University of Washington's Society for Ecological Restoration Native Plant Nursery

Business Plan and Plant Production Manual

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Abstract

This MEH project is divided in two major parts, a Business Plan and a Plant Production Manual. Both were developed for the Society for Ecological Restoration native plant nursery.

Business Plan

In order for an organization to succeed it must have a well developed strategy, and this is true whether the organization is for profit or not for profit. Up until now the SER-UW nursery has not had a cohesive production or financial strategy, and it has in many ways been flying by the seat of its pants. The nursery has received several grants from the Campus Sustainability Fund with the stipulation that the nursery would eventually become self-sustaining. Also, in conversations with administration in the School of Environmental and Forest Sciences and in the University of Washington Botanic Gardens, it became clear that the nursery needed to develop a business plan in order to become a permanent organization at the University of Washington. Thus, this business plan was created to address the above listed issues. It is meant to provide the nursery with a foundation for moving forward over the next 5 years.

Plant Production Manual

The production manual was created to provide a framework for the day-to-day production operations of running the SER-UW native plant nursery, and it will allow future managers to reach the goals outlined in the business plan. The plant production manual is a living document. For the most up-to-date version, please email the nursery managers at sernursery@gmail.com.

Acknowledgements

- The Campus Sustainability Fund for their generous support of the SER-UW nursery
- Dr. Kern Ewing for giving me the financial freedom to pursue a project I am deeply passionate about
- My committee members for their incredible insight and mentorship over the course of this project and my tenure here at the University of Washington
- The University of Washington Botanic Gardens staff for being so accommodating
- All past, current, and future managers of the nursery - Kelly, Anna, Courtney, Mary-Margaret, Kimmy, and Sarah you all have helped to build something pretty extraordinary.
- All of my wonderful interns.. you rock!
- The MEHers.. what a wonderful group of people!
- ..and all the hordes of volunteers that have ever washed a pot, dug up a blackberry, or gotten their hands dirty working with plants in the nursery. We couldn't have done this without you.

University of Washington's Society for Ecological Restoration Native Plant Nursery

Business Plan for 2018 - 2023

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Executive Summary

The Native Plant Nursery of the Society for Ecological Restoration UW Student Guild (SER-UW), established in 2013, provides a local source of native plant material for student ecological restoration projects in the Union Bay Natural Area and Yesler Swamp, as well as for many restoration sites on the University of Washington (UW) campus and throughout the Greater Seattle region. Located at the Center for Urban Horticulture, it has been a much-needed presence as a hub for student involvement in the applications of horticulture and restoration beyond what is available through coursework.

Since its inception 5 years ago, the nursery has never had a coherent production or financial strategy, and the purpose of this document is to create a plan that will allow the nursery to build on its past production and sales successes as it focuses on plant production and financial sustainability over the next five years. Education remains a driving force of the nursery's mission, and it will continue to work closely with the Master of Environmental Horticulture program, as well as continue to offer internships and volunteers opportunities to UW students. The nursery also sees significant room for improvement in its marketing strategy, and it will aim to increase its visibility on and off campus within the next year. Lastly, the nursery will continue to uphold its commitment to advancing environmental, social, and economic sustainability, as it pursues funding to secure a permanent future within the University of Washington. Achieving this commitment will ultimately require the nursery to create a UW revenue budget and hire a full-time, non-student manager.

Mission Statement

Produce plant materials native to the Puget Lowland Region in a responsible and ecologically sound manner, and to be an educational hub for environmental horticulture at the University of Washington.

Vision

Become a major source of locally produced native plants for student projects and community restoration, offer students a unique, hands-on experiential learning opportunity of best nursery practices for native plant production, and continue to improve those practices through research and collaboration with students and community partners.

Products and Services

Plant Materials

The nursery currently grows a wide variety of container trees, shrubs, herbaceous plants, and graminoids native to the Puget Lowland Region. Ferns, though not currently grown at the nursery, are oftentimes acquired through salvage events and made available for purchase. All of these species are commonly used in student and community restoration projects throughout the greater Seattle region.

Education

The nursery offers unique experiential learning unavailable to students through normal course offerings. The nursery is currently and traditionally managed by one or two graduate students, who gain valuable experience in horticultural production, team leadership, and project management. Internships for undergraduate students are offered every quarter, and each intern is responsible for completing an individual applied or research project. All of which are tailored to their interests and designed to further the mission and goals of SER-UW nursery. Throughout the autumn, winter, and spring quarters the nursery hosts weekly volunteer work parties whereby students learn sustainable native plant production techniques through hands-on work. Multiple service learning positions are available each quarter through the Carlson Center, and these positions offer a much more enriching experience compared to one-time volunteers. The nursery is also used as an outdoor laboratory for the Native Plant Production course (ESRM 412) listed in the School of Environmental and Forest Sciences. All student involvement is ultimately overseen and professionally supported by UW faculty and UW Botanic Gardens (UWBG) staff.

Strategic Goals and Objectives

As a growing student run organization, the SER-UW nursery has defined several goals relating to production, education, and sustainability that will allow it to establish itself firmly within the University of Washington over the next five years. These goals and objectives are as follows:

Long-Term Strategic Objective

The nursery has set a goal to become financially self-sufficient by 2024. A combination of revenue, gifts, and endowments will allow the nursery to fund a full-time manager and multiple student staff positions, as well as adequately funding core functions.

Goals

Goal 1: Produce quality plants and maintain genetic diversity of plants appropriate for the Puget Lowland Region.

- ➢ Produce and sell 5,000 quality plants in 2019, and to increase that number incrementally by 500 plants every year till 2023.
- ➢ Produce 100% of all plant material needed for Restoration of North American Ecosystems (ESRM 473) for the next five years.
- ➢ Produce at least 90% of all container plant material needed for the REN Capstone series (ESRM 462-4) by 2020.
- ➢ Produce restoration-ready plants for use in the Union Bay Natural Area and Yesler Swamp.
- ➢ Host two public plant sales every year for the next five years.
- ➢ Build onto existing partnerships and to establish new partnerships with community organizations in need of native plant materials.

Goal 2: Use an Integrated Pest Management (IPM) approach.

- ➢ By using an IPM approach, the nursery will use fewer chemical pesticides reducing carbon pollution and limiting negative impacts to the surrounding ecosystem.
- ➢ An IPM approach will help reduce production costs for the nursery, and it will help to ensure long-term survival of native plants after outplanting.

Goal 3: Provide a unique, hands-on learning experience for students of the University of Washington.

- ➢ Offer internships to at least 8 undergraduate students every year for the next five years.
- ➢ Offer service learning opportunities through the Carlson Center to at least 15 undergraduate students every year for the next five years.
- ➢ Acquire a minimum of 1000 volunteer hours every year for the next five years.
- ➢ Partner with the Native Plant Production (ESRM 412) course every spring quarter for the next five years.
- ➢ Emphasize

Goal 4: Increase marketing of the SER-UW on campus and within the Greater Seattle region.

- ➢ Develop and implement a marketing plan for the nursery (see Appendix B).
- ➢ Create permanent signage at the hoophouse, at SER-UW project sites, and around the UWBG by spring 2019.

- ➢ Create movable signs to be placed along Mary Gates Memorial Dr. NE and NE 45th St. during public plant sales by fall 2018.
- ➢ Develop a protocol for increasing and sustaining our social media presence.
- ➢ Create durable posters to hang in the UW Grounds workshop and around campus.
- ➢ Collaborate with UWBG to increase visibility on the website.

Goal 5: Advance environmental, social, and economic sustainability.

- ➢ Continue to uphold the GOLD standard of the UW Green Dawgs RSO Certification indefinitely (see Appendix C).
- ➢ Research and improve best nursery practices in order to lessen environmental impacts of plant production and to share this information broadly.
- ➢ Impart our knowledge of sustainable practices to students, to the native nursery production community, and to the Greater Seattle region, while also emphasizing the need to maintain genetic diversity in native plant production.
- ➢ Secure the financial resources that will allow the nursery to support its production goals and educational mission indefinitely. All of the following are critical to achieving financial stability:
    - ○ Work with SEFS and UWBG administration to create a revenue budget (see Appendix D).
    - ○ Work with UWBG to pursue donations and endowments from outside UW.
    - ○ Continue strengthening partnerships within the University.
    - ○ Develop and implement a communications plan (see Appendix E).

- Develop and implement an operations plan (see Appendix F).

Strategic Analysis

Strengths, Weaknesses, Opportunities, and Threats (SWOT)

As the nursery continues to grow and advance toward its long-term strategic objective, it will be necessary to gauge progress, seize upon opportunities, and respond to changing trends in the market. By aligning our goals with these factors, the nursery can continue to maximize potential and minimize threats/weaknesses. Listed below is a SWOT analysis constructed by the SER-UW nursery management in 2018 (2). It will allow the nursery to take advantage of its current position, and it will serve as a guide for future analysis and updates.

INTERNAL FACTORS	
STRENGTHS (+)	**WEAKNESSES (-)**
• Student-run • Center for Urban Horticulture (facilities and resources) • UW affiliation (courses and research) • Well-regarded restoration projects (UBNA and REN Capstone) • Volunteers (numbers and capability) • Growing reputation • Passionate community • Unique experiential learning • Location • Rent agreement with UWBG • Access to expertise, education, and knowledge • Invested professors and UWBG staff • UW Green Dawgs Certification • Public plant sales • Internships • Master of Environmental Horticulture students	• Limited financial resources • Quick graduate student turnover (loss of continuity) • Production space (low-tech and limited in size) • Shared space • Lack of collaboration with the rest of SEFS • Marketing and brand awareness on campus • Marketing and advertising of public plant sales • Reliance on grants and professorship funding • Lack of expertise growing specific plant species • Cost of graduate students • Lack of community partners • No full-time manager

EXTERNAL FACTORS	
OPPORTUNITIES (+)	**THREATS (-)**
• UBNA and Yesler Swamp - UWBG restoration projects • UW Grounds • New SEFS Director • Green Seattle Partnership • Student restoration projects • 520 Mitigation funding • Space to expand into • Rhizome and bulb production beds • Local tribal restoration • Public education courses • Research of plant production techniques • SER International and PNW • Partnership with the Native Plant Society	• Competition with for-profit nurseries • Local native plant sales • Ornamental (non-native) plant market • Local rabbit population (crop damage) • Future UWBG Director • Future of the MEH program • Budget cuts in the College of the Environment • Younger generation of students are less interested in environmental horticulture

Sales and Marketing Strategy

Target Customers

- Students working on restoration projects
- UWBG restoration of the Union Bay Natural Area and Yesler Swamp
- UW Grounds improvements
- Members of the public that own property in the Greater Seattle Region
- Governments, tribes, and nonprofit community partners outside of UW (ex. Green Seattle Partnership and the City of Sammamish)
- Contract growing market

Pricing Structure

The nursery operates as a not-for-profit wholesale nursery for students and for the UW Botanic Gardens. Governments and other nonprofit organizations purchasing plants in bulk also receive wholesale pricing (50% of retail pricing). Sales are closed to the general public except during the two plant sales held every year (usually May and November), where plants are sold at retail value. In accordance with state law, retail pricing is set at market rate, which is determined through price comparisons of other local retail native plant nurseries.

Distribution

The nursery does not deliver plants; Customers are expected to pick up plants directly from the nursery located at the Center for Urban Horticulture.

Sales Projection

The nursery has projected a steady increase in the number of units sold over the next five years (Table 1 and Figure 1). These numbers represent the needs of the current customer base, as well as the projected growing demand for native plant materials from the SER-UW nursery. These numbers are ambitious, but certainly achievable, for a graduate student manager. A full-time, non-student manager would be expected to surpass these production numbers.

Table 1: Projected number of plant units sold over the next 5 years

	Units sold		Projected Units Sold					
Form	2016	2017	2018	2019	2020	2021	2022	2023
Pack of Bulbs	0	20	0 (40)	40	50	55	60	70
Plug	0	935	1504 (1800)	2100	2350	2600	2850	3100
4"	260	168	274 (450)	600	770	850	930	1000
1/2 Gallon	115	480	234 (370)	200	0	0	0	0
1 Gallon	623	948	937 (1200)	1400	1650	1800	1950	2100
2+ Gallon	58	70	92 (140)	160	180	195	210	230
Total	1056	2621	3121 (4000)	5000	5500*	6000*	6500*	7000*

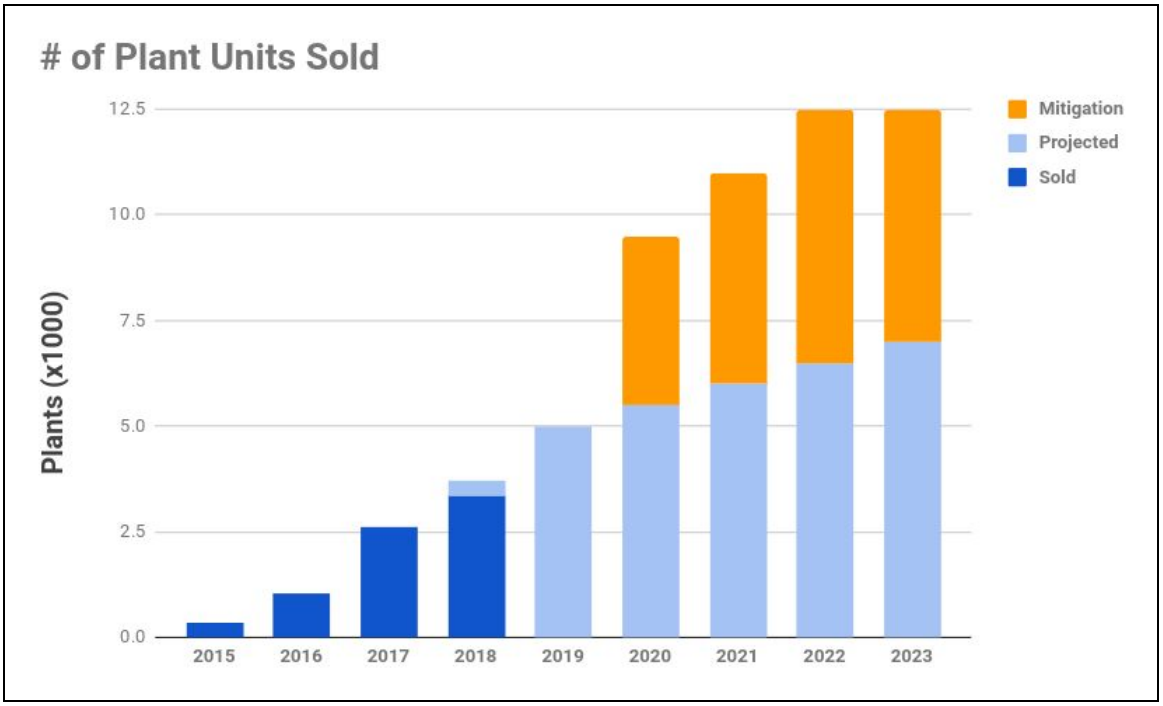
*These numbers do not include plants grown for the 520 Mitigation

520 Mitigation

Over the course of 2017 and the early months of 2018, the Washington Department of Transportation (WSDOT) installed over 60,000 plants in the Union Bay Natural Area in accordance with their requirements to mitigate the impacts of the 520 Bridge expansion. UWBG is anticipating a need for the installation of replacement plants lost due to mortality, estimated to begin in 2019 or 2020. Although there has been no official

agreement from the UWBG for the SER-UW nursery to produce these replacement plants, the nursery is perfectly poised to produce the plants needed to fulfill the mitigation requirements, and the UWBG is certainly aware of the benefit of having these plants produced by the SER-UW nursery. Replacement plant estimates, based off a need to replace 5-10% of all plants installed, have been included in Figure 1 for the years 2020 through 2023. Mortality is expected to be higher than 5-10%, but a conservative estimate is given because WSDOT planted more than was needed to achieve mitigation standards.

Figure 1: Projected number of plant units sold over the next 5 years



Advertising and Promotion

- **Student plant purchases**: The nursery has already formed partnerships with the two main courses in SEFS that complete restoration projects for course requirements (ESRM 462-4 and ESRM 473), but SER-UW managers are still responsible for contacting professors and teaching assistants prior to plant selection. Additionally, SER-UW managers should visit these classes and invite students to tour the nursery, and this will serve to reinforce the nursery's role as a resource available to students assisting them in achieving their restoration goals.
- **Public plant sales**: The nursery organizes two plant sales every year, one in late spring and another in late fall. These plant sales are a great opportunity to increase revenue and to connect with the greater Seattle community. The public has reliably been willing to support student-run projects, and the nursery is no exception. Managers and interns are responsible for marketing campaigns to get the word out months in advance of the sale date. Exit polls from past plant sales have identified Facebook as the primary method of attracting customers to the event, but SER-UW manager's should continue to explore other social media platforms for marketing opportunities. Outside of social media, the UWBG Event Calendar, email notifications, paper flyers, and signage along the CUH access roads are all good ways to increase public awareness.
- **Community restoration partners**: In order for the nursery to become a permanent and economically stable entity at the University of Washington, it is critical for the nursery to build partnerships with governments and nonprofit organizations involved in restoration work outside of the university system.

Nursery managers will be responsible for establishing these connections, determining their plant material needs, and maintaining a good standing relationship with them. This should be accomplished through tours of the SER-UW nursery and in-person interactions.

- **Volunteer events:** SER-UW sends out newsletters through its email listserv for all weekly work parties and special events. Regular class visits at the start of every quarter are another important way to attract volunteers to the nursery.
- **Service Learning**: The nursery posts these opportunities to the Carlson Center website several weeks prior to the start of the quarter.
- **Internships**: Nursery internship advertisements are sent out a month prior to the start of every new quarter.

Human Resources Plan

The SER-UW nursery team is currently lead by the nursery manager and the assistant manager, and both report to the nursery Faculty Advisor, Dr. Jon Bakker, and the Interim Director of the UW Botanic Gardens, Fred Hoyt. Traditionally, these managerial roles have come from within the ranks of the Master of Environmental Horticulture graduate students. Looking forward over the next five years, and in order to keep up with production and sales goals, the nursery manager position will inevitably need to become a full-time, non-student staff position. When this switch in the management structure happens, the nursery should offer paid student staff positions to assist the manager. Reporting to the manager and assistant manager every quarter are two to three unpaid

interns who assist in vital nursery functions. Rounding out the team every quarter are service learning volunteers and various other student volunteers.

Summary of personnel and salary:

- Management Structure Option 1
    - Nursery Manager - Graduate student ($13,790/quarter; includes salary, tution, and benefits)
    - Nursery Assistant Manager - Graduate student ($31.30/hr)
- Management Structure Option 2
    - Nursery Manager - Non-student staff ($45,000 - 60,000/yr)
    - Student Nursery Staff - Undergraduate ($15.30/hr) or graduate student ($31.30/hr)
- Non-paid student help
    - Interns, Service Learners, and Volunteers

Production Plan

Production Space

The SER-UW nursery is located at the Center for Urban Horticulture, and the UW Botanic Gardens provides this space to the nursery in exchange for volunteer hours from the greater SER-UW Student Chapter. Current space allotment is around 3,200 sq ft, which includes a hoophouse structure (~1,400 sq. ft.), an outdoor growing area (~1,600 sq. ft.), a coppice garden for vegetative production and several bulb increase beds (~200

sq. ft. combined). UWBG has agreed to allow the nursery to expand its outdoor growing space in the near future, and pending potential grant awards, this could be done as early as fall 2018. Expansions would include an increase to the outdoor container growing area and multiple rhizome production beds (~1500 sq. ft. combined). These expansions would in turn increase the number of restoration volunteer hours required to maintain good standing on the nursery's rent agreement. Other than space set aside for production, the UWBG allows the nursery staff to utilize work space in the Douglas Research Conservatory headhouse and greenhouse, as well as some of the open space surrounding the nursery. This is provided free of charge.

Equipment

The SER-UW nursery is already a fully functioning native plant nursery and most of the equipment and supplies needed for production were acquired through previous grants and in-kind donations. Current annual recurring costs are estimated at $1700, and the nursery foresees an increase in these costs as production scales up. See Appendix G for a detailed summary of expected recurring costs.

Financial Plan

Income Projections

Listed below are three tables representing income projections for an optimistic scenario (Table 2), a most likely scenario (Table 3 and Figure 2), and a pessimistic scenario (Table 4). This is a common approach when developing a business plan (5, 6), and it is included here to illustrate the range of uncertainty involved in financial projections for the SER-UW nursery. The most likely projection was used as the baseline to estimate the other two projections. It represents the expected level of growth of plant sales over the next five years, and it should be used as a benchmark to measure success. Further detailed assumptions are included after each projection.

Table 2

Optimistic Income Projection								
Revenue	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Capstone	$432	$1,094	$3,350	$6,000	$6,000	$6,000	$6,000	$6,000
NA Resto	$442	$1,868	$2,219	$2,450	$2,450	$2,450	$2,450	$2,450
Plant Sales	$2,530	$4,675	$4,500	$5,175	$5,951	$6,844	$7,871	$9,051
UWBG (UBNA & YS)	$463	$1,193	$1,000	$2,600	$1,500	$1,500	$1,500	$1,500
520 Mitigation	-	-	-	-	$16,875	$21,094	$25,313	$23,203
Other	$1,114	$812	$1,200	$1,500	$1,875	$2,344	$2,930	$3,662
Total	**$4,981**	**$9,641**	**$12,269**	**$17,725**	**$34,651**	**$40,231**	**$46,063**	**$45,866**
Expenditures								
Supplies and Equipment	-	$1,200	$1,400	$1,700	$3,500	$3,325	$3,159	$3,001
Square Fees	$119	$234	$307	$443	$866	$1,006	$1,152	$1,147
Total	**$119**	**$1,434**	**$1,707**	**$2,143**	**$4,366**	**$4,331**	**$4,310**	**$4,147**
Net Sales	**$4,861**	**$8,206**	**$10,562**	**$15,582**	**$30,285**	**$35,901**	**$41,752**	**$41,719**

Optimistic Income Projection Assumptions
Capstone: Max enrollment (75 students)
NA Resto: Max enrollment (70 students)
Plant sales: 15% growth in sales every year
UWBG: Increased need for restoration plants in UBNA and Yesler Swamp
520 Mitigation: A portion of the mitigation funding will go to replacement plants, and the nursery is perfectly poised to grow these plants. Exact amount of funding available is still uncertain. These figures represent a 10-15% replacement of mitigation plantings, with a ramping up period from 2020 to 2022, followed by a steady decrease in the need for plants thereafter.
Other: Includes UW Grounds, governments, tribes, and nonprofit organizations. 25% growth in sales every year.
Expenditures: Expenditures range from 7% - 10% of revenue, decreasing in percentage as number of units produced increases.
Square Fees: A fee charged by Square to process all credit card transactions.

Table 3

Most Likely Income Projection								
Revenue	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Capstone	$432	$1,094	$3,350	$4,500	$4,500	$4,500	$4,500	$4,500
NA Resto	$442	$1,868	$2,219	$2,100	$2,100	$2,100	$2,100	$2,100
Plant Sales	$2,530	$4,675	$4,000	$4,400	$4,840	$5,324	$5,856	$6,442
UWBG (UBNA & YS)	$463	$1,193	$500	$2,100	$1,000	$1,000	$1,000	$1,000
520 Mitigation	-	-	-	-	$13,500	$16,875	$20,250	$18,563
Other	$1,114	$812	$1,000	$1,200	$1,440	$1,728	$2,074	$2,488
Total	**$4,981**	**$9,641**	**$11,068**	**$14,300**	**$27,380**	**$31,527**	**$35,780**	**$35,093**
Expenditures								
Supplies and Equipment	-	$1,200	$1,400	$1,600	$2,500	$2,375	$2,256	$2,143
Square Fees	$119	$234	$277	$358	$685	$788	$895	$877
Total	**$119**	**$1,434**	**$1,677**	**$1,958**	**$3,185**	**$3,163**	**$3,151**	**$3,021**
Net Sales	**$4,861**	**$8,206**	**$9,391**	**$12,343**	**$24,196**	**$28,364**	**$32,629**	**$32,072**

Most Likely Income Statement Assumptions
Capstone: Average enrollment (60 students)
NA Resto: Average enrollment (60 students)
Plant sales: 10% growth in sales every year
UWBG: Average need for restoration plants in UBNA and Yesler Swamp
520 Mitigation: A portion of the mitigation funding will go to replacement plants, and the nursery is perfectly poised to grow these plants. Exact amount of funding available is still uncertain. These figures represent a 5-10% replacement of mitigation plantings, with a ramping up period from 2020 to 2022, followed by a steady decrease in the need for plants thereafter.
Other: Includes UW Grounds, governments, tribes, and nonprofit organizations. 20% growth in sales every year.
Expenditures: Expenditures range from 7% - 10% of revenue, decreasing in percentage as number of units produced increases.
Square Fees: A fee charged by Square to process all credit card transactions.

Figure 2: Plant sale revenue based on the “most likely” income projection

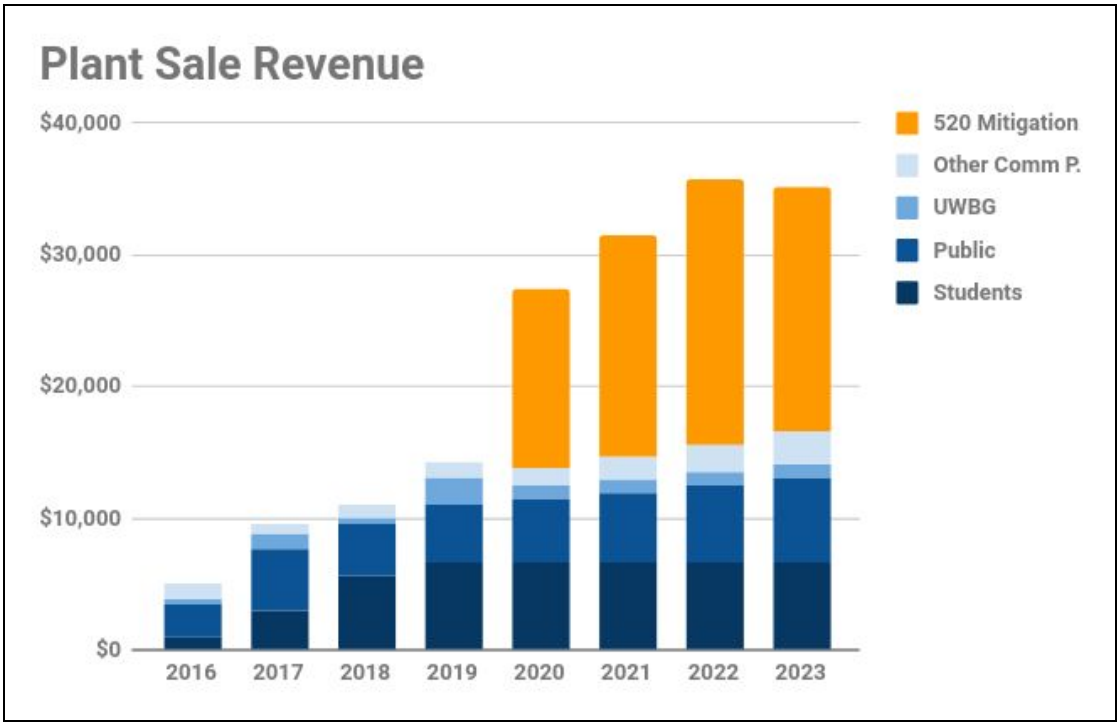


Table 4

Pessimistic Income Projection								
Revenue	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Capstone	$432	$1,094	$3,350	$3,000	$3,000	$3,000	$3,000	$3,000
NA Resto	$442	$1,868	$2,219	$1,575	$1,575	$1,575	$1,575	$1,575
Plant Sales	$2,530	$4,675	$3,500	$3,675	$3,859	$4,052	$4,254	$4,467
UWBG (UBNA & YS)	$463	$1,193	$250	$1,850	$500	$500	$500	$500
520 Mitigation	-	-	-	-	$10,800	$13,500	$16,200	$14,850
Other	$1,114	$812	$1,000	$1,150	$1,323	$1,521	$1,749	$2,011
Total	**$4,981**	**$9,641**	**$10,319**	**$11,250**	**$21,056**	**$24,148**	**$27,278**	**$26,403**
Expenditures								
Supplies and Equipment	-	$1,200	$1,400	$1,400	$1,700	$1,615	$1,534	$1,458
Square Fees	$119	$234	$258	$281	$526	$604	$682	$660
Total	**$119**	**$1,434**	**$1,658**	**$1,681**	**$2,226**	**$2,219**	**$2,216**	**$2,118**
Net Sales	**$4,861**	**$8,206**	**$8,661**	**$9,569**	**$18,830**	**$21,929**	**$25,062**	**$24,286**

Pessimistic Income Statement Assumptions
Capstone: Low enrollment (45 students)
NA Resto: Low enrollment (45 students)
Plant sales: 5% growth in sales every year
UWBG: Low need for restoration plants in UBNA and Yesler Swamp
520 Mitigation: A portion of the mitigation funding will go to replacement plants, and the nursery is perfectly poised to grow these plants. Exact amount of funding available is still uncertain. These figures represent a 3-7% replacement of mitigation plantings, with a ramping up period from 2020 to 2022, followed by a steady decrease in the need for plants thereafter.
Other: Includes UW Grounds, governments, tribes, and nonprofit organizations. 15% growth in sales every year.
Expenditures: Expenditures range from 7% - 10% of revenue, decreasing in percentage as number of units produced increases.
Square Fees: A fee charged by Square to process all credit card transactions.

In-Kind Value

Table 5: In-Kind value of goods and services donated to the nursery

In-Kind	2016	2017	2018	2019	2020	2021	2022	2023
Rent (etc.)	$10,800	$13,680	$16,560	$18,216	$20,038	$20,038	$20,038	$20,038
Volunteer Labor	-	$26,720	$26,720	$28,056	$29,459	$30,932	$32,478	$34,102
Intern Labor	-	$21,643	$19,238	$19,238	$21,643	$21,643	$24,048	$24,048
Total	**$10,800**	**$62,043**	**$62,518**	**$65,510**	**$71,140**	**$72,613**	**$76,564**	**$78,188**

In-Kind Value Assumptions
Rent: The SER-UW Nursery is anticipating an expansion of production space in 2019 & 2020.
Volunteer Labor: The value of a volunteer is determined by the United Way of King County, https://www.uwkc.org/volunteering/volunteers-rock-our-world/, and these figures assume a 5% increase in volunteer hours every year.
Intern Labor: The value of an intern is valued using the same United Way of King County figure, and as production scales up in the nursery there will be an increased need to offer more internship positions. These are reflected in increases in internships for 2020, 2021, & 2022.

Position Salaries

Since the nursery management structure may be in flux over the next five years, Table 6 is provided to represent the different costs of potential student and staff positions. These are recurring expenses, and they have not been included in any of the financial projection scenarios.

Table 6: Management salary options

Position Title	Hourly Pay	Hours	Salary Cost	Benefit %	Benefit Cost	Tuition	Total Cost	Notes
Nursery Manager (non-student)	N/A	100% FTE	$45,000 - $60,000	30.5%	$13,725 - $18,300	N/A	**$58,725 - $78,300**	*Salary comparable to UW Farm Manager*
Graduate Student RA	N/A	50% FTE	$21,687	18.4%	$3,801	$15,882	**$41,370**	***Cost per Academic Year***
Graduate Student Summer	$31.30	200	$6,260	20.7%	$1,296	N/A	**$7,556**	*20 hrs / week for **summer quarter***
Student Staff	$18.38	100	$1,838	18.4%	$338	N/A	**$2,176**	*10 hrs/ week / **quarter***

Appendix

Appendix A - Examples and Resources

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2. Allen, Derek. “SER-UW SWOT Analysis - Strengths, Weaknesses, Opportunities, and Threats.” University of Washington. 2018.

3. “A Sample Plant Nursery Business Plan Template.” *Profitable Venture*. https://www.profitableventure.com/plant-nursery-business-plan/

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5. Davidson, P. “Preparing a Business Plan, A Guide for Agricultural Producers – Wholesale Nursery Example.” BC Nursery Trades Association and the BC Ministry of Agriculture, Fisheries and Food. 1996.

6. “Nursery Business Plan - Executive Summary, Management, and Ownership.” *Reference for Business*. Business Plans Vol. 7. http://www.referenceforbusiness.com/business-plans/Business-Plans-Volume-07/Nursery.html

7. “Starting a Nursery Business in BC, 2nd Edition.” Ministry of Agriculture and Lands. 2006. https://bclna.com/wp-content/uploads/2015/01/new_grower_links.pdf

8. Sellmer, James C. and Dana, Michael N. “Starting in the Nursery Business.” Purdue University Cooperative Extension Service. West Lafayette, IN. https://www.extension.purdue.edu/extmedia/HO/HO-212.pdf

9. “The University of Washington Botanic Gardens Strategic Business Plan.” University of Washington Botanic Gardens. 2012.

Appendix B - The Need to Develop a Marketing Plan

The SER-UW nursery has a strong need to develop a marketing plan in order to achieve its marketing strategy, and this should be done as soon as possible. In it should include a plan for connecting with new and existing customers, connecting with potential donors, attracting student volunteers and interns, and using social media. The nursery team should seek assistance within UWBG, the Communications Department, and the Foster School of Business.

Appendix C - UW Green Dawgs RSO GOLD

According to their website, “The **Green Dawgs Program** at the University of Washington encourages RSO’s to help make their meetings, events, and member practices more sustainable. Green Dawgs Certification recognizes student groups who implement sustainable practices.” The SER-UW nursery was awarded GOLD certification in the winter of 2018. More information can be found here - https://green.uw.edu/green-dawgs.

Appendix D - The Need to Create a UW Revenue Budget

As of the writing of this document, the nursery’s finances are housed in an off-campus bank account, thus it is extremely important for the nursery to work with the SEFS and UWBG administration in setting up a UW revenue budget. This will make plant purchasing through other UW accounts more efficient, and it will allow the nursery to pay salaries and wages of staff. A revenue budget will also offer more financial oversight of nursery assets, better protecting the nursery against potential fraud.

Appendix E - The Need to Develop a Communications Plan

The SER-UW nursery is in need of a communications plan in order to better convey its achievements to the administration, students, and potential donors. Included in the communications plan should be a framework for creating and distributing annual reports.

Appendix F - The Need to Develop an Operations Plan

Until the nursery hires a full-time manager, it will continue to suffer from frequent losses of institutional knowledge due to high management turnover. The development of an operations plan will help to insulate the nursery from this loss of knowledge. Included in the operations plan should be a detailed description of all administrative duties.

Appendix G - Recurring Expenses

Repurchase Rate	Item Description	Unit	Quantity	Price	Extended Price (+10% Tax)
1 year	Clorox Concentrated Bleach	64oz (x2)	2	$15.45	$33.99
1 year	Fine Bark Mulch	Cubic Yard	6	$49.00	$323.40
1 year	Fish and Guano Liquid Fertilizer	Gallon	1	$25.00	$27.50
1 year	GrowCo (Seattle Loop Compost)	.25 cubic yard	1	Donation	$0.00
1 year	Horticultural Oil	Quart	1	$13.00	$14.30
1 year	Irrigation Supplies	Assorted	1	$50.00	$55.00
1 year	Latex Gloves (M & L)	Box of 100	2	$10.50	$23.10
1 year	Office Supplies	-	1	$20.00	$20.00
1 year	Osmocote 13-10-13	50# bag	1	$70.00	$77.00
1 year	Peat, Compressed	3.8 cubic feet	4	$18.00	$79.20
1 year	Pot Label 5" (color)	Box of 1000	1	$18.95	$20.85
1 year	Printing	-	1	$30.00	$30.00
1 year	Rubbing Alcohol	1 gallon	1	$29.00	$31.90
1 year	Safer Insecticidal Soap	1 gallon	1	$70.00	$77.00
1 year	Seeds	Assorted	1	$150.00	$165.00
1 year	Snacks for Work Parties	Assorted	30	$12.00	$396.00
2 years	Coarse Sand	0.5 cubic feet	1	$5.00	$2.75
2 years	Gloves (S, M, & L)	Pack of 12	3	$3.95	$6.52
2 years	Hose - 50'x 3/4"	-	1	$40.00	$22.00
2 years	Pruner - Long Nose	-	3	$12.95	$21.37
2 years	Pruner - Standard	-	3	$23.95	$39.52
2 years	Shut-Off, Brass Wye	-	1	$5.50	$3.03
2 years	Watering Breaker - Aluminum	-	1	$12.95	$7.12
2 years	Watering Wand - 36"	-	1	$8.50	$4.68
3 years	China Marker	-	10	$1.25	$4.58
3 years	Mesh Cloth	-	1	$10.00	$3.67
5 years	Bamboo Stakes 36" (green dyed)	Bundle of 500	1	$35.00	$7.70
5 years	Pump Sprayer	1 gallon	1	$42.00	$9.24
5 years	Wheelbarrow	-	1	$65.00	$14.30
6 years	Cone-tainer Pots	Case of 1100	1	$88.00	$16.13
6 years	Polyethylene Film	-	1	$481.50	$88.28
6 years	Shade Cloth	-	1	$336.00	$61.60
Total Annual Supply and Equipment Expenditures					**$1,686.71**

University of Washington's Society for Ecological Restoration Native Plant Nursery

Plant Production Manual

Prepared by: Derek Allen
Last updated: June 7th, 2018

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List of Acronyms

BIOL: Biology (degree and departmental listing)

CEP: Community, Environment, and Planning (degree listing)

COMM: Communications (degree and departmental listing)

CSF: Campus Sustainability Fund

CUH: Center for Urban Horticulture

DRC: Douglas Research Conservatory

EDUC: Education (degree and departmental listing)

ESRM: Environmental Science and Resource Management (degree and departmental listing)

MEH: Master of Environmental Horticulture

Oxbow: Oxbow Farm and Conservation Center

PoE: Program on the Environment (degree and departmental listing)

REN: Restoration Ecology Network

SEFS: School of Environmental and Forest Sciences

SER-UW: Society for Ecological Restoration - UW Student Guild

TA: Teacher's Assistant

UW: University of Washington

UWBG: University of Washington Botanic Gardens

Introduction

After developing the business plan for the SER-UW nursery, I felt it was necessary to put together a “how to” guide for running the day to day production operations of the nursery. My reasoning for creating this “how-to” production manual is based on the the assumption that incoming student managers will most likely not have a background in nursery management, so this is meant to provide them with a framework to get started with what has been proven to work for the SER-UW nursery. Much of my inspiration for this manual came from a similarly designed manual for the Sustainability in Prisons project, as well as reading through the native plant nursery literature and my own observations over the past 2 years. I took what information I could from the literature and distilled it down into what was I feel is truly applicable in the SER-UW nursery setting. My hope is that future managers can use this manual to achieve the goals I have laid out in the business plan. It must be said though, there is a wealth of information I was unable to fit into this document. It hits the main priorities of day to day production operations for the SER-UW nursery, but I view this as an ever evolving document. Future nursery managers are strongly encouraged to adapt this production manual as they improve on the procedures and protocols outlined within.

Species Selection

Determining which species to grow and in what sizes to grow them in is one of the most difficult challenges for any production nursery. Some nurseries operate mainly as contract growers. This alleviates many of the unknowns associated with plant sales because it allows them to concentrate most of their efforts on plants that have a guaranteed buyer. Unfortunately, the SER-UW nursery has not been able to adopt this model yet. In the three years the nursery has been fully operational, sales have come mainly from two sources, student restoration projects and public plant sales.

Concerning the former, students do not have the knowledge nor the capability to submit plant orders a year in advance, so the best the nursery can do is compare sales trends from prior years and anticipate their needs. The partnerships we have built with the REN Capstone and the Restoration of North America (ESRM 473) courses encourage and incentivize students to purchase from us first. This does allow the nursery some freedom in choosing what to grow, but it should never be viewed as guarantee. As for the latter, when the nursery sells to the public it operates very much at the whim of the retail marketplace, and what sells well for restoration may not be of any interest for the individual buyer at a public plant sale. The word “restoration” is in the name of the nursery though, and this is its primary mission. Public plant sales then should be viewed as a secondary source of income for the nursery. What this means for species selection is that the nursery should never dedicate valuable space in order to cater solely to the retail market. Luckily for the SER-UW nursery, there is considerable overlap in the species needs of both markets, and where there is overlap in the markets is where the nursery should focus a considerable amount of its efforts (see Appendix A for list of species and actions for future managers).

Again, this should not be viewed as a guarantee of sales. Nursery managers still need to think critically about which species to grow. Knee-jerk reactions are not possible for most species grown in a native plant nursery due to the time and resources invested in growing them. Therefore, it is extremely important for the nursery managers to maintain good sales records from year to year. This will help inform species selection and allow the nursery to continue to adapt as the needs of the market shifts.

It should be noted though, succeeding in both the student and retail markets will not be enough to sustain the SER-UW nursery financially. Thus, it is important for the nursery to continue to seek out other customers, and preference should be for those that are in the contract growing market. As of spring of 2018, the nursery secured its first contract grow, and it is now in the process of producing a suite of plants to be installed in Yesler Swamp. Other opportunities, like the 520 mitigation work taking place in UBNA, should be actively pursued by the nursery as it already has experience successfully producing most of the species needed for this restoration site. More details can be found in Appendix A.

Production

Sourcing

Provenance and Genetic Diversity

Native plant nurseries focusing on restoration have a responsibility to source material that represents the genetic diversity of a population, and thus it is important for the SER-UW nursery team to acquire materials from the surrounding ecoregion. It is also important for the nursery to track and maintain this diversity throughout the production process (Carragee, 2016). Listed below are the ways in which the nursery acquires its genetic material, as well as the procedure for recording and tracking the provenance of native plant material.

Seed Collection

The nursery does not currently have a well-developed strategy for wild collecting its own seeds, and this would certainly be a worthwhile project for a future manager or an intern. Small batches of seeds have been collected by nursery staff in the past, and details about these seed lots are listed within the Provenance Database. Whenever wild collecting seeds, make sure to record the species, date collected, location, and elevation. For a detailed summary of collection guidelines designed to preserve genetic diversity see chapter 7 of the Nursery Manual for Native Plants by Dumroese et al.

Action:

- Connect with Oxbow in the late summer or early autumn and see if there are opportunities to harvest seeds from around their property in the Snoqualmie Valley. They have been very supportive of this activity in the past, and it is a useful way of boosting seed stock, as well as a way of providing an educational opportunity for interns and volunteers.

Seed Purchasing

Until the nursery develops its own wild collected sourcing strategy, many seeds will need to be purchased through external vendors. They have the ability to collect species the nursery may not have access to, and they can collect in quantities needed to meet production goals. Inside Passage Seeds has been the nursery's goto vendor for most seed purchases over the past few

years, and they carry a majority of the species the SER-UW nursery will ever need to grow. According to their website, they harvest seeds in the "Salish Sea Bioregion and coastal areas north and south," including the "Duwamish, Snohomish, Stillaguamish, Samish, Skokomish, and Skykomish" river valleys. Much of their collection range falls within the Puget Lowland Ecoregion (Levy-Boyd and Haard, 2013), although there is some concern about genetic incompatibility that may occur due to differences in micro-environments.

Action:

- Begin preparing seed orders in early fall (or sooner), and plan to submit the order by early-mid October. Some species may not be available due to collection timing and abundance, but it is important to reserve seeds as soon as possible.

Cutting Collection

Cuttings are occasionally donated by the UW Grounds team, the UWBG staff, or collected by nursery managers, and they are a great way to supplement the nursery's stock grown from seed or for collecting material to be used as live stakes. When collecting cuttings, or receiving cuttings from UW Grounds, nursery managers are responsible for ensuring the stock comes from as many different individuals as possible, as well as from individuals located distant from each other spatially. The guidelines for collecting seeds listed in chapter 7 of the Nursery Manual for Native Plants are also relevant for cutting collection. Useful locations for collections of material include UBNA, Yesler Swamp, and the SER-UW Native Coppice Garden (Liu, 2017).

Bareroot and Salvage

Plants may occasionally be purchased as bareroot stock from other vendors or salvaged from future development sites. Purchasing bareroot plants is a cost effective way to increase stock numbers of high demand species or species difficult to grow from seed. Potential vendors to consider for bareroot stock include Fourth Corner Nursery up north in Bellingham and the King Conservation District Bareroot Plant Sale. Salvage opportunities are sporadic, but they should be taken advantage of as often as possible. Salvage events are currently the only significant way for the nursery to obtain fern species, which include some of our most popular plants for use in both restoration and public gardens. Salvage events can also be useful for obtaining many herbaceous plants and some woody plants. Now that the King Conservation District Plant Salvage Program has been defunded, organized salvage events are difficult to find. There is a

potential salvage program design in the works by a current MEH student, Elby Jones, slated to be finished by the end of 2018, so future manager should refer to that project for more information.

Provenance Record Keeping

All plant material produced in the nursery should be tracked at the database level and at the individual plant level. In order to save space on individual plant tags, the nursery has developed a coding system that corresponds with a particular entry or provenance listed on the relevant database, and those codes are discussed in detail below. Trays or flats can be labeled as a unit, but individual pots (typically ½ gallon or larger) should be labeled individually.

Provenance Database:

This was formerly known as the Seed Inventory Database, and it was an internship project designed by Will Braks in the fall of 2017. Its original design was to track all plant material grown from seed, but it has since expanded to include provenance tracking for vegetatively propagated plants, bareroot plants, and plants acquired through salvage. It is a living document, and it should be updated regularly when new seeds are acquired, when a seed lot has been used up, when plants are vegetatively propagated, when plants are purchased The following is information relevant to this database:

- Labelling code for plant tags (ex. ANMA001):
    - Species CODE - 4 (or 6) digit code representing the first 2 (3) letters of the genus and the first 2 (3) letters of the species (ex. *Anaphalis margaritacea* - ANMA).
        - 6 digit codes should be used in place of 4 when multiple species would have the same code (ex. *Camas leichtlinii, Carex lenticularis, and Carex leptopoda*)
    - Lot number:
        - For seeds - the three digit number following the CODE that corresponds to a specific seed lot (ex. 001).
        - For cuttings use "-CUT##" (ex. ANMA-CUT01)
        - For divisions use "-DIV##" (ex. ANMA-DIV01)
        - For bareroot use "-BR##" (ex. ANMA-BR01)
        - For salvage use "-SLV##" (ex. ANMA-SLV01)
- Database entries:

- Botanical Name
- Common Name
- CODE
- Lot number
- Provenance
- Source - what entity the material was acquired from (ex. UW Grounds, Jon Bakker, etc.)
- Date collected/purchased
- Expected seed longevity (seed database only)
- Has it been processed? (seed database only)
- Other information - seed weight, seeds per ounce, and approximate seeds per ounce (due to time constraints, this information can be difficult to keep up-to-date.

Seed Treatment

Seed Processing

Seed should be processed prior to long-term storage or sowing. This process typically involves cleaning the seed and removing any fleshy or dry non-seed plant material. Failure to to clean seeds properly can result in inhibited or uneven germination, as well as unfavorable storage conditions (Dumroese et al., 2008). Most seeds purchased through outside vendors will already be processed, but the nursery may occasionally need to process seeds that were purchased externally or that were wild collected. For more information on seed processing techniques, refer to chapter 7 of the Nursery Manual for Native Plants.

Storage

Improper storage of seeds can lead to reduced viability and vigor, so the nursery has developed its own protocol in order to keep its seed stock healthy and viable for as long as possible. Furthermore, the storage conditions listed below are consistent with the methods of our partner nursery, Oxbow, as well as those listed in the literature (Dumroese et al., 2008).

Materials needed:

- Ziploc bags

- Coin envelopes
- Tape for sealing seed envelopes
- Silica gel desiccants

Procedure:
The nursery stores all of its seeds in the walk-in cooler in the DRC, where the temperature is kept between 2 and 5℃. Seeds from each species are stored in individual coin envelopes, and each envelope is labeled so it can easily be identified by its seed lot code. Individual envelopes are arranged alphabetically within large zip-lock bags. The walk-in cooler is not humidity controlled, so each zip-lock bag contains one or two reusable silica gel desiccants to keep the seeds from molding or imbibing water vapor. Large seeds of species that have been stored for long periods of time should be allowed to rehydrate slowly, and failure to do this can result in the loss of those seeds when imbibed. This can be accomplished by moving them to a sealed plastic tub containing a moist paper towel not in contact with the seeds, and this will allow the seeds to slowly absorb water vapor (Dumroese et al., 2008).

Action:
- Connect with the manager of Rare Care, currently Wendy Gibble, to determine the potential for storing seeds in the Seed Vault.

Seed Cleansing and Seed Imbibing

Seeds should be cleansed of bacterial and fungal pathogens prior to sowing, and this is especially true for seeds that are prone to molding. One of the simplest and most effective ways of of cleansing seeds is by soaking and bubbling them in a container of water (Dumroese et al., 2008). This is also the same method the nursery uses to imbibe seeds prior to sowing or stratification, so this is typically done for all species the nursery grows. Some seeds may require a pretreatment of bleach prior to imbibing. These procedures are listed below.

Materials and equipment needed:
- Mesh
- Gauge wire for sealing mesh into pouches
- Labels
- Air pump

- Container for bubbling seeds
- Bleach (only for certain species)

Procedure:
Place individual species in the center of the mesh and use the gauge wire to seal it into a pouch, making sure to allow space for the seeds to move around freely within the pouch (Fig. 1). DO NOT use paper twisty ties, as they are extremely prone to molding. Create a label for each individual pouch, making note of species CODE, date imbibed, as well as any stratification/scarification relevant information (see below). Place mesh pouch in a container full of water and aerate the water with a air pump. Seeds should be left to bubble for 24 to 48 hours, and if possible, the water should be changed every 4-8 hours. For *bleaching of seeds* - make a 10% bleach solution and soak seeds for 5-10 minutes. Rinse seeds off and then follow imbibing procedure.

Stratification

If a seed has an internal dormancy (physiological, morphological, or both) it will need to be stratified at a particular temperature for a period of time, and some seeds may require multiple stratification techniques (Dunroese et al., 2008). Seeds can be naturally or artificially stratified, but the nursery primarily uses artificial stratification to overcome dormancy. The two types of artificial stratification techniques the nursery uses are 1) *cold-moist strat* and 2) *warm-moist strat*. *Cold-moist* strat is done at temperature between 1 and 3°C, and *warm-moist strat* is done at temperatures between 22 and 30°C. Both methods require moist conditions, but care must be made to keep the seeds from becoming overly saturated, as this can create conditions ideal for mold. Stratification should be done after seeds have been cleansed and imbibed.

Materials and equipment needed:

- Peat, loose
- Stratification container (Fig. 2)
- Imbibed seeds in mesh pouches
- Labels

Procedure:

After seeds have been cleansed and imbibed, any seeds that need stratification should then be placed in a stratification container in their respective location. For *cold-moist strat* that is the walk-in cooler in the DRC. For *warm-moist strat* that is the greenhouse (whichever greenhouse SER-UW has their bench reserved). All seeds going into stratification should be labeled with the following: species CODE, seed lot number, date placed in stratification, number of stratification days required, and estimated day seeds should be removed from stratification. A recording of the above information should also be made in the stratification log.

To create a stratification container take a plastic or metal, open-topped box and fill it with 4-8" of loose peat. Dampen the peat until it is wet to the touch, but not dripping water (like a wrung out sponge). Seeds should remain in mesh pouches and placed into the stratification container so that all seeds are buried. The peat should not be allowed to dry out as this may cause the seeds to lose viability. The stratification container should be checked bi-weekly for any signs of mold or seeds germinating in stratification, and this is absolutely crucial to the health the seeds. Seeds that are showing mold should be removed immediately and treated with running or bubbling water for 5-10-min. Seeds with thicker seed coats can be treated with a bleach solution (same rate as above), but this should be avoided for seeds with thin seed coats. If mold continues to be an issue for several weeks in a row, compost the old peat, sanitize the container, and fill with fresh peat. Any seeds that begin to germinate in stratification should be removed as soon as possible and sown into containers (see sowing procedure below). While checking the stratification container, it is recommended to remove all the seeds so the peat can be mixed around. This will help to aerate the media, thus limiting the potential for mold development.

Fig. 1 - Seeds in mesh bag

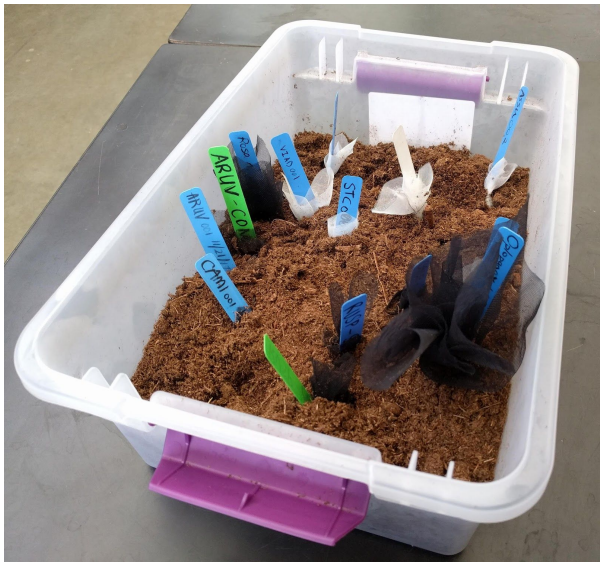

Fig. 2 - Stratification container

Alternative Procedure for tiny seeds:
If the seeds needing to be stratified are too tiny to be placed in mesh, they can instead be put in a ziplock bag with damp (not soaking) peat and placed in stratification. This is especially useful for some carex, juncus, and select herbaceous species.

Action:

- Seeds can be naturally stratified outside or in the hoophouse over winter if space allows for it, and one reason this may be useful is if the seed has a high propensity for molding. Natural stratification has not been explored much at the SER-UW nursery, so managers should connect with other local nurseries or examine the literature to determine if or when to naturally stratify seeds.

Scarification

If a seed has an external dormancy (physical) it will need to undergo a scarification procedure prior to imbibing. The techniques for scarifying seeds vary depending on the species and seed coat thickness (Dumroese et al., 2008), but because the nursery works with an ever growing list of species, it is beyond the scope of this manual to list out all the techniques. Some common techniques from the literature are listed below, and one should refer to chapter 8 of the Nursery Manual for Native Plants for more information on seed scarification.

- Mechanical - filing or nicking the seed with a knife, file, or sandpaper.
    - Note: the nursery has experienced good results using a seed tumbler - a device that uses compressed air to tumble seeds in a chamber lined with sandpaper. This can be an efficient way to scarify a larger seed lot, but further research and testing is needed on an individual species basis.
- Temperature - use of dry or wet heat. Often used for fire-adapted species.
- Chemical - use of acids (e.g. sulfuric or citric acid).
    - Note: the use of sulfuric acid is not recommended for use in the SER-UW nursery due to its dangerous handling and procedural requirements. Instead it is recommended to use a milder chemical like citric acid or to forgo chemical treatment altogether.

Smoke Water

Smoke water treatments have been shown to break dormancy and stimulate germination in many fire-adapted species (Dumroese et al., 2008). The nursery does not currently work with many species known to need smoke treatments, but its benefits should be considered for future use. For more information on smoke water treatments, refer to chapter 7 of the Nursery Manual for Native Plants, the Conservation Nursery Manual written for the Sustainability in Prisons Project, or Broadlick, 2016.

Soil Media Mixes

Overview

A proper growing medium is a crucial component of container nursery plant production, and though there are many variations in growing media, all should be able to perform four basic functions: 1) physically support of the plant, 2) allow for oxygen and gas exchange for root respiration, 3) hold water, and 4) store nutrients (Dumroese et al., 2008). The SER-UW nursery uses three main media mixes - *Germination, All Purpose, and Cutting Mix* - all of which are listed in further detail below. These mixes are meant to represent base versions of what mix to use when germinating, transplanting, or rooting cuttings from the average nursery plant, but certain species may require variations in these base mixes. Nursery managers should consider adjusting a mix for an individual species as needed.

Germination Mix

The nursery's *germination mix* is made with a combination of peat and fine bark mulch. Peat has high water retention (prevents seeds and seedlings from drying out) and high nutrient storage capabilities (useful for establishing seedlings). The fine bark mulch promotes aeration, and it allows the nursery to reduce its reliance on peat without compromising production quality. This mix should be used to germinate seeds and to establish seedlings prior to transplanting to larger containers. This is a very similar mix to what our partner nursery uses for seedlings in their native plant nursery (Oxbow, 2018). For increased drainage and aeration managers should consider adding pumice to this mix.

Materials and equipment needed:

- Soil mixer - 3.5 cu. ft. 2/3 HP Contractor Cement and Concrete Mixer
- Earmuffs
- Dust Mask
- Fine bark mulch - Fir/Hemlock bark, 1.5" minus particle size
- Compressed peat
- Dolomitic Lime (optional)
- Pumice (optional)
- 5-gallon bucket

Procedure:

- Using a 5- gallon bucket, add equal parts fine bark mulch and peat into the soil mixer.
    - Note: You may need to break up large chunks of both types of media prior to adding them in the mixer in order for them to blend evenly.
- Add 2 to 4 quarts of water to the the mixer per 10 gallons of media added. This will help to wet the peat and cut down on dust particles.
- If adding in dolomitic lime, mix in at a rate of 1-2 tablespoons per gallon of media added. If using pelletized lime, let it sit and dissolve in water for 10 minutes prior to adding it to the mixer.
- If adding in pumice, add to the mixer at a rate of 10-15% of the total volume of peat and mulch added.
- Run the soil mixer for 5 to 10 minutes, or until media is consistently mixed.
- Thoroughly clean out soil mixer after use.

- Make sure to record all ingredients added to the mix if storing media.

Future research:

- Further testing needs to be done on the efficacy of adding pumice to the germination mix, and these tests should examine effects of mixing ratio and particle size on individual species.
- Further testing needs to be done on the efficacy of adding dolomitic lime to the germination mix. The pH of the media should be measured against a control and across a range of rates in order to achieve an ideal pH 5.5 - 6.5.
- The nursery should examine the benefits of adding a slow release fertilizer or micronutrient to the media mixing process.
- The nursery should examine the benefits of adding a mycorrhizal inoculum to the media mix.

All Purpose Mix

The nursery's *all purpose mix* is made with mainly fine bark mulch with a little bit of GROCO™ added in to raise pH and increase nutrient and water retention. This mix is used to establish plants in larger containers and to prepare them for outplanting in the field. Seedlings and cuttings ready to be transplanted, salvaged plants, and bareroot plants should all be grown in this mix.

Materials and equipment needed:

- Soil mixer - 3.5 cu. ft. 2/3 HP Contractor Cement and Concrete Mixer
- Earmuffs
- Dust Mask
- Fine bark mulch - Fir/Hemlock bark, 1.5" minus particle size
- GROCO™ soil conditioner
- Osmocote - 13-10-13
- Dolomitic Lime (optional)
- Pumice (optional)
- 5-gallon bucket
- 1-gallon/4000 ml container

Procedure:

- Using a 5- gallon bucket, add fine bark mulch and GROCO™ soil conditioner into the soil mixer at a ratio of 9:1.
    - Note: You may need to break up large chunks of both types of media prior to adding them in the mixer in order for them to blend evenly.
- If the mulch has dried out, add 2 to 4 quarts of water to the the mixer per 10 gallons of media added. This will help to rewet the mulch and cut down on dust particles.
- Add Osmocote 13-10-13 at a rate of 10 grams per gallon.
- If adding in dolomitic lime, mix in at a rate of 1-2 tablespoons per gallon of media added. If using pelletized lime, let it sit and dissolve in water for 10 minutes prior to adding it to the mixer.
- If adding in pumice, add to the mixer at a rate of 10-15% of the total volume of peat and mulch added.
- Run the soil mixer for 5 to 10 minutes, or until media is consistently mixed.
- Thoroughly clean out soil mixer after use.
- Make sure to record all ingredients added to the mix if storing media.

Action:

- Only add pumice to the all purpose mix when a particular species requires increased drainage AND if it has a low water use. Most species will not need this.

Future research:

- Further testing needs to be done on the efficacy of adding dolomitic lime to the all purpose mix.
- The nursery should continue to test and explore organic alternatives to Osmocote controlled-release fertilizer.

Cutting Mix

The nursery's *cutting mix* is made with equal parts fine bark mulch, peat, and perlite. It is designed to be very porous so as to not remain waterlogged when placed into the propagation mist bench, and it should be used to vegetatively propagate cuttings.

Materials and equipment needed:

- Soil mixer - 3.5 cu. ft. 2/3 HP Contractor Cement and Concrete Mixer

- Earmuffs
- Dust Mask
- Fine bark mulch - Fir/Hemlock bark, 1.5” minus particle size
- Compressed peat
- Perlite
- 1-gallon/4000 ml container

Procedure:

- Using a measuring container, add fine bark mulch, peat, and perlite to the mixer at a ratio of 1:1:1.
    - Note: You may need to break up large chunks of the mulch and peat prior to adding it in the mixer in order for itto blend evenly.
- Add 1 to 2 quarts of water to the the mixer per 5 gallons of media added. This will help to wet the peat and cut down on dust particles.
- Run the soil mixer for 5 to 10 minutes, or until media is consistently mixed.
- Thoroughly clean out soil mixer after use.

Sowing Seeds

Sowing in the nursery setting refers to the act of planting seeds in media to trigger the germination process (Dumroese et al., 2008). More information on demonstrating seed sowing to volunteers can be found in Greene, 2017.

Materials and equipment needed:

- *Germination mix*
- Seeds to be sown
- Cone-tainers (with holding tray) or nursery flats - sterilized or new
- Labels and grease pencils
- Tweezers, seed holders, and lab spatulas as needed

Procedure:

- Remove all seeds to be planted that day from stratification or from the imbibe process.
    - If seeds are saturated and difficult to tease apart, spread them on a coarse paper towel to allow them to partially dry out.

    - IMPORTANT - Do not allow seeds to completely dry out as they wait to be sown as this can significantly impact their viability.
- If sowing in individual cone-tainers (1 above) (Fig. 3)..
    - Fill cone-tainers with damp (but not soaking) germination mix. Occasionally tap the cone-tainer on the table to settle the media and remove large air pockets. Leave about ¼" - ½" of the cell unfilled.
    - Number of seeds sown per cell is determined by the expected germination rate. For example, 100%=1-2 seeds; >50%=2-3 seeds; <50%=3-4 seeds, etc.
    - Be consistent with the number of seeds sown per cell, so germination can be easily tracked.
- If sowing in a nursery flat (2 above) (Fig. 4)..
    - Fill flat with damp (but not soaking) germination mix, and spread seeds evenly across surface of the media.
- Lightly cover seed with media (if necessary). General rule of thumb is to plant seeds twice as deep as seed is wide (Elliot et al., 2014), but some seeds require light for consistent germination (examples Carex and Juncus species). This information is beyond the scope of this project, so managers should refer to the literature for individual species preferences.
- Label tray with a plant tag that identifies seed lot and sow date
- Carefully saturate container with water.
- Record species sown, date sown, and seeds sown per cell into the seed sowing database (or an estimated number of seeds if sowing in nursery flat).

Fig. 3 - *Tiarella trifoliata* sown 1 seed per cell

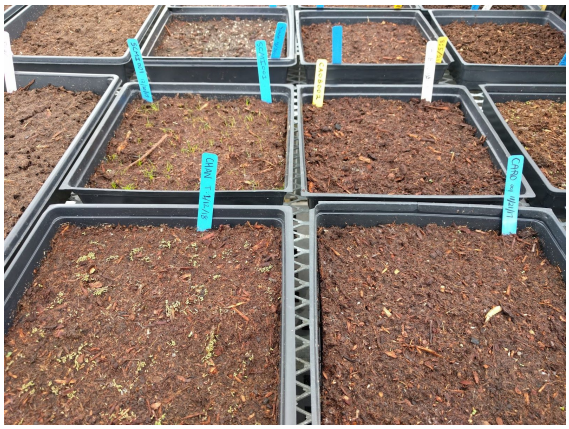

Fig. 4 - Various seeds sown in open flats

Transplanting

Transplanting refers to the process of moving or transferring a plant from one container or soil type to another. It can be a stressful event for plants, especially seedlings, so care should be made to limit the damage to the roots as much as possible. More information on demonstrating transplanting to volunteers can be found in Greene, 2017. The nursery uses the term transplanting to refer to the following three situations:

1. Multiple seedlings have germinated in one cell. This can cause competition for light, water, and nutrients, so seedlings should be carefully transplanted into an empty cells until there is only one per cell. (Fig. 5)
2. Seeds were germinated in a nursery flat (see sowing procedure for more details) and are now ready to be transplanted into individual cone-tainers. This process should be done after seedlings form true leaves, but before they become stressed out due to over-competition. This is a labor intensive task, and it is a good way to get volunteers hands-on experience working with plants. (Fig. 6)
3. A plant has become established or root bound in its current container. An established plant will have a root system that fills the entirety of the container, whereas a root bound plant will be fully established AND show signs of root spiraling or possibly girdling. If left in a root bound state for a long period of time, overall health and outplanting success can be negatively impacted, thus root bound plants should be transplanted into larger containers as soon as possible. This process is also referred to as up-potting. (Fig. 7 & 8)

Materials and equipment needed:

- *All purpose* (up-potting) or *germination mix* (seedlings)
- Plants to be transplanted
- Containers - sterilized or new
- Labels and grease pencils
- Tweezers and lab spatulas as needed
- Pruners and ethanol (or bleach solution) for sanitizing

Procedure:

- If transplanting seedlings (1 and 2 above)..
    - Use a lab spatula to tease apart the roots from individual plants in a way that minimizes damage to the plant.

    - IMPORTANT - work with only a few seedlings at a time, and do not allow roots to dry out. A damp cloth or paper towel can be used to cover roots to prevent them from drying out.
    - If roots are short (<2”) you can prefill cone-tainers with *germination mix* and then create a hole with a lab spatula to transplant into. If roots are long (>2”) hold transplant between index and middle finger inside the cone-tainer as you fill *germination mix* around it, making sure to settle media and remove large air pockets by tapping cone-tainer on the table as you go. For both methods, it is important to ensure the roots point down and out (not up!).
    - Completely cover roots with media, and leave ¼” - ½” of space at the top of the cone-tainer.
- If up-potting plants (3 above)..
    - Squeeze the sides of the container in order to loosen up the media and roots, thus making the plant easier to remove without damaging the roots.
    - If the plant is woody or has a strong, fibrous root system, you should be able to grip the base of the plant right above the media line and gently pull the plant out of the container. For delicate plants and plants in cone-tainers, it is recommended to gently grasp the base of the plant, flip it over, and then tap the rim of the container on the table until the plant begins to slide out.
    - Using your hands, gently break apart the roots and remove some of the existing media. As you do this you can also shake the root mass in order to dislodge more media. Disturbing the roots this way will aid the plant in re-establishing in its new container. Failure to break up the roots can result in a poorly developed root system after transplanting.
        - Use pruners to trim up plant roots prior to transplanting if the roots are longer than the height of the new container or if the plant was root bound in its former container. As a rule, never prune more than ⅓ of the plants root biomass, and depending on how much the roots were pruned, it may be necessary to also prune some of the above ground biomass in order to compensate for the loss of water uptake potential. ALWAYS sanitize pruners before moving on to another plant.
    - Add a thin layer of *all purpose mix* to the bottom of the new container.

    - In order to ensure the roots are pointing down and out (not up!), hold the plant at the root crown and backfill media around the roots, while occasionally tapping the pot on the table to settle the media and remove large air pockets.
    - When you are finished the roots should be completely covered, and the root crown should be centered and about ½" from the top lip of the container.
- Label individual pot (or seedling tray) with a plant tag that identifies seed lot, sow date, and transplant date.
- Carefully saturate container with water.
- Record species and date of activity in the transplant database.

Fig. 5 - Multiple germinants in one cell

Fig. 6 - *Carex* seedlings in need of transplant

Fig. 7 - Root bound *P. capitatus*

Fig. 8 - Establishing *Carex* (left) and *A. millefolium* (right)

Vegetative Propagation

Rooting Cuttings

Due to the need to produce plants that represent a diverse genetic population, native plant nurseries are not the ideal setting for propagation by cutting. Additionally, the nursery does not have a proper environment to root cuttings. Ideally the nursery would want access to a sterile space and a propagation mist bench that was dedicated to nursery use. Unfortunately, the nursery has neither, and even if it did, success can vary considerably depending on the attentiveness of the volunteers propagating the cuttings. Despite these drawbacks, the nursery does occasionally propagate plants through cuttings. In order to save time and resources and in order to maintain a high success rate, the nursery team should only focus on rooting cuttings known to root easily. A short list of these species can be found in Table 1 below. Cuttings can be taken from the coppice garden, but this source should only be used to supplement the existing nursery stock. For more information on rooting cuttings refer to chapter 9 of the Nursery Manual for Native Plants.

Table 1: Species easy to root through cuttings

Species Name	Common Name
Cornus sericea	Red Osier Dogwood
Lonicera involucrata	Twinberry
Physocarpus capitatus	Pacific Ninebark
Ribes sanguineum	Red Flowering Currant
Rosa nutkana	Nootka Rose
Rubus parviflorus	Thimbleberry
Salix spp.	Willows
Sambucus racemosa	Red Elderberry
Symphoricarpos albus	Snowberry

Plant Divisions

The two main plant division techniques the nursery uses are 1) rhizome division and 2) crown division. Rhizomes are modified underground stems that can be easily propagated into new plants (Dumroese et al., 2008). When dividing rhizomes, make sure each cut section contains at least one growing node. Adding to the number of nodes on each cut section, and choosing rhizomes that already contain roots, will significantly increase the success rate of rooting new plants. It should be noted that propagation through rhizome division does not increase genetic diversity because all new plants will be clones of the mother plant. Some rhizomatous species, like *Maianthemum dilatatum*, are very difficult to grow from seed, and the only effective way for the nursery to produce it is through divisions. It also remains to be seen how diverse these populations actually are out in the wild. See Table 2 below for a list of species commonly propagated through rhizome division.

Table 2: Species easy to propagate through plant divisions

Species Name	Common Name
Achillea millefolium	Yarrow
Achlys triphylla	Vanilla Leaf
Asarum caudatum	Wild Ginger
Cerastium arvense	Field Chickweed
Cornus unalaschkensis	Western Bunchberry
Dicentra formosa	Pacific Bleeding Heart
Maianthemum dilatatum	False Lily of the Valley
Oxalis oregana	Redwood Sorrel
Sedum spp.	Stonecrops

Crown divisions are somewhat similar to rhizome division, but instead of cutting small sections of just 1 or 2 nodes, the entire plant is divided into usually 2-4 sections each with an equal portion of the roots intact. These are then potted up and allowed to re-establish. Many graminoid species divide well through this technique, as do most ferns. As with rhizome division, crown division does not increase genetic diversity. Most graminoid species the nursery produces will grow well from seed, so this technique should be used sparingly on them. Until the nursery develops its own fern propagation unit, crown division and salvage are the only two reliable ways to increase their stock.

Watering and Irrigation

Checking Plant Moisture

Most plants will not need to be watered everyday, but ideally, they all should still be checked once a day (sometimes twice).. The nursery team needs to be aware that plants are living organisms, and they may require attention whether it fits with their schedule or not.

Actions:

- Use BOTH the plant and the media as a guide to determine watering needs of individual plants.
- For plants..
    - Wilting, or drooping, of stems and leaves is often a sign of under watering (also over watering; see below).

    - Dry, crispy leaves are more often than not a sure sign of underwatering.
- For media..
    - Check if the media is dry throughout (not just the top inch)
    - Pick up containers to gauge watering needs. A light container is a potential sign that it needs water. After watering, pick up the pot again to get a feel for how the weight has changed.
    - Take a few plants out of their containers to see how saturated (or unsaturated) the media is.
- Establish a watering pattern that saturates the media and then allows it to dry out. Many plants can be pushed to almost wilt point, but DO NOT push them any further as this can cause permanent damage to the plant. This wet and dry pattern encourages active root growth and minimizes the potential for overwatering.

Overwatering

This is just as frequent a problem as under watering, but unlike under watering, where symptoms can manifest rapidly, symptoms of overwatering are typically the result of several days or even weeks of an oversaturated root zone. Symptoms include a reduction in plant vigor, yellowing or browning of lower/older leaves, and wilting caused by stem rot. These symptoms are similar to symptoms of under watering, but with experience it is possible to determine which one is the actual cause (Elliot et al., 2014).

Hand Watering

Hand watering, also known as spot watering, is the most effective way to attain uniform growth and maximize plant health. When hand watering, plants should be watered on an individual, as needed basis.

Procedure:

- Attach water breaker or watering sprayer to the hose.
- Turn water on until you get constant pressure.
- Bleed air from the hose before watering any plants.
- For seeds, seedlings, and delicate plants..

    - Reduce the pressure so you are not blasting the containers with a high pressure stream. The mist setting can be used for very sensitive plants and to not blow lightweight seeds away.
    - Aim the low pressure stream at the surface of the pot, and water using smooth and steady movements. DO NOT let the water pool on the surface as this can wash seeds and seedlings away.
    - FULLY saturate the cone-tainer. This may several waterings due to the small available surface area of the media in the cone-tainer. Water will drip out of the bottom of the cone-tainer when it is fully saturated.
    - Sample a few cone-tainers by picking them up. Check to see how saturated they are, and repeat watering process if necessary.
- For established plants..
    - Aim the watering stream at the surface of the pot (not the plant itself) making sure to keep the stream in the pot as much as possible. Reduce pressure if the stream is too large for the plant. Failure to do this will waste water and can contribute to the overwatering of nearby plants.
    - FULLY saturate the pot. This may require repeated waterings. Water will drip out of the bottom of the pot when it is fully saturated.
    - Sample a few pots by picking them up. Check to see how saturated they are, and repeat watering process if necessary.
- When you are done watering shut off water, open valve to eliminate pressure in the line, and coil the hose. DO NOT store hose with kinks in the line as this can cause damage to the hose over time.

Irrigation

Auto-irrigation systems can significantly reduce the time spent watering by the nursery staff, but even the most well-developed system cannot provide the individual level of watering care plants need. Areas irrigated may dry out faster than others, or they may receive less watering coverage. Individual species vary in their water use requirements, and even plants of the same species and relative size may have different needs. Thus, it should be understood that auto-irrigation systems are not perfect, and they are designed to water based on a common denominator. This may not be ideal for individual plants, but it is a necessity in the SER-UW nursery. Although auto-irrigation will save time on watering, the nursery team should not be complacent about its

effectiveness. Some plants may be receiving too much water or others may still need supplemental hand watering even after the irrigation runs. Also, equipment can fail. It is important for the nursery team to constantly be checking the integrity, coverage, frequency, and rate of irrigation of the equipment to ensure its effectiveness.

Irrigation is used in the hoophouse and outdoor space. For more information on the hoophouse irrigation, see Hoop House Irrigation System (Drugge, 2018). The outdoor irrigation is traditionally set up by students in ESRM 412 during the 6th and 7th week of the quarter. Students are instructed to set up a flexible system that maintains good coverage throughout the zone they are responsible for. Due to the student's unfamiliarity with the nursery's evolving needs, these zones oftentimes require tinkering and adjustment from the nursery team, but this is common with any auto-irrigation system. Since the irrigation in the outdoor space is not static, it is only possible to provide a rough overview of its current set up. Future nursery managers should feel free to tailor the outdoor system to fit the needs of the nursery.

Outdoor irrigation:

- Zone 1 (spray emitters) - Shrubs that prefer full sun and have mid-high water use requirements.
- Zone 2 (spray emitters) - Shrubs and herbaceous plants that prefer part shade and have average water use requirements
- Zone 3 (spray emitters) - Prairie plants and occasionally shrubs that prefer full sun and low-mid water use requirements
- Zone 4 (drip emitters) - Trees and large shrubs that can tolerate full sun

How to Know How Much to Water?

Knowing how to water any one species so it can thrive is a skill that can take years to master. This is compounded in a native plant nursery that grows more than 70 individual species, oftentimes in various life stages and in different target sizes, and once you start factoring in changing weather patterns things can get really tricky. Some factors to consider are described in greater detail below.

Weather:

- Plants can dry out fast on hot, dry days due to increased transpiration rates

    - On a sunny day, and in temperatures over 20℃, plants should checked at least once a day (ideally twice - mid morning and mid afternoon).
- Plants will require less water on cool, moist days.
- Plants will dry out faster during periods of high wind.
- Plant's water use requirements change as the seasons change..
    - Mid spring to late summer are times of rapid growth, and as such plants will require increasingly more water.
    - As deciduous plants senesce during the fall their water use needs will decrease.
    - Most plants will require very little water during the winter months.

Plant age:

- When germinating seeds the media needs to be kept moist at all times so that seeds do not dry out. This may require daily checking and spot watering as necessary.
- Established plants may dry out between waterings. They should be checked everyday or every other day (pending weather and other factors).
- Large plants and root bound plants oftentimes need daily waterings.

Species:

- Each species has its own water use needs. Refer to Appendix B for information on individual species water use requirements.
- As a general rule of thumb..
    - Plants that form tap roots need less water than plants that form dense, fibrous roots (Elliot et al., 2014).
    - Coniferous plants require less water than deciduous plants of the same size.
    - Plants that go dormant in the summer will require less water.

Teaching How to Water

Teaching interns, volunteers, and new managers efficient watering practices can be challenging. The most effective way for new nursery team members to learn how to water is to have them go through each plant one-by-one and have them hand water as needed. Unfortunately, due to time constraints this is generally infeasible. Spring and summer are the quarters that require the most time intensive watering, so it is best to divide watering responsibilities among the nursery team those quarters. Fall is a less intensive time for watering, but there will most likely be plants inside the greenhouse that need to be watering. Managers are encouraged to get interns involved

in watering as soon as possible. For more information on teaching interns how to water, see Greene, 2017.

Actions:

- When training students, show them how to analyze watering needs of each plant. This is best done by having them shadow you while you water. Use that time to discuss the above listed factors (weather, age of plant, and species), as well as to show them when and how much to water.
- After they have shadowed you a few times, have them assess and water (as needed) all the plants in the nursery while you shadow them. This is an important step in their training. Students will most likely be timid at first, but they should be encouraged to take the initiative when watering. Answer any questions they have and provide constructive criticism as they go along.
- When students have become more comfortable with watering have them take on responsibility of watering over the course of several days to a week.

Fertilizing

Overview

Fertilization is a critical component of nursery production, and a properly managed fertilization regime can significantly enhance growth rates, allowing many native plant species to be established within a growing season or less (Dumroese et al., 2008). All of the media mixes the SER-UW nursery uses contain a negligible amount of mineral nutrients, so it is important for the nursery to use supplemental fertilization methods. These methods vary depending on the growing media used, and they are listed below. For more information on plant nutrient needs and fertilization techniques, see chapter 11 of the Nursery Manual for Native Plants.

Seedling Fertilization

Seeds have enough nutrient storage to germinate, but that nutrient reserve will soon be exhausted as the seedling begins to produce true leaves. Once a plant reaches this stage, a fertilization regime should commence. The nursery uses a liquid fertilizer and subirrigation method to fertilize all seedlings grown in the *germination mix*. This subirrigation method allows the nursery to collect and recycle any unused fertilizer solution, and by doing so significantly

reducing waste. Collected fertilizer solution can then be used as an additional supplement for larger plants or for plants that need a boost of easily accessible mineral nutrients.

Actions:

- Allow seedling media to dry out slightly prior to subirrigation. This will ensure the media wicks up nutrients.
- Subirrigate seedling trays that have consistent germination (>30-50%). Seedling trays that have lower germination rates can be top fertilized with the collected fertilizer solution at the end of the subirrigation process. This will cut down on nutrient waste and prevent ungerminated cells from becoming too rich with nutrients.
- If possible, during the hardening phase switch to a fertilizer with a low nitrogen ratio and one that is nitrate-based (as opposed to ammonium-based). This will prevent unwanted, late season shoot growth.
- Refer to Table 3 for fertilizer frequency and rates.

Table 3: Liquid fertilization rates

Growth Phases	Frequency	Rate
Germination	Never	n/a
Seedling Establishment	Once every 2 weeks	0.5 fluid oz per gallon
Rapid Growth	Once every 2 weeks	0.5 fluid oz per gallon
Hardening	Once every 3-4 weeks	0.5 fluid oz per gallon
Overwintering	Rarely to never	0.25 fluid oz per gallon
Greenhouse Seedlings	Once every 2 weeks	0.5 fluid oz per gallon

Materials and equipment needed:

- Liquid fertilizer - Fish and Guano 9-6-2
- Subirrigation tray with drain hose and plug (ex. ear plug)
- 5 gallon bucket(s)
- Measuring cup (ounces or milliliters)
- Seedlings to be fertilized

Procedure:

- Place subirrigation tray on a bench or table, and install drain hose. Plug the drain hose.

- Using a 5 gallon bucket or a large measuring container, fill subirrigation tray with 10 to 12 gallons of water.
- Add liquid fertilizer using the lowest rate (Table 3). Stir until consistently mixed.
- Place seedlings trays into the subirrigation tray (fits 4 trays of cone-tainers comfortably).
- The level of the fertilizer solution should remain fully above the drainage holes at the bottom of the cone-tainer throughout the subirrigation process. Add more water and fertilizer (at the same rate) if the water drops below this level.
- Soak seedling trays in the solution until the media is saturated. This process takes about 10-15 minutes, but more time should be given if the cells are not fully saturated.
- Remove seedling trays one by one. Allow excess fertilizer solution to drip into the subirrigation tray before moving.
- Cycle in new seedling trays and repeat soaking process.
- When all seedling trays have finished soaking, pull the plug on the drain hose and collect unused fertilizer solution in 5 gallon buckets.
- Collected fertilizer solution can be stored temporarily, but long term storage is not recommended. It will begin fermenting after a few days, so it should be used as soon as possible.
- Rinse out subirrigation tray and store upright.

Controlled-Release Fertilizing

GroCo™ soil conditioner does not contain a sufficient amount of nutrients needed for plant production, so the nursery uses a controlled-release inorganic fertilizer for any plants grown in the *all purpose mix*. Controlled-release fertilizers can be used as a top-dressing or they can be added to the media when mixing it. They are rated to last a set amount of time within a given temperature range, so expected temperature and timing of application should be factored into the fertilizing regime when applying.

Recommendations:

- If top dressing, plants should be fertilized as soon as they are up-potted into the *all purpose mix*.
- The nursery currently only uses the *Osmocote 13-10-13 Pro* product, but if up-potting later in the growing season (July and onward) the nursery team should consider

fertilizing with a product that has a low nitrogen ratio and lasts a shorter amount of time. See Table 4 below for more information.

Table 4: Controlled-release fertilization rates

Container Size	Desired Rate
4"	2-3 grams
Deepot #27	2-3 grams
Deepot #40	3-4 grams
1 gallon	10-15 grams
2 gallon	25-30 grams

Future research:

- The nursery should test the performance of several different fertilizer products. Some options are listed in Table 5.
- The nursery should continue to test the efficacy of organic slow-release fertilizer products.

Table 5: Potential controlled-release fertilizers to use in the future

Product	Time Active	Recommended Window of Use
Osmocote 13-10-13 Pro w/ IBDU	5-6 months	March - July
Osmocote 15-9-12	5-6 months	March - July
Osmocote 18-6-12, Regular	8-9 months	March - April
Osmocote 14-14-14	3-4 months	August - September

Propagation Record Keeping

In order to continually improve and share best nursery practices, it is important for the SER-UW nursery to develop and maintain detailed propagation record databases. Many of the propagation databases the nursery is currently using are works in progress. This section should be updated after formatting for these databases is finalized.

Actions:

- Create and maintain databases for the following:

- Plant provenance
- Seed treatments (stratification, scarification, etc.)
- Germination - see *A Guide to Tracking Germination Rates in the SER-UW Nursery* (Braks, 2018).
- Transplanting
- Fertilizing
- Salvage success rates
- General plant health data (watering, growth rates, mortality, etc.)

Integrated Pest Management

Overview

The SER-UW nursery uses an IPM method to address potential pest concerns before they become an economic problem. It is a broad approach to pest management, and it allows the nursery to save on labor and financial resources. By using this method, the nursery uses fewer chemical pesticides, which minimizes the danger to team members and volunteers, limits the toxic impact to the surrounding environment, and reduces the overall carbon footprint of the nursery from chemical manufacturing. The four steps to the nursery's IMP method are 1) set action thresholds, 2) prevention, 3) monitor and identify pests, and 4) control.

Action Thresholds

The nursery alternates between two different action thresholds depending on the time of the year. These action thresholds allow the nursery team to assess the level of control needed when controlling for pests. These are described in further detail in Table 6.

Table 6: SER-UW action thresholds

Action Threshold	Begins	Ends	Description
Public Plant Sale	2 months before each public plant sale	After each public plant sale	Low pest tolerance; High levels of pest control. Plant sales take place in late spring and late autumn. When selling to the public at retail value, visible (cosmetic) signs of pests or pest damage should be kept minimal.
General Production	After each public plant sale	2 months before each public plant sale	Average pest tolerance; Average levels of pest control. Planting season in the PNW takes place in the winter when most plants (and insects) are dormant. Visible (cosmetic) signs of pests and pest damage is tolerable, but controls should be implemented when pests start impacting production quality.

Prevention

Prevention is the first step in minimizing pest pressure in a plant production setting, and in nearly all cases prevention requires less labor and resources than treatment (Dumroese et al., 2008). Important techniques for prevention specific to the SER-UW nursery are listed below.

- Sanitation
    - All used containers should be sanitized in a bleach solution before reusing.
    - Seeds should be cleaned prior to sowing (see Seed Cleaning above).
    - Sterilize pruners before making any cuts on new plants.
    - Regularly sweep up the hoophouse and outdoor spaces. Leaf detritus provides habitat for insect pests and spilled fertilizer can exacerbate weed production.
    - Do not allow water to pool in the production areas. Standing pools of water can be a breeding ground for insect pests and disease pathogens.
    - Sanitize the ground fabric in all production areas with bleach solution at least once a year. This is easier to do in the hoophouse during the summer and in the outdoor spaces in early spring and late fall.
    - Keep areas around production spaces mowed and clear of weeds.
- Production
    - Whenever possible, use a clean and sterile growing media.

- Maintain good plant health. Healthy plants are more capable of resisting insect attacks and infection from bacteria and fungi (Dumroese et al., 2008).
- Avoid overwatering. Overwatering stresses plants out and increases potential for pest outbreaks.
- Do not over fertilize. Excess nutrients can greatly increase pest pressure in the production areas.
- Develop and implement rigorous crop schedules. Individual species have their own growth development timelines, and plants can become stressed when these timelines are extended or shortened (Dumroese et al., 2008).

Monitoring and Identifying Pests

The SER-UW nursery is not a highly controlled production environment, and pest outbreaks will inevitably occur. Thus, it is critical for the nursery team to maintain an active scouting program throughout the year. This is especially pertinent during the active growing season (spring and summer) and during the two months leading up to the autumn public plant sale. Insect and disease pests should be identified as accurately as possible, and proper identification will allow the staff to assess the need and level of control (Dunroese et al., 2008). More information can be found in *A Guide to Pest Scouting for the SER-UW Nursery* (Do, 2018).

Actions for monitoring:

- Scout for pests at least once a week, especially during the spring, summer, and autumn. This does not have to be done all in one setting, but plants should be checked for signs of pests or pest damage every week.
- Use sticky traps to monitor for flying pests, as these can help alert staff to the presence of pests, as well as identify hotspots in the nursery. Unfortunately, they will also trap beneficial flying insects.
- Pest scouting should be passively occurring whenever the nursery team is working with plants. Watering, transplanting, pruning, and moving plants are all good times to be keeping an eye out for signs of pests or pest damage.
- Knowing what to look for and where to look for pests will save the nursery team a considerable amount of time when scouting. This skill takes a while to pick up, but efficiency improves with practice. Experienced nursery staff should constantly be

educating other team members on valuable scouting tips as examples occur in the nursery.

- If you are unsure of the identification of a pest while monitoring, take pictures and make note of morphological features. Also, document any symptoms or signs of damage. This will allow you to easily refer to the literature or consult a pest specialist.

Scouting Records

All pest observations need to be documented by the nursery staff, and this will allow the nursery to track and manage ongoing outbreaks, as well as anticipate future outbreaks. Information to document includes the following:

- Plant species and life stage (ex. seedling or established plant)
- Date
- Location in the nursery (ex. hoophouse or greenhouse)
- Type of pest (ex. insect or fungal) - Identify as accurately as possible
- Location of pest on plant (ex. leaves, stems, or roots)
- Symptoms and signs of damage
- Level of severity
- Beneficial predators (if present) - Identify as accurately as possible

Action:

Create a scouting database and maintain it regularly.

Control

This section will be updated at a future date. Until then, the nursery team should refer to the *Beneficial Insectary Design* (Potoshnik, 2018) and *A Guide to Pest Scouting for the SER-UW Nursery* (Do, 2018).

Spray Records

Nursery managers are responsible for keeping accurate pesticide spray records, as well as for sharing those records with the IPM coordinator at the CUH. See Appendix C for an example of a spray records database.

Internships

Overview

Internships have become an integral part of the success of nursery over the past several years, and they are becoming increasingly competitive as the nursery grows and as students become more familiar with its role at UW. Undergraduate students look to these internships as a way to gain real world, hands-on experience in horticulture, plant production, and project management, and in exchange, the nursery gains valuable assistance in achieving its mission and reaching its production goals. Internships are unpaid, but students are highly encouraged to enroll in internship course credits. Student interns help with all manner of nursery tasks, including but not limited to plant production, data collection, volunteer leadership, and plant sale organization and advertising. Without these internships, and due to the current low funding budget of the nursery, managers would have to significantly scale back operations. In order to achieve its production and sales goals, the nursery has the need for the following three internships: Plant Production, Communication, and Pest Management. Responsibilities for each of these internships are listed in greater detail below. Recommendations for when to offer these internships are listed in Table 7.

Table 7: Internships by academic quarter

Internships	Winter	Spring	Summer	Autumn
Plant Production	x (2)	x	x	x
Pest Management		x	x	
Communications		x		x

Managerial Responsibilities:

- Create and post internship advertisements. Advertisements should be sent out at least three or four weeks in advance of the start of every quarter (allowing extra time for holiday breaks). Give at least two weeks time for students to submit resumes and cover letters.
- Interview potential candidates.

- Orientate students around the CUH, give them set of keys ($20 deposit), and have them fill out forms if enrolling in internship credit - for ESRM students the course listing is ESRM 399, but internship credits are fairly common throughout departments. Students should check with their undergraduate advisors for specific course listings. More information on internship orientation can be found in Greene, 2017.
- Discuss and assign projects. This should be done by the second week of the quarter.
- Schedule a mid-quarter check-in to discuss project progress and internship trajectory.
- Schedule an end of quarter exit interview/evaluation, and send evaluation to the relevant undergraduate advisor.
- Upon completion of project, a pdf should be sent to hortlib@uw.edu, so it can be accessible in the Miller Library SER-UW nursery student projects folder.
    - Format of file: *SER-UW_Project Title_Last Name_year.pdf* (Ex. *SER-UW_Native_Coppice_Garden_Liu_2017.pdf*)

Actions:

- Advertisements should be sent out to a range of departments in order to attract a wide pool of applicants. Departments commonly advertised to include *ESRM, BIOL, CEP, PoE, COMM,* and *EDUC.*
    - Compile a list of emails for relevant department contacts.
- Internships typically last a quarter, but it might be worthwhile for the nursery to consider longer internships.
- The nursery should seriously consider paying interns, at least for the summer quarter, if the budget allows for it.
- The nursery is still young, and many past internship projects have been designed around helping the nursery grow and expand. Once the nursery becomes more established at UW, there will be less of a need for novel internship projects. Instead, managers will need to focus the efforts of the interns on maintaining the practices and projects that make the nursery successful. Three types of regular internships the nursery should offer (Plant Production, Communications, and Pest Management) are described in further detail below, as well as potential ideas for non-regular internships.

Plant Production

The plant production intern is a critical position for the SER-UW nursery team, and the nursery should offer at least one of these internships every quarter. For more information on tracking germination rates, see *A Guide to Tracking Germination Rates in the SER-UW Nursery* (Braks 2018).

Responsibilities:

- Keeping detailed production records and maintaining production related databases
- Tracking germination rates
- Monitoring and assessing plant health
- Researching needs of individual species
- Creating visual production calendars (see Appendix D)
- Assisting in production scheduling
- Running stratification, germination, and various other growth experiments

Communication

Communications interns are needed to help maintain and increase the marketing of the SER-UW nursery to the UW student body and the broader public. They are especially important during the spring and autumn quarters when the nursery hosts its public plant sales. Refer to *So You Want to Host a Native Plant Sale* (Osborn, 2017) for more information on plant sale advertising.

Responsibilities:

- Creating permanent signs for the nursery as soon as possible, as well as for SER-UW restoration sites as needed
- Leading or assisting with the public plant sale advertising
- Developing and maintaining social media presence
- Creating weekly newsletters for the SER-UW listserv
- Taking pictures - plants, volunteer events, public plant sales, etc.

Pest Management

Pest management internships are extremely important during the growing season. They regularly scout the nursery for pests, and as such these interns are often the primary defense against pest outbreaks. For more information on pest monitoring, identification, and control, see *A Guide to Pest Scouting for the SER-UW Nursery* (Do, 2018).

Responsibilities:

- Scouting for pests and beneficial insects
- Creating and maintaining detailed monitoring databases
- Developing identification standards
- Researching insect life cycles
- Using cultural and chemical controls
    - Updating spray records as needed
- Caring for the beneficial insectaries (Potoshnik, 2018)

Other

The internships listed above are designed to help the nursery fulfill its mission, but there may be future needs to include other potential internships. Some unique internships might include a construction, education, or business internship. Nursery managers are free to implement new internships when they align with the nursery goals.

Volunteers

Overview

Without volunteers the nursery would never be able to fulfill its production or education mission. Nursery managers should consult *Designing and Implementing an Education Plan for the SER-UW Nursery* (Green, 2017) for an in depth guide on how to engage volunteers and get the best out of them.

Carlson Center

The nursery has been partnering with the Carlson Center to host service learning volunteers since early 2015, and this partnership remains an excellent way to engage a larger subsect of the UW student body, as well as a way for the nursery to foster public service and civic responsibility in students within an environmental restoration context. In conjunction with their coursework, service learning volunteers are typically required to dedicate 20 hours of their time during the quarter to community-based learning and leadership. Oftentimes, these volunteers develop a much greater appreciation for the nursery than most one-time volunteers, and as the quarter progresses, managers are highly encouraged to offer them an increasing amount of autonomy and responsibility. Not only does create a more enriching experience for these students, but it also helps to alleviate the amount of work that would typically be the responsibility of the core nursery team. Carlson Center volunteers make good candidates for future internships.

The Carlson Center has historically been very good about communicating with the nursery regarding deadlines, but just in case, listed below is a summary of the manager's responsibilities:

- Post service learning positions on the Carlson Center EXPO website at least a week prior to the start of the quarter.
- Schedule an orientation time for registered service learning volunteers. The students are responsible for initiating contact with the manager, but once they do an orientation should take place within the first two weeks. Orientation consists of a quick tour around the pertinent CUH grounds, a brief description of the nursery and its mission, and the student's responsibilities for completing their service learning obligation.

- Update students once or twice throughout the quarter on the number of hours they have completed.
- Evaluate students on the Carlson Center EXPO website during the last week of classes.
- Encourage students to fill out an evaluation form for the nursery, so that future potential volunteers can gain a greater sense of the opportunity the nursery has to offer.

Actions:

1. The number of available service learning positions is currently capped at five a quarter. As the nursery expands its operations this number will most likely need to be increased, and it should be noted the nursery will benefit more by increasing these positions than by hosting more one-time volunteers.
2. Service learning positions were originally set up to give the nursery a consistent volunteer presence during Friday work parties, but this need not always be the case. The nursery has had good results with requiring these students to attend Friday work parties for the first half of the quarter, but then allowing them to join in during team work days as they become more comfortable around the nursery.

ESRM 100

Introduction to Environmental Science (ESRM 100) is an online course that enrolls over 500 students every quarter from nearly every facet of the UW student body. In conjunction with their coursework, students enrolled in this course are required to volunteer for 3-4 hours a quarter with an environmental organization, and over the past several years the nursery has consistently hosted volunteers from this course at our Friday work parties. Their level of experience is more often than not minimal, and their interest in the nursery ranges anywhere from indifference to impassioned environmentalism. No matter their inclinations or level of expertise, their value to the nursery should not be underestimated. With direction and leadership, these volunteers can accomplish quite a lot in the span of one work party.

Managerial Responsibilities:

- Keep a log of volunteer hours so TA's can be informed of students that have completed their volunteer credit.
- Communicate regularly with the SER-UW volunteer coordinator to make sure event sign-ups are closed as they reach their maximum number of students.

- Currently, SER-UW has a volunteer coordinator that handles the event sign-up sheets as well as communication with the students and their TAs. Should someone within the SER-UW student chapter not step into this role, it would be the responsibility of the nursery manager to continue this relationship.

Action:

1. Limit the number of ESRM 100 volunteers to 5-10 per work party, especially when working on more technical nursery tasks. Not only will this lessen the strain on the core nursery team, but it will also improve the quality of work accomplished, as well as improve the quality of education they receive from their volunteering experience.

ERSM 412

Native Plant Production (ESRM 412) is a junior and senior level course that frequently partners with the SER-UW nursery every spring quarter, and a vast majority of the labs take place within the SER-UW nursery. This is lucrative partnership for both student education and for the nursery as a whole. With a little planning and foresight, managers can utilize this course to significantly expand the nursery's production capabilities. A course requirement for this class is for students to gain practical experience by either carrying out an experimental trial or by volunteering at least 10 hours of their time to plant production related tasks. This is a great opportunity for the nursery to achieve production related tasks during the busy spring growing season. Students that take this course are also ideal candidates for internships, either while enrolled in the course or in the future.

Manager's Responsibilities:

- Prior to the start of the quarter, the nursery manager should meet with the professor (currently Dr. Jon Bakker) and the TA to coordinate which species to grow for the production trial experiment. Any plants left over from the experiment will be given to the nursery, and this is a great opportunity to increase stock numbers of species needed for restoration in the following year for classes like the REN Capstone (ESRM 462-4) and Restoration of North America (ESRM 473).
- Communicate regularly with the professor and the TA to align weekly lab tasks so they benefit the production goals of the nursery whenever possible.

Tracking

The nursery tracks all volunteer hours, and this allows the nursery to determine if it is meeting its goals or not. The volunteer management database is kept on the nursery drive. This should be written into policy in the Nursery Operation Manual.

Managerial Succession

To be updated at a later time.

Future Needs

Not an exhaustive list..

- Production
    - Seed sourcing strategy
    - Vegetative propagation protocols
    - Rhizome beds
    - Fern propagation unit
    - Bulb production beds
    - Target sizes
    - Visual production calendar
    - Improve species selection
    - Improve germination rates
    - Maximize plant health
    - Reduce plant mortality
    - Bareroot production
    - Live stake collection strategy
- Research
    - Fertilizer
        - Rates, water soluble, organic
    - Media
        - pH, mycorrhizae, drainage
    - IPM
        - Rabbit control
        - Long-term pest monitor.
        - Insect life cycles
        - Identification handbook
    - Seed treatment techniques
        - Stratification, scarification, etc.
    - Plant health
        - Individual species need
- Administration
    - Marketing plan
    - Communications plan
    - Nursery operations manual
    - Financial policy
    - Plant sales analysis - Public, restoration
    - Strengthen education
        - Public classes, volunteers, interns, ESRM 412
    - New partnerships (ex. SER NW, NPS)
    - New customers (ex. Green Seattle)

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Additional Links

Carlson Center - http://www.washington.edu/carlson/

GROCO™ - http://www.sawdustsupply.com/groco-soil-conditioner-mulch

Inside Passage Seeds - http://www.insidepassageseeds.com/

Oxbow Farm and Conservation Center (Native Plant Nursery) - http://www.oxbow.org/native-plants/

Appendix

Appendix A - Species Selection

The following three tables (Tables 8, 9, and 10) live on the nursery Google Drive. They are still works in progress, and should constantly evolve as the nursery team adapts to changing restoration and public sales markets.

Actions for future managers:

- Focus mainly on species with medium to very high demand, and grow the greatest quantities for species in high and very high demand.
- Focus on plants that have overlapping markets (restoration and public).
- Focus on plants needed for the 520 Mitigation.
- Grow mainly shrubs, herbaceous plants, and graminoids.
- Trees in medium to high demand should be grown, but in smaller quantities.
- Avoid species in low to very low demand unless you have a contract or a dedicated buyer.
    - This is especially pertinent for low to very low demand tree species.

Trees and Shrubs

Table 8: Demand, uses, and target sizes for trees and shrubs

Botanical Name	Propagation Method	Starting Container	Target Size	Estimated Time	Demand	Common Uses	520 Mitigation
Abies grandis	seed	SC10	1 gallon	2 years	low	restoration	
Acer circinatum	seed	SC10	1 gallon	1 year	**very high**	restoration, public	x
Acer macrophyllum	seed	SC10	1 gallon	1 year	low	restoration	x
Alnus rubra	seed	SC10	1 gallon	1 year	medium	restoration	x
Amelanchier alnifolia	seed	SC10	1 gallon	1 year	**very high**	restoration, public	x
Arbutus menziesii	seed	SC10	1 gallon	2 years	low	restoration, public	
Arctostaphylos uva-ursi	seed	SC7	D19	2 years	high	restoration, public	
Berberis aquifolium	seed	SC10	1 gallon	1-2 years	**very high**	restoration, public	x
Berberis nervosa	seed	SC10	1 gallon	1-2 years	**very high**	restoration, public	
Cornus sericea	seed, cutting	SC10	1 gallon, live stake	1 year	medium	restoration	x
Corylus cornuta	seed	SC10	1 gallon	1 year	medium	restoration	
Crataegus douglasii	seed	SC10	1 gallon	1-2 years	**very high**	restoration, public	x
Fraxinus latifolius	seed	SC10	1 gallon	1 year	low	restoration	x
Gaultheria shallon	seed	SC7	D19	1-2 years	**very high**	restoration, public	
Holodiscus discolor	seed	SC10	1 gallon	1 year	high	restoration, public	x
Lonicera ciliosa	seed	SC10	1 gallon	1 year	medium	public	
Lonicera involucrata	seed, cutting	SC10	1 gallon, live stake	1 year	high	restoration, public	x
Malus fusca	seed	SC10	1 gallon	1 year	high	restoration	x
Myrica gale	seed	SC10	1 gallon	1 year	medium	restoration	
Oemleria cerasiformis	seed	SC10	1 gallon	1 year	high	restoration, public	
Oplopanax horridus	seed	SC10	1 gallon	2 years	medium	restoration	
Philadelphus lewisii	seed	SC10	1 gallon	1 year	medium	restoration, public	
Physocarpus capitatus	seed, cutting	SC10	1 gallon, live stake	1 year	high	restoration, public	x
Picea sitchensis	seed	SC10	1 gallon	1-2 years	very low	restoration	x
Pinus contorta	seed	SC10	1 gallon	1-2 years	low	restoration	x
Prunus emarginata	seed	SC10	1 gallon	1 year	medium	restoration, public	
Pseudotsuga menziesii	seed	SC10	1 gallon	1-2 years	medium	restoration	x
Quercus garryana	seed	D40	1 gallon deep	1-2 years	medium	restoration, public	x

Rhamnus purshiana	seed	SC10	1 gallon	1-2 years	medium	restoration	
Ribes bracteosum	seed	SC10	1 gallon	1 year	medium	restoration, public	
Ribes divaricatum	seed	SC10	1 gallon	1 year	medium	restoration, public	x
Ribes lacustre	seed	SC10	1 gallon	1 year	medium	restoration, public	x
Ribes sanguineum	seed, cutting	SC10	1 gallon	1 year	high	restoration, public	x
Rosa gymnocarpa	seed	SC10	1 gallon	1 year	medium	restoration, public	
Rosa nutkana	seed	SC10	1 gallon	1 year	medium	restoration, public	x
Rosa pisocarpa	seed	SC10	1 gallon	1 year	medium	restoration	x
Rubus leucodermis	seed	SC10	1 gallon	1 year	high	restoration, public	
Rubus parviflorus	seed	SC10	1 gallon	1 year	**very high**	restoration, public	x
Rubus spectabilis	seed	SC10	1 gallon	1 year	**very high**	restoration, public	x
Rubus ursinus	seed	SC10	1 gallon	1 year	medium	restoration	
Sambucus racemosa	seed, cutting	SC10	1 gallon	1 year	high	restoration, public	
Spiraea douglasii	seed	SC10	1 gallon	1 year	medium	restoration	x
Symphoricarpos albus	seed, cutting	SC10	1 gallon, live stake	1 year	**very high**	restoration, public	x
Thuja plicata	seed	SC10	1 gallon	1-2 years	medium	restoration	x
Tsuga heterophylla	seed	SC10	1 gallon	2 years	very low	restoration	
Vaccinium ovatum	seed	SC10	1 gallon	1 year	medium	restoration, public	
Vaccinium parvifolium	seed	SC10	1 gallon	1 year	high	restoration, public	
Viburnum edule	seed	SC10	1 gallon	1 year	medium	restoration, public	

Herbaceous Plants

Table 9: Demand, uses, and target sizes for herbaceous plants

Botanical Name	Propagation Method	Starting Container	Target Size	Estimated Time	Demand	Common Uses	520 Mitigation
Achillea millefolium	seed	SC10	1 gallon, D40	6 months	**very high**	restoration, public	x
Achlys triphylla	division				high	public	
Anaphalis margaritacea	seed				medium	restoration, public	
Aquilegia formosa	seed				high	restoration, public	x
Aruncus dioicus	seed				medium	restoration	
Asarum caudatum	division				high	restoration, public	
Camassia leichtlinii	seed		bulb		medium	restoration, public	x
Camassia quamash	seed		bulb		medium	restoration, public	x
Cerastium arvense	seed				medium	restoration	x
Chamaenerion angustifolium	seed				unknown	restoration	
Dicentra formosa	division				high	restoration, public	
Erigeron speciosus	seed				high	restoration, public	x
Eriophyllum lanatum	seed				medium	restoration, public	x
Erythronium oregonum	seed				unknown	public	
Fragaria vesca	seed				medium	restoration, public	
Geum macrophyllum	seed				low	restoration	
Heuchera micrantha	seed				medium	public	
Hydrophyllum tenuipes	division				medium	restoration, public	
Lupinus latifolius	seed				high	restoration, public	x
Lupinus polyphyllus	seed				medium	restoration, public	
Lysichiton americanus	seed				high	restoration	
Maianthemum dilatatum	division				**very high**	public	
Maianthemum stellatum	division				**very high**	public	
Oenanthe sarmentosa	seed				medium	restoration	
Oxalis oregana	division				**very high**	restoration, public	
Potentilla gracilis	seed				high	restoration, public	x
Ranunculus occidentalis	seed				high	restoration, public	x
Sedum spathulifolium	division				**very high**	public	
Solidago canadensis	seed				medium	restoration	
Stachys cooleyae	seed				unknown	restoration	

Symphyotrichum subspicatum	seed				unknown	restoration, public	
Tellima grandiflora	seed				**very high**	restoration, public	
Tiarella trifoliata	seed				medium	restoration, public	
Tolmiea menziesii	seed				**very high**	restoration, public	
Viola adunca	seed				high	restoration, public	x

Graminoids

Table 10: Demand, uses, and target sizes for graminoids

Botanical Name	Propagation Method	Starting Container	Target Size	Estimated Time	Demand	Common Uses	520 Mitigation
Carex deweyana	seed				unknown		
Carex hendersonii	seed				unknown		
Carex inops	seed				high	restoration	x
Carex lenticularis	seed				high	restoration	
Carex obnupta	seed				high	restoration, public	x
Carex rostrata	seed				unknown		
Carex stipata	seed				high		x
Carex tumulicola	seed				unknown		
Danthonia californica	seed				high	restoration	x
Deschampsia cespitosa	seed				**very high**	restoration	x
Eleocharis obtusa var. ovata	seed				unknown		
Eleocharis palustris	seed				high		x
Elymus glaucus	seed				**very high**	restoration	x
Festuca roemeri	seed				**very high**	restoration	x
Festuca rubra	seed				unknown		
Juncus acuminatus	seed				high		x
Juncus ensifolius	seed				high		
Juncus tenuis var. tenuis	seed				high		x
Koeleria macrantha	seed				high		
Luzula parviflora	seed				high		
Schoenoplectus acutus	seed				high		
Scirpus microcarpus	seed				high		
Sisyrinchium idahoense	seed				unknown		

Appendix B - Plant Health

Table 11 shows the sun to shade tolerances, water use requirements, soil moisture preferences, soil types descriptions, and other comments for over 80 different species native to the Puget Lowland. Many of these species are grown in the SER-UW nursery, and this table should be used to inform the nursery team of the watering needs, soil preferences, and placement of individual species within the nursery. This is a living table, and new species should be added to it as needed. Its most current edition can be found on the nursery Google Drive. Data included in this table was compiled from information on the Lady Bird Johnson Wildflower Center, the Washington Native Plant Society, the University of Washington Burke Museum Herbarium, and observations from past SER-UW nursery managers. Table 12 is a key for interpreting the water use and soil description columns.

Table 11: Plant health preferences

Code	Water Use	Sun	Part Sun	Part Shade	Shade	Dry	Moist	Wet	Soil Description	Comments
ABGR	M			x	x				Wd	
ACCI	M			x	x	x	x			
ACMA	M	x	x	x		x	x		Co	Stretches in shade
ACMI	M	x	x	x		x				Drought tolerant
ACTR				x	x		x		Ri	
ALCE		x	x			x	x		Sa, Gr, Hr, Wd	pH >7.2
ALRU	H	x	x	x			x			Stretches in shade
AMAL	M	x	x	x		x	x		Wd	Intolerant to drought
ANMA	M	x	x	x		x			Sa, Gr	
ARDI	M, H		x	x	x		x	x	Ac	pH <6.8
ARME	L	x	x			x	x		Ac, Sa, Gr, Wd	Drought tolerant, Mycorrhizal
ATFI	M			x	x		x	x	Hu	
CAIN		x	x			x	x		Sa	
CAMLEI	M	x	x			x	x			
CAOB		x	x	x	x			x		Saturated soils
CAQU	H	x					x		He	

CARLEN	H	x	x	x	x		x	x	Sa	
CHAN										
COSE			x	x			x	x	Wd	Neutral pH
CRDO	H	x	x	x	x		x	x		
DIFO	L	x	x	x	x		x		Wd, Hu	
DREX				x	x		x	x	Or, Hu	
ELGL	L	x	x			x	x		Wd	
ERLA		x				x			Sa	Drought tolerant, high phenotypic variability
ESRP		x				x	x			
FERO	M	x				x	x		Ro	Drought tolerant
FRLA	M	x					x	x	Ri, Wd	
GASH	H	x	x	x	x	x	x	x	Pe	Needs summer shade
GEMA	M				x		x			
GLEL		x	x	x	x		x	x		
GRIN		x	x				x		Np	
HEMI		x	x	x			x		Ro, Hu	
HODI	H	x	x			x	x		Gr, Ro	
HYTE				x	x		x		Ri	
KOMA	H	x				x			Sa, Ro	
LOCI		x	x	x			x			
LOIN	H		x	x			x	x		Can withstand seasonal inundation
LUPO			x	x			x	x	Co	pH <6.8
LUZPAR	H			x						
LYAM				x				x		Aquatic
MAAQ	L		x	x		x	x		Ac, Gr, Lo, Wd	
MADI					x		x	x		pH <6.8
MAFU		x					x	x		
MANE	L		x	x	x	x	x		Ri, Wd	Slow to establish
MYGA	M	x	x				x	x		
OECE			x	x		x	x		Ri	
OSBE				x			x		Ri	pH >7.2

PHCA	M	x	x	x			x	x	Ri	
PHLE	L		x	x		x	x		Gr, Ri	
PICO	M	x				x	x	x	Gr, Lo, Pe	
PISI	M	x	x	x			x	x	Wd	
POGR	L	x	x				x	x		
POMU	H			x	x	x	x			Drought tolerant, pH <6.8
POTR	H	x	x				x			Volunteers on its own
PSME	M		x	x		x	x		Gr, Wd	
QUGA	L	x	x			x	x		Gr, Sa, Wd	
RHPU	M		x	x	x	x	x	x	Lo	
RIBR				x	x		x	x		
RISA	M	x	x			x	x		Wd	
ROGY	M		x	x		x	x			
RONU	H		x	x		x	x			
ROPI		x	x				x	x		
RULE	M	x	x			x				
RUPA	H		x			x	x		Ro	
RUSP	M	x	x	x			x	x		
RUUR	M	x	x	x			x			
SALU	M	x	x	x			x	x		
SARA	M	x	x	x			x	x		
SCMI	M	x	x				x	x		
SESP	L	x				x			Np, Wd	Likes a little summer water
SOCA	M		x			x	x		Ri, Sa	
SPDO	L	x	x	x			x	x		
STCO										
SYAL	M	x	x	x		x	x		Gr, Sa, Wd	Neutral pH
TEGR										
THPL	M			x	x		x	x	Ac, Ri	
TITR				x	x		x		Or	
TOME				x	x		x		Hu, Or, Ri	
TSHE	M			x	x		x			Seedlings need shade
VAOVAT	L		x	x		x	x		Ac, Np, Wd	

VAPA	L		x	x		x	x		Ac, Ri, Or, Hu	
VIED		x	x	x			x		Co	
XETE	L	x				x	x		Pe, Wd	

Table 12: Plant health table key

Water Use Key		Soil Description Key			
H	High	Ac	Acidic	Or	Organic
M	Medium	Co	Cool	Pe	Peaty
L	Low	Gr	Gravely	Ri	Rich
		He	Heavy	Ro	Rocky
		Hr	Humus-rich	Sa	Sandy
		Lo	Loam	Wd	Well-Drained
		Np	Nutrient-poor		

Appendix C - Spray Records

Table 13: Example of spray record log

Applicator	Date	Time	Where	Pest	Chemical	Rate	Amount	Total Chemical	REI
Derek	6/8/2017	5:00 PM	SER Hoophouse	aphids, powdery mildew, rust	Neem oil	2 tbsp / gal	3 gal	6 tbsp	4 hours
Derek	6/20/2017	5:00 PM	SER Hoophouse	powdery mildew	Sunspray Hort. oil, baking soda, laundry detergent	1 tsp, 1 tsp, 0.5 drops / liter	8 liters	8 tsp, 8 tsp, 4 drops	4 hours
Derek	7/2/2017	6:00 PM	SER Hoophouse	powdery mildew	Sunspray Hort. oil, baking soda, laundry detergent	1 tsp, 1 tsp, 0.5 drops / liter	8 liters	8 tsp, 8 tsp, 4 drops	4 hours
Derek	9/13/2017	6:30 PM	SER Hoophouse	powdery mildew	Hort. oil, insecticidal soap, baking soda, laundry detergent	1 tsp, 5 tbsp, 1 tsp, 0.5 drops / liter	12 liters	12 tsp, 15 tbsp, 8 tsp, 3 drops	4 hours
Derek	9/30/2017	6:00 PM	SER Hoophouse	aphids	insecticidal soap	5 tbsp / gal	2 gal	10 tbsp	4 hours
Derek	10/17/2017	6:00 PM	SER Hoophouse	powdery mildew	Hort. oil, insecticidal soap, baking soda, laundry detergent	1 tsp, 5 tbsp, 1 tsp, 0.5 drops / liter	12 liters	12 tsp, 15 tbsp, 8 tsp, 3 drops	4 hours
Derek	11/3/2017	5:00 PM	SER Hoophouse	aphids	Pyrethrin, insecticidal soap	6.4 oz / gallon	2 gal	12.8 oz	12 hours

Appendix D - Crop Planning Schedule

Table 14: Example of a visual crop planning schedule

SER-UW Nursery Crop Planning Schedule																								
Stock Type	**Scientific Name**	**Common Name**	**Year**	YEAR 1					YEAR 2															
			Month	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC				
Seedling	*Abies grandis*	Grand Fir																						
	Acer Circinatum	Vine Maple																						
	Amelanchier alnifolia	Pacific Serviceberry																						
	Pseudotsuga menziesii	Douglas Fir																						
	Symphoricarpos albus	Snowberry																						
	Vaccinium ovatum	Evergreen Huckleberry																						
							Seed/Cutting Collection			Cold Stratification				Rapid Growth				Overwintering					
							Warm Stratification			Establishment				Hardening									