DOES THE ESTABLISHMENT OF BROADCAST MILKWEED SEEDS VERSUS CONTAINERIZED PLUGS DIFFER IN WILLAMETTE VALLEY RESTORATION PLOTS?

by

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DEDICATION

I dedicate this to my family.

To my husband Colin. His passion for his work and the environment is contagious. My passion increased, just being around him and discussing the difficulties he faces with restoring habitat.

To my son, Ronan, whom I hope to pass the passion for being outside in nature will turn him into an eco-citizen ready to preserve habitat like his dad, in whatever way he chooses. Only we as active citizens can make a difference.

To my mother, Penny. She made sure we got out and went camping and exploring while growing up. She is the true root of my love for being outdoors and in nature. Most of my best memories are from those times. And to my sister, Kiara, with whom I share the love of being outside and exploring new places on Earth. We started in Yellowstone and Glacier National Parks and have made it as far south as Costa Rica. I can't wait to continue these adventures.

Thank you to all my family as they have seen me struggle to find time to accomplish my many tasks including this paper. I feel the love and support and I am truly grateful to have such amazing, supportive people in my life. I'm glad to say this chapter is complete!

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ABSTRACT

Monarch butterflies (*Danaus plexippus plexippus*) have been petitioned for conservation through listing under the Endangered Species Act. In the Willamette Valley, showy milkweed (*Asclepias speciosa*) acts as monarch natal and feeding ground habitat. Today, restoration ecologists are including showy milkweed in the suite of species used in prairie restoration projects to bolster the dwindling monarch populations. These biologists often started with including it as a portion of the seed mixes sown as part of a restoration. Later, many of these biologists switched to planting started, containerized plants (plugs) after failing to see much in the way of results from the previous seeding. This study focused on the establishment rate of containerized plugs versus broadcast seeding in restoration plots. Three prairie restoration sites were selected which had been seeded, then planted with plots of containerized plugs. Stems were counted at each site, both within the plug area, and at random across the rest of the site. Results from 2017 indicated planting plugs was more successful than broadcast seeding. However, the random sampling returned no plants and insufficient study design required a reexamination of the study sites in Summer 2018. My science advisor also recommended using the Focused (Intuitive Controlled) Survey method to collect sown milkweed instead to see if the results were different. The 2018 sampling yielded several individuals or clusters of milkweed in the sown sections. These were productive enough that we question which whether plugging milkweed is necessary.

INTRODUCTION AND BACKGROUND

The monarch butterfly (*Danaus plexippus plexippus*) is a species found all over the United States, including Oregon's Willamette Valley. In 2014, the monarch butterfly was petitioned for protection under the Endangered Species Act (ESA), triggering the United States Fish and Wildlife Service (USFWS) to conduct a study examining possible reasons for the population's decline, and potential solutions to bolster the species (USFWS, 2017). Adult monarchs exclusively lay their eggs on the underside of milkweed plants, as seen in Figure 1. Milkweed serves as a food source for adult monarchs and as a host for their offspring until they pupate. In the United States, milkweed populations have declined because of habitat loss caused by urban development, Round-up® Ready Crops and the broad-scale use of post-emergent herbicides in agricultural areas and roadsides, climate change, and logging are some of the reasons (Luna & Dumroese, 2013; Xerces.org. (2018).

Figure 1. Milkweed with monarch eggs on leaves. Photo by author

I live in the Willamette Valley, and as such, I have an investment in protecting its environment and habitat. Once established, milkweed can form large patches, such as those shown in Figure 2. It can however, be difficult to establish. I wanted to know, does the establishment of broadcast milkweed seeds versus containerized plugs differ in

Willamette Valley Restoration plots? My research focused on comparing establishment rates between broadcast seeding and containerized out-plantings (plugs) of showy milkweed (*Asclepias speciosa*) at three different restoration projects previously restored to wet prairie by the USFWS' Partners for Fish and Wildlife (Partners) Program.

Figure 2. Showy Milkweed (*Asclepias speciosa*) in bloom. Photo by author

CONCEPTUAL FRAMEWORK

The Willamette Valley is a 150-mile-long valley located in northwest Oregon between the Cascade, Oregon Coast, and Calapooya Mountain Ranges (Figure 3). The

Figure 3. Map of Willamette Valley Area (WVNPP, 2018)

Willamette River is the 9th longest river in Oregon, 183 miles long from its headwaters at the southern end of the Willamette Valley, to its wedding with the Columbia River far to the north in Portland (Britannica, 2014). The valley is an elongated, relatively flat body of land ranging from ten feet above sea level to 450 feet above sea level. During the Pleistocene era the Missoula Flood waters pushed up the valley leaving a rich sediment base behind glacial deposits creating fertile agricultural land. Once the marshes and lakes filled with sediment, oak savannahs and grasslands covered much of the valley floor (Robbins, 2017).

The Willamette Valley has a marine climate similar to the Mediterranean Marine Climate. Temperatures are mild, with July average high temperatures ranging from 82ºF to a low of 52ºF. January average temperatures range from a high of 47ºF to a low of 34ºF. The majority of the precipitation comes in the form of rain between October and

April, averaging 35 to 40 inches of rain annually (Highsmith & McNamee, 2018). Much of the precipitation is closely related to elevation. These mild temperatures and precipitation regimes create long growing seasons, while the depositions created by the Pleistocene floods have proven very fertile.

Prior to the Euro-American settlement, Native peoples in the valley used fire to encourage the open grasslands and native forage crops. Under this burning regimen, the majority of the land consisted of prairie and upland forest, and the rest was occupied with savanna, woodland, and riparian forest. Prairies historically covered 31.4% of the Willamette Valley according to Christy and Alverson (2011). Native Americans used the prairies for agricultural production areas. Later these same areas were almost entirely converted to European style agricultural production by incoming settlers, and within fifty years the land had lost many of the characteristics maintained for thousands of years. Euro-American agriculture has been part of the Willamette Valley since the 1800s, with major changes beginning in the 1850s. It has long been producing Christmas trees, grass seed and hazelnuts. There are crops of fruits and vegetables throughout the region as well. In recent decades, it has become renowned for growing hops and grapes respectively used in beer and wine production. As the Euro-American settlers moved in and began farming these areas, they began clearing, ditching, drain tiling and tilling these prairies, savannas, woodlands and riparian areas. These actions led to the creation of the Valley's current agricultural landscape. The habitual application of these practices is not compatible with the long term survival of many of the species historical to the area. Looking at the historical vegetation of the valley helps solidify the need for restoration

projects. Prairies in the Willamette Valley have seen losses upwards of 99% since the 1850's (Figure 4, ODFW, 2006). These diverse and complex habitats were home to some of the valley's most endangered species.

Seed propagation of native species is imperative to restoration projects. Boyer

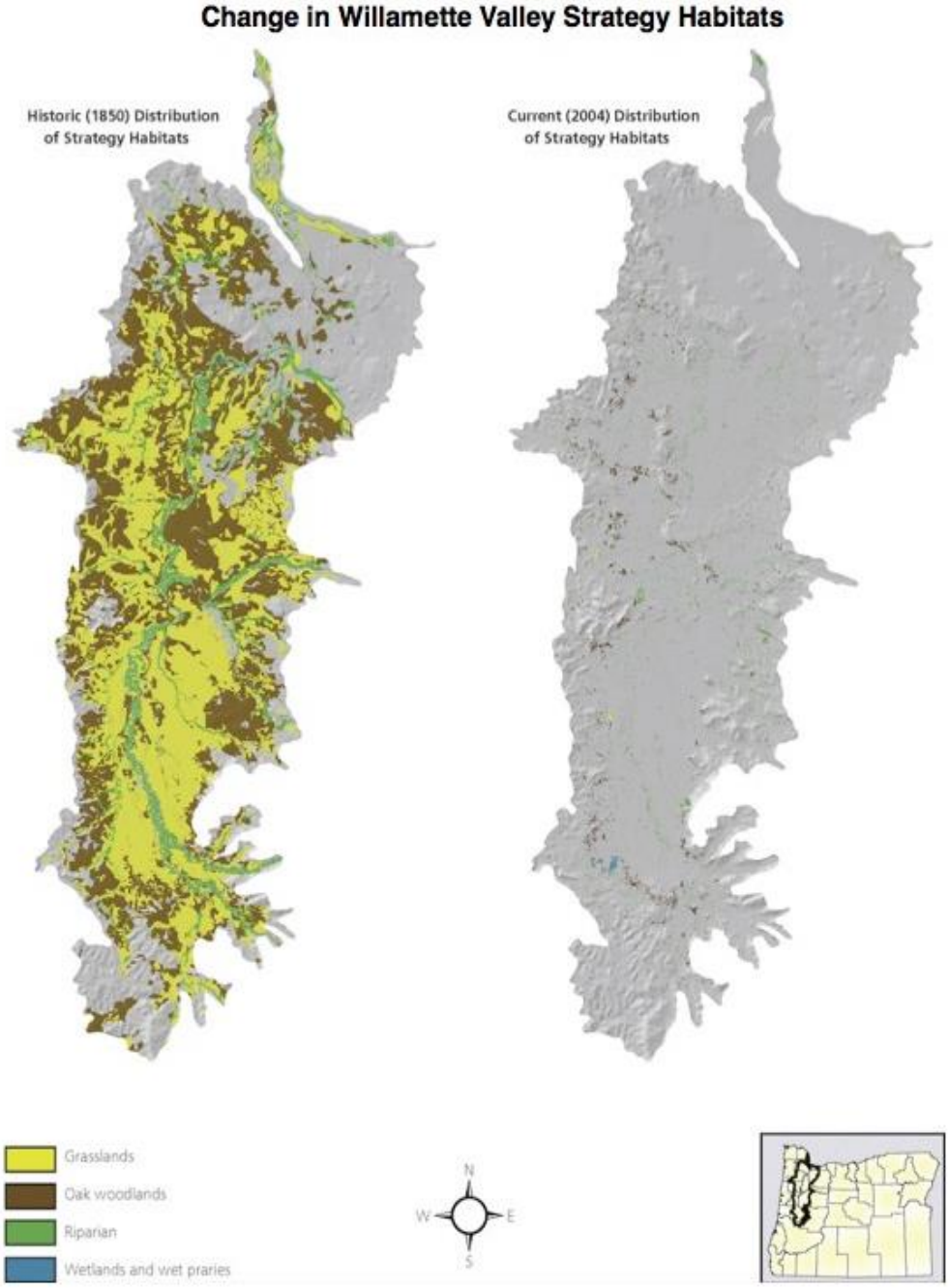

Figure 4. Changes in Willamette Valley Strategy Habitats ODFW (2006).

(2008) concludes prairie forbs native to the Willamette Valley do not lend themselves to commercial seed collection. This has motivated restoration ecologists to explore new

ways to propagate difficult species. To determine the best way to propagate milkweed in large quantities with high establishment rates in restored native habitat, agencies need to look at what has worked. Palmerlee and Young (2010) found that for sown restorations, large seed size was correlated with success. They also found that when compared to containerized stock, direct seeding was more cost effective across all species, especially those with large seeds which could be up to 29 times more cost effective. One article suggested genetic diversity was shown to improve restoration success rates (Basey, Fant, & Kramer, 2015). They found collecting seed from a diverse, yet similar, habitat correlating to the area being restored will increase the chances for establishment and success. The study also found collecting seeds from all plants including those that look less healthy or slightly different will provide genetic diversity and increase the likeliness of success.

Nabhan and Warren (2015) discuss strategies of milkweed propagation including finding ecotypes providing ideal growing conditions, collaborating with public land owners to collect seeds, site selection and preparation based on various environmental factors, and acquiring funds for collection. Whether sowing seeds directly into plots or growing them first as plugs, species restoration begins with seed collection.

Planting species and genotypes indigenous to the area is an important aspect of successful restoration, and milkweed is no exception. Wade (2015) discussed the importance of promoting species of milkweed native to the area planted, as not all species behave the same or are of equal benefit for pollinators. The author notes how tropical milkweed (*Asclepias curassavica*) is the only widely available milkweed in the U.S. and

was used to bolster monarch natal grounds. What southern gardeners did not realize was that when planted in warm environments this species does not die back in winter. This resulted in monarchs overwintering in these areas rather than migrating to Mexico. Tropical milkweed also carries a protozoan which, when ingested, creates spores on the butterflies' wings, making it impossible for them to migrate. The article goes on to say that the monarchs that do migrate are then infecting other monarchs and it could be devastating to the population. The end result of both of these unforeseen side-effects was reduced vigor or death for many of the butterflies in the region. Dunwiddie and Martin (2016) monitored over 5,000 golden paintbrush (*Castilleja levisecta*) plugs planted at equal intervals along one kilometer transects at six different native prairie sites with similar vegetation and soil composition. After five years, they found inconsistent plug survival across all sites. They determined survivorship and subsequent recruitment were strongly influenced by microsite characteristics. Their conclusion was site suitability cannot be assessed on vegetation alone and broad scale site assessments often fall short of predicting establishment viability because these assessments fail to incorporate microsite characteristics such as soil type, vegetation, precipitation, etc.

Young and Evans (2000) found the cost of containerized stock was higher than seeding for woody plants used for restoration. Although the containerized seedling has a jump start on the lone seed, it costs more to get the seedling to this point and survival is still far from assured. They found seedlings grown on site out performed larger plants coming from off-site facilities. Three potential reasons direct seeding outperforms containerized transplants were shock, lack of weatherizing in the area, and root damage

or deformity from being in a container. Three different studies found that although the plants from the containers had a high success rates, they grew smaller and their health wasn't the same as those grown on site. This information could provide valuable insight for restoration projects trying to increase success and decrease cost.

Looking at efforts to restore a different species of milkweed could provide relevant information to improve restoration efforts here in the WV. Roels (2013) discussed the different seed characteristics and site conditions of *Asclepias meadii*, another threatened milkweed. In the study, seeds were raised in a greenhouse and the land was prepared using burning and soil treatments. Seedlings in burned plots were shorter than unburned plots (Roels, 2013). Evidence showed pre-emergent soil disturbance to be detrimental. There was high survivorship of first year seedlings and they suggested that direct sowing of seeds is an effective technique for *Asclepias meadii* in restoration projects. This is evidence for the Partners Program to continue using seeding the *A. speciosa* native to the Willamette Valley as a productive option for restoration projects.

Gisler and Duncan (2011) compared Nelson's checkermallow (*Sidalcea nelsoniana)* establishment via seed propagation, plug production, and rhizome production here in the Willamette Valley. After establishing baseline data, they prepared planting sites using mowing, spraying, and prescribed burning. The plugs were planted over three years and the experiment will be evaluated after five years (results are yet unpublished). The publication was written between phases II and III but noted that while prescribed burning was difficult and time consuming, it significantly improved seeding.

Fischer, Williams, Brower, and Palmiotto (2015) found mowing sustained a more continuous suitable habitat for monarch oviposition and larval development than the control if mowing was between July 1-24. This extended the monarch's breeding season and increased overall monarch reproduction. Mowing was used in the three sites of this project. It would have been ideal to know the dates of the mowing to help determine whether it helped with growth.

METHODOLOGY

Literature reviews indicate seeding can be quite effective with native plant species used in restoration. When examining establishment rates of broadcast seeds versus plugs in the Willamette Valley, biologists I interviewed recommended stem counts for our data collection method. A study conducted by Betz and Lamp (1990) concluded that due to the variability in stem production of different plants, counting stems was a viable way of counting. Stem counts were non-invasive measures to determine if there was survival. As milkweed is rhizomatous, it can be difficult to tell if the plants seen above ground are connected below ground without digging up the plants, defeating the purpose of planting milkweed. Stem counts become our best viable and reliable way of identifying plant establishment and survival.

Our hypothesis was: “Establishment of broadcast milkweed seeds versus containerized plugs differ in Willamette Valley restoration plots differ.” Restoration projects are often funded through grants and typically have limited, finite resources. The importance of finding viable and cost-efficient ways to include targeted plants into a restoration project. This includes the cost of the seeds, plugs, or man power to plant either source. Based on this hypothesis, the research question was: “Does the establishment of broadcast milkweed seeds versus containerized plugs in Willamette Valley restoration plots differ?”

The study examined the establishment rates of milkweed planted as plugs and milkweed grown from seed mixtures at three different prairie restoration sites. The USFWS gained access to three former agricultural lands restored to native wet prairies and held in conservation easements managed by the Partners program based out of the Willamette Valley, Oregon. Two were on the outskirts of Finley National Wildlife

Figure 5. Wood Duck Farms WRP plug site in July, 2017. Photo by author.

Refuge (Sportsmans Goose Club and Wood Duck Farms) south of Corvallis, Oregon and are approximately 30 acres each. The third site, Freerksen, lies between Corvallis and Albany, Oregon and is approximately 60 acres. Reference site photos and maps of these sites are found in Appendices A and B respectively. Each site selected had nearby naturally producing milkweed populations. Additionally, each site had at least one of the following criteria: poor wildflower establishment from seed, abundant volunteer non-native grasses, and soil moisture similar to established nearby populations of milkweed. Each site was sown with a native seed mix, of which showy milkweed was a small component. All three were seeded with milkweed at rates of Wood Duck in 2013 at 4,320 seeds per acre, Sportsmans Goose Club in 2013 at 7,200 seeds per acre, and Freerksen in 2015 at 2,520 seeds per acre, respectively. The sites were additionally planted with blocks of 100 showy milkweed plugs in subsequent autumns between two and four years later: Wood Duck Farms, 2014; Sportsmans Goose Club, 2013, and Freerksen, 2015. Sportsmans Goose Club, Wood Duck Farms and Freerksen had all 100 plugs planted in a single plot, approximately 50 square foot.

Stems were counted to verify success in each plot in mid-July and early August 2017 and again in June of 2018. A Partners biologist delineated the corners of each plot using pin flags, prior to the study. Individual stems were tallied and marked with a pin flag. Many of the plants found in August were on the verge of drying up completely. There were notations of how many live/dead in the data when collected in August but the same was not done in July. In July, there may have been a few that were looking dead but there was no documentation.

In 2017, random sampling was used at each location to determine the success of the broadcast seeding. Starting from the study location, a random direction and distance to the next sampling location was selected. The direction was randomly selected by using a spin wheel with twelve quadrants and walking the direction the arrow pointed. Distance was also determined by spinning the wheel, and walking the number of steps indicated by where the arrow landed. Upon arrival at the sampling point, a hula hoop measuring 35 inches (88.9 cm) inside diameter was tossed on the ground. The vegetation within the hula hoop was examined, counted and recorded. When necessary, crumpled vegetation was pulled through under the hula hoop to be considered. This was repeated ten times at each site and the results were recorded. The random sampling returned no plants and insufficient study design required a reexamination of the study sites in Summer 2018. My science advisor also recommended censusing the sites for seeded milkweed using the Focused (Intuitive Controlled) Survey method to collect sown milkweed instead to see if the results were different. This method requires using life history knowledge to identify the areas most likely to contain a species, and searching this area more intensely. This method is recommended for sample areas greater than one hectare or 2.47 acres. Whiteaker, Henderson, Holmes, Hoover, Lesher, Lippert, Olson, Potash, Seevers, Stein, and Wogen (1998) detail the methods as:

> The surveyor traverses through the project area enough to see a representative cross section of all the major habitats and topographic features, looking for the target species while en route between different areas. Most of the project area will have been surveyed. When the surveyor arrives at an area of high potential habitat, a complete survey for the target species should be made (p.4).

Increased coverage in the sown sections helped tease out poor coverage in the 2017 data set. It also seemed appropriate to go back and collect more data the following spring and see if any of the prescribed treatments of burning, mowing or leaving alone had helped the milkweed numbers.

After discussing the lack of results from the random sampling, it was decided to change the approach of sampling in 2018 to intuitive controlled surveying since the population of milkweed seemed small and the area covered was large. The sampling method is a way to find a small population by using judgement and knowledge of the researcher to decide where to look. It also alleviated the bias of having a random sample not include one of the few milkweed plants encountered while conducting the random sampling, but not included in the hula hoop. The method was simply to walk the seeded plots with an effort to cover most areas and look for milkweed over the whole area. This sampling method proved to be beneficial to the study as any plants we found were able to be counted and recorded.

DATA AND ANALYSIS

2017 data from all three locations and dates collected are displayed in Table 1. Additionally 2018 data from all three locations is in Table 2.

Table 1
Stem Count Data 2017

		Broadcast Rate	Area Seeded	Date Seeded/Plugged	2017 Plugs	2017 Seed	2018 Plugs	2018 Seed
Wood Duck Farms		4,320/Ac (0.06 lbs)	30 Ac	Fall 2014/ Winter 2015	62	0	116	0
Sportsmans Goose Club		7,200/Ac (0.1 lbs.)	30 Ac	Fall 2013/ Winter 2015	66	0	180	57
Freerksen		2,520/Ac (0.035 lbs.)	58.2 Ac	Fall 2015/ Winter 2016	91	0	27	13

Wood Duck Farms: There were no milkweed plants encountered in the random sampling at Wood Duck Farms in 2017. In July and August, there were 56 and 62 plants found in the plug plot respectively. An additional plant was encountered while in transit to one of the random sampling locations. Wood Duck Farms was burned and the plug site was sprayed with a grass specific herbicide in the fall of 2017. In the 2018 sampling, 116 stems were encountered at the plug site. The original count was 94, but two plants were discovered immediately adjacent to the plot, and upon further investigation it was discovered these were two of 22 additional plants that had been part of the plug planting. It turned out the boundaries had not been marked properly at one point, causing us to miscount the stems in previous counts. These 22 plants were added to the 94 others as it was clear these were part of the plug plantings due to the indentations found at the base of many of these. In the intuitive sampling performed in 2018, two samplers walked approximately three miles in an attempt to find local populations of milkweed throughout

the WRP. There were no plants encountered in this sampling other than the two that lead to the discovery of the 22 additional plugged plants.

Sportsmans Goose Club: Like Wood Duck Farms, Sportsmans Goose Club returned no plants for the random sampling from 2017. In July and August, there were 47 and 66 plants found in the plug plot respectively. Sportsmans Goose Club received no treatments of any kind in 2017. In the 2018 sampling, 180 stems were encountered at the plug site. Eight individual plants were discovered at Sportsmans Goose Club in the intuitive sampling survey. Additionally, two large cluster patches of 22 and 25 plants were also discovered at the site.

Freerksen: As with the other two sites, no plants were encountered outside the two adjacent plug sites at Freerksen in 2017. Within these plots, 91 plants were counted in July, yet only 16 were found a month later. Freerksen was mowed in the fall of 2017, as were the pin flags marking the plot boundaries. In the 2018 sampling, 27 stems were encountered at one plug plot with unmarked boundaries (the flags were missing after the mowing). The other was never found despite extensive searching. Thirteen plants were identified outside the plug plots, one patch of three and one patch of five, as well as an additional five singles spread over the property. The plants found in these patches were rarely within several feet of each other (only three groups of two at Sportsmans Goose Club and one group of two at Freerksen).

INTERPRETATION AND CONCLUSION

The research question for this project was "Does the establishment of broadcast milkweed seeds versus containerized plugs differ in Willamette Valley restoration plots?"

The data shows establishment has higher stem counts for plugs than for sown seed, based on the 2017 and 2018 data. But the point of this research was to give managers an idea as to where financial and personnel efforts could be best concentrated. Data from 2017 showed no advantage to seeding milkweed compared to transplanting, but the 2018 data showed a different story. The 68 plants encountered in the seeded area are likely only a sample of the population on each site, while the transplanted individuals were likely over represented in some ways.

Table 2
Pros and Cons of Seeding and Planting Plugs

Seeded		**Plugs**	
Pros	Cons	Pros	Cons
Less expense to plant	Environmental variables may effect establishment	Individual plant survival is more likely	More resources required to plant individual plants
Seeds can be included in a mix without increasing personnel hours		Plants exhibited high establishment rates	Plants only establish in the areas planted
Milkweed are more likely to establish under the conditions they will survive			Plugs could be lost during transplanting
			Depending on the nursery and stock of the milkweed the plants could be more susceptible to dying caused by environmental shock

Milkweed in the plots were counted close to the ground (observers were on hands and knees), while plants in the seeded area were detected from a standing position. If

plug plants were to have been observed from this same height, at a slow walk, they would have been almost entirely overlooked. As seen at Wood Duck Farms, the detection of one or two plants facilitated the detection of an addition score of plants. We estimate that only a half dozen at any one site would have been detected in the plug plots had they not been marked and know to us. Conversely, areas surrounding the seeded milkweed were heavily vegetated, and there were likely many small plants that went unobserved because it was very difficult to pick them out of their surroundings. It may have been advantageous to have pre-surveyed the site and determined what a realistic size is to have detected the plants, and only counted those of both cohorts meeting these criteria. Both methods seem to have worked and may be viable options in future restorations.

Influential Factors

Observer Error: The principle investigator (PI) collected the July 2017 data, while the August 2017 and June 2018 data were collected by the PI and an assistant. In 2017, more plants were found by the assistant after the PI had looked, although the same techniques were used. Likewise, in 2018, these same observer error rates were present. Each observer may vary in their skill regarding these observations. This was undoubtedly at play here, the assistant's experience in the field searching for plants and sign was evident in comparison to the PI's. Morrison (2016) notes 92% of studies reviewed were found to have user error, making it the rule rather than the exception. It may be these results may have been different if the same two people conducted the experiment throughout the sampling.

While the random sampling also entailed sampling from a low height and moving the surrounding vegetation to ensure no plants were missed, it included far too few samples without tremendous variance in location. Before switching to the intuitive controlled survey method, we intended to sample 40 random locations throughout each site, but I still doubt it would have been enough.

Potential Browse: In July 2017, Freerksen had 91% establishment, much higher than any other site. When we returned in August 2017, however, most of the stems appeared to have been browsed off near the base, leaving small one to two-inch shoots at the base of each marking flag. This brought the establishment rate down to a mere 16%, as establishment was counted by shoots with green leaves. The 91 plants found in July compared to the 16 found in August at Freerksen are anomalies. Many of the stems from the above ground vegetation were present, but nothing else. The suspicion lies with animal browse but has no conclusive evidence. Deer and small animals are known to frequent the area and may have found young milkweed plants palatable. Colin Tierney (personal communication, 2017), an ODFW habitat biologist and additional sampler, suggested that marking the plants with flags potentially drew an herbivore's attention to the young milkweed plants. Tierney noted ungulates are known to find milkweed palatable forage and finding one plant may have led to finding many of the rest in the plot. Deer and elk have been known to be curious about new things in their environments, including ribbon and flags.

Reduction of Competitors and Solar Exposure: As with many species, milkweed can be very sensitive to competition, and small amounts of competition can have

significant effects on the growth of even established plants (Tierney, personal communication, 2018). Nate Richardson (personal communication, 2017) advised weeding around each of the milkweed plants, to make them easier to find and possibly giving them a boost. After returning in August some of the previously encountered milkweed plants had dried up and wilted, while many of those discovered in August were still green. One hypothesis could be the sudden lack of vegetation around the plant caused them to senesce more quickly due to exposure. It could also have been the time of year for young plants to terminate their above ground vegetation. These transplant sites have also been nurtured for milkweed in an effort to encourage plant growth. This primarily involves spraying an herbicide over the plot. This may have been a non-selective herbicide like glyphosate (i.e., Round-up®) at a time when all above ground vegetation has senesced, or it may be an herbicide with no effect on the desired species (i.e., a grass specific like Fusilade®). This may have artificially bolstered the establishment of these individuals by reducing competition. Each of these treatments or lack thereof could have an effect on the results seen in 2018. Unfortunately, without many more years of monitoring it will be difficult to determine the effects.

Changing the sampling method from random sampling to intuitive controlled surveying the areas were able to be walked and searched for possible milkweed plants from seed. This increased the number of plants found and any that were found were counted. Summer of 2017 showed no success in plants from seed but 2018 showed there was success and in one area significant establishment in two patches.

Improvement

Literature reviews indicate more in-depth sampling is needed to achieve statistically significant data. I thought three sites would be sufficient to see data trends, but larger sample sizes would have been more appropriate. For consistency's sake, it would have been beneficial to include the same second sampler throughout the sampling process as their encounter rate was greater and more likely to be consistent.

A larger and truly random sampling design for assessing plant establishment from seed would have likely produced more reliable results. My samples were too close together, did not incorporate the entire site and were far too few. By changing from random sampling in 2017 to intuitive controlled sampling in 2018, we were able to find milkweed in the seeded areas in two of the three sites. The change of design allowed us to cover more ground and get a better idea of what was actually present at each site. This is important for rare species that may not appear in other random survey methods.

Not counting dried stems was problematic as it does not reflect the presence of successful plants. The temperature became continually hotter and drier into August, changing the outcomes as wilted or dying plants were left out of the tally, but new plants or those that may have been missed previously were counted. This means many of our tallies for August were off, even as they were often higher. Repeating this survey over several more years rather than two seasons may also dispel some of the haze encountered in this study. Many plants need time to establish before success should be assessed, and different winters could produce different results. Some species grow extensive root systems and store energy reserves prior to producing significant above ground vegetation,

a strategy observed in milkweed (Tierney, personal communication, 2018). This makes it difficult to find these plants because they are often very small. There were also different treatments to each plot and it may be worth examining if those treatments affected to the results or not. Overall, this study was informative but needs additional monitoring to determine if the results are truly accurate.

VALUE

This process has been training my brain to think more critically, as well as more scientifically. Science based capstones, although less frequent, can have just as much power to change your classroom as an educational capstone. It has been almost two decades since I had to come up with and conduct a science experiment. I take data on kids all the time in class, but it isn't the same as designing a project and completing it from start to finish.

In my circumstances, I was able to inform an ongoing project. A local biologist has been trying to restore milkweed habitat for the last five years and had already planted milkweed at different project sites. He wanted to know the success rates of the plants at different sites. He had stopped including milkweed in project seed mixes because he had never seen any success after completion. He had said in the beginning he would be very surprised if we found any milkweed. While piggybacking on a previously started project was helpful; it was difficult not having been part of the planning process.

There are different opportunities for bringing this to the classroom. It could be a class study of planning a project. Giving the students an opportunity to use pieces of the plan at different times to determine best sampling methods, ways to count the plants,

determine whether the amount of areas is enough to determine successes or not. Done in sections with articles for students to use as evidence they could replicate the study and build a plan.

The topic itself lends opportunities to study the loss of habitat for monarchs, and other information about monarch butterflies. There were many websites that encouraged bringing milkweed into personal gardens. A milkweed garden could be brought to the school and that could bring potential study of whether or not breeding is happening. Background information could be studied and then the garden could ensue. Another idea is planting milkweed in different soils and water different amounts to determine where the milkweed grows best. Overall, the study does provide opportunities for students to learn from my mistakes and continue where I left off. There were still many unanswered questions that could be studied while trying to bring milkweed into restoration projects.

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APPENDICES

APPENDIX A

PHOTOGRAPHS OF STUDY AREAS

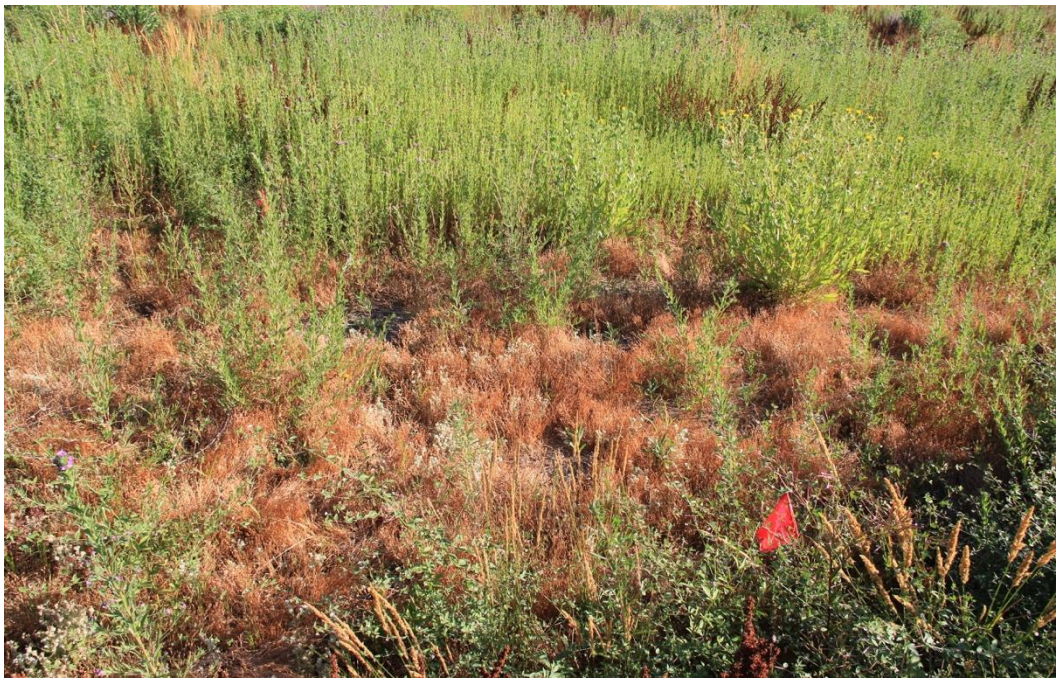

Figure 6. Freerksen WRP plug plot, July, 2017. Photo by author. Flag represents the corner of plot before counting.

Figure 7. Freerksen WRP restoration prairie, July, 2017. Photo by author.

Figure 8. Sportsmans Goose Club WRP plug plot, August, 2017. Photo by author. Flags represent individual milkweed stems.

Figure 9. Wood Duck WRP plug plot, August, 2017. Photo by author. Flags represent individual milkweed stems.

APPENDIX B

MAPS OF THE STUDY AREA

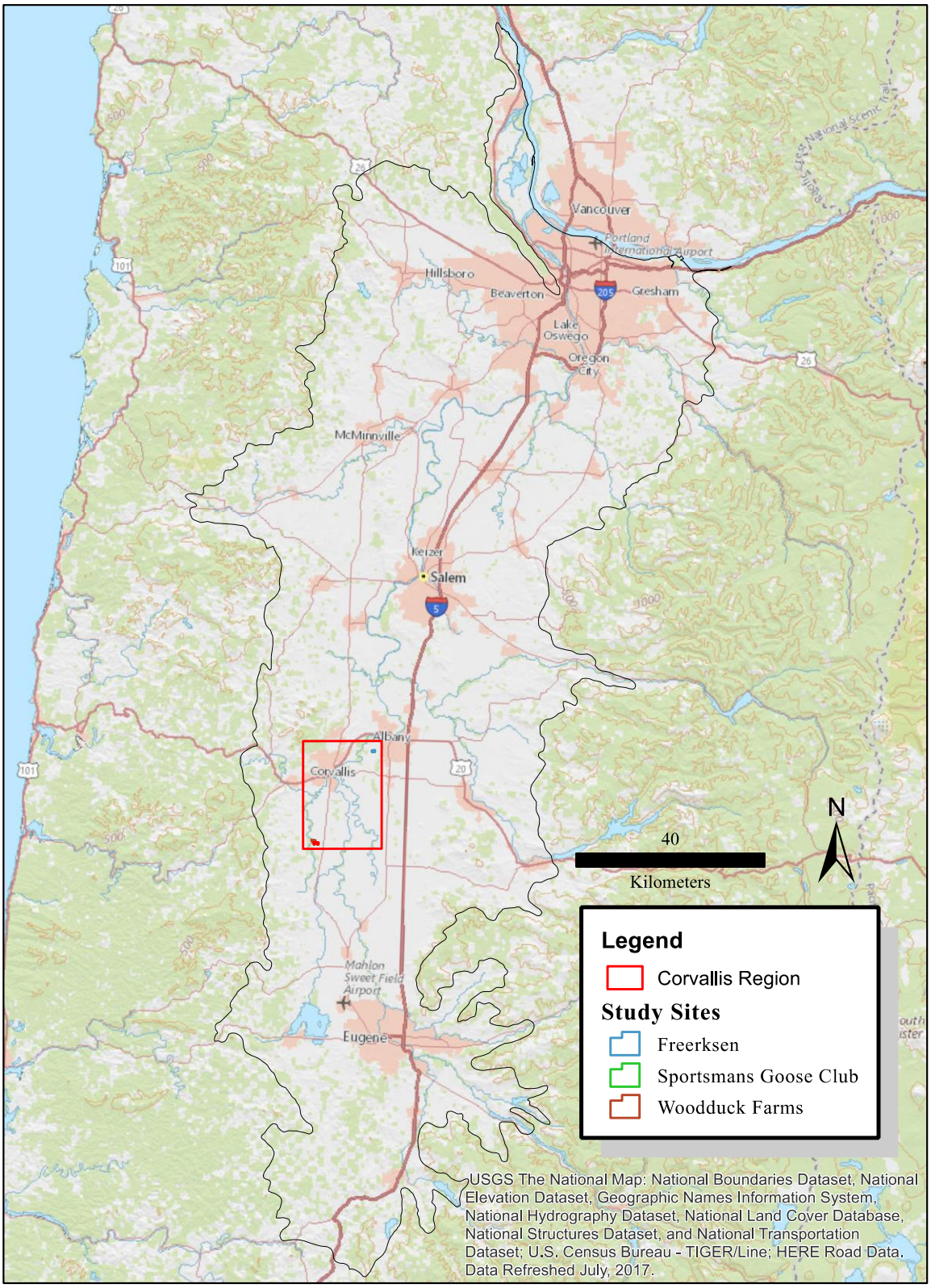

Figure 10. A map of the Willamette Valley showing the areas of Figure 9 in red.

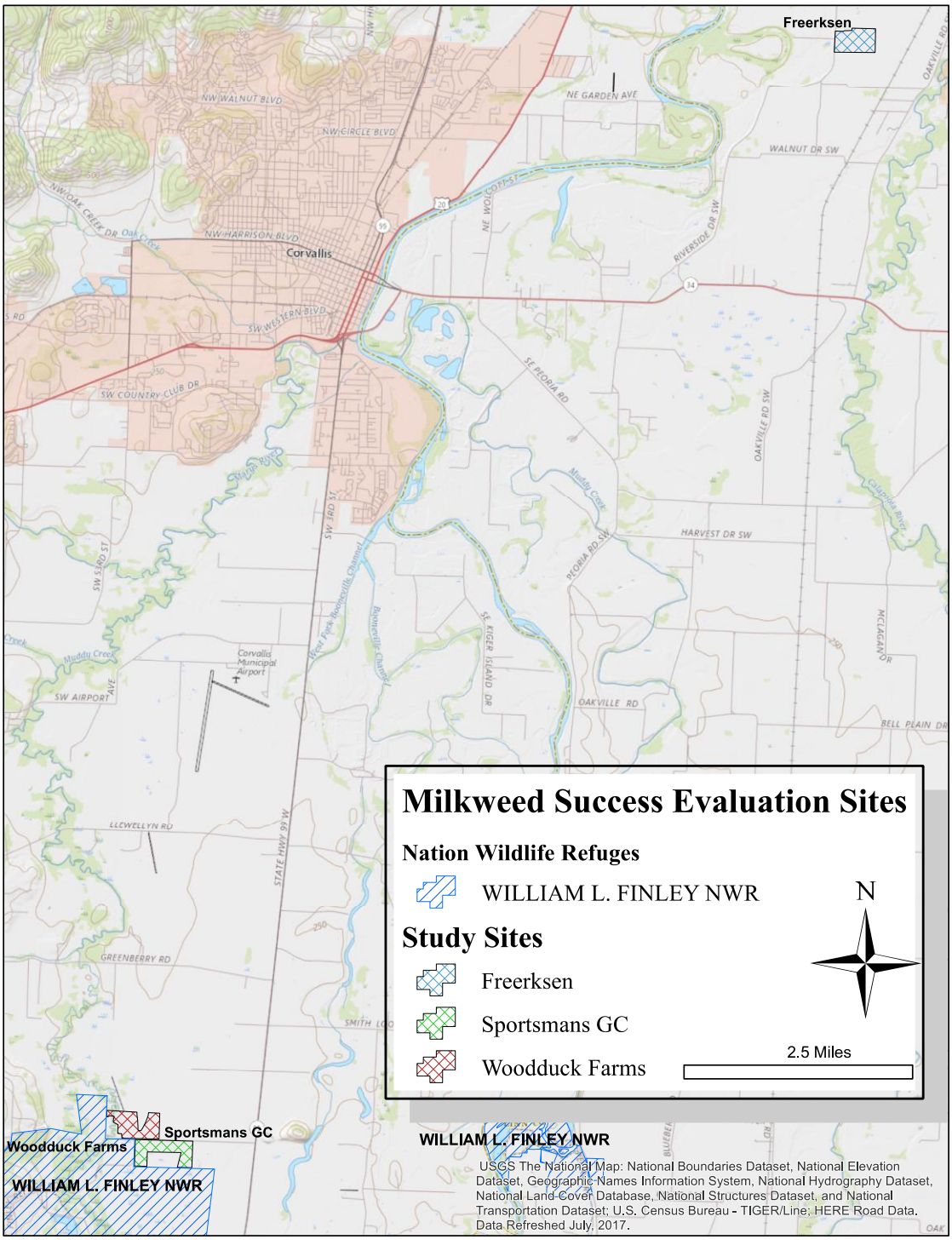

Figure 11. A map showing the study sites in relation to each other and surrounding areas of the Willamette Valley.

Figure 12. Freerksen

*Figure 13.*Wood Duck Farms and Sportsmans Goose Club