Interim Forest Management Policy for High Conservation Value Forests

HCV: Goblin Fern (*Botrychium mormo*)

Table 1. Key Statistics	
Total Number of documented occurrences	143 element occurrences in NHIS
Number of documented occurrences on HCVF (non-STL)	3 element occurrences in NHIS
Number of documented occurrences on HCVF (STL)	3 element occurrences in NHIS

Source: MNDNR - NHIS database 2018

Status: State-listed threatened

Location: Primarily north-central Minnesota, with a concentration in the Chippewa National Forest and Leech Lake Reservation (Cass and Itasca counties).

Brief Description

Botrychium mormo (goblin fern) is a very small fern, no more than 9 cm (3.5 in.) tall. It is almost exclusively found in the interior of mature rich mesic hardwood forests that have an intact duff layer and a relatively closed, layered canopy typical of the forest type. The vast majority of the records are from north-central Minnesota in the Laurentian Mixed Forest Province, with a concentration in the Chippewa National Forest and Leech Lake Reservation (Cass and Itasca counties). Most of goblin fern's life cycle takes place underground in the organic humus layer overlying mineral soil. At any given time, as much as 90% of the overall population is underground. Buffered against surface disturbances such as drought, fire, and herbivory, the underground matrix protects the population from local extirpation. A local population of goblin fern will remain viable as long as environmental conditions support each of the life stages, both above and below ground.

Policy for Goblin Fern within High Conservation Value Forests[1]

Process Overview

This policy *assumes* the Natural Heritage Screen or Review for the proposed Activity determined an intersection with a digital goblin fern record in the DNR Natural Heritage Information System. This document helps you from that point forward by outlining site-level steps to verify presence or absence of goblin fern relative to the Activity Impact Area and how to proceed accordingly.

Management Guidance Overview

This policy document outlines the steps necessary to determine the on-the-ground presence of goblin fern, the condition of the site relative to life history requirements, and associated forest management options. The guidance starts with on-the-ground site visits.

Step 1: Site Visits

Purpose: to determine goblin fern presence and condition and determine invasive earthworm presence and condition.

[1] Find key definitions related to the management guidance on page 5.

Site-level management decisions are not to be based on the location and size of goblin fern populations as presented in the Natural Heritage Information System alone. Site-level management decisions that involve goblin fern require field visits in July or August to detect and precisely define the population and avoid direct and indirect take. Site visits should be started at least three years before a stand is scheduled to be put on an exam list to ensure there is sufficient time available to make a positive or negative find of the species.

Site visits involve 1) attempting to relocate the population as recorded in the NHIS, these site visits can result in successfully finding goblin fern (i.e. positive finds) or not finding goblin fern (i.e. negative finds); and 2) assessing the site for invasive earthworm presence using the Invasive Earthworm Rapid Assessment Tool (IERAT; see Key Definitions section).

- **Positive finds:** If a previous record of goblin fern is successfully located, or a new location is discovered during a site visit, then a total of 3 field seasons of survey during non-drought years is adequate to develop management recommendations. Because goblin fern is variable year-to-year in terms of displaying aboveground plants, multiple growing seasons of observation during non-drought years is recommended before finalizing management decisions to account for annual variation in the number and distribution of aboveground plants.

- **Negative finds:** If a previous record of goblin fern cannot be located, the duff layer is intact or nearly so (IERAT score of 1, 2 or 3) and forest conditions are suitable as outlined in this document and the species profile, then assume goblin fern is still present. Base PB on the combination of the original NHIS record, the extent of potential habitat, and the extent of Botrychium genus community species.

  If a previously recorded population of goblin fern cannot be located and the duff layer is compromised (IERAT score of 4 or 5) or forest conditions are no longer suitable as outlined in this document and the species profile for goblin fern, a population is considered extirpated from the site.

Step 2: Required Management Activities

- Follow the harvest guidance in Table 3, using the site's IERAT score to determine the management approach.
- Use the following **General Guidance** for all sites and all IERAT scores for harvest outside of the OB/PB to the stand boundary:
  - Conduct harvest operations on frozen ground or continuous $\geq$10" of snow pack on the ground
  - Retain multi-age, multi-strata, multi-species trees and shrubs
  - Minimize damage to advanced regeneration and shrub layer
  - Minimize skid trails
  - Block and obliterate access routes after completion of timber sale
  - Place landings and roads outside of OB and PB (when used)
  - Clean all equipment of mud and dirt prior to entering or reentering the harvest area
  - People accessing or reentering the harvest area have clean boots, clothing, and equipment
  - Favor silviculture methods that do not require site prep.
    - If site prep is needed, minimize disturbance to ground layer with patch scarification, for example.

- Favor silviculture methods that do not require herbicides.
    - If herbicides are needed, minimize by spot spraying and strip spraying and only use herbicides outside of the PB and OB.
    - Broadcast herbicide is generally not recommended.
- Favor moving even-aged forests in the same NPC as *B. mormo* to uneven-aged conditions over time (i.e. soft conversions)

- Additional options to consider for sites with IERAT scores 1, 2 or 3
    - Take a heightened approach to preventing the spread of invasive earthworms:
        - Identify, if available, a natural worm barrier (e.g. wetlands, permanently saturated soils) that protects the site from worms moving into the site on their own. Keep on the outside of the natural worm barrier all landings and associated equipment, roads, and trucks and vehicles that leave and enter the site during harvest operations.
    - Use occurrence buffers and population buffers to maintain the natural extent of the required forest conditions as they exist (i.e. habitat with documented goblin fern and good potential habitat w/out documented aboveground goblin fern) in the stand/NPC and contiguous adjacent forest(s).
    - Restore or promote goblin fern forest conditions in contiguous stands and goblin fern-associated NPCs that do not currently meet suitable goblin fern forest conditions. This includes attention to the following:
        - Thick, earthworm-free duff/humus; (minimize diffuse skidding patterns)
        - Interior forest conditions (light, temperature, humidity, soil moisture, etc.); (maintain areas of closed canopy)
        - Natural canopy and understory tree diversity and structure;
        - Uneven age-class distribution;
        - Favor retention and enhancement of tree and plant species that are positively associated with goblin fern (see species profile or DNR Rare Species Guide goblin fern profile);
        - Protection from earthworms to the distance of at least the nearest natural barrier to worm travel.

	Table 3. Management approaches for goblin fern within HCVFs
#	Approach, description and consequences
1	**IERAT Score = 5.** Listed species lead should identify an occurrence buffer (OB) and/or population (PB). Activity lead should place the physical buffers on the ground. Conducting timber management activities, developing new access routes, improving existing access routes, and/or using access routes are not permitted within the OB/PB. Existing designated system roads may be used within the OB/PB. Harvest beyond OB/PB to the stand boundary applying the "General Guidance" listed above. **Consequences** • Low risk of direct take of goblin fern. • Moderate risk of indirect take in the short-term. • High risk of introducing earthworms outside of OB/PB and therefore high risk of indirect take over time as worms migrate through the site. • If suitable habitat exists beyond the OB/PB, high risk of impacts to belowground population and undocumented aboveground occurrences. • Permits clear-cuts outside of the OB/PB.
2	**IERAT Score = 4.** Listed species lead should identify an occurrence buffer (OB) and/or population (PB). Activity lead should place the physical buffers on the ground. Conducting timber management activities, developing new access routes, improving existing access routes, and/or using access routes are not permitted within the OB/PB. Existing designated system roads may be used within the OB/PB. Use cover type and/or stand conditions to determine management approach. • When conducting an uneven-aged or selection harvest, do so outside the OB/PB to the stand boundary. In selection harvests, maintain a minimum canopy cover of 60%. • When conducting an even-aged harvest do so outside the OB/PB and for 250' out from the PB/OB retain at least 60% canopy cover This retention may be feathered from >60% near the PB/OB and <60% near the outer edge of this zone. • Apply "General Guidance" listed above. **Consequences** • Low risk of direct take of goblin fern. • Moderate risk of indirect take in the short-term. • High risk of introducing earthworms outside of OB and therefore high risk of indirect take over time as worms migrate through the site. • If suitable habitat exists beyond the OB, high risk of impacts to belowground population and undocumented aboveground occurrences.
3	**IERAT Score = 1, 2 or 3.** Listed species lead should identify an occurrence buffer (OB) and/or population (PB). Activity lead should place the physical buffers on the ground. Conducting timber management activities, developing new access routes, improving existing access routes, and/or using access routes are not permitted within the OB/PB. Existing designated system roads may be used within the OB/PB. Where possible, listed species lead and activity lead should work together to identify a natural worm barrier within the associated cover type and NPC. Use cover type and/or stand conditions to determine management approach. • When conducting an uneven-aged or selection harvest, do so outside the OB/PB to the stand boundary. In selection harvests, maintain a minimum canopy cover of 60%.

	Table 3. Management approaches for goblin fern within HCVFs
#	**Approach, description and consequences**
	• When conducting an even-aged harvest do so outside the OB/PB and for 250' out from the PB/OB retain at least 60% canopy cover. This retention may be feathered from >60% near the PB/OB and <60% near the outer edge of this zone. • Maximize the distance between landings and roads and the perimeter of the harvest area. • Where available, place landings and roads beyond a natural worm barrier. • Apply "General Guidance" listed above. **Consequences** • Low risk of direct take of goblin fern. • Moderate risk of indirect take. • High risk of introducing earthworms outside of FIM/NPC. • High risk of introducing worms inside of natural worm barrier. • Moderate risk of impacts to belowground population and undocumented aboveground occurrences. • Potentially lower economic output compared to sites with higher IERAT scores. • Impacts to canopy cover and soil disturbance will be avoided within the OB and PB.

Key Definitions

Single Occurrence Buffer (OB): 250' reserve area surrounding the observed aboveground goblin fern population as measured from the outside perimeter of the population.

Population Buffer (PB): A population buffer is used when *Botrychium* genus communities (as defined below) occur within goblin fern OBs. When an OB intersects a genus community, delineate the OB based on the combined outer perimeter of the genus community and the goblin fern occurrence. When an OB is delineated in this way it is termed a population buffer (PB).

Associated Native Plant Community (NPC): Predominantly includes MHn47 (Northern Rich Mesic Hardwood Forest) with records also found in MHn46b (Northern Wet-Mesic Hardwood Forest), MHn35 (Northern Mesic Hardwood Forest), MHc47 (Central Wet-Mesic Hardwood Forest), and MHc36 (Central Mesic Hardwood Forest, Eastern).

Genus Community: Goblin fern often occurs with other *Botrychium* species. Multiple *Botrychium* species occurring in the same location are termed genus communities (Farrar 2017). In Minnesota, duff-dependent *Botrychium* species strongly associated with goblin fern include *Botrychium simplex* var. *tenebrosum, B. lanceolatum*, and *B. matricarifolium*. Each of these three uncommon species are strong indicators of goblin fern habitat and indicators of where goblin might be present but not aboveground. When any or all of them are present in the OB, use a population buffer as described above.

Natural earthworm barrier: Permanent natural features that inhibit earthworm viability and movement (e.g. saturated soils, perennial surface water, very coarse soils). The natural worm barrier can be estimated from aerial photos and maps (e.g. topographic, NWI) but should be confirmed on the ground.

Invasive Earthworm Rapid Assessment Tool (IERAT) (Loss et al. 2013): a protocol that allows rapid classification of earthworm invasion into five stages based primarily on visual assessment of the forest floor. The score (1-5 scale) obtained from the IERAT is a strong predictor of the probability of occupancy or extirpation for known goblin fern populations. IERAT scores are defined as:

	Table 2. IERAT Scores and their relationship to *B. mormo* occupancy (Zlonis & Henderson 2018)
IERAT SCORE	Description, implications
1 or 2	Invasive earthworms present but habitat appears to remain suitable for *B. mormo*. Sites can remain in this condition and not progress to higher scores.
3	Invasive earthworms present with the probability of *B. mormo* occupancy decreases but remains above 50%. Sites can remain in this condition and not progress to higher scores.
4	Invasive earthworms present, probability of *B. mormo* occupancy drops below 50%. Sites at this state are likely to progress to score = 5.
5	Invasive earthworms present, appear unable to support *B. mormo*.

Species Description

Botrychium mormo (goblin fern) is a very small fern, no more than 9 cm (3.5 in.) tall. It is almost exclusively found in the interior of mature rich mesic hardwood forests that have an intact duff layer and a relatively closed, layered canopy typical of the forest type. The majority of Minnesota records are associated with MHn47 (Northern Rich Mesic Hardwood Forest) with records also found in MHn46b (Northern Wet-Mesic Hardwood Forest), MHn35 (Northern Mesic Hardwood Forest), MHc47 (Central Wet-Mesic Hardwood Forest), and MHc36 (Central Mesic Hardwood Forest, Eastern) with one outlier from FDn43 (Northern Mesic Mixed Forest) in Cook County.

Goblin fern is a Great Lakes endemic whose geographic range is confined to forests in portions of Minnesota, Wisconsin, Michigan, and far southern Quebec. The vast majority of the records are from north-central Minnesota in the Laurentian Mixed Forest Province, with a concentration in the Chippewa National Forest and Leech Lake Reservation (Cass and Itasca counties).

Most of goblin fern's life cycle takes place underground in the organic humus layer overlying mineral soil. *Botrychium* lack root hairs and depend upon connections with endomycorrhizal fungi in the soil for water, minerals, and carbohydrates for all life stages. At any given time, as much as 90% of the overall population is underground, even during the mid- to late summer period when goblin fern may be visible above the humus. Belowground is a reserve of dormant plants in various stages that will eventually produce aboveground individuals. Buffered against surface disturbances such as drought, fire, and herbivory, the underground matrix protects the population from local extirpation as long as those perturbations are not extreme enough to alter or destroy the duff layer.

The species is scarce even within its northcentral Minnesota stronghold, and it is becoming increasingly rare throughout its range. While concerns over habitat loss and degradation prompted the listing of goblin fern as special concern in 1984, an even more insidious threat has emerged in recent years. The invasion of non-native earthworms is responsible for an accelerating rate of habitat degradation. Earthworms, which were introduced from Europe, can rapidly consume the humus layer of the soil, the layer goblin fern requires for all life stages, thereby rendering the habitat unsuitable for goblin fern (Gundale 2002). A significant number of goblin fern populations have disappeared within the last decade, and the trend appears to be continuing (Zlonis and Henderson 2018). Consequently, the status of goblin fern was elevated to threatened in 2013 (MNDNR 2018).

A recent study conducted by the Leech Lake Band of Ojibwe (LLBO) estimates that 62% (range 51-75%) of goblin fern populations on Leech Lake lands have been extirpated (Zlonis and Henderson 2018). Recent field reports from the Chequamegon-Nicolet National Forest in Wisconsin indicate a dramatic decline in goblin fern in recent years, with most locations on national forest lands now considered extirpated (Parker 2018). In all studies, invasive earthworms were the driving cause of extirpation. Additional documented declines are reported in the literature dating back to 1990s and early 2000s.

Conservation Needs

Goblin fern is almost exclusively associated with mature rich mesic hardwood forests that have an intact duff layer, closed canopy, and interior forest conditions. This species is dependent upon soil endomycorrhiza, sensitive to forest-edge effects, and intolerant of conditions created by exotic earthworms.

Goblin fern requires a rich, thick humus layer of decayed leaf litter that supports a healthy endomycorrhizal fungal community (Farrar 2017). Goblin fern relies on endomycorrhizal fungi to extract water and nutrients from the humus layer. These fungi The mycorrhiza (*Glomus* spp.) that goblin fern depend on are common in the humus layer of forests dominated by maple, basswood, black ash, or northern white cedar and by herbaceous,

perennial, flowering plants. These fungi are less common in forests dominated by oaks, hickories, pines, or other trees whose roots are typically associated with ectomycorrhizal fungi (Farrar 2017).

A local population of goblin fern will remain viable as long as environmental conditions support each of the life stages, both above and below ground. Within a population, individual plants come and go. As some individuals die, new plants are likely to establish in the same spots or in new microsites in the immediate vicinity. The overall population within a geographic location will persist and likely flourish if habitat conditions remain suitable (Johnson 2018).

The following conditions are detrimental to *B. mormo* habitat, populations, and individual plants regardless of the activity causing them (Berlin et al. 1998):

- soil compaction;
- loss of soil nutrients;
- loss of duff layer (0 horizons);
- loss of darkness provided by the duff layer, forest canopy, interior forest;

Management considerations that informed policy development

- Maintain an absence of earthworms
    - Avoid transport and introduction of earthworms into goblin fern sites.
    - Any action that brings people or equipment into a location has risk of moving worms regardless of season.
- Maintain intact duff/humus
- Maintain multi-layered, continuous canopy cover typical of mature rich mesic hardwood forests
- Maintain interior forest conditions
- Buffer populations from direct and indirect disturbance.
- Avoid soil disturbance.
- Field surveys for goblin fern occur during July-August.
    - Field surveys required for 2-3+ years (depending on IERAT score) in *non-drought* years to gain an accurate assessment of goblin fern, a species that is highly variable year-to-year and sensitive to drought.

Revision Date(s)

Initial Draft: December 2018
Revised: December 2019
Final Interim: August, 2021

Development Team

- Bruce Carlson, Ecological and Water Resources, Topic Lead/Management SME/Topic Profile SME
- Ben Lang, Forestry, Management SME
- Michael Lee, Ecological and Water Resources, Topic Profile SME
- Brook Haworth, Ecological and Water Resources, Topic Profile SME