Impact Evaluation Report
EarthCorps Restoration Methods

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1 INTRODUCTION

EarthCorps is a Seattle-based non-profit that trains young adults in environmental restoration techniques along shorelines, forests, and trails in the Puget Sound area. Over the course of a year-long training program, volunteers learn practical skills that can be used to combat global warming, pollution, and environmental degradation.

In order to comply with Corporation for National and Community Service (CNCS) grant requirements, EarthCorps has retained The Watershed Company (Watershed) to provide an independent evaluation of restoration outcomes. The purpose of this evaluation plan is to design an independent and statistically valid assessment of EarthCorps restoration projects. This impact evaluation report provides a description of the sampling approach and analysis.

The purpose of this impact evaluation report is to assess the effectiveness of EarthCorps restoration methods. As the independent reviewer, staff from The Watershed Company, tabulated and analyzed the data EarthCorps crews collected.

2 PURPOSE

2.1 Theory of Change

EarthCorps' Theory of Change engages AmeriCorps members to scale up green infrastructure in order to better manage stormwater, which will decrease pollution into Puget Sound watersheds. Deploying AmeriCorps members to increase the scale of "green" stormwater management is an innovative model, providing person power to a critically under-staffed profession. Across the US, it is estimated that 85% of water pollution comes from stormwater runoff. The Pacific Northwest is a national leader in applying green infrastructure to stormwater management, perfecting techniques that are needed here and elsewhere. Recent studies on the effectiveness of watershed restoration activities (e.g. restoring forests) and engineered green stormwater infrastructure

(e.g. rain gardens) indicate that the selected green infrastructure intervention can be expected to produce the proposed results of reducing polluted runoff. The urban tree canopy intercepts and slows precipitation (https://www.epa.gov/green-infrastructure/what-green-infrastructure#raingardens). According to City of Seattle's 2013 Urban Forestry Stewardship Plan, forests in the city remove 725 metric tons of pollution from the environment each year (http://www.seattle.gov/trees/docs/2013%20Urban%20Fores%20Stewardship%20Plan%20091113.pdf).

EarthCorps members spend approximately 70% of their time in watershed restoration activities, 10% of their time in installing and maintaining engineered green stormwater infrastructure; and 20% of their time in education, training, and reflection activities. Because most of the member service will be designated to watershed restoration activities, this evaluation will focus on the outcome of these activities. The intent is to monitor and track outcomes on the same set of watershed restoration project sites over the timeframe of approximately 10 years, a timeframe that coincides with the long-term outcomes stated in our logic model. The current evaluation represents the first stage in our longitudinal study of these project sites. It focuses on the first phase in the restoration sequence: initial invasive plant removal. Future evaluations will focus on successive restoration phases: maintenance, native plant installation, and adaptive management.

Outside of the framework of this current evaluation, EarthCorps plans to monitor the outcomes of the other member activities. They may focus on those activities in a future evaluation.

2.2 Outcome of Interest

The outcome of interest for this evaluation plan is the medium-term outcome listed in the attached logic model: "Natural areas are healthier." This outcome aligns with the theory of change because members will engage in watershed restoration activities, which will make natural areas healthier. Healthier natural areas will retain more stormwater, reducing runoff. The selected indicator for determining whether natural areas are healthier as a result of member activities is a decrease in invasive plant cover compared to baseline after 1 year. Invasive plant cover is a commonly used ecological measurement of the percentage of a

given area of land that is covered by invasive plant foliage. Invasive plants pose a threat to natural areas by out-competing native plants, damaging trees, and suppressing native plant and tree regeneration. Trees, especially conifers, are the most effective plants for stormwater capture, retention, evapotranspiration and filtration in the Pacific Northwest. To protect existing and future trees, it is vital to significantly reduce or eliminate invasive plants. Removing invasive plants and keeping them from taking over again is a medium-term outcome that can take three or more years. It is an essential step to making natural areas healthier, more sustainable, and most importantly, increasing their stormwater retention capacity.

RESTORATION TREATMENTS

Watershed restoration activities can include a wide range of intervention actions. Because the outcome of interest for this evaluation is decreased invasive plant cover, we observed the impact of AmeriCorps members' actions aimed at eradicating or suppressing invasive plants by using power tools, hand tools, and herbicide. Treatment sites with Himalayan blackberry were treated with brush cutting (using a power tool to cut stalks) and foliar spray (spraying herbicide on the remaining foliage). Treatment sites with English ivy were treated through manual control and removal (grubbing out the stems and roots by hand or with hand tools). Initial treatment occurred in spring/summer 2018 and follow-up maintenance treatment occurred in spring/summer 2019. No invasive plant removal or herbicide application occurred on control sites.

2.3 Research Question

This evaluation seeks to answer the question, "Does the restoration action done by EarthCorps achieve the outcome of making natural areas healthier?" The evaluation of this outcome will be based on the indicator of decreasing invasive plant coverage. If AmeriCorps restoration actions result in a significant sustained reduction in invasive plant coverage, then restoration actions are deemed effective in making natural areas healthier.

For each evaluated site, the evaluator will assess:

1) What was the percentage of invasive cover on the site before the initial intervention? (baseline data from 2018)
2) What is the percentage of invasive cover after the intervention? (intermediate-term indicator, after one growing season)

The evaluation described in this report assesses invasive plant coverage before and after restoration actions. This evaluation represents monitoring performed one year after the initial invasive removal/treatment intervention in 2018. This

enables EarthCorps to assess the medium-term outcome of making natural areas healthier. EarthCorps intends to continue to monitor the site for up to 10 years after the initial intervention.

In addition to invasive plant cover, data collection on native woody plant cover and conifer density on the sites will measure short-term gains toward the goal of restoring a native forest community. This data will enable the evaluation of relevant longer-term outcome indicators such as increase in native woody plant cover or increase in conifer density in future impact evaluations.

3 METHODS

3.1 Study Participants

This study was led by EarthCorps. Staff from EarthCorps and The Watershed Company collaborated on sample methodologies, study questions of interest, and study design. EarthCorps supervisors and crew members implemented the restoration treatments and collected and compiled field data. EarthCorps funded the restoration project through a cost-share partnership (75/25). EarthCorps funded the evaluation. Staff from The Watershed Company developed the Evaluation Plan, assisted with plot set up, analyzed data provided by EarthCorps, and summarized results in this report.

3.2 Plan Design

The sampling framework incorporates a Before, After, Control, Impact (BACI) design. BACI requires an examination of pre-restoration site conditions and post- restoration site conditions, as well as a comparison of the post-restoration site to a reference site. The before-after data shows how the sites changed over time.
The control-impact data allows restoration actions to be differentiated from natural variability and stochastic events.

Using permanent plots to track changes to the landscape over time will provide a repeatable measure of the resource condition at these locations. Using invasive species cover as an outcome indicator allows comparison across different habitat types and the varied restoration objectives of our agency partners. As shown on the program logic model, reducing invasive species is a key medium-term outcome of members' watershed restoration activities.

In order to minimize the variability between treatment sites and control sites, control sites should be situated near the corresponding restoration site and they should experience similar environmental conditions but be independent of activities affecting the restoration site. Sampling techniques should be

replicable among all sites. Sampling periods should be identical between reference and restoration sites, to the extent possible. Since some time delay between field visits to various sites is inevitable, sampling periods are scheduled by season.

3.3 Treatment Sites

3.3.1 Site Selection

EarthCorps identified seven sites for restoration treatment, considering factors such as land ownership, access, site characterization, restoration treatments, seasonality, and the evaluation timeline. The ability for EarthCorps to secure on-going permission to access a site was an important consideration, to ensure that monitoring data can be collected on each site throughout the evaluation time period, and potentially in the future.

A second important consideration for the initial site selection was to limit the variety of treatments and invasive plant species being evaluated, in order to be able to observe identical treatments across multiple sites. EarthCorps chose to focus on two of the most prevalent invasive plant species in our region: Himalayan blackberry (*Rubus armeniacus*) and English ivy (*Hedera helix*). EarthCorps identified the project sites that fulfilled the requirements of on-going access, having the invasive plant species, and with restoration actions scheduled in spring/summer 2018. Seven project sites met this requirement. There was no random selection of sites because these seven project sites represent 100% of the sites scheduled to receive invasive species treatment within the timeframe of the evaluation. Evaluating seven sites is within the capacity of EarthCorps and the independent evaluator, so it was not necessary to select fewer than seven sites.

Sites are in the greater Seattle, Washington area (Table 1). Treatment sites are characterized by a prevalence of non-native, invasive vegetation, including Himalayan blackberry (*Rubus armeniacus*) and/or English ivy (*Hedera helix*). Sites with Himalayan blackberry were treated with brush cut and foliar spray. Sites with English ivy were treated through manual control and removal. Treatment sites range in size, with a minimum size of ~4,000 square feet.

Four of the seven sites that EarthCorps has identified have additional areas where no restoration actions are currently planned to occur. These areas are proposed as control sites.

Table 1. Treatment sites and associated characteristics.

Site Name / ID	Primary Weed	Control Site?
Discovery Park (06-01), Seattle	Himalayan blackberry	No
Discovery Park (17-13), Seattle	Himalayan blackberry	No
Discovery Park (19-01), Seattle	Himalayan blackberry	No
Hylebos Natural Area, Fife	Himalayan blackberry	Yes
Lake Hills Greenbelt, Bellevue	English ivy	Yes
Lewis Creek, Bellevue	Himalayan blackberry	Yes
Nature Trails Park, Normandy Park	English ivy	Yes

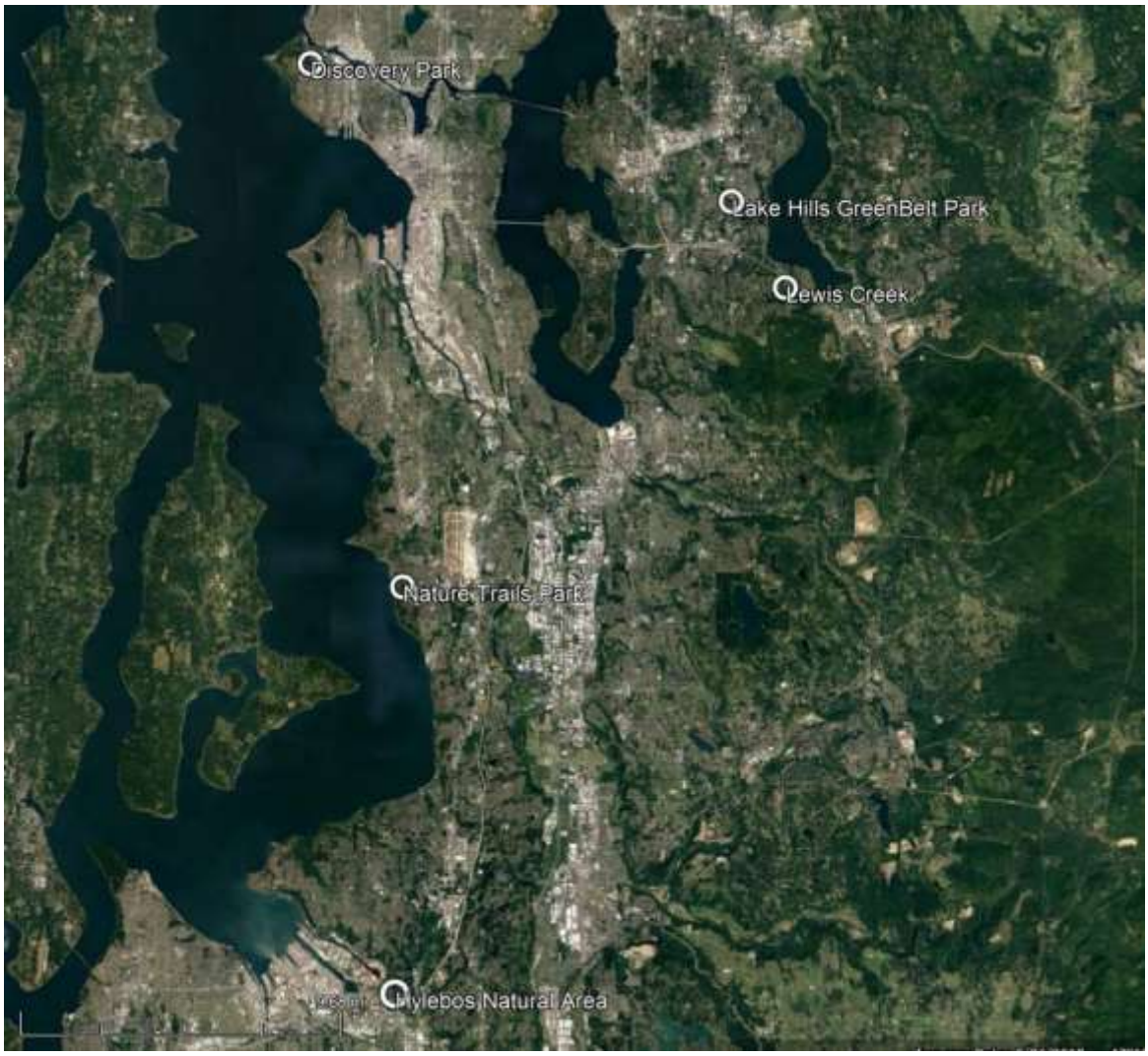

Figure 1. Map of treatment site locations, in incorporated King and Pierce Counties.

3.3.2 Plot Selection

Plot selection considered safety and accessibility for the people performing data collection. For example, a plot was not sited on a dangerously steep ravine.

Stratified randomization was used to select plot center points on a map of each site in order to randomize the placement of the sample plots at each site to minimize sampling bias. Sample plot are described further in section 3.5.1 below.

3.4 Data collection

Each "Treatment" site was monitored three times: 1) immediately prior to restoration action in spring 2018; 2) immediately following restoration action in the spring/summer 2018; and 3) late spring/early summer 2019, one growing season after the restoration actions on the treatment sites. Each "Control" site was also monitored three times, on the same schedule as the treatment sites. Data collection in spring/summer 2018 was not required, but the field crews included controls in their data collection.

3.4.1 Before (pre-restoration site conditions)

Pre-restoration site conditions were recorded at each site prior to invasive species removal. Data collection included:

- a description of the dominant invasive plants at each site (treatment species and non-treatment species)
- visual estimates of invasive cover (treatment / non-treatment species estimates)
- native woody cover, differentiating between evergreen and deciduous cover, and (non-native, non-invasive woody cover added)
- conifer density.

3.4.2 After (post-restoration site conditions)

Post-restoration conditions were recorded following the restoration action (spring/summer 2018) and one full growing season later (late spring/early summer 2019), as described below.

Spring/Summer 2018

To capture initial treatment site conditions and document potential variability among sites, initial treatment site data collection documented restoration methods. Variables such as invasive plant removal/treatment methods, soil amendments, or any native planting, were recorded.

Data collection included the same metrics identified above.

Late Spring/Early Summer 2019

In late spring/early summer 2019, one growing season after the initial restoration activities, each site was re-evaluated, using the same metrics identified above.

3.4.3 Control Sites

Data collection at "Control" sites will follow the same protocol as the "Treatment" sites, except that no "After" monitoring will be conducted in 2018.

All five control plots, spanning four sites, were visited in spring/summer 2018. One control plot at the Lewis Creek site was not revisited in spring/summer 2019. The control sites should not be directly impacted by restoration actions. However, some control plots experienced partial clearing due to work conducted by others not aware of EarthCorps' work.

3.5 Monitoring Stations

3.5.1 Sample Plots

Prior to any restoration action, EarthCorps crews established monitoring plots for representative sub-sampling at each site (including both "Treatment" and "Control" sites). Monitoring plots were 33 feet by 33 feet. The center of each plot was marked in the field using a metal post wrapped with field flagging tape and metal identification tags and the corners will be marked with pin flag or field tape for visual reference. Plots were demarcated during monitoring assessment using two transect tapes arranged perpendicular to each other (Figure 1). Plot locations were marked on aerial photos or site maps.

The number of sample plots varied by site size. The number of plots for each site is shown in Table 2.

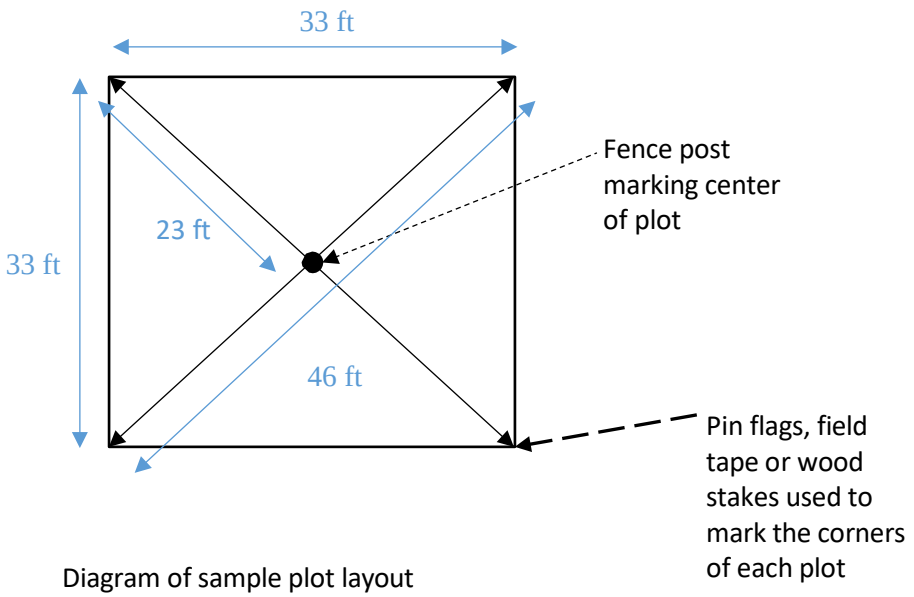

Figure 2. Diagram of sample plot layout

Table 2. Treatment sites and sample plots.

Site Name / ID	Primary Weed	Number of Treatment Plots	Number of Control Plots	Site size (acres)
Discovery Park (06-01), Seattle	Himalayan blackberry	3	0	0.77
Discovery Park (17-13), Seattle	Himalayan blackberry	1	0	0.19
Discovery Park (19-01), Seattle	Himalayan blackberry	5	0	1.19
Hylebos Natural Area, Fife	Himalayan blackberry	3	1	0.34
Lake Hills Greenbelt, Bellevue	English ivy	0	1	0.11
Lewis Creek, Bellevue	Himalayan blackberry	6	1	1.38
Nature Trails Park, Normandy Park	English ivy	7	2	2.86

Invasive species composition, cover, native woody cover (evergreen and deciduous), and conifer density was visually estimated within each sample plot. In all cases, cover was assessed based on the leafed-out condition.

Areas not directly covered by the monitoring plots will be visually assessed for general conditions and any anomalous areas not represented by the monitoring plots will be noted.

3.5.2 Photo Points

Photo points include before-after photo points at each plot. Photos were taken from each plot corner towards the center of the plot. Four photos were taken at each plot during each of the three visits.

"Before" and "After" pictures were taken from the same locations at each treatment site. "After" pictures were taken in spring/summer 2018 and again in spring/summer 2019.

Control site photos were taken from the same locations at each reference site in spring/summer 2018 and again in spring/summer 2019.

4 STATISTICAL APPROACH

The study uses a quasi-experimental design with randomized control to ascertain correlations between site treatments and plant cover. The study consists of

randomized plots, including untreated control (reference) plots as detailed in Section 3.5 above.

Data collected on percent cover of native and invasive plants were analyzed using one and two-tailed t-test. The approach tested the null hypothesis that there is no difference between invasive plant cover before and after restoration actions.

Statistical significance was based on an alpha of 0.05. With seven treatment sites, the power to detect a 30 percent difference in invasive cover, given a standard deviation of 20 percent is 0.85. The standard deviation of control sites was below 7 percent, allowing for the use of a smaller number of samples for the control sites.

5 RESULTS

Plots treated with restoration exhibited significantly decreased invasive species cover after treatment (Figure 3, $p=2.4e^{-22}$). There was not a significant change in invasive species cover in control plots ($p=0.4$)

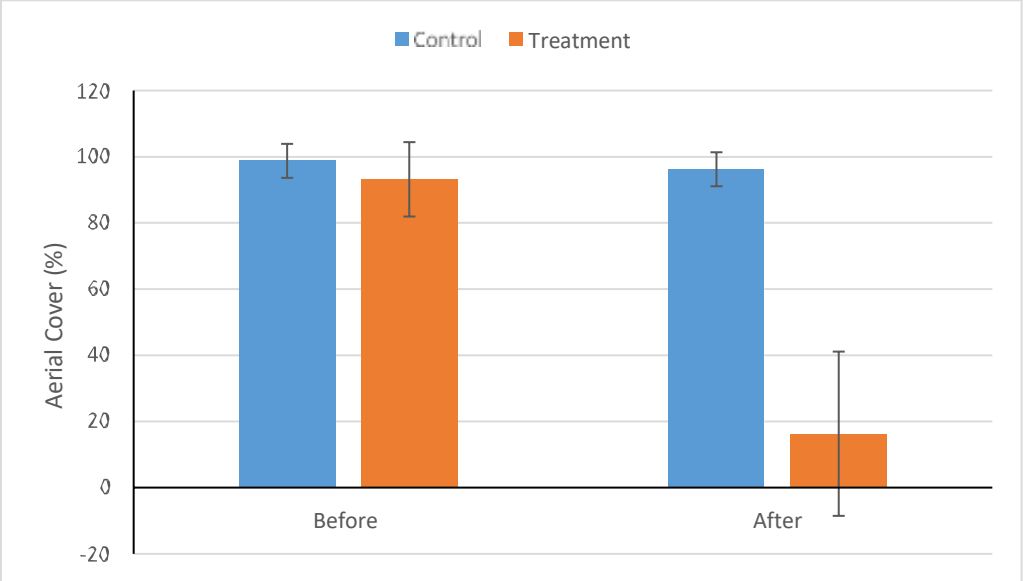

Figure 3. Comparison of invasive species cover before and after treatment in both control and treatment plots.

Table 3. Relative Standard deviations and average cover of invasive species in control and treatment plots before and after restoration.

	Control Before	Control After	Treatment Before	Treatment After
Standard Deviation (%)	2.2	5.1	11.2	24.8
Average Cover Invasive (%)	98.8	96.2	93.2	16.3

Table 4. Statistical analysis data on multiple comparisons of data. P Value used as final dataset is underlined.

Invasive Plant Cover Analysis	T-Stat	P Value One Tail	P Value Two Tail	Degrees of Freedom	Significant result?
Control Before Compared to Control After	0.871437	0.20106755	0.402135099	11	No
Treatment Before Compared to Treatment After	14.21542	2.39131E-22	4.78262E-22	68	Yes
Treatment After Compared to Control After	9.444397	2.9865E-13	5.97299E-13	53	Yes

Average percent cover of invasive species in the control plots was 98.8 percent at the beginning of the study and 96 percent at the end of the study, with standard deviations of 2 and 5 percent respectively. After restoration, average percent cover of invasive species dropped from 93 percent to 16 percent, with a standard deviation of 24.8 percent (Table 3). Reduction in invasive cover at the treatment sites over the study period was statistically significant. Minor variation in invasive cover in the control plots over the study period was not statistically significant (Table 4).

Additional data, including native cover and conifer density, were collected and may be utilized in further studies. Average percent cover of native woody plants remained substantially constant during the monitoring period, with average cover at 68 percent before restoration and 67 percent cover after. Conifer density at study plots ranged from zero to 19 conifers per 1,089 square foot plot. On average there were three conifers per sample plot.

6 DISCUSSION

Based on the results of this experiment, the restoration techniques used by EarthCorps crew members are an effective way to decrease invasive species at both sites dominated by Himalayan blackberry and English ivy in one growing season. While this result is positive, it leaves many longer-term questions unanswered.

Subsequent studies may monitor invasive plant cover at these study plots over additional growing seasons. If more plots dominated by English ivy are added to the next study, it may be possible to compare the impact of restoration work on English ivy relative to Himalayan blackberry. The level of effort required to displace invasive plants is expected to vary by species.

Another potential study question for further monitoring is: How many growing seasons a site must be maintained before a significant increase in native plant cover is realized? To assess this question, restoration efforts, including planting densities, would need to be standardized across treatment and control plots.

In addition to decreasing invasive cover, increasing conifer density and cover is a long-term goal of EarthCorps' work. The baseline data collected during this study may be utilized to track increases in conifer density and cover over future growing seasons. Since baseline data collected during this study includes deciduous and conifer cover in each sample plot, later studies may compare conifer success under differing canopy conditions.

While the short-term impact of EarthCorps' work to remove invasive plants is evident both in photographic documentation and statistical data analysis, EarthCorps seeks to learn more through additional longer-term studies. The outcome of future studies may improve adaptive management strategies implemented by EarthCorps members.

Appendix A

ReferencePhotographs

2018 March 01 - Discovery Park (17-13) Plot 1 NW

2019 March 22 - Discovery Park (17-13) Plot 1 NW

2018 March 01 - Discovery Park (17-13) Plot 1 NE

2019 March 22 - Discovery Park (17-13) Plot 1 NE

2018 March 01 - Discovery Park (17-13) Plot 1 SE

2019 March 22 - Discovery Park (17-13) Plot 1 SE

2018 March 01 - Discovery Park (17-13) Plot 1 SW

2019 March 22 - Discovery Park (17-13) Plot 1 SW

2018 March 15 – Nature Trails Park A Plot 5 SE

2019 Sep 05 – Nature Trails Park A Plot 5 SE

2018 March 15 – Nature Trails Park A Plot 5 SW

2019 Sep 05 – Nature Trails Park A Plot 5 SW

2018 March 15 – Nature Trails Park A Plot 4 SE

2019 Sep 05 – Nature Trails Park A Plot 4 SE

2018 March 15 – Nature Trails Park A Plot 4 SW

2019 Sep 05 – Nature Trails Park A Plot 4 SW