

IRVINE PRAIRIE

Winter Meeting | Feb. 28, 2024

C. Irvine, B. Pippert, L. Jackson, J. Meissen, L. Walter,
A. Olson, A. Phillips



Tallgrass Prairie
CENTER

University of Northern Iowa.

Science Update

2023



Irvine Prairie Science Update

Year 6 (2023)

Prepared by Justin Meissen • Tallgrass Prairie Center
University of Northern Iowa • February 2024

Introduction

We began the restoration of an additional 220 acres of diverse tallgrass prairie at Irvine Prairie in 2022, seeding the first ~ 25 ac of previously farmed land on the southwest corner of the new addition. We monitor our progress through detailed vegetation sampling to make sure our restoration methods continue to be effective. Monitoring also allows us to anticipate potential problems in the future, and

helps us tweak our management practices in order to get the best results we can get out of the seeds and plants we've planted. In this update we 1) review how we conducted our monitoring (Methods), 2) show what the monitoring tells us (Results), and 3) discuss steps we should take based on our results (Management Implications).

Methods

Our approach to monitoring is to use systematically placed, permanent plots to answer our questions about the performance and ecology of Irvine Prairie. We added 30 new monitoring points in 2022. We measured species identity and vegetation density metrics at sampling locations in September 2022 for new seeding areas and in July 2022 for 3 and 5 year old plantings. To sample plant composition at each point, we used a modified nested quadrat sampling method described in the National Protocol Framework for Monitoring Vegetation in Prairie Reconstructions (McColpin et al. 2019). In this method, observers record plant identity and presence in a series of nested quadrats (0.0625, 0.125, 0.25, 0.5, and 1m²). For newly seeded areas, we additionally measured density of sown species in the 0.125 m² quadrats, where we counted and identified all individuals (ramets) of seeded species

>10 cm tall. We calculated frequency and Shannon's diversity (e^H , effective species) using the 1 m² quadrat measurements.

To measure plant composition at Irvine Prairie more generally, we conducted meandering walks through each seed mix area. During the walk, we recorded all planted species encountered, and estimated their overall abundance using a qualitative scale: Very Common, Frequent, Occasional, Sparse. See (McColpin et al. 2019) for a detailed description of the method used for meandering walk surveys. We used this walkthrough data to calculate species richness across seeding areas.

Results

Irvine Prairie Overall

We seeded and transplanted 130 species of native plants in fall 2022 and spring 2023, across a total of around 25 acres. We sowed 123 species as seed and transplanted 2283 plugs of 22 species. With the addition of that work, total acres restored at Irvine Prairie has reached approximately 100 acres using 168 species. Additional restoration was conducted in fall 2023 which will be discussed in the 2024 Science Report. In the 2023 growing season, we found 95 species across Irvine Prairie (Fig. 1).

Over all our years of monitoring, including this year, we have found 102 unique plant species. We are encouraged to find species diversity continuously increasing.

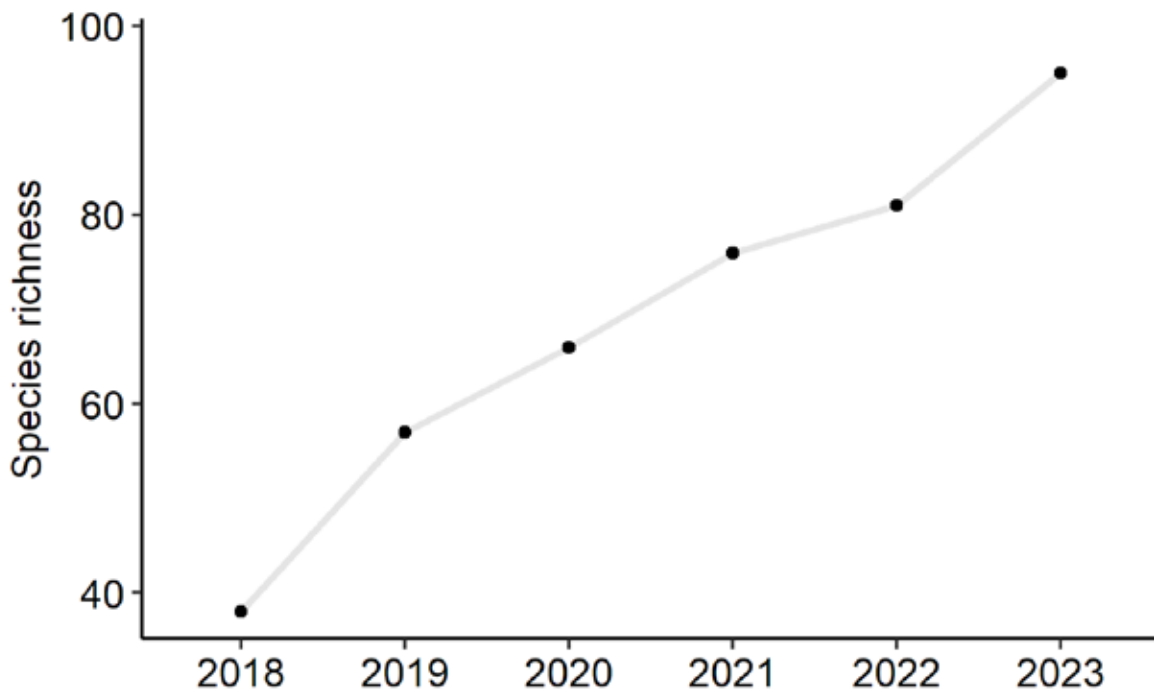


Figure 1: Overall site plant species richness (walkthrough data)

2023 Planting Area (first growing season)



Figure 2: Typical view in September of the southwest corner of the northern addition (seeded Nov 2022). Smooth oxeye and false boneset flowering

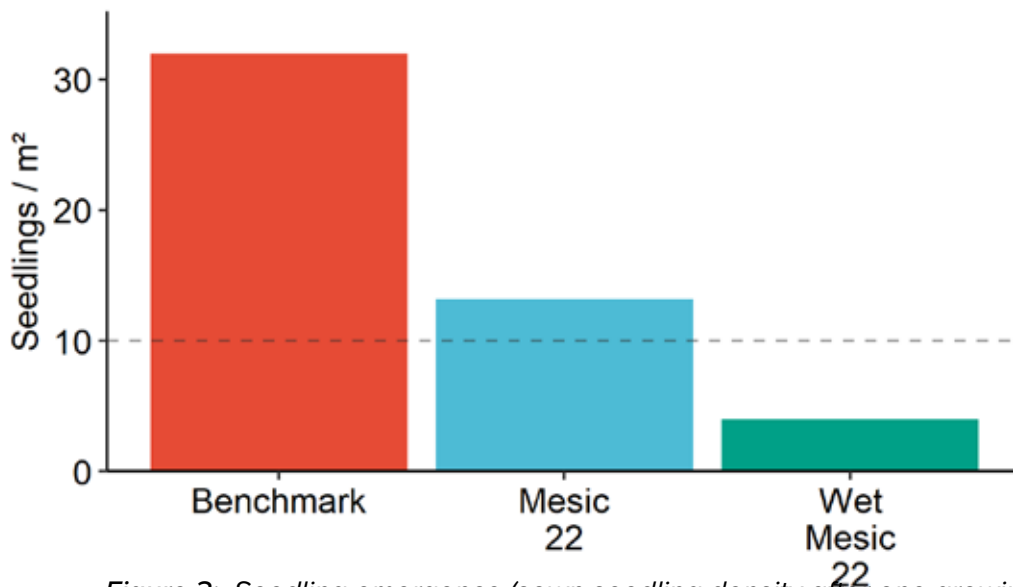


Figure 3: Seedling emergence (sown seedling density after one growing season) in 2023 seeding areas

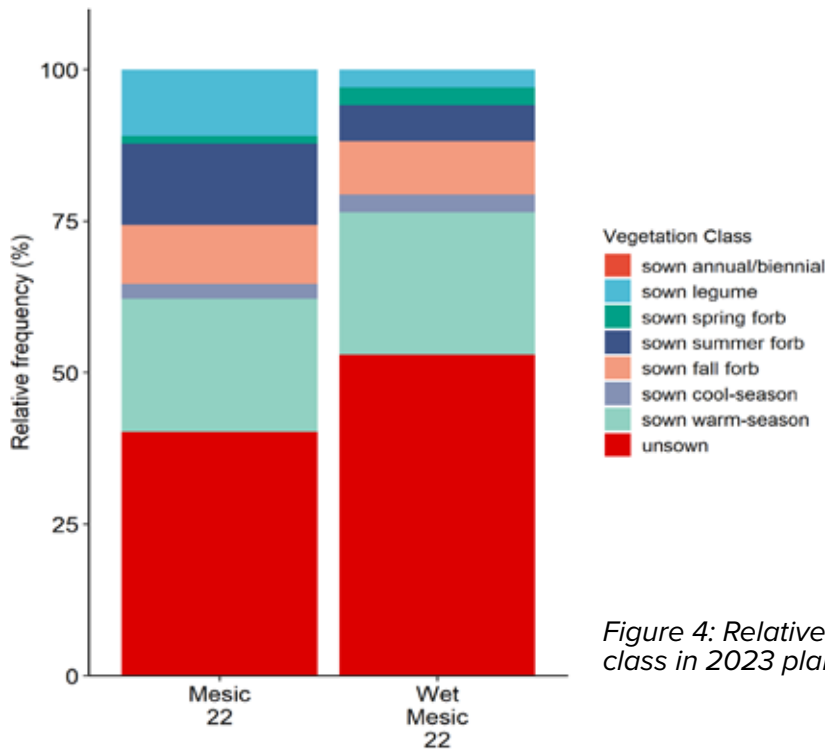


Figure 4: Relative frequency (2023) by vegetation class in 2023 planting areas.

Initial restoration results on the new North Tract seeding areas are mixed. Weeds were either very abundant or nearly absent, depending on the landscape position. Patches of crabgrass (*Digitaria sanguinalis*) were quite dense in the lowland areas, while some upland areas were dominated by witchgrass (*Panicum capillare*) (Fig. 2). Hilltops, especially in the western part of the restoration area, had very few weeds. Perennial weeds were mostly absent, but smooth brome (*Bromus inermis*) is invading from the western field border. Cover crop growth was minimal during fall 2022, and despite quick snow cover after seeding in November 2022, most of the restoration area was essentially bare during the winter. High winds and bare soil may have led to seed loss over the winter. Rill erosion was common by spring, though after spot field cultivation, we had no significant erosion during the growing season.

Over the entire restoration area, seedling establishment was low (Fig. 3). Compared to other benchmark seed mixes, establishment in the Mesic 22 mix was much less than our TPC Experimental

site but met the the rule-of-thumb minimum for successful prairie reconstruction (10 individuals/m²) (Smith et al. 2010). The Wet Mesic 22 mix did not meet the threshold for success, and must be considered a candidate for re-seeding in the future. The exceptional drought conditions throughout most of the year, but especially during the spring, likely contributed to such low establishment.

Vegetation structure was mostly dominated by annual weeds in the 2023 planting areas, as is typical for new plantings (Fig. 4). In terms of the relative abundance of sown functional groups, warm season grasses were dominant. Spring, summer, and fall forbs were all present, but spring forbs were quite sparse. The abundance of cool-season grass was also very low.

While the initial abundance of sown species was low, species richness was relatively high. We found 50 species throughout both planting sites, which was comparable to fall 2021/spring 2022 plantings.

Table 1: Species and abundance found in the 2023 seeding areas (first growing season)

Common Name	Scientific Name	Abundance	Common Name	Scientific Name	Abundance
common yarrow	<i>Achillea millefolium</i>	Sparse	marsh muhly	<i>Muhlenbergia racemosa</i>	Occasional
leadplant	<i>Amorpha canescens</i>	Sparse	biennial beeblossom	<i>Oenothera gaura</i>	Sparse
big bluestem	<i>Andropogon gerardii</i>	Sparse	switchgrass	<i>Panicum virgatum</i>	Occasional
white sagebrush	<i>Artemisia ludoviciana</i>	Occasional	foxglove beardtongue	<i>Penstemon digitalis</i>	Occasional
swamp milkweed	<i>Asclepias incarnata</i>	Sparse	pinnate prairie coneflower	<i>Ratibida pinnata</i>	Occasional
common milkweed	<i>Asclepias syriaca</i>	Occasional	blackeyed Susan	<i>Rudbeckia hirta</i>	Occasional
butterfly milkweed	<i>Asclepias tuberosa</i>	Occasional	sweet coneflower	<i>Rudbeckia subtomentosa</i>	Sparse
Canadian milkvetch	<i>Astragalus canadensis</i>	Occasional	fringeleaf wild petunia	<i>Ruellia humilis</i>	Occasional
white doll's daisy	<i>Boltonia asteroides</i>	Sparse	little bluestem	<i>Schizachyrium scoparium</i>	Very Common
sideoats grama	<i>Bouteloua curtipendula</i>	Occasional	Maryland senna	<i>Senna marilandica</i>	Sparse
false boneset	<i>Brickellia eupatorioides</i>	Frequent	wholeleaf rosinweed	<i>Silphium integrifolium</i>	Occasional
arctic brome	<i>Bromus kalmii</i>	Occasional	stiff goldenrod	<i>Solidago rigida</i>	Occasional
partridge pea	<i>Chamaecrista fasciculata</i>	Sparse	Indiangrass	<i>Sorghastrum nutans</i>	Sparse
stiff tickseed	<i>Coreopsis palmata</i>	Sparse	composite dropseed	<i>Sporobolus compositus</i>	Frequent
white prairie clover	<i>Dalea candida</i>	Frequent	smooth blue aster	<i>Symphotrichum laeve</i>	Occasional
purple prairie clover	<i>Dalea purpurea</i>	Sparse	New England aster	<i>Symphotrichum novae-angliae</i>	Sparse
Illinois ticktrefoil	<i>Desmodium illinoense</i>	Frequent	skyblue aster	<i>Symphotrichum oolentangiense</i>	Sparse
pale purple coneflower	<i>Echinacea pallida</i>	Frequent	bluejacket	<i>Tradescantia ohimensis</i>	Sparse
Canada wildrye	<i>Elymus canadensis</i>	Sparse	swamp verbena	<i>Verbena hastata</i>	Occasional
tall thoroughwort	<i>Eupatorium altissimum</i>	Sparse	hoary verbena	<i>Verbena stricta</i>	Occasional
common sneezeweed	<i>Helenium autumnale</i>	Sparse	prairie ironweed	<i>Vernonia fasciculata</i>	Occasional
sawtooth sunflower	<i>Helianthus grosseserratus</i>	Frequent	prairie violet	<i>Viola pedatifida</i>	Sparse
stiff sunflower	<i>Helianthus pauciflorus</i>	Frequent	meadow zizia	<i>Zizia aptera</i>	Sparse
smooth oxeye	<i>Heliopsis helianthoides</i>	Frequent	golden zizia	<i>Zizia aurea</i>	Occasional
roundhead lespedeza	<i>Lespedeza capitata</i>	Occasional			
wild bergamot	<i>Monarda fistulosa</i>	Sparse			

2022 Planting Area (second growing season)



Figure 5: Typical view in July of the eastern mid-slopes looking south (seeded Apr 2021). Blackeyed Susan, Canada wildrye, and smooth oxeye flowering.

Eastern areas of Irvine Prairie planted in 2021/2022 performed quite differently than other restoration areas (Fig. 6). We found 52 species throughout the planting site, more than we found the previous year (Table 2). Prickly lettuce (*Lactuca biennis*) was ubiquitous throughout the seeding areas this year, though was less abundant in the dormant broadcast area in the south. Native species in the dormant broadcasted area were much larger, and many forbs flowered this year. We found many highly desirable species to be abundant in these areas, like prairie phlox (*Phlox pilosa*) and rough blazingstar (*Liatris aspera*). Grass composition here is also atypical, with high abundance of Kalm's brome (*Bromus*

kalmii), marsh muhly (*Muhlenbergia racemosa*), rough dropseed (*Sporobolus compositus*), and side oats grama (*Bouteloua curtipendula*). Indiangrass (*Sorghastrum nutans*) and big bluestem (*Andropogon gerardii*) are fairly uncommon. In the northern half that was drilled in spring 2022, we found many species at relatively high abundance. However, typical plant size was extremely small. This is partly due to the mowing that occurred in June to control prickly lettuce, but may also be the result of drought conditions during the year.

Table 2: Species and abundance found in the 2022 seeding areas (second growing season)

Common Name	Scientific Name	Abundance	Common Name	Scientific Name	Abundance
big bluestem	Andropogon gerardii	Occasional	wild bergamot	Monarda fistulosa	Sparse
pale Indian plantain	Arnoglossum atriplicifolium	Occasional	marsh muhly	Muhlenbergia racemosa	Occasional
white sagebrush	Artemisia ludoviciana	Occasional	biennial beeblossom	Oenothera gaura	Occasional
common milkweed	Asclepias syriaca	Occasional	wild quinine	Parthenium integrifolium	Occasional
butterfly milkweed	Asclepias tuberosa	Sparse	downy phlox	Phlox pilosa	Sparse
whorled milkweed	Asclepias verticillata	Sparse	whorled mountainmint	Pycnanthemum pilosum	Sparse
Canadian milkvetch	Astragalus canadensis	Frequent	pinnate prairie coneflower	Ratibida pinnata	Very Common
sideoats grama	Bouteloua curtipendula	Very Common	blackeyed Susan	Rudbeckia hirta	Occasional
false boneset	Brickellia eupatorioides	Frequent	sweet coneflower	Rudbeckia subtomentosa	Occasional
arctic brome	Bromus kalmii	Very Common	little bluestem	Schizachyrium scoparium	Frequent
partridge pea	Chamaecrista fasciculata	Frequent	wholeleaf rosinweed	Silphium integrifolium	Occasional
white prairie clover	Dalea candida	Sparse	compassplant	Silphium laciniatum	Occasional
purple prairie clover	Dalea purpurea	Sparse	gray goldenrod	Solidago nemoralis	Frequent
showy ticktrefoil	Desmodium canadense	Sparse	stiff goldenrod	Solidago rigida	Frequent
Illinois ticktrefoil	Desmodium illinoense	Occasional	showy goldenrod	Solidago speciosa	Frequent
tall cinquefoil	Drymocallis arguta	Frequent	Indiangrass	Sorghastrum nutans	Frequent
pale purple coneflower	Echinacea pallida	Frequent	composite dropseed	Sporobolus compositus	Very Common
Canada wildrye	Elymus canadensis	Very Common	white heath aster	Symphotrichum ericoides	Frequent
Virginia wildrye	Elymus virginicus	Very Common	smooth blue aster	Symphotrichum laeve	Frequent
button eryngo	Eryngium yuccifolium	Sparse	New England aster	Symphotrichum novae-angliae	Occasional
tall thoroughwort	Eupatorium altissimum	Sparse	skyblue aster	Symphotrichum oolentangiense	Occasional
flowering spurge	Euphorbia corollata	Occasional	hoary verbena	Verbena stricta	Frequent
sawtooth sunflower	Helianthus grosseserratus	Occasional	prairie ironweed	Vernonia fasciculata	Occasional
smooth oxeye	Heliopsis helianthoides	Very Common	meadow zizia	Zizia aptera	Frequent
prairie Junegrass	Koeleria macrantha	Occasional	golden zizia	Zizia aurea	Frequent
tall blazing star	Liatris aspera	Occasional			
prairie blazing star	<i>Liatris pycnostachya</i>	Occasional			
prairie blazing star	Liatris pycnostachya	Occasional			

2021 Planting Area (third growing season)



Figure 6: Typical view in July of the central midslopes looking south (seeded May 2020). Pinnae prairie coneflower and smooth oxeye dominates the area, with beebalm and Canada milkvetch blooming.

East central areas of Irvine Prairie planted in 2021 performed well this year (Fig. 6). We found 58 species throughout the planting site, more than we found the previous year (Table 3). Species abundance was variable, and we found most at low abundance (sparse to occasional). Plant communities in these areas were functionally diverse, with the relative frequency of most functional groups quite high (Fig. 7), though spring forbs were not very abundant here this year.

We found species diversity to be ~18 in the dry-mesic planting, but otherwise the 2021 planting areas met our goal of 20 effective species (Fig. 8). Typical early successional species remained dominant, including both Virginia and Canada wild rye. We found agueweed (*Gentianella quinquefolia*), a unique gentian species, in the wet-mesic waterway mix.

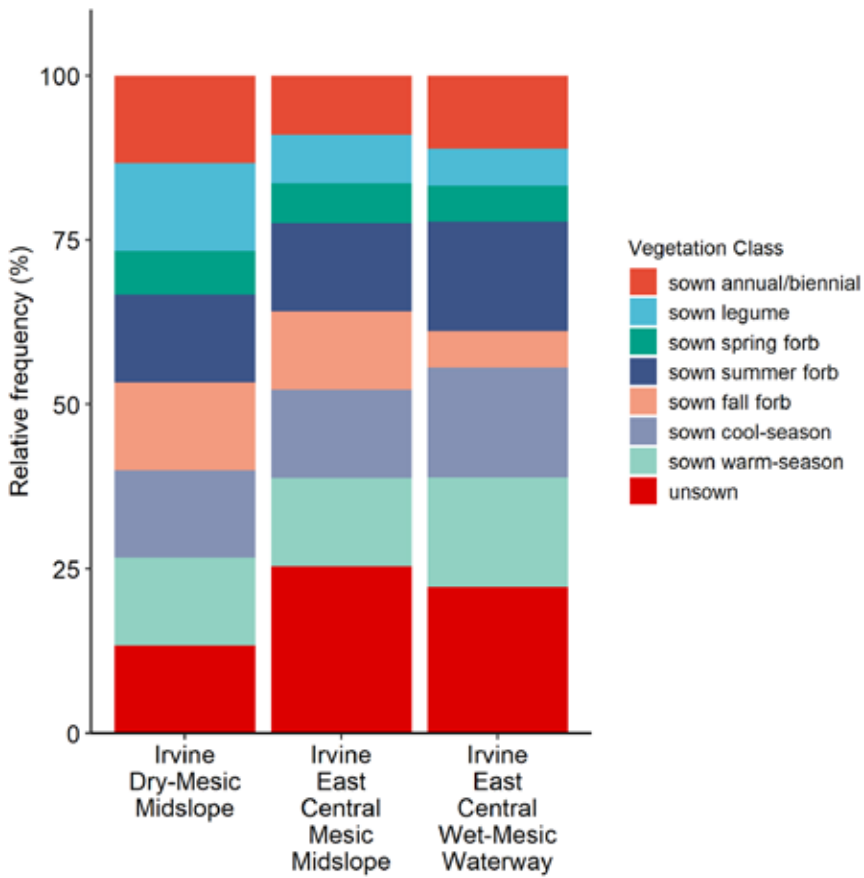


Figure 7: Relative frequency (2023) by vegetation class in 2021 planting areas.

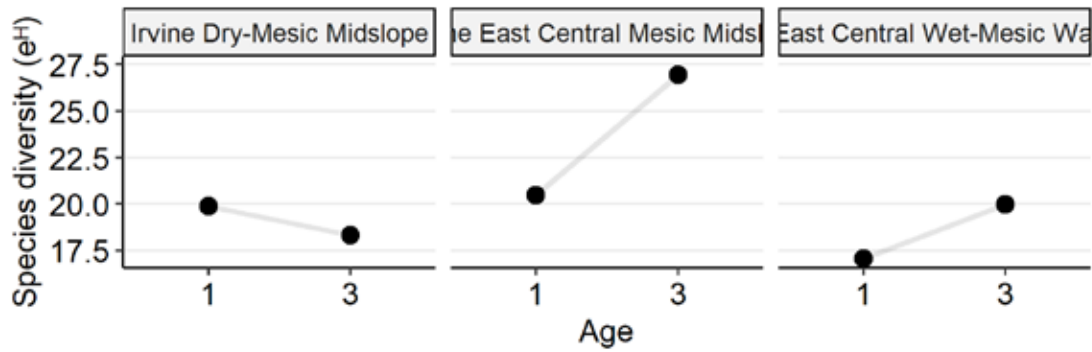


Figure 8: Diversity (Shannon's e^H) among seed mix areas over time.

Table 3: Species and abundance found in the 2021 seeding areas.

Common Name	Scientific Name	Abundance	Common Name	Scientific Name	Abundance
leadplant	<i>Amorpha canescens</i>	Sparse	smooth oxeye	<i>Heliopsis helianthoides</i>	Very Common
big bluestem	<i>Andropogon gerardii</i>	Very Common	prairie Junegrass	<i>Koeleria macrantha</i>	Occasional
white sagebrush	<i>Artemisia ludoviciana</i>	Frequent	roundhead lespedeza	<i>Lespedeza capitata</i>	Frequent
swamp milkweed	<i>Asclepias incarnata</i>	Sparse	wild bergamot	<i>Monarda fistulosa</i>	Frequent
common milkweed	<i>Asclepias syriaca</i>	Occasional	marsh muhly	<i>Muhlenbergia racemosa</i>	Occasional
butterfly milkweed	<i>Asclepias tuberosa</i>	Sparse	switchgrass	<i>Panicum virgatum</i>	Very Common
whorled milkweed	<i>Asclepias verticillata</i>	Sparse	wild quinine	<i>Parthenium integrifolium</i>	Occasional
Canadian milkvetch	<i>Astragalus canadensis</i>	Occasional	foxglove beardtongue	<i>Penstemon digitalis</i>	Frequent
largeleaf wild indigo	<i>Baptisia lactea</i>	Sparse	large beardtongue	<i>Penstemon grandiflorus</i>	Sparse
sideoats grama	<i>Bouteloua curtipendula</i>	Very Common	whorled mountainmint	<i>Pycnanthemum pilosum</i>	Sparse
false boneset	<i>Brickellia eupatorioides</i>	Occasional	pinnate prairie coneflower	<i>Ratibida pinnata</i>	Very Common
arctic brome	<i>Bromus kalmii</i>	Occasional	prairie rose	<i>Rosa arkansana</i>	Sparse
shortbeak sedge	<i>Carex brevior</i>	Sparse	blackeyed Susan	<i>Rudbeckia hirta</i>	Frequent
partridge pea	<i>Chamaecrista fasciculata</i>	Frequent	fringeleaf wild petunia	<i>Ruellia humilis</i>	Sparse
stiff tickseed	<i>Coreopsis palmata</i>	Sparse	little bluestem	<i>Schizachyrium scoparium</i>	Very Common
tall tickseed	<i>Coreopsis tripteris</i>	Sparse	wholeleaf rosinweed	<i>Silphium integrifolium</i>	Occasional
white prairie clover	<i>Dalea candida</i>	Occasional	compassplant	<i>Silphium laciniatum</i>	Sparse
purple prairie clover	<i>Dalea purpurea</i>	Frequent	stiff goldenrod	<i>Solidago rigida</i>	Occasional
Illinois bundleflower	<i>Desmanthus illinoensis</i>	Sparse	showy goldenrod	<i>Solidago speciosa</i>	Occasional
showy ticktrefoil	<i>Desmodium canadense</i>	Frequent	Indiangrass	<i>Sorghastrum nutans</i>	Frequent
Illinois ticktrefoil	<i>Desmodium illinoense</i>	Occasional	composite dropseed	<i>Sporobolus compositus</i>	Very Common
tall cinquefoil	<i>Drymocallis arguta</i>	Sparse	white heath aster	<i>Symphotrichum ericoides</i>	Occasional
pale purple coneflower	<i>Echinacea pallida</i>	Frequent	smooth blue aster	<i>Symphotrichum laeve</i>	Occasional
Canada wildrye	<i>Elymus canadensis</i>	Very Common	New England aster	<i>Symphotrichum novae-angliae</i>	Frequent
Virginia wildrye	<i>Elymus virginicus</i>	Very Common	aromatic aster	<i>Symphotrichum oblongifolium</i>	Frequent
agueweed	<i>Gentianella quinquefolia</i>	Sparse	skyblue aster	<i>Symphotrichum oolentangiense</i>	Sparse
American licorice	<i>Glycyrrhiza lepidota</i>	Sparse	hoary verbena	<i>Verbena stricta</i>	Occasional
sawtooth sunflower	<i>Helianthus grosseserratus</i>	Occasional	prairie ironweed	<i>Vernonia fasciculata</i>	Sparse
stiff sunflower	<i>Helianthus pauciflorus</i>	Very Common	golden zizia	<i>Zizia aurea</i>	Sparse

2020 Planting Area (fourth growing season)

After a prescribed burn in April, we observed good progress in the central areas of Irvine Prairie planted in 2020. In this area's fourth year, we observed considerable abundance of more conservative species (Fig. 9). We found 70 species throughout the planting site, considerably more than the previous year (Table 4). Species abundance varied, but we found overall higher abundance of warm-season grasses than in previous years. We also found relatively high abundance of some conservative species such as compassplant (*Silphium laciniatum*) and rattlesnake master (*Eryngium yuccifolium*) in the mesic areas, and we found some less common species like rough blazingstar (*L. aspera*), new jersey

tea (*Ceanothus americanus*), and leadplant (*A. canescens*). Lowland areas had some characteristic wet-mesic species like flat-top aster (*Doellingeria umbellata*), American licorice (*Glycyrrhiza lepidota*), prairie cordgrass (*Spartina pectinata*), and Maryland senna (*Senna marilandica*).

The 2-acre area broadcast seeded in fall 2019 remained sparsely vegetated but native plants are slowly increasing in abundance. The continued limited spread of perennial weeds and the increasing establishment of native species suggests the area is still on track for slow but satisfactory restoration.



Figure 9: Typical view in July of the central midslopes looking south (seeded May 2020). Pinnate prairie coneflower and smooth oxeye dominates the area, with beebalm and Canada milkvetch blooming..

Table 4: Species and abundance found in the 2020 seeding areas (fourth growing season)

Common Name	Scientific Name	Abundance	Common Name	Scientific Name	Abundance
leadplant	<i>Amorpha canescens</i>	Sparse	common sneezeweed	<i>Helenium autumnale</i>	Occasional
big bluestem	<i>Andropogon gerardii</i>	Very Common	sawtooth sunflower	<i>Helianthus grosseserratus</i>	Frequent
candle anemone	<i>Anemone cylindrica</i>	Sparse	stiff sunflower	<i>Helianthus pauciflorus</i>	Frequent
white sagebrush	<i>Artemisia ludoviciana</i>	Occasional	smooth oxeye	<i>Heliopsis helianthoides</i>	Very Common
swamp milkweed	<i>Asclepias incarnata</i>	Sparse	roundhead lespedeza	<i>Lespedeza capitata</i>	Occasional
common milkweed	<i>Asclepias syriaca</i>	Occasional	tall blazing star	<i>Liatris aspera</i>	Sparse
butterfly milkweed	<i>Asclepias tuberosa</i>	Sparse	prairie blazing star	<i>Liatris pycnostachya</i>	Sparse
whorled milkweed	<i>Asclepias verticillata</i>	Occasional	wild bergamot	<i>Monarda fistulosa</i>	Very Common
Canadian milkvetch	<i>Astragalus canadensis</i>	Frequent	marsh muhly	<i>Muhlenbergia racemosa</i>	Frequent
largeleaf wild indigo	<i>Baptisia lactea</i>	Sparse	switchgrass	<i>Panicum virgatum</i>	Frequent
sideoats grama	<i>Bouteloua curtipendula</i>	Very Common	wild quinine	<i>Parthenium integrifolium</i>	Frequent
false boneset	<i>Brickellia eupatorioides</i>	Occasional	foxglove beardtongue	<i>Penstemon digitalis</i>	Occasional
yellowfruit sedge	<i>Carex annectens</i>	Frequent	obedient plant	<i>Physostegia virginiana</i>	Sparse
shortbeak sedge	<i>Carex brevior</i>	Frequent	whorled mountainmint	<i>Pycnanthemum pilosum</i>	Occasional
heavy sedge	<i>Carex gravida</i>	Sparse	Virginia mountainmint	<i>Pycnanthemum virginianum</i>	Sparse
troublesome sedge	<i>Carex molesta</i>	Frequent	pinnate prairie coneflower	<i>Ratibida pinnata</i>	Frequent
New Jersey tea	<i>Ceanothus americanus</i>	Sparse	sweet coneflower	<i>Rudbeckia subtomentosa</i>	Occasional
partridge pea	<i>Chamaecrista fasciculata</i>	Sparse	little bluestem	<i>Schizachyrium scoparium</i>	Frequent
stiff tickseed	<i>Coreopsis palmata</i>	Sparse	Maryland senna	<i>Senna marilandica</i>	Sparse
tall tickseed	<i>Coreopsis tripteris</i>	Occasional	wholeleaf rosinweed	<i>Silphium integrifolium</i>	Frequent
white prairie clover	<i>Dalea candida</i>	Frequent	compassplant	<i>Silphium laciniatum</i>	Frequent
purple prairie clover	<i>Dalea purpurea</i>	Frequent	stiff goldenrod	<i>Solidago rigida</i>	Frequent
showy ticktrefoil	<i>Desmodium canadense</i>	Frequent	showy goldenrod	<i>Solidago speciosa</i>	Sparse
Illinois ticktrefoil	<i>Desmodium illinoense</i>	Occasional	Indiangrass	<i>Sorghastrum nutans</i>	Very Common
parasol whitetop	<i>Doellingeria umbellata</i>	Sparse	prairie cordgrass	<i>Spartina pectinata</i>	Sparse
tall cinquefoil	<i>Drymocallis arguta</i>	Sparse	composite dropseed	<i>Sporobolus compositus</i>	Very Common
pale purple coneflower	<i>Echinacea pallida</i>	Occasional	white heath aster	<i>Symphyotrichum ericoides</i>	Frequent
Canada wildrye	<i>Elymus canadensis</i>	Very Common	smooth blue aster	<i>Symphyotrichum laeve</i>	Occasional
Virginia wildrye	<i>Elymus virginicus</i>	Very Common	New England aster	<i>Symphyotrichum novae-angliae</i>	Frequent
button eryngo	<i>Eryngium yuccifolium</i>	Occasional	skyblue aster	<i>Symphyotrichum oolentangiense</i>	Sparse
tall thoroughwort	<i>Eupatorium altissimum</i>	Sparse	purple meadow-rue	<i>Thalictrum dasycarpum</i>	Sparse
flowering spurge	<i>Euphorbia corollata</i>	Sparse	hoary verbena	<i>Verbena stricta</i>	Frequent
flat-top goldentop	<i>Euthamia graminifolia</i>	Occasional	prairie violet	<i>Viola pedatifida</i>	Sparse
American licorice	<i>Glycyrrhiza lepidota</i>	Sparse	golden zizia	<i>Zizia aurea</i>	Frequent

2019 Planting Area (fifth growing season)

Areas of Irvine Prairie planted in 2019 performed well again this year (Fig. 10). We found 60 species throughout the planting site, more than we found the previous year (Table 5). Plant communities in these areas were functionally diverse (Fig. 11), but unsown species abundance was somewhat high (over 30%) in the wet-mesic lowland area. We found species diversity to be very high in this area, with 30 or more effective species in most cases (Fig. 12). The 2019 planting areas exceed our overall goal of 20 effective species by a large margin. Legumes like purple prairie clover (*D. purpurea*) and tick trefoil

(*Desmodium canadense*) area very abundant here and sedges are comparatively abundant, particularly in the transplanted areas and the lowest areas. Conservative species of interest found this year include bottle gentian (*Gentiana andrewsii*) and American licorice (*G. lepidota*). While we did not pick up many invasive species in our monitoring efforts, walkthroughs indicated sweetclover (*Melilotus albus*) was locally very common in some parts of the lowland areas and occasional in other areas.



Figure 10: Typical view in June of the west hillslope looking south (seeded May 2019). Golden alexanders flowering; purple prairie clover, showy tick trefoil, and others in bud.

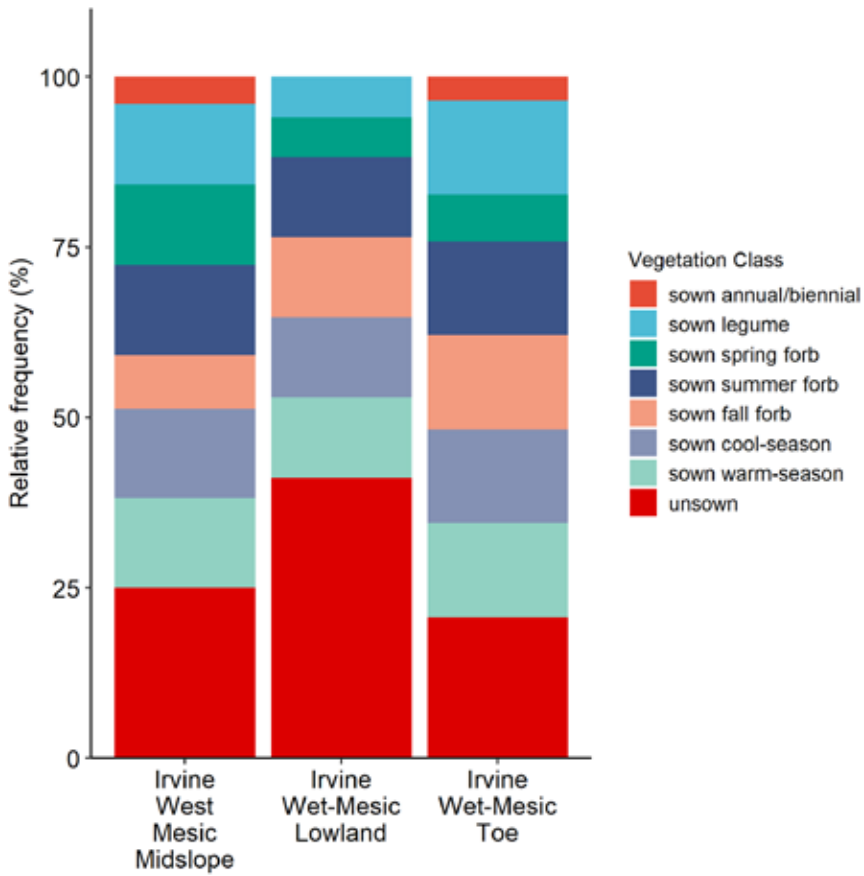


Figure 11: Diversity (Shannon's e^{-H}) among seed mix areas over time.

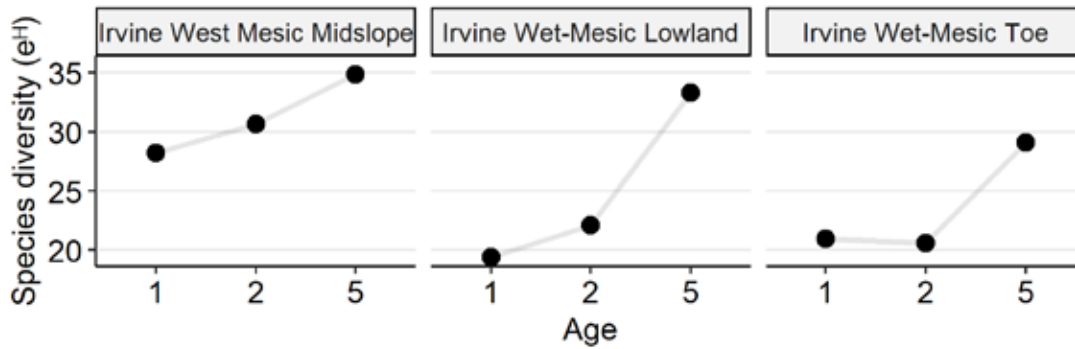


Figure 12: Diversity (Shannon's e^{-H}) among seed mix areas over time.

Table 5: Species and abundance found in the 2019 seeding areas (fifth growing season)

Common Name	Scientific Name	Abundance	Common Name	Scientific Name	Abundance
leadplant	<i>Amorpha canescens</i>	Sparse	closed bottle gentian	<i>Gentiana andrewsii</i>	Sparse
big bluestem	<i>Andropogon gerardii</i>	Very Common	American licorice	<i>Glycyrrhiza lepidota</i>	Sparse
Canadian anemone	<i>Anemone canadensis</i>	Occasional	common sneezeweed	<i>Helenium autumnale</i>	Occasional
candle anemone	<i>Anemone cylindrica</i>	Occasional	sawtooth sunflower	<i>Helianthus grosseserratus</i>	Frequent
white sagebrush	<i>Artemisia ludoviciana</i>	Frequent	smooth oxeye	<i>Heliopsis helianthoides</i>	Very Common
swamp milkweed	<i>Asclepias incarnata</i>	Occasional	roundhead lespedeza	<i>Lespedeza capitata</i>	Frequent
common milkweed	<i>Asclepias syriaca</i>	Occasional	wild bergamot	<i>Monarda fistulosa</i>	Very Common
butterfly milkweed	<i>Asclepias tuberosa</i>	Sparse	biennial beeblossom	<i>Oenothera gaura</i>	Occasional
Canadian milkvetch	<i>Astragalus canadensis</i>	Frequent	switchgrass	<i>Panicum virgatum</i>	Very Common
largeleaf wild indigo	<i>Baptisia lactea</i>	Sparse	foxglove beardtongue	<i>Penstemon digitalis</i>	Occasional
sideoats grama	<i>Bouteloua curtipendula</i>	Very Common	whorled mountainmint	<i>Pycnanthemum pilosum</i>	Occasional
arctic brome	<i>Bromus kalmii</i>	Occasional	Virginia mountainmint	<i>Pycnanthemum virginianum</i>	Sparse
yellowfruit sedge	<i>Carex annectens</i>	Sparse	pinnate prairie coneflower	<i>Ratibida pinnata</i>	Very Common
Bicknell's sedge	<i>Carex bicknellii</i>	Sparse	blackeyed Susan	<i>Rudbeckia hirta</i>	Very Common
shortbeak sedge	<i>Carex brevior</i>	Sparse	sweet coneflower	<i>Rudbeckia subtomentosa</i>	Occasional
troublesome sedge	<i>Carex molesta</i>	Sparse	little bluestem	<i>Schizachyrium scoparium</i>	Frequent
broom sedge	<i>Carex scoparia</i>	Occasional	wholeleaf rosinweed	<i>Silphium integrifolium</i>	Sparse
fox sedge	<i>Carex vulpinoidea</i>	Occasional	compassplant	<i>Silphium laciniatum</i>	Sparse
New Jersey tea	<i>Ceanothus americanus</i>	Sparse	stiff goldenrod	<i>Solidago rigida</i>	Frequent
partridge pea	<i>Chamaecrista fasciculata</i>	Sparse	Indiangrass	<i>Sorghastrum nutans</i>	Very Common
tall tickseed	<i>Coreopsis tripteris</i>	Sparse	prairie cordgrass	<i>Spartina pectinata</i>	Occasional
white prairie clover	<i>Dalea candida</i>	Occasional	composite dropseed	<i>Sporobolus compositus</i>	Very Common
purple prairie clover	<i>Dalea purpurea</i>	Very Common	white heath aster	<i>Symphotrichum ericoides</i>	Occasional
showy ticktrefoil	<i>Desmodium canadense</i>	Very Common	smooth blue aster	<i>Symphotrichum laeve</i>	Occasional
Illinois ticktrefoil	<i>Desmodium illinoense</i>	Occasional	New England aster	<i>Symphotrichum novae-angliae</i>	Occasional
tall cinquefoil	<i>Drymocallis arguta</i>	Sparse	longbract spiderwort	<i>Tradescantia bracteata</i>	Sparse
pale purple coneflower	<i>Echinacea pallida</i>	Sparse	prairie ironweed	<i>Vernonia fasciculata</i>	Occasional
Canada wildrye	<i>Elymus canadensis</i>	Very Common	American vetch	<i>Vicia americana</i>	Sparse
Virginia wildrye	<i>Elymus virginicus</i>	Very Common	golden zizia	<i>Zizia aurea</i>	Frequent
flowering spurge	<i>Euphorbia corollata</i>	Sparse			
flat-top goldentop	<i>Euthamia graminifolia</i>	Sparse			

2018 Planting Area (sixth growing season)

The west hilltop was characterized by diverse native forbs and dense native grasses (Fig. 13). We found 52 species throughout the planting site, which was slightly less than the previous year (Table 6). We continued observing conservative species such as sky-blue aster (*Symphyotrichum oolentangiense*), New Jersey tea (*C. americanus*), and leadplant (*A. canescens*). This area continues to support an exceptional stand of milkweed species. Butterfly milkweed (*Asclepias tuberosa*), whorled milkweed (*Asclepias verticillata*) and common milkweed

(*Asclepias syriaca*) were all frequent to very common in this area, making the hilltop prime monarch habitat. White wild indigo (*Baptisia lactea*) and compassplant (*S. laciniatum*) are becoming more abundant (or more readily observed) as this planting matures. Encouragingly, native grasses do not appear to be increasing in abundance, which suggests diversity may remain high here.



Figure 13: Typical view in June of the west hilltop looking south (seeded May 2018). Switchgrass, indiagrass and big bluestem dominate, with pale purple coneflower, wild quinine, butterfly milkweed and common milkweed flowering; showy tick trefoil in bud.

Table 6: Species and abundance found in the 2018 seeding areas (sixth growing season)

Common Name	Scientific Name	Abundance	Common Name	Scientific Name	Abundance
big bluestem	<i>Andropogon gerardii</i>	Very Common	smooth oxeye	<i>Heliopsis helianthoides</i>	Frequent
candle anemone	<i>Anemone cylindrica</i>	Sparse	roundhead lespedeza	<i>Lespedeza capitata</i>	Occasional
white sagebrush	<i>Artemisia ludoviciana</i>	Frequent	switchgrass	<i>Panicum virgatum</i>	Very Common
common milkweed	<i>Asclepias syriaca</i>	Frequent	wild quinine	<i>Parthenium integrifolium</i>	Frequent
butterfly milkweed	<i>Asclepias tuberosa</i>	Frequent	foxglove beardtongue	<i>Penstemon digitalis</i>	Sparse
whorled milkweed	<i>Asclepias verticillata</i>	Very Common	whorled mountainmint	<i>Pycnanthemum pilosum</i>	Frequent
Canadian milkvetch	<i>Astragalus canadensis</i>	Occasionalw	Virginia mountainmint	<i>Pycnanthemum virginianum</i>	Sparse
largeleaf wild indigo	<i>Baptisia lactea</i>	Occasional	pinnate prairie coneflower	<i>Ratibida pinnata</i>	Very Common
sideoats grama	<i>Bouteloua curtipendula</i>	Very Common	blackeyed Susan	<i>Rudbeckia hirta</i>	Frequent
false boneset	<i>Brickellia eupatorioides</i>	Frequent	sweet coneflower	<i>Rudbeckia subtomentosa</i>	Occasional
yellowfruit sedge	<i>Carex annectens</i>	Sparse	little bluestem	<i>Schizachyrium scoparium</i>	Frequent
shortbeak sedge	<i>Carex brevior</i>	Frequent	wholeleaf rosinweed	<i>Silphium integrifolium</i>	Occasional
troublesome sedge	<i>Carex molesta</i>	Sparse	compassplant	<i>Silphium laciniatum</i>	Occasional
New Jersey tea	<i>Ceanothus americanus</i>	Sparse	gray goldenrod	<i>Solidago nemoralis</i>	Sparse
partridge pea	<i>Chamaecrista fasciculata</i>	Sparse	stiff goldenrod	<i>Solidago rigida</i>	Occasional
stiff tickseed	<i>Coreopsis palmata</i>	Sparse	showy goldenrod	<i>Solidago speciosa</i>	Sparse
purple prairie clover	<i>Dalea purpurea</i>	Frequent	Indiangrass	<i>Sorghastrum nutans</i>	Very Common
showy ticktrefoil	<i>Desmodium canadense</i>	Very Common	composite dropseed	<i>Sporobolus compositus</i>	Very Common
Illinois ticktrefoil	<i>Desmodium illinoense</i>	Frequent	smooth blue aster	<i>Symphotrichum laeve</i>	Occasional
tall cinquefoil	<i>Drymocallis arguta</i>	Sparse	skyblue aster	<i>Symphotrichum oolentangiense</i>	Sparse
pale purple coneflower	<i>Echinacea pallida</i>	Frequent	longbract spiderwort	<i>Tradescantia bracteata</i>	Occasional
Canada wildrye	<i>Elymus canadensis</i>	Very Common	bluejacket	<i>Tradescantia ohiensis</i>	Occasional
button eryngo	<i>Eryngium yuccifolium</i>	Occasional	hoary verbena	<i>Verbena stricta</i>	Occasional
tall thoroughwort	<i>Eupatorium altissimum</i>	Occasional	prairie ironweed	<i>Vernonia fasciculata</i>	Occasional
flowering spurge	<i>Euphorbia corollata</i>	Sparse	golden zizia	<i>Zizia aurea</i>	Frequent
flat-top goldentop	<i>Euthamia graminifolia</i>	Sparse			
sawtooth sunflower	<i>Helianthus grosseserratus</i>	Occasional			

Cool Season Grass Enhancement Experiment Update

Our initial impressions about the importance of intense site preparation have been strengthened by a second year of data. Simply seeding native species into cool season grass stands, even when using a no-till drill, results in essentially no native establishment. Single applications of herbicide result in two year old stands that are more like control plots than 2x sprayed plots. The prediction that the low

initial seedling density would lead to stand failure is proving correct. Stands seeded after two herbicide applications, while more dominated by perennial weeds and with lesser native plant density than seedings planted into former cropland, still somewhat resemble diverse, functional prairie reconstruction at least in the second growing season.(Fig. 14).

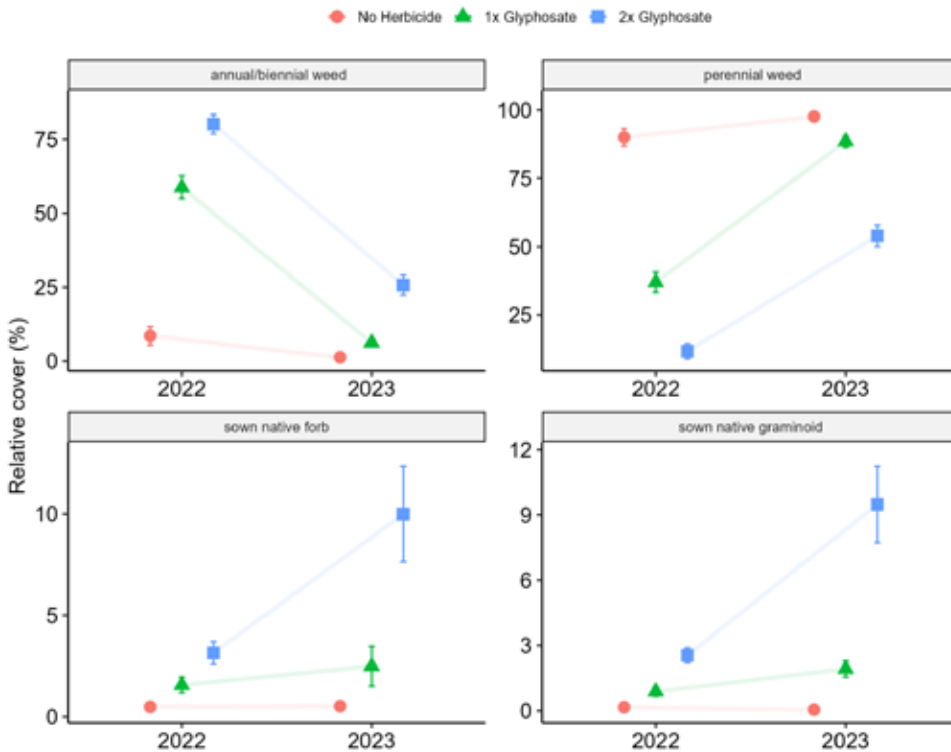


Figure 14: Canopy cover of sown grasses and forbs, perennial weeds, and ruderal (annual/biennial) weeds in plots treated with no herbicide, one application of glyphosate, or two applications of glyphosate.

MANAGEMENT IMPLICATIONS

Irvine Prairie continues to establish and progress well. Current site-preparation, seeding, and establishment management activities have resulted in success, though our assessment of new seeding techniques has been somewhat confounded by serious external environmental factors (wind/water erosion, extreme drought). To date, we have not needed to reseed any significant area of Irvine Prairie, though some areas seeded in 2022 may need intervention if establishment does not rapidly improve. The lowland areas of the 2022 seeding area, especially near the road and waterways are the most at risk, and we will continue to monitor this area closely.

Results from our waterway conversion experiment suggest some areas where we have attempted conversion to prairie from non-native cool season grass may need added management.

We are considering using grass selective herbicide (clethodim) on areas with limited success, especially early in the growing season when invasive cool season grasses are growing and when native warm season grasses are not.

Sweetclover monitoring and control will be important this year, especially in areas burned in 2022 (2019 planting areas). While some scattered patches may be controlled by pulling or spading, there are some areas that are very large and dense that will need to be mowed. Cutting stems close to the ground after leaves on the lower stems have died (before flowering occurs) through the early flowering period prior to seed formation has shown promise in Missouri to prevent resprouting.

Acknowledgments

We thank Lucas Pistek for field support in data collection and research plot management.

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