NRCS Conservation Innovation Grant Technical Report

Forest Understory Vegetation Enhancement Project

Laura Taylor, Conservationist & Education Coordinator

Michael Ahr, Forest Conservationist

West Multnomah Soil & Water Conservation District

September 30, 2020

Introduction

In northwest Oregon, woodland managers on private and public land manage their forests with several objectives in mind. Two common goals shared by owners of private, family woodlands include:

1) Managing a healthy forest where invasive weed species are under control. When family woodland owners are asked about their planned forest activities over the next 5 years, 58% of ownerships (more than 2 million acres) report that they will be working on invasive weed control.
2) Providing ample wildlife habitat for a variety of species. When asked about reasons for owning their woodlands, 66% of ownerships cite motivation "to protect or improve wildlife habitat" and 70% aim to protect nature or biological diversity. *(Butler et al. 2016)*

In the temperate rainforests of western Oregon, diversity is key to high quality wildlife habitat. Wildlife are abundant in forests that have a variety of tree species that cover a variety of age classes. Wildlife need an array of different food sources such as berries, leaves, nuts, and seeds and they thrive in forests that have a healthy forest floor, or understory, where much of the food and shelter is found (Hagar, 2007). Invasive species in our region such as Armenian blackberry *(Rubus armeniacus)* and English holly *(Ilex aquifolium*) occupy growing space and compete for resources with native plant species that wildlife depend on for food and cover. Threats to forest biodiversity are often a function of threats to herbaceous layer species (Jolls 2003). Invasive ground cover such as ivy *(Hedera species)* will often spread much more quickly than native plants on the forest floor and threaten diverse habitat (Copp, 2014).

The forest shrub layer is very important to wildlife as a food and shelter resource. The majority of birds in the Portland metro region nest in the shrub layer close to the ground (Bureau of Environmental Services, 2017). With this in mind, many landowners and ecologists are working to build robust shrub layers under forest canopy.

Overall, understory vegetation adds and supports biodiversity in our forests. In a review of studies across the United States, Gilliam (2007) found the herb layer averaged 80% of the species richness of a temperate forest. The same assessment found as much as 16% of litter fall on the forest floor coming from the herbaceous layer and higher concentrations of carbon and nitrogen in herbaceous plant leaves compared to leaves from the tree canopy. Understory seeding and restoration has long been used to reduce erosion on roads, trails, and steep slopes, and following disturbance such as wildfire.

West Multnomah Soil & Water Conservation District's (WMSWCD) Forest Understory Vegetation Enhancement Project set out to gather information on managing the various forest layers – understory, middlestory, and overstory – with a goal of minimizing invasive cover while maximizing diverse, native plants. This report details methods used along with recommendations and lessons-learned pertaining to invasive species control and understory species establishment. Whether planting a shade tolerant shrub or spreading seeds that will grow into the next forest wildflowers, this report offers considerations along with some guidance on how to establish the forb and shrub layer of the forest to enhance native habitat.

Methods related to forest understory seeding

Setting – Eight study sites were chosen in northwest Oregon in the Tualatin Mountains northwest of Portland, Oregon. All sites were on private, family-owned forests where WMSWCD had been contacted by woodland owners to assist with forest health. WMSWCD managed a restoration project at each site with the main objectives to treat invasive weeds, thin trees to reduce competition in the overstory, and install native plants. Armenian blackberry was removed at two sites, English ivy or vinca was removed at four sites, and the forest was thinned at three sites (one thinned site also had blackberry removed). The weed management and thinning were completed before any planting or seeding took place. After seeding, herbicide was no longer used to make sure seedlings were not killed which would have affected the data. Sites represented a range of forest types from predominantly coniferous forests dominated by Douglas-fir and western hemlock (3 sites), to deciduous forests dominated by bigleaf maple and red alder (2 sites), with some mixed canopy forests supporting many of these species together (3 sites). All study sites were in upland forests away from streams.

Seeding trials - 46 circular study plots 11 feet in diameter were installed at the eight sites described above. On seven of these properties, six plots were established: two were raked clear of leaves and duff and then seeded with a diverse seed mix (Table 1), two control plots were raked but not seeded, and two plots were not raked and were seeded with a minimal seed mix containing only more readily available species (Table 2). On the eighth property, only four plots were established due to the small size of the ownership with one plot raked and seeded, one plot raked but not seeded, and two unraked seeded plots. Data were collected at each plot for three consecutive years. Baseline conditions were documented in June of 2018 prior to site preparation and seeding which occurred over the summer and fall of 2018. Results of the seeding trials were then monitored in April and June of 2019 and June of 2020. The following variables were measured at each plot: slope, aspect, canopy cover, deciduous vs. coniferous canopy composition, density of worms, soil compaction, percentage cover of plant species within plots, and aerial cover of target species (those in our seed mixes) within a five foot radius buffer outside of each plot. Four 0.25 m^2 subplots, one in each cardinal quadrant of the plot, were used to count the number of individuals of each plant species that occurred within each subplot. Seeding treatments and other environmental variables were tested for their effects on plant cover, abundance, and plot species diversity using multivariable model Poisson regression analysis performed by Bio Lab Analytics.

Soil analysis - Soil samples were collected from each plot in each year of the study. In 2018, plot samples were combined into one sample from each site, while in 2019 and 2020, soil samples were combined from plots of the same treatment. Samples were analyzed by Oregon State University Central Analytical Laboratory for the following variables: sand, silt, and clay composition; water stable aggregates; volumetric moisture; carbon, nitrogen, and organic matter composition; active carbon; CO_2 respiration; potentially mineralizable nitrogen; pH; electrical conductivity; and concentration of phosphorous, potassium, calcium, magnesium, and cation exchange capacity.

Methods related to forest shrub planting

Setting – Five study sites were chosen in Northwest Oregon, three of which also had forest understory seeding plots. All sites were on private, family-owned forests where WMSWCD has worked with the landowner on forest restoration. WMSWCD managed a restoration project at each site with the main objectives to treat invasive weeds and install native plants. Armenian blackberry was removed at three sites and English ivy was removed at two sites. The weed management began before the shrubs were planted and continued after the planting as a form of maintenance to reduce competition from weeds. On the five sites, two of the shrub plantings would be characterized as forest edge plantings at a transition to an open field. One planting was among gaps that had been cleared of blackberry surrounded by mixed forest, and two plantings were installed under a mature, mixed species forest canopy. All shrub plantings were installed under or next to mixed conifer-deciduous forest. All study sites were in upland forests away from streams.

Table 1 Diverse understory forb seed mix used in raked, seeded plots.

Common Name	**Latin Name**	**bulk grams per plot**	**tz test % viability**	**PLS grams per plot**	**seeds per pound**	**% of mix**
Pathfinder	*Adenocaulon bicolor*	1.5	0.91	1.365	100,666	3
Western columbine	*Aquilegia formosa*	0.7	0.85	0.595	248,000	3
Columbia brome	*Bromus vulgaris*	1.7	0.85	1.445	100,000	3
Slender-foot sedge	*Carex leptopoda*	0.8	0.89	0.712	647,142	10
Enchanter's-nightshade	*Circaea alpina*	0.6	0.88	0.528	838,889	9
Miner's-lettuce	*Claytonia perfoliata*	0.8	unknown	<0.8	261,346	4
Siberian miner's-lettuce	*Claytonia sibirica*	1.2	unknown	<1.2	404,000	9
Blue wildrye	*Elymus glaucus*	1.4	0.97	1.358	130,000	4
Western fescue	*Festuca occidentalis*	0.4	0.52	0.208	605,000	3
Large-leaved avens	*Geum macrophyllum*	0.8	0.9	0.72	906,000	14
Pacific waterleaf	*Hydrophyllum tenuipes*	16.2	0.9	14.58	45,300	13
Small-flowered nemophila	*Nemophila parviflora*	1	0.88	0.88	250,000	5
Sweet-cicely	*Osmorhiza berteroi*	4	0.89	3.56	60,670	4
Broad-leaved penstemon	*Penstemon ovatus*	0.2	0.89	0.178	600,000	2
Fringecup	*Tellima grandiflora*	0.1	0.74	0.074	7,000,000	11
Piggyback plant	*Tolmiea menziesii*	0.2	0.89	0.178	600,000	2
Inside-out flower	*Vancouveria hexandra*	1	0.87	0.87	113,398	2

Table 2 Minimal understory forb seed mix used in unraked, seeded plots.

Common Name	Latin Name	bulk grams per plot	tz test % viability	PLS grams per plot	seeds per pound	% of mix
Large-leaved avens	*Geum macrophyllum*	~ 12	unknown	unknown	906,000	48
Pacific waterleaf	*Hydrophyllum tenuipes*	~ 16	unknown	unknown	45,300	3
Oregon phacelia	*Phacelia nemoralis*	~ 2.5	unknown	unknown	~559,172	3
Fringecup	*Tellima grandiflora*	~ 1.5	unknown	unknown	7,000,000	46

Planting approach – Unique mixes of shrub species were planted on each site with spacing ranging from four to eight feet. The species mix was crafted with consideration for the amount of sunlight, moisture, erosion, and existing shrub composition present during site preparation activities. The three sites that were characterized as forest edge or gap plantings had been cleared of blackberry that still presented a concern in terms of future competition, so the sites were planted very dense. Two sites were planted at four foot spacing, or a density of 2,722 shrubs per acre while one was planted at five foot spacing, or a density of 1,742 shrubs per acre. One of the planting sites under the forest canopy was also planted at 2,722 shrubs per acre density and focused on areas with noticeable erosion on steep slopes. The last site, which was under forest canopy, was treated to control ivy and planted at eight foot spacing, or a density of 681 shrubs per acre.

Results and Discussion of Seeding Trial

Raking and Seeding Treatment Effects – Raking and seeding had the strongest effect on the number of plants that germinated and established in our plots compared with other environmental factors measured (Table 3, Fig. 1). Seeding trials were very successful in raked seeded plots, with an average of 261 seedlings per m^2 of our target seeded species present in June of the first growing year, 2019. This is significantly higher than the number of seedlings of target species found in 2019 in raked control plots where no seed was sown (17 seedlings per m^2). Unraked seeded plots had marginally higher presence of target species growing than in the control plots, with 40 seedlings per m^2. In 2019, the average abundance of all native plants was over six times higher in the raked seeded plots compared to control plots (319 and 50 plants/m^2 respectively), and almost four times higher than the unraked seeded plots (83 plants/m^2; Fig 1). Conversely, the unraked seeded plots had about half as many non-native plants compared to the raked control and raked seeded plots (23, 56, and 54 plants/m^2 respectively; Fig 1). This demonstrates that while raking the accumulated leaves away is clearly valuable for promoting the establishment of sown native seed, it also creates more susceptibility to non-native plant establishment. However, the proportion of native to non-native individuals was much higher in both seeded treatments than in the control treatment, suggesting that seeding native species could result in a more native-dominant plant community on the forest floor if these plants are able to grow vigorously to continue occupying the space.

In the second growing year of 2020, the number of target seedlings decreased by 38% in the raked seeded plots and by 34% in unraked seeded plots, whereas the levels of target seedlings only decreased by 28% for control plots. We would expect seedling density to decrease over time as some seedlings die and others become more established. The higher mortality rate of target seedlings from 2019 to 2020 for both of the seeded treatments suggests that these seedlings are still highly vulnerable when they are newly germinated, and there will be an acute self-thinning process in the first year or so of growth as seedlings compete for space and resources. The raked seeded plots continued to have far higher numbers and proportions of target seedlings than the control and unraked seeded plots, but numbers of introduced plants were twice as high in control plots than in either of the raked or unraked seeded plots in 2020 (Fig 1). Since native plant abundance was higher in both the raked and unraked seeded plots, it makes sense that these native plants were able to effectively occupy more of the space, while introduced weedy plants were able to take advantage of the open space available in the raked control plots that did not have native seed added.

Table 3 Results of the multivariable Poisson regression analysis testing the effects of site, year, treatment (raking and/or seeding), seed mix, species origin (native, exotic, invasive, or unknown), and other environmental variables on the number of plants growing in each subplot. Significant effects are in bold, stronger effects are represented by higher LR Chi Square values.

Number of plants			
Source	Df	LR Chi Square	P
Year	2	**39.26**	**<0.0001**
Site	7	**22.42**	**0.0021**
Subplot	3	2.62	0.4547
Treatment	2	**10.00**	**0.0067**
Seed mix	3	**72.44**	**<0.0001**
Species origin	3	**15.63**	**0.0014**
Slope	2	0.19	0.9097
Aspect	3	**21.51**	**<0.0001**
Soil compaction	2	1.80	0.4085
Diversity index	1	**34.97**	**<0.0001**
Canopy cover	1	0.03	0.8718
Forest canopy type	2	0.32	0.8510

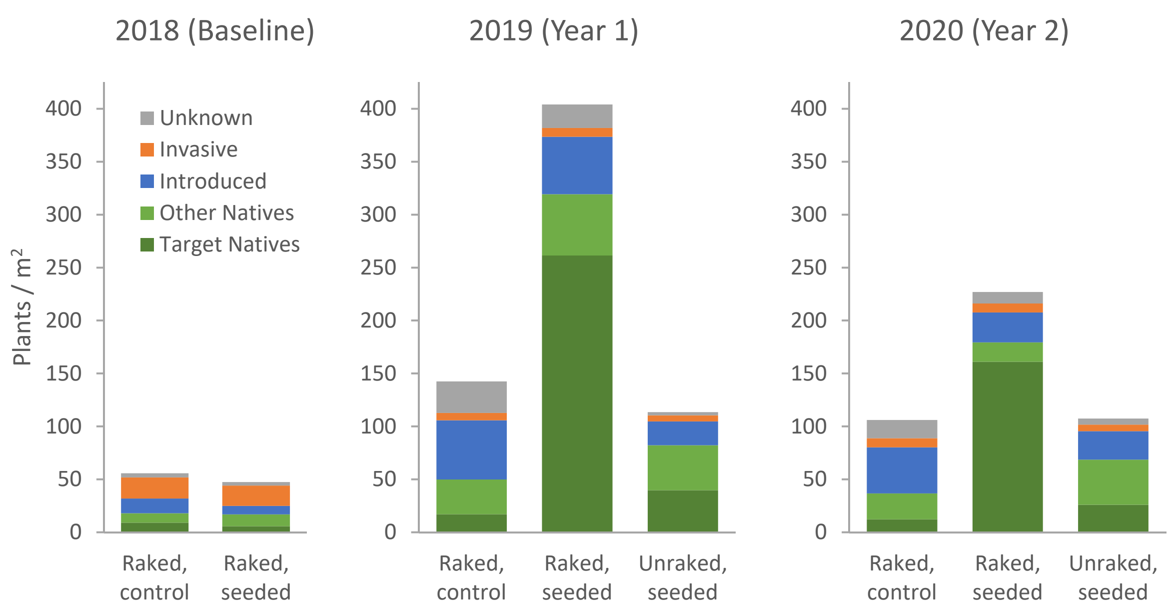


Figure 1 Average abundance of individual plants belonging to species of target native, other native, introduced, invasive, and unknown origin status for each treatment over the three years of the study.

Seasonal Effects – In the first year of emergence, the abundance of target species seedlings did not change much at all per plot from April to June for most of the species. The exceptions to this were small flowered nemophila, which diminished in numbers by 20% over the three months, and slender-foot sedge which increased in numbers by 15% over the three months. Small flowered nemophila is an early spring annual which dies back once rainfall drops off, so its decline is not surprising. Slender-foot sedge appears to be a slightly later-emerging species. May to early June appears to be the optimal time to monitor for emergence to effectively capture all species with only one visit.

Germination Performance - In raked, seeded plots where the more diverse seed mix was sown, some species emerged at higher rates than that rate at which they were originally sown, while other species were underrepresented compared to their seeding rate (Table 4, Fig. 2). This suggests that seeds of overrepresented species were more successful at germinating than those of underrepresented species. One species, enchanter's nightshade was found at rates very similar to its seeding rate. Most seeded species were relatively equally abundant once emerged, representing between 6% to 11% of the target species community assemblage (Fig. 2). This is a good indication that the seed mix composition was well designed for equal representation of most species. The few exceptions to this are broad-leaved penstemon, Siberian miner's lettuce, and Western columbine which were relatively rare to non-existent in our plots. While this was expected for broad-leaved penstemon and Western columbine due to their low seeding rates, it is not clear why Siberian miner's lettuce was so underrepresented. One possibility is that the seed from this species had poor viability for some reason. While most species were tested for seed viability with a tz test, the two miner's lettuce species were not, so there is no data to support this theory (Table 1). Given that this trial relied on only one batch of seeds, and that our partners doing similar trials report successful germination rates for Siberian miner's lettuce, we don't believe the Siberian miner's lettuce results from our trials should be used to make generalizations about this species' germination performance.

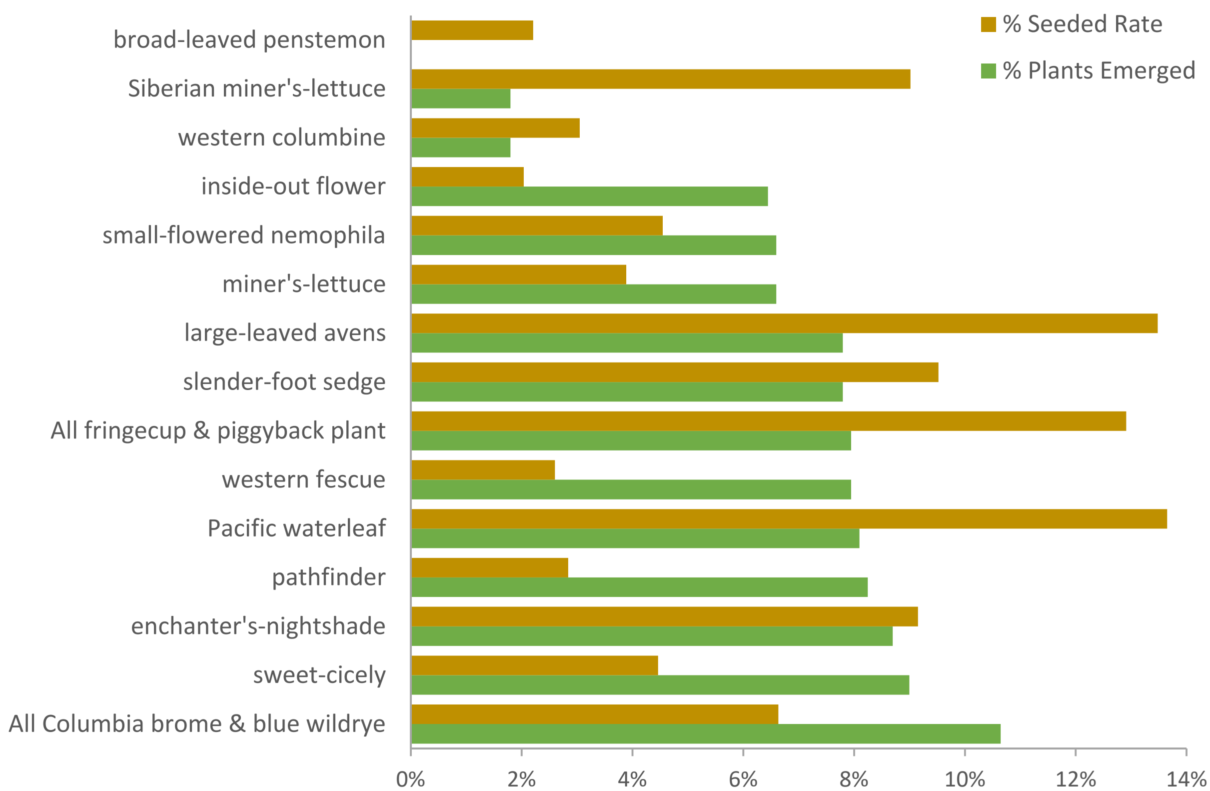


Figure 2 Germination performance. Comparison of the original percent composition of each species in the diverse seed mix to the species composition of native target seedlings that germinated in raked, seeded plots in June of 2019, one growing season after seeding.

Table 4 Overrepresented and underrepresented native plant species observed emerging one year after seeding. Overrepresented species were found in higher percentages of the target species community compared to the original seeding rate, while underrepresented species were found at lower percentages of the target species community compared to the original seeding rate.

Overrepresented species:	Underrepresented species
Inside-out flower	Broad-leaved penstemon
Small-flowered nemophila	Siberian miner's lettuce
Miner's lettuce	Western columbine
Western fescue	Large-leaved avens
Pathfinder	Slender-foot sedge
Sweet cicely	Fringecup and Piggy-back plant (lumped)
Columbia brome and blue wildrye (lumped)	Pacific waterleaf

Growth Performance - While successful germination and establishment of high numbers of plants is one indication of a successful seeding effort, another indicator is how quickly and effectively the plants grow and occupy the space. Most planted species remained very small in their first year of growth, with total target species cover only reaching an average of 2.9% in raked seeded plots, and 4.6% in unraked seeded plots (Fig. 3). By the second year of growth in 2020, target species had grown to cover an average total of 24% of raked seeded plots, while target species cover remained stagnant at 5.8% in unraked seeded plots (Fig. 3). Whether plots were seeded or not was the strongest predictor of differences in plot coverage, with raked seeded plots developing significantly higher cover of target native plants by 2020 than the other two treatments (Table 5, Fig 3). Differences between years also had a strong effect on plot coverage as plants grew to fill the space over time (Table 5, Fig 3).

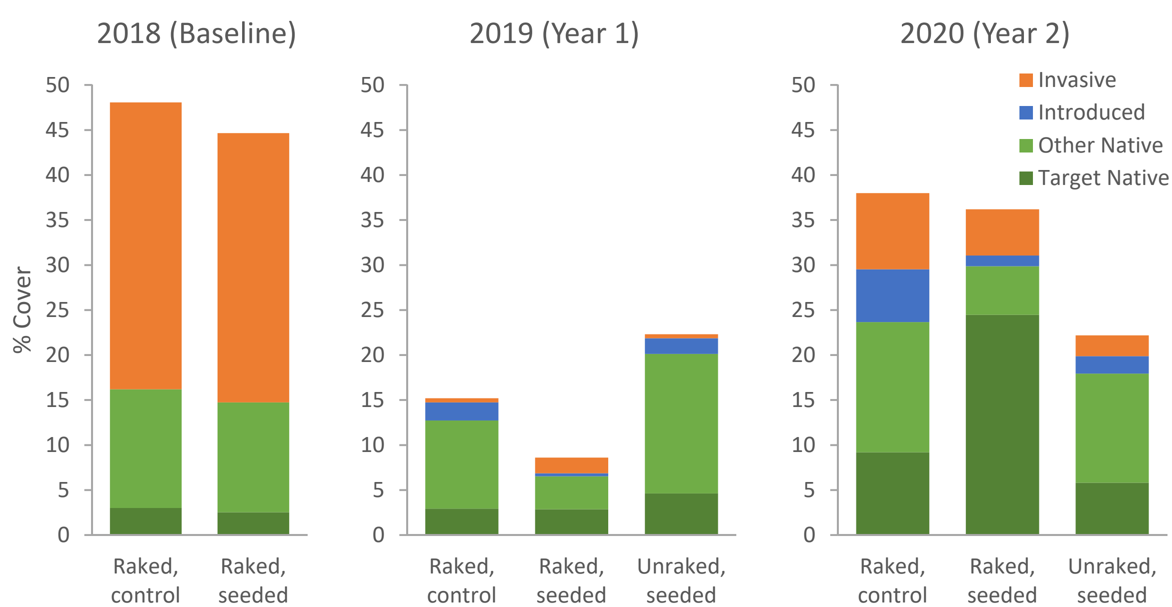


Figure 3 Average percentage cover of plants belonging to species of target native, other native, introduced, invasive, and unknown origin status for each treatment over the three years of the study.

Table 5 Results of the multivariable Poisson regression analysis testing the effects of site, year, treatment (raking and/or seeding), seed mix, species origin (native, introduced, invasive, or unknown), and other environmental variables on the cover of plants growing in each plot. Significant effects are in bold, stronger effects are represented by higher F values.

Cover of plants Source	Df	F Value	P
Year	2	**7.36**	**<0.0001**
Site	7	1.29	0.2515
Treatment	2	0.64	0.5251
Seed mix	3	**8.14**	**<0.0001**
Species origin	3	**6.52**	**0.0002**
Slope	2	0.59	0.5533
Aspect	3	1.33	0.2640
Soil compaction	2	0.38	0.6834
Diversity index	1	**6.64**	**0.0102**
Canopy cover	1	3.82	0.0510
Forest canopy type	2	0.53	0.5912

By 2020, some target species had grown to cover more of the plots than others. Figure 4 shows the average plot cover attained by each target species by June of 2020. Sweet-cicely, blue wildrye, Pacific waterleaf, and western fescue reached the highest cover (over 3% each) by their second year of growth, and thus might be good choices for sites where more rapid cover is needed (Fig. 4).

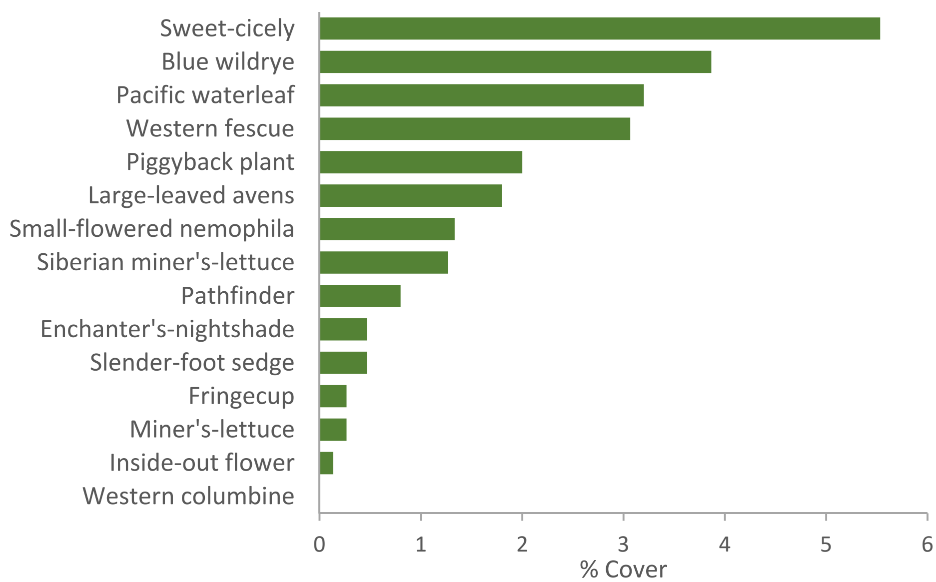


Figure 4 Growth performance. Average percentage cover per plot of each species in the diverse seed mix in raked, seeded plots in June of 2020 after two years of growth.

Effects of Restoration Project Type - In general, seedling emergence rates for each species did not vary greatly between the different project types – vinca and ivy removal, blackberry removal, and forest thinning (Fig. 5). There were a few exceptions to this trend. For example, the grasses Columbia brome and blue wildrye performed a bit better in ivy/vinca removal projects than they did in blackberry removal or thinning projects, and pathfinder performed a little better in thinning projects than at sites where ivy, vinca, or blackberry removal was the project focus (Fig. 5). Overall, the project type does not appear to play a major role in which of these species are most successful at germinating in the first growing season. This shows that it is more important to match the selected species to the appropriate forest habitat and to prepare the seeding site sufficiently than which weed species or forest density existed initially.

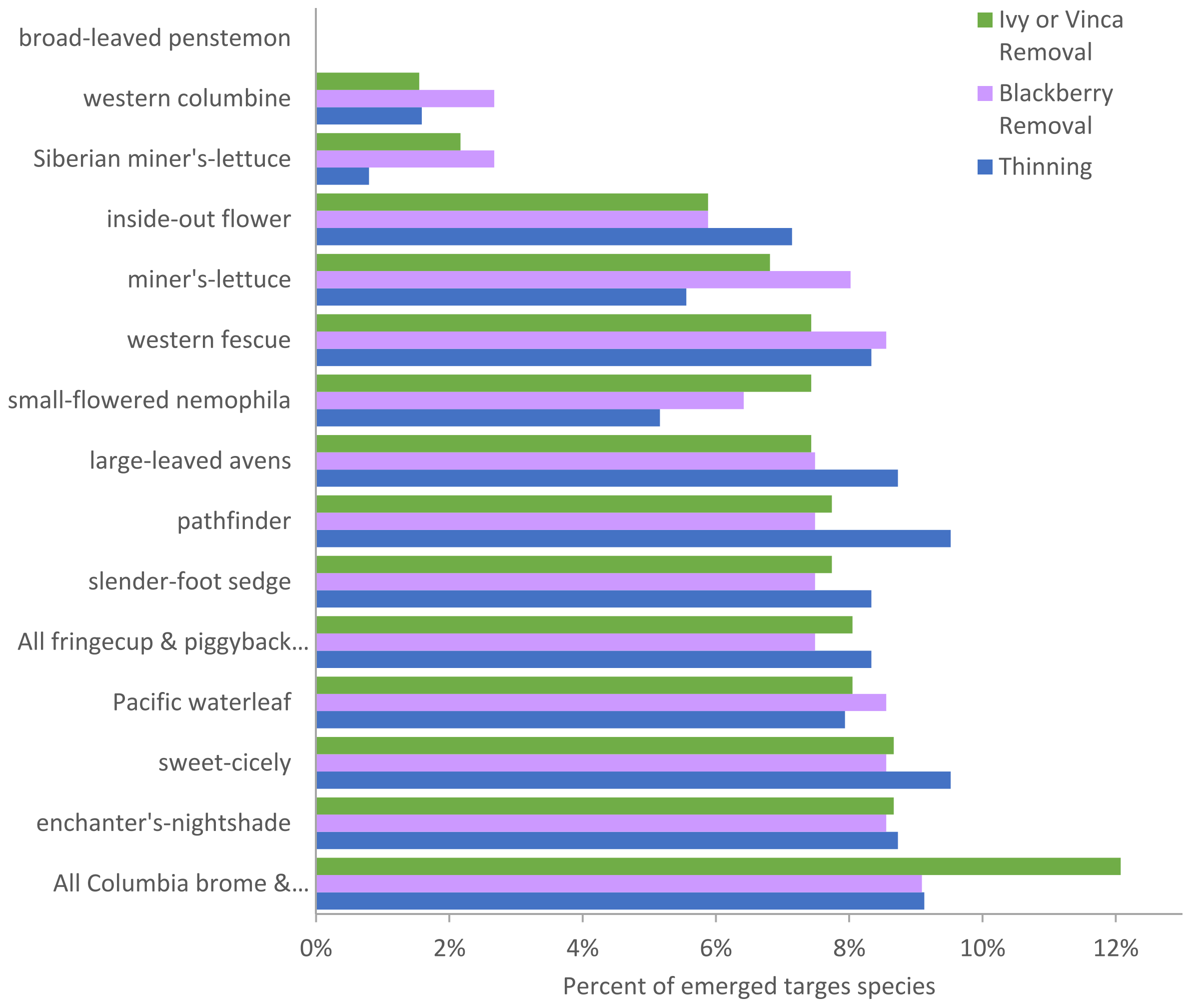


Figure 5 Comparison of percent species composition in the original seeding mix to the percent species composition of native seedlings emerged in raked, seeded plots of different project types (ivy or vinca removal, blackberry removal, and forest thinning) in June of 2020, one growing season after seeding.

Environmental factors – Among all the environmental factors measured (slope, aspect, soil compaction, presence of worms, canopy cover, and forest type), only aspect had a significant effect on the abundance of plants in our plots (Table 3), and none of the environmental factors exerted a significant effect on plant cover (Table 5). It is likely that at far enough extremes of too much light or hardpan soil for example, many of these variables would influence forest understory seedling germination and establishment. Our study was intentionally confined to upland forest habitats suitable for our target species, so these environmental factors did not vary enough for us to observe different preferences or limits of habitability for most of these parameters. Our study did not have many plots with north or east aspect; however, we did have enough plots of both south and west aspect to observe some preferences between the two by our target species. Preference was measured as the presence of six or more plants per m^2 on average in plots of south or west aspect compared to the average for south and west plots combined. Blue wildrye, Pacific waterleaf, and Siberian miner's-lettuce showed a preference for southern aspects. Enchanter's nightshade, small-flowered nemophila, western fescue, and piggyback plant showed a preference for western aspects. Other target species showed little preference for southern or western aspects.

Plant Diversity – Plant species diversity differed by treatment, and significantly influenced both the number and cover of plants in our study plots (Tables 3 and 5, Fig. 6). Diversity was measured using Simpson's Diversity Index which takes into account both the number of species, and the number of individuals representing each species. The more evenly distributed the individuals are between species, the higher the diversity index. Unraked seeded plots had lower diversity than in other treatments, with these plots supporting overall fewer plant species, more uneven distribution of individuals between species, and therefore lower diversity (Fig. 6). The raked seeded plots had the highest diversity index, reflecting a much more even distribution of individuals especially among sown native plant species as compared to very high numbers of a few native plant species (Pacific waterleaf, and bigleaf maple and red alder seedlings) in the control plots (Fig. 6). These results show that the combination of raking leaf litter away and seeding a diverse mix of native plant species can increase the abundance and diversity of the native plant community establishing on the forest floor. Whether or not this will promote a more dense and diverse mature forest floor plant community requires ongoing study.

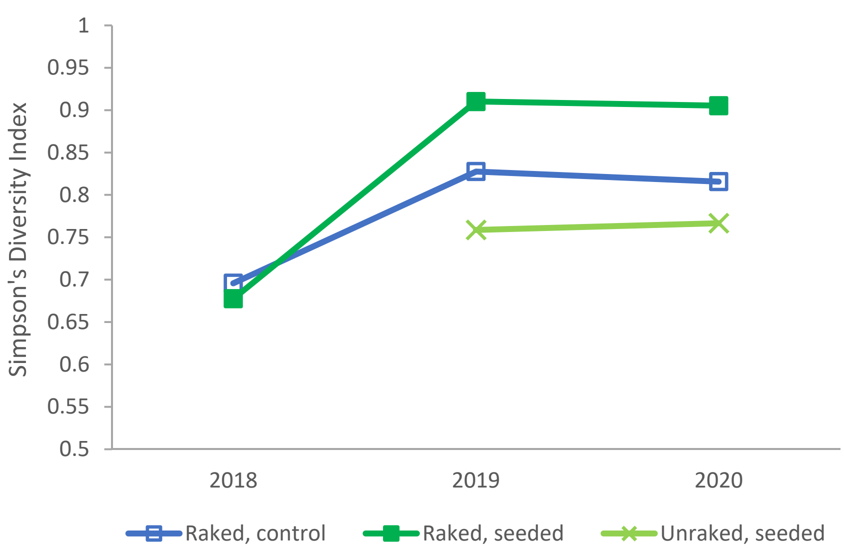


Figure 6 Simpson's diversity index values for each plot treatment type over the three years of the study. 0 = no diversity, 1 = highest level of diversity.

Results and Discussion of Soil Analysis

Three years of soil data were analyzed by Bio Lab Analytics. A longer timeframe of sampling with more sites would have yielded more robust data to draw conclusions, however, some interesting trends were observed.

Organic matter – Organic matter is very important to soil health and has a positive relationship with carbon, nitrogen, and active carbon. This correlation was observed in the soil data for this project. When organic matter was higher on a site, carbon, nitrogen, and active carbon were also higher.

Active carbon – Active carbon has a positive correlation with microbial respiration and aggregate stability which are important to forest soil health. In this project, active carbon tended to decrease over time. The raking of plots along with vegetation management to reduce invasive weeds may have led to a reduction in organic matter that affected active carbon. Nitrogen and pH also decreased; perhaps for the same reasons as active carbon.

Unraked plots – The physical appearance of the unraked, seeded plots in the project was quite different than the raked plots in that there was often a few inches of piled leaf or conifer needle debris covering the seeded area. When soil samples were taken from the unraked plots, they were consistently, across all years, higher than the raked plots in phosphorus, potassium, calcium, magnesium, and cation exchange capacity. This finding suggests that raking plots has a measurable impact on these nutrients and processes in the soil and would imply that raking should be minimized to focused seeding areas and not performed over large expanses of forest.

Raked, seeded compared to raked, unseeded plots – Raked, unseeded plots (control plots) had slightly more carbon and organic matter in the soil sample results compared to raked, seeded plots. Otherwise, there was no observation of consistent differences in soil characteristics between the two types of plots. The carbon and organic matter observation might suggest more leaf fall on the control plots than the seeded plots. Note that while only one type of plot was seeded, all plots experienced some growth of native and non-native vegetation. It's possible that leaves from the tree canopy were able to accumulate better in the control plots causing the slightly elevated levels of organic matter and carbon.

Two properties where seeding plots were installed were farm fields or pasture that was planted to Douglas-fir about 20 years ago. The understory where seeding took place on both properties was largely void of vegetation with thick mats of Douglas-fir needles in some areas. A third property was in a similar condition with the exception that it had been overgrown with a significant amount of ivy that was treated with herbicide, and effectively controlled shortly before our first soil sampling in 2018. The soil samples associated with plots on these three properties ranked near the bottom for organic matter, carbon, nitrogen, and active carbon. It was observed that seeded plots appeared to grow with less vigor on these sites. The other five properties in this project had higher composition of vegetation on the forest floor, a more-established shrub layer, and more deciduous trees in the forest canopy. This finding may suggest that consistent input of Douglas-fir needles over time does not provide as much organic matter, carbon, nitrogen, and active carbon in the soil as a forest with deciduous leaf input from the understory, shrub layer, and diverse overstory. More information about forest soils related to understory can be found in Appendix B.

Results and Discussion of Shrub Planting

Monitoring plots in the shrub plantings were 1/100th acre circle plots (11.7 foot radius). Monitoring occurred in August and September, about six months after the shrubs were planted.

Survival – Three plots were measured in forest edge habitat and were highly variable for seedling survival in year one with anywhere from 35-95% seedling survival. In one plot, 34% of the planted seedlings were found dead. Three plots were measured in forest gaps where survival of planted seedlings ranged from 66-100%. In one plot, 14% of the planted seedlings were found dead. In the five plots measured under forest canopy, survival ranged from 37-90% with about 15% of planted seedlings suffering mortality.

Factors that led to seedling mortality likely included inappropriate species selection or planting stock and lack of moisture. To a lesser extent, weed competition and animal browse also contributed to reduced success in a few of the plots. Bareroot seedling orders were placed with nurseries before the last fall site preparation treatment was complete. This may have led to ordering shrubs for shady sites that actually ended up being quite sunny, or ordering shrubs that needed more light only to find that the site had more shade than anticipated. Often, some species of shrubs are planted even though their chances of success are limited. This can occur because of a strong desire to have species that flower at certain times of the year to benefit pollinators, or because that species was more available or less expensive. Part of the rationale for planting at very high density is that it allows for increased mortality while still leaving plenty of living shrubs to fill the space. Two of the plots under mature forest understory were planted into areas of high erosion with unstable slopes. Live stakes can be installed in these highly eroded areas quickly at low cost. On these plots, several willow stakes were attempted knowing that the shade might make their establishment difficult. The shade did prove to be a problem as several willow died, but other cuttings such as red-osier dogwood, performed much better.

Overall shrub coverage – When planting understory shrubs, there are often an array of existing shrubs in place already. The shrub planting adds to the overall objective of having a healthy understory. In the five plots under forest canopy, between 800 and 1,800 planted shrubs per acre survived. When added to existing shrubs, between 800 and 3,400 shrubs per acre were established in the understory. At the densities that these shrubs were planted, some sites experienced poor survival while still leaving enough shrubs left to fill in the understory over time. It may be advised on many sites to plant at lower densities such as eight to ten foot spacing because shrubs can add to the overall project budget and overplanting might not result in great value to the long term success of the project. In areas where blackberry is being replaced or erosion is prevalent, higher densities tend to help shade the competition and stabilize the soil.

Recommendations for Establishing and Maintaining Forest Understory Vegetation

Site preparation

Thorough site preparation was crucial for successful forest understory seeding and shrub establishment in this project. The following three actions seemed to be the most critical:

Controlling invasive species – When attempting to establish native plant species from seed or established seedlings, it is especially important to reduce the cover of invasive species. Invasive species can occupy the site and greatly reduce the establishment and survival of native plants installed. Also, existing vegetation cover will make the spreading of seed difficult as hand casted seeds will not make soil contact and might instead be eaten by birds, slugs, earthworms, or decompose before germinating in the soil. When we seeded sites where invasive species had previously dominated, the continued presence of low levels of that weed was not a concern. We primarily focused on reducing the cover of invasive species to below a tolerable threshold prior to deeming a site ready for seeding or shrub planting.

Thinning considerations – Increased sunlight will often benefit most understory species. There may be exceptions, and limitations to how much light we chose to allow into a forest, but all plants will need some reliable sunlight to flourish. A great example of limited available light in western Oregon is an even-aged Douglas-fir forest. These forests can grow in tight spacing for decades. While growing, these sites can be very dark in the understory and may only have live plants covering 5% of the ground which is otherwise bare or covered in decaying fir needles. Even shade-tolerant plants seeded or planted in a forest like this will have low survival rates because the sunlight is just too scarce. The simple act of thinning such a forest may allow enough sunlight for sword ferns and a few understory species to establish and expand. When such forests are also seeded around the time of thinning, the forest floor responds positively with an increase in cover and diversity.

Soil contact – On a site where there were already some desired native plants such as ferns and wildflowers, we cast seed strategically by searching out specific areas of bare ground to spread seeds. Most sites where this work is typically performed will have larger areas where invasive species have been controlled or the forest understory cover is lacking overall, perhaps due to shade. In these areas, move dead leaves, remnants of invasive weeds (ivy leaves, blackberry canes, etc), and other material away from the seeding area to ensure direct seed-to-soil contact. This can be done by raking the debris or simply moving the forest floor litter by use of your hands or feet.

Seeding

Seed availability – A major hurdle to this work is that seed for forest understory herbaceous species are hard to find in commercially available quantities. Seed vendors in our region often only have seed for native grasses and sun-loving forbs. There is speculation that contributing factors to this may be a lack of demand, lack of knowledge on how best to cultivate seed from these plants in a nursery setting, and also the fact that many of these species don't produce seeds in abundant quantities or consistently every year making it difficult to gather a reliable supply.

Techniques – In these experimental plots, the seed was premixed (see Table 1 for species and quantities) and hand casted after raking debris and leaves off of the "rake treatment" plots. The raking provided direct soil contact for the seed. We chose to test a more limited subset of the most economical species on unraked plots in order to determine how effective seeding could be while skipping the labor-intensive step of raking.

Seeding Rates – Determining proper seeding rates for the species planted is important. Seeding too lightly won't cover the area and may allow competing, less desired plants to thrive. Seeding too heavily can be costly as seed is expensive and might also lead to overrepresentation of some species and underrepresentation of others. In this project, raked and seeded plots had 261 seedlings per m^2. A mature, native forest understory would have far fewer plants per m^2 suggesting that the seed mix used had more seeds than necessary. Future trials with ¼ to ½ as much seed might prove sufficient.

The overall proportions of different species in the seed mix appeared to be ideal since all the successful seedlings were pretty equally abundant once germinated. The project did not experiment with different amounts of the seed mix, and the sites have not been monitored to maturity making it difficult to make firm recommendations.

Diverse mixes work well since the different species fill more niches, but it's not necessary. Even one or a few species could be very valuable to plant. In future seeding, one could refer to the overrepresented and underrepresented results (Table 4) to tailor a mix for their needs. Land managers can continue to experiment with trying different rates to see what works best for their forest.

Shrub Planting

Factors to consider when planting shrubs in the forest understory include the site preparation recommendations mentioned above as well as canopy cover, topography and soil conditions, and shrub species selection.

Canopy cover - In recent years foresters have experimented with diversity by planting different tree species into existing monocultures. In western Oregon, this has involved planting shade tolerant conifer like western redcedar or western hemlock into Douglas-fir plantations. Less research has been done on shrub establishment, but we have successfully borrowed some of the ideas from the tree research:

Dense forest canopy: If you plant into a forest with full canopy closure, the shrubs often do not survive with such limited sunlight. The shrubs that are still alive after a few years don't thrive and fail to develop the size and characteristics that led forest managers to want the shrubs in the first place. They will not flower, bear fruit, or begin to reproduce as vigorously.

Thinned forest canopy: Many forest stands have thinner forest canopy and allow light to filter down to the forest floor. When you plant shade tolerant shrubs in this environment, they can often grow well. This approach to integrating shrubs will result in a multi-layered forest over time where you have more of a "middlestory" of shrubs and an overstory of trees. When planting the shrubs, try to evaluate the forest canopy and plant denser in areas where small canopy gaps exist. These are the areas where more sunlight will filter through. Woodland owners commonly perform a light thinning to allow more light before planting shrubs. Existing shrubs will often flourish after these thinning practices.

Gap creation: Managers from the USDA Forest Service and state agencies in the Pacific Northwest have implemented prescriptions where trees are harvested in gaps of a few acres. This creates new planting space where they can plant a younger age class of Douglas-fir or bring in species like western redcedar, grand fir, western hemlock, red alder and other species. A similar approach can work well for native shrub establishment. Gaps of one-tenth to one-quarter of an acre can be created to allow light that will help a planting of shrubs establish quickly. Larger gaps can be created to bring in more shrubs that need abundant light. This can be a method to establish some early seral patches for wildlife. This approach produces a patchwork mosaic of forest diversity rather than a multi-layered stand but can be a very efficient way to install shrubs on the landscape. This approach is perhaps easiest in a younger (6-12 year old) Douglas-fir plantation where 40-100 trees can be cut while they're still small and easier to manage by hand, however it can also be done in mature forests where logging equipment can harvest these patches across an accessible area of the forest. The gap creation approach can result in more invasive weed encroachment. Blackberry and Scotch broom will thrive in the increased sunlight. To mitigate this, take time before planting to control weeds through chemical or mechanical means. Also, consider planting the gaps at dense spacing. Many shrubs can be planted 3 to 5 feet apart and as they fill in the space, weeds will be shaded out.

Topography and soil conditions - In addition to wildlife habitat and aesthetics, shrub plantings can also reduce erosion, add to bank stabilization, and improve soil health. The roots of any plant will help to hold soil in place. Tree and shrub roots penetrate deep into the soil and have the ability to keep hillsides and streambanks intact. Many forests have healthy trees at densities of 200 to 300 trees per acre (or 12 to 15 foot spacing). On steep slopes, a healthy mix of shrubs will complement these trees and prevent erosion by adding root mass beneath the soil. In our region, shrubs are commonly planted in restoration projects arounds streams. The shrubs' ability to shade the stream is often highlighted, but it is equally important along streams on forested hillsides that these shrubs are stabilizing the streambank and preventing erosion that would add to stream turbidity and adversely affect water quality. In conifer dominated forests, the deciduous leaves of shrubs can add organic matter to the forest floor which is very helpful in supplying all the forest plants with unique nutrient needs. Organic matter also improves soil water holding capacity.

Species selection - When choosing species for understory shrub establishment, focus on those with at least partial shade tolerance. Assess the canopy cover of the area you're planting, and plant denser in areas where gaps exist. Recognize that your forest canopy is almost certainly trending towards increased canopy cover rather than becoming sunnier. Appendix A is a list of species that are available and often grow well when planted in the forest understory. Most species on the list can be planted as dense as 3 feet apart. A few of the larger shrubs, such as Indian-plum, might be better at 5 to 6 foot spacing. Unlike shade tolerant forest seed, native shrubs that can be planted within the forest are highly available in Oregon. Wholesale nurseries in the Willamette Valley produce hundreds of thousands of bareroot native shrubs each year, and retail nurseries will also stock native shrubs in gallon pots.

Maintenance

Significant maintenance is needed while establishing plantings to ensure they continue to persist over time.

Use of herbicide – Herbicides can be used to reduce competition around the desired species. Most herbicide options will be toxic to both the target weed species as well as the desired species you hope to enhance. Herbicide application should be done using backpack sprayers to better target only the pest species.

Manual techniques – Hand pulling weeds and other competition in the planting is highly effective. If woody weeds, such as blackberry establish, there may be opportunity to cut them with power saws or brush cutters as long as the cut is done above the seeded herbaceous layer.

Overtime, moving from herbicide to manual techniques is advised. Overuse of herbicides in one area often leads to degradation of the native layer.

Monitoring

All seeding study plots were monitored in 2018, 2019, and 2020. For specifics on timing and variables monitored, see "*Seeding Trials"* in the methods section near the beginning of this report. The analysis of this data is summarized in the Results section. For information about how the plots were monitored as well as details on point intercept monitoring, see Appendix C "Understory Forest Monitoring: A Guide for Small Forest Managers."

As for the monitoring of shrub plantings, West Multnomah Soil & Water Conservation District has historically used a fixed radius plot model that is more simplified than the method described in Appendix C. The method used with shrubs assesses numbers of woody plants in an 11.7' radius plot as well as mortality.

Acknowledgments

The Understory Species Increase Project team contributed greatly to this project by establishing a monitoring protocol, species mix for seeding, and by providing us with seed to use in our trials. We thank this group of ecologists from Clean Water Services, Metro, Portland Bureau of Environmental Services, Portland State University, and Native Plantscapes Northwest including John Goetz III, Marsha Holt-Kingsley, Erin McElroy, Toby Query, Adrienne St. Clair, Christa Von Behren, Tori Yoder, Anil Devnani, Alicia Robe, Joni Elteto, and Endre Elteto.

Field work associated with this project was largely a success due to the contributions of West Multnomah Soil & Water Conservation District seasonal interns Hannah Spencer, Cole Carr, Sam Mularz, Indi Keith, J. Ari Sindel and Amber Johnson. Renee Magyar, Communications & Outreach Manager at WMSWCD, helped edit several documents associated with this project and led the graphic design of the fact sheets.

References

Bureau of Environmental Services, City of Portland, 2017. Protecting Nesting Birds: Best management practices for vegetation and construction projects. Available online at: https://www.portlandoregon.gov/bes/index.cfm?a=322164; Last accessed September 24, 2020.

Butler, B. J.; Hewes, J. H.; Dickinson, B.J.; Andrejczyk, K.; Butler, S.M.; Markowski-Lindsay, M. 2016. USDA Forest Service National Woodland Owner Survey: national, regional, and state statistics for family forest and woodland ownerships with 10+ acres, 2011-2013. Res. Bull. NRS-99. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.

Copp, S. R. 2014. Community level impacts associated with the invasion of English ivy (*Hedera spp.*) in Forest Park: a look at the impacts of ivy on community composition and soil moisture. Dissertations and Theses. Paper 2024. https://doi.org/10.15760/etd.2023

Gilliam, F.S. 2007. The ecological significance of the herbaceous layer in temperate forest ecosystems. BioScience 57: 845-858.

Hagar, J.C. 2007. Wildlife species associated with non-coniferous vegetation in Pacific Northwest conifer forests: A review. Forest Ecology and Management. 246, 108-122.

Jolls, C.L. 2003. Populations of and threats to rare plants of the herb layer: more challenges and opportunities for conservation biologists. Pages 105-162 in: Gilliam, F.S. and M.R. Roberts, eds. The herbaceous layer in forests of eastern North America. New York: Oxford University Press.

APPENDIX A: Shade tolerant shrub species

Common name	Latin name	Light needs	Notes
vine maple	*Acer circinatum*	shade	Grows thick once established, great fall color
hazel	*Corylus cornuta*	shade	Flowers in early spring, beneficial to pollinators; produces nuts
salal	*Gaultheria shallon*	shade	small, low growing shrub
oceanspray	*Holodiscus discolor*	partial sun	Flowers later in season
tall Oregon-grape	*Mahonia aquifolium*	shade	yellow flowers, evergreen leaves
dwarf Oregon-grape	*Mahonia nervosa*	shade	small, low growing shrub
osoberry	*Oemleria cerasiformis*	shade	A tall shrub that leafs out early in the spring
mockorange	*Philadelphus lewisii*	partial sun	Plant in partially open gaps or edges, large white flowers
cascara	*Rhamnus purshiana*	partial sun	Plant in partially open gaps or edges
baldhip rose	*Rosa gymnocarpa*	shade	pink flowers
thimbleberry	*Rubus parviflorus*	partial sun	Plant in partially open gaps or edges, edible fruit
salmonberry	*Rubus spectabilis*	partial sun	Grows well near streams, brilliant purple flowers, edible fruit
red elderberry	*Sambucus racemosa*	partial sun	Red fruit
snowberry	*Symphoricarpos albus*	shade	produces white berries that wildlife will eat late in the season

APPENDIX B

Healthy Forest Understory Vegetation and Soil

FACT SHEET

Healthy Forest Understory Vegetation and Soil:

A Guide for Soil Conservationists and Small Forest Managers

WEST MULTNOMAH
Soil & Water Conservation District

With funding provided by

USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

A dense Douglas-fir canopy in need of thinning hinders understory growth.

Healthy soil contributes to a healthy, diverse understory.

Foresters and private woodland owners, and the scientists and conservationists that support them, have an interest in what is growing on the forest floor.

A healthy understory can offer:

- Flowers for native pollinators
- Food for wildlife
- Resiliency against invasion by forest weeds
- Organic material to build healthier soil
- Stable soil that doesn't erode into nearby streams
- Beautiful views while recreating in the forest

Healthy soils that are rich in nutrients and organic matter better support native grasses and forbs.

In turn, a vibrant forest understory replenishes the soil with valuable nutrients each growing season, completing a cycle of soil health and diverse forest habitat.

Woodland owners often have ambitious goals for their land with hopes of growing a healthy forest with high quality wildlife habitat. When forming a management plan, it's important to assess current conditions and take note of any limitations or variables that might impact the outcome of a plan. This includes examining the soil in the forest. General observations of the soil will inform which strategies are best for enhancing understory vegetation.

Forest understory seeding study

Between 2018 and 2020, the West Multnomah Soil & Water Conservation District (WMSWCD) ran a study of seeding understory vegetation on eight forested properties in the Tualatin River Watershed which included soil research to learn what impact soil condition might have on seedling success.

Findings from this study inform the recommendations in this document.
Contact WMSWCD at info@wmswcd.org for the full study report.

About the study sites:

Five properties had a forest floor with abundant native and non-native vegetation. Three properties had a much simpler understory largely bare of vegetation. These three latter properties were Douglas-fir plantations with very little diversity, and soils sampled here ranked near the bottom for organic matter, carbon, nitrogen, and active carbon. Researchers also observed that seeded plots appeared to grow with less vigor on these sites.

This finding may suggest that consistent input of Douglas-fir needles over time does not provide as much organic matter, carbon, nitrogen, and active carbon in the soil as a forest with deciduous leaf input from the understory, shrub layer, and diverse overstory.

A plot before and after raking.

Raking impact on soil and seeding:

The study team tested seeding plots they had raked down to bare soil as well as plots they had not raked. They discovered the raked plots grew much better than the unraked.

In conjunction, the team studied the soil before raking, at 1 year after raking, and again at 2 years after raking. Soil samples from the unraked plots were consistently higher than the raked plots in phosphorus, potassium, calcium, magnesium, and cation exchange capacity (CEC) across all years. This finding suggests that raking plots has a measurable negative impact on these nutrients and processes in the soil. The team also found that higher levels of organic matter on a site showed higher levels of carbon, nitrogen, and active carbon. When CEC was higher, those soils also had more potassium, calcium, and magnesium which are important cations in the soil.

The study team's final conclusion is that raking several small patches in an acre will help seedlings get established, but best practice is to leave most of the organic layer intact. If the seeding is successful, it is likely to spread through the forest over time.

Soil samples were collected from 46 total plots in each year of the study. In 2018, plot samples were combined into one sample from each site, while in 2019 and 2020, soil samples were combined from plots of the same treatment (1. raked, seeded; 2. raked, unseeded; 3. unraked, seeded). Samples were analyzed by Oregon State University Central Analytical Laboratory for the following variables: sand, silt and clay composition; water stable aggregates; volumetric moisture; carbon, nitrogen and organic matter composition; active carbon; CO2 respiration; potentially mineralizable nitrogen; pH; electrical conductivity; and concentration of phosphorous, potassium, calcium, magnesium, and cation exchange capacity. Three years of soils data were analyzed by Bio Lab Analytics, LLC.

Common soil conditions and recommendations

Erosion – Erosion is common near roads and streams. In these areas, seeding can be very helpful, but keep in mind that seeds can be easily washed away until slopes are stabilized. It's advisable to use a low-cost, shade-tolerant native grass seed mix to stabilize the area until the erosion decreases. Shrubs can also be great at stabilizing eroding slopes.

Seeding a slope like this with shade tolerant native grass could help slow erosion.

Bare ground – Sometimes the forest floor has nothing, or very little, growing on it besides the trees. This may be attributed to shade from a conifer forest, but it's also possible the soil is deficient in several nutrients normally present in an older forest. Check for compaction. If it seems very difficult to drive a shovel into the ground throughout the entire year, the soil may have become compacted by livestock or farming in the past. On these sites, plant a shade tolerant grass to start building organic matter that will later support more biodiversity.

A raked plot prepared for seeding. Plots should remain small to lose fewer nutrients.

Clearing organic matter – Clearing (or raking) organic matter such as maple or alder leaves to prepare for seeding has negative impacts on soil that can be detected within the first year after clearing, since this material adds nutrients to the soil as it breaks down. Yet, the clearing of leaves and other organic matter is essential to make sure the seeds make contact with the soil. When seeding in the forest, make a few small clearings for seed rather than clearing large areas. If the seeding is successful, it's likely to spread through the forest over time.

High levels of organic matter and nutrients support impressive growth in a seeded plot.

Building organic matter for healthy soil – Soils are created and shaped by complex interactions between geology, weather, topography, microbial activity, and land management. Some soil characteristics won't change significantly from land management practices. However, in the forests of northwest Oregon, managing organic matter is an effective way to improve soil conditions. Organic matter is very important to soil health. High levels of organic matter result in high levels of carbon, nitrogen, active carbon, and cation exchange capacity – all necessary for healthy soil. To improve or maintain organic matter in your forest, avoid disrupting leaf litter that accumulates, instead allow it to decompose and integrate into the soil. Growing diverse forests will allow many different nutrients to infiltrate the soil, perpetuating the cycle of healthy soil and healthy vegetation.

Lower levels of organic matter and nutrients in a seeded plot show less vigorous growth.

Why are these components important in forest soil…

Active carbon is the organic matter that feeds the soil microbial communities that provide nutrients to trees. Higher levels of organic matter will increase active carbon and will lead to more productive soils over time.

Soil organic matter is an important source of nutrients for forest vegetation. It increases nutrient exchange, retains moisture, reduces compaction, and increases water infiltration into soil.

Phosphorus is critical in the process of photosynthesis, which gives the trees and shrubs energy to grow.

Nitrogen is needed to build amino acids – the building blocks of proteins – which plant cells need to grow. Without adequate nitrogen, plants tend to turn yellow and produce less foliage and smaller fruits and flowers.

Calcium holds together the cell walls in plants. When plants lack calcium, they may show distorted growth.

Magnesium is the core of the chlorophyll molecule which helps absorb light for photosynthesis – the process of turning sunlight into energy for plant growth.

Cation Exchange Capacity (CEC) is the ability for a soil to hold cations which are positively charged ions. A soil with a high CEC will better hold Calcium, Magnesium, and Potassium for plant uptake.

For more information about understory forest vegetation and soil, contact:

Michael Ahr, Forest Conservationist
michael@wmswcd.org, 503.238.4775 x 109

Laura Taylor, Conservationist & Education Coordinator
laura@wmswcd.org, 503.238.4775 x 112

APPENDIX C

Understory Forest Monitoring

FACT SHEET

Understory Forest Monitoring:

A Guide for Small Forest Managers

WEST MULTNOMAH
Soil & Water Conservation District

With funding provided by

USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

BEFORE: A dense monoculture of invasive periwinkle (Vinca species).

AFTER: A diverse mix of native vegetation beginning to establish. It will mature into a lush forest floor of native wildflowers.

Managing a healthy forest is not just about having healthy trees.

Foresters, scientists, and private woodland owners have an interest in what is growing on the forest floor. A healthy understory can offer:

- Flowers for native pollinators
- Food for wildlife
- Resiliency against invasion by forest weeds
- Organic material to build healthier soil
- Stable soil that doesn't erode into nearby streams
- Beautiful views while recreating in the forest

Just like taking inventory of the forest, measuring tree diameters and spacing, it is also important to monitor the changes over time on the forest floor.

Herbaceous forest plants tend to reach their peak bloom and cover in mid to late spring (mid-May to mid-June in western Oregon). It's best to monitor forest understory consistently at this time of year.

There are dozens of ways to monitor the understory plants in a forest. Two effective methods are described here.

Point intercept method

This method is performed by laying out a straight line transect in the forest and documenting what is growing on the forest floor at one-foot increments along the transect.

West Multnomah Soil & Water Conservation District often sets up multiple transects that are 33' in length giving us 33 data points per transect.

The data gathered from the plots can be used to find the average cover of different vegetation types in your forest. Longer or shorter transects can be utilized as required.

This method was adopted by partners of the Greater Forest Park Conservation Initiative (GFPCI) in Portland, Oregon and is described in detail on pages 3-6 in the Vegetation Module of the Unified Monitoring Protocol found on the GFPCI web page.

Simplified step-by-step methods:

1. Choose random points within the project area at a rate of at least one point per two acres.
2. Navigate to a point and mark the starting point with a high-visibility monument such as a wooden post that is painted and/or flagged with bright colors so it will be visible and easy to locate in future years.
3. Label each starting point with a unique transect name, and mark the point with a GPS if possible.
4. Run a measuring tape for 33 feet along the forest floor, always going in a consistent direction, such as North. Use two posts and clips at either end of the transect to hold the tape about 3 feet above the ground. Mark the end of the transect with a whisker or pin flag.
5. Use a 4-foot long ¼-inch diameter steel rod as a sampling rod. Hold the sampling rod at each foot along the transect so that it hangs directly down, and lower it to the ground.
6. List each plant species that the sampling rod hits, and tally the number of times each species is hit along the 33 feet of transect sampled. For points with no plants, tally the number of times the rod hit bare soil or organic matter – duff, twigs, or logs. Every foot interval where the sampling rod touches a plant species counts as a 'hit'.
7. Repeat steps 2 – 6 for each random point.
8. Getting information out of the data: Divide the number of times each species is hit by the total number of hits possible (33 in this case) and then multiply by 100. This shows the percent cover of each species in that transect.

   For example, if sword fern is hit 16 times out of 33 readings, the forest has about 50% ground cover of sword fern. It's possible to get over 100% cover of all the species combined if several species are hit at each foot. This scenario indicates a forest with multiple layers of thriving understory species.

Pros:

- Longer transects help track a larger area of the forest floor, and increase the chance of capturing variability.
- Estimating percent cover can be inaccurate and allow bias. The point intercept method reduces the potential for bias when measurements are taken accurately at the designated interval (i.e. one reading for every foot increment along the transect).
- Once set up, this method is relatively quick and easy to repeat. We recommend this method for the family forest owner.

Cons:

- Laying out a transect can be time consuming.
- There are some supplies needed, including the sampling rod.
- There's a chance that a plant exists adjacent to or along the transect, but can be missed at any of the 1-foot increments. Make a note of species along the transect that don't get sampled.

Fixed radius plot method

This method was developed by the Understory Seed Increase Project (USIP) Partnership in Portland, Oregon.

It is performed by creating a circle plot with a radius of 5.5 feet. All the plant species observed within the plot that cover a significant amount of area (> 5%) are recorded, and the percentage of the plot covered by each species is estimated.

Smaller square subplots can be used within the circular plot to get a detailed count of plants per square foot if this level of detail is desired, such as when monitoring the success of a recent seeding.

Getting an average between several plots will provide a good overall sense of the state of a forest stand's understory.

Simplified step-by-step methods:

1. Select at least 2 plot locations within the project area that are relatively clear of shrubs and are good candidates for forest seeding. Mark the center of each plot with a whisker flag or other high-visibility durable monument. Label each plot with a unique plot name, and mark the point with a GPS if possible.

2. Using a compass, measuring tape, and pin flags, mark the perimeter of the plot 5.5 feet out from the center at each of the cardinal directions (N, E, S, W).

3. Take photos of each plot at each monitoring event, always facing the same direction from the same location.

4. It is optional to record influential environmental factors for each plot such as canopy cover, percent evergreen vs. deciduous tree canopy, slope, aspect, and soil characteristics.

5. List all plant species that cover 5% or more in the plot (and any amount of a particular species, such as those that are being seeded). Estimate the percent of the plot covered by each species as seen from directly above. It helps to determine what different percent areas look like to compare with the cover of the plants observed. For reference, within a full 95 ft^2 plot, 1% cover = ~1 ft^2 (1 ft x 1 ft); 5% cover = 4.75 ft^2 (2.2 ft x 2.2 ft); 25% cover = 23.75 ft^2 (5 ft x 5 ft).

6. If a detailed inventory of plant density per square foot is desired, use smaller square subplots (0.25 m) placed half way between the center and each pin flag. Count all the individuals of every plant species found in the subplot at each cardinal direction.

7. Getting information out of the data: Find the average of the number of plants (for subplots) and the percent cover (for plots) for each species of interest to get a sense of how well that species is establishing and filling in throughout the project area.

Pros:

- This method better tracks very small changes in the plant community. In a small area, everything can be tracked.

Cons:

- The set-up of these plots is meticulous and can take a bit of time.

- When tracking percent cover, there is a risk of estimating poorly.

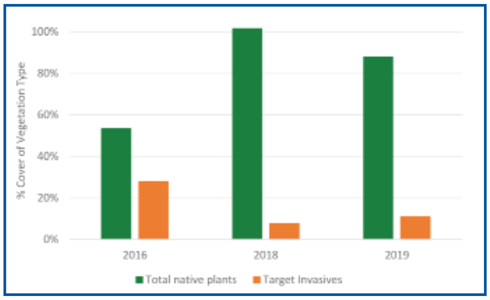
Summary pros and cons

Pros:

Many woodland managers are treating invasive species in their forests and it can feel like a never ending battle. Monitoring forest understory over the years can offer encouragement as invasive species cover decreases and native species begin to flourish.

It would be useful to gain some understanding of potential invasive weeds in the region. Catching an aggressive invasive weed when it first arrives can be one of the best methods of controlling it before it spreads throughout the forest.

Change in forest understory cover over four years using point intercept



Information gathered at a forest site in the Abbey Creek Watershed, Multnomah County, Oregon.

Cons:

Plant identification can be difficult, especially in the spring when plants are very small. Learning which plants are common to the area can be rewarding and helpful in the exercise of monitoring. It isn't critical to identify every plant.

Thank you to our partners who showed leadership in creating these monitoring protocols: Forest Park Conservancy, Clean Water Services, Metro, Portland Bureau of Environmental Services.

For more information about understory forest monitoring, contact:

Michael Ahr, Forest Conservationist
michael@wmswcd.org, 503.238.4775 x 109

Laura Taylor, Conservationist & Education Coordinator
laura@wmswcd.org, 503.238.4775 x 112