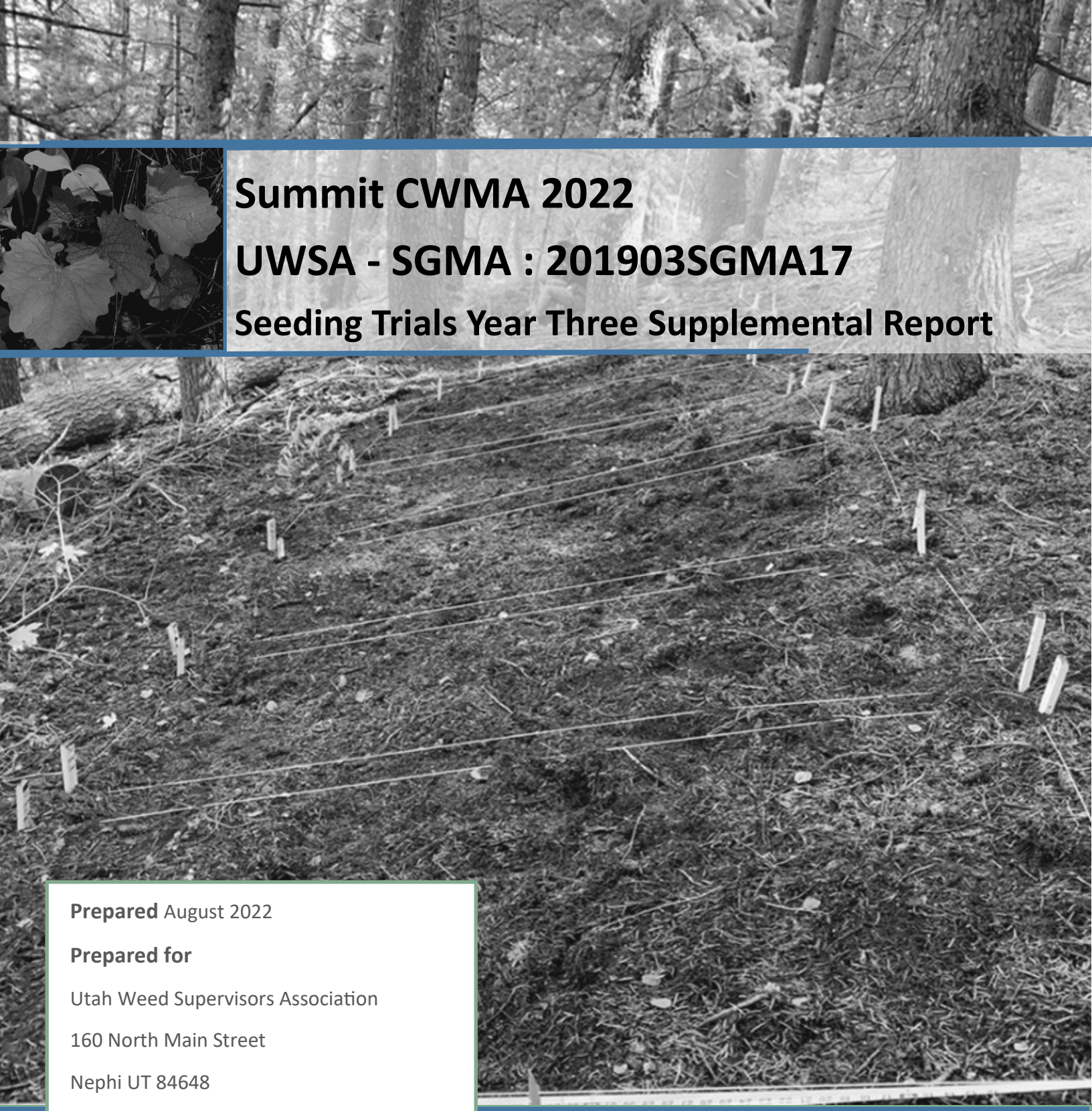

Summit CWMA 2022

UWSA - SGMA : 201903SGMA17

Seeding Trials Year Three Supplemental Report

Prepared August 2022

Prepared for

Utah Weed Supervisors Association

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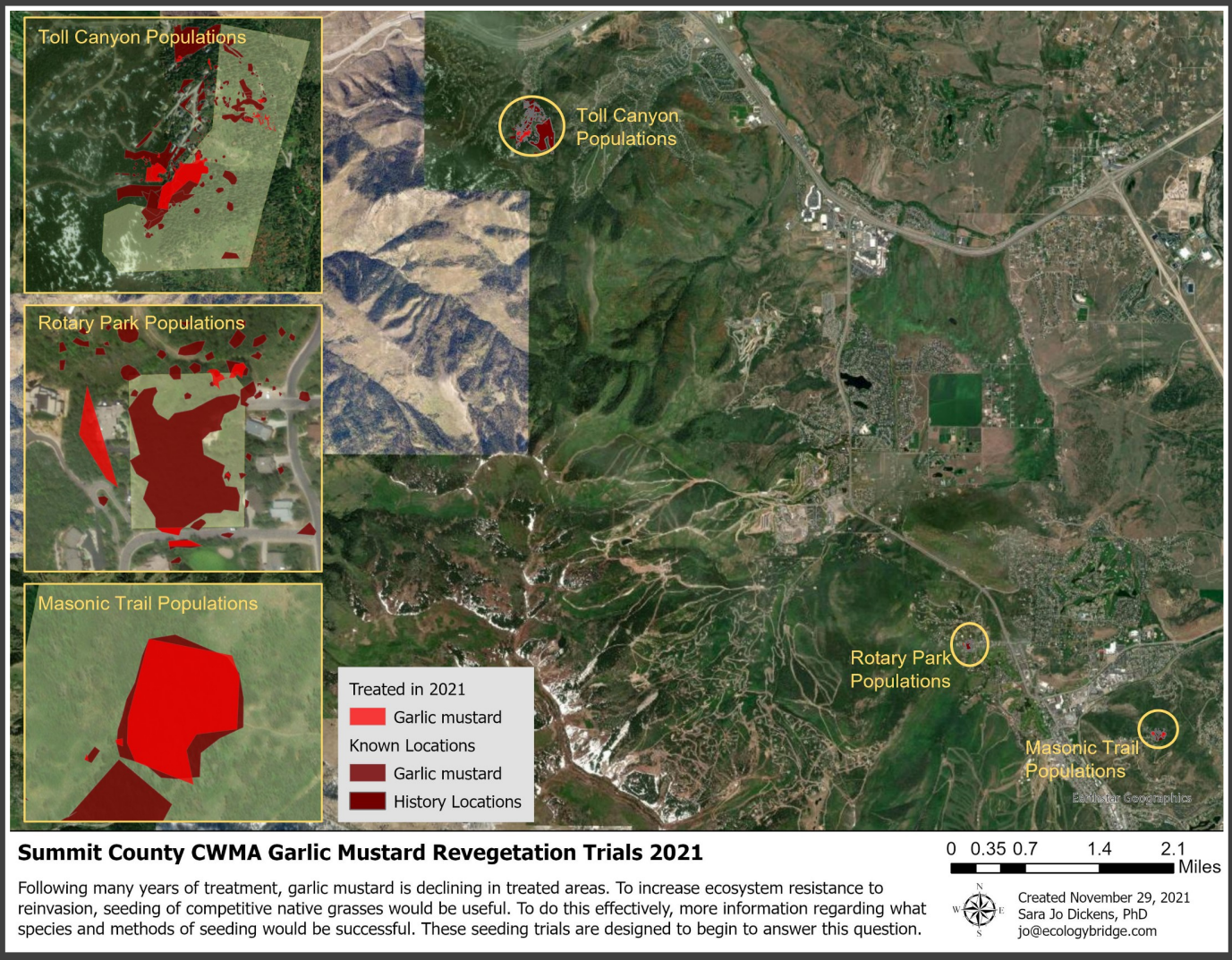
PROJECT DESCRIPTION

In 2020, the Summit CWMA established seeding trials to address the potential legacy effects of garlic mustard (Alliaria petiolata), a Class 1B state listed noxious weed, on soils, native plant germination, and native plant establishment in forests and forest/sagebrush habitat. Garlic mustard is an aggressive, allelopathic invader that displaces natives and suppresses the soil fungal communities forest species rely on for resistance to drought, disease, beetle kill, and other stressors. Forests that have been heavily invaded by garlic mustard are at greater risk of tree mortality; higher mortality, in turn, increases fire risk and watershed health concerns.

Since 2014, the CWMA has been treating garlic mustard in Summit, Salt Lake, and Wasatch Counties as part of

Project Site Locations within Summit County, UT



the Summit CWMA ISM Garlic Mustard Control Program. Through this program, known garlic mustard populations are treated by hand thinning tall, flowering plants and applying herbicide to rosettes. This seeding trial piggybacks on the long-term CWMA ISM garlic mustard program. The sites included in this project have been treated through the Summit CWMA garlic mustard control program and are of particular interest because they have experienced significant reduction of garlic mustard.

In previous revegetation efforts, slender wheat grass (*Elymus trachycaulus*) and mountain brome (*Bromus marginatus*) have been successfully established via seed in sunny locations, but have not established post-garlic mustard treatment under forest and shrub canopy. It is unclear if this is due to shading, lack of necessary site preparation, low seeding rates in a single seeding event or the soil legacy effects of garlic mustard's allelopathy. To begin to understand the limitations for revegetation in shaded forest and shrubland areas impacted by garlic mustard, the Summit CWMA established seeding trial test plots in three locations in the Park City and Snyderville Basin areas of Summit County, UT. By testing four native grass seed mixes with and without soil amendments, we aim to identify the best methods and species mixes for reestablishing native plant cover and increasing resistance to garlic mustard reinvasion and expansion on sites historically dominated by garlic mustard.

METHODS

Garlic mustard percent cover and control history for study sites.

Garlic Mustard Percent Cover	Toll Canyon	Masonic Trail	Rotary Park
First Control Year	75	95	100
2019	30	15	20
2020	7	0	0
2021	24	4	14
2022	2	19	1

Test sites are located within three different forest types. The Masonic Trail site sits under maple/oak woodland surrounded by sagebrush shrubland; the Rotary Park site is located within an aspen stand; and the Toll Canyon site is located in a conifer forest. Sites are characterized by differing soil characteristics, understory plant communities (in terms of presence, composition, and density), and levels of light at the forest floor.

Garlic mustard control began once each population was first discovered such that the first year each site was treated differs (Rotary Park - 2014, Toll Canyon - 2015, and the Masonic Trail - 2018). In spring 2020— prior to seeding— all sites and adjacent areas were treated with 2, 4D amine (64 oz/ac) and MSM 60 (1.5 oz/ac) to control fall germinated and newly germinated garlic mustard seedlings. Additional treatments occurred in fall 2020 and spring 2021 as needed. Toll Canyon and Rotary Park have been treated every spring and most falls for the last five years; these sites were treated a third time in years that mid-summer germination was observed. Additionally, these sites were hand weeded to thin flowering plants each spring for up to 3 years. These sites initially had large, uniform populations but, by 2019, had limited, patchy populations. In the spring of 2021, treatment in the plots and

Species composition of the four native grass seed mixes used in the seeding trial.

Common Spp Name	*Latin Name*	Seed Mix 1	Seed Mix 2	Seed Mix 3	Seed Mix 4
Alpine Bluegrass	*Poa alpine*	20			
Arizona Fescue	*Festuca arizonica*			5	10
Big/Sandberg Bluegrass	*Poa secunda*			9	10
Blue Wildrye	*Elymus glaucus*		20	14	30
Fringed Brome	*Bromus ciliates*	20			
Mountain Brome	*Bromus marginatus*	10	10	20	25
Prairie Junegrass	*Koeleria macrantha*		20	5	
Rocky Mountain Fescue	*Festuca saximontana*	20			
Slender Wheatgrass	*Elymus trachycaulus*	10	10	20	25
Spike Tricetum	*Trisetum spicatum*		20		
Streambank Wheatgrass	*Elymus lanceolatus*	20		20	
Tufted Hairgrass	*Deschampsia cespitosa*		20	5	

areas adjacent plots was limited to hand weeding due to low percent cover of garlic mustard.

The Masonic Trail site was first treated in 2018 when it was weeded to thin flowering plants then treated with herbicide three times in 2018, twice in 2019 and 2020, and once in 2021. The garlic mustard population at this site was a complete understory monoculture in 2018 and in 2019; by spring 2021 it was limited to small patches of seedlings and a few rosettes. In summer 2021, late rains triggered a second round of germination resulting in greater percent cover of garlic mustard; in all sites, garlic mustard reached levels nearly equivalent to those of 2019.

2020 Established Plots (Original Plots) - Treatments

Plots ranged in size based on the usable size of the study site. Plots are 4x10 ft at Rotary Park , 4x15 ft at the Masonic Trail and 4x20 ft at Toll Canyon. Soil amendments were applied late spring to early summer dependent on snowmelt. Following soil amendments, three native grass mixes were hand broadcast and gently raked into the appropriate plots in both spring and fall of 2020. Irrigation to support seedling establishment was provided using a backpack sprayer at the Masonic Trail and Toll Canyon sites. Rotary Park site had direct access to a faucet so watering was done by hose.

Species composition of the wildflower/forb seed mix.

Common Spp Name	*Latin Name*	Percent Seed Mix
Arrowleaf Balsamroot	*Balsamorhiza sagittata*	12.5
Blue Flax	*Linum lewisii*	12.5
Purple Coneflower	*Echinacea purpurea*	12.5
Mountain Lupine	*Lupinus argenteus*	12.5
Rocky Mountain Penstemon	*Penstemon strictus*	12.5
Showy Goldeneye	*Heliomeris multiflora*	12.5
Utah Sweetvetch	*Hedysarum boreale*	12.5
Western Yarrow	*Achillea millefolium*	12.5

In addition to the 2020 native grass seeding, the upslope half of each plot was seeded with a native forb mix fall of 2021 to see if native forbs could establish in the dense grass and if allelopathic effects of garlic mustard on the soils were still present and impacting forb recovery.

2021 Established Plots (Expanded Plots)- Treatments

Results from the 2020 seeding trial plots suggested seed limitation as a potential primary cause of low native plant recovery following garlic mustard control. We had made the assumption that the soil was the primary cause and therefore did not include a soil amendment free (control) treatment. Accordingly, in fall 2021, a new set of plots was established to include this missing treatment. Additionally, early results from the 2020 plots indicated that blue wildrye had the most successful establishment; blue wildrye was the only species to flower. To further examine this observation, we increased the percent of blue wild rye in seed mix 3 and renamed the mix seed mix 4.

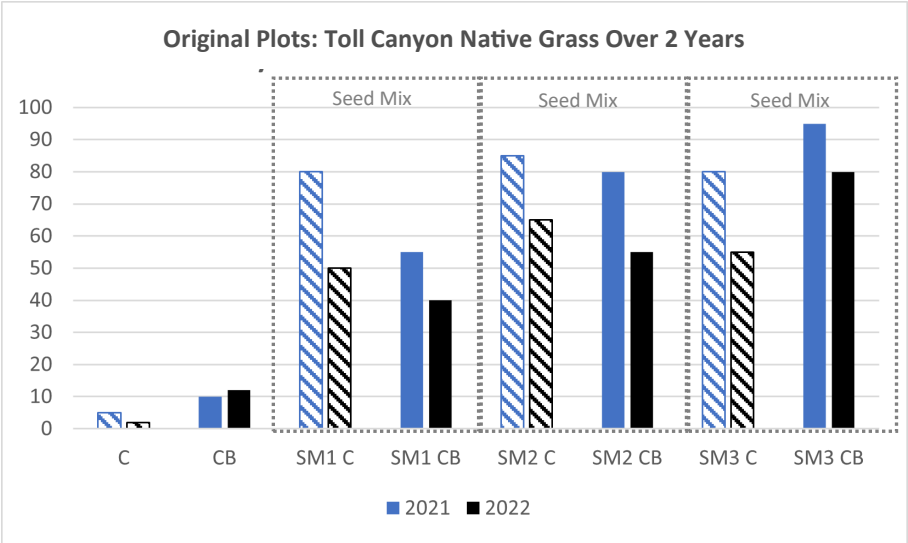
Installation methods were the same as the 2020 plots except that installation occurred in the fall to be sure to take advantage of the spring snow melt in 2022. Plot sizes were different than in 2020 due to limited space in study areas. Plots were 4 x 8 ft in the Masonic Trail location, 4 x 10 ft in Toll Canyon and 4 x 4 ft in Rotary Park.

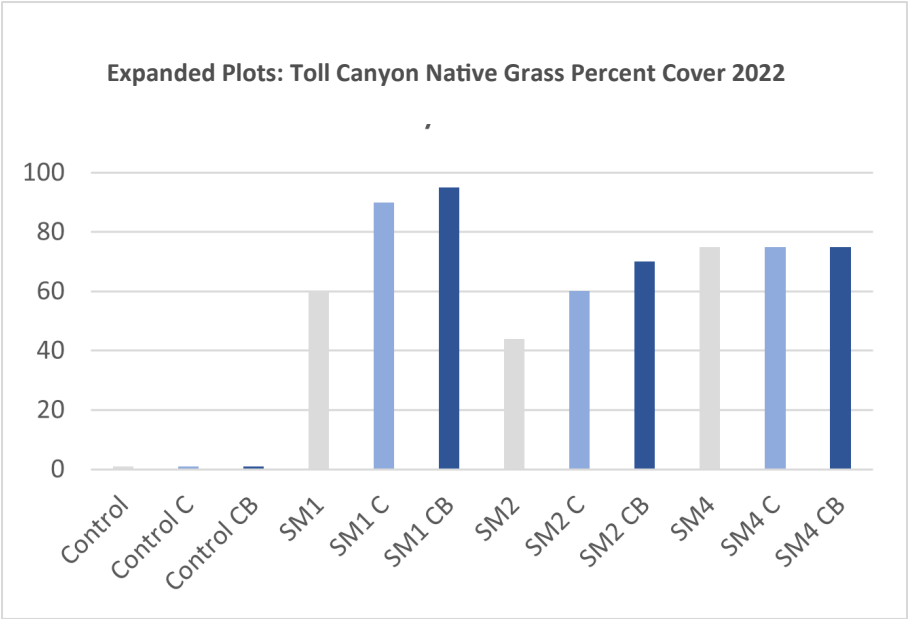
View of original plots in Toll Canyon from above.

RESULTS - 2022

As of August 2022, native grasses are established in all plots that received seeding. Native grass establishment is greatest in Toll Canyon and in Rotary Park, while Masonic Trail shows significantly lower rates, both within the original 2020 test plots and those added in 2021. This discrepancy is likely due to the dense canopy and limited moisture available at the Masonic site. Percent cover of native grass is somewhat down from last year in 2020 test plots across all sites; which is likely a reflection of annual variation due to weather patterns. The study sites experienced an early snowmelt in 2022, followed by a prolonged cold, wet spring. Temperature fluctuations may have slowed germination and growth and/or killed off early germinating seedlings . It should also be noted that the decline in native grass in Toll Canyon and at Masonic Trail is somewhat offset by a substantial increase in native forbs.

SITE SPECIFIC RESULTS





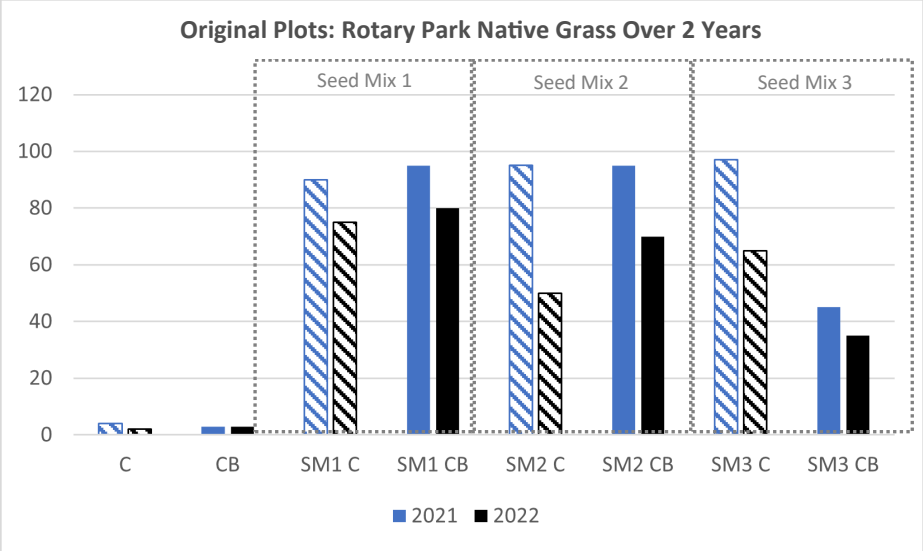
Abbreviations are as follows: C = compost only, CB = compost + biochar, and a lack of a C or CB indicates no soil amendment. The control in the expanded plots received no soil amendments or seeding.

Toll Canyon Results

The original and expanded sets of plots tell slightly different stories in Toll Canyon. The original plots suggest that Seed Mix #3 with compost and biochar is the most effective combination for reestablishing native grass in conifer forest. However, in the absence of biochar, Seed Mix #2 is the most effective option. This statement represents a shift from 2021, when Seed Mix #1 appeared to be the best choice when biochar application is not feasible. In expanded test plots, Seed Mix #1 appears to be the best option (10-15% better) when soil amendments are added; this result echoes 2021 data from the original plots. However, in the absence of soil amendment, Seed Mix #4 may be the best option. The dominant species establishing include a mix of slender wheatgrass and wild rye. Because much of the grass has not gone to flower, it is not possible to determine what proportion each makes up. The expanded plots lacked flowering grasses and this was true at all sites.

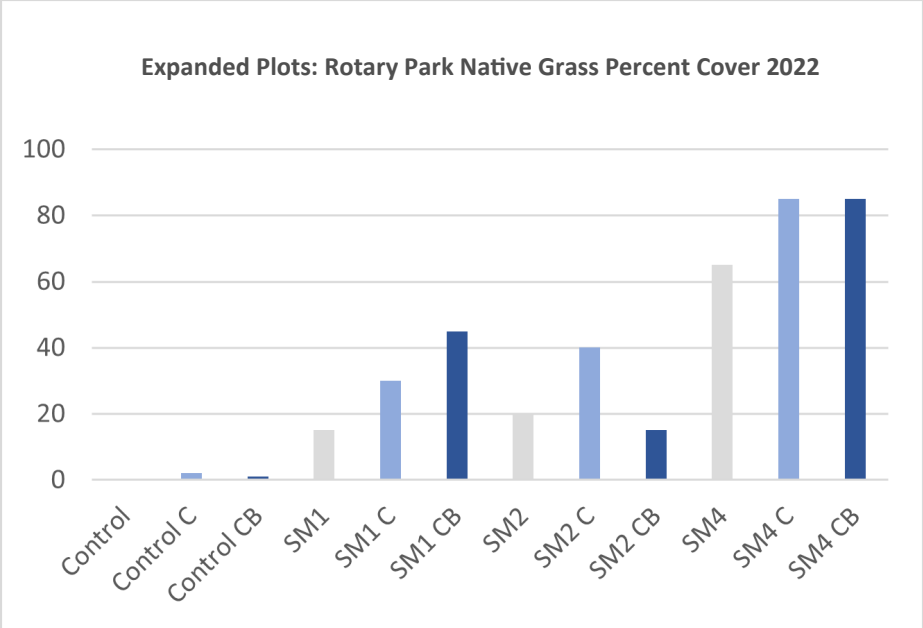
The primary native forb species present in Toll Canyon plots are common yarrow (*Achillea millefolium*) and sweet cicely/aniseroot(*Osmorhiza longistylis*). In original plots, mountain snowberry (*Symphoricarpos oreophilus*) was observed as seedlings but at covers lower than 5%. In the expanded plots, woodland star (*Lithophragma parviflorum*), sweet cicely/aniseroot, hooked violet (*Viola adunca*), alum root (*Heuchera rubescens*), ballhead waterleaf (*Hydrophyllum capitatum*), twisted stalk (*Streptopus amplexifolius*), western larkspur (*Delphinium occidentale*), mountain bluebell (*Mertensia ciliate*), Engelmann's aster (*Eucephalus*

engelmannii), western meadow rue (*Thalictrum occidentale*), Utah sweet Sweetvetch (*Hedysarum boreale*), ninebark (*Physocarpus malvaceus*), mountain snowberry and wood rose (*Rosa woodsii*) were all recorded.



Rotary Park Results

The original plots in Rotary Park suggest that Seed Mix #1 is the best choice with or without biochar for moist aspen forests. This result is a shift from last year when all seed mixes produced similar results at the site. In the expanded plots, Seed Mix #4 appears to be the best choice with or without soil amendments. The species that established best seemed to be responding to differenced in light across the plots with the slender wheatgrass dominating sunny areas with a few mountain brome and fescue mixed into the most sunny locations and wild rye dominating the shadier areas.



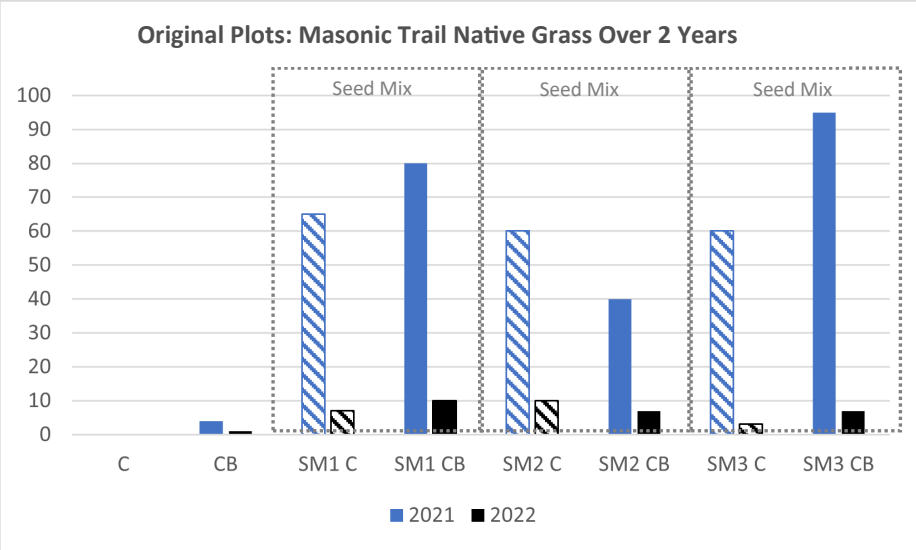
Abbreviations are as follows: C = compost only, CB = compost + biochar, and a lack of a C or CB indicates no soil amendment. The control in the expanded plots received no soil amendments or seeding.

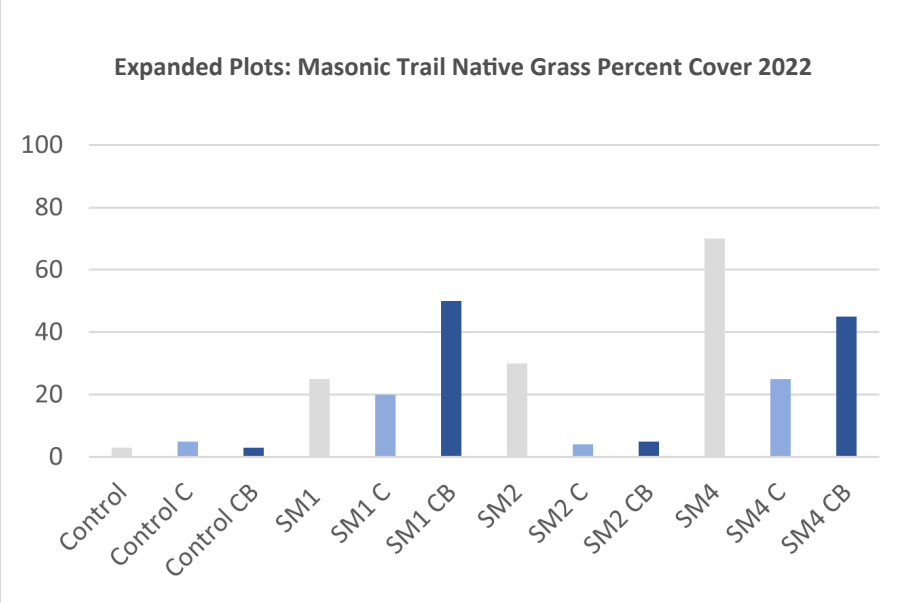
Garlic mustard and maple seedlings at the Masonic Trail Site.

Native forb percent cover remained equal to or less than 1% with no relationship to soil amendments in the original plots. In the expanded plots, forb cover was highest in the control (no grass seed) plots. Though compost only increased cover slightly, adding compost and biochar increased coverage by 30%. In native grass seeded plots, compost and biochar only showed slight increases in native forb percent cover and isn't likely to be significant.

Masonic Results

Compared the other test sites, Masonic has low establishment of native grass. That said, the seeded native forbs, including yarrow and lupine, show high cover. Native forb cover averaged 22-28%. Adding compost and biochar increased forb coverage by only a 6% in the original plots and made a negligible difference in native forb cover in the expanded plots. In addition, maple seedlings from the natural seedbank had 10-15% cover across the site.



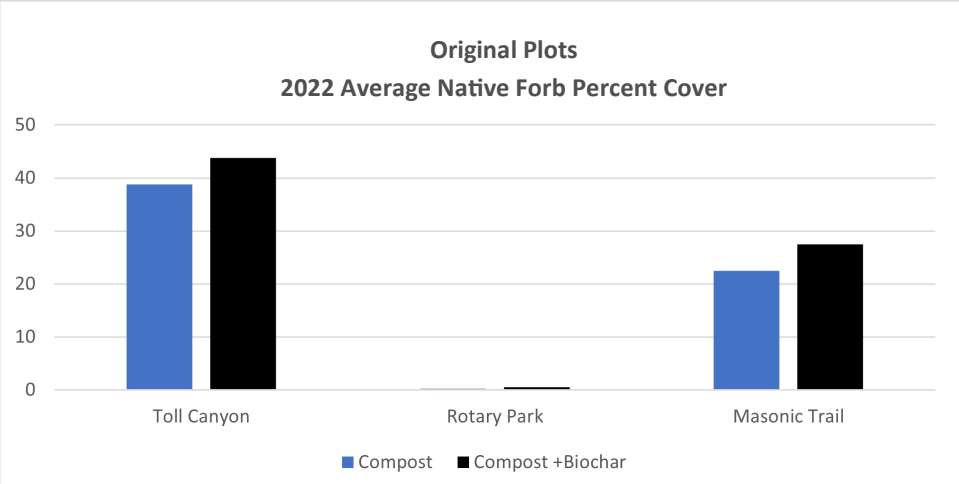


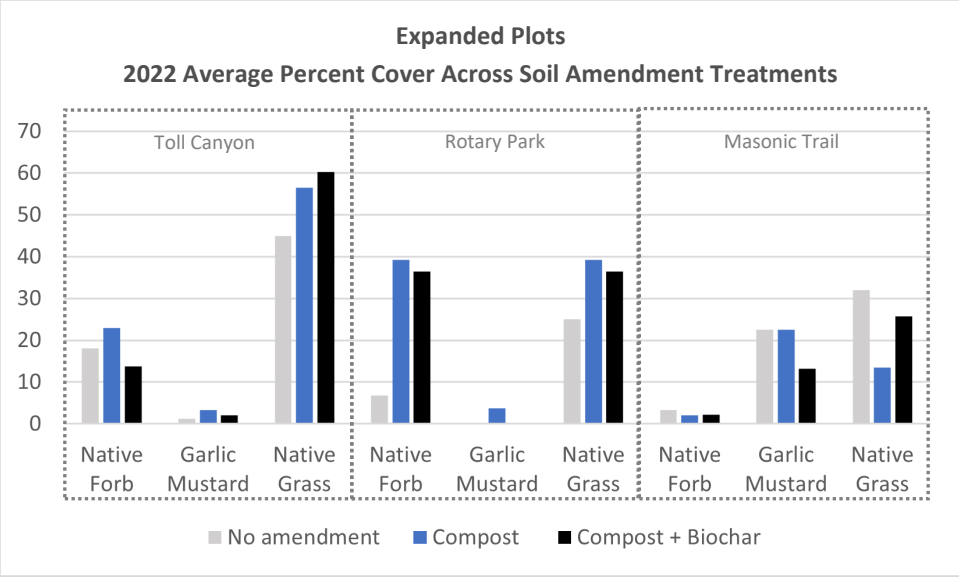
Abbreviations are as follows: C = compost only, CB = compost + biochar, and a lack of a C or CB indicates no soil amendment. The control in the expanded plots received no soil amendments or seeding.

Within the original test plots at the Masonic trail, Seed Mix #1 and Seed Mix #2 wee most successful; differences between the two mixes are negligible. In the expanded plots, Seed Mix #4 performed best overall, especially with no soil amendments. However, Seed Mix # 1 performed better than Seed Mix #4 when compost and biochar were applied. Slender wheat grass clearly dominated across all plots with a wild rye component that varied but with no obvious pattern associated with treatments.

OVERALL RESULTS

As in previous years, seeded plots yielded dramatically higher seedling density and percent cover of native grass compared to control plots. Apart from one Toll Canyon control plot (established in 2020 and supplemented with biochar), control sites produced 0-7% cover of native grass across sites and years of establishment. These results suggest that seed availability is an important – if not the primary – determining factor in the reestablishment of natives on sites historically dominated by garlic mustard.





Seeding of native forbs increased yarrow and lupine percent cover in all plots seeded with the wildflower mix, but plots that did not receive native grass seed had 30-40% more forb cover than the grass seeded plots. This suggests native forbs may also be seed limited and that competition with native grasses may limit establishment.

The impacts of biochar on native seed establishment vary greatly across sites and seed mixes. Masonic is the only location where biochar made a dramatic difference in native grass establishment when added to compost. In the expanded Masonic plots, Seed Mix #1 and Seed Mix #4 had higher success rates (by 20% and 30%, respectively) when applied with compost and biochar than when applied with compost alone. However, Seed Mix #2 and Seed Mix #4 performed best when applied with no soil amendment at all (no compost or biochar), suggesting that, while compost and biochar may work better than compost alone, soil amendments may not be necessary. 2020 plots also indicate that the advantages of biochar application may diminish with time. While the original Masonic plots treated with biochar showed significantly higher rates of establishment in 2021 compared to those without, the contrast is far less pronounced this season. It is difficult to say whether this decline is a statistical issue – considering the overall limited growth and reduced coverage observed in the original Masonic plots this year – or if it suggests a long-term trend. Continued study is necessary to understand biochar's impacts on reestablishment in oak/maple woodlands long-term.

Regarding the relationship between biochar and various seed mixes, very few distinct patterns arise. Seed Mix #1 is consistently more successful when paired with amendment containing biochar then when applied alone or with compost. In all other cases, more research needs to be done to determine the species, site

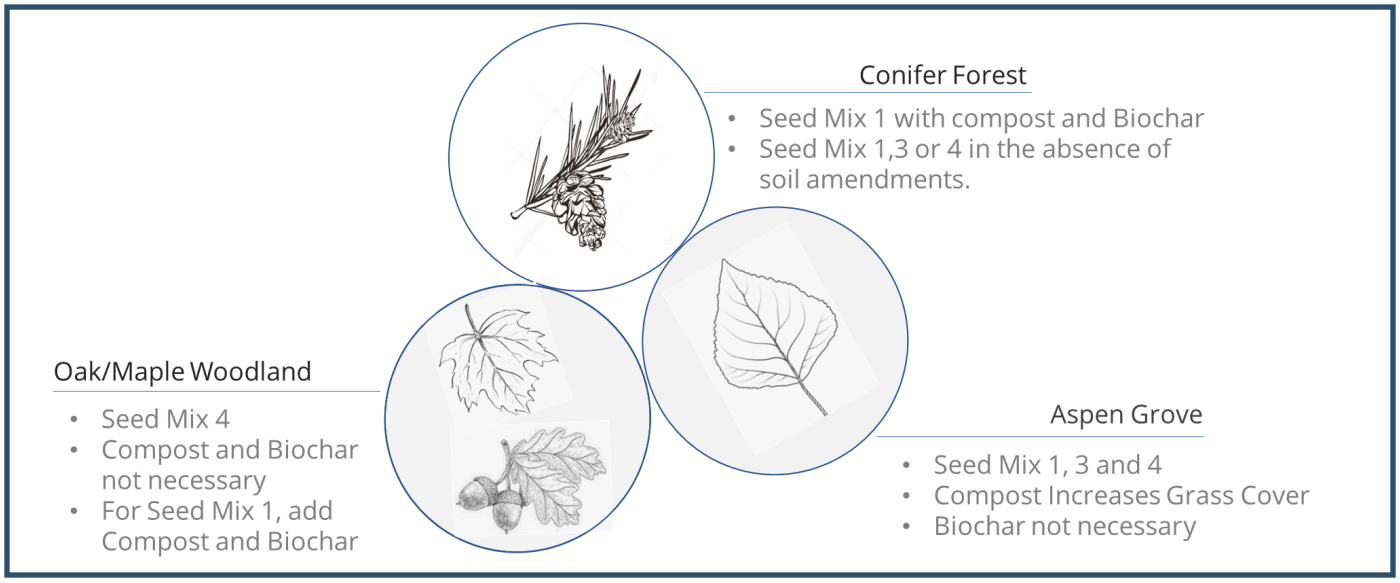
characteristics, soil components, and treatment histories that link biochar with enhanced establishment.

CONCLUSIONS

The sites of this study have been invaded by garlic mustard for 10-15 years. Native seedbank longevity is species specific and for many species may not be long enough to persist through this 10-15 years of garlic mustard dominance. Native seeds may have simple expired or plants may have died at germination due to natural conditions or garlic mustard allelopathic effects. Regardless, revegetation of forest understory through seeding following garlic mustard control can significantly increase recovery rates.

All seed mixes show high rates of native grass establishment. Among the expanded plots, Seed Mix #1 and Seed Mix #4 had the highest rates of establishment. Within the original plots results were mixed. Seed Mix #3 had the highest rate of establishment in Toll Canyon's dense conifer forest; Seed Mix #1 was the most successful mix in Rotary Park's moist aspen groves; and Seed Mixes #1 and #2 performed equally well in the oak/maple woodland on Masonic Trail.

Native grasses are known to be effective competitors with forbs, which is one reason they are often used in revegetation efforts. They also tend to germinate more reliably, provide erosion control and can reclaim ground even while weedy forbs are being treated using selective herbicide. This project supports this theory and thus suggests care should be taken to balance the forb to grass ratio of seed mixes to minimize competition while still meeting establishment goals. An additional approach may be to seed in a mosaic fashion seeding patches of forbs only and grass only with a blend in between. This approach may also allow for microsite conditions to be taken advantage of to meet specific species or functional group preferred growing conditions.



Given each of these sites is forest and understory grass percent cover over 20-30 percent is not a natural state and could limit native forb species cover, all our seed mixes could be appropriate at lower seeding rates. Further study using single grass species seeding could inform a less species rich native grass mix that may be more cost effective for large scale revegetation.

In most cases, compost appears to have a positive effect on native grass reestablishment. In Toll Canyon and Rotary Park, all seed mixes performed better (16.8% on average) when supplemented with compost. The addition of biochar in these locations did not appear to significantly increase establishment. Given the cost of biochar, knowing that it may not provide additional benefit in conifer and aspen forests helps to keep the costs of amendments in revegetation down. However, the same cannot be said for the Masonic Trail site. At the Masonic site, Seed Mix #1, Seed Mix #2, and Seed Mix #4 performed better when applied alone than with compost. Similarly, the control plot amended with compost performed only marginally better than the control without. The Masonic site is unique in that it receives very little moisture and sunlight. This theory may explain why biochar, which can increase soil moisture, appeared to help amended plots where it was applied. Biochar may provide a buffer to drought conditions in this more arid habitat.