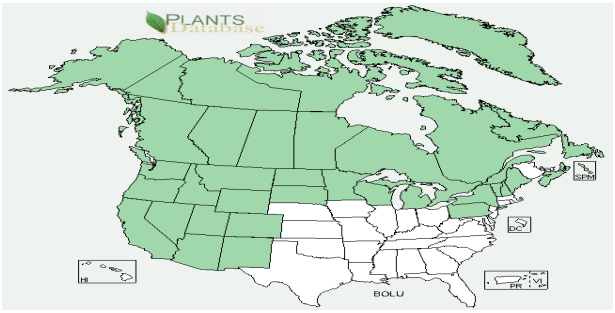
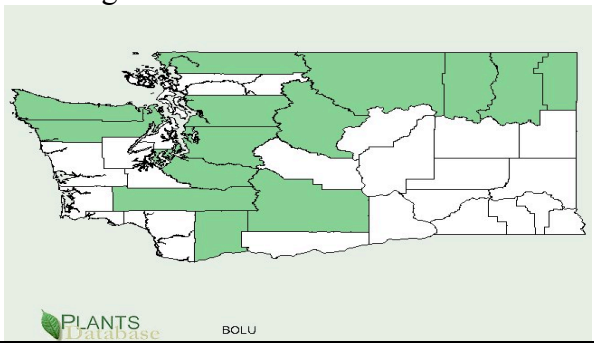
Plant Propagation Protocol for *Botrychium lunaria*
ESRM 412 – Native Plant Production

TAXONOMY	
Family Names	
Family Scientific Name:	*Ophioglossaceae*
Family Common Name:	Adder's-Tongue family
Scientific Names	
Genus:	*Botrychium*
Species:	*lunaria*
Species Authority:	L. and Sw. (Linnaeus and Swartz)
Variety:	N/A
Sub-species:	N/A
Cultivar:	N/A
Authority for Variety/Sub-species:	N/A
Common Synonym(s) (include full scientific names (e.g., *Elymus glaucus* Buckley), including variety or subspecies information)	*Botrychium lunaria* var. *onondagense* ((Underwood) House), *Botrychium onondagense* (Underw.), and *Osmunda lunaria* (L.). Genus synonym: *Eubotrychium*. (NYNPH)
Common Name(s):	Common Moonwort, Moonwort, and Moonwort Grape Fern. (NYNPH)
Species Code (as per USDA Plants database):	BOLU
GENERAL INFORMATION	
Geographical range (distribution maps for North America and Washington state)	North America 

	Washington State 
Ecological distribution (ecosystems it occurs in, etc):	Open fields, meadows, sandy or gravelly streambanks, dry pastures, hillsides, and rocky slopes. Generally occurs in areas where bedrock is calcareous. (NYNPH)
Climate and elevation range	Occurs in high elevations and low elevations in both upper and lower latitudes. Found on sparsely vegetated, talus slopes in upper elevations and sand dunes in lower elevations. Also found in open to lightly wooded meadows in both elevation types. (Bot.)
Local habitat and abundance; may include commonly associated species	Generally found in either calcareous, talus sloped woodland habitats or agricultural land used for livestock. Mostly found in moist, but well-drained soils with a pH near neutral. Commonly associated with mountain maple (*Acer spicatum*), lyre-leaved rockcress (*Arabidopsis lyrata*), wild sarsaparilla (*Aralia nudicaulis*), Mingan's moonwort (*Botrychium minaganense*), fragile rockbrake (*Cryptogramma stelleri*), marginal wood fern (*Dryopteris marginalis*), Virginia strawberry (*Fragaria virginiana*), naked bishop's-cap (*Mitella nuda*), and northern white cedar (*Thuja occidentalis*). (NYNPH) (Bot.)
Plant strategy type / successional stage (stress-tolerator, competitor, weedy/colonizer, seral, late successional)	Spores are released in late spring to early summer. Spore infiltration into the soil and germination can take up to 5 years, although many germinate more quickly. The non-photosynthetic gametophyte requires infection by an endophytic fungus in which it becomes a parasite of the mycorrhizal fungus. Gametophytes are thought to obtain carbohydrates from neighboring plants also infected by the same mycorrhizae. The fungus necessary for the survival of the gametophytes and sporophytes is thought to be vesicular arbuscular mycorrhizae. (Conserv.)
Plant characteristics (life form (shrub, grass, forb), longevity, key characteristics, etc)	Small, diploid, perennial fern with single frond up to 10 cm tall. The single aboveground frond is visible until midsummer and contains a thick, dark green (sterile leaf), fleshy leaf. Has up to 9 pairs of pinnae that spread and overlap when not shaded. Fan-shaped pinnae with margins nearly entire or undulate. Apical lobe generally cuneate to spatulate. Venation shows no midrib. Fertile leaves consist of 1 to 2 pinnate that are 0.8 to 2 times the sterile leaves' length. (NYNPH)

PROPAGATION DETAILS	
Ecotype (this is meant primarily for experimentally derived protocols, and is a description of where the seed that was tested came from):	Ecotype for tested *Botrychium lunaria* specimen is unknown. Since it is a rare, but highly distributed species that only grows in distinct habitat types it is likely that gametophytes tested would come from habitats aforementioned.
Propagation Goal (Options: Plants, Cuttings, Seeds, Bulbs, Somatic Embryos, and/or Other Propagules):	Plants and spores. (Plants) (Common)
Propagation Method (Options: Seed or Vegetative):	Either.
Product Type (options: Container (plug), Bareroot (field grown), Plug + (container-field grown hybrids, and/or Propagules (seeds, cuttings, poles, etc.))	Bareroot or Propagules (sprigs or spores). (Common) (Plants)
Stock Type:	No information found for *Botrychium lunaria* stock type.
Time to Grow (from seeding until plants are ready to be outplanted):	Spores should be placed in compost in a humid environment (pots in bags) from late spring/early summer (harvest time) until late summer when spores have ripened into clumps that are large enough to handle. Should be kept moist in the greenhouse environment until late spring following the first winter. (Plants)
Target Specifications (size or characteristics of target plants to be produced):	Up to 10 cm tall with single pinnae.
Propagule Collection (how, when, etc):	Spores should be collected late spring just before release. If this timing does not work out, collecting soil near *Botrychium lunaria* populations in early summer (after release and soil infiltration) may be achievable.
Propagule Processing/Propag	Sporophytes should be kept in high humidity conditions in a greenhouse environment, preferably in compost contained in a plastic bag. (Plants)

ule Characteristics (including seed density (# per pound), seed longevity, etc):	
Pre-Planting Propagule Treatments (cleaning, dormancy treatments, etc):	Necessary for gametophytes and sporophytes to become infected by vesicular arbuscular mycorrhizae since they do not photosynthesize at this stage. May also be necessary for these propagules to be placed in soil with other plants and connected by mycorrhizae in order for *Botrychium lunaria* to acquire carbohydrates essential for survival and aboveground establishment. No dormancy treatments required. (Plants)
Growing Area Preparation / Annual Practices for Perennial Crops (growing media, type and size of containers, etc):	Growing media must be inoculated with mycorrhizal fungi for the survival of gametophytes and sporophytes. Once the Botrychium lunaria specimens establish themselves with aboveground, photosynthetic plant matter, necessity for this relationship is unknown. (Conserv.)
Establishment Phase (from seeding to germination):	Needs humid environment and moist soil conditions for successful germination.
Length of Establishment Phase:	Can take up to 5 years for gametophyte to germinate and become established. Established moonwort plants may or may not have aboveground plant tissue each year. (Conserv.)
Active Growth Phase (from germination until plants are no longer actively growing):	Late spring to late summer.
Length of Active Growth Phase:	Up to 3.5 months.
Hardening Phase (from end of active growth phase to end of growing season; primarily related to the development of cold-hardiness and preparation for winter):	No information found for *Botrychium lunaria* hardening phase.
Length of Hardening Phase:	No information found for *Botrychium lunaria* hardening phase length.
Harvesting, Storage	Store in a greenhouse environment over first winter after harvest.

and Shipping (of seedlings):	(Plants)
Length of Storage (of seedlings, between nursery and outplanting):	Gametophytes that germinated quickly in greenhouse environment should be outplanted in late spring after spending their first winter in the greenhouse.
Guidelines for Outplanting / Performance on Typical Sites (eg, percent survival, height or diameter growth, elapsed time before flowering):	No information found for *Botrychium lunaria* outplanting guidelines.
Other Comments (including collection restrictions or guidelines, if available):	Clustered sporangia make harvesting easy. (Pojar)
INFORMATION SOURCES	
References (full citations):	"Botrychium Lunaria." Iowa State University. Web. 16 May 2012. <www.public.iastate.edu/~herbarium/botrychium/B-lunaria.pdf>. "Common Moonwort (Lunaria)." *Garden Guide*. Web. 16 May 2012. <http://www.gardenguides.com/taxonomy/common-moonwort-botrychium-lunaria/>. "Conservation Assessment for Common Moonwort (Botrychium Lunaria)." *USDA Forest Service, Eastern Region*. 2001. Web. 16 May 2012. <www.fs.fed.us/r9/wildlife/tes/ca-overview/.../Common-Moonwort.pdf>. "NYNPH Conservation Guide for Common Moonwort." *NYNHP Conservation Guide*. 5 Oct. 2011. Web. 16 May 2012. <www.acris.nynhp.org/report.php?id=9850>. *Plants For A Future*. Web. 16 May 2012. <http://www.pfaf.org/user/Plant.aspx?LatinName=Botrychium+lunaria>. Pojar, Jim, A. MacKinnon, and Paul B. Alaback. *Plants of the Pacific Northwest Coast: Washington, Oregon, British Columbia & Alaska*. Redmond, WA: Lone Pine Pub., 1994. Print. *USDA Natural Resources Conservation Service*. United States

	Department of Agriculture. Web. 16 May 2012. <http://plants.usda.gov/java/profile?symbol=BOLU>.
Other Sources Consulted (but that contained no pertinent information) (full citations):	Atkinson, Scott, and Fred Sharpe. *Wild Plants of the San Juan Islands*. Seattle, WA: Mountaineers/San Juan Preservation Trust, 1993. Print. Kozloff, Eugene N. *Plants and Animals of the Pacific Northwest: An Illustrated Guide to the Natural History of Western Oregon, Washington, and British Columbia*. Seattle: University of Washington, 1976. Print. "Native Plant Database." *Botrychium Lunaria (Common Moonwort)*. Web. 16 May 2012. <http://www.wildflower.org/plants/result.php?id_plant=BOLU>.
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