

**Added to CNPS Inventory on March 5, 2012**

**Rare Plant Status Review: *Botrychium yaaxudakeit***

**Proposed New Add to Rank 2.1, G3G4 / S1**

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Changes to original document appear in blue text.

Three *Botrychium* species (*B. paradoxum*, *B. tunux*, and *B. yaaxudakeit*) are new to California and were recently discovered by Alison Colwell in the vicinity of Yosemite National Park. They are individually discussed in separate status review proposals; however, all of the proposals contain the same background information on the *Botrychium* genus, which is outlined in the first section below.

**Background on the *Botrychium* genus**

The genus *Botrychium* is a group of ferns in the Ophioglossaceae that are perennial rhizomatous herbs. Understanding the unique *Botrychium* morphology is important to differentiating species. The aboveground sporophyte, which only emerges some years, consists of a single leaf divided into a sporophore (spore-bearing segment) and trophophore (vegetative segment). The majority of *Botrychium* spp. are cryptic, owing to their paucity of morphological features, the plasticity of those features, and the fact that many morphologically similar species are separated by genetic isolating mechanisms (Hauk and Haufler 1999). Because of this, all but one of the known California occurrences of the three species have been confirmed through genetic testing by Dr. Don Farrar (D. Farrar pers. comm. 2011).

Some general threats and management considerations for these three species can be inferred from studies done on other *Botrychium* spp. The California occurrences are highly disjunct from neighboring populations (D. Farrar pers. comm. 2011). Many such plants would be considered at risk of inbreeding depression or genetic drift; *Botrychium* spp., however, reproduce almost exclusively by intragametophytic self-fertilization, eliminating these concerns (J. Clines et al. 2009, D. Farrar, and C. Johnson 2011).

These plants are highly dependent on endomycorrhizal associations with fungi in the genus *Glomus* throughout their life cycle. The *Glomus* fungi are dependant on other green plants for photosynthetic nutrition, and they strongly prefer to associate with perennial herbs (as well as trees in the Cupressaceae and a few broadleaf tree species; D. Farrar pers. comm. 2012). Perennial herbaceous vegetation can be a short-lived successional stage following anthropogenic disturbances. Therefore, some individuals and populations of rare *Botrychium* spp. as a whole tend to be ephemeral, growing only after the herbaceous vegetation has had time to colonize and before other vegetation has taken over (generally 15 to 50 years post-disturbance). Three different *Botrychium* spp. (including *Botrychium paradoxum*) studied over 6 years had relatively short life spans of individuals after sporophyte emergence, with half-lives ranging from one to three years (Lesica and Ahlenslager 1995). However, *Botrychium* spp. also grow

in habitats with perennial herbaceous vegetation that is not maintained by anthropogenic disturbance, such as mountain meadows and prairies. Recent observations from naturally-formed habitats have shown that individuals can have significantly longer life spans, ranging from 20 to more than 44 years (D. Farrar pers. comm. 2012). The high-elevation populations of *B. yaaxudakeit*, *B. tunux*, and *B. paradoxum* are more likely to be longer-lived, given that they occur in more stable, natural habitats.

~~Also, many populations of *Botrychium* spp. undergo routine extirpations and colonizations of new areas, which could be attributed to their affinity for a moderate degree of disturbance (Clines et al. 2009). However, *Botrychium* spp. populations are usually highly buffered, with a “seed bank equivalent” consisting of spores, gametophytes, and underground sporophytes (Clines et al. 2009). While similar demographic data are not available for *Botrychium tunux* and *Botrychium yaaxudakeit*, the possibility of natural extirpation of the California occurrences of these 3 species over time should be considered. Because of these typical population dynamics, the California occurrences of these rare *Botrychium* spp. should be monitored frequently, and surrounding lands with potential habitat should be surveyed and managed for the potential colonization of spores to form new populations (Clines et al. 2009).~~

### **Background on *Botrychium yaaxudakeit***

*Botrychium yaaxudakeit* is found infrequently from Alaska south to the Yosemite area of California. This fern was described by Stensvold et al. (2002) and is included in *The Jepson Manual, Second Edition (TJM 2; available online at [http://ucjeps.berkeley.edu/cgi-bin/get\\_IJM.pl?tid=91733](http://ucjeps.berkeley.edu/cgi-bin/get_IJM.pl?tid=91733))*, but was not included in the *Flora of North America, Vol. 2* or *The Jepson Manual (1993)*. *Botrychium yaaxudakeit* is an allotetraploid species, derived from an ancient hybridization event between two diploid species, *Botrychium neolunaria* ined. (a North American taxon formerly confused with European *B. lunaria*), and *Botrychium lunaria* var. *lunaria* (Stensvold and Farrar 2008). *Botrychium yaaxudakeit* had been collected prior to its original description, but was initially identified as *B. lunaria*, as the two species are very difficult to distinguish (Stensvold et al. 2002). Genetic data and spore diameter (46-57µm in *B. yaaxudakeit*, as opposed to 33-39 µm in *B. lunaria*) are the only characters that can reliably differentiate the two species (Stensvold et al. 2002, Stensvold and Farrar 2008, D. Farrar pers. comm. 2011). *Botrychium yaaxudakeit* plants tend to have a “taller stature, shorter common stalk, more ovate trophophore, and strongly overlapping pinnae that also overlap the rachis” when compared to *B. lunaria* (Stensvold et al. 2002). However, members of this genus tend to vary morphologically with their environment, making identification difficult (Stensvold et al. 2002). In California, *Botrychium yaaxudakeit* has been observed with sporangia in August (Consortium of California Herbaria 2011).

*Botrychium yaaxudakeit* was found in moist alpine meadows within alpine boulder and rock fields of Yosemite National Park in 2007. This area contains rare outcroppings of limestone and marble and supports a number of other rare moonworts as well (Clines et al. 2011~~2009~~). This type of habitat is very uncommon and usually highly localized, so

the plants are generally never very abundant at a given location, even outside of California (A. Colwell pers. comm. 2012). The California occurrence is at an elevation of approximately 3,200 meters.

*Botrychium yaaxudakeit* is only known in California from a single occurrence in Yosemite National Park, in Tuolumne County. *Botrychium* spp. can be very difficult to spot in the field, so surveys of other high-elevation calcareous substrates could result in the discovery of more California occurrences (D. Farrar pers. comm. 2011). Most of the known California collections of *Botrychium lunaria* have been confirmed by D. Farrar through review of herbarium specimens; of the California specimens examined, none have proven to be *B. yaaxudakeit*. A voucher that has been treated as *B. lunaria* had been previously collected in 1939 (Sharsmith 4132; California Natural Diversity Database – CNDDDB EO #4) and may actually be *B. yaaxudakeit*, as *B. yaaxudakeit* was later collected by A. Colwell in the same location, at the head of Virginia Canyon (D.W. Taylor pers. comm. 2012). However, five known occurrences of *B. lunaria* have been documented in the California Natural Diversity Database (CNDDDB; EO #s 2, 5, 6, 7, and 8) with field survey forms, but without collections. Any of those populations could contain *B. yaaxudakeit*, so individuals from those populations should be collected and genetically tested (through spore size measurement or genetic analyses) to determine their actual identity. A collection was treated as *B. yaaxudakeit* in *Flora of the Yosemite Sierra* (D.W. Taylor 7891, CAS?), which is currently included in the CNDDDB as *Botrychium lunaria* (Element Occurrence #8). The current location and identity of this specimen is uncertain (D.W. Taylor pers. comm. 2011). Regardless of the specimen's identity, the population is likely extirpated. Lee Vining Creek was diverted in 1981, but water has since been restored to the stream. Surveys of the creek in the mid-2000s, however, did not produce any *Botrychium* finds (D.W. Taylor pers. comm. 2011).

Although *Botrychium yaaxudakeit* is broadly distributed, but only rare in the southern extent throughout much of its range. The species is ranked by NatureServe as Imperiled (S2; generally 5-20 occurrences) in Alaska, and Critically Imperiled (S1; generally ≤5 occurrences) in Montana and the Yukon Territory in Canada (NatureServe 2011). It is probably more common than currently known in those states, due to both the difficulty in separating it from *B. lunaria* as well as the difficulty in finding the plants (A. Colwell and D. Farrar pers. comm. 2012). It has not yet been ranked in other Canadian Provinces (Alberta, British Columbia) or U.S. States where it occurs (California, Colorado, and Oregon, and Utah; Stensvold and Farrar 2008, D. Farrar pers. comm. 2011).

No threats to the California occurrence of *B. yaaxudakeit* are currently known, but given its location in Yosemite National Park, it should be considered well-protected. However, with its extreme scarcity in California and the ephemeral nature of some populations of *Botrychium* taxa, a threat rank of .1 may be appropriate.

Based on the available information, CNPS and CNDDDB recommend that *Botrychium yaaxudakeit* be added to California Rare Plant Rank 2.1 of the CNPS Inventory. If some of the California *Botrychium lunaria* populations are discovered to actually be *B. yaaxudakeit*, its threat rank may be re-evaluated at that time.

**Recommended Actions**

*Botrychium yaaxudakeit*

CNPS: Add *Botrychium yaaxudakeit* to CNPS 2.1

CNDDDB: Add *Botrychium yaaxudakeit* to G3G4 / S1

**Draft CNPS Inventory Record**

*Botrychium yaaxudakeit* Stensvold & Farrar

giant moonwort

Ophioglossaceae

Rank 2.1

Tuolumne

Alaska, ~~Colorado~~, Montana, Oregon

Dunderberg Peak (471D) 3811913

Alpine boulder and rock fields (meadows) / limestone and marble; elevation 3,200 meters

Perennial rhizomatous herb. Fertile in August.

Discovered in California in 2007 by Alison Colwell; known only from Virginia Canyon in Yosemite NP. Similar to *B. lunaria*. Not in *The Jepson Manual* (1993). See *American Fern Journal* 92(2):150-160 (2002) for original description.