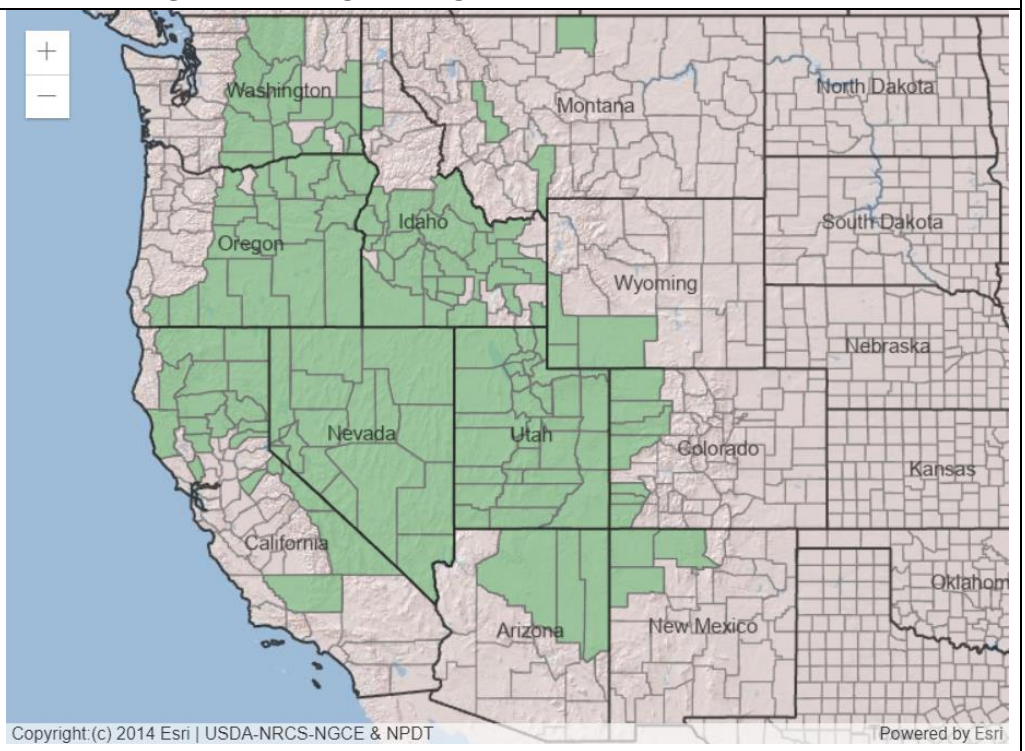
Plant Propagation Protocol for *[Zigadenus paniculatus]*
ESRM 412 – Native Plant Production
URL: https://courses.washington.edu/esrm412/protocols/*[2024]*/*[*ZIPA2.*pdf]*

Image of Foothill Deathcamas inflorescence. (Mitton, 2022a)

TAXONOMY	
Plant Family	
Scientific Name	Liliaceae
Common Name	Lily family
Species Scientific Name	
Scientific Name	*Zigadenus paniculatus (Nutt.) S. Watson*
Common Synonym(s)	*Toxicoscordion paniculatum (Nutt.) Rydb.* *Helonias paniculatus Nutt.*
Common Name(s)	Foothill Deathcamas, Sandcorn, Panicled Deathcamas. (Howard, L. J., 1993) Poison Onion. (Heller, 1909-1910) Panicled Zygadene (Dayton, W. A., 1960) (P) koggie-a-den-up; see-goh-oh; tah-beese-e-goh (S) tah-bah-she-go; tah-vah-see-go (W) koh-gah-des-ma

	(Train et al., 1941) It was unclear from the online document what tribes they were referring to due to worn and torn pages, but these seem to be pronunciation from 3 distinct tribes that were documented alongside their given scientific name and the medicinal uses that these three indigenous tribes had for Foothill Deathcamas. I narrowed them down to being Northern and Southern Paiute, Shoshone, and Washoe. They are part of Nevada's Great Basin Tribes, there are currently 20 federally recognized tribes in Nevada according to the latest Nevada legislature. (*Nevada's Great Basin tribes*)
Species Code (as per USDA Plants database)	ZIPA2
GENERAL INFORMATION	
Geographical range	 (*Foothill Deathcamas Distribution Data Map* 2014) Washington, east to Montana and south to California, northern Arizona, and northwestern New Mexico. In states: AZ, CA, CO, ID, NV, NM, OR, UT, WA, WY (Howard, L. J., 1993) Another source: "Ranges from Saskatchewan and Montana to northwestern New Mexico, northern Arizona, Nevada, California (largely on the east side of the Sierra Nevada), Oregon, Washington, and Idaho. (Dayton, W. A., 1960)
Ecological distribution	Douglas-fir, ponderosa pine, lodgepole pine, sagebrush, and pinyon-juniper forests, as well as agricultural fields. (Howard, L. J., 1993)

Climate and elevation range	In dry, loamy to gravelly soils. Found 4,000 to 7,500 feet (1,300-2,000 m) in elevation. (Howard, L. J., 1993) From an older source: Grows mostly on dry open hillsides between elevations of 2,000 and 9,000 feet. Occasionally on flats, but typically sandy, gravelly, or even rock sites. Sometimes they will be found on moist to wet loamy or clayey soils. Grows sparsely and scattered, but occasionally dense. (Dayton, W. A., 1960). Many sources seem to note that they are generally found in lower elevations than the other Deathcamas.
Local habitat and abundance	Occurs eats of the Cascades in Washington, north central Washington to California, east to the Rocky Mountains. (Howard, L. J., 1993) They often are associated with the big sagebrush (*Artemisia tridentata*) plant community which include cheatgrass (Bromustectorum), Sandberg bluegrass (*Poa secunda*), and low larkspur (*Delphinium bicolor*). They also have associations in the true pinyon-Utah juniper (*Pinus edulis-Juniperus osteosperma*) community which include Utah serviceberry (*Amelanchier utahensis*), banana yucca (*Yucca baccata*), rubber rabbitbrush (*Chrysothamnus nauseosus*), Fendler bluegrass (*Poa fendleriana*), bottlebrush squirreltail (*Elymus elymoides*), and hairy telegraphplant (*Heterotheca villosa*). (Howard, L. J., 1993)
Plant strategy type / successional stage	Stress-tolerator: grows and spreads more with disturbance especially by grazing. Competitor: competes with other species of Camas being one of the first to begin its growth in spring. Weedy: farmers often find these weedy, but these are native to the range. Mid-late seral stages (Hauser, A. S., 2006) Information partially based on *Zigadenus venenosus.*
Plant characteristics	Perennial forb that grows from fibrous roots at the base of a “deep-set” underground bulb. The inflorescence is a raceme of polygamous flowers with fruits that are 3-celled capsules. The peduncle grows up to 8-21 inches (20-60 cm), with the acaulescent leaves growing from 12-20 inches (30-50 cm). (Howard, L. J., 1993) The flowers have cream colored tepals with yellow or light green nectarines at the base of each tepal. Their flowers are presented in a panicle with a loose branching cluster of flowers. (Mitton, 2022b) Note that *Zigadenus paniculatum* and *Zigadenus venenosus* are reported to hybridize and both are hard to differentiate between distinctly and confidently. (Mitton, 2022b)

PROPAGATION DETAILS: FROM SEED (Skinner, D., 2008)	
Ecotype	Paradise Creek drainage near Pullman, Washington. (Skinner, D., 2008)
Propagation Goal	Bulbs
Propagation Method	Seed
Product Type	Container (plug)
Stock Type	10 cubic inch conetainers
Time to Grow	Based on *Zygadenus venenosus* protocol: 0
Target Specifications	n/a
Propagule Collection Instructions	Seeds are collected when capsules turn brown and begin to split in August from areas where of which the plants were plentiful. They were then stored in paper bags or envelopes at room temperature until they were cleaned. All plant parts are poisonous and hence be handled with care. There were not any specific precautions noted but take precautions by using gloves and a mask and washing your hands after. Seeds can be collected by shaking them into the paper bags or envelopes from the capsule or the entire capsule can be removed and collected as well. (Skinner, D., 2008)
Propagule Processing/Propagule Characteristics	Seeds that were shaken out of the capsules require no cleaning, but if whole capsules were taken then the capsules may be crushed to help release the seeds. One way to clean them is with an air column seed separator in which they would be separated by density. These cleaned seeds would then be stored in controlled conditions at 40 ° Fahrenheit and 40% relative humidity. (Skinner, D., 2008) Note that this may be quite pricey as of 2024 even with a sale the price of one is $9,500.00. (*Continuous air stream separator* 2023) The density or seed longevity was not provided.
Pre-Planting Propagule Treatments	In Western Washington, the highest germination occurred with 6 weeks of cold moist stratification and cool germination temperatures. (This is taken from a paper referenced in this protocol that I could not find access to). (Skinner, D., 2008) For this specific Palouse ecotype studied, cold moist stratification is also needed. Following that up with cool spring temperature is noted to be also needed. No germination occurred without stratification and no seeds germinated after 30 days of cold moist stratification. The seeds for this experiment during the first season seeds sown in December and left outside did not germinate but germinated after a second winter. While seeds sown in November germinated in the following spring. (Skinner, D., 2008)
Growing Area Preparation / Annual Practices for Perennial Crops	Seeds were sown in late October or early November in 10 cu. In. Ray Leach Super Cell Cone-tainer filled with Sunshine #4 mix. They were covered lightly with a thin layer of coarse grit to prevent the seeds from floating when watering. The conetainers were watered deeply and placed outside. In late October, the seeds can be sown directly into the ground at a rate of 30-40 seeds per linear foot. The seedling should be made firm in a weed-free

	seedbed to ensure and hold moisture near the surface of the soil while assuring accurate seed placement. Seeds should be barely covered by soil. (Skinner, D., 2008)
Establishment Phase Details	The conetainers remain outside and are only watered during dry spells. Germination will begin and occur over 2-4 weeks with the changes in daytime temperatures during March and May. (Skinner, D., 2008)
Length of Establishment Phase	2-4 weeks
Active Growth Phase	The plants were watered as needed and fertilized once a week with water soluble fertilizer. They are then moved into the lath house in June in which they will not grow beyond the 1-2 true leaf stage the first season. They then senesce in mid-summer in which they then will be given only enough water to prevent the medium from completely drying. (Skinner, D., 2008)
Length of Active Growth Phase	2-3 seasons
Hardening Phase	Since the plants are grown outside and dormant in the autumn, additional hardening is not needed. (Skinner, D., 2008)
Length of Hardening Phase	0
Harvesting, Storage and Shipping	Over winter, the plants are stored in the lath house and covered with mulch or foam sheets which protects them from the extreme cold temperatures. The protection is removed late winter or early spring as temperatures begin to rise. They are then kept in containers for 2 or more seasons in the lath house. During the third year, in August or September the containers are dumped out and bulbs are separated from the soil using hand screens. (Skinner, D., 2008)
Length of Storage	8-10 months (estimated was not provided in the protocol).
Guidelines for Outplanting / Performance on Typical Sites	Not provided.
Other Comments	This propagation protocol advises that this method be used for plants growing in cultivation. Plants should not be dug up from stands in the wild. (Skinner, D., 2008) Not noted in the protocol, but it's important to take precautions during the entire process as mentioned previously every part of the plant is poisonous. It's likely that you are looking to avoid collection of these bulbs and instead looking for camas for consumption, but they are hard to differentiate between until they are fully grown. The only way to truly differentiate them between edible variants of Camassia is when they are inflorescent.

	Indigenous peoples have been recorded using their crushed bulbs as a wet dressing or poultices or rheumatism, sprains, lameness, neuralgia, toothache, or any sort of swelling. They were also seen roasted then crushed and applied as hot poultices. (Train et al., 1941) Those are some recorded external uses of their bulb, but there is also record of indigenous peoples boiling the bulbs to prepare for an emetic tea. (Train et al., 1941) (Pojar, J., & MacKinnon, A., 2016) Based on previous observations, insect visitation appears to be limited. The pollen and potentially nectar, of *Z. venenosus S. Wats* was observed to be toxic to honeybees (*Apis mellifera*) and possibly other potential visitors. Hypothesis suggests that the alkaloids present in the flowers serve to reduce pollinator visitation, thereby enhancing the efficiency of the pollination system. (Tepedino, V. J., 1981) Note that there are some more one more protocol on *Zigadenus venenosus* that can be found on the RNGR (Reforestation, Nurseries, & Genetic Resources network but it is not as extensive as this one which is why I have not included it in here. There are protocols listed for Camassia leichtlinii and Camassia quamash on RNGR as well which I recommend checking out as further reference but will not be included on here.
PROPAGATION DETAILS: VEGETATIVE (Lambert, M. S., 2001).	
Ecotype	n/a Note that this comes from a research scientist that seemed to be working in Pullman Washington at the time, but this does not necessarily mean they were collected there.
Propagation Goal	Plant
Propagation Method	Vegetative
Product Type	Bareroot (field grown)
Stock Type	Bareroot Bulb
Time to Grow	0
Target Specifications	Height and Caliper not applicable but aiming to have a well-developed bulb that is 1.5 to 2.0 cm wide. (Lambert, M. S., 2001). Well-developed bulbs often form bulblets that is used to further propagate and spread them.
Propagule Collection Instructions	This vegetative protocol is based on *Camassia quamash* or commonly known as Common Camas. They generally prefer full sun to partial shade with the bulb depth ranging from 5 to 20 cm (2 to 8 in). Most commonly bulb depth is found to be between 10 to 15 cm (4 to 6 in). For common camas they are often smaller in size and found in substantially shallower soil comparatively to great camas. (Lambert, M. S., 2001).

	Note that there were no specific depths found for Foothill Deathcamas but for Meadow Deathcamas they occur 2 to 8 in (5 to 20 cm) underground. (Hauser, A. S., 2006) It is noted however the bulbs for Foothill Deathcamas were deep-set. (Howard, L. J., 1993). Bulb depth is limited by high water tables, anoxic conditions, or restrictive layers. Plants require moist soil conditions or irrigation to become established. (Lambert, M. S., 2001). With a permit, common camas can be harvested in the wild but there are also commercially grown bulbs available. Due to the loss of wetland habitats harvesting plants from the wild is rarely appropriate or legal except under salvage situations. It's strongly recommended to use bulbs or seeds from local nurseries or greenhouses instead. (Lambert, M. S., 2001). The bulbs are best excavated from early summer though mid-fall. Commercially, they are harvested when leaves are still green to avoid damage as the bulb tunic or covering is very thin. The windows for digging and harvesting the bulbs are quite narrow as the summers dry out the clay and silt. It's best to harvest when the soil is still moist after flowering in the spring. The next available harvest date would be in fall after rain. (Lambert, M. S., 2001).
Propagule Processing/Propagule Characteristics	During the processing phase, the bulbs are stored in a dry, dark, cool, and well-ventilated place in potting medium for planting in the fall or spring. They must be kept from completely drying as they sit in dry peat moss. It's important to store them at around 17 to 20 degrees Celsius while in transport or storage. (Lambert, M. S., 2001). When they are procured vegetatively, they produce offsets, but in the wild only 1% of them may produce offsets. (Lambert, M. S., 2001). The density or seed longevity was not provided.
Pre-Planting Propagule Treatments	Bulbs, bulblets, and offsets can be used but if the desired goal is flowering plants, then bulbs must be at least 3 to 5 years old and have 3 to 4 bulb leaves or scales. This is as bulbs with just 2 bulb leaves/scales never flower, those with 3 routinely flower, and those with 4 almost always flower. Older bulbs are found at a deeper depth, and mature bulbs that flower will be at least 1.5 to 2.0 cm (0.6 to 0.8 in) wide. Commercially, the minimum size for export and flowering is at a circumference of 6.0 cm (2.4 in). (Lambert, M. S., 2001).
Growing Area Preparation / Annual Practices for Perennial Crops	The seeds were planted in an outdoor bareroot field with larger bulbs at greater planting depths. Planting depth ranged from 1.2 to 2.5 cm (0.5 to 1 in) for 1- to 2-y-old bulblets, and for mature bulbs up to 10 to 15 cm (4 to 6 in). Larger bulbs (4 cm (1.5 in) diameter or greater) can be planted deeper (at 20 to 25 cm [8-10 in]) if drainage is appropriate. (Lambert, M. S., 2001).

	During commercial production they transplant immature bulbs from October to November in well-drained soil (with pH levels of 6 to 7) with at least 2% organic matter and bulbs covered with at least 7.5 cm (3 in) of soil above the bulb's top end, followed by 6 cm (2 in) of straw mulch. Seed propagation is not commonly used. (Lambert, M. S., 2001).
Establishment Phase Details	7N:14P2O5:28K2O fertilizer was applied four weeks after planting. The camas bed was kept damp, but once plants become senescent after flowering, watering is halted. Shortly, the seeds will form, with bulbs curing. (Lambert, M. S., 2001).
Length of Establishment Phase	Not provided.
Active Growth Phase	Some pest control was done by immersing bulbs in a hot water treatment for 4 hours at 43.5 to 45 Celsius (110 to 113 Fahrenheit). No serious insect pests were noted but diseases from the fugus *Rhizoctonia tuliparum*. (Lambert, M. S., 2001).
Length of Active Growth Phase	Not provided.
Hardening Phase	Hardened naturally in outdoor bareroot bulb beds. (Lambert, M. S., 2001).
Length of Hardening Phase	n/a
Harvesting, Storage and Shipping	Bulbs are harvested in late July. (Lambert, M. S., 2001).
Length of Storage	Not provided.
Guidelines for Outplanting/ Performance on Typical Sites	Not Provided.
Other Comments	The previous statements about how all plant parts are poisonous still holds from the seed propagation details, but further details on insect visitation from new sources further support the idea of deadly alkaloids within all parts of the plant. Some symptoms include: Salivation, Lacrimation, Urination, Defecation, Gastric distress, and Emesis (This also known as S.L.U.D.G.E.). Cardiac toxicity leads to very low blood pressure while neural toxicity results initially with pins and needles in the extremities followed by loss of coordinated movement, coma, and then death. (Mitton, 2022b) Domesticated animals such as sheep, cows and horses fall susceptible to all types of death camas, especially during early spring with consumption of about half a pound of leaves and stems is lethal. (Mitton, 2022b) Though it's been found that sheep are the most likely to graze and eat camas hence

	poisoned more frequently. In which they usually die but can recover if they do not consume too much. ("Deathcamas (Zigadenus Gramineus, Z. Venenosus, Z. Paniculatus, Z. Nuttallii): USDA ARS") California Tribes would often generally call bulbs, corms, rhizomes, taproot, and tubers they dug up "Indian potatoes" and "root foods". Women from these tribes would harvest and pry them loose from the soil using digging sticks when the flowers were inflorescence. These sticks were made from mountain mahogany, serviceberry, or buck brush and fire-harden to increase durability for long-term usage. When harvesting, they would only take what was needed, and propagated the rest of the bulblets and cormlets that fell off or was took off from the mother bulb or corm. This ensures future plant generations, while the digging kept the soil aerated in the process. Fires were also set after to improve the quality and numbers of the bulbs. (Anderson, M. K., 2006) Additional Propagation timing info: **Regal Lily:** since their seeds germinate spontaneously, sow them during late winter or early spring. The heat will speed up their process and rapidly develop into small bulbs by the end of the first season. They will form bulbs large enough to plant by late summer or early autumn. Many will grow large enough to produce flowers the following summer. (Thompson, P., 2005) **Based on Camassia:** Seed: Fresh Bulb Divisions: Summer; gouge as hyacinths. (Thompson, P., 2005) **Based on Zigadenus:** Seeds: Fresh Bulb Divisions: Autumn, early winter. (Thompson, P., 2005)
INFORMATION SOURCES	
References	1. Continuous air stream separator. Hoffman Manufacturing Inc. (2023, April 24). https://www.hoffmanmfg.com/products/continuous-air-stream-separator/ 2. Dayton, W. A. (1960). In *Notes on western range forbs: Equisetaceae through Fumariaceae* (p. 53). essay, Forest Service, U.S. Dept. of Agriculture, 1960. Retrieved May 2, 2024, from https://www.biodiversitylibrary.org/page/32645368#page/5/mode/1up. 3. Deathcamas (Zigadenus gramineus, Z. venenosus, Z. paniculatus, Z. nuttallii) : USDA ARS. (2018, June 26). Usda.gov. https://www.ars.usda.gov/pacific-west-area/logan-ut/poisonous-plant-research/docs/deathcamas-zigadenus-gramineus-z-venenosus-z-paniculatus-z-nuttallii/ 4. *Foothill Deathcamas Distribution Data Map*. (2014). USDA United States Department of Agriculture. Retrieved May 2, 2024, from https://plants.usda.gov/home/plantProfile?symbol=ZIPA2.

5. Heller, A. A. (1909). The Death Camas. In *Muhlenbergia* (Vol. 5, p. 51). essay, Library of the New York Botanical Garden. Retrieved May 2, 2024, from https://www.biodiversitylibrary.org/page/32092413.
6. Howard, L. J. (1993). Zigadenus paniculatus. In: Fire Effects Information System, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Retrieved May 2, 2024, from https://www.fs.usda.gov/database/feis/plants/forb/zigpan/all.html.
7. Lambert, M. S. (2001). Propagation protocol for production of Bareroot (field grown) Camassia quamash plants. RNGR Reforestation, Nurseries, & Genetic Resources. https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=liliaceae-camassia-462
8. Mitton, J. (2022a). *inline 1 death camas flowers close 1 p*. Colorado Arts and Sciences Magazine. Colorado Arts and Sciences Magazine. Retrieved May 2, 2024, from https://www.colorado.edu/asmagazine/2022/04/01/rare-relationship-between-death-camas-and-death-camas-miner-bees.
9. Mitton, J. (2022b, April 1). *A rare relationship between death camas and Death Camas miner bees*. Colorado Arts and Sciences Magazine. https://www.colorado.edu/asmagazine/2022/04/01/rare-relationship-between-death-camas-and-death-camas-miner-bees
10. *Nevada's Great Basin tribes*. Nevada Legislature. (n.d.). https://www.leg.state.nv.us/App/NELIS/REL/80th2019/ExhibitDocument/OpenExhibitDocument?exhibitId=36430&fileDownloadName=Nevadas+Great+Basin+Tribes_Nevada+Indian+Commission.pdf
11. Skinner, D. (2008). Propagation protocol for production of Container (plug) Zigadenus venenosus S. Watson bulbs 10 cu. in. Rngr Reforestation, Nurseries, & Genetic Resources. https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=liliaceae-zigadenus-3496
12. Tepedino, V. J. (1981). NOTES ON THE REPRODUCTIVE BIOLOGY OF ZIGADENUS PANICULATUS, A TOXIC RANGE PLANT. The Great Basin Naturalist, 41(4), 427–430. http://www.jstor.org/stable/41711842
13. Train, P., Henrichs, J. R., & Archer, A. W. (1941). Zigadenus paniculatus S. Wats. In *Medicinal uses of plants by Indian tribes of Nevada Part III (pages 130-199)* (Ser. Contributions toward a flora of Nevada, no. 33, p. 149). essay, Division of Plant Exploration and Introduction, Bureau of Plant Industry, U.S. Dept. of Agriculture, 1941. Retrieved May 2, 2024, from https://www.biodiversitylibrary.org/page/44371965.

	14. Zigadenus paniculatus (Nutt.) S. Watson foothill deathcamas. USDA plants database. (n.d.). https://plants.usda.gov/home/plantProfile?symbol=ZIPA2
Other Sources Consulted	1. Anderson, M. K. (2006). Plant Foods Belowground Bulbs, Corms, Rhizomes, Taproots, and Tubers. In Tending the Wild Native American Knowledge and the Management of California's Natural Resources (pp. 292–305). essay, University of California Press. 2. Hauser, A. S. (2006). Zigadenus venenosus. In: Fire Effects Information System, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Retrieved May 2, 2024, from https://www.fs.usda.gov/database/feis/plants/forb/zigven/all.html. 3. Pojar, J., & MacKinnon, A. (2016) Lily. In Revised Plants of the Pacific Northwest Coast Washington, Oregon, British Columbia & Alaska (p. 109). essay, B.C. Ministry of Forests, Partners Publishing and Lone Pine Publishing. 4. Thompson, P. (2005). Plants with Bulbs and Corms. In Creative Propagation (Second Edition, pp. 220–240). essay, Timber Press, Inc.
Protocol Author	Ruihua Huang
Date Protocol Created or Updated	05/02/2024