

**Flint Hills Resources  
Pine Bend Bluffs Property**

**2020 Ecological Activities Report**



Unit DD1 Restored Prairie with huge native field thistle, very popular with monarch butterflies.

March, 2021



**Friends of the Mississippi River**

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## PROJECT SUMMARY

This report describes the ecological activities completed by Friends of the Mississippi River and Great River Greening at the Flint Hills Resources Pine Bend Bluffs natural area from March 2020 through February 2021. This restoration work has been on-going for 21 years and there is a lot to show for it. Nearly 200 acres of forest, prairie and savanna have been restored, and the associated wildlife have rebounded, including an endangered bumblebee and 14 species of greatest conservation need (SGCN). The long-term goal is to restore all the accessible, non-aquatic areas of the FHR bluffland, about 400 acres.

Due to COVID-19, bluffland management did not begin until mid-August, and no volunteer events were held. Nevertheless, it was still a very successful year with 84 acres of prairie and woodland managed.

Acres	Habitat	Activity
37	Woodland & oak forest	Exotic brush control (cut/stump treat, foliar spray)
7	New restored prairie	Management (pull and cut invasive weeds)
35	Former restored prairie & savanna	Management (pull and cut invasive weeds, cut/treat woody, spot mow)
10	Native Sand-gravel prairie	Management (pull and cut invasive weeds)
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89		

### Project highlights

The second annual pollinator survey, conducted at the restored prairie/savanna area and the native remnants, again resulted in a finding of the endangered rusty patched bumble bee plus eight other bumble bee species, including one SGCN.

The 3-acre woodland that was cleared of mature buckthorn in 2019 was progressing exceptionally well with seeded prairie species taking hold and buckthorn seedling cover very low.

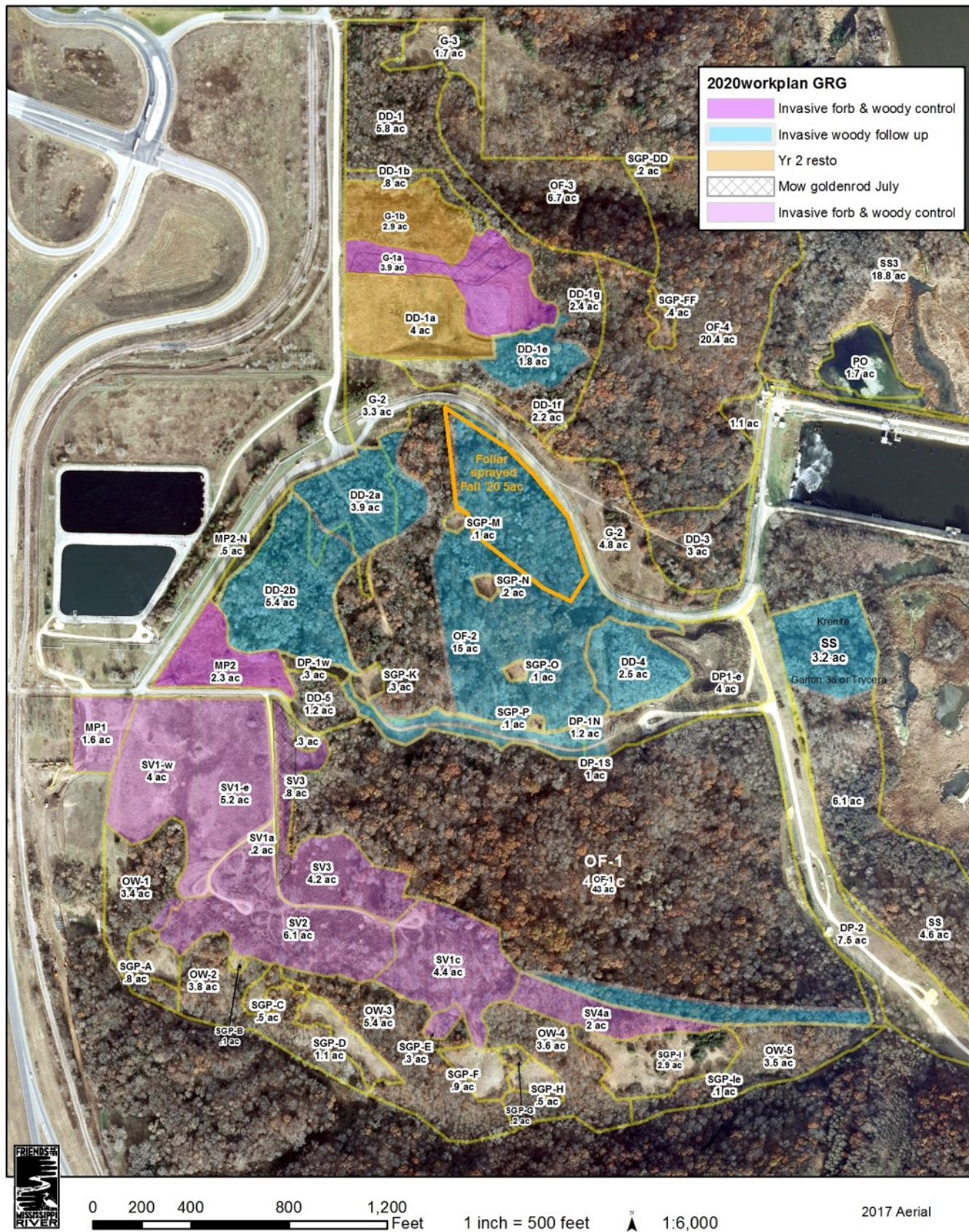
Over 18 acres of dense buckthorn was cleared from the OF2/DD4 units, transforming the woodland view.

The 11-acres of restored prairie near the entrance gate, in different stages of restoration, was showing great progress with an abundance of wildflowers.

The Canada goldenrod control implemented in 2019 was very successful.



# MAP 1. Project Work Completed 2020





## FOREST RESTORATION – ON-GOING ENHANCEMENT, 37 AC

**Unit DD2a:** Prior to management, this 4-acre woodland unit reflected fairly significant past disturbance. The tree canopy was (and still is) dominated by boxelder, a weedy native species. The shrub layer was a very dense thicket of large (1-6” diameter) buckthorn and the deep shade of the groundlayer was nearly devoid of plants. In March 2019, the unit was forestry mowed, then foliar sprayed in June, followed by seeding a mix of seven native grasses in late Feb 2020.

There was a moderate flush of buckthorn seedlings in 2020, which were foliar treated in fall 2020, along with a few missed large stems, which were cut and treated. A vegetation survey (**Appendix A**) showed a significant increase in grass cover from the seeded species, which will help to suppress buckthorn seedlings. A comparison of before and after pictures (**Photos 1 and 2**) shows the dramatic change over the past two years. The short-term goal for this unit is just invasive woody eradication. Once the buckthorn is fully controlled, the trees could be thinned and bur oaks added to convert it to savanna, the historical plant community



*Photos 1 and 2. DD2a was dense buckthorn (left) before clearing in 2019. In 2020, buckthorn seedlings were spot-sprayed and seeded grasses are providing good cover (right).*

**Unit DD2b:** This 5-acre unit included the area of the 2018 volunteer event. We did follow-up woody control there in 2019, girdling a stand of about 35 Siberian elm trees (avg 8” dbh), and basal bark treatment of black locust. The area was seeded in 2019 with a mix of native savanna species. In 2020, new buckthorn and black locust seedlings were spot-sprayed, as well as birdsfoot trefoil, smooth brome and burdock. By fall 2020 the unit had a dense cover of the native species, especially white snakeroot and Canada wild rye (**Photos 3 and 4**). Small honeysuckle plants are returning and will need to be treated in spring 2021. Buckthorn was also removed throughout most of the rest of this unit, where large stems were still present in the ravines.





*Photos 3 and 4. DD2b, the 2018 community volunteer event unit, before woody removal (left) and in 2020 with native ground cover (right).*

**Unit DD1e.** This 3-acre unit was the site of the 2019 fall community volunteer event. It had a very dense shrub layer of 1-4" diameter buckthorn that was cut and treated in fall 2019, followed by the volunteer brush haul event. It was later overseeded with native grasses. In fall 2020 we foliar treated the flush of new buckthorn seedlings.

**Unit OF1:** A site evaluation and vegetation survey (**Appendix B**) was done in September 2020. Overall, buckthorn cover was moderately abundant throughout the unit but the plants were mostly quite short, few more than two feet tall. Surprisingly, we noted that most of them had been browsed (**Photos 5 and 6**). Deer do not typically eat buckthorn, so the browsing indicates an over-abundance of deer in the area and scarcity of food. In this case, the deer abundance may have the positive effect of keeping buckthorn from maturing.



*Photos 5 and 6. OF1 has low plant diversity and very little shrub cover (left), including buckthorn. The buckthorn present is small and has been browsed (right) – indicative that the deer population is too high as they typically avoid it.*



The deer, however, are browsing all woody plants and there was little or no regeneration of native trees and virtually no shrub cover. The herbaceous plant species diversity was also very low and wood nettle, a somewhat weedy native plant, was the dominant forb. Adding native shrubs to this unit to bolster the diversity would be beneficial, but they would have to be protected with strong fencing.

Two areas were noted with an abundance of invasive woody plants – there was a dense stand of about an acre of Tatarian honeysuckle flanking the north edge of the unit, and an abundance of buckthorn and honeysuckle along the south edge. Both areas were managed in fall 2020 by cutting, treating and stacking the invasive plants.

**Unit OF2 and DD4:** A total of 18 acres was managed for invasive woody plants at these two units. In late winter (Feb 2020) the buckthorn in about 5 acres of the northeastern part of the unit was cut and stump-treated. In fall 2020, that area was foliar sprayed to eradicate the new buckthorn seedlings and the remaining 13 acres were cut and stump-treated (**Photos 7 & 8**) in January and February 2021. The entire unit, especially openings and the foliar treated area, was seeded with native grasses (seed mix in **Appendix A**) in late February 2021 to help suppress buckthorn growth.



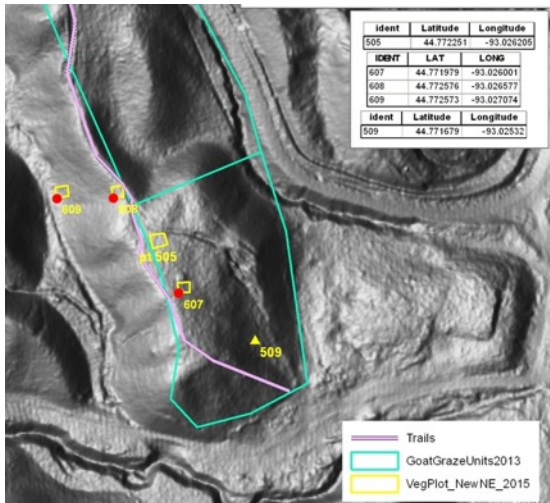
*Photos 7 and 8. Invasive woody removal in OF2 included dense honeysuckle on the south edge, and dense (but skinny) buckthorn throughout most of the 22-ac unit.*

We also surveyed the OF2 vegetation plots in September (**Appendix B**). Two of the units (survey plots 505 & 607) had been goat browsed for 3 years ending in 2015, followed by buckthorn removal and overseeding in 2018, then forestry mowing in 2019. The third unit (plot 608) had buckthorn removal in 2008, but no management since then and buckthorn had regenerated to a stand of 7-foot tall stems, mostly not fruiting. These were cut and treated in January 2021.

Positive changes we have seen in the managed areas, plots 505 and 607 were:

- Forestry mowing and seeding has maintained good buckthorn suppression in plot 505, which is sunny and supports good grass growth (**Photo 9**).
- In plot 607 a new orchid was found - Autumn coralroot. Buckthorn was still very short, and appeared browsed. It could be mowed/brush cut again to keep it set back.

Negative or neutral changes: honeysuckle was starting to increase in 505.



*Location of the vegetation survey plots in OF2.*



*Photo 9. Seeding has resulted in very good vegetative cover in open portions of the OF2 woods.*

**Unit OW 2-5:** These units are located in the ravines between the SGP A-I bluff prairies. We surveyed the condition to assess the level of invasive woody plants. The woods were in generally good shape, with low to moderate abundances of buckthorn. They were mostly two to four feet slender stems. They will likely need to be managed in two to three years.

**Unit SS:** Non-native invasive woody plants were cut and treated in fall at the middle 3 acres of the SS unit. The northern unit was seeded with native grasses in openings and bare areas.

## NEW PRAIRIE/SAVANNA RESTORATION, 7 AC

### Savanna Reconstruction Unit DD1a 4 ac

This unit was in its second growing season in 2020. Typically it would be mowed once in June to reduce weeds and promote the natives prairie plants. Due to COVID-19 management did not begin until August, so the unit was not mowed. The site was managed for weeds in August, when non-native thistles and spotted knapweed were cut and bagged.

A vegetation survey was completed and native species dominated the unit (**Photo 10**), but Canada goldenrod – a native but very aggressive weedy species was dominant. Fourteen of the



40 seeded species were detected (**Appendix B**). While this is a low number, we expect to see more as the prairie matures. Also, some early-blooming species were likely missed in 2020.

The unit is planned for a burn in spring 2021. It will need to have weeds spot-treated during the growing season, including bull thistle, Queen Anne's lace, spotted knapweed, and burdock. The goldenrod should be mowed in early August, just as it starts to flower.



*Photo 10. DD1a was dominated by native plants, such as field thistle and yellow coneflower seen here. Grasses were under represented and Canada goldenrod was over-abundant.*



*Photo 11. Unit G1b was dominated by a good diversity of native prairie species. Native grasses were common and black-eyed Susan was the dominant flower. Monarchs seen here loved the field thistle, which was also abundant.*

### **Prairie Reconstruction Unit G1b, 3 ac**

Unit G1b was seeded at the same time as DD1a, with a similar mix and had the same management since then, with invasive weed species cut and removed in late summer 2020. A vegetation survey in September noted that the site was dominated by a good diversity of native species (**Photo 11**), especially black-eyed Susan. So far just 17 of the 44 species seeded were detected (**Appendix B**), but as noted the survey was late in the season.

The unit is planned for a burn in spring 2021. It will need to have weeds spot-treated, including bull and Canada thistle, spotted knapweed, and mullein.

## RESTORED PRAIRIE/SAVANNA – ON-GOING MANAGEMENT, 35 AC

### Prairie Reconstruction Unit G1a, 4 ac

Seeded in fall 2015, this restoration was in its fifth growing season in 2020. It was well-established with native species, but switchgrass has become almost a monoculture over several acres (Photo 6). Canada goldenrod had also become over-abundant, so an area of about 2 acres was mowed in late August 2020. Overall the species diversity, especially native forbs, seemed reduced from past years (**Appendix B**). Part of that may have been due to the late season survey.

This unit will be burned in 2021, followed by horse grazing on the two acres where switchgrass was most abundant. Grazing animals were an important part of the prairie ecosystem and are now largely absent. Horses only eat grasses so it will be a way to set back the grasses and promote the flowering plants. The goldenrod areas may also be mowed again in early August.



*Photo 12. Dense switchgrass over 6 feet tall has become over-abundant on about two acres of the unit.*



*Photo 13. G1a, in its fifth growing season, had an abundance of native prairie flowers, seen here in September.*

### Restored Prairie Unit MP2, 3 ac

In May 2019, the non-native Kentucky bluegrass was sprayed with a grass herbicide, as it had become almost like a lawn in places. Additional seeding was done and those areas were much improved in 2020, with more native diversity, but the non-native grasses were still fairly abundant. So in early October, when most native plants were dormant, we treated the northwest half of the unit with glyphosate, and the southeast half with a grass herbicide to compare the two treatments. We also treated the birdsfoot trefoil throughout the unit in August.



*Map 2. Two treatments to address non-native grasses at MP2.*



Plans for 2021 are to burn the unit in spring, overseed with native species, spot treat the weed species and to mow the goldenrod in late summer.

#### **Restored Savanna, all SV units. 28 ac.**

Overall, the SV units looked very good, with few invasive woody plants and an abundance of natives. The value of this restored savanna for wildlife was made evident by the abundance of butterflies and pollinators found there, including a rusty patched bumble bee, for the second year in a row (see Wildlife section, and pollinator survey in **Appendix D**). Dozens of monarch butterflies were seen in one afternoon in early September 2020, nectaring on goldenrod and native thistles as they prepared for migration.

In 2019, several acres on the east side of Unit SV1a that had been dominated by Canada goldenrod, were mowed in late summer, then spot-treated in late fall. In 2020 the area had successfully converted back to a more diverse cover of natives (**Photo 14**). Other areas of SV, especially to the east, were still over-dominated by goldenrod (**Photo 15**). However we don't want to eradicate the goldenrod, as it is still a very valuable native plant. Further, the rusty patched bumble bee was located in that area so any management needs to be done very cautiously.

All the SV units were managed for invasive non-native woody plants in the fall – black locust, buckthorn, honeysuckle - which were cut and treated. A stand of black cherry that was encroaching to the north of SGP-E was also removed. In August, thistles and other invasive weedy plants were cut and removed.



*Photo 14, 15. The goldenrod mowed in 2019 has now restored to more diverse natives (left). Much of the savanna unit is still dominated by Canada goldenrod (right).*

## NATIVE PRAIRIE – ON-GOING MANAGEMENT

Units SGP A,B,C,D,E,F,G,H,I,K, M,N,O,P 10 ac

### Invasive Weed and Woody Control SGP A-I

In August, spotted knapweed was pulled and bagged at Unit I, where a sizable number of plants can still be found each year on the south edge of the western half of the unit. Fortunately the annual removal has prevented it from spreading.

In the far east unit of SGP-1, common mullein had become quite abundant in the area where the Jame's polanisia is most abundant (**Photo 16**). The mullein was cut and removed to prevent additional seeding. The plants are biennial so the cut plants will not persist. The area will continue to be monitored in 2021 to address any additional weed issues.

On several dates from August to November, invasive woody plants, especially black locust and buckthorn, were cut and treated along woodland edges at the SGP units.

In 2019, a large dense cover of invasive woody plants were removed from SGP-E. There was not much regeneration of native plants observed in 2020, so a mix of prairie seed was broadcast there in Jan 2021.



*Photo 16. SGP-I had a large amount of common mullein, which was cut and removed.*



*Photo 17. Unit SGP-F with a nice patch of blazing star in late August.*



## Rare Plant Survey

The annual survey for the state endangered **James's polanisia** (JP) was completed at the sand-gravel prairie units on August 25. The populations at all previous locations were surveyed using the same transect survey methods as previous years. Historically the plant has been found at seven units, but in recent years it has mostly at SGP-I, with a few at D and F. The population is mostly concentrated at the east end of SGP-I, at the bottom of the slope. This population has been fluctuating dramatically over the years, with as few as 8 plants one year and as many as 796 in another (**Table 1 and Figure 1**). In 2020, there was a 93 percent decrease in the population from the previous year, with 35 plants recorded.

A few years ago we speculated that the increasing abundance of cheatgrass at SGP-I may be out-competing the polanisia by occupying the bare soil, so we did an early spring cutting to reduce the cheat in 2018. This step was missed in 2019, but for whatever reason, the population rebounded and at Unit I we recorded the second highest count in 12 years of surveys. The wetter than normal conditions in 2018 and 2019 may have helped promote the plants survival. Unit I was not mowed in 2020, due to COVID-19. The abundance of mullein may have suppressed the polanisia. We will continue annual monitoring and will plan to mow the area in early May 2021, before the polanisia has germinated.

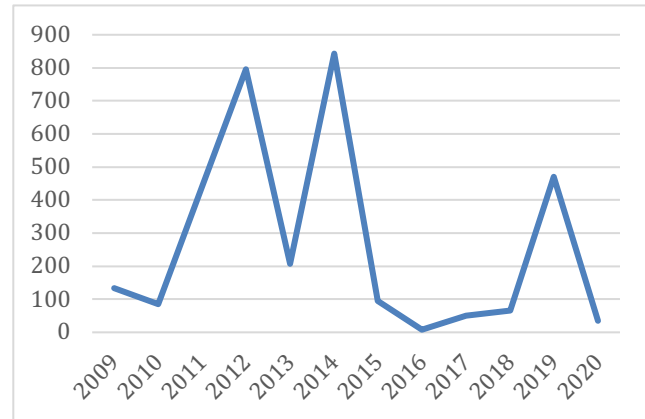


Figure 1. Annual fluctuations of James's Polanisia population.

How long the seeds remain viable in the soil is not known, but it is thought that a plant that grows in such dry conditions as this one is likely to have long seed viability, which will hopefully help the population to recover at some of the other units.

**Table 1.** James's Polanisia (*Polanisia jamesii*) Monitoring at Flint Hills Resources Bluff Prairies

	2003	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Survey Dates		7/25	6/28, 7/7	8/14, 21	7/29, 8/5	7/29, 8/12, 9/16	8/4, 8/16, 9/1	8/8	9/4	8/14, 8/28	8/5	8/8	8/14	8/15	7/31	8/25
SGP-A	Present	-	-	-	2	2	0	1		0	0	0	0	0	0	
SGP-D east	Present	15+	Present	35 +	23	26	282	99		154	0	0	0	0	18	6
SGP-F	-	-	-	-	-	-	-	49	207	292	9	0	3	3	5	1
SGP-H east	-	-	-	-	50	0	15	0		0	0	0	0	0	0	
SGP-I east	Present	27	-	Dozens	55	47	134	509	0	397	86	8	44	63	448	28
SGP-I mid	-	3	-	Dozens	-	1	0	67	0	0	0	0	0	0	0	
SGP-I west	Present	-	5	Unkno wn	3	9	12	71	0	0	0	0	3	0	0	
		45		88	133	85	443	796	207	843	95	8	50	66	471	35
% change from previous yr					51%	-36%	421%	80%	-74%	307%	-89%	-92%	525%	32%	614%	-93%

## WILDLIFE SURVEYS

While the native plant community restoration at FHR has progressed very well over the past 20 years, we have relatively little information on how wildlife have responded to the changes. To help answer that question, FMR hired wildlife biologist Chris Smith in 2020 for the second year in a row, to conduct bumble bee and butterfly surveys at both the native bluff prairies and the restored savanna and prairie units. The results were very positive and a clear demonstration that native plant communities are vital to the survival of native wildlife species.

Due to Covid-19, the early and mid-summer surveys were not completed, but three surveys were done in August and September (Photos 18, 19, 20). The results are provided in the 11-page document in **Appendix D**, and summarized here. The primary focus was on bumble bees and butterflies.

The most notable finding was a single male individual of the federally endangered **rusty-patched bumble bee** (RPBB), which was again found in a restored savanna (unit SV1), in a similar area as in 2019. Male bumble bees tend to roam more than the females, so a single record may not indicate that a nest is in the immediate area. But it certainly indicates that suitable nectaring habitat is present.

When conducting any management activities or any activity that affects any habitat at the bluffs, it is important to carefully consider pollinator requirements in general, but the RPBB in particular. The USFWS has [published guidelines](#) for considerations in areas where RPBB are known to occur, and we carefully follow those guidelines in our woodland and prairie management.



*Photo 18, 19, 20. Chris Smith doing a pollinator survey (left), the rusty patched bumble bee (center), a beautiful locust borer beetle (right). The locust borer may help to reduce the invasive black locust tree that is abundant at the bluffs.*

In 2020, there was a total of 9 bumble bee species recorded, the same species as in 2019. There were 7 species in the remnant prairies and 9 in the restored. There were also fewer animals in the remnants with 105 bees versus 431 in the restored. The restored units appear to support over four times more bumble bees than the native remnants. Over half of the bees in the restored units,



however, were from one species, common eastern bumble bees. So actual diversity (species and abundance), was slightly lower in the restored units.

A total of 18 butterfly species was recorded at the restored and remnant prairies. This was five fewer than 2019, likely due to the shortened survey season. There were 11 species found in the restored prairies (425 individuals), and 17 species in the remnant (166 individuals). Although there were more individuals in the restored unit, 85% of them were monarch butterflies. In that regard the restorations provide an excellent resource for that animal, which is severely declining and in need of such habitat as this. Overall, however, diversity in the restored units was somewhat lower than the remnants, which had slightly higher numbers of more species.

**Table 2.** Summary of Pollinator Survey

Bumble bees		Remnant 1	Remnant 2	Remnant 3	Resto 1	Resto 2	Grand Total	Remnant	Resto
1	Black and Gold / American Bumble Bee	1		1	29	44	75	2	73
2	Brown-belted Bumble Bee	3		1	29	22	55	4	51
3	Common Eastern Bumble Bee	7	7	6	139	99	258	20	238
4	Half Black / Sanderson's Bumble Bee	3	2	5	18	13	41	10	31
5	Lemon Cuckoo Bumble Bee	19	31	9	1	20	80	59	21
6	Red-belted Bumble Bee	4	4	1	9	5	23	9	14
7	Rusty-patched Bumble Bee					1	1	0	1
8	Two-spotted Bumble Bee					1	1	0	1
9	Yellow Bumble Bee		1			1	2	1	1
Grand Total		37	45	23	225	206	536	105	431
								7	9

Butterflies		Remnant 1	Remnant 2	Remnant 3	Resto 1	Resto 2	Grand Total	Remnant	Resto
1	Cabbage White	31	16	13	12	26	98	60	38
2	Clouded Sulphur		2	3	1	2	8	5	3
3	Common Buckeye			1			1	1	0
4	Common Checkered Skipper		1				1	1	0
5	Eastern Comma	1					1	1	0
6	Eastern Tailed-Blue	14	7	10		3	34	31	3
7	Eastern Tiger Swallowtail		1		1	2	4	1	3
8	Gray Comma	1					1	1	0
9	Great Spangled Fritillary	1			1	4	6	1	5
10	Little Yellow					1	1	0	1
11	Monarch	22	9	11	253	107	402	42	360
12	Northern Broken-Dash	1					1	1	0
13	Orange Sulphur	3	8	4	7	2	24	15	9
14	Painted Lady			1	1		2	1	1
15	Peck's Skipper	1					1	1	0
16	Red Admiral	1					1	1	0
17	Silver-spotted Skipper		1	1	1		3	2	1
18	Unk. Crescent		1			1	2	1	1
		76	46	44	277	148	591	166	425
								17	11

Bumble bees		No. spp	No. individuals	Biodiversity Index
	Resto	9	431	0.02
	Remnant	7	105	0.07
Butterflies		No. spp	No. individuals	Biodiversity Index
	Resto	11	425	0.03
	Remnant	17	166	0.10

The yellow bumble bee, a species of greatest conservation need (not rare or endangered, but of concern due to declining populations), was found in both the remnant and restored prairies.

The findings of the pollinator surveys again demonstrate how valuable the restored savanna and prairie habitat is that FHR has invested in. One endangered bumble bee, and both a bumble bee and a butterfly that are listed as species of greatest conservation need, have all been found at the restored habitats in both years that surveys were conducted.



## APPENDIX A. Seeding in 2020

Species seeded at OF2 and SS (north), Feb 2021

Seed order to Minnesota Native Landscape							
Sci Name	Com Name	% of mix	Oz	LB	\$/lb	Cost	Origin
<b>Grasses</b>							
<i>Andropogon gerardii</i>	big bluestem	11%	65.3	4.10	\$9.00	\$36.90	Dakota Co MN
<i>Elymus canadensis</i>	Canada wild rye	22%	251.3	15.80	\$10.00	\$158.00	Kossuth Co. IA
<i>Elymus hystrix</i>	Bottlebrush grass	6%	48.7	3.10	\$95.00	\$294.50	Benton/Wright Co MN
<i>Elymus trachycaulus</i>	slender wheatgrass	7%	48.4	3.10	\$16.50	\$51.15	Rice Co MN
<i>Elymus villosus</i>	Silky wild rye	5%	59.4	3.71	\$35.00	\$129.94	Houston Co. MN
<i>Elymus virginicus</i>	Virginia wild rye	25%	363.0	22.70	\$8.00	\$181.60	MN
<i>Sorghastrum nutans</i>	Indian grass	7%	36.3	2.30	\$9.00	\$20.70	Dakota Co MN
<b>TOTAL</b>		84%	872.5	54.53		<b>\$872.79</b>	
<b>Forbs</b>							
<i>Monarda fistulosa</i>	wild bergamot	5%	5.60	0.35	\$130.00	\$45.50	Rice Co MN
<i>Rudbeckia hirta</i>	Black-eyed susan	11%	8.52	0.53	\$40.00	\$21.31	Dakota Co MN
		16%		0.882699		<b>\$66.81</b>	
	Total			55.4		<b>\$939.60</b>	

## APPENDIX B. Vegetation Surveys

### Disturbed Deciduous Woodland DD-2a

NON-Nativ	Family	Scientific name	Common Name	2018	Notes	10/7/20	Notes
<b>Ground layer (0 to 0.5 meter)</b>				<b>4</b>		<b>4</b>	
	<b>Herbaceous &amp; vines</b>					2	
	Asteraceae	<i>Ageratina altissima</i>	white snakeroot	0.5		0.5	
x	Brassicaceae	<i>Alliaria officinalis</i>	garlic mustard			1	
	Asteraceae	<i>Conyza canadensis</i>	horseweed			1	
	Asteraceae	<i>Erechtites hieraciifolius</i>	pilewort			2	
	Rubiaceae	<i>Galium triflorum</i>	sweet-scented bedstraw			1	
	Boraginaceae	<i>Hackelia virginiana</i>	Virginia stickseed			1	
x	Lamiaceae	<i>Leonurus cardiaca</i>	motherwort	0.5		2	
	Asteraceae	<i>Symphotrichum ericoides</i>	Heath aster			0.5	
x	Scrophulariaceae	<i>Verbascum thapsus</i>	mullein			1	
	<b>Graminoids</b>			<b>0</b>		<b>3</b>	
	Poaceae	<i>Agrostis gigantea</i>	red top grass			0.5	
	Poaceae	<i>Andropogon gerardii</i>	big bluestem			0.5	
	Poaceae	<i>Carex blanda</i>	common woodland sedge			0.5	
	Poaceae	<i>Elymus virginiana - cf</i>	Virginia wild rye			3	
x	Poaceae	<i>Eriochloa villosa</i>	hairy cup grass			2	
x	Poaceae	<i>Phalaris arundinacea</i>	reed canary grass			0.5	
x	Poaceae	<i>Setaria faberi</i>	giant foxtail			1	
	Poaceae	<i>Sorghastrum nutans</i>	Indiangrass			0.5	
	<b>Deciduous</b>			<b>0.5</b>		<b>1</b>	
	Ulmaceae	<i>Celtis occidentalis</i>	Hackberry	0.5		0.5	
	Roseaceae	<i>Prunus serotina</i>	black cherry			0.5	
	Fagaceae	<i>Quercus rubra</i>	Red oak			0.5	
x	Rhamnaceae	<i>Rhamnus cathartica</i>	common buckthorn			1	
	Roseaceae	<i>Rubus occidentalis</i>	black raspberry			0.5	
	Vitaceae	<i>Vitis riparia</i>	Wild grape vine			1	
<b>Shrub layer (0.5-3 meters)</b>				<b>5</b>		<b>1</b>	
x	Caprifoliaceae	<i>Lonicera tartarica</i>	Tartarian honeysuckle	1			
x	Rhamnaceae	<i>Rhamnus cathartica</i>	common buckthorn	5	1/2" to >6 dbh. Mostly ≥1"	1	A few 8" dbh male plants, plus 1-2" next to trees. Removed 2020.
<b>Canopy &amp; Subcanopy (3 meters to 20 meters)</b>				<b>4</b>		<b>no change</b>	
	Aceraceae	<i>Acer negundo</i>	Boxelder	4	mostly 12"dbh. 8-15"		
	Roseaceae	<i>Prunus serotina</i>	black cherry	1	12"		
	Fagaceae	<i>Quercus rubra</i>	Red oak	1	14		

\* Cover Classes for individual species and vegetation layers: + (0-1%), 1 (1-5%), 2 (5-25%), 3 (25-50%), 4 (50-75%), 5 (75-100%)



## Oak Forest (OF1) Vegetation Survey

NON-Native	Family	Scientific name	Common Name	Cover*	Diameter (Inches)	Comment
	<b>Canopy</b>			<b>5</b>		
	Aceraceae	<i>Acer negundo</i>	boxelder	1	10-12	
	Ulmaceae	<i>Celtis occidentalis</i>	Hackberry	1	12	
	Fagaceae	<i>Quercus macrocarpa</i>	Bur oak	2	12	
	Fagaceae	<i>Quercus rubra</i>	Red oak	3	10-18	
	Ulmaceae	<i>Ulmus americana</i>	American elm	1	10	
	<b>Subcanopy</b>			<b>2</b>		
	Ulmaceae	<i>Celtis occidentalis</i>	Hackberry	1		
	Roseaceae	<i>Prunus serotina</i>	black cherry	1		
	Ulmaceae	<i>Ulmus americana</i>	American elm	1		
	<b>Shrub layer (1-3 meters)</b>			<b>+</b>		
x	Berberidaceae	<i>Berberis thunbergii</i>	Japanese barberry	+		Found one, flagged
	Saxifragaceae	<i>Ribes missouriensis</i>	Missouri gooseberry	+		
	Rutaceae	<i>Zanthoxylum americana</i>	prickly ash	+		
	<b>Ground layer (0 to 1 meter)</b>			<b>4</b>		
	<b>Forbs</b>			<b>3</b>		
	Asteraceae	<i>Ageratina altissima</i>	white snakeroot	2		
x	Brassicaceae	<i>Alliaria officinalis</i>	garlic mustard	2		
	Polypodiaceae	<i>Athyrium filix-femina</i>	lady fern	1		
	Apiaceae	<i>Cryptotaenia canadensis</i>	Honewort	1		
	Rubiaceae	<i>Galium aparine</i>	cleavers	1		
	Urticaceae	<i>Laportea canadensis</i>	wood nettle	3		
	Umbelliferae	<i>Osmorhiza claytonii</i>	sweet cicely	2		
	Urticaceae	<i>Pilea pumila</i>	clearweed	2		
	Liliaceae	<i>Smilax sp.</i>	greenbriar	1		
	<b>Graminoids</b>			<b>1</b>		
	Poaceae	<i>Oryzopsis asperifolia</i>	Mountain ricegrass	1		
	Poaceae	<i>Leersia virginica</i>	White grass	1		
	<b>Woody</b>			<b>2</b>		
	Aceraceae	<i>Acer negundo</i>	boxelder	+		
	Juglandaceae	<i>Carya cordiformis</i>	bitternut hickory	+		
	Ulmaceae	<i>Celtis occidentalis</i>	Hackberry	1		
x	Caprifoliaceae	<i>Lonicera tartarica</i>	Tartarian honeysuckle	1		
	Roseaceae	<i>Prunus serotina</i>	black cherry	1		
	Fagaceae	<i>Quercus rubra</i>	Red oak	1		
x	Rhamnaceae	<i>Rhamnus cathartica</i>	common buckthorn	2		
	Saxifragaceae	<i>Ribes missouriensis</i>	Missouri gooseberry	+		
	Ulmaceae	<i>Ulmus americana</i>	American elm	1		

\* Cover Classes for species & vegetation layers: + (0-1%), 1 (1-5%), 2 (5-25%), 3 (25-50%), 4 (50-75%), 5 (75-100%).

## Oak Forest (OF2) Vegetation Survey Plots

- Three vegetation survey plots were established in 2013. 10x10 m each.
- Plots 505 & 607 were grazed by goats for 2 weeks in early September 2013 & 2014, and July/Aug 2015. Cut/stump-treat Feb 2018.
- Plots 608 was not grazed or brush cut, but buckthorn was foliar-treated in 2014.
- Notable (positive) changes in coverage\* are highlighted in green. Negative changes are in orange.

Native				Plot 607							Browsed 2013-15							Plot 608							Unbrowsed							505					Browsed 2013-15				
	Ht (m)	Scientific name	Common Name	10/2/13	5/5/15	9/8/16	9/24/18	8/7/19	10/7/20	Notes	10/2/13	diam	5/5/15	9/8/16	9/24/18	8/7/19	5/5/15	9/9/16	9/24/18	8/7/19	10/7/20																				
	5-20	CANOPY	% cov of ht class	5.0	5.0		4.0		4.0		5.0		5.0		5.0		2.0		3.0		3.0																				
		<i>Acer negundo</i>	boxelder																																						
		<i>Celtis occidentalis</i>	hackberry						1.0										0.5																						
		<i>Fraxinus pensylvanica</i>	green ash																																						
		<i>Populus deltoides</i>	cottonwood														0.5		0.5																						
		<i>Populus tremuloides</i>	quaking aspen	2.0	2.0		0.0				1.0	6.0	1.0		1.0		0.5																								
		<i>Prunus serotina</i>	black cherry	2.0	2.0		2.0																																		
		<i>Quercus macrocarpa</i>	bur oak								1.0	2-6																													
		<i>Quercus rubra</i>	red oak								1.0	4	1.0		1.0		2.0		3.0		3.0																				
		<i>Quercus ellipsoidalis</i>	pin oak	4.0	4.0		4.0		3.0	16", 10"	4 dom	12-18"	4.0		4.0																										
	2-5	SUBCANOPY			2.0				1.0				2.0		2.0		1.0		0.0		0.5																				
		<i>Prunus serotina</i>	black cherry		2.0				1.0	6"					1.0		1.0				0.5																				
		<i>Quercus macrocarpa</i>	bur oak											1.0			1.0																								
		<i>Quercus rubra</i>	red oak		1.0								2.0		2.0																										
	1-2	SHRUB LAYER		4.0	2.0	1.0	1.0	0.5	0.5		4.0		2.0	3.0	5.0	5.0	3.0	3.0	0.0	0.0	0.5																				
x		<i>Lonicera tartarica</i>	Tartarian honeysuckle	2.0	0.5	0.5		0.5	0.5		1.0				1.0	1.0					0.5																				
x		<i>Rhamnus cathartica</i>	common buckthorn	4.0	2.0	1.0	1.0				3.0	~45%, 3-4 ft	2.0	3.0	5.0	5.0	3.0	3.0																							
		<i>Prunus serotina</i>	black cherry					0.5	0.5						1.0																										
		<i>Zanthoxylum americana</i>	prickly ash			0.5																																			
	0-1	GROUND LAYER		1.0	3.0	4.0		4.0	4.0		3.0		2.0	3.0	3.0		5.0	4.0	3.0	4.0	5.0																				
		Forbs, vines		0.5	3.0	3.0	2.0	3.0	3.0		2.0		1.0	1.0	0.5		2.0	2.0	1.0	3.0	3.0																				
		<i>Achillea millefolium</i>	yarrow					0.5																																	
		<i>Ageratina altissima</i>	white snakeroot			3.0	2.0	2.0	2.0		0.5				0.5	0.5	1.0	1.0	1.0	1.0	2.0																				
x		<i>Alliaria petiolata</i>	garlic mustard	0.5	3.0		0.5	0.5	0.5		2.0		1.0			0.5	1.0	1.0	0.5	0.5	0.5																				
		<i>Ambrosia artemisiifolia</i>	common ragweed					0.5																																	
x		<i>Arctium minus</i>	common burdock					0.5	0.5										0.5	0.5	0.5																				
		<i>Arisaema triphyllum</i>	Jack in pulpit																	0.5																					
		<i>Asclepias syriaca</i>	common milkweed															0.5																							
		<i>Campanula americana</i>	American bellflower																	0.5																					
		<i>Cerastium sp</i>	chickweed					0.5																																	
		<i>Circea lutetiana</i>	enchanter's nightshade		0.5			0.5								1.0	1.0	1.0																							
		<i>Corallorhiza odontorhiza</i>	Autumn coralroot						0.5																																
		<i>Cuscuta pentagona</i>	field dodder																	1.0																					
		<i>Erechtites hieraciifolia</i>	pilewort					0.5										0.5	1.0																						

Native	Ht cls (m)	Scientific name	Common Name	10/2/13	5/5/15	9/8/16	9/24/18	8/7/19	10/7/20	Notes	10/2/13	diam	5/5/15	9/8/16	9/24/18	8/7/19	5/5/15	9/9/16	9/24/18	8/7/19	10/7/20
x		<i>Fallopia sp</i>	bindweed					0.5											0.5		
		<i>Galium aparine</i>	cleavers		0.5			0.5	1.0				0.5	0.5			1.0	1.0		1.0	1.0
		<i>Galium triflorum</i>	sweet-scented bedstraw		1.0		0.5				0.5		1.0								
		<i>Geum canadense</i>	white avens		0.5		0.5	0.5					0.5		0.5	0.5	0.5	0.5	0.5		
		<i>Hackelia virginiana</i>	Virginia stickseed		1.0			0.5	1.0				0.5							1.0	1.0
x		<i>Leonurus cardiaca</i>	motherwort	0.5	0.5		0.5	0.5	0.5				1.0			0.5			0.5		1.0
		<i>Menispermum canadense</i>	moonseed					0.5													
		<i>Mianthemum canadense</i>	Canada Mayflower					0.5													
x		<i>Nepeta cataria</i>	catnip						0.5										0.5		
		<i>Osmorhiza claytonii</i>	sweet cicely		0.5		0.5	0.5	0.5		0.5										
		<i>Persicaria pensylvanica</i>	Pennsylvania smartweed																	0.5	
		<i>Phyrma leptostachya</i>	lopseed			0.5		0.5													
		<i>Pilea sp</i>	clearweed					1.0	0.5							0.5					
x		<i>Plantago major</i>	plantain																	0.5	
		<i>Polygonatum</i>	Sol seal					0.5					0.5								
		<i>Ranunculus abortivus</i>	small-flowered crowfoot		0.5																
		<i>Smilax tamnoides</i>	Bristly greenbrier				0.5	0.5	0.5										0.5		0.5
		<i>Solanum dulcamara</i>	bittersweet nightshade					0.5													
		<i>Solidago canadensis &amp; gigantea</i>	Canada & late goldenrod					0.5											1.0	1.0	1.0
x		<i>Taraxacum officinale</i>	dandelion					0.5													
		<i>Urtica dioica</i>	stinging nettle		1.0		0.5	0.5								0.5					
x		<i>Verbascum thapsus</i>	mullein																	0.5	0.5
		<i>Verbena urticifolia</i>	white vervain																0.5		
		<i>Viola sororia</i>	common blue violet	0.5													0.5	0.5	0.5		
		No. gr cover forbs:		4.0	11.0	3.0	9.0	25.0	11.0		5.0	0.0	8.0	2.0	3.0	8.0	7.0	8.0	13.0	13.0	9.0
		Graminoids		0.5	0.5		1.0	1.0	1.0		0.5		1.0		0.0	0.0	0.5	1.0	2.0	3.0	3.0
x		<i>Agropyron repens</i>	quack grass														0.5				
		<i>Carex blanda</i>		0.5			0.5	1.0	1.0		0.5		1.0					1.0	1.0	1.0	1.0
		<i>Carex pensylvanica</i>	Pennsylvania sedge					0.5											1.0		1.0
		<i>Carex sp</i>	deer browsed		0.5		0.5	0.5					1.0								
		<i>Elymus canadensis</i>	Canada wild rye																	2.0	2.0
		<i>Grass spp</i>	Branched stems, patches.																2.0	1.0	1.0
		<i>Leersia virginica</i>	White grass					0.5													
		<i>Panicum virgatum</i>	swithgrass																	0.5	
		<i>Sorghastrum nutans</i>	Indiangrass																	1.0	1.0
		No. gr cover grams:		1.0	1.0	0.0	2.0	4.0	1.0		1.0	0.0	2.0	0.0	0.0	0.0	1.0	1.0	3.0	5.0	5.0

5%, 2=5-25%, 3=25-50%, 4=50-75%, 5=75-100%



Native	Ht cls (m)	Scientific name	Common Name	10/2/13	5/5/15	9/8/16	9/24/18	8/7/19	10/7/20	Notes	10/2/13	diam	5/5/15	9/8/16	9/24/18	8/7/19	5/5/15	9/9/16	9/24/18	8/7/19	10/7/20
		<b>Woody plants</b>		<b>0.5</b>	<b>3.0</b>	<b>2.0</b>	<b>3.0</b>	<b>3.0</b>	<b>4.0</b>		<b>3.0</b>		<b>3.0</b>	<b>3.0</b>	<b>3.0</b>	<b>3.0</b>	<b>3.0</b>	<b>3.0</b>	<b>2.0</b>	<b>0.5</b>	<b>2.0</b>
		<i>Acer negundo</i>	boxelder			0.5	0.5	0.5								0.5					
		<i>Acer rubra</i>	red maple		0.5								0.5								
		<i>Celtis occidentalis</i>	hackberry		0.5	1.0	1.0	0.5	0.5				1.0	1.0	1.0	1.0		0.5	0.5	0.5	0.5
		<i>Cornus alternifolia</i>	pagoda dogwood																		
x		<i>Frangula alnus</i>	glossy buckthorn												0.5						
		<i>Fraxinus pensylvanica</i>	green ash				0.5	0.5	0.5		0.5					0.5					
		<i>Juniperus virginiana</i>	red cedar					0.5											0.5		0.5
x		<i>Lonicera tartarica</i>	Tartarian honeysuckle		1.0	1.0	1.0	1.0	1.0				1.0	1.0	1.0	1.0	1.0	1.0	1.0		2.0
		<i>Ostrya virginiana</i>	Ironwood	0.5			0.5	0.5	0.5		2.0										
		<i>Parthenocissus inserta</i>	Virginia creeper				1.0	1.0	0.5		0.5		1.0	1.0		1.0		1.0	1.0		
		<i>Prunus serotina</i>	black cherry		1.0		1.0	1.0	1.0		0.5		1.0	1.0	0.5	2.0	0.5	0.5	0.5	0.5	1.0
		<i>Prunus virginiana</i>	chokecherry					0.5							0.5	0.5					
		<i>Quercus macrocarpa</i>	bur oak														0.5				
		<i>Quercus rubra</i>	red oak		0.5		1.0	0.5	0.5		0.5		0.5		1.0	0.5			0.5	0.5	0.5
x		<i>Rhamnus cathartica</i>	common buckthorn	0.5	2.0	2.0	2.0	2.0	3.0	nearly 50%	2 dom		3 dom	3.0	3.0	1.0	3.0	3.0	1.0		1.0
		<i>Ribes sp</i>	currant/gooseberry		0.5	0.5	0.5	0.5									1.0	1.0			0.5
		<i>Rubus allegheniensis</i>	blackberry	0.5		0.5	0.5				0.5		0.5		0.5	0.5					
		<i>Rubus ideaus</i>	raspberry	0.5		0.5	0.5		0.5		0.5		0.5		0.5	0.5		1.0	0.5		
		<i>Rubus occidentalis</i>	black cap				0.5	1.0	1.0							1.0			0.5		1.0
		<i>Toxicodendron radicans</i>	poison ivy				0.5														
		<i>Ulmus americana</i>	American elm		0.5		0.5	0.5								0.5	0.5	0.5		0.5	
		<i>Vitis riparia</i>	wild grapevine	0.5			1.0	1.0	0.5		0.5				0.5	1.0	1.0	1.0	1.0		
		<i>Zanthoxylum americana</i>	prickly ash				1.0									1.0		1.0	0.5		0.5
		Bare ground															0.1		0.4	0.5	1.0
		No. gr cover woody:		5.0	8.0	7.0	17.0	15.0	11.0		8.0	0.0	8.0	5.0	10.0	15.0	8.0	10.0	12.0	5.0	10.0
		TOTAL No. Gr cover spp		10.0	20.0	10.0	28.0	44.0	23.0		14.0	0.0	18.0	7.0	13.0	23.0	16.0	19.0	28.0	23.0	24.0

2016	2018	2019	2020
607: Goats reduced BT ~50%. BT was small to start with, so it was optimal size. 608: no significant changes - buckthorn was bigger. About 2% of the were dead from the foliar spray. Stems still <1/2", not fruiting (very shady) 505: No major changes, but a few more forbs, seedling trees showing up. Buckthorn bigger.	607: Cut/treat in Feb 2018 has kept BT cover low, none in shrub layer. Goat browse provided good start. Veg diversity increased a little - trees esp. Forb diversity is still poor. 608: very overgrown, BT 6ft tall, but not fruiting. 1/2" diam or less (base). Diversity decreased a little. 505: cut/treat Feb 2018 - no BT left in	<b>Positive changes</b> Forestry mowing eliminated buckthorn in the shrub layer in 505 & 607. 607: 13 new native forbs, 2 grasses & coverage increase from about 20 to 45%. 505: 4 new native forbs, 2 grasses & increase coverage from about 45 to 70%. 608: increase in native woody seedlings. But they are not likely to persist in dense BT. <b>Negative or neutral</b> 608 - no change to buckthorn coverage, still maximum (5). Low level GM in all plots. 505: decrease in native woody seedlings	<b>Positive changes</b> 607: Coralroot! BT is still very short, appears browsed. 505: Still very little BT, ground cover increased. <b>Negative or neutral</b> 607: BT coverage is a little greater than 2019. Forb diversity decreased - may be due to later survey time. 505: HS starting to increase

## Lowland Hardwood Forest (SS1-North) Vegetation Survey

NON-Native	Family	Scientific name	Common Name	9/15/20	
	Groundlayer - forbs, ferns, woody			<b>3</b>	
	Asteraceae	<i>Ageratina altissima</i>	white snakeroot	2	
	Fabaceae	<i>Amphicarpaea bracteata</i>	hog peanut	2	
x	Asteraceae	<i>Arctium minus</i>	common burdock	1	
	Campanulaceae	<i>Campanulastrum americanum</i>	tall bellflower	0.5	
	Onagraceae	<i>Circaea lutetiana</i>	sweet cicely	1	
	Apiaceae	<i>Cryptoaenia candensis</i>	honewort	1	
	Urticaceae	<i>Laportea canadensis</i>	wood nettle	1	
x	Lamiaceae	<i>Leonurus cardiaca</i>	motherwort	1	
	Urticaceae	<i>Pilea pumila</i>	clearweed	0.5	
	Asteraceae	<i>Rudbeckia laciniata</i>	goldenglow	0.5	
	Boraginaceae	<i>Scrophularia lanceolata</i>	lance-leaved figwort	1	
	Lamiaceae	<i>Teucrium canadense</i>	American germander	1	
	Urticaceae	<i>Urtica dioica</i>	stinging nettle	0.5	
	Groundlayer - graminoids			<b>0</b>	
	Groundlayer - woody			<b>3</b>	
	Juglandaceae	<i>Carya cordiformes</i>	bitternut hickory	0.5	
	Cannabaceae	<i>Celtis occidentalis</i>	hackberry	1	
	Vitaceae	<i>Parthenocissus inserta</i>	Virginia creeper	2	
	Roseaceae	<i>Prunus serotina</i>	black cherry	0.5	
x	Rhamnaceae	<i>Rhamnus alnifolia</i>	glossy buckthorn	0.5	
x	Rhamnaceae	<i>Rhamnus cathartica</i>	common buckthorn	2	
	Roseaceae	<i>Ribes sp</i>	gooseberry	0.5	
	Shrub layer			<b>0</b>	
	Canopy/Subcanopy			<b>5</b>	
	Aceraceae	<i>Acer negundo</i>	boxelder	4	
	Juglandaceae	<i>Carya cordiformes</i>	bitternut hickory	1	
	Ulmaceae	<i>Ulmus americana</i>	American elm	2	

Cover Classes for species and vegetation layers: 0.5=0-1%, 1=1-5%, 2=5-25%, 3=25-50%, 4=50-75%, 5=75-100%

## Prairie Restoration Unit DD1a Vegetation Survey

Species were seeded Fall 2018

9/4/20

	Scientific Name	Common Name	Seeded lbs	Coverage*
<b>Graminoids-seeded</b>			<b>3</b>	
1	<i>Andropogon gerardii</i>	big bluestem	7.8	
2	<i>Bouteloua curtipendula</i>	side-oats grama	10.3	1
3	<i>Elymus canadensis</i>	nodding wild rye	7.5	2
4	<i>Elymus hystrix</i>	bottlebrush grass	0.4	
5	<i>Elymus trachycaulus</i>	slender wheatgrass	4.7	
6	<i>Schizachyrium scoparium</i>	little bluestem	7.9	1
7	<i>Sorghastrum nutans</i>	Indian grass	9.5	
8	<i>Sporobolus heterolepis</i>	Prairie dropseed	1.3	
<b>Total</b>			<b>49.4</b>	
<b>Forbs-seeded</b>			<b>Seeded Oz</b>	<b>3</b>
1	<i>Agastache foeniculum</i>	blue giant hyssop	7	0.5
2	<i>Allium stellatum</i>	Prairie Wild Onion	1.1	
3	<i>Amorpha canescens</i>	lead plant	9	
4	<i>Aquilegia canadensis</i>	columbine	1.8	
5	<i>Asclepias syriaca</i>	common milkweed	1	
6	<i>Asclepias tuberosa</i>	butterflyweed	2.7	
7	<i>Asclepias verticillata</i>	whorled milkweed	1.1	
8	<i>Baptisia alba</i>	white wild indigo	30.7	
9	<i>Chamaecrista fasciculata</i>	partridge pea	3.9	0.5
10	<i>Dalea candida</i>	white prairie clover	8.1	
11	<i>Dalea purpurea</i>	purple prairie clover	1.6	
12	<i>Desmodium canadense</i>	Canada tick trefoil	2.5	
13	<i>Eryngium yuccifolium</i>	rattlesnake master	1.2	
14	<i>Galium boreale</i>	northern bedstraw	1	
15	<i>Helianthus maximiliani</i>	Maximilian's sunflower	0.8	1
16	<i>Heliopsis helianthoides</i>	ox-eye	1.4	1
17	<i>Lespedeza capitata</i>	round-headed bush clover	1.1	
18	<i>Liatris ligulistylis</i>	northern plains blazing star	1	
19	<i>Liatris pycnostachya</i>	prairie blazing star	1	
20	<i>Monarda fistulosa</i>	wild bergamot	3	1
21	<i>Penstemon grandiflorus</i>	large-flowered beard tongue	1.7	
22	<i>Pycnanthemum virginianum</i>	Virginia mountain mint	1.3	
23	<i>Ratibida pinnata</i>	gray-headed coneflower	4.1	2
24	<i>Rudbeckia hirta</i>	black-eyed susan	5.7	2
25	<i>Solidago rigida</i>	stiff goldenrod	1.7	1
26	<i>Solidago speciosa</i>	showy goldenrod	3	
27	<i>Symphyotrichum laeve</i>	smooth aster	1.3	1
28	<i>Symphyotrichum novae-angliae</i>	New England aster	1.6	
29	<i>Tradescantia ohiensis</i>	Ohio spiderwort	1.1	
30	<i>Verbena stricta</i>	hoary vervain	7.5	1
31	<i>Veronicastrum virginicum</i>	Culver's root	5.5	
32	<i>Zizia aurea</i>	golden alexanders	6.7	1
<b>Total</b>			<b>122.2</b>	
<b>Native species not seeded</b>				
1	<i>Achillea millefolium</i>	yarrow		1
2	<i>Ageratina altissima</i>	white snakeroot		0.5
3	<i>Artemisia ludoviciana</i>	prairie sage		0.5
4	<i>Aster pilosus</i>	frost aster		1
5	<i>Cirsium discolor</i>	field thistle		2
6	<i>Conyza canadensis</i>	horseweed		1
7	<i>Erigeron sp</i>	Fleabane		1
8	<i>Hackelia virginiana</i>	Virginia stickseed		2



9	<i>Solidago canadensis</i>	Canada goldenrod	3
10	<i>Verbena urticifolia</i>	white vervain	1
11	<i>Viola sp</i>	Violet	0.5

#### Non-native species

1	<i>Arctium minus</i>	common burdock	0.5
2	<i>Berteroa incana</i>	hoary alyssum	0.5
3	<i>Centaurea stoebe</i>	Spotted knapweed	0.5
4	<i>Cirsium vulgare</i>	bull thistle	1
5	<i>Daucus carota</i>	Queen Anne's lace	0.5
6	<i>Eriochloa villosa</i>	hairy cupgrass	1
7	<i>Melilotus alba</i>	white sweet clover	0.5
8	<i>Setaria pumilla</i>	yellow foxtail	2
9	<i>Verbascum thapsus</i>	common mullein	1

## Prairie Restoration Unit G1b (west) Vegetation Survey

Species 1-57 were seeded Fall 2018

Seeded		Scientific Name	Common Name	Seeds/ s.f.	9/4/20
x	1	<i>Andropogon gerardii</i>	big bluestem	1.2	
x	2	<i>Bouteloua curtipendula</i>	side-oats grama	4.8	1
x	3	<i>Bromus kalmii</i>	kalm's brome	0.5	
x	4	<i>Carex bicknellii</i>	Bicknell's sedge	0.4	
x	5	<i>Elymus canadensis</i>	Canada wild rye	2.1	1
x	6	<i>Schizachyrium scoparium</i>	little bluestem	8.3	
x	7	<i>Sorghastrum nutans</i>	Indian grass	2.2	1
x	8	<i>Sporobolus heterolepis</i>	Prairie dropseed	1	
x	9	<i>Stipa spartea</i>	Porcupine grass	0.25	
				<b>20.8</b>	
		<b>FORBS</b>			9432%
x	1	<i>Agastache foeniculum</i>	blue giant hyssop	0.80	
x	2	<i>Allium stellatum</i>	Prairie Wild Onion	0.20	
x	3	<i>Amorpha canescens</i>	lead plant	0.90	
x	4	<i>Aquilegia canadensis</i>	columbine	0.30	
x	5	<i>Artemisia ludoviciana</i>	prairie sage	0.30	0.5
x	6	<i>Asclepias syriaca</i>	common milkweed	0.20	
x	7	<i>Asclepias tuberosa</i>	butterfly milkweed	0.10	
x	8	<i>Baptisia alba</i>	white wild indigo	0.10	
	9	<i>Centaurea stoebe</i>	spotted knapweed		1
x	10	<i>Chamaecrista fasciculata</i>	partridge pea	0.60	
	11	<i>Cirsium arvense</i>	Canada thistle		1
	12	<i>Cirsium discolor</i>	field thistle		2
	13	<i>Cirsium vulgare</i>	bull thistle		1
	14	<i>Conyza canadensis</i>	horseweed		1
x	15	<i>Coreopsis palmata</i>	bird's foot coreopsis	0.20	
x	16	<i>Dalea purpurea</i>	purple prairie clover	3.30	
x	17	<i>Desmodium canadense</i>	Canada tick trefoil	0.30	
	18	<i>Dryocallis arguta</i>	tall cinquefoil		1
x	19	<i>Epilobium angustifolium</i>	fireweed	0.60	
	20	<i>Erigeron sp</i>	fleabane		1
x	21	<i>Eryngium yuccifolium</i>	rattlesnake master	0.30	

x	22	<i>Euphorbia corollata</i>	flowering spurge	0.10	
x	23	<i>Gentiana flavida</i>	yellowish gentian	1.20	
	24	<i>Helianthus rigida</i>	stiff sunflower		1
x	25	<i>Heliopsis helianthoides</i>	ox-eye	0.20	1
x	26	<i>Lespedeza capitata</i>	round-headed bush clover	0.10	
x	27	<i>Liatris ligulistylis</i>	northern plains blazing star	0.30	0.5
x	28	<i>Liatris pycnostachya</i>	great blazing star	0.20	
x	29	<i>Lobelia siphilitica</i>	great blue lobelia	9.20	1
	30	<i>Melilotus alba</i>	white sweet clover		1
x	31	<i>Monarda fistulosa</i>	wild bergamot	0.60	
x	32	<i>Penstemon grandiflorus</i>	large-flowered beard tongue	0.20	
	33	<i>Potentilla recta</i>	sulfur cinquefoil		1
x	34	<i>Pycnanthemum virginianum</i>	Virginia mountain mint	0.30	
x	35	<i>Ratibida pinnata</i>	gray-headed coneflower	0.80	1
x	36	<i>Rosa blanda</i>	smooth rose	0.13	
x	37	<i>Rudbeckia hirta</i>	black-eyed susan	1.90	3
x	38	<i>Silphium laciniatum</i>	compass plant	0.22	
	39	<i>Solidago canadensis</i>	Canad goldenrod		1
	40	<i>Solidago speciosa</i>	showy goldenrod		1
x	41	<i>Symphyotrichum ericoides</i>	heath aster	0.70	1
x	42	<i>Symphyotrichum laeve</i>	smooth aster	0.10	
x	43	<i>Symphyotrichum novae-angliae</i>	New England aster	1.60	
x	44	<i>Tradescantia ohiensis</i>	Ohio spiderwort	0.40	
	45	<i>Verbascum thapsus</i>	mullein		1
x	46	<i>Verbena hastata</i>	blue vervain	0.30	1
	47	<i>Verbena stricta</i>	hoary vervain		1
	48	<i>Verbena urticifolia</i>	white vervain		1
x	49	<i>Veronicastrum virginicum</i>	Culver's root	8.80	
x	50	<i>Zizia aurea</i>	golden alexanders	0.50	

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## Prairie Restoration Unit G1a (east) Vegetation Survey

Species 1-57 were seeded Fall 2015

First burn Spring 2018

			Coverages*			
	Scientific Name	Common Name	Seeded lbs	9/10/18	7/31/19	9/4/20
	<b>Graminoids</b>			<b>4</b>	<b>4</b>	<b>4</b>
1	<i>Andropogon gerardii</i>	big bluestem	1.60	1.0	1.0	1.0
2	<i>Bouteloua curtipendula</i>	side-oats grama	6.60	1.0	1.0	1.0
3	<i>Carex bicknellii</i>	Bicknell's sedge	0.20			
4	<i>Elymus canadensis</i>	nodding wild rye	3.30	1.0	2.0	1.0
5	<i>Panicum virgatum</i>	switchgrass	3.60	2.0	2.0	3.0
6	<i>Schizachyrium scoparium</i>	little bluestem	4.00			
7	<i>Sorghastrum nutans</i>	Indian grass	2.50	2.0	1.0	2.0
8	<i>Sporobolus heterolepis</i>	Prairie dropseed	0.30			
9	<i>Stipa spartea</i>	Porcupine grass	0.30			
<b>Total gram</b>			<b>22.4</b>	<b>5.0</b>	<b>5.0</b>	<b>5.0</b>
	<b>Forbs</b>		<b>Seeded Oz</b>	<b>2</b>	<b>3.0</b>	<b>2.0</b>
10	<i>Agastache foeniculum</i>	blue giant hyssop	1.1	0.5		
11	<i>Amorpha canescens</i>	lead plant	7.3			
12	<i>Antennaria neglecta</i>	field pussytoes	0.1			
13	<i>Aquilegia canadensis</i>	columbine	1.1			
14	<i>Artemisia ludoviciana</i>	prairie sage	0.2	1.0	1.0	1.0
15	<i>Asclepias syriaca</i>	common milkweed	5.1	1.0	0.5	0.5
16	<i>Asclepias tuberosa</i>	butterfly milkweed	4.0	0.5	0.5	
17	<i>Aster ericoides</i>	heath aster	0.4		1.0	0.5
18	<i>Aster laevis</i>	smooth aster	0.8			1.0
19	<i>Aster novae-angliae</i>	New England aster	3.1	1.0	0.5	
20	<i>Baptisia alba</i>	white wild indigo	5.0			
21	<i>Campanula rotundifolia</i>	harebell	0.2			
22	<i>Ceanothus americanus</i>	New Jersey tea	2.8			
23	<i>Chamaecrista fasciculata</i>	partridge pea	28.3	1.0	1.0	0.5
24	<i>Dalea candida</i>	white prairie clover	14.3			
25	<i>Dalea purpurea</i>	purple prairie clover	1.5	1.0		
26	<i>Desmodium canadense</i>	Canada tick trefoil	6.2	0.5	0.5	0.5
27	<i>Epilobium angustifolium</i>	fireweed	0.1			
28	<i>Eryngium yuccifolium</i>	rattlesnake master	5.7	0.5	1.0	
29	<i>Euphorbia corollata</i>	flowering spurge	2.1			
30	<i>Galium boreale</i>	northern bedstraw	0.8		0.5	
31	<i>Gentiana flavida</i>	yellowish gentian	1.1			
32	<i>Geum triflorum</i>	prairie smoke	0.4			
33	<i>Glycyrrhiza lepidota</i>	wild licorice	3.3			
34	<i>Heliopsis helianthoides</i>	ox-eye	4.0	1.0	1.0	1.0
35	<i>Heuchera richardsonii</i>	alumroot	0.1			
36	<i>Hypericum pyramidatum</i>	great St. John's wort	0.4			
37	<i>Lespedeza capitata</i>	round-headed bush clover	2.1		0.5	
38	<i>Liatris ligulistylis</i>	northern plains blazing star	3.6	0.5		0.5
39	<i>Liatris pycnostachya</i>	great blazing star	2.7		0.5	
40	<i>Lilium michiganense</i>	Michigan lily	0.3			
41	<i>Monarda fistulosa</i>	wild bergamot	1.2	1.0	2.0	1.0
42	<i>Prenanthes racemosa</i>	smooth rattlesnakeroot	0.7			
43	<i>Pycnanthemum virginianum</i>	Virginia mountain mint	0.2		0.5	
44	<i>Ratibida pinnata</i>	gray-headed coneflower	3.4	1.0	2.0	3.0
45	<i>Rosa arkansana</i>	prairie rose	1.9			
46	<i>Rudbeckia hirta</i>	black-eyed susan	2.8	1.0	1.0	1.0
47	<i>Scrophularia lanceolata</i>	Lance-leaved Figwort	0.9		1.0	



48	<i>Silphium integrifolium</i>	rosinweed	10.6			
49	<i>Silphium laciniatum</i>	compass plant	9.7			
50	<i>Solidago rigida</i>	stiff goldenrod	0.6	1.0	1.0	1.0
51	<i>Solidago speciosa</i>	showy goldenrod	0.7			
52	<i>Tradescantia ohiensis</i>	Ohio spiderwort	6.9			
53	<i>Verbena hastata</i>	blue vervain	1.4	1.0		1.0
54	<i>Verbena stricta</i>	hoary vervain	1.5		0.5	0.5
55	<i>Veronicastrum virginicum</i>	Culver's root	1.4			
56	<i>Vicia americana</i>	American vetch	3.7			
57	<i>Zizia aurea</i>	golden alexanders	2.2		0.5	
<b>Total forbs</b>			<b>158.0</b>	<b>16.0</b>	<b>20.0</b>	<b>14.0</b>
<b>Total gram &amp; forbs</b>			<b>32.3</b>	<b>21.0</b>	<b>25.0</b>	<b>19.0</b>
<b>Native species not seeded</b>						
1	<i>Achillea millefolium</i>	yarrow		0.5		1.0
2	<i>Ambrosia artemisifolia</i>	common ragweed			0.5	
3	<i>Aster pilosus</i>	frost aster		0.5		
4	<i>Cirsium discolor</i>	field thistle				2.0
5	<i>Conyza canadensis</i>	horseweed			1.0	
6	<i>Helianthus rigida</i>	stiff sunflower		1.0	1.0	
7	<i>Oenothera biennis</i>	evening primrose		0.5		
8	<i>Panicum sp</i>	giant witchgrass sp			0.5	
9	<i>Pascopyrum smithii</i>	western wheatgrass			0.5	
10	<i>Solidago canadensis</i>	Canada goldenrod		2.0	2.0	2.0
11	<i>Solidago gigantea</i>	late goldenrod			2.0	
12	<i>Teucrium canadense</i>	American germander		1.0		
				6.0	7.0	3.0
<b>Non-native species</b>						
	<i>Cirsium arvense</i>	Canada thistle		1.0		
	<i>Pastinaca sativa</i>	wild parsnip		0.5		
	<i>Phalaris arundinacea</i>	reed canary grass		1.0	0.5	1.0
	<i>Setaria faberi</i>	giant foxtail				0.5
	<i>Setaria pumilla</i>	yellow foxtail		2.0		
	<i>Verbascum thapsus</i>	common mullein				1.0
				4.0	1.0	3.0

\* Cover Classes: 0.5 (0-1%), 1 (1-5%), 2 (5-25%), 3 (25-50%), 4 (50-75%), 5 (75-100%).

#### Notes

9/10/18: Natives dominate (90%), but mostly grasses. Switchgrass too abundant, also big blue. Forb cover/diversity fairly low.

It was a burn year, which favors grasses, so forbs may rebound next year.

Lots of yellow foxtail.

Canada goldenrod likely to take over. Need to control.

Roadside is bad - all thistle. Need to re-do.

Dredge pile area is worst for weeds, RCG. Better closer to rd

7/31/19:

Good balance gram:forb. Approx 50:50 or 60:40

East end looks especially fabulous - abundant forbs

9/4/20: Borrow pit and east are getting heavily dominated by switchgrass.

Very few forbs there or other species.

West end has a little more forbs than before.

Overall diversity is low.

Species count may be less due to late season survey.

Plan to graze switchgrass area in 2021.

## APPENDIX C. Activities Log – all units

Date	Unit	Activity	Who	Outcome	Herbicide rpt
<b>FOREST UNITS</b>					
9/10/20	DD1e	Exotic brush follow-up	GRG	Buckthorn - foliar spray Triclopyr	x
9/2/20	DD2a	Exotic brush follow-up	GRG	Cut/treat.	
10/7/21	DD2a	Eval and veg survey.	FMR-KS	Need to scout for missed BT - several >4" stems - most are males. Cut berries off one female. There is still a lot of wood chip on the ground. A moderate amount of seeded grasses are present (about 30% cover). Need to spray garlic mustard this fall or spring '21. Overall large patches unvegetated, cover is about 50%. May need to broadcast more seed in '21.	
2/23/21	DD2a	Exotic brush control	GRG	Cut/stump treat, stack. Used daubers. Jan 2 days	Garlon 4
10/9/20	DD2b	Exotic brush follow-up. 2018 vol event area.	GRG	9/10 Buckthorn - foliar spray Triclopyr. 9/10- transline for BFT, burdock & bl locust. 10/9- spray grass with "Tapout" =clethodim.	
9/4/20	DD2b south edge	Eval	FMR-KS	Looks GOOD. Sib elm trees dead, Ground cover is dense Ageratina, wild rye in dense patches. Some HS - need to treat in early spring.	
2/23/21	DD4	Exotic brush control	GRG	Cut/stump treat, stack. Used daubers. Jan & Feb, 6 days	Garlon 4
10/7/21	OF1	Eval	FMR-KS	Solid honeysuckle on north edge of OF1, south edge of DP1. GRG cut in Dec. Rest of unit - low diversity, no shrubs. All woody plants have been browsed including buckthorn. Buckthorn cover low, and small plants. Wood nettle dominant forb. Earthworms=5.	
10/7/20	OF2	Eval	FMR-KS	West edge of OF2 is thicket of buckthorn, 8' tall, $\leq 1/2$ " stems, virtually nothing else. Was cleared once many years ago.	
11/25/20	OF2	Follow-up exotic woody control on additional ac not completed in 2019	GRG	Buckthorn - foliar spray <b>TRYCERA</b> . Also used 3A. (Uphill is Trycera, downhill is 3A) South border: 11/25, cut/treat HS & BT, G4, handsprayer. 4 days 9/18-11/25	x
2/23/21	OF2	Exotic brush control	GRG	Cut/stump treat, stack. Garlon 4, daubers. Jan & Feb, 8 days	x
2/23/21	OF2	Broadcast seed	GRG	Grass mix in openings and the foliar sprayed unit.	

Date	Unit	Activity	Who	Outcome	Herbicide rpt
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#### FOREST UNITS

8/25/20	R wds betw bluff prairies	eval	FMR-KS	Woods betw SGP-I & H not bad - BT saplings will need to be cut in 2 yrs. Betw F & D - good. 2-4ft BT, not abund.	
10/14/20	SS mid	Exotic brush control	GRG		x
9/15/20	SS north	Eval	FMR-KS	Get grass seeds for sparse areas. Spot spray small plants later in fall when natives are dormant, cut/treat larger stems.	
10/14/20	SS north	Exotic brush control	GRG	Triclopyr, foliar	x
2/23/21	SS north	Broadcast seed	GRG	Grass mix	

#### NEW PRAIRIE RESTORATION UNITS

8/19/20	DD1a	Invasive forb control	GRG	Cut and bagged - thistles, knapweed etc.	
11/23/20	DD1a	Eval	FMR	Lots of spotted knapweed along road edge, esp by old road bed to the north.	
8/31/20	G1a, G1b	Invasive forb control	GRG	Cut and bagged - thistles, knapweed etc. 8/1, & 8/31	
8/31/20	G1a (east)	Mowed goldenrod	GRG		

#### OLD SAVANNA RESTORATION UNITS

8/25/20	SV1a	Eval	FMR-KS	The area mowed in 2019 for goldenrod (and rosettes sprayed in fall '19) Looked good. Towering big bluestem. Goldenrod still abundant but much reduced.	
8/26/20	SV-1e, SV-3, MP-1	Cut/mow/pull invasives	GRG	Thistles, etc.	
8/26, 10/2/20	MP-2	Prairie mgmt	GRG	Oversprayed MP2 - NW 1/2 with glyphosate, SE 1/2 with Tapout (grass herbicide). Milestone throughout for BFT.	
9/1, 9/3, 10/9/20	All SVs	Manage SV for non-natives herbaceous and woody plant.	GRG	Black locust - basal bark or girdle with G4 and Milestone. Buckthorn foliar, Garlon 3a.	x
8/26/20	SV3	Mow goldenrod	GRG	done	
9/4/21	SV2	Eval	FMR-KS	Canada goldenrod is taking over. Plan to mow in 2021 (Aug).	
8/25/20	Swift House	Eval	FMR-KS	Not used in 2020.	



**BLUFF PRAIRIE UNITS**

Date	Unit	Activity	Who	Outcome	Herbicide rpt
8/25/20	SGP A-I	James polanisia survey	FMR-KS	Total of 35 plants. 93% less than 2019.	
8/25/20	SGP A-I	eval	FMR-KS	Unit I overrun with mullein - notified GRG to lop and bag.	
11/12/20	SGP A-I	Prairie maintenance	GRG	A, B: black locust on wd edge - basal treat with G4 and Triclopyr. SGP-I: Cut/stump buckthorn, Triclopyr. 4 dates 8/20-11/12/20	
9/3/20	SGP A-B	Exotic brush control	GRG	Black locust. Garlon, Milestone	X
1/7/21	SGP-E	Seeding	FMR-KS	Broadcast seed mix (Used the mix for SV, purchased in 2019)	
11/24/20	SGP-k,m,n,o,p, DP1	Invasive <b>forb &amp; woody</b> control	GRG	11/24: Buckthorn and Honeysuckle, triclopyr. 3 dates 8/19-11/24/20	x
1/20/21	SGP-O	Exotic brush control	GRG	Cut/stump treat, stack. Used daubers. Jan, Feb, 5 dates.	Garlon 4
1/7/21	SV1c	Eval	FMR-KS	Southern side of the SV1c unit, near SGPe and to the west, has become really overgrown with cherry/other woody. Need to cut/treat/burn. Also knoll west of SGPe- need to stack and burn cut honeysuckle. Also, west of SGP-e, edge of prairie, is <b>barberry</b> .	
1/20/21	SV1c	Eval	GRG	Cut/treated cherries.	x

## APPENDIX D. 2020 POLLINATOR SURVEY

### A Survey of Bumble Bees and Butterflies at Flint Hills Resources' Pine Bend Bluffs



#### Final Report - 2020

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##### Prepared For:

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## Study Area:

Flint Hills Resources property is located in Dakota County, Minnesota and is owned by Flint Hills Resources, LLC (44.771211° N, 93.030100° W; WGS 84). Portions of the property east of Highway 52 are maintained and enhanced to benefit natural resources in collaboration with Friends of the Mississippi River. The areas surveyed are approximately 65 acres (Figure 1).

## Survey Methods:

Insect surveys were completed in five plots (Figure 1; Table 1), and targeted butterflies (including skippers) and bumble bees. Surveys consisted of meandering walks throughout a plot, and focused on areas within the plot with floral resources when present. A handheld GPS unit was used to avoid meandering through areas of the plot already surveyed that day, and to avoid meandering into adjacent plots. Insect plot surveys were time-constrained to 15-30 minutes per plot per visit depending on plot size (Table 1). The same single observer was used to complete these surveys. Plots were surveyed twice per month in both August and September. Surveys were not conducted in May-July due to scheduling and contract delays associated with the global COVID-19 pandemic. Surveys were conducted between 1330 hrs and 1730 hrs during weather conditions suitable for butterfly and bumble bee activity. Unless otherwise noted, only individuals identifiable to species-level were recorded (i.e., unknown flybys were not counted). Due to the difficult nature of field identification for a few species of bumble bee, and one species of butterfly, individuals were either recorded at the genus level (e.g., crescent butterflies) or as species groups (e.g., *Bombus vagans* / *sandersoni*). When practicable, photographs were taken for documentation purposes.

Table 1: Survey plots and survey durations per visit.		
Plot Name	Approximate Acreage	Survey Duration (mins)
Remnant 1	14	30
Remnant 2	4	15
Remnant 3	5	15
Restoration 1	14	15
Restoration 2	28	30

## Results:

Eighteen species of butterfly and nine species, or species groups, of bumble bee were detected during these surveys (Table 2 and Table 3, respectively). Plots where each of the butterfly and bumble bee species occurred are also reported, reference Figure 1 for plot locations. Total counts for each species are reported in Table 4. Observations per 15 minutes of survey (i.e.,

effort) was quantified for those species with 10 or more observations. Effort was calculated for plots receiving 15 mins of survey per visit by taking the total count per species for a plot divided by the number of times surveys were completed (Formula 2). For plots receiving 30 mins of survey per visit, effort was calculated by taking the total count per species for a plot divided by two times the number of visits (Formula 3). and A site level (i.e., “Combined”) effort calculation is also provided (Formula 4). A summary of observations by unit effort is included in Table 5. Due to the difficulty in identifying crescent butterflies in the field, all crescents are reported to genus level.

**Formula 2:**  $Effort (15) = Count \div \# \text{ of visits}$

**Formula 3:**  $Effort (30) = Count \div (2 \times \# \text{ of visits})$

**Formula 4:**  $Combined = \Sigma Effort \div \# \text{ plots}$

<b>Table 2: Species list of butterflies detected during insect plot surveys.</b>		
<b>Common Name</b>	<b>Scientific Name</b>	<b>Plot Detected</b>
Cabbage White	<i>Pieris rapae</i>	Remnant 1, Remnant 2, Remnant 3, Restoration 1, Restoration 2
Clouded Sulphur	<i>Colias philodice</i>	Remnant 2, Remnant 3, Restoration 1, Restoration 2
Common Buckeye	<i>Junonia coenia</i>	Remnant 3
Common Checkered Skipper	<i>Pyrgus communis</i>	Remnant 3
Eastern Comma	<i>Polygonia comma</i>	Remnant 1
Eastern Tailed-blue	<i>Everes comyntas</i>	Remnant 1, Remnant 2, Remnant 3, Restoration 2
Eastern Tiger Swallowtail	<i>Papilio glaucus</i>	Remnant 2, Restoration 1, Restoration 2
Gray Comma	<i>Polygonia progne</i>	Remnant 1
Great Spangled Fritillary	<i>Speyeria cybele</i>	Remnant 1, Restoration 1, Restoration 2



Little Yellow	<i>Eurema lisa</i>	Restoration 2
Monarch Butterfly	<i>Danaus plexippus</i>	Remnant 1, Remnant 2, Remnant 3, Restoration 1, Restoration 2
Northern Broken-Dash	<i>Wallengrenia egeremet</i>	Remnant 1
Orange Sulphur	<i>Colias eurytheme</i>	Remnant 1, Remnant 2, Remnant 3, Restoration 1, Restoration 2
Painted Lady	<i>Vanessa cardui</i>	Remnant 3, Restoration 1
Peck's Skipper	<i>Polites peckius</i>	Remnant 1
Red Admiral	<i>Vanessa atalanta</i>	Remnant 1
Silver-spotted Skipper	<i>Epargyreus clarus</i>	Remnant 2, Remnant 3, Restoration 1
Unknown Crescent	<i>Phyciodes</i> sp.	Remnant 2, Restoration 2

**Table 3: Species list of bumble bees detected during insect plot surveys.**

Common Name	Scientific Name	Plot Detected
Black and Gold / American Bumble Bee	<i>Bombus auricomus / pensylvanicus</i>	Remnant 1, Remnant 3, Restoration 1, Restoration 2
Brown-belted Bumble Bee	<i>Bombus griseocollis</i>	Remnant 1, Remnant 3, Restoration 1, Restoration 2
Common Eastern Bumble Bee	<i>Bombus impatiens</i>	Remnant 1, Remnant 2, Remnant 3, Restoration 1, Restoration 2
Half Black / Sanderson's Bumble Bee	<i>Bombus vagans / sandersoni</i>	Remnant 1, Remnant 2, Remnant 3, Restoration 1, Restoration 2
Lemon Cuckoo Bumble Bee	<i>Bombus citrinus</i>	Remnant 1, Remnant 2, Remnant 3, Restoration 1, Restoration 2
Red-belted Bumble Bee	<i>Bombus rufocinctus</i>	Remnant 1, Remnant 2, Remnant 3, Restoration 1, Restoration 2

Rusty-patched Bumble Bee	<i>Bombus affinis</i>	Restoration 2
Two-spotted Bumble Bee	<i>Bombus bimaculatus</i>	Restoration 2
Yellow Bumble Bee	<i>Bombus fervidus</i>	Remnant 2, Restoration 2

**Table 4: Total count of butterfly and bumble bee species detected during insect plot surveys.**

Common Name	Scientific Name	Count
Black and Gold / American Bumble Bee	<i>Bombus auricomus / pensylvanicus</i>	75
Brown-belted Bumble Bee	<i>Bombus griseocollis</i>	55
Common Eastern Bumble Bee	<i>Bombus impatiens</i>	258
Half Black / Sanderson's Bumble Bee	<i>Bombus vagans / sandersoni</i>	41
Lemon Cuckoo Bumble Bee	<i>Bombus citrinus</i>	80
Red-belted Bumble Bee	<i>Bombus rufocinctus</i>	23
Rusty-patched Bumble Bee	<i>Bombus affinis</i>	1
Two-spotted Bumble Bee	<i>Bombus bimaculatus</i>	1
Yellow Bumble Bee	<i>Bombus fervidus</i>	2
Cabbage White	<i>Pieris rapae</i>	98
Clouded Sulphur	<i>Colias philodice</i>	8
Common Buckeye	<i>Junonia coenia</i>	1
Common Checkered Skipper	<i>Pyrgus communis</i>	1
Eastern Comma	<i>Polygonia comma</i>	1
Eastern Tailed-blue	<i>Everes comyntas</i>	34

Eastern Tiger Swallowtail	<i>Papilio glaucus</i>	4
Gray Comma	<i>Polygonia progne</i>	1
Great Spangled Fritillary	<i>Speyeria cybele</i>	6
Little Yellow	<i>Eurema lisa</i>	1
Monarch Butterfly	<i>Danaus plexippus</i>	402
Northern Broken-Dash	<i>Wallengrenia egeremet</i>	1
Orange Sulphur	<i>Colias eurytheme</i>	24
Painted Lady	<i>Vanessa cardui</i>	2
Peck's Skipper	<i>Polites peckius</i>	1
Red Admiral	<i>Vanessa atalanta</i>	1
Silver-spotted Skipper	<i>Epargyreus clarus</i>	3
Unknown Crescent	<i>Phyciodes</i> sp.	2

**Table 5: Observations per 15 minutes of effort for those species with 10 or more observations. Observation rates are included at the plot level and as a combined mean across the entire property. An asterisk (\*) identifies those species that were observed in all five insect survey plots.**

Common Name	Scientific Name	Count/Effort					
		Remnant			Restoration		Combined
		1	2	3	1	2	
Black and Gold / American Bumble Bee	<i>Bombus auricomus / pensylvanicus</i>	0.13	0.00	0.00	7.25	5.5	2.58
Brown-belted Bumble Bee	<i>Bombus griseocollis</i>	0.38	0.00	0.25	7.25	2.75	2.13
Common Eastern Bumble Bee*	<i>Bombus impatiens</i> *	0.88	1.75	1.50	34.75	12.38	10.25
Half Black / Sanderson's Bumble Bee*	<i>Bombus vagans / sandersoni</i> *	0.38	0.50	1.25	4.50	1.63	1.65
Lemon Cuckoo Bumble Bee*	<i>Bombus citrinus</i> *	2.38	7.75	2.25	0.25	2.50	3.03
Red-belted Bumble Bee*	<i>Bombus rufocinctus</i> *	0.50	1.00	0.25	2.25	0.63	0.93
Cabbage White*	<i>Pieris rapae</i> *	3.88	4.00	3.25	3.00	3.25	3.48
Eastern Tailed-blue	<i>Everes comyntas</i>	1.75	1.75	2.50	0.00	0.38	1.28
Monarch Butterfly*	<i>Danaus plexippus</i> *	2.75	2.25	2.75	63.25	13.38	16.88
Orange Sulphur*	<i>Colias eurytheme</i> *	0.38	2.00	1.00	0.88	0.25	0.90



## Discussion:

Generally speaking, bumble bees were more abundant in restorations when compared to remnants. Butterfly abundance was approximately the same between remnants and restorations, with the exception of the Monarch Butterfly which was much more abundant in restorations. Bumble bee and butterfly communities are typical for eastern Minnesota. Bumble bee species encountered during these surveys were the same as those encountered during 2019 surveys, however butterfly species richness was lower which I attribute to phenological differences resulting from the lack of surveys May-July (see methods)(Smith 2019). No rare or state-listed butterflies were encountered.

Both the yellow bumble bee (*Bombus fervidus*) and the rusty-patched bumble bee (*Bombus affinis*) were detected during surveys, and both species have been identified by the Department of Natural Resources as a species in greatest conservation need (SGCN). In addition, the rusty-patched bumble bee was listed as endangered under the federal Endangered Species Act by the U.S. Fish & Wildlife Service in 2017. As was the case in 2019, only a single male rusty-patched bumble bee was detected in 2020. Despite the presence of seemingly high-quality habitat at Flint Hills, it appears that rusty-patched bumble bees are rare on site and perhaps limited to dispersing males. Increasing the number of “Plants Favored by Rusty Patched Bumble Bee” could benefit efforts to enhance habitat for this and other pollinators (USFWS 2020).

## References:

Smith, Christopher E. 2019. A Survey of Bumble Bees and Butterflies at Flint Hills Resources' Pine Bend Bluffs -- Final Report. Friends of the Mississippi River. 11 pp.

USFWS. 2020. Plants Favored by Rusty Patched Bumble Bee. Accessed 13 Dec. 2020.  
<https://www.fws.gov/midwest/endangered/insects/rpbb/plants.html>

## Flint Hills Resources - 2020 Survey Areas

