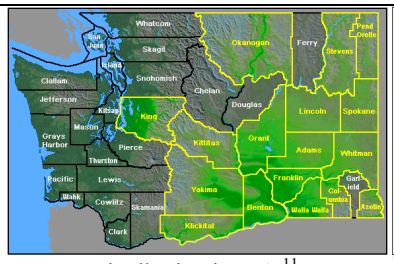
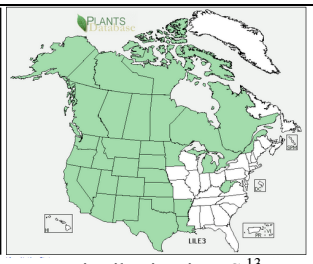
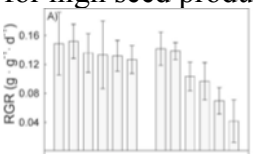
Plant Propagation Protocol for *Linum lewisii*
ESRM 412 – Native Plant Production

TAXONOMY	
Family Names	
Family Scientific Name:	Linaceae
Family Common Name:	Flax Family
Scientific Names	
Genus:	*Linum*
Species:	*lewisii*
Species Authority:	Pursh
Variety:	*lewisii* *alpicola* *lepagei*
Sub-species:	
Cultivar:	
Authority for Variety/Sub-species:	Hult, Löve & Löve, Eat. & J. Wright
Common Synonym(s) (include full scientific names (e.g., *Elymus glaucus* Buckley), including variety or subspecies information)	*Linum perenne* var. *lewisii*
Common Name(s):	Blue flax, Lewis flax, Prairie flax, Lewis' blue flax, Western blue flax[1]
Species Code (as per USDA Plants database):	LILE3
GENERAL INFORMATION	
Geographical range (distribution maps for North America and Washington state)	 Distribution in WA [11]  Distribution in US [13]
Ecological distribution (ecosystems it occurs in, etc):	It is abundant at deep soils, lower slopes of the meadows.[1] Mainly grows in upland areas, but it can also be found in higher elevation desert areas.
Climate and elevation range	Middle to high elevations (1,000 to 6,000 feet)
Local habitat and abundance; may include commonly associated species	Grows over a broad range of elevations in the Rocky Mountains.[10]
Plant strategy type / successional stage (stress-tolerator, competitor,	Flax also thrives on well- drained, infertile to disturbed soils, and is tolerant of semi-shaded conditions[11]

weedy/colonizer, seral, late successional)	They are fire resistant since leaves and stems stay green with relatively high moisture content during most of the fire season.[12]
Plant characteristics (life form (shrub, grass, forb), longevity, key characteristics, etc)	Lewis blue flax is a short-lived, semi-evergreen perennial forb[11]
PROPAGATION DETAILS	
Ecotype (this is meant primarily for experimentally derived protocols, and is a description of where the seed that was tested came from):	Natural areas of the mixed-grass prairies of the Dakotas and eastern Montana [9] Gothic, Gunnison County, Colorado (altitude: 2,900 m), containing low nutrient soils. [3]
Propagation Method (Options: Seed or Vegetative):	Seeds
Product Type:	Pots (15 cm diameter) and bareroot (field grown)
Time to Grow:	April to October
Target Specifications:	1 ft to 2.5 ft in height
Propagule Collection (how, when, etc):	From July to late August, seeds shatter once capsules open, then mature seeds can be collected.[12]
Propagule Processing/Propagule Characteristics (including seed density (# per pound), seed longevity, etc):	It is reported that dry seeds stored at – 15°C for 15 years did not show any reduction in viability.[4] Seed yields of 600 to 700 pounds per acre of *L. Lewisii* can be expected under irrigated conditions and 200 to 300 pounds per acre under dry land conditions.[12]
Pre-Planting Propagule Treatments (cleaning, dormancy treatments, etc):	Has the ability to pass through the digestive tract of cattle and successfully germinate. [11] Fall weather pre-chills seeds and reduces seed dormancy which may be present.[12]
Growing Area Preparation / Annual Practices for Perennial Crops (growing media, type and size of containers, etc):	Approximately 10–20 seeds were planted in pots filled with a 1:1 mixture of sandy loam field soil and coarse sand. Pot sizes for the first and second harvest were 4 cm in diameter by 21 cm deep and 12 cm in diameter by 36 cm deep, respectively. Larger pots (20 cm diameter by 50 cm deep) were used for the third and fourth harvests.[6]
Establishment Phase (from seeding to germination):	Due to low germination rates in *L. lewisii,* seedlings were germinated on moist filter paper and then transferred to the pots. In each pot, 0.4 g Nitrogen in the form of slow release nutrients was thoroughly mixed within the top 5–15 cm of soil [5] During the experiment, ample water and nutrients were supplied 4 times a week with 2 L of water to achieve a moisture content close to 20%. [6]
Length of Establishment Phase:	5-14 days
Active Growth Phase (from germination until plants are no longer actively growing):	In the experiment, germination of all species occurred by April 7th, and all flats were placed outside at the field site 2 weeks prior to transplanting. On May 28th,

	seedlings were transplanted into the subplots with a 2 cm diameter hole. Transplants were watered with approximately 100 mL of water everyday. [7] Drip emitters placed at the base of individual plants watered 4 times per week from pre-flowering through fruit collection. Fertilizer was added in the water. If plants were hand-pollinated, they received supplemental pollen for 6 days per week throughout the blooming period. In the experiment, hand pollination enhanced stigma pollen receipt by 61% in *L.* compared to natural pollination.[3]
Length of Active Growth Phase:	April to late July[11]
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):	They have excellent cold winter tolerance (semi-evergreen).[12]
Harvesting, Storage and Shipping (of seedlings):	Seedling vigor is good and germination occurs the first growing season usually.
Length of Storage (of seedlings, between nursery and outplanting):	[15]Transplant survival for all collections at the Nephi common garden 1 year after planting was 95.3 percent.
Guidelines for Outplanting / Performance on Typical Sites (eg, percent survival, height or diameter growth, elapsed time before flowering):	*L. lewisii* is dependent on insects such as bees and flies for seed production. However, at high elevations, summer snowfalls, low temperature, and high winds might limit pollinator activity. Thus, accessibility to other dipteran and hymenopteran pollinators are crucial for high seed production.[10]  (LILE is second to the right) LILE had Root Growth Rate and root elongation rates that were much lower than the invasive species. Thus, special care is needed in order to retain the population with wild, invasive species. [8]
Other Comments (including collection restrictions or guidelines, if available):	*L. lewisii* is insensitive to altered soil biota and may be valuable as 'nurse' species in restoration efforts.[5]
INFORMATION SOURCES	
References (full citations):	See below
Other Sources Consulted (but that contained no pertinent information) (full citations):	
Protocol Author (First and last name):	Sarah Choe
Date Protocol Created or Updated	06/08/12

Note: This template was modified by J.D. Bakker from that available at: http://www.nativeplantnetwork.org/network/SampleBlankForm.asp

Reference:

[1]Addicott, Fredrick T. "Flower Behavior in Linum Lewisii: Some Ecological and Physiological Factors in Opening and Abscission of Petals." *American Midland Naturalist* 97.2 (1977): 321-32.*JSTOR*. Web. 29 Apr. 2012. <http://www.jstor.org/stable/2425097>.

[2]Allard, H. A. "Linum Lewisii and Bouteloua Curtipendula in West Virginia." *Southern Appalachian Botanical Society* 3.2 (1938): 13-14. *JSTOR*. Web. 29 Apr. 2012. <http://www.jstor.org/stable/4031209>.

[3]Burkle, Laura A., and Rebecca E. Irwin. "The Effects of Nutrient Addition on Floral Characters and Pollination in Two Subalpine Plants, Ipomopsis Aggregata and Linum Lewisii." *Plant Ecology*203.1 (2009): 83-98. *SpringerLink*. Web. 29 Apr. 2012. <http://dx.doi.org/10.1007/s11258-008-9512-0>.

[4]Diederichsen, Axel. "Ex Situ Collections of Cultivated Flax (Linum Usitatissimum L.) and Other Species of the Genus Linum L." *Genetic Resources and Crop Evolution* 54.3 (2007): 661-78.*SpringerLink*. Web. 29 Apr. 2012. <https://springerlink3.metapress.com/content/t38341483k2hn414/fulltext.pdfhttp://>.

[5]Drenovsky, R. E., C. E. Martin, M. R. Falasco, and J. J. James. "Variation in Resource Acquisition and Utilization Traits between Native and Invasive Perennial Forbs." *American Journal of Botany*95.6 (2008): 681-87. Print.

[6]Guo, Q. "Seed Size- and Density-related Hidden Treatments in Common Biodiversity Experiments." Journal of Plant Ecology 4.3 (2011): 132-37. Oxford Journals. Web. 10 May 2012. <http://http://jpe.oxfordjournals.org/content/4/3/132>.

[7]Haag, Joshua J., Malcolm D. Coupe, and James F. Cahill. "Antagonistic Interactions between Competition and Insect Herbivory on Plant Growth." *Journal of Ecology* 92.1 (2004): 156-67. Print.

[8]James, Jeremy J., and Rebecca E. Drenovsky. "A Basis for Relative Growth Rate Differences Between Native and Invasive Forb Seedlings." *Rangeland Ecology & Management* 60.4 (2007): 395-400. *BioOne*. Web. 29 Apr. 2012. <http://www.bioone.org/doi/full/10.2111/1551-5028%282007%2960%5B395%3AABFRGR %5D2.0.CO%3B2>.

[9]Jordan, Nicholas R., Diane L. Larson, and Sheri C. Huerd. "Soil Modification by Invasive Plants: Effects on Native and Invasive Species of Mixed-grass Prairies." *Biological Invasions* 10.2 (2008): 177-90. *SpringerLink*. Web. 29 Apr. 2012. <http://dx.doi.org/10.1007/s10530-007-9121-1>.

[10]Kearns, Carol Ann, and David W. Inouye. "Fly Pollination of Linum Lewisii (Linaceae)." *American Journal of Botany* 81.9 (1994): 1091. *Jstor*. Web. 29 Apr. 2012. <http://http://www.jstor.org.offcampus.lib.washington.edu/stable/pdfplus/2445470.pdf?acceptTC=true>.

[11]*Linum Lewisii. Digital image. WTU Herbarium Image Collection - Burke Museum.* Burke Museum of Natural History and Culture. Web. 14 May 2012. <http://biology.burke.washington.edu/herbarium/imagecollection.php?Genus=Linum>.

[12]Ogle, D.G., L. St. John, J.S. Peterson, and D.J. Tilley. 2009. Plant guide for blue flax (Linum perenne) and Lewis flax (L. lewisii). USDA-Natural Resources Conservation Service, Idaho State Office. Boise, ID.

[13]PLANTS Profile. Digital image. *Welcome to the PLANTS Database | USDA PLANTS.* USDA. Web. 14 May 2012. <http://plants.usda.gov/java/profile?symbol=lile3>.

[14]Shinderman, Matthew J., and Christopher A. Call. "Establishment of Forbs in Cattle Dungpats Deposited in Vegetation Gaps in a Degraded Sagebrush Community." *Ecological Restoration* 19.2 (2011): 99-106. Print.

[15]Kitchen, Stanley G. "Return of the Native: A Look at Select Accessions of North American Lewis Flax." US Forest Service. Web. <http://www.fs.fed.us/rm/pubs_int/int_gtr315/int_gtr315_321_326.pdf>.