MAURY ISLAND MARINE PARK FIRST YEAR MONITORING RESULTS 2013

Vashon Nature Center LLC
www.vashonnaturecenter.org

Table of Contents

Executive Summary

We report results from the first season of monitoring at Maury Island Marine Park restoration area. We conducted 2 monitoring sessions in 2013—one at the start and one at the end of the growing season (May, September). Plant mortality and stress levels of all planted species were sampled during a zone walk through of the site. In addition, mortality, stress, and growth of plants experiencing different soil amendment treatments were measured. Lastly, madrone seedlings were counted in plots containing mature madrones and plots containing no madrones and survival of seedlings through the growing season was noted. Full sampling protocols and methods can be found in the companion report (VNC 2013) entitled: *Maury Island Marine Park Restoration Baseline Documentation 2013*.

Zone walk through assessments revealed the following trends in plant mortality: hardy shrubs and dry adapted trees tended to fair best; the most successful restoration planting action in terms of lowest plant mortality was underplanting of the early successional alder forests (Zone 4); highest mortality occurred, not surprisingly, in south facing, sandy, early successional zones 1 and 2; Garry Oak, oceanspray, and snowberry seemed best suited to these challenging zones (1,2). We recommend seeding of hardy early successional natives in these zones in the future to see if growing from seed increases plant survival in these zones.

More plants survived and growth rates were higher in fully amended soils compared to restricting amendments to the planting hole or not amending the soils at all. Percent cover of volunteer species (weeds and natives) did not differ between soil treatments. Interestingly, species richness of native volunteers was higher in fully amended plots than partially amended plots and plots with no amendments. Control plots where no planting or other disturbance had occurred during the growing season, had similar levels of native volunteer species richness to fully amended plots. We recommend monitoring soil amendment plots for a second season as these trends could change when roots grow below the soil amendment layer.

The presence of mature madrones seems key to seedling germination and survival. Few seedlings were found in seeded or unseeded plots that had no trees. Madrone seedling emergence was positively correlated with bare ground cover in the plots. It is still unclear what other variables affect madrone seedling emergence and survival. We recommend trying a different seed stratification technique as seeded plots had fairly equal seedling counts to unseeded plots indicating that seed germination wasn't too successful in sown plots. We experienced a higher average survival rate of madrone seedlings compared to the literature (25% vs. 8%). This may be because we observed seedling survival near mature madrones which could be conferring some benefit to seedlings. However, survival rate calculations were partially confounded by a late summer rain event that appeared to cause a flush of new seedlings in the plots. This apparent flush was an interesting finding in itself as it leads to the question: do late sprouting madrone seedlings have an advantage over spring emerged seedlings in terms of water availability for early growth? We recommend further madrone studies and seeding efforts because of the iconic nature of madrone forests on this site and the many questions surrounding their propagation and survival.

INTRODUCTION

The detailed results of the 2013 season monitoring effort are detailed below for 3 separate monitoring activities: zone walk through assessment of plant mortality; soil amendment plots; and madrone seedling counts. These results include data analysis comparing beginning and end of season numbers. At the beginning of each results section we have presented a quick summary of results in a question answer format for easy interpretation. The detailed results follow this initial summary for more depth. At the end of each section we have presented a brief interpretation and management or further monitoring suggestions when applicable.

METHODS

Below we provide a brief description of the 3 monitoring activities outlined in this report. Baseline photo documentation of the site as well as full detailed methods and protocols for all monitoring activities are available in the companion report (VNC 2013) entitled: *Maury Island Marine Park Restoration Baseline Documentation 2013.*

Zone walk through assessment: At the end of the growing season all areas designated as monitoring areas within each zone were walked by a Washington Conservation Core team trained in the protocol for zone walk through assessment by Vashon Nature Center staff. This assessment follows a standard sampling protocol found originally in Miller et al. (1996). WCC members walked through with lists of what was planted in their area and as they found each plant they marked it as alive, dead, stressed, or missing. In addition, as they walked through they added comments on other plants and animals that they were seeing and additional information pertinent to management of the restoration area.

Soil Amendment Plots: 4 treatments were included—full amendment, partial amendment (only in planting hole), no amendment, and no planting. The same suite and configuration of plants were planted in each plot except for the no planting treatment plots where nothing was planted. Plants were individually marked with metal tags and measured for height, and width (in two directions). Mortality and stress were noted at time of measuring. At the end of the growing season mortality, stress, and size measurements were taken again for each plant and compared between treatments. Cover categories of bare ground, herb, shrub, planted, and non-planted volunteer species were estimated in both seasons.

Madrone seedling plots: 23 circular plots with madrones in the center and 7 circular plots with no tree cover were divided into 4 quarters each. 2 quarters were randomly chosen to be seeded with madrone seeds and 2 quarters were not. Volunteers measured the thickness of the duff layer in cm, took spherical densiometer measurements of the canopy in each quarter, took a hemispherical photo of canopy cover in each quarter and counted number of seedlings, saplings, and grown trees in the circular plot. Cover category of bare ground, grass/herb, shrub, and canopy were also estimated. Seedling counts were made in July as it was too hard to tell which seedlings were madrone at the beginning of the growing season. Seedling counts were made again in mid-September to calculate seedling survival throughout the growing season.

RESULTS

Zone walk through assessment:

SUMMARY:

Important note: Weed cover was high at the end of the growing season obscuring many of the plants. Planted plants were hard to find during zone walk thru monitoring so many were marked missing. Mortality figures were calculated by dividing the number of dead plants found by the total number of plants found for each species. This could result in an underestimate of mortality if most of the missing plants were missing because they were dead not just weed covered and hard to find.

- Which plant species were best suited to the site (lowest mortality across the site)? *Of the widely planted trees drier adapted varieties outperformed those needing wetter conditions. For example, western white pine did better than douglas fir and douglas maple outperformed both vine and bigleaf maple. Sitka spruce did well across a variety of sites surprisingly although sample size was small. Alder did very poorly all across the site. Trees that performed excellent in micro-habitats include garry oak (no mortality) grand fir, western red cedar and madrone (although sample size was small).*
  Snowberry outperformed other shrubs throughout the site with very low mortality. However, many other hardy shrubs did well both across the site and in appropriate micro-habitats (see table below).
- Which zones had lowest mortality? *Zone 4 had the lowest mortality of plants as compared to all other zones. Zone 4 is an early successional alder forest on fairly flat terrain with clay soils. Zone 1 and 2, the south facing slopes with sandy soils experienced the highest mortality. Zone 2 had slightly lower mortality than zone 1 possibly due to more tree cover providing shade. High mortality in zone 2 seemed mostly confined to areas 12 and 28.*
- Are there zones or areas where less hardy plants survive better than most areas on site? *Zone 4 seemed to have the best growing conditions for less hardy plants. Particular microhabitats for cedar were picked very well as cedar experienced very low mortality. Garry oak performed extremely well on south facing sunny slopes and is recommended as a good tree cover alternative where other trees fail to thrive in zones 1 and 2.*

Table 1. Mortality rates of different species planted on site. Best zone= zone where the plant exhibited lowest mortality. Worst zone= zone where plant exhibited highest mortality rate.

Common Name	Scientific Name	Form	Mortality (%)	Zones found	Best zone	Worst zone
bigleaf maple	*Acer macrophyllum*	tree	36*	1,2,7	7	2
douglas-fir	*Pseudotsuga menziesii*	tree	33	1,2,3,5,7	7	2
douglas maple	*Acer glabrum*	tree/shrub	13	1,2	1,2	2
garry oak	*Quercus garryana*	tree	0	1	all	none
grand fir	*Abies grandis*	tree	0	2,3,7	all	none

madrona	*Arbutus menziesii*	tree	0	1,2,5	all	none
red alder	*Alnus rubra*	tree	54*	1,2,5,7	2.28	5
sitka spruce	*Picea sitchensis*	tree	12	2,3,4,5,7	3,4,7	2
western redcedar	*Thuja plicata*	tree	1	3,4	3	none
western white pine	*Pinus monticola*	tree	13	2,3,4,7	all	none
shore pine	*Pinus contorta*	tree	0	4	4	none
baldhip rose	*Rosa gymnocarpa*	shrub	11	2,6	2	none
cascara	*Rhamnus purshiana*	shrub	17	2,3,4	2,4	3
chokecherry	*Prunus virginiana*	tree	19	3,4,7	4,7	3
hazelnut	*Corylus cornuta*	shrub	27	2,3,4,7	3,4,7	2
osoberry	*Oemlera cerasiformis*	shrub	3	2,3,4,7	all	none
mock orange	*Philadelphus lewisii*	shrub	31	1,2	2	1, 2
ninebark	*Physocarpus capitatus*	shrub	0	4,6	all	none
nootka rose	*Rosa nutkana*	shrub	13	1,2,5,6,7	all	none
ocean spray	*Holodiscus discolor*	shrub	10	1,4,5,6	all	none
pacific crab apple	*Malus fusca*	shrub	31	2,5,7	5,7	2
peafruit rose	*Rosa pisocarpa*	shrub	13	2,3,4,5,7	all	none
redflowering currant	*Ribes sanguineum*	shrub	17	1,4,6	4,6	1
salmonberry	*Rubus spectabilis*	shrub	18	2,3,7	3	2,7
serviceberry	*Amelanchier alnifolia*	shrub	18	1,2,4,5,6	4,5	1, 2
snowberry	*Symphocarpus albus*	shrub	4	2,3,4,5,6,7	all	none
snowbrush	*Ceanothus velutinus*	shrub	87*	2	none	2
tall oregon grape	*Mahonia aquifolium*	shrub	20	2,4,5,6	all	2
thimbleberry	*Rubus parviflorus*	shrub	24	1,2,5,6,7	1	2
vine maple	*Acer circinatum*	tree/shrub	31	2,3,4,7	4	2

3 species with the highest mortality rates are starred.

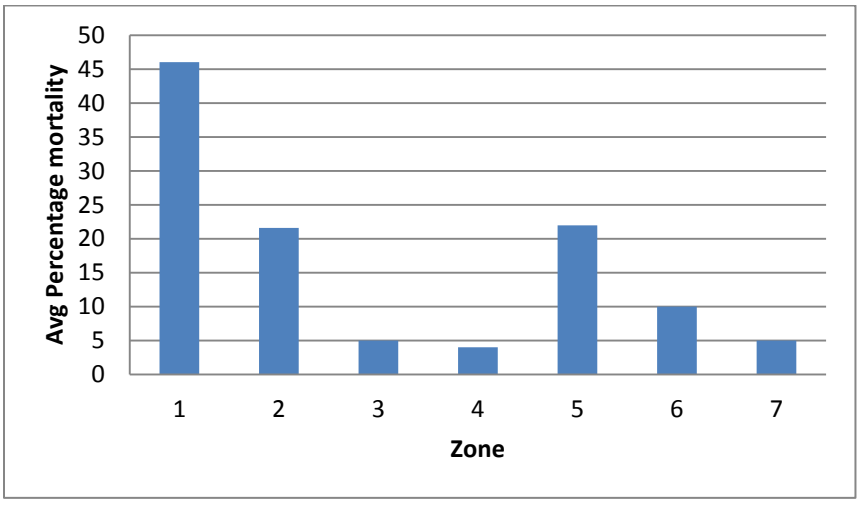

Figure 1. Average percent mortality of all planted species combined for each zone. Zone 4 had lowest mortality and Zone 1 had highest mortality. Mortality rates are likely higher than estimated as more than 1/3 of the plants in each zone could not be found and were not counted in these mortality figures.

LESSONS LEARNED: ZONE WALK THRU ASSESSMENT

Dry adapted and early successional species seemed to perform best overall on the site including most shrubs--snowberry, Rosa species, oceanspray, Oregon grape, serviceberry, but also some trees Garry oak, douglas maple, madrone, grand fir, shore pine, and western white pine.

Western red cedar does well as an underplanted species in the alder forest in Zone 4. This is encouraging because if the cedars continue to do well they will eventually provide later successional canopy cover as these alder forests mature and fall.

Garry oak is the choice tree for planting in zones 1 and 2. Garry Oak exhibited very low mortality in the 2 zones that had highest mortality rates for plants overall. For shrubs that succeed in these conditions the following species are recommended: snowberry, all Rosa species, oceanspray. Consider sowing seeds in zones 1 and 2 as seeds of hardy early successional natives might perform better than seedlings in these hot, dry, early successional areas. Consult the list of native volunteers in the companion baseline monitoring report Appendix A and also see Soil Amendment results below for recommended native species.

Soil Amendment Plot Study:

SUMMARY:

- Does soil amendment affect plant survivability and stress level*? Yes. All species experienced lowest mortality in fully amended plots.*
- Which species are best suited to the site (experience the lowest mortality/stress)? *Hardy shrubs are best suited to this site including: snowberry, oceanspray, nootka rose, and serviceberry.*
- Do different soil amendment treatments differ in ability to suppress or encourage volunteer plant colonization? *No. Overall volunteer species cover did not statistically differ between soil amendment treatments.*
- What volunteer plant species are present on the site? *Over 60 different species were recorded, 26% (16) of them were native.*
- Are there any native plant species volunteers that should be encouraged*? Yes pearly everlasting, and lupine are both doing very well in a variety of areas and conditions in all plot treatments. All grass species volunteers including some non-natives might be considered as important for their successional value in building soils on this stripped site. See Table 1.*
- Does soil amendment affect volunteer plant species composition in any way? *Yes. Native species richness of volunteer species was highest in fully amended plots as compared to other treatments. Plots where no planting had been done had native species richness of volunteers equal to fully amended plots perhaps because disturbance was lower due to no planting.*

RESULTS:

Soil Amendment Plots---Mortality and Stress of planted plants

Trees had higher mortality rates overall (30-87% mortality) compared with shrubs (2-31% mortality) with the exception of thimbleberry and kinnicknick (62-85% mortality). Douglas Fir outperformed alder in all soil treatments and responded best to fully amended soils (full amendment resulted in a considerable decrease in douglas fir mortality--73% to 30%).

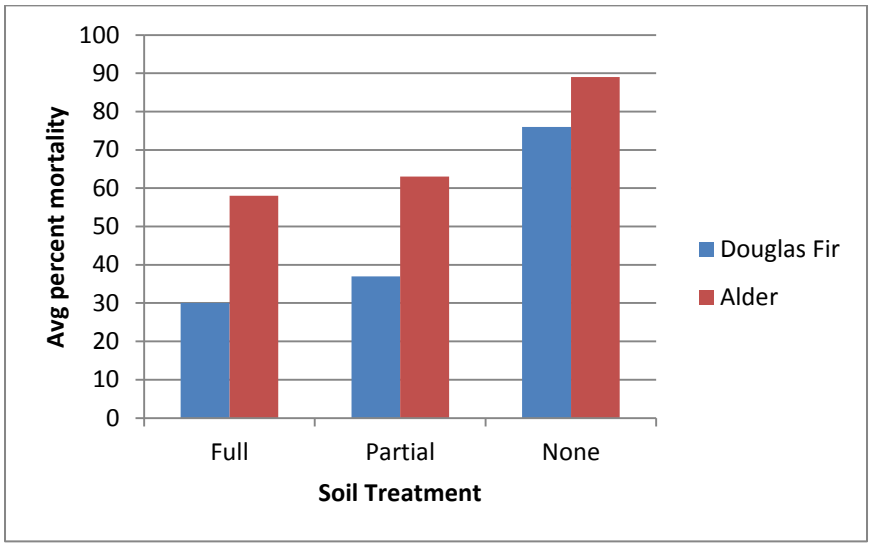

Figure 2. Fully amended soils had lower mortality than other soil treatments for both alder and douglas fir.

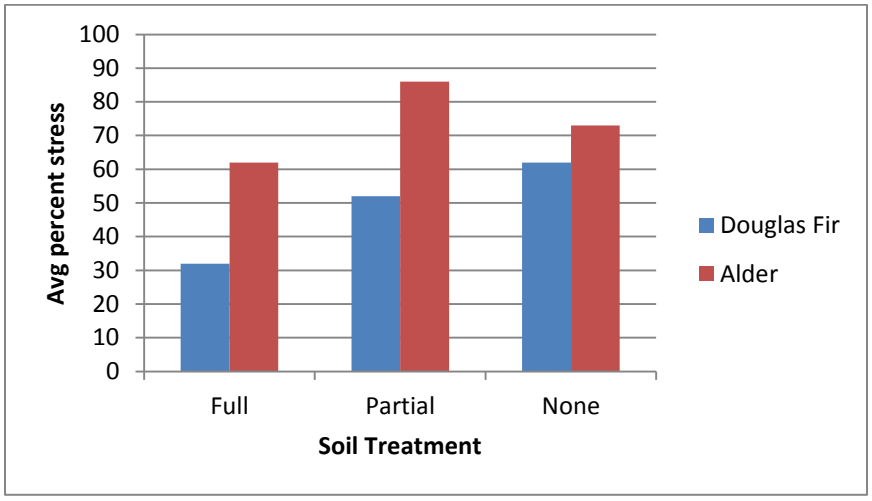

Figure 3. Stress was lowest for both douglas fir and alder in fully amended plots.

Shrubs performed much better than trees in all treatments, with the exception of thimbleberry and kinnicknick which had greater than 50% mortality in all treatments. Mortality for all hardy shrubs was at the lowest levels in the fully amended plots. Snowberry performed the best of all shrubs and was very successful even in completely un-amended soils: 1% mortality in full amendment, 14% mortality with no amendment. Oceanspray was the second hardiest shrub for all treatments followed by Nootka Rose and Serviceberry. All of these shrubs had higher percent mortality in un-amended soils than Snowberry (30%).

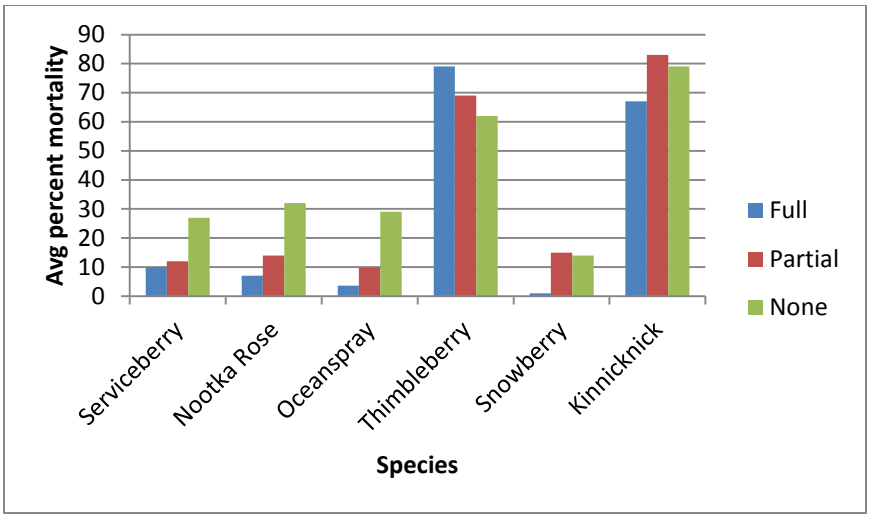

Figure 4. Hardy shrubs had significantly lower mortality than thimbleberry and kinnicknick in all treatments. All shrubs had lowest mortality in fully amended plots.

Soil Amendment Plots: Volunteer species cover and composition

We recorded 66 volunteer species on site 42 of which occurred in the soil amendment plots. Of these 42, 16 were native. Grasses were not all keyed to species. Grass species provided the highest percent cover (most dominant) in all plots regardless of soil treatment followed by sheep sorrel (*Rumex acetosella*). Common tansy (*Tanacetum vulgare*) and Lamb's quarters (*Chenopodium album*) were the next most dominant volunteer species. A lupine species was released with the clearing of non-native blackberry and scotch broom and seems to be gaining cover fairly rapidly. It was recorded growing in many diverse areas by the end of the growing season and was always in very good health. We did not get a positive species identification on the lupine. This needs to be done in the next growing season.

Table 2. List of volunteer species recorded at Maury Island Marine Park on soil amendment plots. Most dominant by percent cover are shaded in gray.

Form	Genus	species	Common name	Native	Non-native	Perennial
Tree	*Arbutus*	*menziesii*	Madrona	x		x
Shrub	*Buddleja*	*davidii*	Butterfly bush		x	x
Shrub	*Cytisus*	*scoparius*	scotch broom		x	x
Forb	*Achillea*	*millefolium*	Yarrow	x		x
Forb	*Anaphalis*	*margaritacae*	pearly everlasting	x		x
Forb	*Artemisia*	*suksdorfii*	coastal mugwort	x		x
Forb	*Chenopodium*	*album*	Lambs quarters		x	
Forb	*Cirsium*	*arvense*	canadian thistle		x	x
Forb	*Cirsium*	*vulgare*	bull thistle		x	x
Forb	*Claytonia*	*sibirica*	Miner's lettuce	x		
Forb	*Crepis*	*capillaris*	Smooth hawksbeard		x	
Forb	*Digitalis*	*purpurea*	Foxglove	x		x

Forb	*Epilobium*	*angustifolium*	willowherb sp.	x		x
Forb	*Equisetum*	*sp*	Horsetail	x		x
Forb	*Galium*	*aparine*	Cleavers	x		
Forb	*Geranium*	*robertianum*	herb Robert		x	
Forb	*Hypericum*	*perforatum*	st. john's wort		x	x
Forb	*Hypochaeris*	*glabra*	smooth cat's ear		x	
Forb	*Hypochaeris*	*radicata*	hairy cat's ear	x		x
Forb	*Lamium*	*purpureum*	Purple dead nettle		x	
Forb	*Ligustrum*	*sp*	privet sp.		x	x
Forb	*Lupinus*	*sp*	lupine sp.	x?		x
Forb	*Mysotosis*	*laxa*	Forget me not	x		
Forb	*Plantago*	*lanceolata*	english plantain		x	x
Forb	*Plantago*	*major*	common plantain		x	x
Forb	*Polygonum*	*sp*	smartweed sp			
Forb	*Rumex*	*acetosella*	sheep sorrel		x	x
Forb	*Rumex*	*crispus*	curly dock		x	x
Forb	*Senecio*	*vulgaris*	Common groundsel		x	
Forb	*Sonchus*	*asper*	spiny sow thistle		x	
Forb	*Stellaria*	*media*	Chickweed		x	
Forb	*Tanacetum*	*vulgare*	common tansy		x	x
Forb	*Taraxacum*	*officinale*	Dandelion		x	x
Forb	*Trifolium*	*repens*	white clover		x	x
Forb	*Urtica*	*dioica*	stinging nettle	x		x
Forb	*Vicia*	*americana*	american vetch	x		x
Grass	*Grass*	*sp*	All grasses	x	x	x
Grass	*Agrostis*	*sp*	Agrostis sp			
Grass	*Cynosurus*	*echinatus*	Hedgehog dogtail		x	
Grass	*Fescue*	*sp*	Fescue sp			
Grass	*Holcus*	*lanatua*	common velvet grass		x	x
Grass	*Trisetum*	*sp*	Trisetum?			
Fern	*Polypodium*	*glychyrrhiza*	Licorice fern	x		x

There was no significant difference in cover of volunteer species between any of the treatments (median cover category for percent cover of volunteers—full=4, partial=4, no amendment=4, not planted=5; median cover category for percent bare ground—full=4, partial=5, no amendment=5, no plants=3). This indicates that fully amending soil does not either suppress or encourage more volunteer growth compared to other treatments.

Interestingly, native volunteer species richness was highest in plots with fully amended soils and plots with no plantings as compared to the other 2 treatments (Average native species volunteer richness—

full=1.2; no plants=1.1; partial=.3; no amendment=.3). This trend was statistically significant: ANOVA with post hoc tests: F-critical=4.74, p=.02*, df=3. *significant difference was between full and partial, full and no amendment, no plants and partial, no plants and no amendment. There was no significant difference between full and no plant treatments). Percent cover of non-native volunteers did not differ between treatments.

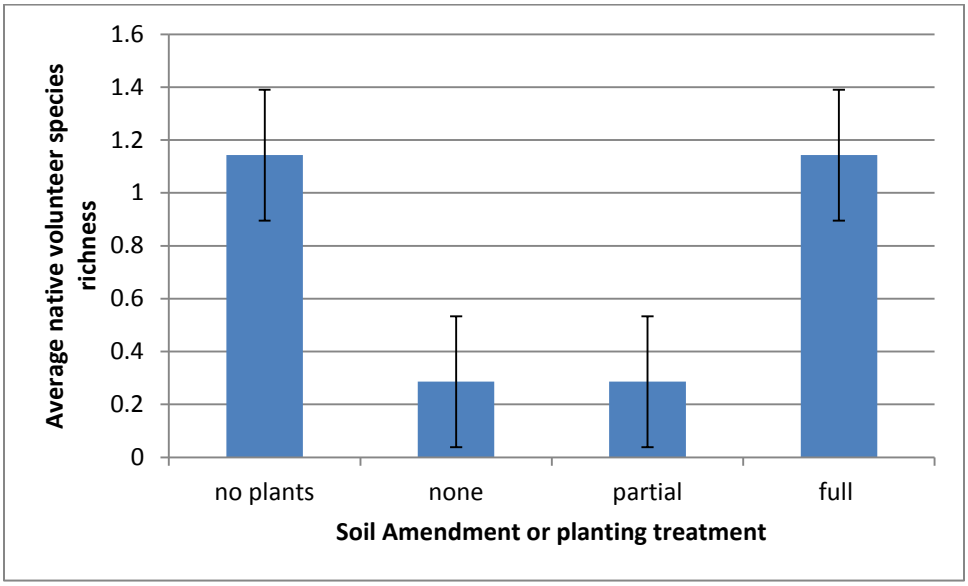

Figure 5. Average native volunteer plant species richness was significantly greater in plots with no plantings or plots with full soil amendment compared to the other two treatments. Error bars represent mean standard error. Percent cover of non-natives did not differ between treatments.

LESSONS LEARNED: SOIL AMENDMENT PLOTS

All planted plants responded with decreased mortality in fully amended soils. In addition, fully amended plots did not result in more weedy cover than other treatments. However they did appear to encourage more native volunteer species than other treatments with the exception of the plots that had not been planted at all. It is recommended that monitoring be continued for a second growing season as results may vary when roots begin to grow lower than the soil amendment layers.

Give preference to hardy shrubs over trees. Hardy shrubs including snowberry, oceanspray, nootka rose, and serviceberry, had significantly lower mortality rates than trees. Snowberry can be planted with success without the need for amendments. Oceanspray, Nootka rose, and Serviceberry could also be planted without amendments but mortality rates will likely be higher (30%).

Soil amendment does not appear to significantly help alder survival. This species did very poorly in all treatments. Alder needs moist soils to survive and may have been extremely challenged by the dry conditions of the plots. If alder must be planted we recommend planting it at the bottom of slopes or in areas where the water table is shallow or where more soil moisture could be retained through mulching or watering.

In terms of native species management, we recommend encouraging all native volunteer species and most grass species cover to build soils. In addition, consider seeding early successional native plants and grasses as an alternative to planting starts. Include lupine and pearly everlasting as well as native grasses.

MADRONE SEEDING EXPERIMENT

MAJOR QUESTIONS:

- Do more madrone seeds sprout near mature trees than in open, grassy areas? *YES.*
- Do plot quarters that have been seeded have more madrone seed germination than those that are not seeded? *YES, but barely. We recommend researching another seed stratification technique to increase germination. Perhaps cold stratification.*
- What is the survival rate of seedlings in the first season? *18-25%. This is higher than reported in other publications (0-8%).*
- What affects madrone seedling survival in the first growing season after germination? The presence of other trees seems to be needed for both emergence and survival. There was no statistical relationship between duff layer depth and madrone seed emergence or survival. Presence of bare ground increased the chance of madrone seedling emergence.

Results:

Tree Cover—

Significantly more seedlings were found in plots with madrone tree cover indicating that seedlings are positively associated with tree cover however it is not clear what it is about tree cover that is beneficial.

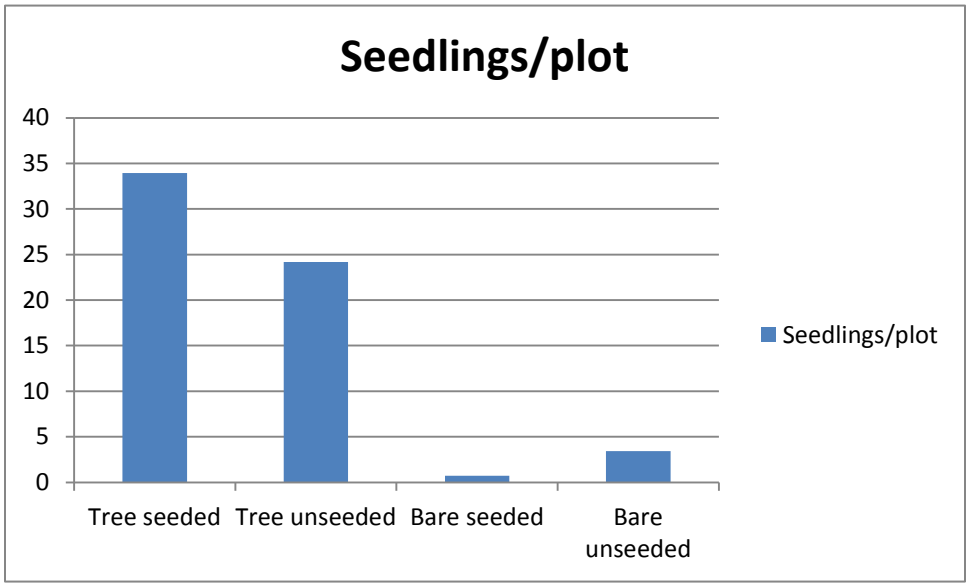

Figure 6. More seedlings germinated in plots with trees than plots in the open. Seeded quarters of plots had slightly more seedling germination than unseeded quarters but this trend was only borderline statistically significant (p=.054, paired t-test between seeded and unseeded quarters of each tree plot, df=44).

Seeded vs. Unseeded Plots—

There were slightly more seedlings coutned in seeded quarters of plots compared to unseeded quarters however this result was only borderline statistically significant (t-test p=.054) indicating that perhaps seed preparation techniques need to be changed. Stratifying madrone seeds is a complicated process and cold stratification (for 60 days) is recommended by some rather than acid scarring (Maleike and Hummel 1995).

In the early summer count of madrone seedlings 73% of unseeded quarters contained seedlings in the tree plots and 76% of seeded quarters contained seedlings in the tree plots. Only one seeded and unseeded quarter contained seedlings in the bare plots.

Seedling survival—

Seedling survival was relatively high compared to other studies (0-8%; Tappeneir et al. 1986; McDonald et al. 1983). We found an average of 25% seedling survival in unseeded tree plots and 18% survival in seeded tree plots. No seedlings survived in the barren plots indicating that trees are necessary not only for increased germination rates but also seedling survival. At the end of the growing season 44% of seeded quadrants still contained at least 1 madrone seedling and 36% of unseeded quadrants contained at least 1 madrone seedling.

The above results could indicate that the presence of mature madrones confers some sort of benefit to seedling germination and survival (i.e. mychorrizal inoculation, shade, moisture, nutrients). Higher survival rates could have been confounded by a flush of new seedlings that emerged following end of summer rains. These seedlings were not differentiated from original seedlings in the end of season counts so this likely increased the apparent survival numbers. However, this does not explain the clear difference in seedling germination in plots containing mature madrones compared to plots with no madrones indicating that mature madrones do confer some benefit at least in germination and likely in survival as well.

Causes of seedling success—

Duff layer depth, as well as herbaceous and shrub cover were not related to madrone seedling germination or survival (multiple regression, $p>.05$ for both, $R2\ adj<.3$ for all).

Bare ground cover did not seem to affect seedling survival. However, the percentage of bare ground was positively related to seedling germination (seedling counts). Significantly more seeds germinated when there was more than 10% bare area in a plot (ANOVA: $p=.038$, $F=3.11$, $df=2,80,82$). And seedling counts

increased as bare ground increased however the relationship was not significant after 50% bare ground cover was reached.

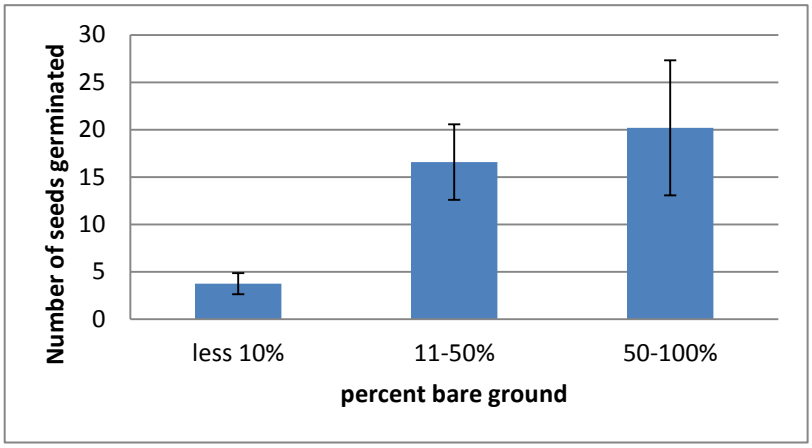

Figure 7. Number of madrone seedlings counted in plots with less than 10% bare ground compared to 11-50% bare ground and over 50% bare ground. There were significantly less seedlings counted in plots with less than 10% bare ground than the other two cover categories. There was a slight increase in number of seeds counted between 11-50% bare ground cover and 50-100% bare ground cover but the difference was not significant.

LESSONS LEARNED: MADRONE PLOTS

Although we are far from understanding all the factors that may contribute to successful madrone seedling germination and survival it appears that presence of mature madrone trees increases seedling emergence and possibly survival. All seedlings found in the madrone plots were within the dripline of a mature madrone. Additionally, presence of bare ground patches increases the number of madrone seedlings that emerge. Survival through the growing season was not related to the presence of bare ground but seedling emergence was.

Because of the iconic and ecologically unique value of the large madrone forests on site, we recommend that further research is done to uncover physical and ecological factors on site that encourage successful madrone seedling germination and survival. We also recommend continuing madrone seeding efforts using seeds from trees on site.

FURTHER RESEARCH AND MONITORING SUGGESTIONS:

We recommend following the soil amendment plots for a second year to see if results change as roots grow below the amended zone. Continuing research on madrone propogation is highly recommended as the dominant forest type on most of the park site is madrone forest and this is one of the last healthy madrone forest stands in the Puget Sound. Herbicide monitoring results were not presented in this report as herbicide treatment of the study plots has not yet happened. If herbicide use continues we recommend monitoring the herbicide plots to compare the results of grubbing vs. grubbing and herbicide application. Comparisons can be made for returning vegetation cover, planted plant health, and overall management effort differences between the two treatments.

Overall, monitoring of the vegetation restoration effort at Maury Island Marine Park has increased our knowledge of the intricacies of this site, uncovered information about plant needs and patterns of

mortality and stress that can inform future efforts, and instigated investment of local residents in the outcome of this restoration. We hope that any future monitoring done on this site can build on this initial effort through time.

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