2025 Report

Cost-effectiveness of soil amendments for native plant establishment in highly disturbed uplands in Boulder County.

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EXECUTIVE SUMMARY

The purpose of this research project was to evaluate the cost-effectiveness of common soil amendments used in restoring upland vegetation following high severity disturbances in the eastern plains of Colorado, such as in pipeline corridors. Soil amendments included low compost (60 cy/ac), high compost (100 cy/ac), PermaMatrix (manufacturer recommended rate), seed only, and Richlawn. The treatments were installed in November 2024, on a pipeline corridor on Erie property, near the regional airport. This site was reclaimed previously, but the site had become dominated by *Kochia scoparia* and other non-native weeds.

First growing-season results were evaluated in July, 2025. The low compost treatment (60 cy/ac) produced the highest total vegetation cover, and supported 35 seedlings per square meter. Most of the seedlings were native grass, primarily *Sporobolus cryptandrus*. Most of the total vegetation cover was comprised of the non-native *Kochia scoparia*. Considering the high standard deviations in native plant cover across treatments, we do not believe any of the results are statistically significant. There were many confounding variables in the way in which treatments were applied, and we are reluctant to make firm decisions based on just first-season monitoring results. This said, the consistent high number of seedlings in nearly all research plots was a positive response to treatments.

AloTerra Restoration Services and the Economic Restoration Institute provided in-kind services (staff time) for this research project, for which we are greatly appreciative. Thank you again for BCPOS's financial support and staff support for this research. The City of Longmont also provided financial support for this research.

ABSTRACT

Establishment of self-sustaining native plant communities is an important goal for many upland ecological restoration projects in Boulder County and elsewhere. While the incorporation of organic matter is often beneficial to plant establishment in disturbed sites, the amount of literature comparing different organic amendment alternatives for upland restoration is highly limited, or it is focused on just one product, such as compost, topsoil, Biotic Earth, etc. In terms of project feasibility, incorporating compost or other soil amendments is often a budgetary constraint on restoration projects.

This research project intended to determine the cost-effectiveness of several common soil amendments in the establishment of native vegetation in the short-grass prairie ecoregion of Boulder County, Colorado. The primary hypothesis is that compost, at 60 cubic yards per acre (S-1 treatment), is the most cost-effective approach to restoring highly disturbed upland plant communities in this environmental context. Six treatments were applied, with three replicates per treatment.

This project contributes to the needs and interests of Boulder County Parks and Open Space (BCPOS) by determining the most cost-effective means to establishing desirable native plant communities on degraded properties they aim to restore. We believe this research will contribute to furthering scientific knowledge and public education in Colorado, and perhaps in the surrounding states with similar environmental contexts where upland restoration is being performed on degraded grasslands.

First-season results, including seedling counts, are not conclusive as-to treatment effect. Several confounding variables were also present, summarized in the discussion.

One of those was a high cover of Kochia, a non-native weed. At least two more monitoring seasons may be necessary to derive more complete treatment response.

Key Words: ecological restoration, soil amendments, compost, prairie restoration.

INTRODUCTION

Establishment of native vegetation on highly disturbed sites of the eastern plains of Colorado is limited by many factors (e.g., low precipitation; extreme temperatures; soils with low organic matter, high salinity, or other soil chemistry and biological constraints; competitive pressure from non-native plant; and so on.) This research project was established to help fill a gap in the effectiveness of different soil amendments in vegetation establishment in this context, and contributes to the needs of BCPOS in several ways. The research site occurs on a reclaimed water pipeline in the Town of Erie, where previous reclamation efforts failed to produce a desirable stand of native vegetation. Prior to installation of research plots, the site was dominated by non-native plants (i.e., 90% or more of the vegetation cover comprised of non-native plants).

Details of the initial revegetation efforts are not known. However, from field observations, it appears that topsoil was not salvaged and/or replaced on the reclaimed soil surface prior to initial revegetation efforts. Lack of weed management pre- and post-revegetation efforts is likely another cause of failure. We did not encounter any residual mulch on the site during baseline assessments. We did encounter furrow rows, indicating that the site was drill seeded. However, we are unaware of the seed mix used, or any soil amendments that may have been applied.

Boulder County is engaged in a wide range of restoration projects in their land management system, and desires to determine the most cost-effective means to restoring native plant communities on degraded properties. We also believe this research will contribute to **furthering scientific knowledge** and public education in Colorado, and perhaps in the surrounding states where upland restoration is being performed in similar arid environmental contexts.

The **objective** of this research project is to determine the cost-effectiveness of several common soil amendments in the establishment of native vegetation in the short-grass prairie ecoregion of eastern Colorado. The **null hypothesis** being tested is that there is no difference between the soil amendments being tested. The alternative hypothesis is that a combination of compost (at 60 cubic yards per acre) + 300 lbs/ac of Biosol 7-2-1 is the most cost-effective approach to restoring highly disturbed upland plant communities in this environmental context. In this case, "cost-effective" means that the treatment will produce at least 40% vegetation cover within the first two to three growing seasons following installation of treatments, and support a healthy stand of desirable native vegetation.

Several benefits of compost are reported in the literature: a) increased soil moisture retention, b) increased soil porosity, c) increased cation exchange capacity of soils, which increases nutrient capture, and d) increase in beneficial microbes and soil biota. These characteristics aid in the proliferation of the soil microbiome, buffer soil pH, and allows plants to more effectively utilize nutrients (Alexander, R. 2005). Some of these benefits are also provided by other organic amendments, such as pelletized humic acid (i.e., humate), and similar humic contents in Biosol, Richlawn, and other commercial amendments. Other products such as Biotic Earth Black™ and PermaMatrix™ also provide various forms of organic matter, and can include some mycorrhizal fungi and other soil biota found in compost (ECB-VERDYOL, 2024). Biotic Earth Black™ and PermaMatrix™ have a very high C:N ratio (35:1), comprised of 95% sphagnum peatmoss and straw, and often requires high N application rates to offset the high carbon content. To balance this, we added the recommended 500 lbs/ac of 7-2-1 organic fertilizer.

The background level of soil organic matter (SOM) in prairie soils of Boulder County can range between 1 and 4%. However, in a restoration setting, with highly disturbed soils, a higher % SOM is often necessary to favor successful establishment of desirable seeded species. Until an adequate native plant community is established, initial SOM volumes will often decline—often times quickly—following ripping, discing, and seeding. Much of the SOM can be volatized into CO2 in the first few years. For this reason, it is recommended that % SOM be increased above the reference condition, a strategy corroborated by the EPA, which recommends doubling the %SOM for a restoration project (EPA, 2007).

Research on the cost-effectiveness of the above soil amendments (tested side-by-side on the same site) is very limited in the U.S., and from the PIs literature search similar research is absent in the eastern plains of Colorado. Research on many soil amendments is often done on just the one amendment in question (Myrowich and Nelsen, 2024), or it is produced by the manufacturer (ECB-VERDYOL, 2024). One study did compare Biotic Earth, ProGranics, and Topsoil in Canada, but did not test compost or other industry standard side by side with those treatments (Hilvers, 2015).

From an environmental and economic sustainability standpoint, there is currently a surplus of compost on the Colorado Northern Front Range (Sanders, 2023). If this research does show that compost is a cost-effective amendment for restoring native habitats, this project may also provide evidence for a regional use of a readily available material, which also removes pressure of landfilling organic waste, and the associated environmental impacts, all of which are goals of Boulder County.

METHODS

Integrated weed management occurred for two growing seasons prior to installation of research plots (e.g., mowing 3-4 times per year + limited application of Milestone^{TM} & Quinstar^{TM} herbicides). Five soil amendments (SA) were evaluated alongside a seed only treatment, with three replicates per treatment, for a total of 18 treatment blocks. Research plots measured approx. 0.1 acres in size (45' x 100'), and were buffered by an additional 5' on all sides. Plot corners were surveyed to sub-meter accuracy using a Bad Elf GPS unit.

Following ripping (6-8" actual depth, which was less than the desired 10-12" depth), soil amendment treatments were broadcast and then disced 4-6" into the soil. The soil treatment matrix is provided in **Table 1**. The PermaMatrix^{TM} application followed the company guidelines (4,000 lbs per acre, + 500 lbs acre of 7-2-1 fertilizer), and was applied dry. PermaMatrix is often applied as a slurry, but we did not encounter any evidence that a slurry application is more effective than a dry application.

The rates of Richlawn are based on the PIs 25 years of experience with this and similar amendments in Colorado upland restoration projects, and also balanced with the experience of staff at Rocky Mountain Bioproducts (Tom Bowman). The Richlawn application rates were also influenced by the N and % SOM in the compost and in the site soils. Soil amendment treatments are summarized as follows:

S-1: Compost (low rate, at 60 cy/ac) + Richlawn 7-2-1 (at 300 lbs/ac) + seed.

S-2: Compost (high rate, at 100 cy/ac) + Richlawn 7-2-1 (at 500 lbs/ac) + seed.

S-3: Perma Matrix (at 4,000 lbs/ac) + Richlawn 7-2-1 (at 500 lbs/ac) + seed.

S-4: Richlawn 7-2-1 (at 500 lbs/ac) + humic acid (granular, at 300 lbs/ac) + seed.

S-5: Seed only.

S-6: Richlawn 7-2-1 (at 500 lbs/ac) + seed.

Baseline vegetation conditions were determined from a rapid ocular estimate in fall 2024. Soil samples were obtained via five subsamples across the research site, ranging from 6-8” depth. Soil analysis was conducted by Weld Labs. Some of the results (e.g., low SOM and low N), influenced the final N rates applied. Experimental treatments were installed in November, 2024. Photos of the research site following weed management and prior to installation of treatments are provided in **Appendix A**.

First-season vegetation cover was assessed in July 2025, via the Line Point Intercept method (Herrick et al., 2005), with six 90-foot transects per treatment plot. Each transect included three Daubenmire plots (1 sq meter) to measure seedling counts. Belt transects were assessed in each transect to capture uncommon species.

Vegetation cover was recorded by species and life history trait, when possible. Due to lack of ability to consistently and accurately identify grass and forb seedlings, seedling counts and some cover data were reported to the highest taxa level the monitoring crew felt comfortable using (e.g., introduced grass, grass, forb, native grass). Bare soil (gravel, sand, silt, and clay), and litter cover (all organic matter on the soil surface, including standing dead) was also recorded. Data was analyzed for basic statistics (e.g., means and standard deviation) using standard formulas in MS Excel.

RESULTS

The research site's baseline condition is characterized by about 85% bare soil, 10% non-native plant cover, and 5% litter. Soils are sandy clays, with a neutral to moderately high pH, low N, average salt content, and low to average soil organic matter. Soil lab results are provided in **Appendix B**.

Vegetation responses are documented in tables **3 and 4**, by treatment. A summary of those findings is provided here. The **S-1** (low compost) treatment had the highest total vegetation cover, and **S-5** (seed only) had the lowest total vegetation cover. Most of the cover was comprised of *Kochia scoparia*, an early successional non-native weed. The **S-4** (Richlawn + humic acid) treatment had the highest total native plant cover. Total native cover among the other treatments varied between 1.1% (**S-6**, Richlawn alone) and 4.8% (**S-4**, Richlawn + humic acid).

Average seedling counts varied from 30 seedlings (**S-3**, PermaMatrix) to 39 seedlings per square meter (**S-5**, seed only). Native grass seedlings represented the largest vegetation classification (75-95% of total seedlings, depending on the treatment), almost entirely comprised of *Sporobolus cryptandrus*, a very small-seeded native plant present in the seed mix and likely in the soil seedbank. Introduced grasses introduced forbs comprised the remainder of seedlings, mostly *Bromus tectorum* and *Kochia scoparia*, respectively.

Due to the high standard deviations among treatments with respect to species cover (**Table 3**), the treatment effects are not statistically significant, and should be interpreted with caution.

DISCUSSION

The hypothesis that the low compost application rate would result in the highest vegetation cover was confirmed by this study. However, the dominant vegetation was *Kochia scoparia* (an early successional non-native forb). We did not determine any patterns in the data that would indicate one treatment effect had a more positive outcome on desired native vegetation cover than any other treatment, when considering the standard deviations around the mean. The largest variation in grass seedling counts and vegetation cover appeared to be in the compacted access track running through a portion of the research plots (roughly ¾ the way toward the east end of the research plots). In those areas, total seedling counts and percent total canopy cover were much lower than in surrounding areas (**Appendix A**, image 4).

Discussing treatment application conditions with the pipeline restoration supervisor (Stephen Shoemaker of AloTerra) and David Hirt of Boulder County, a few confounding variables were observed that may have impacted seedling emergence an/or seedling growth in the research plots:

- Seeding was done in November, 2024, and the installation crew was juggling multiple snow events, with variable seeding consistency due to soil moisture and frozen soil conditions.
- Access for delivery of compost to research plots was limited to a narrow dirt band, which included a portion of the research plots (about ¾ of the way toward the eastern side of the

treatment plots). The site was ripped once prior to compost staging, then it was accessed by skids (small to medium sized), then ripped again. David Hirt noticed that this same area may have also been the primary pipeline corridor, due to the number of manholes and location stakes, and as such may have potentially had subsoil mixed with topsoil during the excavation and backfilling process. See **Appendix A**, image 4 for photo of effected area.

- There was a concern that the 2nd series of work (once the restoration crew could get back into the site after a series of snow events) down the access road may have compacted the soil further (soil was moist at the time), and so that area was ripped again, to 6-7" deep. The first ripping was also just 6-7" deep, instead of the desired 10-12" deep.
- This project was the first time the contractor used their new Brillion seeder. It is possible there were some inconsistencies in the calibration on seeding depth, though this cannot be confirmed. However, the fact that a small-seed native plant (*Sporobolus cryptandrus*) was the dominant plant in seedling counts indicates that the seed mix may have been shallowly sown.
- The northern block (A replicate) of the research site had just been mowed by a third-party contractor after treatment installation and prior to the monitoring effort. See **Appendix A,** image 3 for photo of effected plots. This led to a lot of kochia lying horizontally as litter in the plots.
- There was good early spring moisture, then the site dried out quickly and severely in June/July.

Based on the results, it is tempting to believe that none of the soil amendments was more cost-effective than the other in establishing a desirable stand of native vegetation on this research site. However, we do not support this conclusion due to the first-year results, and due to several confounding variables. Vegetation monitoring in

2026 and/or 2027 may provide a different reflection of treatment effects, as new seedlings emerge and as the drought-impacted seedlings from 2025 express themselves more fully. Possible variations in ripping depths, seeding effectiveness, and other variables may have also influence treatment effects.

Though two-years of weed management was conducted on the research site prior to installing treatments, the weed treatment effects did result in low enough weed cover (ideally) for a native plant research project. For similar research studies of this type, more thorough weed management treatments and/or the use of a weed-free site would help to reduce the confounding variable of weed cover. Other confounding variables that can be managed should be managed (e.g., seeding consistency, timing of seeding, and others).

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FIGURES AND TABLES

All figures and tables are provided below, with the respective figure or table number referenced in the narrative above.

Table 1. Research treatments (actual installed amendments and quantities)

Trt Label	Amendment	Qty Needed	Units	Application Rate	units	Plot Size (sf)	Plot Size (ac)
S-1	**Compost (low rate)**	5.6	cy	60	cy/ac	4050	0.093
	+ Richlawn (7-2-1)	27.89	lbs	300	lbs/ac	4050	0.093
S-2	**Compost (high rate)**	9.3	cy	100	cy/ac	4050	0.093
	+ Richlawn (7-2-1)	46.49	lbs	500	lbs/ac	4050	0.093
S-3	**Perma Matrix (dry applied)**	371.90	lbs	4,000	lbs/ac	4050	0.093
	+ Richlawn (7-2-1)	46.49	lbs	500	lbs/ac	4050	0.093
S-4	**Richlawn (7-2-1)**	46.49	lbs	500	lbs/ac	4050	0.093
	+ humic acid (granular humate)	27.89	lbs	300	lbs/ac	4050	0.093
S-5	**Seed Only**						
S-6	**Richlawn only (7-2-1)**	46.49	lbs	500	lbs/ac	4050	0.093

Table 2. Upland Seed Mix

Acres (**upland**): 1.0
Seeds Per Sq. Ft. (Broadcast): 110

Upland Seed Mix

Scientific Name (USDA)	Common Name (USDA)	Cultivar or Ecotype	Life History	% Mix	Pounds PLS Needed
Achillea lanulosa var. occidentalis	Western yarrow	Eagle or Yakima	NPF	2	0.03
Adenolinum lewisii	Lewis flax	Maple Grove or CO ecotype	NPF	2	0.32
Aristida purpurea	purple threeawn	CO Ecotype preferred	NPG-L	4	0.74
Artemisia frigida	prairie sagewort	CO Ecotype preferred	NPF	2	0.02
Bouteloua curtipendula	sideoats grama	Niner	NPG-L	8	2.02
Bouteloua gracilis	blue grama	Fremont CO ecotype	NPG-L	10	0.65
Buchloe dactyloides	buffalograss	Cody	NPG-L	7	5.99
Cleome serrulata	Rocky Mountain beeplant	CO Ecotype (or VNS)	NAF	2	0.84
Coreopsis tinctoria	plains coreopsis	CO Ecotype (or VNS)	NBF	4	0.14
Dalea candida	white prairie clover	CO Ecotype preferred	NPF	2	0.26
Elymus elymoides	squirreltail	Pueblo or Wapiti	NPG-L	10	2.50
Elymus trachycaulus	slender wheatgrass	Pryor	NPG-L	12	3.97
Gaillardia aristata	blanketflower	CO Ecotype (or VNS)	NPF	3	0.77
Grindelia squarrosa	curly cup gumweed	CO Ecotype (or VNS)	NBF	2	0.24
Helianthus annuus	common sunflower	CO Ecotype (or VNS)	NAF	1	0.42
Liatris punctata	dotted blazing star	CO Ecotype (or VNS)	NPF	0.5	0.14
Monarda fistulosa	wild bergamot	CO Ecotype (or VNS)	NPF	3	0.10
Pascopyrum smithii	western wheatgrass	Arriba	NPG-L	12	5.05
Penstemon angustifolius	broadbeard beardtongue	CO Ecotype or San Juan Germ.	NPF	2	0.31
Ratibida columnifera	upright prairie coneflower	CO Ecotype (or VNS)	NPF	2	0.12
Rudbeckia hirta	blackeyed Susan	CO Ecotype (or VNS)	NBF	3	0.09
Sporobolus cryptandrus	sand dropseed	CO Ecotype preferred	NPG-L	6	0.06
			Totals:	**100**	**24.8**

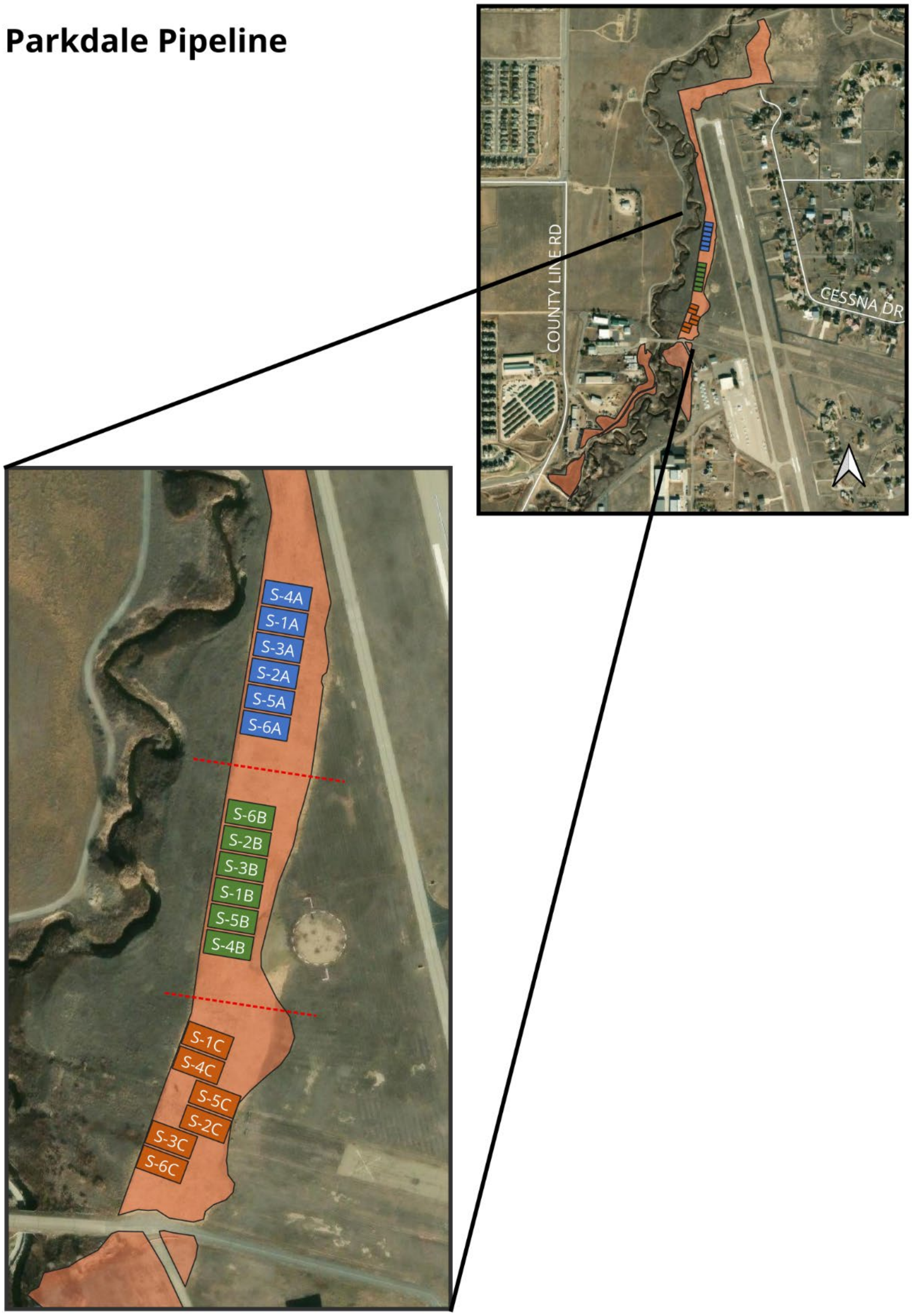
Table 3. Ground cover by cover class and by treatment type.

	Average Cover and StdDev by Cover Class (Trt S-1 through S-6)											
	S-1		S-2		S-3		S-4		S-5		S-6	
Cover Class	**Average**	**StdDv**	**Average**	**StdDv**	**Average**	**StdDv**	**Average**	**StdDv**	**Average**	**StdDv**	**Average**	**StdDv**
Bareground	31.7%	10.25	32.0%	25.05	35.6%	15.18	39.2%	13.65	42.7%	24.48	39.3%	22.97
Litter	28.9%	16.35	35.4%	16.83	31.7%	8.05	27.4%	9.43	26.3%	11.35	24.6%	15.14
Forb	0.0%	0.00	0.0%	0.00	0.1%	0.08	0.0%	0.00	0.0%	0.00	0.0%	0.00
NG	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.1%	0.10	0.2%	0.29	0.0%	0.00
IG	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.1%	0.10	0.0%	0.00	0.0%	0.00
Grass	0.2%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.1%	0.00	0.0%	0.00
IAF	30.5%	4.33	28.3%	22.58	27.0%	11.02	23.9%	5.78	22.9%	12.38	34.0%	17.30
IBF	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.1%	0.00	0.0%	0.00	0.0%	0.00
IPF	0.2%	0.00	0.1%	0.12	0.1%	0.00	0.4%	0.00	0.0%	0.00	0.1%	0.02
IPG-L	0.1%	0.00	0.1%	0.10	0.2%	0.24	1.9%	2.70	0.4%	0.19	0.1%	0.00
IAG-L	5.2%	6.97	2.7%	3.86	2.0%	3.18	2.3%	3.37	3.9%	4.58	0.8%	0.71
NAF	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.2%	0.00	0.1%	0.00	0.0%	0.00
NBF	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
NPF	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
NPG-L	3.3%	2.18	1.3%	0.48	3.3%	1.40	4.6%	2.97	3.4%	2.59	1.1%	0.31
NAG-L	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Metal	0.0%	0.00	0.0%	0.00	0.1%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00
Plastic	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.1%	0.00
Total Cover:	100.0%		100.0%		100.0%		100.0%		100.0%		100.0%	
Total Veg Cover:	39.4%		32.5%		32.6%		33.4%		31.1%		36.0%	
Total Native Cover:	3.3%		1.3%		3.3%		4.8%		3.7%		1.1%	
Total Non-Native Cover:	35.9%		31.2%		29.2%		28.6%		27.2%		35.0%	
Total Unknown or Other:	0.2%		0.0%		0.1%		0.0%		0.1%		0.1%	

Table 4. Seedling Counts by Treatment Type

	Treatment Type					
	S-1	**S-2**	**S-3**	**S-4**	**S-5**	**S-6**
Average Seedling Count / sq.m.:	35	33	30	39	39	37
Seedlings by Taxa (%)						
Forb	0.5%	2.3%	8.7%	4.2%	10.3%	5.4%
NG	93.3%	88.6%	81.6%	90.6%	81.7%	82.8%
IG	3.6%	8.5%	9.7%	5.1%	7.9%	2.3%
AGRCRI	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ASCSPE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BUCDAC	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BOUCUR	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BOUGRA	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BROINE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BROTEC	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
CLESER	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
CONARV	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%
DACGLO	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ELYREP	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ELYTRA	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ERACIL	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
EUPDAV	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Euphorbia spp	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
KOCSCO	2.6%	0.7%	0.0%	0.0%	0.0%	9.5%
metal	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
PASSMI	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Plastic	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
RUMCRI	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SCHSCO	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SECCER	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Solanum spp	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SOLTRI	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SPOCRY	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sporobolus spp	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Unk grass	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
VERBLA	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Totals:	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Figure 1. Map of research site and plot locations.



Appendix A: Baseline & Monitoring Conditions

Image 1. Baseline Condition: Summer 2023.

Image 2. Baseline Condition: November 2024.

Image 3. Monitoring Condition (Mowed Kochia). July 2025.

Image 4. Monitoring Condition. July 2025. Low seedling cover and total vegetation cover in compacted access road (possibly the original pipeline alignment).

Appendix B: Soil Lab Results