**The Evergreen State College**

**Graduate Program on the Environment**

### Thesis Prospectus

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**STUDENT AGREEMENT:**



**SIGNATURE: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ DATE\_**12/11/2020**\_\_\_\_\_\_**

**FACULTY READER APPROVAL:**

**SIGNATURE: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ DATE\_**12/11/2020**\_\_\_\_\_\_**

**MES DIRECTOR APPROVAL:**

**SIGNATURE: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ DATE\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

1. Provide the working title of your thesis[[1]](#endnote-1).

Quantifying the competition effects of Herb Robert (*Geranium robertianum*) on native forbs in mixed forest understory

1. In 250 words or less, summarize the key background information needed to understand your research problem and question.

Non-native plants become “invasive” if they reproduce and spread prolifically due to a lack of natural enemies and competition. Invasive plant species pose a threat to the biodiversity of native plant communities by outcompeting and replacing native species, often dominating entire ecosystems (Vitousek et al., 1997; Power & Sánchez Vilas, 2020). This results in a possible reduction in biodiversity and extirpation of native species (Meekins & McCarthy, 1999). These alterations to the composition of plant communities can displace wildlife by eliminating food sources and functional habitat, and disrupt pollinator networks and relationships, further inhibiting the success of native plants. In fact, invasion of non-native species is the second highest driving factor of biodiversity loss, behind only direct habitat loss (Carlson et al., 2010). In addition, while the extirpation or extinction of native species can be the consequence of invasives, reductions in species richness and habitat quality due to their presence can lead to long-term ecosystem changes that are not yet fully understood (Clavero & Garcia-Berthou, 2005).



Figure 1. Close-up photo of Herb Robert (Geranium robertianum). [Source: King County Noxious Weed Control Program]



Figure 2. Typical forest understory dominated by Herb Robert. [Source: King County Noxious Weed Control Program]

1. State your research question(s).
	1. What are the direct effects of the invasive species Herb Robert (*Geranium robertianum*) on the germination, growth, and establishment of native forbs?
	2. Is there evidence of an allelopathic effect of Herb Robert on native forbs?
2. Situate your research problem within the relevant literature. What is the theoretical and/or practical framework of your research problem?

The impacts of non-native and invasive species have been a growing concern, producing a new branches of study within biology and ecology—invasion biology and restoration ecology, respectively—aimed at addressing invasive species and restoring native ecosystems (Simberloff & Von Holle, 1999). Additionally, experts continue to discuss the impacts of invasive species, often without providing a specific definition of impact (Parker et al., 1999). They use the term equally for different plants with varying degrees of effects on native ecosystems. Parker et al. (1999) suggested quantifying impact by looking at range, abundance, and the per-biomass effect of the invader. However, the issue of quantifying the impacts of non-natives/invasives is further confounded by the presence of multiple invasives, as well as other environmental stressors (i.e. anthropogenic disturbances). The interactions of multiple invasives – invasional meltdown – may impact ecosystems on a larger scale than what would be expected if their impacts were measured individually (Simberloff & Von Holle, 1999). Other biotic and abiotic factors influence the degree of impact – pollinators, seed-dispersers, herbivory patterns, soil type, and fire regimes.

When assessing the impact of invasive species, researchers commonly assess their economic cost in terms of damage or eradication efforts (Parker et al., 1999). This method can be limiting and focuses primarily on human needs, favoring short-term outcomes over long-term consequences and ignoring ecosystem function as a factor. Quantifying the value of ecosystem function remains problematic, as it also requires placing a human-based measure of value on a non-human system. Additionally, limited funding can emphasize measures of impact that directly correlate to costs, especially in agricultural regions. This leaves a gap of information for invasive species with impacts that are not of immediate economic importance. These species would benefit from further study focused on their success and interactions with recipient plant communities, such as allelopathy and seed-dispersal methods, to assess their impacts – without regard to economics.

Del Fabbro et al. (2013) and others argue that allelopathy is one of several mechanisms that contribute to the success of invasive species (Callaway & Ridenour, 2004). Allelopathic compound producing plants quickly dominate recipient ecosystems that possess no adaptation or tolerance to the compounds. These compounds can suppress the germination and growth of native species (Carlson et al., 2010, Del Fabbro et al., 2013). The advantage gained by invasives with this property was termed the “Novel Weapons Hypothesis” by Callaway and Ridenour (2004) to explain why some invasive species are so successful in recipient ecosystems. No longer suppressed by specialist consumers or other competitive plants in their native habitat, these species flourish and dominate quickly. Interestingly, allelopathic potential has primarily been supported and assessed in controlled laboratory experiments but lacks robust evidence from field studies (Del Fabbro et al., 2013).

Two well-studied invasive plant species offer a practical framework on how to investigate the potential impacts of Herb Robert on native species composition and biodiversity: Bromus tectorum (cheatgrass) and Alliaria petiolate (mustard garlic). Both of these invasive species have spread rapidly in North America, altering Great Basin shrub-steppe and Northeastern woodland ecosystems, respectively. Mustard garlic is particularly useful as a model for studying Herb Robert due to its status as an aggressive invasive with the ability to invade mature, undisturbed forests. Similar to Herb Robert, mustard garlic displaces native herbaceous plants in forest understory after establishment (Meekins & McCarthy, 1999).

1. Explain the significance of this research problem. Why is this research important? What are the potential contributions of your work? How might your work advance scholarship?

The Puget Sound region is home to many invasive and non-native plant species which can impact ecosystems by crowding out beneficial native species and reducing biodiversity (English ivy, Himalayan blackberry, and purple loosestrife, to name a few). Originally from Europe and Asia, Herb Robert adapts easily to many different plant communities, especially woodland communities. It spreads quickly and creates large, monoculture patches in the forest understory. While not as prolific in open or dry environments, Herb Robert grows outside of shaded forest understory, allowing it to spread via roadsides and cleared land. Its ability to spread easily and quickly, and dominate forest understory has led to its being listed as a Class B noxious weed by the state of Washington (WA NWCB).

Few researchers have examined the impacts of Herb Robert on native woodland/forest understory species. Able to winter over and survive deep frost, Herb Robert gains a competitive edge over frost tender native forbs. As a result, its long growing season allows it to compete with many taxa of native species with divergent phenologies – early, mid-, and late seral species. Fewer native herbaceous species grow where it occurs but the exact mechanisms responsible for Herb Robert’s success as an invader are not fully understood (WA NWCB). Herb Robert’s success could be attributed to many of its characteristics: explosive seed dispersal; sticky seeds capable of being transported by insects, animals, and humans; large quantity of seed set per plant; seeds viable in soil for up to 6 years; and suspected allelopathy (Carlson et al., 2010; Tofts, 2004). Additionally, Herb Robert produces a pungent odor in its stem and foliage and is not palatable to wildlife, giving it no competition from herbivory.

The Washington State Noxious Weed Control Board lists Herb Robert as a Class B weed—weeds whose distribution is limited in some regions, but wide spread in others. Prevention of new infestations is their goal, and as such, its removal from property is encouraged but not required in all counties. The Thurston County Noxious Weed Control Board does not list Herb Robert despite its presence here. This could be due to priorities and resources placed on species that directly impact human health, livestock, and agriculture. Changing its status to one that requires control and removal might be necessitated if it can be shown that the species causes more damage to ecosystems or spreads more rapidly than previously thought. Understanding the level of competiveness exhibited by Herb Robert through an analysis of native species biomass production in the presence and absence of Herb Robert would be beneficial to land managers and noxious weed boards in addressing and combating this invasive species.

1. Summarize your study design[[2]](#endnote-2). If applicable, identify the key variables in your study. What is their relationship to each other? For example, which variables are you considering as independent (explanatory) and dependent (response)?

I will examine the potential impacts Herb Robert has on the germination, growth, and development of native forbs (species to be determined). Specifically, I will look at the germination rate of native forb seeds in the presence and absence of Herb Robert as well as the total above and belowground biomass of native forbs grown in the presence and absence of Herb Robert. Given the success of Herb Robert as an invasive species, this study will attempt to quantify the mechanism responsible – does Herb Robert inhibit the germination and growth of native forbs or outcompete them? An additional treatment will examine the potential allelopathic capacity of Herb Robert with the use of activated charcoal to absorb toxins. Plants will be grown in 1-gal pots with treatments and controls receiving equal amounts of seed or plugs as well as water and light. Each treatment will be replicated at least five times.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Treatment | Control | Explanatory | Response | Question Addressed |
| 1) Herb Robert plugs + native forb seeds | Native forb seeds | Presence/absence of Herb Robert | Germination rate & Biomass of native forbs | a |
| 2) Native forb plugs + Herb Robert seeds | Native forb plugs | Presence/absence of Herb Robert | Biomass of native forbs & germination rate of Herb Robert | a |
| 3) Plugs of Herb Robert + native forb seeds + activated charcoal | Plugs of Herb Robert + native forb seeds | Presence/absence of activated charcoal | Germination rate & Biomass of native forbs | b |

1. Describe the data that will be the foundation of your thesis. Will you use existing data, or gather new data (or both)? Describe the process of acquiring or collecting data[[3]](#endnote-3).

I will collect new data for my thesis. I will gather data using greenhouse plots for each treatment group. After a predetermined period of time, germination rates for the treatment and control groups will be counted. Total dry weight biomass will be analyzed by harvesting plants, separating the shoots from the roots then drying and weighing.

1. Summarize your methods of data analysis. If applicable, discuss specific techniques that you will use to understand the relationships between variables (e.g., interview coding, cost-benefit analysis, specific statistical analyses, spatial analysis) and the steps and tools (e.g., lab equipment, software) that you will take to complete your analyses.

After drying and weighing the samples, I will compare the samples means of dry biomass for each treatment group and its respective control using a parametric statistical analysis (two-sample/independent t-test) on R statistical software. Similarly, I will compare the samples means of germination rates. Germination rates and dry biomass will be interpreted as proxies for interspecific competition between the native forbs and Herb Robert. Depending on where I source my plants and seeds from, I may have to consider source as a covariate in my analyses.

1. Address the ethical issues[[4]](#endnote-4) raised by your thesis work. Include issues such as risks to anyone involved in the research, as well as specific people or groups that might benefit from or be harmed by your thesis work, perhaps depending on your results. List any specific reviews you must complete first (e.g., Human Subjects Review or Animal Use Protocol Form).

No Human Subjects Review or Animal Use Protocol necessary for this research project. Those who would benefit from my thesis work would likely be limited to noxious weed control boards and others researching invasive species and biological invasions. Ethical issues include careful use and disposal of Herb Robert plants and seeds used in the research project. While there are no specific county or state regulations related to disposal of Herb Robert, best practices involve bagging plants and placing them in the garbage.

1. List specific research permits[[5]](#endnote-5) or permissions you need to obtain before you begin collecting data (e.g. landowner permissions, agency permits).

No known permits at this time. Herb Robert is not included on the State NWCB’s “Quarantine List,” so obtaining seed for the research experiment, if necessary, is not illegal and would not require any special permits. Collecting mature Herb Robert plants for transplant into the experimental plots would require verbal permission from my neighbors.

1. Reflect on how your positionality as a researcher could affect your results and how you will account for this in the research process[[6]](#endnote-6).

While I have a background education in science (geology), I am new to this particular field and am perhaps more strongly dependent on the knowledge, perspectives, and analyses of others compared to those with more experience. This intersects with my long history of place – my family has been in Washington for five generations – which involves a strong personal connection with the Puget Sound region. I recognize that this personal connection with the region and its flora and fauna gives me a negative bias toward non-native and invasive species. As such, I need to be cognizant of this while collecting and interpreting my thesis data.

1. Provide at least a *rough* estimate of the costs associated with conducting your research.  Provide details about each budget item so that the breakdown of the final cost is clear.

|  |  |  |  |
| --- | --- | --- | --- |
| Need | Description | Source | Cost |
| Supplies | 1-gal plastic pots | Donations, local nurseries, online | $75 |
|  | Soil medium (peat moss, sand, perlite) & charcoal | Local nurseries, online | $275 |
|  | Grow lights & scale | Loan (SSC) | $0 |
|  | Native seed & plugs | Nurseries, WA NPS, local sources | $300 |
|  | Herb Robert seed & plugs | Local (backyard, neighborhood) for plugs, possibly online for seeds | $100 |
|  | Plastic netting to protect plants | Online | $25 |
| Direct Cost | Electricity bill increase | Increase use due to grow lights and room temperature regulation | $200 |
| Total cost | ~$975 |

1. Provide a detailed working outline of your thesis.

**Thesis introduction**

1. Title page
2. Signature Page
3. Table of Contents
4. List of figures
5. List of tables…
6. Acknowledgements
7. Funding
8. People

**Written Introduction**

1. Topic introduction
2. Broad – Biological Invasions/Impacts to ecosystems
3. Narrow – Herb Robert in WA (Maps of coverage?)
4. What this thesis will address
	1. Research Question(s)
		1. 1 – Competition effects
		2. 2 – Potential allelopathy
	2. Positionality statement

**Literature Review**

1. Literature Review
	1. Introduction
		1. Thesis Statement
	2. Herb Robert
		1. *Description*
		2. *Distribution*
		3. *Habitat*
		4. *Reproduction*
	3. Invasion Biology
		1. *Invasive species*
		2. *Mechanisms for Invasion*
			1. *Novel Weapons Hypothesis/Allelopathy*
		3. *Invasional Meltdown*
		4. *Biotic Homogenization*
	4. Ecological Impact of Invasives
	5. Invasive Species Management
	6. Experimental Frameworks
		1. *Mustard Garlic & Cheatgrass case studies*
	7. Conclusion and Transition

**Methods**

1. Roadmap
2. Experimental Design/description(s)
3. Pictures/diagram (?)
4. Method the first: data / sample collection
5. Rationale
6. Description
	1. Example photographs
7. Benefits and limitations
8. Method the second: sample analysis
9. Rationale
10. Description
11. Benefits and limitations
12. Method the third: data analysis
13. Statistical analyses (germination, biomass (no charcoal), biomass (charcoal))
14. Test #1
	1. description & rationale
	2. This method was used to answer <1>
	3. Limitations & utility
15. Test #2:
	1. description & rationale
	2. This method was used to answer <2>
	3. Limitations & utility
16. Test #3:
	1. description & rationale
	2. This method was used to answer <3>
	3. Limitations & utility

**Results**

1. Introduction and roadmap
2. Data / sample collection details
3. What went wrong
	1. Acknowledge and
4. What went right
5. Summary of all data produced
6. Tables!
7. Written description
8. Basic figures (descriptive)
9. Statistical tests and results (R charts/graphs)
10. Transition

**Discussion & Conclusion**

1. Introduction and roadmap
2. Summary of key results
3. Recap of highlights
4. Interpretation of results
5. Correlation and / or causation
6. Figures (analytical and / or explanatory)
7. What was expected
8. What was unexpected
9. Conclusions based on just this data
10. Connecting results to framework / context
11. What agrees with previously published work
12. What is different than published work
13. Conclusions based on agreement / disagreement with published work
14. Final conclusions
15. Big picture meaning & implications for broader work (Local, regional, global?)
16. Directions for future research

**References**

Zotero list

Additional information / supplementary tables / Raw data / R Code (?)

1. Provide a specific work plan and a timeline for each of the major tasks in the work plan. Be as realistic as you can, even though you will probably need to alter this schedule as you complete the tasks. Remember that faculty readers take time to return your drafts and that the final polishing and formatting of your thesis for binding will take longer than you ever imagined.

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| --- | --- | --- |
| Activity | Start Date | Due Date |
| \*\*Poster | **11/20/20** | **12/03/20** |
| \*\*Final thesis prospectus |  | **12/06/20** |
| \*\*Prospectus to MES Director |  | **12/11/20** |
| Prospectus: Complete draft | **10/26/20** | **10/30/20** |
| Lit Review: Working Outline | **11/01/20** | **11/08/20** |
| Lit Review: 1st paragraph & thesis statement | **11/04/20** | **11/12/20** |
| Prospectus Draft 2 | **TBD** | **11/15/20** |
| Lit Review: Topic 1 | **11/16/20** | **11/19/20** |
| Lit Review: Topic 2 | **11/20/20** | **11/24/20** |
| Lit Review: Topic 3 | **11/25/20** | **11/28/20** |
| Lit Review: Working Draft |  | **11/29/20** |
| Methods: Germination | **TBD** | **TBD** |
| Methods: Dry weight biomass | **↓** | **↓** |
| Introduction: Invasion Bio ? |  |  |
| Introduction: other ? |  |  |
| Analysis: Germination |  |  |
| Analysis: Dry weight biomass |  |  |
| Results: Germination |  |  |
| Results: Dry weight biomass |  |  |
| Discussion |  |  |
| Conclusion |  |  |
| \*\*Complete Draft to Reader |  | **04/09/2021** |
| Prepare presentation |  |  |
| Revisions |  |  |
| Formatting |  |  |
| \*\*Request to present |  |  |
| \*\*Thesis Presentations |  |  |
| \*\*Final thesis to Reader |  |  |
| \*\*Final thesis to MES Director |  |  |

1. Who, beyond your MES faculty reader, will support your thesis? Indicate support both within and outside of Evergreen. Be specific about who they are and in what capacity they will support your thesis. If you are working with an outside agency or expert, be specific about their expectations for your data analysis or publication of results.

Support within MES cohort: Claire Olson, Adam Martin, & Savannah Richards

Family support: Mom will help with executing research project (setup, monitoring, watering, etc)

Additional/future support: TBD

1. List the 3-5 most important references you have used to identify the specific questions and context of your topic, help with issues of research design and analysis, and/or provide a basis for interpretation. For each annotated reference, explain how your project specifically connects to the source by extending, challenging, or responding to the conclusions, methods, or implications. For any other sources cited in this document provide a complete bibliographic citation.

Callaway, R. M., & Ridenour, W. M. (2004). Novel Weapons: Invasive Success and the Evolution of Increased Competitive Ability. *Frontiers in Ecology and the Environment*, *2*(8), 436–443.

* The authors introduce a new concept on why some invasive species are so successful at dominating recipient communities. Specifically, they are looking at chemicals that the plants exude (allelopathic compounds) that the novel ecosystems have no adaptations or defenses against. They’ve termed this concept the “Novel Weapons Hypothesis.” They argue that the evolutionary selective advantage of possessing allelopathic compounds may result in the rapid evolution of higher quantities of the compound or compounds that target other adjacent species when introduced to a new/novel ecosystem, thus increasing their ability to dominant and rapidly spread.

Leger, E. A., Goergen, E. M., & Forbis de Queiroz, T. (2014). Can native annual forbs reduce Bromus tectorum biomass and indirectly facilitate establishment of a native perennial grass? *Journal of Arid Environments*, *102*, 9–16. https://doi.org/10.1016/j.jaridenv.2013.10.015

* Experimental study involving restoration efforts against invasive cheatgrass. The authors used the basic ecological principle of plant community succession to determine whether mimicking natural plant succession and heavy seeding of native forbs could outcompete invasive cheatgrass. The native forbs used were a disturbance-oriented species and phenologically similar to cheatgrass, meaning they would likely be more competitive than native perennial forbs. They used both field and greenhouse experiments and analyzed their data using ANOVA. Their results indicated that three of the seven native species were effective at competing with cheatgrass. This paper offers an excellent framework that can be applied to other studies on invasive species.

Meekins, J. F., & McCarthy, B. C. (1999). Competitive Ability of *Alliaria petiolata* (Garlic Mustard, Brassicaceae), an Invasive, Nonindigenous Forest Herb. *International Journal of Plant Sciences*, *160*(4), 743–752. https://doi.org/10.1086/314156

* Practical framework study that looked at the competitive ability of A. petiolate (garlic mustard). This study is particularly useful as a case study for Herb Robert due to the similarities between the plants. For their study the researchers seeded native species with garlic mustard in greenhouse plots and measured the aboveground dry-weight biomass (yield) which was used to calculate a mean “aggressivity” index. This is a useful framework for determining which natives offer a competitive edge against invasives as well as which natives may be particularly vulnerable to invasives.

Tofts, R. J. (2004). Geranium robertianum L. *Journal of Ecology*, 20

* In-depth descriptive botanical study of *Geranium robertianum* (Herb Robert) as a native species on the British Isles. This study also offers a list of plants often found in association with Herb Robert. Several of these associated species have likewise been introduced in our region. Useful reference for specific characteristics of this plant.

Rua, M., Somereet, N., Johnson, A., Rogers, W., & Siemann, E. (2008). Experimental approaches to test allelopathy: A case study using the invader Sapium sebiferum. *Allelopathy Journal*, *22*(1), 1–14.

* Study that delves into different experimental approaches to determine allelopathic potential of invasive species. Discusses the theoretical framework of “Novel Weapons Hypothesis” and offers three different experimental designs to test the validity of the hypothesis using an invasive species of tree from China. The experimental designs can be used as an example for developing appropriate experiments for Herb Robert.
1. You are not locked into this title; its purpose is to help you identify the main point or topic of your thesis at an early stage. [↑](#endnote-ref-1)
2. You might discuss selection of case studies, sampling methods, experimental design, and/or specific hypotheses you will test. You should also address any specialized knowledge or skills that are necessary to complete the research. [↑](#endnote-ref-2)
3. If you are planning to use existing data, explain the specific source, contact information, arrangement with collaborating agencies, and expectations about use of data and final products of your research. If you are planning to gather new data, describe specific methods, time, place, and equipment that will be required. [↑](#endnote-ref-3)
4. If you’re not sure where to start, consult a ‘Code of Ethics’ or other similar document from an academic society in an applicable field of study. [↑](#endnote-ref-4)
5. If you are collecting ANY samples or data, even observational data, on public lands (city, county, state and/or federal) it is your responsibility to find out the permit requirements BEFORE you collect data. Conducting research with tribal members/on tribal lands will have different and additional requirements. [↑](#endnote-ref-5)
6. Your *positionality as a researcher* refers to the fact that one’s “…beliefs, values systems, and moral stances are as fundamentally present and inseparable from the research process as [one]’s physical, virtual, or metaphorical presence when facilitating, participating and/or leading the research project…” (The Weingarten Blog 2017). [↑](#endnote-ref-6)