to a much larger earthworm study being conducted by Great Lakes Worm Watch and UMD NRRI.

The **third goal** is to analyze the data with the assistance of Forest Service botanist Kirk Larson in order to determine:

- 1) Is Goblin fern abundance and distribution diminishing on the Leech Lake Reservation/Chippewa National Forest?
- 2) Identify the factors responsible for diminishing population abundance and/or extirpations at the local scale.
- 3) Identify conservation strategies/plans which will need to be addressed and/or developed in order to minimize further negative effects to Goblin fern habitat and populations.

III. OVERALL PROJECT STATUS UPDATES:

Project Status as of October 30, 2015:

In early July Kirk Larsen and I began field activities to relocate and establish the probable goblin fern plots based on available coordinates for each location. The oldest 40 locations proved to be the greatest challenge as many

of these locations were observed pre GPS days. Consequently, I was forced to seek out the closest available habitat and/or forest community matching the descriptions documented in the original field forms.

As a result of poor or inadequate field notes, timber management activities, and/or ecological issues, some locations were not relocated in 2015. This forced us to establish the most probable location within a reasonable distance of the inferred coordinate. Unfortunately, there were a number of instances where little or no suitable goblin fern habitat remained within a 300' radius of the given UTM and in some instances there was no suitable goblin fern habitat within 1000' of the original coordinates. But one could observe that there had been goblin fern habitat within the past 20 years.

For 2015, Goblin fern phenology appeared to be approximately 2 weeks behind schedule compared to previous 6 years phenology monitoring I've conducted. Kirk and I strongly suspect this was the result of environmental factors (winter and spring drought conditions) we observed during early 2015. For a phenology reference we visited a known location where hundreds goblin fern are typically observed, but struggled to find a dozen plants this past season. These environmental factors possibly explain why we encountered a number of locations where habitat continues to exist, but no plants were observed.

With the use of the Invasive Earthworm Rapid Assessment Tool (IERAT), earthworm damage is ranked on a scale of 1-5; 1 being a fully intact forest floor and 5 representing no forest floor. For each location visited the habitat was examined and assigned a rank using the IERAT scale. Although the data has not been compiled, our preliminary field observations strongly suggest less than 8% of our sites have a fully intact forest floor.

Project Status as of April 15, 2016:

Since our initial 2015 relocation efforts of the 80 goblin fern sites, I began to compile and enter the 2015 field data in regards to target species presence, population viability, habitat conditions, earthworm activity per IERAT, and canopy cover.

Currently we are preparing for the 2016 field season. Field activities will commence late June/early July provided phenology and environmental conditions allow.

Project Status as of October 30, 2016:

The second year of site revisits and data collection began the third week in June and concluded the mid-August 2016. Phenology appeared to be a little earlier than the 2015 field season, plus environmental conditions appeared more favorable as the spring was not as droughty compared to spring 2015.

Being a somewhat subterranean species, small populations of goblin fern can be difficult to observe from year to year as this species is capable of completing all necessary biological functions without emerging during years where environmental conditions are less than favorable. However, this should not be mistaken for a habitat which no longer exists as a result of extensive and severe earthworm degradation.

Overall the field work is going well and will resume June 2017.

Project Status as of April 15, 2017:

Currently we are preparing for the 2017 field season. Field activities will commence late June/early July provided phenology and environmental conditions allow. 2016 field data was entered over the course of winter.

Project Status as of October 30, 2017:

The third and final year of site revisits and data collection began the third week in June and concluded early September 2017. Phenology appeared to be odd this year compared to the previous two field seasons. Environmental conditions appeared favorable as spring began with adequate moisture, but quickly became dry and remained that way from mid-June through August.

Being a somewhat subterranean species, small populations of goblin fern can be difficult to observe from year to year as this species is capable of completing all necessary biological functions without emerging during years where environmental conditions are less than favorable.

Overall, the project has been time consuming during the summer months, but the data collected is beginning to answer questions surrounding the species requirement for quality habitat. We are currently planning to extend the project additional years beginning June 2018. The protocol will be refined to collect data only from extant sites vs. all eighty locations, with a similar focus of monitoring habitat and population density. This will be important data collection as a number of sites are in serious jeopardy of extirpation as a result of advancing worm fronts. To capture an extirpation while it is occurring is extremely valuable research.

Retroactive Amendment Request (04/09/2018):

We are seeking an amendment to 1) retroactively add Katie Zlonis as project personnel to the budget and 2) extend the project end date to June 30, 2018. Bobby Henderson accepted a position with the USFS in 2016 and has continued to work on the project as the Project Manager. In March 2017, Katie began working as the Plant Resources Program Manager at Leech Lake DRM and has since worked on data analysis, synthesis, and writing the resulting manuscript for the project. Her work on the project prior to 2018 includes approximately 1 day of work in May 2017, which we understand won't be reimbursed, and approximately 60 hours of work from November 20, 2017–December 15, 2017 (approximately \$1,500). Her work on the project continued after January 1, 2018 (approximately 150 hours to date, ~\$3,600) and is ongoing.

In addition, we are requesting an extension in the project end date to June 30, 2018 so that we can conclude publication of a peer-reviewed manuscript that is nearly ready to be submitted and complete management plans.

Amendment Approved: [04/11/2018]

Project Status as of April 15, 2018:

All data collected over the past three field seasons have been collected, entered, checked, and analyzed.

As of April 15, a manuscript detailing methods and results of this project were nearly ready for submission to a peer-reviewed journal. The manuscript was submitted after this reporting period on May 1, 2018.

Project Status as of September 14, 2018:

As of August 2018 our manuscript was accepted and ultimately published by *Forest Ecology and Management* 430 (2018) 291–298. Along with the updated report and budget is the journal article titled “Invasive earthworm damage predicts occupancy of a threatened forest fern: Implications for conservation and management”.

Though data collection for the initial goblin fern project was not planned beyond three years, Kirk Larson and I continued monitoring the extant 27 locations during August/September 2018. We feel the project should continue for an additional seven years in order to collect a long term data set for the remaining sites. Though I'm now employed with US Forest Service, I continue to consult with LLBO representatives Steve Mortensen and Kate Hagsten regarding the long term plans and goals of this project. Currently we are in the process of planning a meeting with representatives from other natural resource management agencies to discuss the long term implications of current forest management uses and practices. At this time, the initial three year phase of the project has been completed.

Overall Project Outcome and Results

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Though startling, our study provides current published information about the loss of critical habitat, and subsequent decrease in occurrence and abundance of this state threatened species across its native range within Minnesota. With exception to the driftless area in southeastern Minnesota, there are no earthworm species native to the state, especially the rich maple and basswood forests of northern Minnesota. Contrary to long held belief, earthworms, especially those known as “crawlers”, cause irreparable damage to the forest floor and soil. As a result, much of the vital habitat required for the survival of goblin fern has become seriously degraded and/or fragmented across the north woods of Minnesota.

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Identify Experimental Units, Finalize Project Design, Survey and Assess Locations.

CNF botanist Kirk Larson and I will examine the CNF Goblin fern records to identify four sub-sets of experimental units. The sub-sets will be based on five year increments from 1992 – 2011 giving us a sample period of 20 years. It is important to note that CNF Forest Service lands are divided into districts, compartments, and timber stands, so each experimental unit has a unique identifier (District - Compartment/Stand number). For each five year period we will randomly identify our 20 experimental units for a total of 80 unique experimental units.

Sample units will be based on the element of occurrence (Goblin fern record) within the experimental unit. Each experimental unit will contain a sample unit identified by a unique corporate number for the EO (example: BOMO3001) There will be a total of 80 sample units to coincide with the 80 experimental units. For timber stands containing more than one Goblin fern EO, a sample unit will be randomly selected for survey and monitoring.

Sub-set 1: 1992-1996 – 20 experimental units – 20 sample units

Sub-set 2: 1997-2001 – 20 experimental units – 20 sample units

Sub-set 3: 2002-2006 – 20 experimental units – 20 sample units

Sub-set 4: 2007-2011 – 20 experimental units – 20 sample units

Once the experimental and sample units are identified, CNF botanist Kirk Larson and I will design the survey and data collection protocol for the three year project. Much of the information we wish to obtain is related to habitat quality and population viability (*goblin fern presence/persistence, canopy closure, soil moisture, associated species, soil organic layer, earthworm presence and effects*). This simple base data will be important for decisions regarding future Forest Plan updates.

The first year of surveys will be most labor intensive as the location coordinates from early observations tend to be highly inaccurate. If ground truthing the original EO proves to be difficult, then the experimental unit (timber stand) will be fully surveyed to help establish the probable EO coordinates. If the original location goes without

detection, the original field notes will be utilized to identify the best habitat within proximity of the given EO coordinates. Once the probable habitat is identified it will be designated as the sample unit.

For sample plots where Goblin fern continues to persist, there will be pin flags placed in the ground to identify a meter square sample unit at the site. At EO locations where Goblin fern is absent, there will be a single pin flag placed in the vicinity of the coordinates or habitat to identify the location as a sample unit. If at a later date Goblin fern is observed in the vicinity, then there will be a meter square sample unit placed around the EO to identify it as the probable location.

By mid-August most Goblin fern have senesced, so intensive field work is required as there is approximately a six week time window from late June – early August for conducting quality Goblin fern surveys. Kirk Larson and I are highly experienced in *Botrychium* surveys and identification so this accounts for the decision to utilize only two surveyors for the project. Data consistency and thoroughness are crucial to reduce inaccuracy which also contributes to the decision for only two surveyors.

Summary Budget Information for Activity 1:

ENRTF Budget: \$ 37,400
Amount Spent: \$ 27,188
Balance: \$ 10,212

Outcome	Completion Date
1. Establish project and survey protocol and identify experimental and sample units	July 2015
2. Survey experimental and sample units late June-mid August 2015, 2016, 2017	August 2017
3. Compile and analyze data from survey and monitoring efforts	December 2017

Project Status as of October 30, 2015:

In early March we identified our random sample of locations and began preliminary data collection for the goblin fern sites to be relocated and monitored over the next three years. After the 80 random locations were identified, GIS specialist Devona Berndt with the USDA Forest Service offered up her services to produce maps along with copies of existing documentation for each of the 80 locations. Between March and June 2015 Kirk Larson and I met on a number of occasions to discuss parameters of the project and establish relocation protocol.

Between early July through early September, Kirk and I completed our field work activities. This included relocation efforts, assigning and marking the population (plot), collecting all relevant data (described in activity 2) as it pertains to the project, plus collecting photos of the actual plants. A total of approximately 412 hours have been contributed to preliminary data gathering and compiling, cartography, relocation and survey efforts.

Project Status as of April 15, 2016:

Although it's too early in the project to draw conclusions, there have been some interesting but not unforeseen correlations between species absence and earthworm activity. As the project progresses I expect recurring patterns in the data where earthworm activity is ranked 4 or higher.

Project Status as of October 30, 2016:

Between late June to early August, Kirk and I conducted and completed the 2016 field activities. This included relocation efforts, assigning and marking the population (plot) for 12 populations which were not observed during the 2015 field visit, collecting all relevant data (described in activity 2) as it pertains to the project, plus collecting photos of the actual plants at the locations.

Compared to the 2015 field season, April and May 2016 offered greater early season soil moisture which carried into June when goblin fern begins to emerge. As field work progressed we observed a number of locations which exhibited greater numbers of plants vs. the 2015 field season, plus 12 populations which were not observed during the 2015 field visit.

For summer 2016, Kirk and I contributed a combined total of 321 hours for survey efforts and data collection.

Project Status as of April 15, 2017:

Although it's too early in the project to draw conclusions, there have been some interesting but not unforeseen correlations between species absence and severe earthworm activity. As the project progresses I expect recurring patterns in the data where earthworm activity is ranked 4 or higher. There is a direct correlation between earthworm activity and habitat integrity, which comes as no surprise, but is still valuable data to record.

Project Status as of October 30, 2017:

Between late June to early September, Kirk and I completed the 2017 field data collection. This included revisiting efforts, population counts, habitat assessment, collecting all relevant data (described in activity 2) as it pertains to the project, locating and marking populations that have not been observed the previous two field seasons, and ensuring all the locations are well marked for additional revisits which will begin summer 2018.

Compared to the previous two field seasons, 2017 field season was very dry during the emergence period, so population numbers were either low, or in a number of instances plants were absent altogether.

Project Status as of April 15, 2018:

As of April 15, 2018, all collected field data were entered, checked, and sent to Katie Zlonis at LLBO for analysis.

Final Report Summary:

During the course of the project, goblin fern was observed during at least one of three survey seasons at 27 locations (33.75%). Abundance across extant sites was relatively low with 42 plants observed in 2015, 62 plants in 2016, and 54 plants in 2017; range equals 1 - 12 plants with a mean of 3.

The Invasive Earthworm Rapid Assessment Tool (IERAT) was used at all locations to gather baseline information on soil and habitat condition. IERAT assessments range from 1-5; 1 being non-impacted, 5 representing severely degraded by invasive earthworms, especially *Lumbricus spp.* "night crawlers".

Goblin fern was documented at 27 of 80 sites (33.75%), with IERAT scores of 1-4; IERAT 1: 1 location, IERAT 2: 5 locations, IERAT 3: 16 locations, IERAT 4: 5 locations. Conversely, 53 locations (66.25%) displayed zero plants over the course of three field seasons. The locations where goblin fern was absent received IERAT assessments of 3-5; IERAT 3: 9 locations, IERAT 4: 21 locations, and IERAT 5: 22 locations.

Forest canopy conditions, including sub canopy, were monitored at all locations to document any significant changes that may occur in the canopy closure between survey periods. The majority of locations have a canopy closure range of 62% to 98%. Years of repeated field observation suggests canopy closure and structure play a complex role in maintaining environmental and microclimate conditions within viable goblin fern habitat. But the range of canopy closure alone does not appear to contribute to existence, absence, or abundance of goblin fern colonies. In summary, the range of canopy closure does not add any explanatory power for whether goblin fern remains present or absent above and beyond habitat degradation resulting from invasive earthworm activity.

ACTIVITY 2: Data Analysis, Submit Results to CNF, Assist in Development of Mitigation Plan for Updated CNF Forest Plan

For each sample unit, we will monitor and collect data for three consecutive seasons in order to document population health for our random selection of sample units. The data collection protocol will focus on target species presence, population viability, probable extirpations, current habitat conditions and earthworm activity. From this project we can potentially conduct long term monitoring of the locations which continue to contain viable Goblin fern populations.

Specific data we wish to collect includes:

- 1) Target species presence
- 2) Conduct plant count at sample units
- 3) Population viability (based on plant count, habitat conditions, earthworm activity)
- 4) Canopy composition
- 5) Canopy density
- 6) Associate vegetation species
- 7) Habitat conditions
- 8) Soil moisture
- 9) Evaluate Earthworm activity with the assistance of IERAT

Within the data analysis we will search for correlations between population abundance, habitat conditions and earthworm activity. Through repeated field observations I've observed what appear to be Goblin fern extirpations in the wake of earthworm invasions, but there has been very little work on the CNF to document or prove these events.

The major goal of this project is to extract enough information from data to support proposal for the development of improved Goblin fern habitat mitigation strategies and species conservation plans.

The intensive three year survey and monitor project will help in identifying the most detrimental issues surrounding Goblin fern habitat and populations. From this data, Leech Lake Band of Ojibwe will be able to develop appropriate Goblin fern habitat mitigation strategies and species conservation plans to insure appropriate protection for Goblin fern and Goblin fern habitat on tribally owned and managed lands.

As a co-managing agency, Leech Lake Band of Ojibwe must collaborate with Chippewa National Forest to insure habitat mitigation strategies and species conservation plans are developed at the forest wide level. This will help insure the species and habitat on Forest Service managed lands within the Leech Lake Reservation boundaries are adequately protected.

The Chippewa National Forest, Forest Management Plan is scheduled for review and revision on a 10 year cycle, but has not been revised since 2004. This indicates the Forest Plan is up for review and revision this year. As a result, the current forest plan is probably inadequate for the long term conservation of Goblin fern and the required habitat for this species. As a co-management agency, Leech Lake Reservation will request review of the current CNF Forest Plan with the intentions of co-developing a current and appropriate species conservation plan for Goblin fern and all struggling moonwort species residing on Leech Lake Reservation/Chippewa National Forest.

Summary Budget Information for Activity 2:

ENRTF Budget: \$ 23,600
Amount Spent: \$ 12,088
Balance: \$ 11,512

Outcome	Completion Date
1. Predict probable extirpations within our experimental and sample units	October 2017
2. Updating CNF records to account for extirpations	October 2017
3. Submit data to support a larger earthworm project	December 2017
4. Coordinate with CNF to develop and implement new habitat mitigation and species conservation plans	April 2018
5. Develop and implement new habitat mitigation plans for Leech Lake Tribal Lands	April 2018
6. Disseminate results to interested management agencies	April 2018

Project Status as of October 30, 2015:

No data analysis at this time as 2015 data has yet to be compiled and analyzed.

Project Status as of April 15, 2016:

2015 data has been compiled and entered, but as a result of project infancy no conclusions can be drawn based on a single year of data.

Project Status as of October 30, 2016:

2015 data has been compiled and entered and 2016 data entry is in progress. As a result of project infancy no conclusions can be inferred based on a two years of data collection.

Project Status as of April 15, 2017:

2016 data was compiled and entered.

Project Status as of October 30, 2017:

2017 data entry is almost completed. We have not begun data analysis yet, but that is planned to begin in November.

Retroactive Amendment Request (04/09/2018):

Project Status as of April 15, 2018:

As of April 15, 2018 Katie Zlonis has conducted data analysis, synthesis, and nearly completed a draft manuscript for the project. This includes predictions of probability of occupancy/extirpation for each goblin fern study site. Her work on the project prior to 2018 includes approximately 60 hours from November 20, 2017-December 15, 2017. Since January 1, 2018 to date, Katie has contributed approximately 150 hours to the project and her work is ongoing.

Leech Lake DRM is organizing a meeting with stakeholders, which includes Minnesota DNR biologists, US Forest Service biologists, and TNC biologists. The purpose of this meeting is to raise awareness of the severe and rapid loss of goblin fern habitat as a direct result of forest management activities which perpetuate invasive earthworms invading these fragile ecosystems. At the current rate of extirpation, goblin fern could very well become petitioned for Federal listing within 10 years. The time has come for all parties to seriously discuss and develop comprehensive conservation strategies for the future of goblin fern within Leech Lake Reservation/Chippewa National Forest.

The Chippewa National Forest has shown an interest in continuation of the project for an additional 7-10 years in order to monitor and collect data on the remaining 27 populations within the original project. This will continue to be a collaborative project between LLBO and CNF.

Final Report Summary:

Data collected from the project, along with observations and data collected outside the project indicate the presence or absence of goblin fern within its habitat has a direct correlation with IERAT. We conducted occupancy modeling, taking detectability across years into account, to assess probability of presence and absence of goblin fern, and environmental factors that may influence that probability. The best model for explaining goblin fern occupancy, evaluated by Akaike's Information Criterion (AIC), included only IERAT score. We found that probability of occurrence decreased significantly as IERAT score increased. At IERAT stage 2, which is characterized by worm species that do not completely consume the duff layer, goblin fern was present at least one year in every site, suggesting these sites are still good habitat for goblin fern. We identified IERAT 3 as the tipping point at which habitat is rapidly becoming unsuitable for goblin fern due to invasion of *Lumbricus* spp. At IERAT 4, occupancy probability decreased below 50%, and at IERAT 5 we found no evidence that goblin fern can still be supported (i.e. no plants were found during the three-year survey period at any sites classified as IERAT 5).

The Leech Lake Reservation/Chippewa National Forest appears to be the final stronghold for this species. Based on the analysis performed for this project, we estimate that at the current rate of extirpation, goblin fern could soon become a candidate for federal listing, so if goblin fern is to persist, a strict and conscious conservation plan must be developed for the species.

V. DISSEMINATION:

Description:

Once we compile all relevant data, the results will be shared with interested agencies and organizations who express similar interest in the conservation of Goblin fern. All relevant earthworm data will be shared with NRRI, University of Minnesota, Duluth to help with their ongoing research. This information will include coordinates, and severity of infestation. Since this Goblin fern is considered a Threatened, Endangered, Sensitive species by Leech Lake Band of Ojibwe and the Chippewa National Forest, data and results will be shared at the discretion of the two co-management agencies.

Project Status as of October 30, 2015:

Data and findings will not be disseminated until project is completed.

Project Status as of April 15, 2016:

Data and findings will not be disseminated until project is completed.

Project Status as of October 30, 2016:

Data and findings will not be disseminated until project is completed.

Project Status as of April 15, 2017:

Data and findings will not be disseminated until project is completed.

Project Status as of October 30, 2017:

Data and findings will not be disseminated until project is completed.

Retroactive Amendment Request (04/09/2018):

Project Status as of April 15, 2018:

Project results have been informally shared with relevant DNR, USFS, and LLBO biologists. Once the manuscript is accepted for publication, we will disseminate it widely across agencies to all relevant staff. In addition, as stated previously, LLBO is arranging a meeting across agencies to disseminate the results of this research and discuss conservation measures to take going forward for this species.

Project Status as of September 14, 2018:

Dissemination of field data has been completed with US Forest Service and is currently being entered into the corporate data base. The journal article has recently been distributed to interested parties including LLBO, US Forest Service, Minnesota DNR, and other interested natural resource management and academia professionals. IERAT data has been compiled and will be shared with NRRI within the month. This concludes obligations outlined in the grant proposal.

Final Report Summary:

Our abstract was submitted for peer review in June 2018. Upon receiving comment, review and revisions were made to the abstract, which was submitted in July 2018, and ultimately accepted for publication. The published article has been disseminated amongst select individuals within Minnesota Department of Natural Resources, Chippewa National Forest, Superior National Forest, and Ottawa National Forest for the purpose of developing and implementing improved habitat conservation measures. Additionally, all data collected from the project were

shared with the USFS, Chippewa National Forest for the purposes of updating database records. The publication and IERAT data will be shared with NRRI before 2019.

- 1) Zlonis, K.J., Henderson, B.W., 2018. Invasive earthworm damage predicts occupancy of a threatened forest fern: Implications for conservation and management. Forest Ecology and Management 430, 291-298

VI. PROJECT BUDGET SUMMARY:

A. ENRTF Budget Overview:

Budget Category	\$ Amount	Overview Explanation
Personnel:	\$42,091	Bobby Henderson, project manager, botanist, data analysis (80% salary, 20% benefits) 35% FTE for 2 years; 20% FTE for 1 year
	\$10,109	Katie Zlonis, data analysis, manuscript preparation and submission (80% salary, 20% benefits) 15% FTE for 1 year
Equipment/Tools/Supplies:	\$2050	High precision GPS for establishing sites, Densimeters, Field supplies: collection bags, batteries, flagging,
Travel Expenses in MN:	\$6750	Travel to, between, and from survey and data collection sites. Mileage:
TOTAL ENRTF BUDGET:	\$61,000	

Explanation of Use of Classified Staff: N/A

Explanation of Capital Expenditures Greater Than \$5,000: N/A

Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation: 1.05

Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation: N/A

B. Other Funds:

Source of Funds	\$ Amount Proposed	\$ Amount Spent	Use of Other Funds
Non-state	\$0	\$0	
State	\$0	\$0	
In-kind Services To Be Applied			
USDA Forest Service: Botanist Kirk Larson.	\$11,100	\$12,321	Survey and data collection support.
Leech Lake Division of Resource Management.	\$40,000	\$19,973	IDC, Administrative support, office space, computers, GIS programs, vehicles and maintenance.
TOTAL OTHER FUNDS:	\$51,000	\$32,204	

VII. PROJECT STRATEGY:

A. Project Team/Partners

Funded:

Bobby Henderson, Leech Lake Band of Ojibwe Botanist

Katie Zlonis, Leech Lake Band of Ojibwe, Plant Resources Program Manager

Non-funded/in-kind partners:

- Kirk Larson (Chippewa National Forest, Botanist/rare plants specialist, assist in survey and data collection).
- Dr. Don Farrar professor emeritus (Iowa State University, leading moonwort expert), support for Botrychium species.
- Dr. Cindy Johnson-Groh (Gustavus Adolphus College, Professor of Biology and Environmental Studies, moonwort expert) support for project design and protocol.

B. Project Impact and Long-term Strategy:

1. Provide data to support the degree of imperilment Goblin fern may be currently facing in Minnesota.
2. Facilitate the development of long term mitigation strategies and conservation plans to protect remaining Goblin fern habitat and populations.
3. Facilitate revisions to the current CNF Forest Plan.
4. Invoke more conscious decisions for updating and implementing BMPs in northern hardwood forests.
5. Provide data to support updating records in the CNF corporate database.
6. Provide Earthworm data to a much larger earthworm study being conducted by Great Lakes Worm Watch and UMD NRRRI.
7. Neighboring state agencies continue to express interest in the results of this project as Goblin fern faces extinction within neighboring states.

C. Funding History:

Funding Source and Use of Funds	Funding Timeframe	\$ Amount
N/A		

IX. VISUAL COMPONENT or MAP(S): See attached figures

X. RESEARCH ADDENDUM: N/A

XI. REPORTING REQUIREMENTS:

Project Status as of October 30, 2015:

Year one of project field work was completed in September 2015.

Project Status as of April 15, 2016:

Year one of project data entry was completed in February 2016.

Project Status as of October 30, 2016:

Year two of project field work was completed in August 2016.

Project Status as of April 15, 2017:

Year two of project data entry was completed in April 2017.

Project Status as of October 30, 2017:

Year three of project field work concluded in September 2017.

Project Status as of April 15, 2018:

Retroactive Amendment Request (04/09/2018):

Project Status as of September 14, 2018:

The final report is being compiled at this time (final report scheduled for December 18 2018)

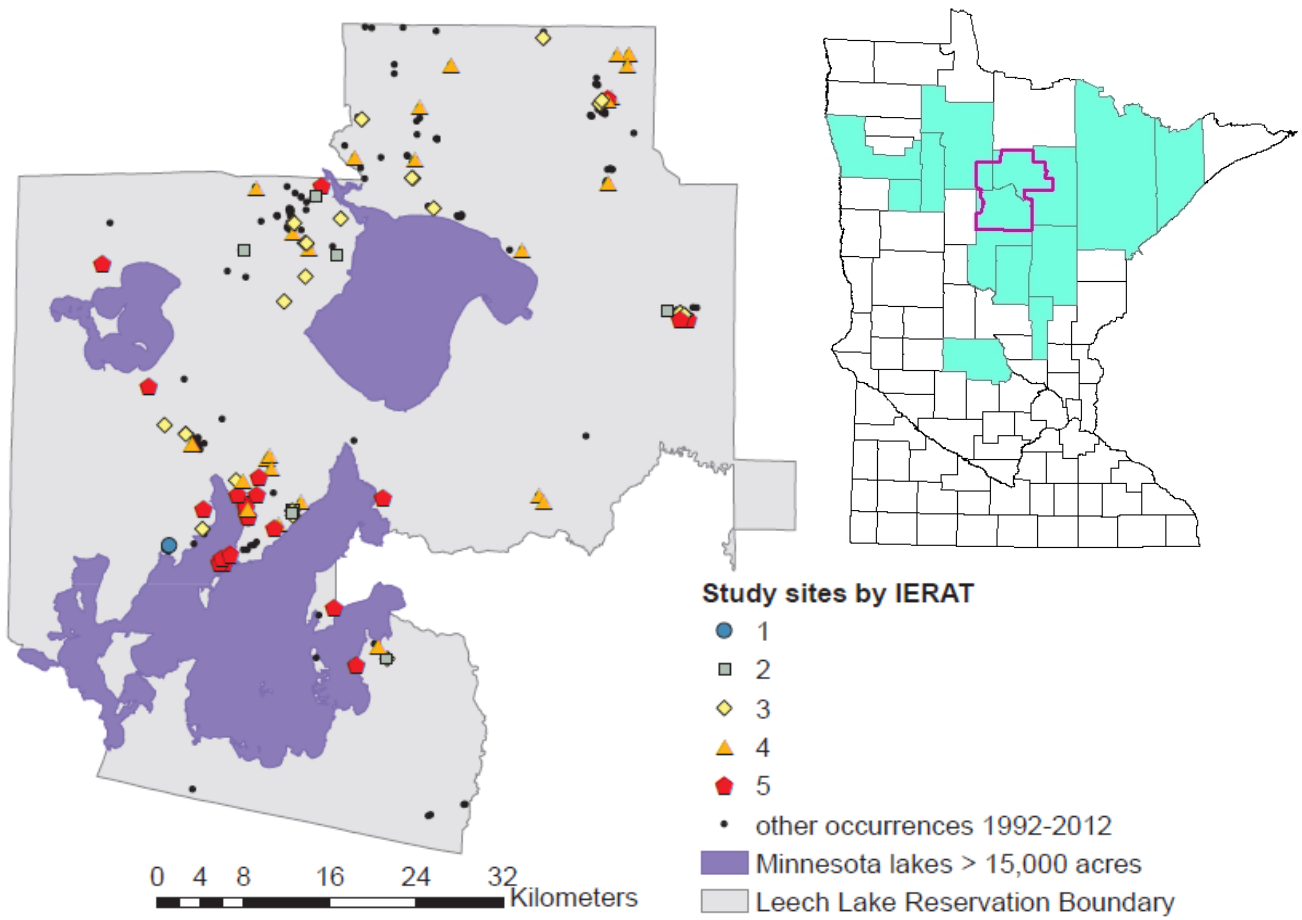


Figure 1. Map displaying general location of Chippewa National Forest/Leech Lake Reservation within Minnesota, with historic goblin fern range highlighted in blue. Leech Lake Reservation goblin fern study sites represented by IERAT stages: 1 – blue circle; 2 – green square; 3 – yellow diamond; 4 – orange triangle; 5 – red pentagon), additional historic occurrences documented from 1992 to 2012 (black dots).



Figure 2. Goblin fern (Botrychium mormo); plant on left approximately 2.5cm tall, plant on right approximately 10cm tall. Typical size range for this species varies from .25cm – 12cm, with an average height of only 4cm. In locations where leaf duff is intact and healthy, the species often only peaks through the duff layer.



Figure 3. Left: (IERAT 1) thick duff layer (O) horizon atop the mineral soil (E) horizon. The duff layer or humus layer greatly differs from “leaf litter”; duff forms a thick mat of leaf mould which holds moisture, creates a cool and stable microclimate for goblin fern and other organisms including mycorrhiza, plus the decomposing material is a consistent nutrient release. Right: (IERAT 5) duff layer (O) horizon has been completely removed and incorporated into the mineral soil. At IERAT 4 and 5 the distinct soil layers have been incorporated into a single dark layer (A) horizon as seen in the photo. At this stage of worm damage a number of forest health issues begin to occur; loss of habitat for organisms beneficial to forest health, microclimates at the soil level disappear, soils become highly compacted, dry, and erosion begins to occur.



Figure 4. A healthy sugar maple and basswood forest floor complete with intact duff layer, abundant forest dwelling perennial plants, and sugar maple regeneration.



Figure 5. A severely earthworm damaged forest floor exhibiting greatly diminished plant diversity, abundance, and absence of tree seedling regeneration. At this stage, the forest soils are greatly altered and inhibitive of supporting a healthy forest.

**Environment and Natural Resources Trust Fund
FINAL M.L. 2015 Project Budget**



Project Title: Habitat Mitigation for Goblin Fern Conservation

Legal Citation: M.L. 2015, Chp. 76, Sec. 2, Subd. 03s

Project Manager: Bobby Henderson

Organization: Leech Lake Band of Ojibwe

M.L. 2015 ENRTF Appropriation: \$61,000

Project Length and Completion Date: 3 years, June 30, 2018

Date of Report: June 30, 2018

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget	Amount Spent	Activity 1 Balance	Activity 2 Budget	Amount Spent	Activity 2 Balance	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM	Identify, Project Design, Survey, and Assess Locations		Data Analysis, Submit Results to CNF, Assist in Development of Mitigation Plan for Updated CNF Forest Plan					
Personnel (Wages and Benefits)	\$28,600	\$25,096.73	\$3,503	\$23,600	\$12,088.14	\$11,512	\$52,200	\$15,015
Bobby Henderson, project manager, botanist, data analysis (80% salary, 20% benefits) 35% FTE for 2 years; 20% FTE for 1 year							\$42,091	
Katie Zlonis, data analysis, manuscript preparation (80% salary, 20% benefits) 15% FTE for 1 year							\$10,109	
Equipment/Tools/Supplies	\$2,050		\$1,557				\$2,050	\$1,557
2 High precision GPS for relocating sites (\$1300)								
2 Densimeters (\$220)		\$225						
Field supplies: collection bags, batteries, flagging, (\$530)		\$268						
Travel expenses in Minnesota								
Travel to, between, and from survey and data collection sites. Mileage: \$6750	\$6,750	\$1,598	\$5,152				\$6,750	\$5,152
COLUMN TOTAL	\$37,400	\$27,188	\$10,212	\$23,600	\$12,088	\$11,512	\$61,000	\$21,724