10 Year Comprehensive Report of McIntyre Holding and The Field Restoration Efforts at the Boardman Conservation Area: 2006-2016

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Abstract: The Nature Conservancy has restored over 500 acres of grassland on the Boardman Conservation Area near Boardman, Oregon. This report details the development of restoration on the property, the restoration and monitoring methods used, and the 10-year monitoring results from 2006-2016. Bluebunch wheatgrass was successfully established on most restoration sites, with observed density similar to that of reference grasslands. Establishing other native perennial grasses had less success. Several species of forbs were prioritized for planting due to their high survival and flowering rates, especially yarrow. Increases in native perennial cover did not appear to reduce cheatgrass cover, which remains the largest obstacle to successful restoration.

I. Background

(Adapted from Private Stewardship Grants Program final report 2009)

The 20.5 million acre Columbia Plateau Ecoregion was once dominated by shrub-steppe, lowland grasslands and Palouse prairie and covered most of eastern Washington, portions of Idaho, and 4.4 million acres of north-central Oregon (EPA 2016). By 2000, more than 85% of that area had been converted for agriculture or other uses (Kagan et al. 2000). The 22,642 acre Boardman Conservation Area, together with the adjacent 47,432 acre Naval Weapons Systems Training Facility, represents the largest remaining intact parcel of native Columbia Plateau habitat in Oregon (Figure 1).

The shrub-steppe and grassland habitats at the Boardman Conservation Area (BCA) have been identified as significant for conservation by The Nature Conservancy (1999), the Environmental Protection Agency (Kagan et al. 2000), the Northwest Power and Conservation Council (2004), and Audubon (2008). The Umatilla/Willow Creek Subbasin Plan (Northwest Power and Conservation Council 2004) lists the BCA as one of five critical areas that contain the highest quality remnants of low-elevation shrub-steppe habitat in the subbasin. The BCA was also identified as a Conservation Opportunity Area proposed for focused conservation investments in the Oregon Department of Fish and Wildlife's Comprehensive Wildlife Conservation Strategy (2005) because they contain some of the best remaining shrub-steppe and grassland habitat in the Columbia Plateau Ecoregion.

The Boardman Conservation Area (BCA) was established as part of litigation settlement over proposed water withdrawal from the Columbia River, and has been managed by The Nature Conservancy (TNC) since 2001 under a lease agreement with Threemile Canyon Farms. The U.S. Fish and Wildlife Service along with Threemile Canyon Farms, Portland General Electric, TNC, and the Oregon Department of Fish and Wildlife have entered into a Multi-Species Candidate Conservation Agreement with Assurances to protect habitat for the Washington ground squirrel, ferruginous hawk, loggerhead shrike, and sage sparrow on private lands owned by Threemile Canyon Farms, including the BCA, and Portland General Electric (DEA, Inc. 2003). The purpose of the Agreement is to facilitate implementation a variety of conservation measures to benefit conservation of the covered species at the site.

Restoring and preventing further degradation of shrub-steppe and grasslands is identified as a key strategy in the Oregon Conservation Strategy (ODFW 2005) and the Mainstem Columbia and Umatilla Subbasin Plans (Northwest Power and Conservation Council 2001, 2004). Among the greatest threats to the BCA and other shrub-steppe and grassland habitats are introduced plant species because they replace native vegetation and degrade wildlife habitat. Additionally, introduced species create a more continuous fuel bed that facilitates frequent large, severe wildfires. Severe wildfires in shrub-steppe ecosystems further degrade native vegetation, creating a cycle that is impossible to reverse without active restoration. Restoration strategies for these critical areas include enhancing and maintaining habitat by reducing introduced species and seeding areas where native grasses and herbaceous plants are absent.

II. Description of Study Area

(Adapted from Private Stewardship Grants Program final report 2009)

The BCA, located in Morrow County, is ten miles east-to-west and seven miles north-to-south (Figure 1). The southern portion consists largely of deep loess-derived soils and supports shrub-steppe dominated by big sagebrush (*Artemisia tridentata* ssp. *tridentata*) and perennial grasslands dominated by bluebunch wheatgrass (*Pseudoroegneria spicata* spp. *spicata*) and Sandberg's bluegrass (*Poa secunda* ssp. *secunda*). The northern portion consists of sandy fluvial deposits and eolian dunes and supports shrub-steppe dominated by big sagebrush and antelope bitterbrush (*Purshia tridentata*) and perennial grasslands dominated by needle-and-thread grass (*Hesperostipa comata*) and Sandberg's bluegrass. Historically, extensive cryptobiotic crust composed of algae, cyanobacteria, moss, and lichen dominated interstitial spaces between bunchgrasses and shrubs, especially in the southern habitat types.

Although the BCA contains some of the highest quality habitat in the Columbia Plateau Ecoregion, portions of the property have been degraded as a result of the invasion of non-native plant species and cattle grazing. Historic records from the area identify introduced species as early as 1902 (Northwest Power and Conservation Council 2004) and 39 of the 142 plant species listed for the BCA are introduced. Historically the BCA was grazed by cattle which continued until 2005. Soil disturbance, damaged cryptobiotic crusts, and increased bare ground around stock handling and watering sites facilitated colonization by cheatgrass (*Bromus tectorum*) and other invasive species. Once established these species can spread into and degrade adjacent high quality grasslands.

III. Methods

Restoration history

(Adapted from Private Stewardship Grants Program final report 2009)

In 2001, approximately 20 acres of grassland habitat in McIntyre Holding invaded by the introduced annual grass medusahead rye (*Taeniatherum caput-medusae*) was treated with herbicide. Because medusahead tends to form monocultures, its elimination allowed further invasion by other introduced plant species, in particular Russian thistle (*Salsola kali*) and kochia (*Kochia scoparia*). In order to rehabilitate the chemically treated area, and develop methods to restore larger areas of degraded grasslands and shrub-steppe on the BCA, the first grassland restoration project on the site was initiated in 2005 (Figure 1).

Vegetation maps created in 2002 characterized the ecological condition of the plant communities on the BCA based on the abundance of cheatgrass and other nonnative plant species (see: in Plant Communities of the Boardman Study Area, Elseroad 2002). The McIntyre medusahead site was mapped as among the most severely degraded restoration sites and was located immediately west of a large parcel of high-quality grassland (Figure 2). The site was also adjacent to the road, which made the results of the 2001 herbicide spray highly visible but offered easy access for restoration and future demonstration. The confluence of these factors prioritized McIntyre Holding for the first BCA restoration project. The initial 56 acres of restoration (later designated McIntyre 1) was funded with a grant from U.S. Fish and Wildlife.

Restoration began with a prescribed burn on McIntyre 1 in April, 2005. Unfortunately, the fuels were too wet to adequately carry the fire and only 10 of the 54 acres were burned (Carlson 2007). Additionally, post-burn reconnaissance revealed a much more severe infestation of introduced species. Prescribed burning was replaced with multiple glyphosate sprays to better address the scope and scale of introduced species and avoid the difficulties of planning and conducting a prescribed burn. McIntyre 1 was seeded with native perennial grasses in December 2006 using an ageing Laird seed drill borrowed from Oregon Fish and Wildlife. The disrepair of the drill severely impacted the efficacy and consistency of seeding, and in 2008 TNC purchased a new Truax seed-drill (Carlson 2007).

In 2007, TNC developed a site restoration plan that identified priority restoration sites on the BCA, outlined restoration approaches for each site, and identified funding and infrastructure needs for accomplishing restoration at a meaningful scale at Boardman (see: Boardman Conservation Area Restoration Plan, Elseroad 2007). In 2008, TNC developed a Wildlife Habitat Incentive Program agreement with the Natural Resources Conservation Service for restoration on an additional 450 acres over five years. Between 2008 and 2012, TNC conducted five more phases of restoration in the pastures surrounding McIntyre 1 (designated McIntyre 2, 3 and 4 and The Field 1 and 2) (Figure 2). For complete details, see Boardman Conservation Area Restoration Plan (Elseroad 2007).

In fall of 2008, a portion of McIntyre 2 was initially sprayed with imazapic, an annual-specific herbicide. By the next summer the area sprayed with imazapic was densely covered in Russian thistle and other warm-season annuals that were unaffected by the winter application. The site needed to be mowed before forbs could be planted in fall of 2009. Due to the additional work required to manage Russian thistle, imazapic treatments were discontinued (Carlson 2009). Glyphosate levels were adjusted between 16 oz./acre and 30 oz./acre depending on the condition of the site. At 30 oz./acre, glyphosate greatly reduced existing native cover, hampering restoration (Carlson 2010).

The finalized restoration treatments at each site consisted of reducing non-native annual plant cover with an herbicide (glyphosate) in winter, drill seeding with native grasses the same winter/spring as the herbicide spray, and hand planting native forb and grass plugs, typically one year after grass seeding. A timeline summarizing the treatments implemented at each site is provided in Appendix A and B. The composition of the grass seed mixture and the forb plugs depended on the availability of the plant materials and was slightly different at each site (see Appendix D, F). The two-part restoration objective was 1.) to increase native perennial vegetation to more than 50% of total plant cover and 2.) to reduced introduced vegetation to less than 50% of total plant cover.

Monitoring methods

The drill seeded grass plantings were monitored in 100m x 100m plots at each restoration site. Two plots were established in McIntyre Holding-1; two plots were established in McIntyre Holding-2, one in each of two herbicide treatments (glyphosate and imazapic); and one plot each was established in McIntyre Holding-3, McIntyre Holding-4, The Field 1, and the Field 2 (Figure 2). Within each plot, 1m^2 quadrats were sampled. From 2006-2008, 25 1m^2 quadrats were sampled, but the number of quadrats sampled was reduced to 20 in subsequent years. Data collected within each quadrat included the percent cover of each plant species, litter, and bare ground, and the number of individuals for each grass species that was seeded. Cover data were not continuous, but instead each observation was assigned the midpoint of a corresponding cover category (Table 1), these were then averaged across quadrats to calculate plot means. Data were collected the spring prior to grass seeding (pretreatment) and at one, two, three, five, and ten years post-seeding (see Appendix C).

Forb and grass plug survival was monitored in randomly selected planting locations. Planting locations were selected prior to planting, and at each location, 5-10 individuals were planted and marked with blue pin flags. The intent was to monitor a minimum of 50 individuals per species. However, because the wrong species was inadvertently planted at some monitoring locations, and for some species less than 50 individual plants were planted, the actual number of individuals monitored ranged from 10 to 250. At each monitoring location, data collected included the number of live plants and the number of plants in flower. Forb monitoring data were collected at one, two, and three years post planting (see Appendix C).

In this report, herbicide treatment effectiveness was analyzed by comparing pretreatment and five-year posttreatment mean cover estimates of cheatgrass (*Bromus tectorum)* (ten-year posttreatment data was used for McIntyre 1, and three-year posttreatment data was used for The Field 2 plots). Means were compared by Wilcoxon's signed-rank tests (α=0.10) using JMP 11.2.1 statistical software (SAS 2013). The success of grass seeding was assessed by comparing pretreatment and five-year posttreatment (ten-year posttreatment data was used for McIntyre 1, and three-year posttreatment data was used for The Field 2 plots) mean cover for each of three native perennial grasses species: Bluebunch wheatgrass (*Pseudoroegneria spicata* subsp. *spicata),* Sandberg's bluegrass (*Poa secunda* subsp. *secunda*)*,* and squirreltail (*Elymus elymoides*) using the same methods as the herbicide treatments.

Table 1. Cover class designations. Each observation of cover was assigned the midpoint of the range for its respective class.

Cover class	Percent cover range	Midpoint
1	0.1	0.1
2	0.25	0.25
3	0.5	0.5
4	1	1
5	2	2
6	3	3
7	4	4

Cover class	Percent cover range	Midpoint
8	5	5
9	6-10	8
10	11-25	18
11	26-50	38
12	51-75	63
13	76-95	85.5
14	96-100	98

Figure 1. Location of the Boardman Conservation Area and Columbia Plateau Ecoregion.

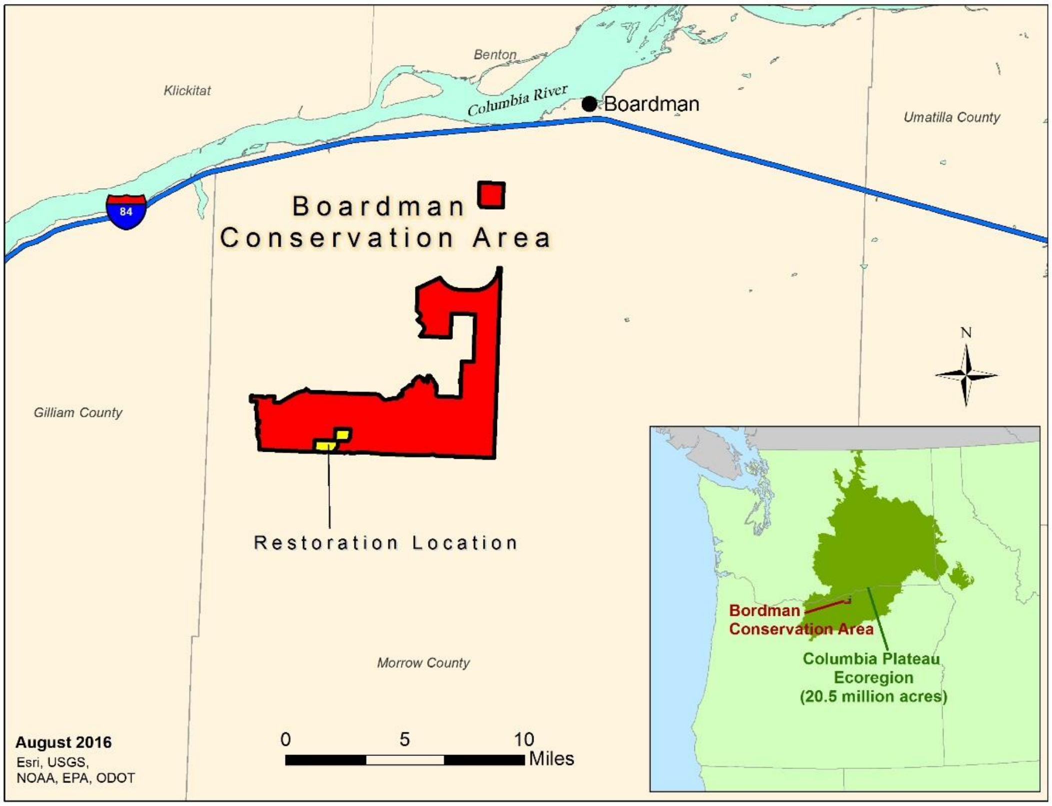
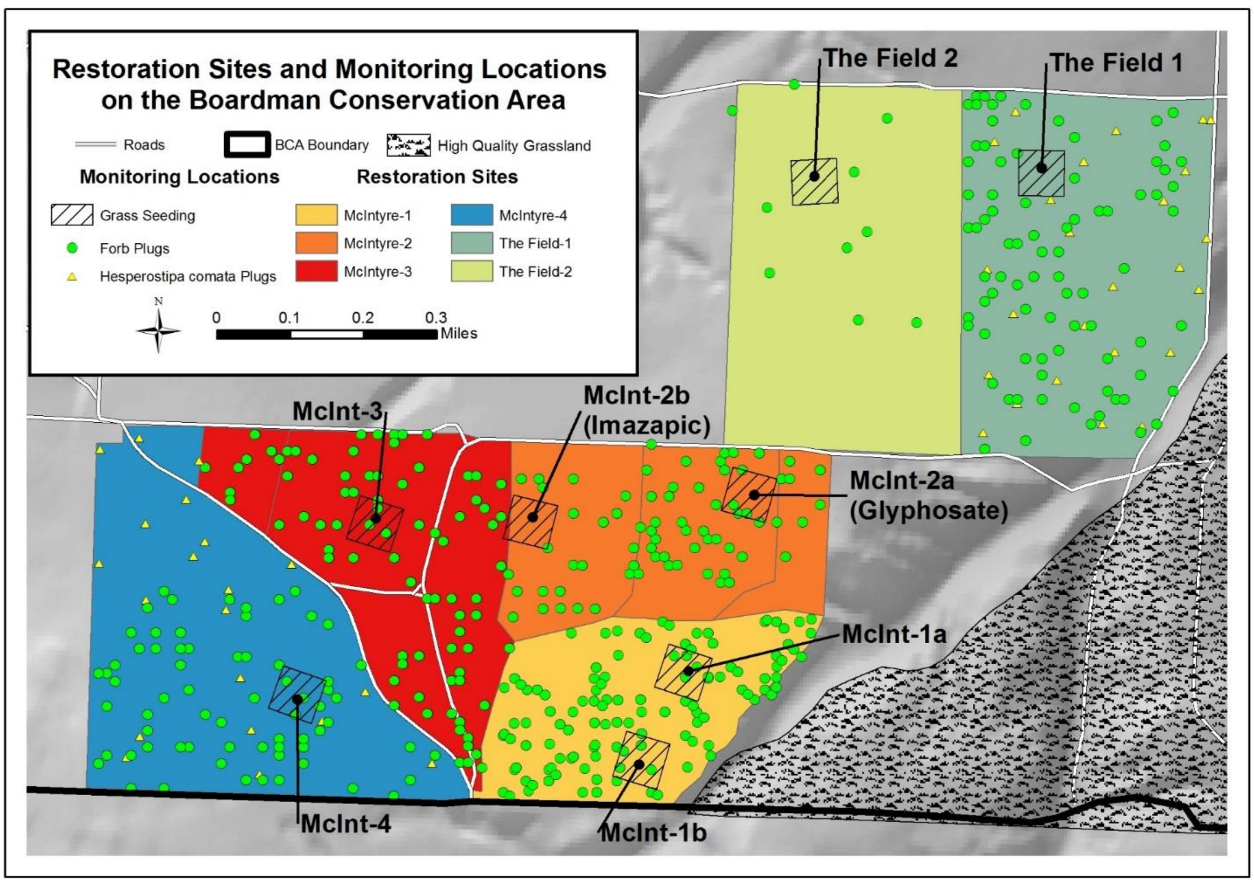


Figure 2. Map of restoration sites and monitoring locations on the Boardman Conservation Area.



Results and Discussion

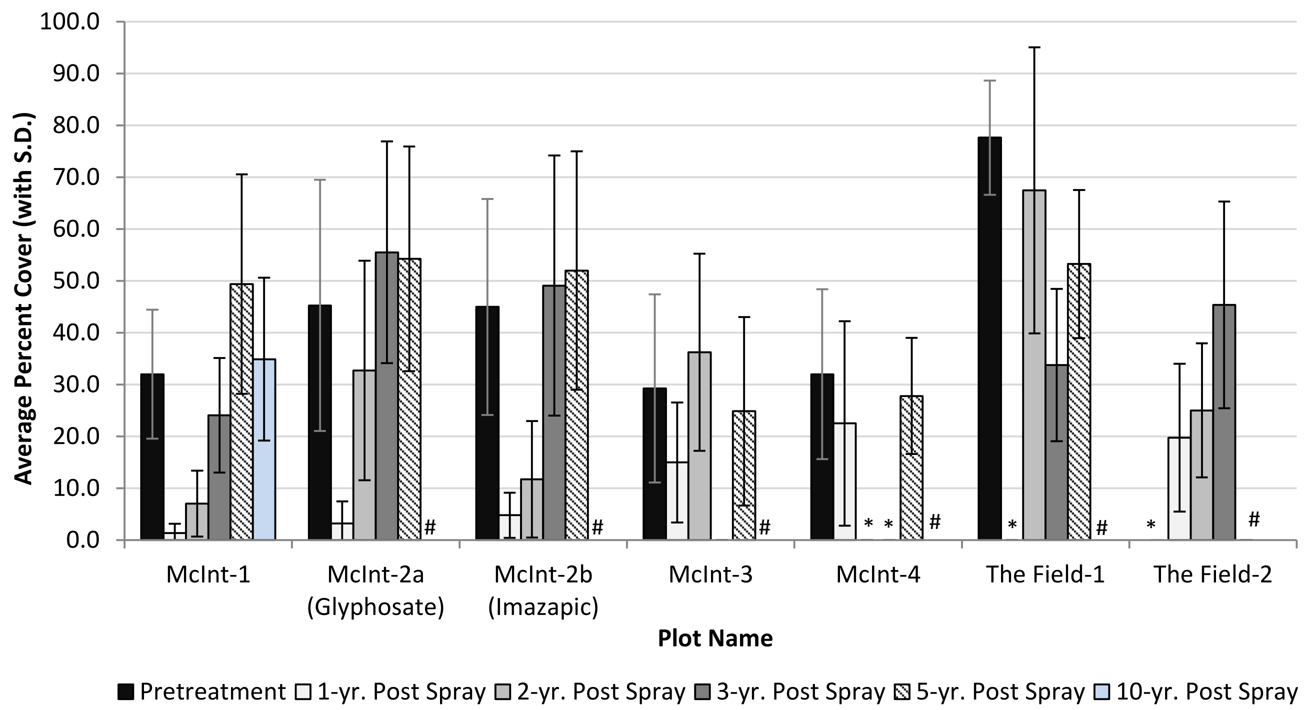
Herbicide treatments

Herbicide treatments appeared to reduce cheatgrass cover one growing season following treatment, though the effect was large on only three of five plots. Cheatgrass cover was reduced on McIntyre 1 from 32.0% to 1.4%, on McIntyre 2 (glyphosate) from 45.3% to 3.2%, and on McIntyre 2 (imazapic) from 45.0% to 4.8%. The decreases were smaller on McIntyre 3 (from 29.3% to 15.0%) and McIntyre 4 (from 41.5% to 32.0%) (Figure 3, Table 2). First year reductions in cheatgrass cover could not be calculated for the Field 1 and 2 due to lack of monitoring data. On all McIntyre holding plots cheatgrass cover was near pretreatment levels within 3 years, except McIntyre 4 which lacks data (Figure 3). After five years of monitoring cheatgrass cover decreased significantly on The Field 1 from 77.6% to 33.8% (χ^2=20.8474, p<0.0001). Change in cheatgrass cover was not calculated for The Field 2 due to lack of monitoring pretreatment data.

Herbicide applications were intended to reduce the initial competition experienced by native grasses following seeding. As expected, initial herbicide sprays controlled cheatgrass for one year with little or no longer-term effects on coverage, except on The Field 1, where initial cheatgrass cover was notably high. For each site, in the most recent monitoring cheatgrass was an equal or larger proportion of total plant cover compared to pretreatment levels (Figure 4). Because cheatgrass makes up the vast majority of all introduced cover, reducing cheatgrass is essential to meeting the primary objective of reduced introduced vegetation cover.

An unintended consequence of reducing cheatgrass cover was a temporary increase in the abundance of introduced annual forbs in some restoration sites (Figure 5). In McIntyre 1 and in the portion of McIntyre 2 sprayed with glyphosate, increases were driven by red-stem filaree (*Erodium cicutarium*), while in the portion of McIntyre 2 sprayed with imazapic, the increases were driven by prickly lettuce (*Lactuca serriola*) and Russian thistle (*Salsola kali*). The dead Russian thistle plants in McIntyre 2 created a dense stand of tall, prickly litter that required mowing to allow access for weed control and forb planting. On all sites, cover of introduced annual forbs decreased to under 5% within 5 years (10 for McIntyre 1) suggesting that introduced annual forbs are only a temporary restoration issue. Additionally, after 5 years, there are no discernable differences in the effects of glyphosate and imazapic on cheatgrass cover in McIntyre 2.

Figure 3. *Bromus tectorum* cover in McIntyre Holding restoration sites pre- and post-herbicide application (values are means ± 1 S.D.).



*Data not collected; # Future Monitoring

Table 2. Results of Wilcoxon's signed-rank tests (α=0.1) on cover of *B. tectorum* in BCA restoration plots. Included are means and standard deviations for each compared year, test statistic, sample size, p-value. **Bold text** highlights significant results.

Plot	Years Compared	$\overline{x}_1$	s_1	$\overline{x}_2$	s_2	n	χ^2	p
McIntyre 1	0 & 10	32.0	12.4	34.9	*15.7*	50, 40	0.3713	.5423
McIntyre 2 (G)	0 & 5	45.3	24.2	54.3	21.7	20, 20	1.3074	0.2529
McIntyre 2 (I)	0 & 5	45.0	20.8	52.0	23.0	19, 20	0.8323	0.3616
McIntyre 3	0 & 5	29.3	18.1	24.9	18.2	20, 20	0.9681	0.3252
McIntyre 4	0 & 5	41.5	16.4	27.8	11.2	20, 25	0.1542	0.6946
The Field 1	0 & 5	77.6	11.0	33.8	14.7	20, 20	**20.8474**	**<0.0001**
The Field 2[1]	1 & 3	19.8	14.3	45.4	20.0	20, 20	-	-

Notes: McIntyre 2 was divided between glyphosate (G) and imazapic (I) herbicide treatments.
[1]The Field 2 had no test performed because no pretreatment data was collected.

Figure 4. Average percent of total plant cover by category and year for each restoration site. Categories include cheatgrass - *Bromus tectorum* (BRTE), other introduced cover, native perennial cover, and other native cover.

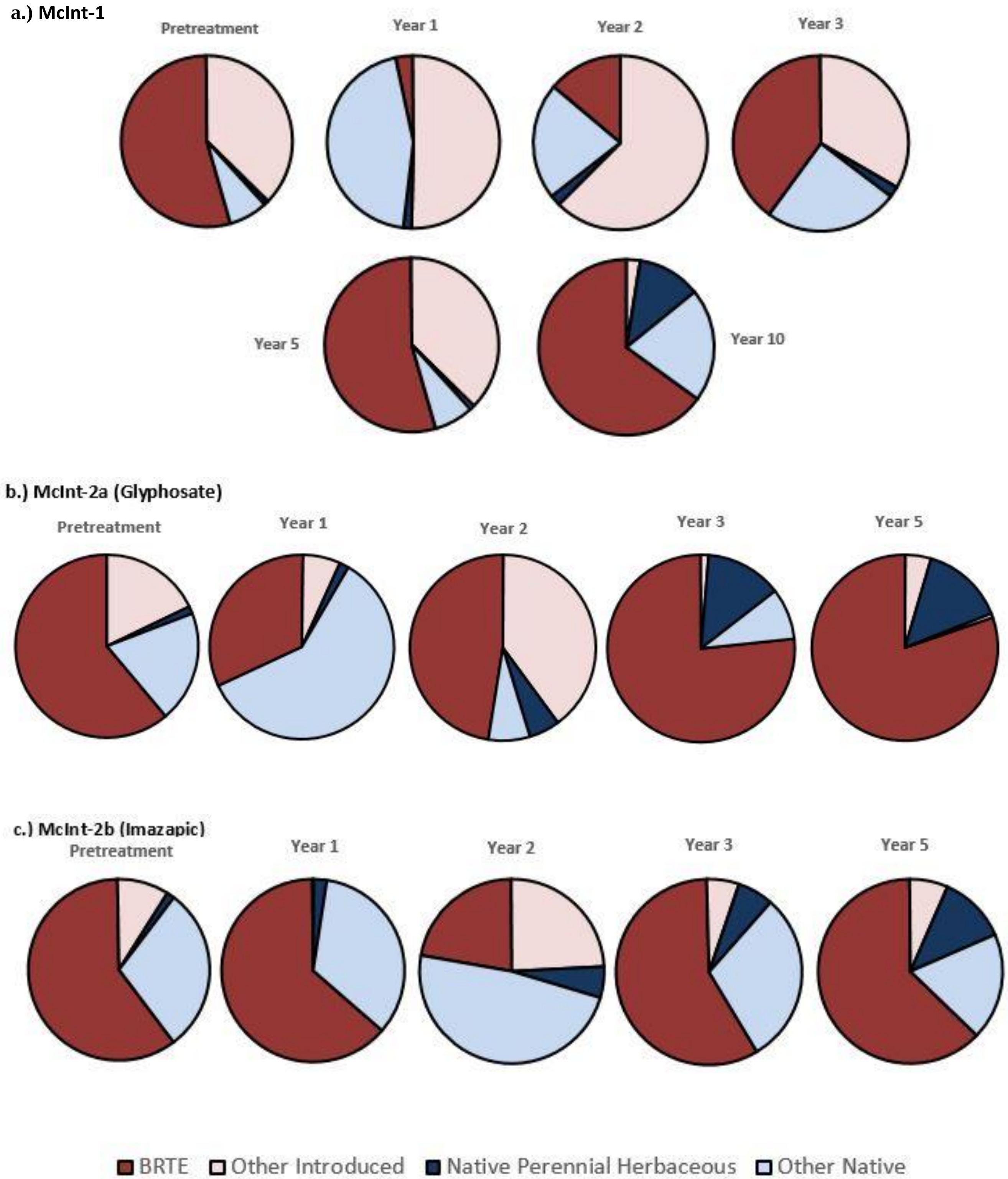


Figure 4. Continued Average percent of total plant cover by category and year for each restoration site. Categories include cheatgrass - *Bromus tectorum* (BRTE), other introduced cover, native perennial cover, and other native cover.

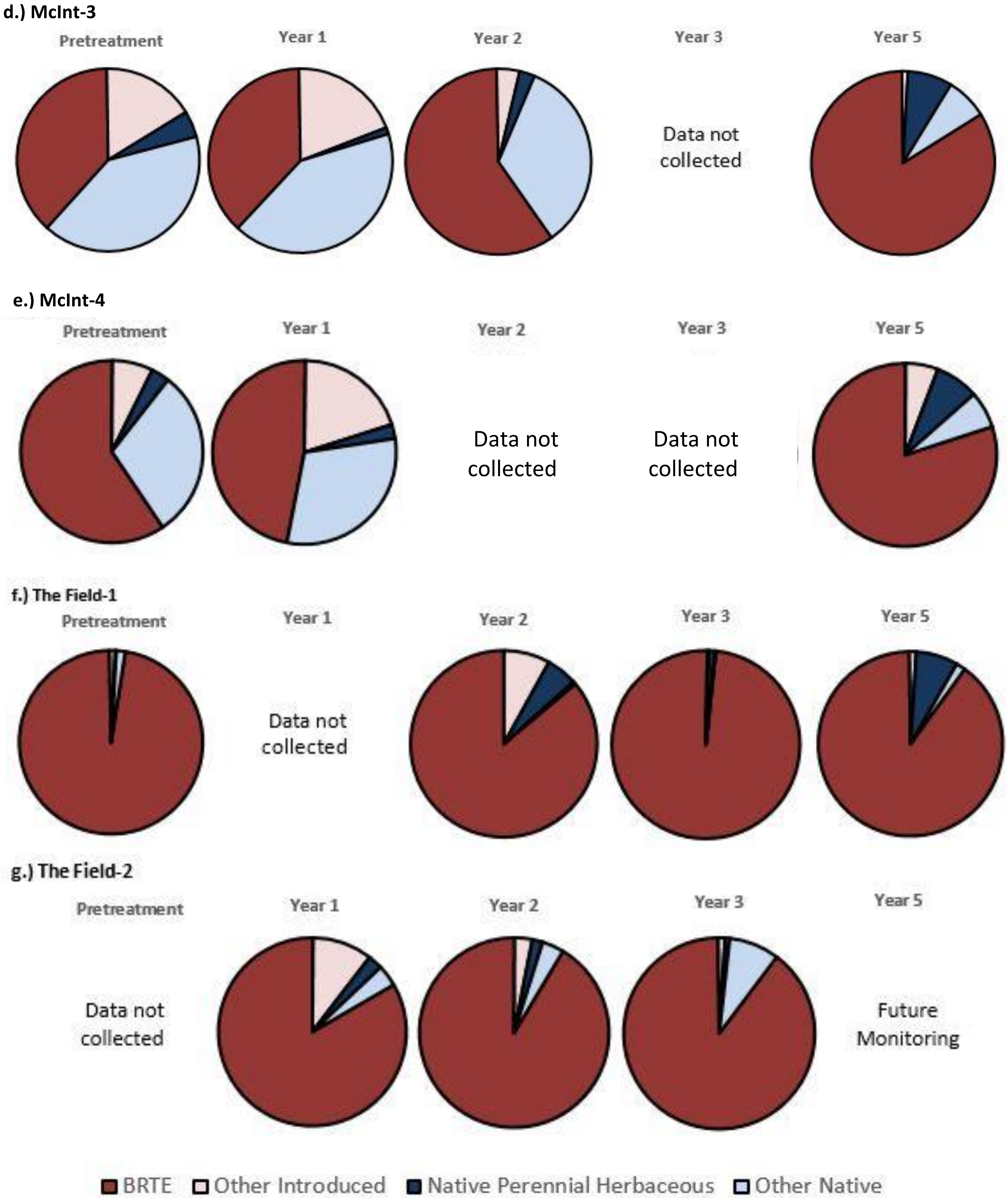
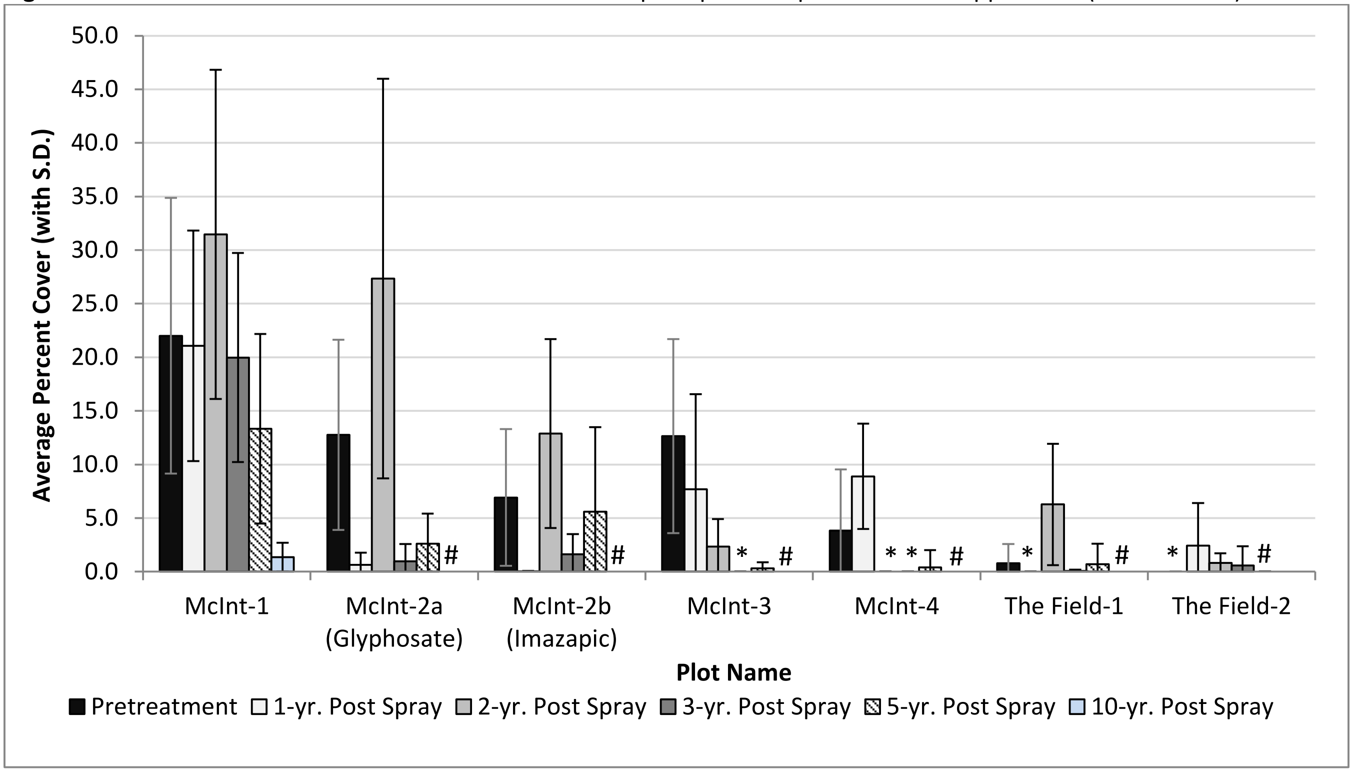


Figure 5. Introduced annual forb cover on BCA restoration plots pre- and post-herbicide application (means ± S.D.).



*Data not collected; # Future Monitoring

Grass seeding

Restoration efforts appear to have increased cover of native perennial grasses, most notably of bluebunch wheatgrass. Density of bluebunch wheatgrass on most restoration plots approximates observed densities on high-quality reference grasslands (Figure 6). All plots had significant increases in bluebunch wheatgrass cover between pretreatment and the most recent monitoring data (The Field 2 was not tested due to the lack of pretreatment data) (Figure 7, Table 3). After five years, cover of bluebunch wheatgrass was greatest on the two McIntyre 2 plots, though variation was high; cover was 9.1 ±8.0% and 4.9 ±5.4% for the glyphosate and imazapic plots respectively (Table 3). Anecdotally, obvious rows of planted bluebunch wheatgrass are common on McIntyre 2 and McIntyre 3 treatments, though they appear less common on other sites.

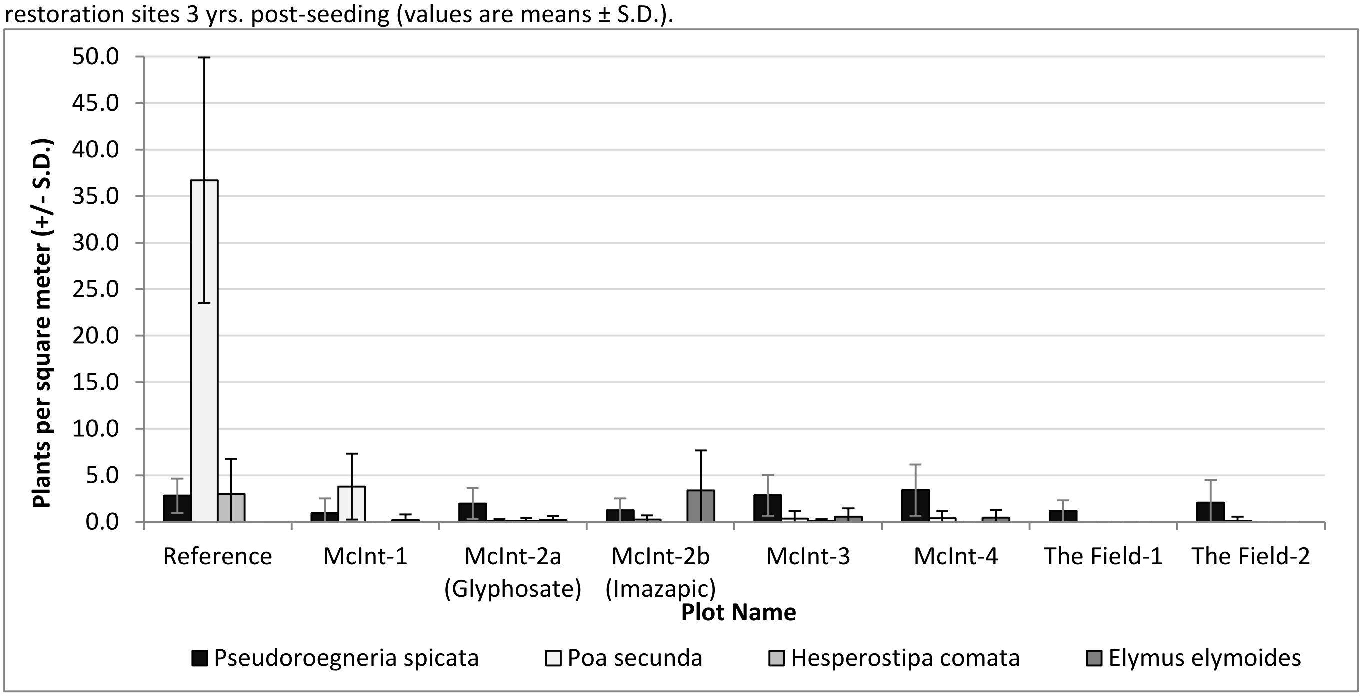
Efforts to increase cover of Sandberg's bluegrass do not appear as successful. After ten years, one McIntyre 1 Sandberg's bluegrass cover significantly increased from 0.2% to 1.7% (χ^2=52.2782, p=<0.0001). Sandberg's bluegrass cover also increased significantly after five years on McIntyre 2 (imazapic) χ^2=6.5080, p=0.0107 respectively) though actual cover values remained well under 1% and are unlikely to be ecologically meaningful (Table 2). Two other plots with initially high cover of Sandberg's bluegrass, McIntyre 3 and 4, had the species almost completely disappear after five years (Figure 6). Sandberg's bluegrass is among the earliest emerging species, and existing plants may have suffered from winter herbicide applications. This issue was addressed in the herbicide application timing for the McIntyre 4 treatment, though in that plot cover of Sandberg's bluegrass still decreased.

The timing of mid-spring monitoring may be too late to accurately capture Sandberg's bluegrass cover if plants are already senesced. Currently, plant densities on plots are extremely low compared to healthy reference grasslands (Figure 6). Sandberg's bluegrass is a smaller and shorter-lived species than Bluebunch wheatgrass and typically occurs at much higher densities on healthy grasslands where it may be important for outcompeting cheatgrass in between bluebunch wheatgrass plants. Successful restoration could depend as much on increasing Sandberg's bluegrass cover as much as it does bluebunch wheatgrass cover.

Results for cover for squirreltail were mixed. Cover of squirreltail increased significantly on McIntyre 2 (imazapic) (χ^2=18.9880, p<0.0001) and McIntyre 4 (χ^2=3.4275, p=0.0641) (Table 3). However, only McIntyre 2 (imazapic) had ecologically meaningful cover but with high variation at 4.8 ±5.3%. Observed squirreltail cover was near-zero on all other plots (Figure 6).

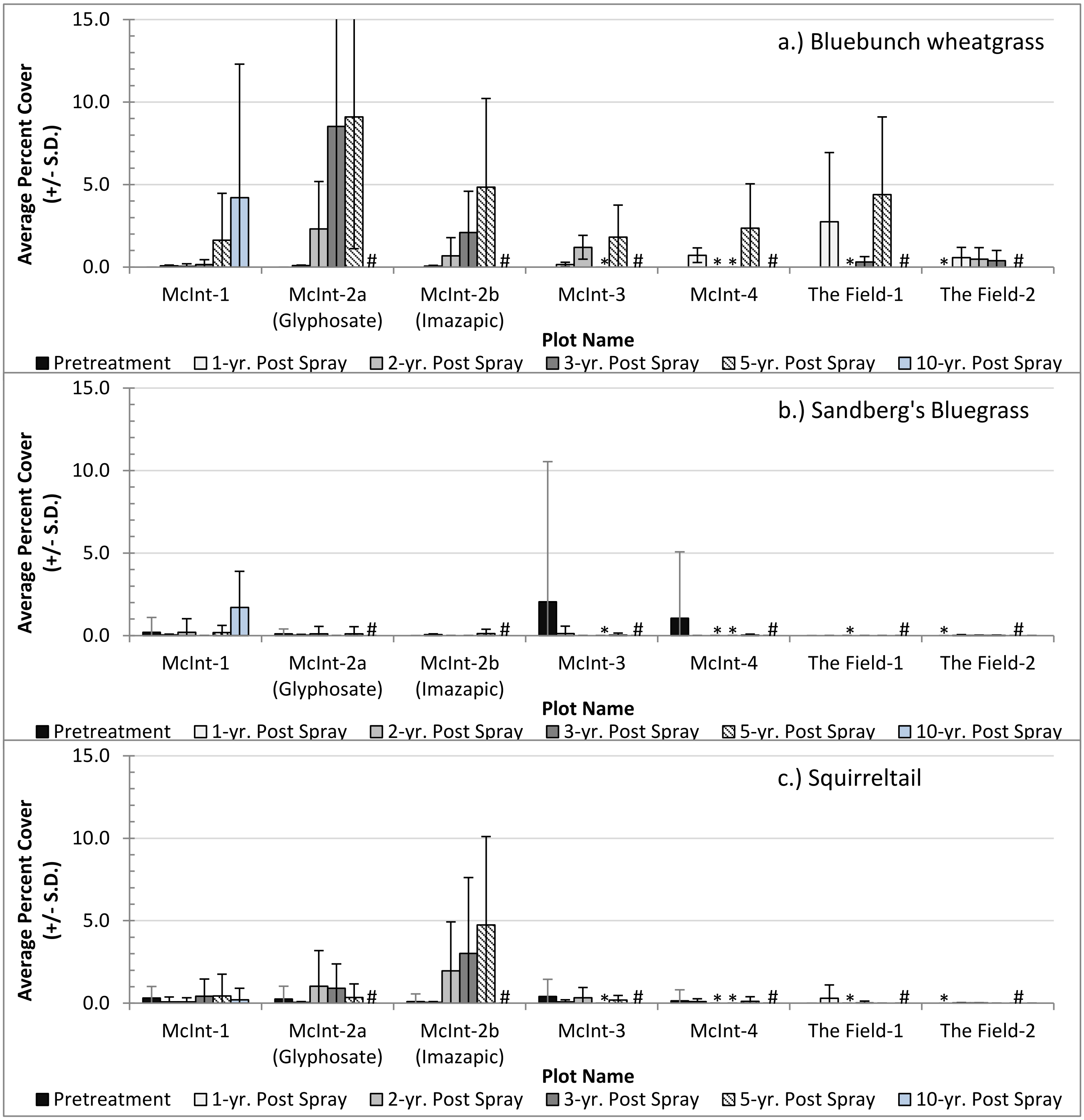
Needle-and-thread grass, a fourth native perennial bunchgrass, was seeded in McIntyre-1, McIntyre 2 (glyphosate) and McIntyre 3, but early monitoring should almost no recruitment. In response, approximately 5,000 plugs of this species were planted in both McIntyre Holding-4 in November 2010 and in The Field 1 in January 2012 instead of seeding. Eighty-three percent of the plugs survived in the first year, which is high, but resulted in plant densities of only 0.01 plants/m^2 (40 plants/acre), within the range of 0-0.05 plants/m^2 established in previous years via seeding at 0.5-2.5 lbs/acre. Three years after planting, 45% and 62% of plants were alive on McIntyre 4 and The Field respectively. The cost of planting 5,000 plugs ($8,500 total, or $1.70/plug) is equivalent to seeding 1.1 lbs PLS/acre at the current price of $75/lb of seed. Therefore, depending on long-term survival rates of both plugs and seeded plants, plug planting may not be a more cost-effective successful approach than seeding. However, the limited availability of seed in some years may make plug planting the only option for establishing needle-and-thread grass in restoration sites.

Figure 6. Comparison of reference grassland* selected native perennial grass seedling densities to McIntyre Holding restoration sites 3 yrs. post-seeding (values are means ± S.D.).



*see Elseroad (2008a) for methods used to estimate reference grassland densities

Figure 7. Observed cover of three native perennial grass species (a. bluebunch wheatgrass, b. Sandberg's bluegrass, and c. squirreltail) on BCA restoration plots for all monitored years (means ± S.D.).



Note: Squirreltail was not seeded on McIntyre 1. Y-axis maximum is 15% cover.

* Data not collected; #Future monitoring

Table 3. Results of Wilcoxon's ranked-sum tests (α=0.10) on cover of the native perennial grasses bluebunch wheatgrass - *Pseudoroegneria spicata* (PSSP), Sandberg's bluegrass - *Poa secunda* (POSE), and squirreltail - *Elymus elymoides* (ELEL) in BCA restoration plots. Included are means and standard deviations for each compared year, test statistic, sample size, and p-value. **Bold text** highlights significant results.

Plot	Years Compared	Species	$\overline{x}_1$	s_1	$\overline{x}_2$	s_2	χ^2	n	p
McIntyre 1	0 & 10	**PSSP**	*nil*	*nil*	4.2	8.1	23.7619	50, 40	**<0.0001**
		POSE	0.2	0.9	1.7	2.2	52.2782		**<0.0001**
		ELEL[1]	0.3	0.7	0.2	0.7	1.1695		0.2795
McIntyre 2 (G)	0 & 5	**PSSP**	*nil*	*nil*	9.1	8.0	20.0105	20, 20	**<0.0001**
		POSE	0.1	0.3	0.1	0.4	0.2842		0.5940
		ELEL	0.3	0.8	0.4	0.8	0.6146		0.4331
McIntyre 2 (I)	0 & 5	**PSSP**	*nil*	*nil*	4.9	5.4	20.9426	19, 20	**<0.0001**
		POSE	*nil*	*nil*	0.1	0.3	6.5080		**0.0107**
		ELEL	0.1	0.5	4.8	5.3	18.9880		**<0.0001**
McIntyre 3	0 & 5	**PSSP**	*nil*	*nil*	1.8	1.9	26.2025	20, 20	**<0.0001**
		POSE	2.1	8.5	<0.1	0.1	0.1086		0.7417
		ELEL	0.4	1.0	0.2	0.3	0.6272		0.4284
McIntyre 4	0 & 5	**PSSP**	*nil*	*nil*	2.4	2.7	25.2511	20, 25	**<0.0001**
		POSE	1.1	4.0	<0.1	0.1	0.0022		0.9624
		ELEL	0.2	0.7	0.1	0.3	3.4275		**0.0641**
The Field 1	0 & 5	**PSSP**	*nil*	*nil*	4.4	4.7	17.9493	20, 20	**<0.0001**
		POSE	*nil*	*nil*	*nil*	*nil*	-		-
		ELEL	*nil*	*nil*	*nil*	*nil*	-		-
The Field 2[2]	0 & 3	PSSP	-	-	0.4	0.6	-	20, 20	-
		POSE	-	-	*nil*	*nil*	-		-
		ELEL	-	-	*nil*	*nil*	-		-

Notes: For clarity, zero values are recorded as *nil;* values greater than zero but less than 0.1 are recorded as <0.1.

[1]Squirreltail was not seeded on McIntyre 1.

[2]Because The Field 2 had no pretreatment data collected no test was performed

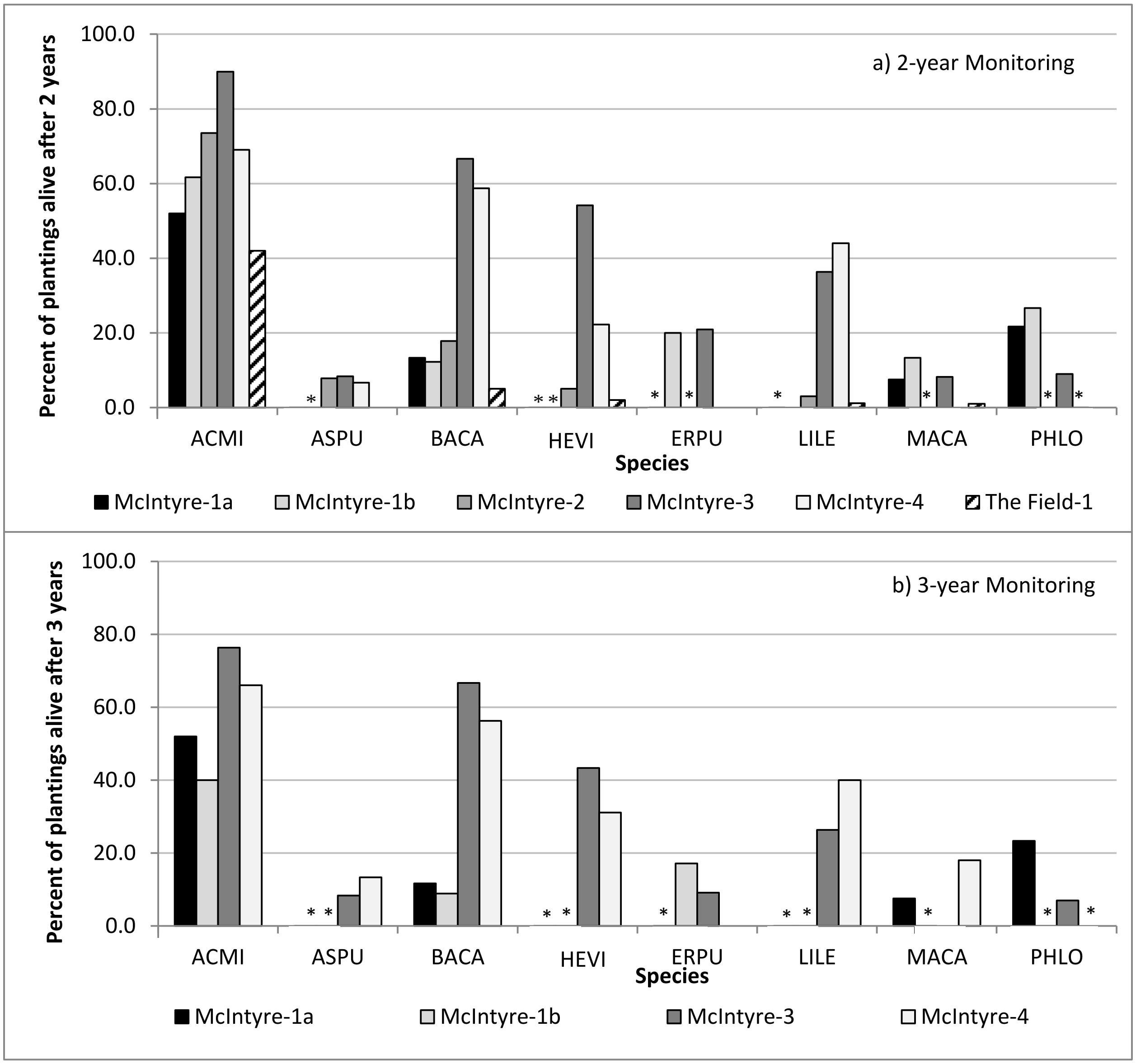
Forb planting

Survival of monitored planted forbs varied considerably between species. Survival of yarrow (*Achillea millefolium*) was between 42-90% of plants two years post planting and between 40-76% of plants three years post planting (Figure 8). Other species with survival rates of at least 40% on at least one restoration area three years post planting include Carey's balsamroot (*Balsamorhiza careyana*), hairy golden aster (*Heterotheca villosa*), and Lewis's flax (*Linum lewisii*). Of these four species, yarrow was most consistently in flower, with between 46-95% of living plants in flower 2 years post planting, and between 50-83% of living plants in flower 3 years post planting (Figure 9). Lewis's flax also maintained a high proportion of living plants in flower both two and three years post planting.

Monitoring results strongly suggest that yarrow is a consistently high-performing species for both long-term survival and flowering. Because yarrow produces abundant, easily collected seed, it may be more cost-effective to mostly or exclusively target this species in future forb plantings. Previous site-specific seeding trials demonstrated that yarrow can be effectively established from seed (Elseroad 2011b); inclusion of yarrow seed with native grass seed when range drilling should be considered in addition to or as an alternative to future forb planting.

While current restoration objectives for BCA restoration do not specifically address forb cover (see below), forbs are an important component of grassland structure and diversity. Setting specific density and cover objectives for forbs would help guide species selection and appropriate planting methods for future restoration efforts.

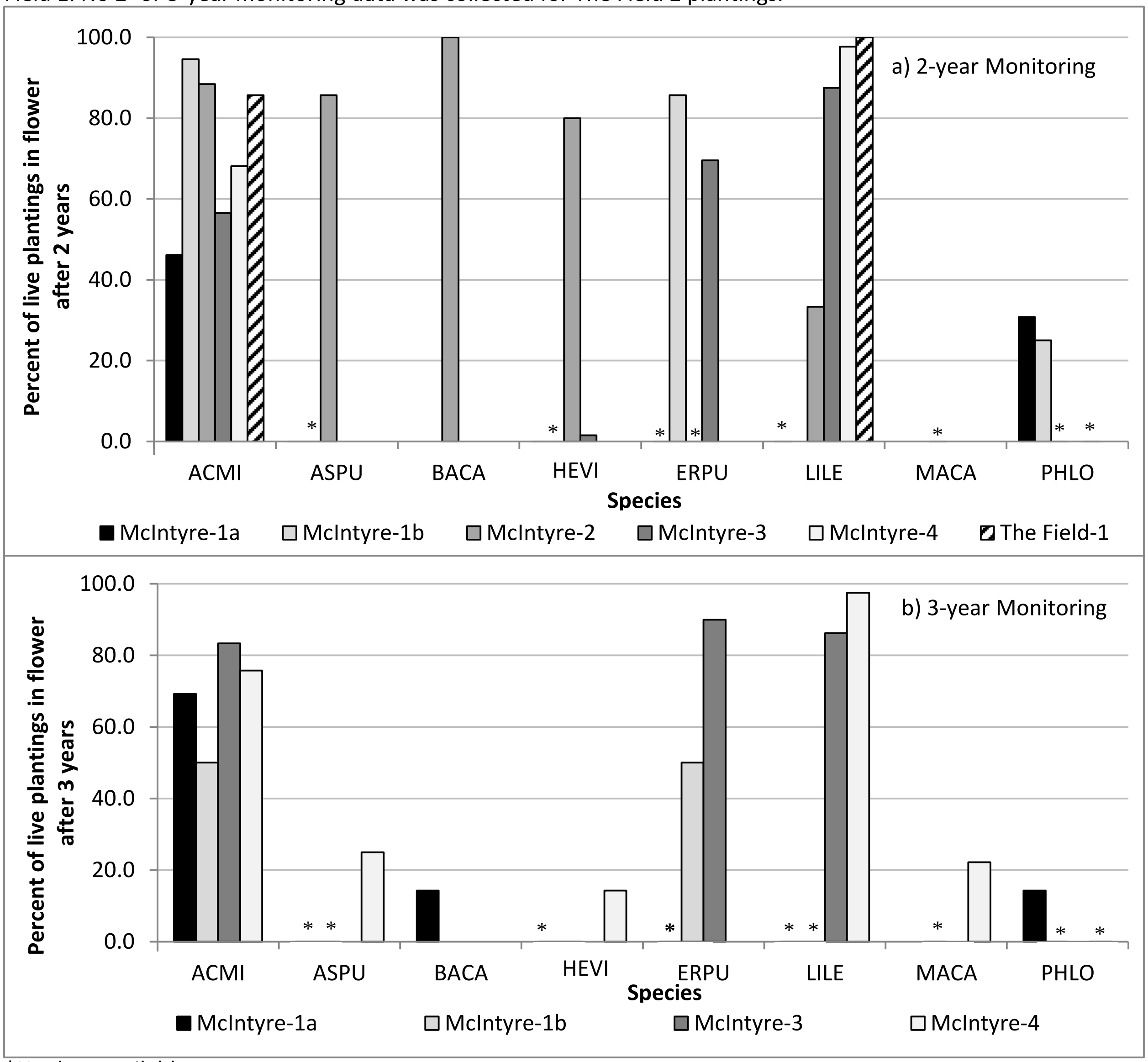
Figure 8. Percentage of monitored planted forbs alive after a) 2 years and b) 3 years by BCA restoration area. Only species with living plants on three or more areas were included. McIntyre 1 had two separate forb plantings called McIntryre-1a (2007) and McIntyre-1b (2009). No 3-year data was collected for McIntyre 2 and The Field 1. No 2- or 3-year monitoring data was collected for The Field 2 plantings.



*No data available.

Species include yarrow - *Achillea millefolium* (ACMI), woolypod milkvetch - *Astragalus purshii* (ASPU), Carey's balsamroot - *Balsamorhiza careyana* (BACA), hairy golden aster - *Heterotheca villosa* (HEVI), shaggy daisy - *Erigeron pumilis* (ERPU), Lewis's flax - *Linum lewisii* (LILE), hoary tansyaster - *Machaeranthera canescens* (MACA), and longleaf phlox - *Phlox longifolia* (PHLO).

Figure 9. Percentage of living monitored planted forbs in flower after a) 2 years and b) 3 years by BCA restoration area. Only species with living plants on three or more areas were included. McIntyre 1 had two separate forb plantings called McIntryre-1a (2007) and McIntyre-1b (2009). No 3-year data was collected for McIntyre 2 and The Field 1. No 2- or 3-year monitoring data was collected for The Field 2 plantings.



*No data available.

Species include yarrow - *Achillea millefolium* (ACMI), woolypod milkvetch - *Astragalus purshii* (ASPU), Carey's balsamroot - *Balsamorhiza careyana* (BACA), hairy golden aster - *Heterotheca villosa* (HEVI), shaggy daisy - *Erigeron pumilis* (ERPU), Lewis's flax - *Linum lewisii* (LILE), hoary tansyaster - *Machaeranthera canescens* (MACA), and longleaf phlox - *Phlox longifolia* (PHLO).

Evaluation of Objectives

Restoration objectives for the BCA restoration sites are to 1) increase native perennial herbaceous cover to at least 50% of total plant cover and 2) to decrease non-native species cover to less than 50% of total plant cover (Elseroad 2007). These objectives now appear unrealistic and unlikely to be met. The persistence and prevalence of cheatgrass, especially three or more years following herbicide treatments, strongly suggests that non-native species cover will remain above 50% of total plant cover. While innovative solutions are being developed, including the use of soil bacteria and fungal pathogens to control root growth and fecundity (Solomon 2016), currently no method exists to control cheatgrass at scale.

Restoration efforts have, for the most part, increased bluebunch wheatgrass density and cover. However, total native perennial herbaceous cover remains well below 50% of all plant cover. Increased Sandberg's bluegrass density and cover may be needed to fill the inter-tussock spaces between bluebunch wheatgrass plants in order to increase competition with cheatgrass and establish perennial soil crust. Careful attention to the Sandberg's bluegrass phenology to best time seeding and herbicide sprays may help increase establishment.

Looking forward, bunchgrass density would likely be a better measurement to tie to project objectives. Density is more easily measured and compared than cover. Cover, in general, is a difficult and time-consuming attribute to precisely measure, and this project's use of cover-class midpoints further obscures both the actual values and the interpretations of results. Because cheatgrass prevalence is unlikely to change without more specific methods for control, it is not helpful or realistic to have objectives that address cheatgrass (or introduced species cover, as cheatgrass will likely compose the vast majority of that category).

Considering that no further restoration actions are currently planned on the BCA and that most plots will be monitored only one more time, the same methods for monitoring should be used to keep results comparable. Alternatively, the final planned monitoring efforts could be replaced with a new and more targeted sampling method developed to compare all sites together at one time with more robust statistical power and inference. If this route is chosen, bluebunch wheatgrass density would be the most useful attribute to measure.

IV. Summary and management implications

1. **Herbicide treatments-** Glyphosate is an effective tool for temporarily reducing cheatgrass and reducing competition with seeded grasses. While fall applications may not be as effective as late winter applications, fall applications eliminate the risk of accidentally impacting germinating grass seedlings. Timing of glyphosate application should take into consideration the phenology of Sandberg's bluegrass to limit damage to mature plants during vulnerable winter growth periods. Imazapic is not recommended for use in restoration sites as the resulting Russian thistle litter impedes management activities and may have resulted in lower native grass establishment.

   Currently, herbicide applications reduce cheatgrass cover for 1-2 years before cover returns to pretreatment levels. Alternative methods should be tested that increase the window of reduced cover in order to help young bunchgrass individuals fully establish.

2. **Grass seed mix-** Seeding rates of 7-8 lbs/acre seem sufficient for establishing bluebunch wheatgrass. Rates used for Sandberg's bluegrass (2-3 lbs/acre) and squirreltail (1-2 lbs/acre) did not results in the desired plant densities or coverages. Substantially increasing the seeding rate of these species may result in increased establishment.

3. **Forb planting-** Forb plug survival has been highly variable by species and has not resulted in detectable increases in native perennial forb cover in restoration sites. Objectives for forb survival should be set and planting lists modified to include only species with relatively high survival rates. Experimenting with seeding forbs along with grasses should be explored as a means to increase native plant cover and diversity in restoration sites. Yarrow, Carey's balsamroot, and Lewis's flax appear to be the best suited species for large scale restoration.

4. **Monitoring –** Careful and iterative monitoring planning is needed to discern restoration success. Bunchgrass density is probably a better metric to use than cover. Sample sizes may have been too low to accurately measure the cover of seeded grasses, and measuring only one macroplot reduced our ability to detect variation within restoration sites. Larger sample sizes across a larger area in more marcoplots (using a more efficient metric like density) could produce a more robust dataset.

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Appendix A. Timeline of McIntyre restoration treatment efforts on the Boardman Conservation Area for 2006-2011 by year and restoration area (plot names in italics).

Date	McIntyre Holding-1 (56 acres)	McIntyre Holding-2 (67 acres)		McIntyre Holding-3 (74 acres)	McIntyre Holding-4 (105 acres)
	McInt-1a & McInt-1b	*McInt-2a*	*McInt-2b*	*McInt-3*	*McInt-4*
2001	Herbicide: Oust				
April 2005	Prescribed burn				
Dec. 2006	Grass drill seeding				
Feb. 2007	Herbicide: 16 oz./acre glyphosate				
May 2007		Herbicide: 32 oz./acre glyphosate + 3 oz./acre dicamba*	Herbicide: 32 oz./acre glyphosate + 3 oz./acre dicamba*		
Nov. 2007	Forb plug planting				
May 2008		Herbicide: 32 oz./acre glyphosate*	Herbicide: 32 oz./acre glyphosate*	Herbicide: 32 oz./acre glyphosate*	
Nov. 2008		Grass drill seeding	Grass drill seeding		
Nov. 2008			Herbicide: 4 oz./acre imazapic		
Jan. 2009	Forb plug planting				
Feb. 2009		Herbicide: 30 oz./acre glyphosate			
Nov. 2009		Forb plug planting	Forb plug planting	Grass drill seeding	
Feb. 2010				Herbicide: 16 oz./acre glyphosate	Herbicide: 16 oz./acre glyphosate
Nov. 2010				Forb plug planting	Herbicide: 16 oz./acre glyphosate
Nov. 2010					Grass drill seeding
Nov. 2010					*Hesperostipa comata* plug planting
Nov. 2011					Forb plug planting

*These herbicide applications targeted yellow starthistle (*Centaurea solstitialis*) and were not intended to control *Bromus tectorum*.

Appendix B Timeline of The Field restoration treatment efforts at the Boardman Conservation Area for 2009-2014 by year and restoration area (plot names in italics).

Date	The Field - 1 (103 acres)	The Field - 2 (101 acres)
	The Field 1	*The Field 2*
Jun. 2009	Herbicide: 30 oz./acre glyphosate	Herbicide: 30 oz./acre glyphosate
Dec. 2011	Herbicide: 30 oz./acre glyphosate	
Jan. 2012	Grass drill seeding	
	Hesperostipa comata plug planting	
Dec. 2012	Forb plug planting	Grass drill seeding
Dec. 2013		Herbicide: 30 oz./acre glyphosate
Jan. 2014		Forb plug planting

Appendix C. Timeline of BCA restoration monitoring efforts 2006-2022 by year and restoration area. Numbers represent years following either grass seeding for cover and density or forb planting for forbs.

Cover	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
McInt-1a	0	1	2	3		5					10						
McInt-1b	0	1	2	3		5					10						
McInt-2a		0		1	2	3		5					10				
McInt-2b		0		1	2	3		5					10				
McInt-3		0			1	2	3		5					10			
McInt-4					0	1	2	3		5					10		
The Field-1						0	1	2	3		5					10	
The Field-2							0	1	2	3		5					10

Density	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
McInt-1a		1	2	3		5					10						
McInt-1b		1	2	3		5					10						
McInt-2a				1	2	3		5					10				
McInt-2b				1	2	3		5					10				
McInt-3					1	2	3		5					10			
McInt-4						1	2	3		5					10		
The Field-1							1	2	3		5					10	
The Field-2								1	2	3		5					10

Forbs	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
McInt-1a			1	2	3												
McInt-1b				1	2	3											
McInt-2a					1	2	3										
McInt-2b					1	2	3										
McInt-3						1	2	3									
McInt-4							1	2	3								
The Field-1								1	2	3							
The Field-2									1	2	3						

Monitoring Effort:	Data Collected	Data Not Collected	Future Monitoring

Appendix D. Native grass species mix, seeding rates, and average seeding density for McIntyre Holding and The Field restoration sites at the Boardman Conservation Area (values are means ± S.D.).

Restoration site	Planting date	Species seeded	Seeding rate (PLS/acre)	Average seedling density (plants/m^2)				
				Year 1	Year 2	Year 3	Year 5	Year 10
McIntyre Holding-1	Dec. 2006 - Jan. 2007	*P. spicata*	6.5	3. ± 3.4	0.2 ± 0.7	0.3 ± 0.6	0.5 ± 0.8	0.9 ± 1.6
		P. secunda	2	0.6 ± 0.9	0.2 ± 1.3	0. ± 0.	0.3 ± 0.8	3.8 ± 3.6
		H. comata	2.5	0. ± 0.1	0. ± 0.1	0. ± 0.	0. ± 0.	0. ± 0.
		All species	**11**	3.6 ± 3.8	0.4 ± 1.4	0.3 ± 0.6	0.8 ± 1.	4.9 ± 5.8
McIntyre Holding-2 (glyphosate)	Nov. 2008	*P. spicata*	6.6	5.2 ± 5.1	1.8 ± 1.9	2.7 ± 1.6	2. ± 1.7	#
		P. secunda	2	0.8 ± 1.4	0.2 ± 0.5	0. ± 0.	0.1 ± 0.2	
		H. comata	1.5	0. ± 0.	0. ± 0.	0. ± 0.	0.1 ± 0.3	
		E. elymoides	1	0.8 ± 1.	0.4 ± 0.6	0.6 ± 0.7	0.2 ± 0.4	
		All species	**11.1**	6.7 ± 6.1	2.4 ± 2.3	3.3 ± 2.	2.3 ± 1.6	
McIntyre Holding-2 (imazapic)	Nov. 2008	*P. spicata*	8.4	3.1 ± 3.1	0.7 ± 0.9	0.7 ± 0.8	1.3 ± 1.3	#
		P. secunda	2.4	1.5 ± 2.	0. ± 0.	0.1 ± 0.2	0.3 ± 0.4	
		E. elymoides	1.2	1.5 ± 1.9	0.7 ± 1.1	0.6 ± 0.6	3.4 ± 4.3	
		All species	**12**	6.1 ± 5.2	1.4 ± 1.7	1.3 ± 1.1	4.9 ± 4.4	
McIntyre Holding-3	Nov. 2009	*P. spicata*	7.6	6.5 ± 5.8	7.8 ± 5.2	8.5 ± 5.	2.9 ± 2.2	#
		P. secunda	3	0.7 ± 1.5	0. ± 0.	0. ± 0.	0.4 ± 0.8	
		H. comata	0.5	0. ± 0.	0.1 ± 0.2	0.2 ± 0.4	0.1 ± 0.2	
		E. elymoides	1	2. ± 2.6	1.1 ± 1.4	1.9 ± 1.4	0.6 ± 0.9	
		All species	**12.1**	9.2 ± 7.9	8.9 ± 5.6	10.6 ± 5.1	3.8 ± 3.2	
McIntyre Holding-4	Nov. 2010	*P. spicata*	10.3	24.2 ± 10.	9.5 ± 5.5	*No Data*	3.4 ± 2.8	#
		P. secunda	2.2	0. ± 0.	0.5 ± 0.8		0.4 ± 0.8	
		E. elymoides	1.4	0.8 ± 1.1	0.6 ± 0.9		0.4 ± 0.8	
		All species	**13.9**	25. ± 9.7	10.6 ± 5.4		4.2 ± 2.9	
The Field - 1	Jan. 2012	*P. spicata*	8.7	1.3 ± 1.7	2.1 ± 1.9	*No Data*	1.2. ± 1.1	#
		P. secunda	2.1	0. ± 0.	0. ± 0.		0. ± 0.	
		E. elymoides	1.3	0.2 ± 0.5	0.1 ± 0.2		0. ± 0.	
		H. comata	0.2	0. ± 0.	0. ± 0.		0. ± 0.	
		All species	**12.3**	1.5 ± 2.	2.1 ± 1.9		1.2 ± 1.1	
The Field - 2	Dec. 2012	*P. spicata*	6.5	5.6 ± 5.3	0.9 ± 0.8	2.1 ± 2.5	#	#
		P. secunda	0.7	0.2 ± 0.4	0. ± 0.	0.1 ± 0.4		
		E. elymoides	0.8	0.2 ± 0.4	0.1 ± 0.2	0. ± 0.		
		All species	**8.0**	5.9 ± 5.5	0.9 ± 0.9	2.2 ± 2.7		

Future Monitoring Data

Appendix E. Average cover of plant guilds and seeded native perennial grasses at the Boardman Conservation Area from 2006-2011 (values are means ± S.D.; zero values are listed as *nil*).

		Plant Guilds						**Seeded Native Perennial Grasses**			
Plot	Year (number since treatment)	Bromus tectorum	Introduced Annual Forb	Native Annual Forb	Native Perennial Forb	Native Perennial Grass	Shrub	P. spicata	P. secunda	E. elymoides	H. comata
McInt-1 (a & b)[1]	2006 (pre-treatment)	32.0 ± 12.4	22.0 ± 12.9	0.5 ± 1.0	*nil*	0.5 ± 1.2	0.6 ± 1.8	*nil*	0.2 ± 0.9	0.3 ± 0.7	*nil*
	2007 (1 yr.)	1.4 ± 1.8	21.1 ± 10.8	7.0 ± 8.6	0.1 ± 0.2	0.6 ± 2.0	0.8 ± 2.0	0.1 ± 0.0	0.0 ± 0.1	0.1 ± 0.3	0.4 ± 1.8
	2008 (2 yr.)	7.0 ± 6.4	31.5 ± 15.4	0.9 ± 0.9	0.7 ± 1.3	0.3 ± 1.0	2.3 ± 6.8	0.0 ± 0.2	0.2 ± 0.8	0.1 ± 0.2	*nil*
	2009 (3 yr.)	24.1 ± 11.0	20.0 ± 9.8	2.0 ± 3.1	0.6 ± 1.0	0.6 ± 1.2	4.1 ± 7.1	0.1 ± 0.3	0 ± 0	0.4 ± 1.0*	*nil*
	2011 (5 yr.)	49.4 ± 21.2	13.3 ± 8.9	0.2 ± 0.3	1.3 ± 1.6	2.3 ± 3.2	2.6 ± 5.4	1.6 ± 2.8	0.2 ± 0.4	0.4 ± 1.3	*nil*
	2016 (10 yr.)	34.9 ± 15.7	1.3 ± 1.9	0.1 ± 0.3	0.1 ± 0.4	6.1 ± 9.3	1.5 ± 3.5	4.2 ± 8.1	1.7 ± 2.2	0.2 ± 0.7	*nil*
McInt-2a (glyphosate)	2007 (pre-treatment)	45.3 ± 24.2	12.8 ± 8.9	2.2 ± 3.0	0.6 ± 1.9	0.4 ± 0.8	0.9 ± 4.0	*nil*	0.1 ± .3	0.3 ± 0.8	*nil*
	2009 (1 yr.)	3.2 ± 4.3	0.7 ± 1.1	*nil*	*nil*	0.2 ± 0.1	*nil*	0.1 ± .0	*nil*	0.0 ± 0.1	*nil*
	2010 (2 yr.)	32.7 ± 21.2	27.3 ± 18.6	0.2 ± 0.4	0.3 ± 1.1	3.4 ± 3.9	*nil*	2.3 ± 2.9	0.1 ± 0.4	1.0 ± 2.2	*nil*
	2011 (3 yr.)	55.5 ± 21.4	1.0 ± 1.6	*nil*	0.1 ± 0.5	9.4 ± 10.2	0.2 ± 0.9	8.5 ± 9.3	0 ± 0	0.9 ± 1.5	*nil*
	2013 (5 yr.)	54.3 ± 21.7	2.6 ± 2.8	*nil*	*nil*	9.8 ± 8.1	0.4 ± 1.1	9.1 ± 8.0	0.1 ± 0.4	0.4 ± 0.8	0.2 ± 0.6
McInt-2b (imazapic)[2]	2007 (pre-treatment)	45.0 ± 20.8	6.9 ± 6.4	10.9 ± 10.7	0.8 ± 2.1	0.2 ± 0.6	3.7 ± 14.5	*nil*	*nil*	0.1 ± 0.5	0.1 ± 0.5
	2009 (1 yr.)	4.8 ± 4.4	0.0 ± 0.1	0.0 ± 0.1	*nil*	0.2 ± 0.1	0.0 ± 0.1	0.1 ± 0.0	0.1 ± 0.1	0.1 ± 0.1	*nil*
	2010 (2 yr.)	11.7 ± 11.2	12.9 ± 8.8	4.4 ± 5.5	0.3 ± 0.6	2.6 ± 3.6	2.2 ± 8.4	0.7 ± 1.1	*nil*	2.0 ± 3.0	*nil*
	2011 (3 yr.)	49.1 ± 25.1	1.6 ± 1.9	0.3 ± 1.0	0.2 ± 0.7	5.1 ± 5.4	2.1 ± 4.1	2.1 ± 2.5	*nil*	3.0 ± 4.6	*nil*
	2013 (5 yr.)	52.0 ± 23.0	5.6 ± 7.9	0.1 ± 0.4	0.2 ± 0.7	9.7 ± 7.4	9.4 ± 9.3	4.9 ± 5.4	0.1 ± 0.3	4.8 ± 5.3	*nil*
McInt-3	2007 (pre-treatment)	29.3 ± 18.1	12.6 ± 9.1	9.8 ± 9.8	1.1 ± 4.1	2.5 ± 8.5	*nil*	0 ± 0	2.1 ± 8.5	0.4 ± 1.0	*nil*
	2010 (1 yr.)	15.0 ± 11.6	7.7 ± 8.9	3.4 ± 4.2	0.1 ± 0.2	0.4 ± 0.4	2.8 ± 5.9	0.2 ± 0.1	0.1 ± 0.4	0.1 ± 0.1	*nil*
	2011 (2 yr.)	36.3 ± 19.0	2.3 ± 2.6	2.0 ± 2.3	0.1 ± 0.3	1.5 ± 1.0	1.3 ± 2.0	1.2 ± 0.7	*nil*	0.3 ± 0.6	*nil*
	2014 (5 yr.)	24.9 ± 18.2	0.3 ± 0.6	*nil*	0.3 ± 0.9	2.1 ± 2.0	2.2 ± 4.2	1.8 ± 1.9	0.0 ± 0.1	0.2 ± 0.3	0.1 ± 0.2
McInt-4[3]	2009 (pre-treatment)	41.5 ± 16.4	9.6 ± 8.6	.4 ± 1.0	0.6 ± 1.9	0.3 ± 0.7	6.2 ± 21.8	*nil*	0.1 ± 0.2	0.2 ± 0.7	*nil*
	2010 (1 yr.)	32.0 ± 19.7	3.8 ± 5.7	1.1 ± 1.1	0.5 ± 1.8	1.2 ± 4.0	10.6 ± 23.9	*nil*	1.1 ± 4.0	0.2 ± 0.7	*nil*
	2011 (2 yr.)	22.5 ± 12.3	8.9 ± 4.9	5.1 ± 4.4	0.4 ± 0.7	0.8 ± 0.5	2.7 ± 5.7	0.7 ± 0.4	*nil*	0.1 ± 0.2	*nil*
	2015 (5 yr.)	27.8 ± 11.2	0.4 ± 1.6	.0 ± .1	0.2 ± 0.5	2.5 ± 2.6	0.6 ± 1.1	2.4 ± 2.7	0.0 ± 0.1	0.1 ± 0.3	*nil*
The Field-1[3]	2011 (pre-treatment)	77.6 ± 11.0	0.8 ± 1.8	*nil*	0.2 ± 0.5	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*
	2013 (2 yr.)	67.5 ± 27.6	6.3 ± 5.7	0.3 ± 1.1	1.2 ± 4.1	3.1 ± 4.6	*nil*	2.8 ± 4.2	*nil*	0.3 ± 0.8	*nil*
	2014 (3 yr.)	33.8 ± 14.7	0.1 ± 0.1	*nil*	0.0 ± 0.1	0.3 ± 0.4	0.0 ± 0.1	0.3 ± 0 .3	*nil*	0.0 ± 0.1	*nil*
	2016 (5 yr.)	53.3 ± 14.3	0.7 ± 1.9	*nil*	*nil*	4.4 ± 4.7	0.4 ± 1.8	4.4 ± 4.7	*nil*	*nil*	*nil*
The Field-2[3]	2013 (1 yr.)	19.8 ± 14.3	2.4 ± 4.0	0.1 ± 0.1	*nil*	0.6 ± 0.6	0.3 ± 0.9	0.6 ± 0.6	*nil*	*nil*	*nil*
	2014 (2 yr.)	25.0 ± 12.9	0.8 ± 0.9	0.1 ± 0.2	*nil*	0.5 ± 0.7	0.9 ± 4.0	0.5 ± 0.7	*nil*	*nil*	*nil*
	2015 (3 yr.)	45.4 ± 20.0	0.6 ± 1.8	0.1 ± 0.2	*nil*	0.4 ± 0.6	4.2 ± 11.6	0.4 ± 0.6	*nil*	*nil*	*nil*

[1]*Elymus elymoides* was not included in seeding efforts. [2]*Hesperotipa comata* was not included in seeding efforts and **[3]** live plugs were planted instead.

Appendix F. Survival and flowering percentage of forb plugs transplanted at the Boardman Conservation Area from 2007-2015.

Species		McIntyre Holding 1 (2007 planting)			McIntyre Holding 1 (2009 planting)			McIntyre Holding 2		McIntyre Holding 3			McIntyre Holding 4			The Field 1		The Field 2
		Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 1
ACMI	Survial	96	52	52	68	62	40	84	74	94	90	76	86	69	66	84	42	65
	flowering	92	46	69	71	95	50	92	88	36	57	83	40	68	76	40	86	89
ASFI	Survial	-	-	-	-	-	-	40	50	22	9	7	0	-	14	0	0	-
	flowering	-	-	-	-	-	-	100	100	5	0	83	-	-	10	-	-	-
ASPU	Survial	0	0	0	-	-	-	14	8	21	8	8	10	7	13	17	0	-
	flowering	-	-	-	-	-	-	92	86	20	0	0	0	0	25	80	0	-
BACA	Survial	23	13	12	19	12	9	23	18	83	67	67	78	59	56	20	5	-
	flowering	0	0	14	0	0	0	95	100	0	0	0	0	0	0	0	0	-
CHDO	Survial	0	0	0	15	15	5	-	-	-	-	-	-	-	-	-	-	-
	flowering	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-	-	-
ERPU	Survial	-	-	-	31	20	17	-	-	36	21	9	5	0	0	0	0	-
	flowering	-	-	-	91	86	50	-	-	58	70	90	0	-	-	-	-	-
HEVI	Survial	-	-	-	-	-	-	5	5	63	54	43	40	22	31	13	2	-
	flowering	-	-	-	-	-	-	44	80	0	2	0	0	0	14	0	0	-
LIPE	Survial	-	-	-	9	0	0	4	3	47	36	26	61	44	40	8	1	-
	flowering	-	-	-	0	0	0	25	33	33	88	86	57	98	98	0	100	-
MACA	Survial	18	8	8	20	13	0	-	-	45	8	0	12	0	18	6	1	-
	flowering	0	0	0	0	0	-	-	-	0	0	-	0	-	22	0	0	-
PHLO	Survial	33	22	23	31	27	0	-	-	13	9	7	-	-	-	0	0	-
	flowering	10	31	14	36	25	-	-	-	8	0	0	-	-	-	-	-	-
Avg. Survivorship		**28**	**16**	**16**	**28**	**21**	**10**	**28**	**26**	**47**	**34**	**27**	**36**	**29**	**30**	**16**	**6**	**65**
Avg. Flowering		**25**	**19**	**24**	**28**	**29**	**20**	**75**	**81**	**18**	**24**	**43**	**14**	**33**	**35**	**20**	**31**	**89**