**The Evergreen State College**

**Graduate Program on the Environment**

### Thesis Prospectus

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| **Name** | **Tim Atkinson** | | | **ID Number** | **A00420693** |
| **Mailing Address** | | | **3323 Windolph Loop NW APT B** | | |
|  | | | **Olympia, WA 98502** | | |
| **Telephone** | | **(360)-320-3875** | |
| **E-mail** | | **Atktim28@evergreen.edu** | |

**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).

**Garry Oaks: An Analysis of Seedling Survival and Growth in JBLM Prairie Restoration Sites**

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

Prairie/oak ecosystems (commonly referred to as prairies, grasslands, woodlands, savannas and meadows dominated by Oak and grasses) once encompassed huge swaths of land in the Willamette Valley-Puget-Trough-Georgia Basin (WPG), extending 600 km from Vancouver Island in the north to Willamette Valley in the south and including parts of British Columbia, Washington, and Oregon. The ecoregion spans a wide spectrum of various hydrologic and soil conditions. Although the WPG occupies less than four percent of the total land area in WA, OR and BC, 75% of the combined regional population live in areas that either partially or totally include the WPG ecoregion. In western Washington, grasslands have been reduced by approximately 91%, with the largest remaining acreage found on Joint Base Lewis McChord (JBLM) (Dunwiddie & Bakker, 2011). These habitats support sensitive wildlife species including two federally endangered species: Taylor’s checkerspot butterfly (*Euphydryas editha taylori*) and the Mazama pocket gopher (*Thomomys mazama*). The oak stands found on JBLM fall under the Existing Endangered Species Management Plan’s (ESMP) jurisdiction. Therefore, these prairies must be maintained and restored to benefit sensitive wildlife while supporting their military-training value. The military utilizes the open prairies for artillery firing practice. Oak habitat degradation is a result of conifer encroachment due to lack of fire, introduction of exotic and invasive species along with the decline of native species, and overall habitat loss due to construction. Oak growth and survival relies on the existing symbiosis between the trees and mycorrhizal fungi (Zaady & Perevolotskyb, n.d.).

1. State your research question(s).

Does mycorrhizal inoculation affect the rate of first year survival or growth of Garry Oak seedlings in prairie-oak restoration sites on Joint Base Lewis McChord in Washington State?

1. Situate your research problem within the relevant literature. What is the theoretical and/or practical framework of your research problem?

Prairie and oak savannas in the WPG have endured extreme levels of degradation and are now highly endangered in North America (Stanley et al., 2011) Historically, Native Americans’ frequent burning of these habitats helped maintain them. However, fire suppression, habitat fragmentation, development, species invasion and native species decline have contributed to their increasing rarity in the WPG ecoregion and the South Puget Sound specifically (Dunwiddie & Bakker, 2011). Conservation efforts have increased over time and regional collaborations have occurred at extraordinary levels, as highlighted in the 24 papers published in a special issue of *Northwest Science,* thejournal of the Northwest Scientific Association, and the creation of the Cascadia Prairie-Oak Partnership (CPOP) (Dunwiddie & Bakker, 2011). These academic articles discuss the importance of conserving and restoring prairie and oak savannas to protect sensitive species and preserve the rare habitats they support.

Garry Oak (*Quercus garryana)* is the only oak species native to the Pacific Northwest and encompasses an important ecological role in prairie and oak savannas. It exists in multiple stand types, including, oak savanna, closed-canopy woodlands associated with prairie edges and mixed conifer-oak woodlands. Garry oaks support associated native flora and fauna in three main ways. First, oak acorns are an essential food source for numerous mammals. Second, oaks act as homes for reptiles, birds, mammals, amphibians, and many plant species. Third, if allowed to establish (through the use of fire to limit competition), oaks shade out invasive species, allowing shade-tolerant natives to grow. Often, species richness is higher in areas dominated by oaks than adjacent conifer forests. Moreover, Garry oaks are essential for maintaining ecosystem resilience and species diversity and must be supported by restorationists (Gould et al., 2011).

Although a number of academic articles analyze variables responsible for Garry oak survival, scholarship focusing on tree survival rates after planting in South Puget Sound (SPS) prairies is lacking. Gould et al., (2011) address this dearth of information and note the lack of information about oak growth rates and survival in restoration projects. The authors utilize multiple multi-year growth studies to evaluate variables responsible for growth and survival.

The variables responsible for oak seedling survival are highly dependent on the site characteristics and trophic dynamics present, which heightens the salience of my research in that differences exist in vegetation cover, planting orientations, soil types, topography and proximity to established oak stands in the six planting sites. Of the studies focusing on seedling survival of Garry oaks, few acknowledge the role mycorrhizal fungi play in oak seedling survival and success over time.

Garry oak survival requires the development of mycorrhizas in seedling lateral root tips. Mycorrhizal association is the process by which certain fungi colonize the roots of host plants through the creation of fungal strands (known as hyphae) either around the existing roots or within the host’s cellular root structures. The former describes ectomycorrhizal fungi, and the latter, arbuscular mycorrhizal fungi (AMF), also known as endomycorrhiza (Valentine et al., 2009). Mycorrhizal inoculation benefits the host plant through hyphae extending the ability of the tree to access water and nutrients deeper in the soil. Inoculation also helps protect against harmful organisms and diseases. In return, the host plant provides sugars (through photosynthesis) to the associated fungi. People working in nursery settings often ignore this symbiotic relationship, although it has been the subject of increasing levels of awareness in the ecological community (Gould et al., 2011).

Southworth et al., (2009) highlight the lack of awareness regarding mycorrhizal inoculation in nursery and field plantings. As part of their study, the authors analyze the morphology of mycorrhizas from oaks that grew in a nursery (n = 40) and oaks from field sites (n = 9). They compare seedling height, trunk diameter and basal growth area over multiple growing seasons and identify mycorrhizal phylotypes through DNA analysis. The results indicate seedlings grown in the field acquired a higher diversity of ectomycorrhizal species, none of which were identified on the nursery seedlings. Furthermore, the seedlings that were infected with inoculum “correlated positively with height, root biomass, height growth, and basal growth…” (Gould et al., 2011; p. 157). However, the authors indicate they are unsure how the differences in mycorrhizal communities between nursery and field grown seedlings will affect seedlings after they are planted. They acknowledge certain types of fungi perform better than others in association with oaks but before mycorrhizal preference becomes dominant, growth could be negatively impacted. Although my research will not include DNA analysis and includes seedlings that were artificially inoculated, my sample size is much larger (n=1,050) which increases the statistical power of my results and will lead to robust conclusions about the variables responsible for survival and growth.

In winter 2019 1,050 Garry oak seedlings were planted in six different sites at JBLM, half inoculated with mycorrhizae and half not inoculated. Inoculation requires additional time and resources and its long-term success as a restoration treatment is relatively unknown. My research will analyze the first-year survival and growth of these seedlings to ascertain whether inoculation makes a statistically significant difference in that first-year survival. Understanding the importance of artificial inoculation and variables responsible for seedling survival and growth lie at the heart of my research. If there is not a statistically significant difference in size (height and trunk diameter) or survival rates between inoculated and non-inoculated oaks, it may be a result of viable fungi communities already existing in relative abundance in planting sites. Some of the replanting sites at JBLM lie close to established oak stands, and although artificial inoculant was applied to half the seedlings, that procedure may have a negative impact on their performance and survival. I aim to unveil variable associations and possible correlations between growth and survival rates with inoculation, soil type, planting orientation (slope direction if present), site to site proximity, and site proximity to established oak stands.

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?

Although the relationship between mycorrhizae and Garry oaks has been studied with some fervor in the scientific community for decades, there has never been an analysis in replanted JBLM sites of first-year oak survival with inoculation as an independent variable. Determining whether inoculation makes a significant difference among the study groups may produce results that could help in future conservation planning efforts, reduce costs and lead to greater long-term regional ecosystem resilience. On a smaller scale, it will help planners understand which sites within JBLM are the most suited for oak survival and where resources should be efficiently allocated. My research can aid in preserving this rare type of habitat and the sensitive wildlife it supports through increasing the collective understandings of mycorrhizal inoculation in Garry oak prairie restoration sites. In addition, this project highlights the importance of government and non-government partnerships through the collaboration between the Sustainability in Prisons Project (SPP), JBLM Fish and Wildlife and the U.S. military. The power of these partnerships has allowed restoration efforts to occur and my study to be feasibly conducted.

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 extracted the design for this study from conversations with my boss Dennis Buckingham and the JBLM Fish and Wildlife’s Oak Planting Report. The Oak Planting Report outlines a concerted effort to restore South Puget Sound (SPS) prairies by enhancing habitats for federally listed endangered species, as required under the Endangered Species Act and the Existing Endangered Species Management Plans (ESMP). In this case, Taylor’s checkerspot and Mazama pocket gophers are the targeted species and require open prairies without dense understories to thrive (*JBLM Fish and Wildlife :: Joint Base Lewis-McChord*, n.d.). The replanting efforts were not carried out with the intention of being studied scientifically on an individual level, but merely to enhance habitat through successful seedling survival and long-term establishment. Therefore, I will analyze independent and dependent variables retrospectively and utilize the survival, height, and trunk diameter data I gathered this fall to unveil possible variable associations responsible for survival or growth, but it will not be as robust due to a lack of a full factorial design. I will use descriptive and inferential statistics to determine the survival rates of inoculated and non-inoculated oak seedlings, grouped by the six planting locations. Following is a table of variables.

Seedling Survival

* Independent Variables
  + Planting Site
  + Age of Seedlings
  + Soil Type
  + Site proximity to established oak stand
  + Inoculation
* Dependent Variables
  + Survival rate
  + Height of seedlings
  + Trunk diameter

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).

Interns, active duty military personnel and I collected the data that serves as the foundation of my thesis. During October and November of 2020, we drove to the various planting sites and geolocated each seedling, determined if the tree was alive or dead, whether or not it had been inoculated, the height (cm), and the trunk diameter 10 cm. from the ground. We used white zip-tie (to signify the tree had been inoculated) and a black zip-tie (to designate not inoculated). These zip ties were attached to the blue protective tube encased over each seedling immediately after planting. The data are reflected in the Arc GIS collector application as individual points with notes commenting on the aforementioned information. I may need to go back out into the field and attain more measurements to better characterize the site conditions.

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.

Survivability is measured on a bivariate scale, while means between groups (six planting sites) will be compared using t tests to highlight possible group differences in survival and or other measures of success (such as tree height). Variables including site to site proximity, soil type, adjacent canopy cover and proximity to established oak stands will be statistically analyzed using multiple logistic regression because there will be more than one independent variable under analysis. Furthermore, I will use GIS to visually represent my data and highlight specific variables that might be responsible for differences in dependent variables. GIS will also allow me to clearly demonstrate the extent of planting, current restoration size and future conservation possibilities through geospatial 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).

There are several potential ethical issues involved in this research: 1) Acknowledging indigenous groups’ historical role in maintaining oak/savannah landscapes, and 2) Properly crediting individuals who have helped shape my thesis.

First, although I am analyzing the survival of replanted Garry oak seedlings in multiple sites on JBLM land, the ability to do so is a result of my positionality as a white male in this society and a product of settler colonialism in general. JBLM sits on what was primarily Nisqually tribal land, and the prairie landscapes exists because of periodic burning conducted by indigenous members in an effort to promote ecological health and manage resources up until removal 150 years ago at the time of the Medicine Creek Treaty (Wilkinson, 2005). The inequities that have allowed the physical landscape to exist and me to study them must be properly acknowledged in my thesis to avoid silencing groups and or ignoring important histories.

The second ethical pitfall I must avoid is not adequately crediting those responsible for the existence of my research questions and data. The 1000 oak seedlings that are the subject of my thesis are the product of work done by the Sustainability in Prisons Project (SPP) and numerous other groups. Contacting relevant groups responsible for planning, those in charge of nursing the seedlings and deciding on inoculation methods needs to be a part of my research because their knowledge and expertise will help bolster any claims I plan to make. In addition, my research could come into conflict with current conservation methods. For example, if results of my survival analysis show inoculation does not make a significant impact on seedling survival, that potentially renders the time and effort expended to inoculate the seedlings as a waste. Therefore, I want to make sure that I am being sensitive to those who have put forth a lot of time and effort into oak/savanna restoration.

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).

I have already gathered some of the data (survival rates) I will need, except for soil maps which are available to the public and don’t require permits. I am planning to go back into the field with a team to measure trunk diameter and height. I am currently an intern for the Department of Fish and Wildlife at JBLM and have therefore already acquired the permit I need to access the planting areas, and have already received the packaged survival data from the resident GIS expert on base.

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).

As a white male I must acknowledge how my position of power and privilege in society has allowed me to create this research project and collect data. I have faced few barriers in my attempts to work at JBLM as a restoration intern, attend The Evergreen State College as an MES student and subsequently conduct my thesis research and acquire assistance. My presence as a researcher in this environment perpetuates troubling norms currently present in the environmental field. I hope to help disrupt these norms by using my privilege to call in a diverse group of voices to comment on my project and highlight incongruities I may not have accounted for. I will discuss the collaboration I have participated in as an intern at JBLM and the partnerships between active duty military and non-military students that have allowed me to collect data in a timely manner.

In addition, I must discuss the histories that have resulted in JBLM existing as a military base and how settler colonialism has negatively impacted prairie/oak landscapes through forced removal of indigenous people and a lack of active management. Prairie/oak ecosystems would not exist without frequent burning by tribal members and it would be unethical to ignore that in my research or results discussion.

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.

At this point the only costs I have accrued have been the gas required to commute to my internship, and I would be driving that distance regardless of my thesis.

1. Provide a detailed working outline of your thesis.





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.

Attached is my Ganntt chart.

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.

Dennis Buckingham is my boss and mentor at JBLM department of fish and wildlife who pointed me in the direction towards this research, John Withey (MES) has advised me in my study design and overall result discussion and has agreed to help me with statistics, Carl Elliot at SPP has provided information on the seedlings and inoculation methods, multiple. fellow MES students have acted as sound boards, Mike Ruth will supply GIS advice. There are no publishing expectations, although Dennis agreed to help with that process if I choose to take that route.

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.

Dunwiddie, P. W., & Bakker, J. D. (2011). The Future of Restoration and Management of Prairie-Oak Ecosystems in the Pacific Northwest. *Northwest Science*, *85*(2), 83–92. <https://doi.org/10.3955/046.085.0201>

This source offers essential information regarding the extent and historical conversion of oak-dominated landscapes within the Willamette Valley Puget Trough-Georgia Basin (WPG) ecoregion into predominantly agricultural lands. This background is important for my research because my study sites are within the WPG and are being actively managed to promote oak savannah, closed canopy prairie edge woodlands and mixed conifer-oak woodlands. This article also describes the important and varied ecological roles prairie/oak ecosystems play and the biodiversity loss that has occurred as a result of their degradation. Additionally, the authors highlight the future challenges organizations and land-owners face when attempting to restore oak/savannah landscapes and the need to take a holistic approach.

Dunwiddie, P. W., Bakker, J. D., Almaguer-Bay, M., & Sprenger, C. B. (2011). Environmental History of a Garry Oak/Douglas-Fir Woodland on Waldron Island, Washington. *Northwest Science*, *85*(2), 130–140. <https://doi.org/10.3955/046.085.0205>

The authors of this piece convey the importance of understanding historical ecosystem conditions in Garry Oak/ Douglas-fir woodlands in order to realistically plan ecological restoration goals. This is pertinent to my research topic because the planting sites I am evaluating and the determination to inoculate half of the seedlings were partially based on a holistic understanding of historic conditions. For readers to understand variables responsible for survival it is necessary to analyze how the land has changed over time, what has contributed to habitat degradation and how that affects future site selection and inoculation.

Frank, J., Barry, S., & Madden, J. (n.d.). *Oaks Belowground: Mycorrhizas, Truffles, and Small Mammals*. 8.

Inherent to understanding oak survivability is having a clear comprehension of mycorrhizal and Garry Oak, also known as Oregon White Oak, symbiosis. This source explains the mutually beneficial process by which Garry Oaks form ectomycorrhizas with many different species of fungi and how natural inoculation occurs through mammalian distribution. An important reason the seedlings in my research were created was to help create habitat for sensitive wildlife species who’s populations are currently threatened.

Pande, V., Palni, U. T., & Singh, S. P. (2007). Effect of ectomycorrhizal fungal species on the competitive outcome of two major forest species. *Current Science*, *92*(1), 80–84. JSTOR.

This journal article unveils how certain types of mycorrhizae positively contribute to tree survivability and plant growth when competing with other plants. I need to fully understand the various types of fungi involved in oak inoculation to analyze my study groups and potential variables responsible for survival and mortality. The authors unpack the process by which Garry oaks require fungi to provide essential nutrients in exchange for carbohydrates, which is a key variable I am analyzing.

Zaady, E., & Perevolotskyb, A. (n.d.). *Enhancement of growth and establishment of oak seedlings (Quercus ithaburensis Decaisne) by inoculation with Azospirillum brasilense*. 3.

Zaady, E., & Perevolotyskyb, A. provide foundational knowledge in their article about the importance of inoculating oak seedlings to improve their development while in nursery environments. Because all of the oak seedlings under my research scope were started in a nursery, I need to understand the methods of growth and inoculation and why such methods were selected. This source provides the biological evidence to support inoculation and could supply some of the answers to my research question.

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)