

**CANDIDATE AND LISTING PRIORITY ASSIGNMENT FORM**

**SCIENTIFIC NAME:** *Botrychium tunux* Stensvold & Farrar

**COMMON NAME:** Tunux Moonwort

**LEAD REGION:** 7

**INFORMATION CURRENT AS OF:** September 20, 2007

**STATUS/ACTION** [*Check all that apply.*]:

Species assessment - determined species did not meet the definition of endangered or threatened under the Act and, therefore, was not elevated to Candidate status

Initial 12-month Petition Finding:  not warranted  
 warranted  
 warranted but precluded

New candidate

Continuing candidate

Non-petitioned

Petitioned - Date petition received:

90-day positive - FR date:

12-month warranted but precluded - FR date:

Is the petition requesting a reclassification of a listed species?

Listing priority change

Former LP:  New LP:

Latest Date species first became a Candidate:

Candidate removal: Former LP:  (Check only one reason)

A - Taxon more abundant or widespread than previously believed or not subject to a degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status.

F - Range is no longer a U.S. territory.

M - Taxon mistakenly included in past notice of review.

N - Taxon may not meet the Act's definition of "species."

X - Taxon believed to be extinct.

**ANIMAL/PLANT GROUP AND FAMILY:** Plant family, Ophioglossaceae

**HISTORICAL STATES/TERRITORIES/COUNTRIES OF OCCURRENCE:**

Yakutat forelands of south coastal Alaska and additional populations in Interior AK and adjacent Canada.

**CURRENT STATES/ COUNTIES (optional)/TERRITORIES/COUNTRIES OF OCCURRENCE:** Currently known only from the Yakutat forelands of south coastal Alaska.

**LEAD REGION CONTACT:** Ecological Services, Alaska Regional Office, Sonja Jahrsdoerfer (907) 786-3323

**LEAD FIELD OFFICE CONTACT:** Anchorage Fish and Wildlife Field Office, Judy Jacobs, (907) 271-2780

Note: This Candidate Assessment was initiated in 2004, shortly after the species was described. Completion of the Candidate Assessment was held in abeyance, pending further surveys to substantiate incomplete information indicating potential for additional populations. In 2007, FWS candidate conservation funds were made available to conduct further survey work. Surveys were conducted during summer 2007, and a final report is due in May 2008. Although genetic analyses are not yet complete, morphological evidence of the samples collected leads the botanists who described this species to conclude preliminarily that *Botrychium tunux* is much more abundant than originally believed. Therefore, we have determined that elevation to Candidate status for *Botrychium tunux* is not appropriate at this time. This determination may be reconsidered following receipt (in May 2008) of report analyzing genetic composition of samples collected in 2007.

The attached status assessment, largely completed in May 2004, reflects our thinking at that time; updates based on 2007 findings have been included. Specifics on the locations of additional *B. tunux* populations cannot be provided at this time, but will be available in the final report.

## **BIOLOGICAL INFORMATION:**

**Background** – Moonwort ferns are in the genus *Botrychium*, within the subgenus *Botrychium* of the Adder's-tongue family (Ophioglossaceae). According to European folklore, they were thought to have magical powers if collected by moonlight. European peasants believed that the leaves always faced the moon.

The above-ground portion of the plant consists of a common stalk supporting a leaf with a fertile segment (sporophore) and a sterile segment (trophophore). The fertile segment is generally a branched stalk bearing spherical sporangia, often resembles a bunch of tiny grapes (hence the often used common name for the genus of "grapefern" – see Figure 1). Each sporangium contains thousands of spores. The sterile segment is leaf-like; the blade is variously shaped and once- or twice-divided. The belowground portion of *Botrychium* consists of an upright, unbranched rhizome, terminating in primordial leaves (leaf buds) that will emerge in future years, nested within the base of the current year's common stalk. The rhizome bears several fleshy roots, which are associated with endomycorrhizal fungi. Moonworts are dependent on these fungi for nutrition throughout their life cycle. This fungal partnership allows the moonworts to remain dormant for several years, similar to orchids, but greatly decreases the chances for successful transplantation.

*Botrychium tunux* is a small perennial fern, averaging 9 cm tall. The common stalk averages 1.5 cm in length. The trophophore averages 4 cm in length, is somewhat leathery in texture; yellow-green in color and once pinnate, with 4-6 pairs of symmetrically to asymmetrically fan-shaped leaf segments (pinnae). The sporophore averages 7 cm in length and is shorter than or equal to the trophophore (Stensvold *et al.* 2002). Spores are shed in late June and July. Similar to other *Botrychium* species, the tiny, lightweight spores may be disseminated by wind, water, or possibly by animal vectors (Zika *et al.* 1995).

Before 1995, little attention was paid to Alaskan moonworts. Information gained from rare plant surveys since then has improved our knowledge of moonwort abundance, distribution, and relationships. Stensvold *et al.* (2002) identified two new species of moonwort native to Alaska, *Botrychium tunux* and *B. yaaxudakeit*. The existence of these morphologically and genetically distinct species has been confirmed through starch gel enzyme electrophoresis (Stensvold *et al.* 2002). The names for these new species were chosen by the elders of the Yakutat Tlingit Tribe. "*Tunux*" honors Tunux, a Tlingit warrior in the Eagle Moiety of the Teikweidí (Brown Bear) Clan. The word Tunux is pronounced with a guttural "x" similar to the German "ach," making the name sound like "toonook," with a soft "k."

### **Distribution** –

Live populations of *B. tunux* are known from four locations in the Yakutat area: (1) at the east side of Point Carrew near the village of Yakutat; (2) Blacksand Spit off the mouth of the Situk River; (3) Akwe Beach; and (4) the northwest shore of Dry Bay. There is a

herbarium specimen from another site just north of the mouth of the Situk River near Yakutat, but that site may have been obliterated when the mouth of the river shifted.

Note: In addition to those presented here, populations of both *B. tunux* and *B. yaaxudakeit* have been potentially confirmed in the Wrangell-St. Elias Mountains during 2007. Specific information on the size of the area or the number of populations and plants is not currently available, but we expect to receive this information by December 2006.

The four known (as of 2004) locations of *B. tunux* are on the Yakutat forelands, an area 80-kilometer (km) (50 mile) long extending between Point Carrew and Dry Bay in habitats adjacent to saltwater but not influenced by saltwater inundation. Potential habitat for *B. tunux* extends along the Alaska coastline for 250 km (155 miles) in either direction from Yakutat. Searches for *Botrychium* species in similar habitat on the Copper River Delta barrier islands, near the mouth of the Kaliakh River, Pt Riou, a portion of the Malaspina Glacier forelands, Cross Sound, Icy Strait, Glacier Bay and the Lynn Canal area revealed no additional populations of *B. tunux*.

Moonworts genetically and morphologically similar to *B. tunux* have been found in the Wrangell St. Elias National Park in the vicinity of Pingpong Mountain and near Chisana, and in Canada's Kluane National Park near Kluane Lake. Surveys of moonworts have been completed at these locations, and study results, including genetic analyses, will be available in May 2008 to verify their affinity with *B. tunux*.

**Demography** – *Botrychium tunux* is a perennial plant, with an underground stem. As mentioned earlier, the leaves may not emerge every season (Johnson-Groh 1999). Analysis of soil associated with *Botrychium* has found that in addition to plants that did not emerge, other below-ground structures may be present. These structures include ungerminated spores, gametophytes of various ages, gemmae and sporophytes that have not yet matured enough to produce aboveground leaves. Such underground structures and propagules may be more abundant than plants showing aboveground (Johnson-Groh *et al.* 2002).

When leaves do emerge, *Botrychiums* produce a multitude of spores. *Botrychium* species have between 20 and 100 sporangia per sporophore, and each sporophyte may produce thousands of spores, possibly the highest number of spores per case of all vascular plants (Wagner 1998). *Botrychium* has a high reproductive output (Wagner 1998), which likens them to other “r” selected species (using the classification scheme of MacArthur and Wilson 1967), although their longevity and slow growth do not. Like all Pteridophytes, but unlike angiosperms and gymnosperms, *Botrychium* spores develop into gametophytes that live independently of the sporophyte.

Alternation of generations occurs in all plants, but in the ferns (Figure 2) the gametophyte lives independently of the sporophyte, and the two often have different ecological requirements. The subterranean nature of *Botrychium* gametophytes probably restricts

many *Botrychium* species to self-fertilization (McCauley et al. 1985, Soltis and Soltis 1986). Unlike other species of *Botrychium* for which the growing season is more protracted, *B. tunux* has a narrow window of opportunity for growth and reproduction due to the relatively short growing season in the areas it occupies. The lifespan, age at first spore release and survivorship of *B. tunux* are unknown.

**Phenology** - The single leaf of *B. tunux* emerges from the below-ground upright rhizome in June, releases spores from mid-July to early August, and withers back to ground level in the early autumn. Permanent plots to track the life history individual plants have been established at three sites on the Yakutat forelands. These sites are located: (1) near the mouth of the Ankau River; (2) on Blacksand Spit; and (3) near the mouth of the Akwe River.

**Habitat** - *B. tunux* grows in habitats ranging from open sand on dunes and upper beaches to well- drained upper beach meadows with sandy substrates. The plants may occur as scattered individuals or in loosely associated groups. Vascular plants most commonly associated with *B. tunux* include *Achillea borealis*, *Festuca rubra*, *Fragaria chiloensis*, *Gentianella amarella*, *Leymus mollis*, *Lupinus nootkatensis*, *Oxytropis campestris*, and *Rhinanthus crista-galli*. Bryophytes commonly found with *B. tunux* include *Ceratodon purpureus*, *Racomitrium canescens*, and *Rhytidiadelphus squarrosus*. These vegetation assemblages represent early seral stages (Stensvold et al. 2002). The moonworts *B. ascendens*, *B. lunaria*, *B. minganense*, and *B. yaaxudakeit* also grow in these meadows. Vascular plant and bryophyte cover can range from a trace to 100%, with the percent cover and species number increasing landward.

*Botrychium* often grows in “genus communities” with several species growing together. Perhaps this is a result of similar mycorrhizal associations. However, in Montana Vanderhorst (1997) found that populations of sympatric species grew in low densities and occupied slightly different microsites, with *B. crenulatum* in the lower-lying, wetter areas and *B. ascendens* on the uphill edges of the habitat. Thus, direct interspecific competition for resources may not be a significant factor for the species in the Vanderhorst study.

Like many epiphytes, lichens, and bryophytes, *Botrychiums* are characterized by small stature, slow relative growth rates, and small propagules. A distinguishing characteristic of plants in this category is that stressful conditions are experienced during growth. Moderate to light disturbance may be a critical part of the autecology of *Botrychium* species (Lellinger 1985, Wagner and Wagner 1993).

#### THREATS:

A. The present or threatened destruction, modification, or curtailment of its habitat or range.

This appears to be the major known threat facing the species. The upper beach meadows and sandy beach that comprise the type locality for *Botrychium tunux* have been heavily impacted by recreational all-terrain vehicle (ATV) use. Drivers of these vehicles (mostly

high school students and other young people) made countless tracks through the meadow area and sandy beach habitat, to reach the open beach. The open beach provides an inviting area for doing “donuts” and churning up the sand occupied by these plants (Stensvold, U.S. Forest Service, pers. comm. September, 2002). A site visit in November 2002, revealed ATV tracks within 10 feet of one of the beach study plots occupied by *B. tunux*. This churning affects not only aboveground plants, but also the larger, belowground segment of the population. During the past couple of decades, off-road vehicle traffic has increased significantly on the sandy areas of the Yakutat Forelands.

The belowground structures of *Botrychium* (i.e., gametophytes, juvenile sporophytes, gemmae, and spores) and mycorrhizal interactions may help *Botrychium* species to survive low-intensity aboveground perturbations (Johnson-Groh *et al.* 2002), and this may have played a role in the evolutionary ecology of the genus, allowing these plants to occupy less favorable, frequently disturbed habitats where competition with other plants is decreased. However, the deep churning of sand caused by ATVs can readily disrupt the species’ below-ground population components.

Note: In 2004, in cooperation with the Yakutat Salmon Board, a moonwort protection project was completed that provided some protection from ATVs for the Akwe Beach (Ankau Dunes) population of *B. tunux*. This project is summarized below under “Prelisting,” and a report of this work is on file.

*B. tunux* is found in open and early successional areas. Thus, as succession proceeds and competition increases, local populations of *Botrychium* may be extirpated. Vegetational succession, whether from trees invading and shading the habitat, or from competition with grasses and herbs may compromise plants’ ability to germinate, by shading or by the establishment of thick duff layers. Moonwort is a poor competitor in these situations.

B. Overutilization for commercial, recreational, scientific, or educational purposes.

*Botrychium tunux* does not appear at present to be directly threatened by overutilization for recreational, scientific or educational purposes. However, recreation, in the form of ATV use, as mentioned in Factor A above, appears to be a primary threat to the species’ continued existence.

*B. tunux* is not a source for human food, nor is it currently of commercial horticulture interest. Therefore, overutilization is not considered to be a threat to this species at the present time.

However, simply listing a species can precipitate commercial or scientific interest, both legal and illegal, which can threaten the species through unauthorized (and uncontrolled) collection for scientific and/or commercial purposes. The listing of species as threatened or endangered publicizes their rarity and may make them more susceptible to collection by researchers or curiosity seekers. The populations of *Botrychium tunux* are small enough that even limited collection pressure could have adverse impacts on their reproductive or genetic viability.

### C. Disease or predation

*Botrychium* species are presumably susceptible to herbivory and habitat change by native herbivores (e.g., ungulates, small mammals, slugs, insects). The extent and effects of native herbivory on *B. tunux* have not been studied. It is possible that native herbivores, such as fossorial mammals, may play an important role in the maintenance of suitable habitat, creation of open sites for colonization, and spore dispersal. They can also graze or damage existing individual plants. There is no cattle grazing at *B. tunux* sites, but there is moose activity in this habitat (B. Lucey, Yakutat Salmon Board, pers. comm. 2004) as well as grazing by brown bear. If grazing occurs prior to the maturation and release of spores, the capacity for reproduction of grazed plants may be compromised.

Ferns, in general, are not susceptible to insect predation but can be vulnerable to fungal decay (Lellinger 1985). A lack of discussion in the literature on the effects of parasites and diseases on *Botrychium* species indicates either that these threats have not been studied or do not appear to be problematic. In addition, the effects of parasites or diseases on the mycorrhizae associated with *Botrychium* species are not known. Neither disease nor parasites are known to be a threat to *Botrychium tunux*.

### D. The inadequacy of existing regulatory mechanisms.

Although *Botrychium tunux* is considered to be rare and imperiled by the Alaska Natural Heritage Program, the State heritage program ranking is not a legal designation and does not confer State regulatory protection to this species. The Forest Service designated the plant as “Sensitive” in the Alaska Region of the Forest Service. This designation provides some protection in that all projects authorized by the Forest Service are analyzed to determine how the project may affect *B. tunux*. This plant is not protected under any other state, local, or Federal ordinance.

### E. Other natural or manmade factors affecting its continued existence.

No other threats are known to affect *B. tunux*. Several potential threats exist, although we have no data documenting that these threats are impacting populations.

The small size of existing *B. tunux* populations makes this species vulnerable to extirpation due to random naturally occurring events. Small populations are more vulnerable to extirpation, whether from natural stochastic events or human activities. A single random environmental event could extirpate a substantial portion or all of the individuals at a given site.

Large populations of *B. tunux* on Blacksand Spit at Yakutat may be imperiled by the potential change in the Situk River drainage if the Hubbard Glacier closes Russell Fjord, forming Russell Lake. The new outlet of Russell Lake would generally follow the flow of the Situk River, greatly increasing its size; the increased flow could obliterate the northernmost end of Blacksand Spit.

Global climate change may be a threat to a species like *B. tunux*, which occurs in cooler areas. If the few areas where the species occurs warm significantly in the future, they may no longer be suitable for growth and maintenance of this moonwort.

Exotic species may threaten existing and/or future habitats and populations of *B. tunux*. In some instances, exotic plants can outcompete native plants for light, space, nutrients, or water.

Herbivory and habitat alteration by introduced mollusks and annelids have been identified as conservation threats to other rare *Botrychium* species. Sessions and Kelly (2001) documented a decline in a population of *Botrychium australe* in New Zealand that was strongly associated with the invasion of an introduced slug, *Deroceras reticulatum*, which was foraging on the ferns. Gundale (2002) observed a correlation between the introduced earthworm, *Lumbricus rubellus* and extirpated populations of *Botrychium mormo* in Minnesota. Gundale demonstrated that the foraging activities of the earthworm caused a decrease in the surface organic layers of this fern's woodland habitat, thereby rendering the habitat unsuitable

It is worth noting that because this species reproduces from spores and has evolved highly specific, localized endomycorrhizal associations, transplanting individuals, or propagating them off-site, is not possible with current technology.

Uplifts in the land resulting from tectonic forces and glacial rebound are hastening succession along the beaches at Yakutat. Consequently, *Botrychium* habitat in upper beaches and upper beach meadows are undergoing successional changes and developing into forests of Sitka spruce (*Picea sitchensis*). This loss of habitat may be balanced by the deposition of sand and silt along the beaches by ocean currents. These deposition areas are developing into beaches and into *Botrychium* habitat. Because of glacial retreat, it is not known how long material will be deposited along south coastal Alaska.

#### SUMMARY OF REASONS FOR NOT ELEVATING THE SPECIES TO CANDIDATE STATUS:

*Botrychium tunux* is a rare, endemic fern ally, originally believed to be restricted to the area of the Yakutat forelands, Alaska. However, surveys conducted during the 2007 growing season revealed additional populations of this species in the Wrangell-St. Elias Mountains. Although this area is being affected by natural events and human activities, threats to *B. tunux* at its type locality have been reduced through management, as summarized below under "Prelisting." Pending genetic analysis, we conclude that elevation to Candidate status for *Botrychium tunux* is not appropriate at this time. This determination may be reconsidered following receipt of genetic information in May 2008.

FOR RECYCLED PETITIONS: (N/A)

- a. Is listing still warranted?
- b. To date, has publication of a proposal to list been precluded by other higher priority listing actions?
- c. Is a proposal to list the species as threatened or endangered in preparation?
- d. If the answer to c. above is no, provide an explanation of why the action is still precluded.

#### LAND OWNERSHIP:

*B. tunux* occurs primarily on lands managed by the U.S.D.A. Forest Service; the Ankau population occurs on lands owned by Yak-Tat Kwaan. Surveys in 2007 revealed additional populations of this species in the Wrangell-St. Elias Mountains, on lands managed by the National Park Service and Parks Canada.

#### PRELISTING:

No conservation agreements exist.

In FY 2003, a project was funded through the Private Stewardship Grant Program to protect the species from disruption of its habitat by ATVs at the type locality on the Yakutat forelands. This project, which is now completed, involves rerouting ATV traffic away from high concentrations of *B. tunux* on the Yak-Tat Kwaan Ankau Land Holding. Additionally, this project included production of a video for educating local ATV users on the importance of *B. tunux* and other flora that can be impacted by off-road users. A recent update indicates that as of 2007, most ATV traffic seems to stay between the logs and away from the moonwort populations. The video continues to be shown to school groups and at BIA conferences and appears to be making some difference (B. Lucey, pers. comm. September 2007).

#### REFERENCES:

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LISTING PRIORITY (place \* after number):

THREAT			
Magnitude	Immediacy	Taxonomy	Priority
High	Imminent	Monotypic genus	1
		Species	2
		Subspecies/population	3
	Non-imminent	Monotypic genus	4
		Species	5
		Subspecies/population	6
Moderate to Low	Imminent	Monotypic genus	7
		Species	8
		Subspecies/population	9
	Non-imminent	Monotypic genus	10
		Species	11
		Subspecies/population	12

**APPROVAL/CONCURRENCE:**

Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes to the candidate list, including listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all additions of species to the candidate list, removal of candidates, and listing priority changes.

Approve: \_\_\_\_\_  
Regional Director, Fish and Wildlife Service      Date \_\_\_\_\_

Concur: \_\_\_\_\_  
Director, Fish and Wildlife Service      Date \_\_\_\_\_

Do not concur: \_\_\_\_\_  
Director, Fish and Wildlife Service      Date \_\_\_\_\_

Director's Remarks:

Date of annual review:

Conducted by:

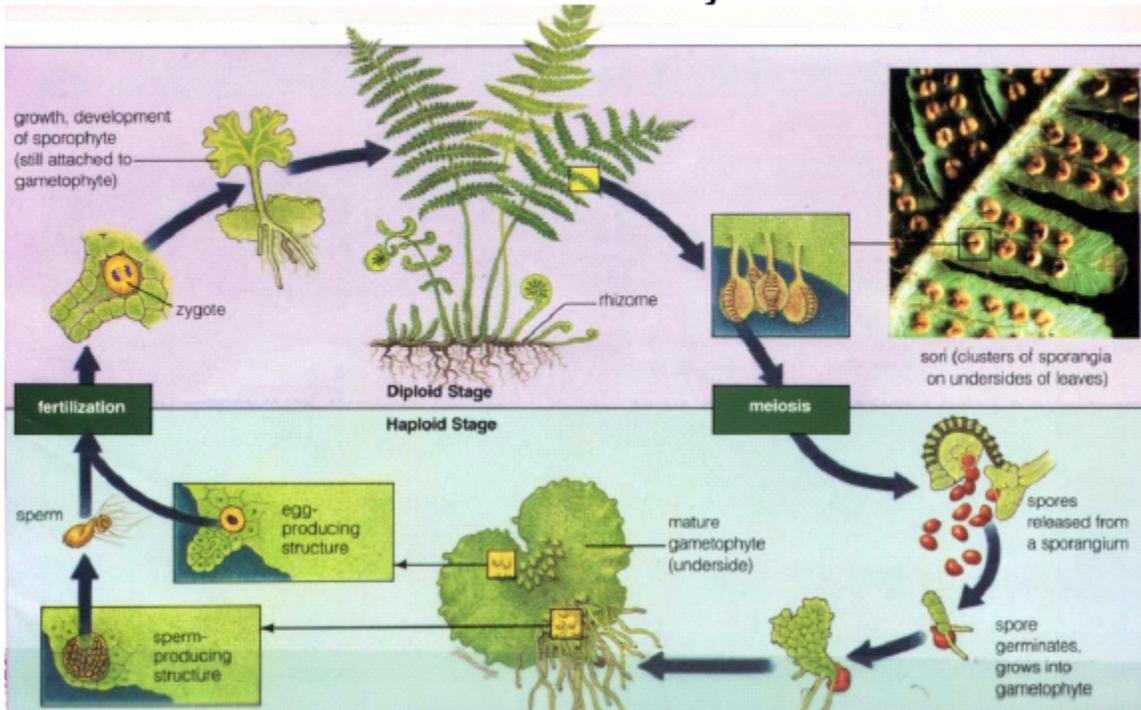
Comments:

(rev. 5/02)

Figure 1. *Botrychium tunux*, about 8 cm tall.



## Fern Life History



### Fern Sporangia



### Fern Gametophyte



Figure 2. Generalized fern life history