Plant and Insect Community Responses to Manure Application in Prairies

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Iowa State University

Master's Thesis Defense

May 2023
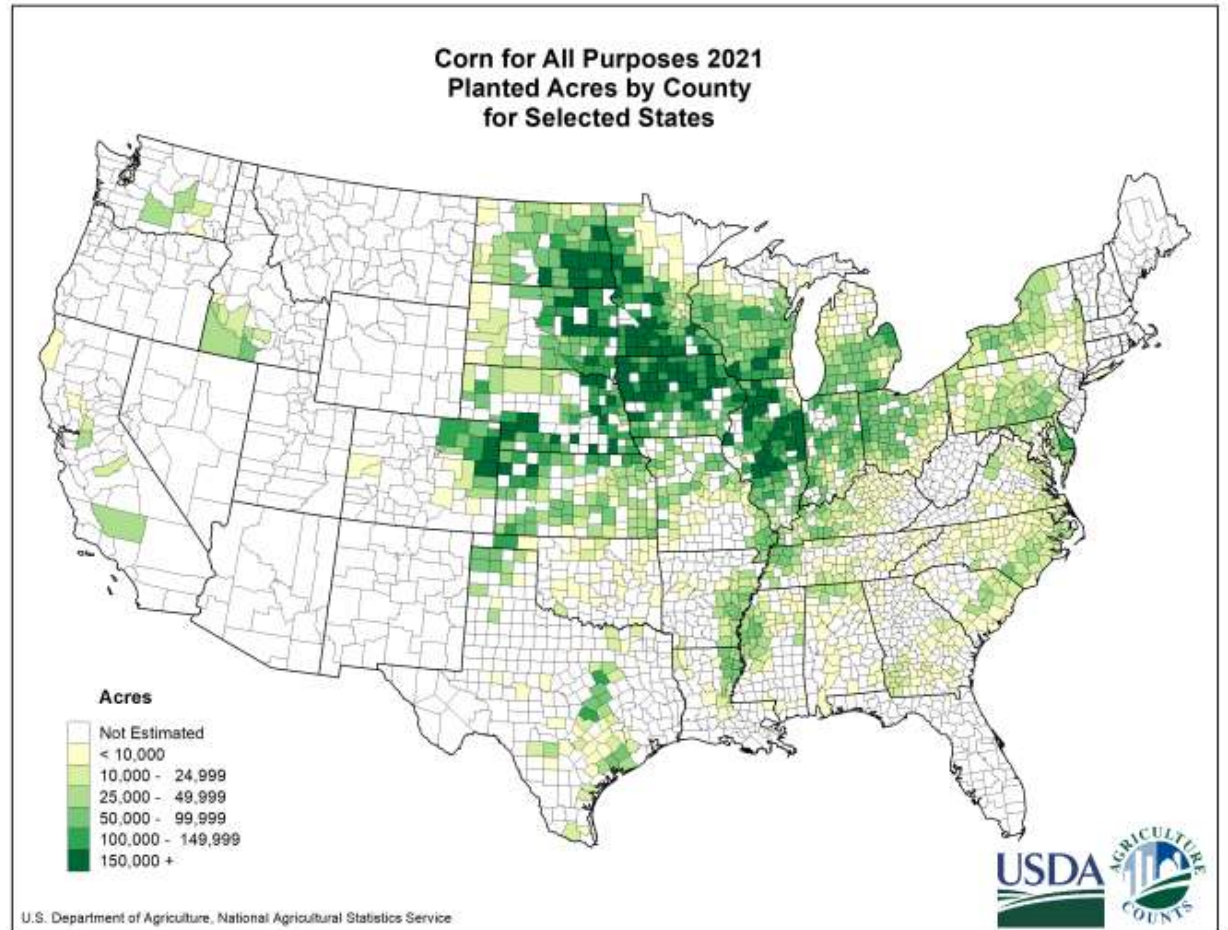
Presentation Summary

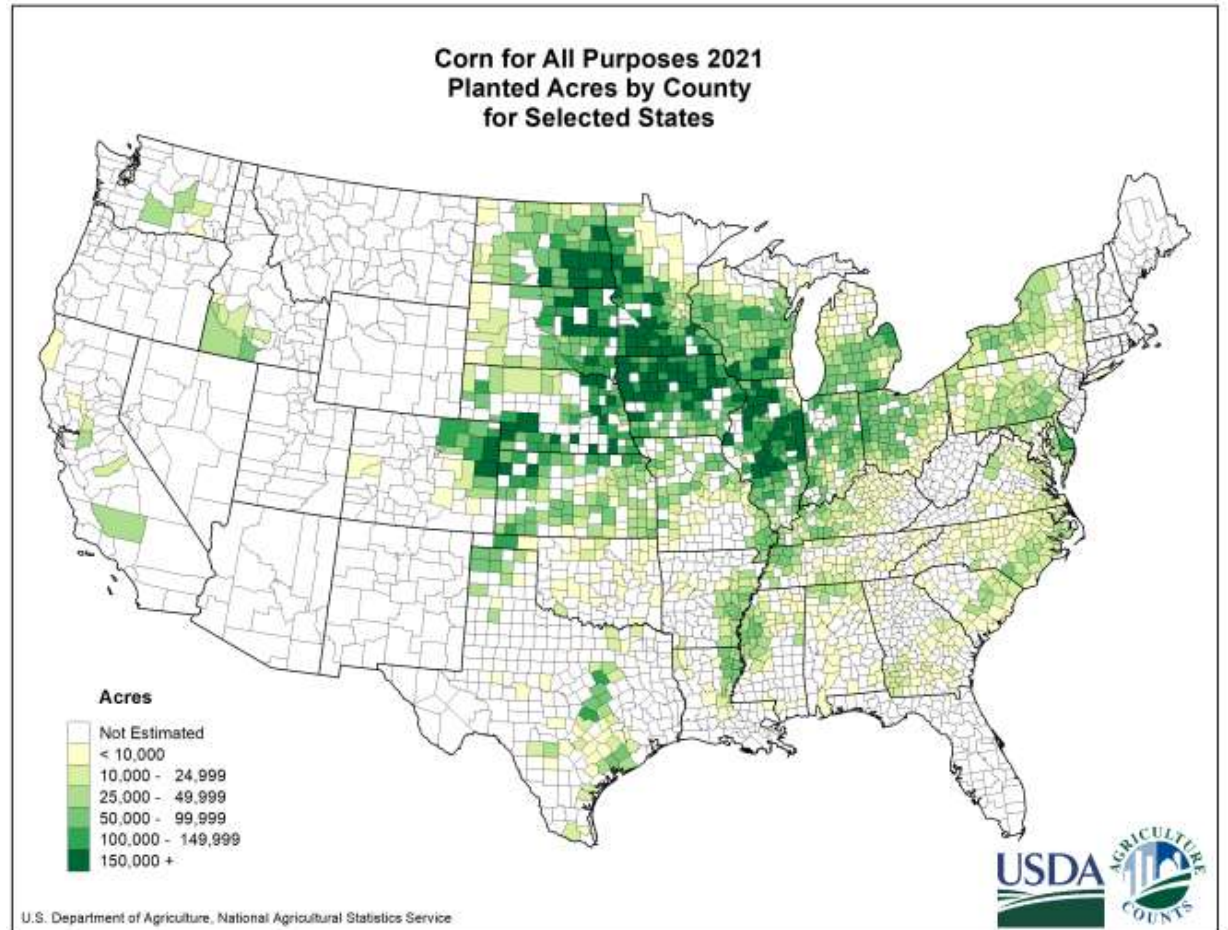INTRODUCTION

RESEARCH OBJECTIVES
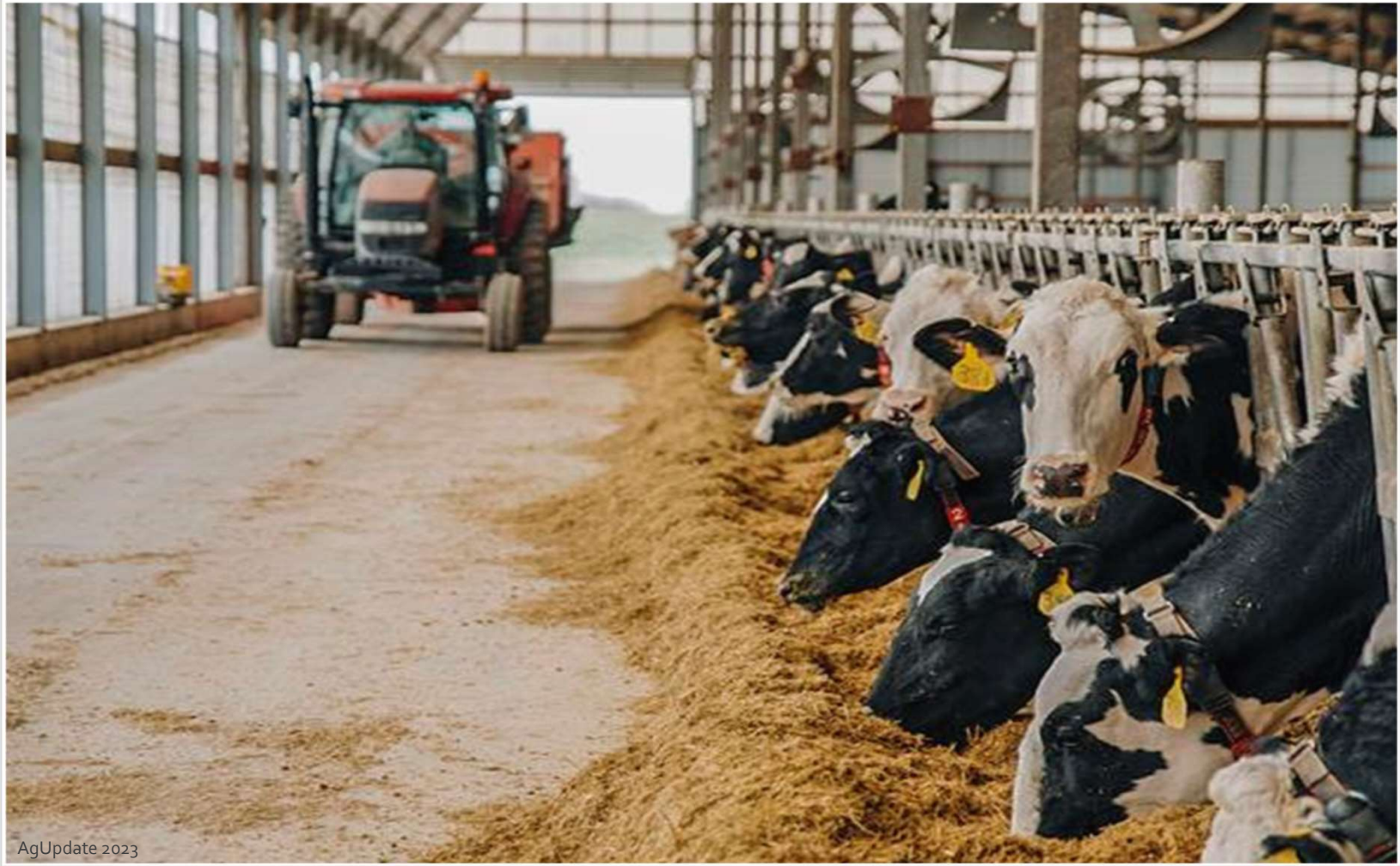
METHODS

RESULTS

DISCUSSION

Midwest Agriculture

Getty Images: halbergman

Corn for All Purposes 2021
Planted Acres by County
for Selected States

Acres

	Not Estimated
	< 10,000
	10,000 - 24,999
	25,000 - 49,999
	50,000 - 99,999
	100,000 - 149,999
	150,000 +

U.S. Department of Agriculture, National Agricultural Statistics Service

USDA

Midwest Agriculture

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	50,000 - 99,999
	100,000 - 149,999
	150,000 +

U.S. Department of Agriculture, National Agricultural Statistics Service

USDA

Best Management Practices

- Vegetative filter strips (VFS)
- Prairie strips

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Primary Research Objective:

How do prairie plant and insect communities respond to incremental manure application?
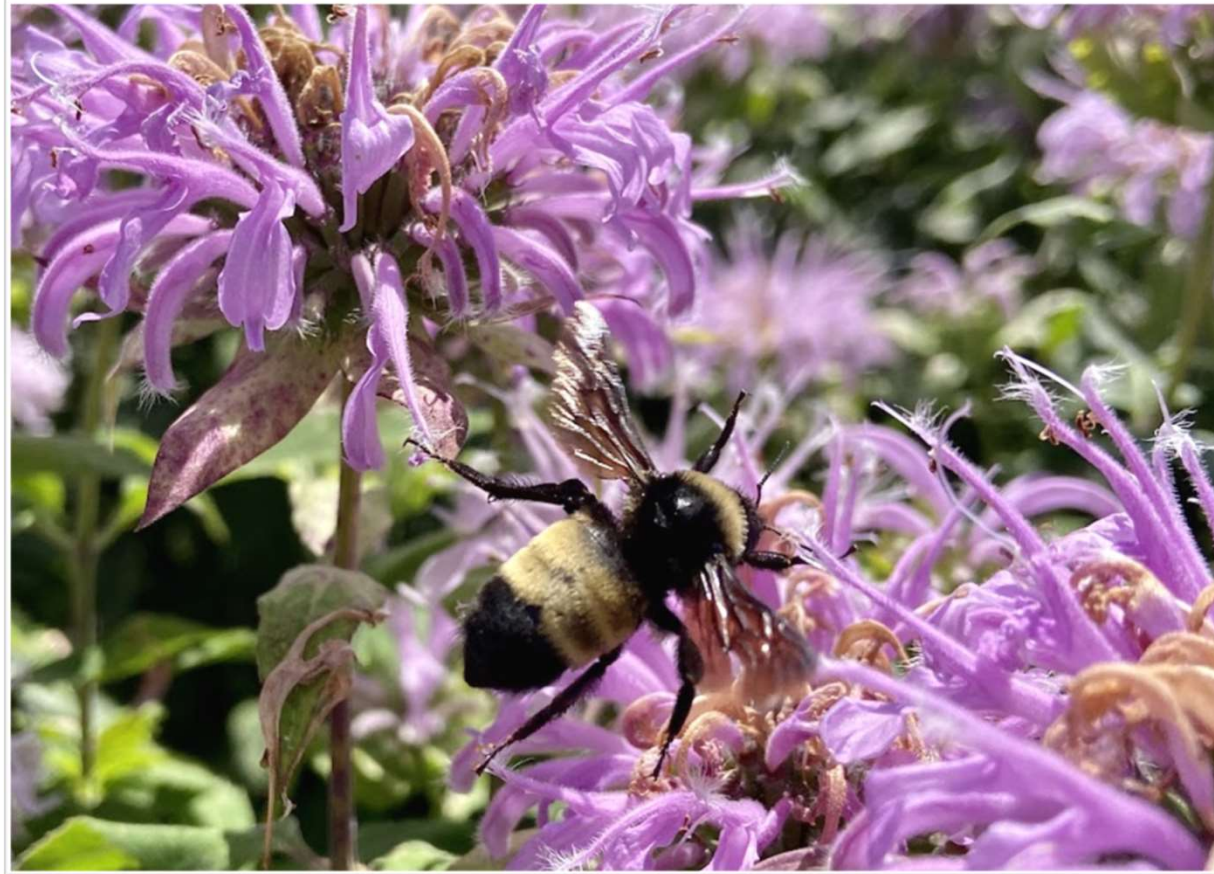
Primary Research Objective:

How do prairie plant and insect communities respond to incremental manure application?

- Soil nutrients

- Floral availability, plant height, and community composition

- Insect community and population abundance

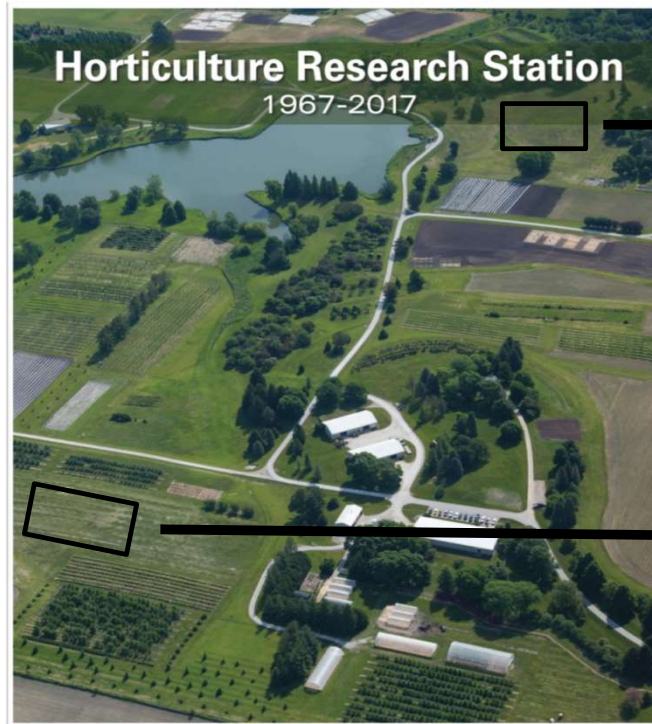 - Beneficial insects (pollinators & predators)

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STRIPS

Methods

Site Preparation & Characteristics

2 Field Sites:
  16 plots/site

- Established tallgrass prairie

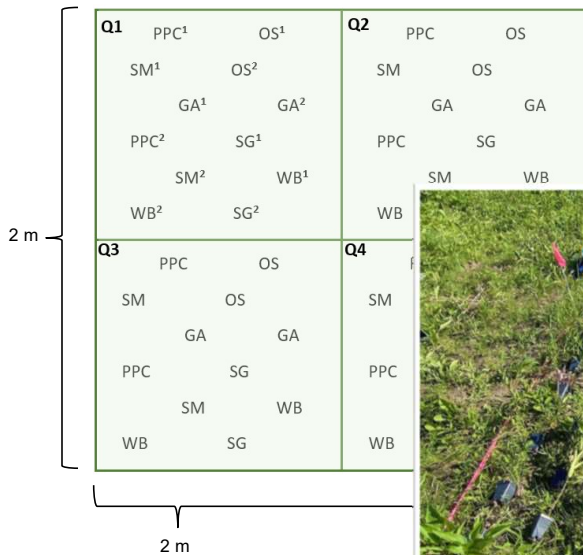- Tilled crop field

Established prairie

Tilled field

Site Preparation & Characteristics

4 m^2 plots

Established prairie plots
48 plants/plot

CODE	COMMON NAME	TYPE
PPC	**Purple prairie clover**	forb
WB	**Wild bergamot**	forb
SM	**Swamp milkweed**	forb
OS	**Ox-eye sunflower**	forb
GA	**Golden Alexander**	forb
SG	**Stiff goldenrod**	forb
BB	**Big bluestem**	grass
IG	**Indian grass**	grass
LB	**Little bluestem**	grass

Tilled field plots
72 plants/plot

Site Preparation & Characteristics

ID	Common/Scientific Name	Individual flower	Bloom Period						Insects Attractiveness	
			MAY	JUNE	JULY	AUG	SEPT	OCT	bees & wasps	natural enemies
GA	Golden Alexander *Zizia aurea*	cluster; umbel							★★	★★★
PPC	Purple prairie clover *Dalea purpurea*	cluster; spike							★★★	★★
SM	Swamp milkweed *Asclepias incarnata*	cluster; umbel							★★	★★★
OS	Ox-eye sunflower *Heliopsis helianthoides*	solitary; flower head							★★	★★★
WB	Wild bergamot *Monarda fistulosa*	cluster; head							★★★	★★★
SG	Stiff goldenrod *Solidago rigida*	cluster							★★★	★★★

= Iowa bloom   ★ = good   ★★ = better   ★★★ = best

Golden Alexander

Purple prairie clover

Swamp milkweed

Ox-eye sunflower

Wild bergamot

Stiff goldenrod

Experimental Design

Treatment levels	Final amount of manure/plot	
6.5 gallons (~25 liters)	gallons	liters
1. Control	0	0
2. Once/season	13	49
3. Biweekly (every other week)	130	492
4. Weekly	260	985

Manure application for 20 weeks (June-Nov) 2021 & 2022

4 randomized plot replications / site

Cumulative amount of manure by treatment across 2-year study
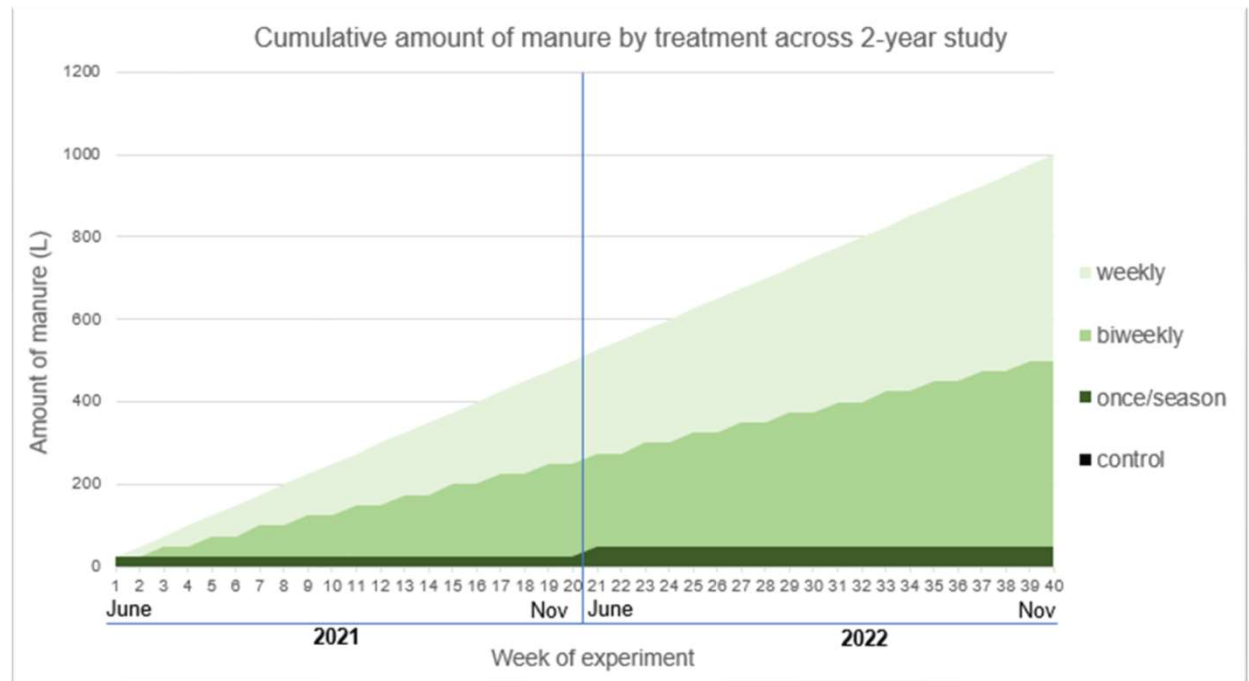
ISU Dairy Farm
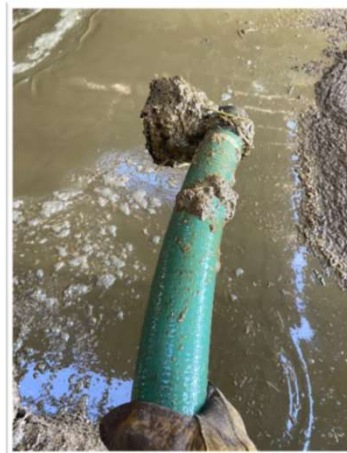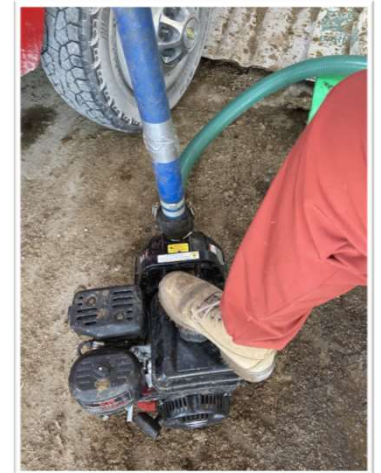
Data Collection: Soil

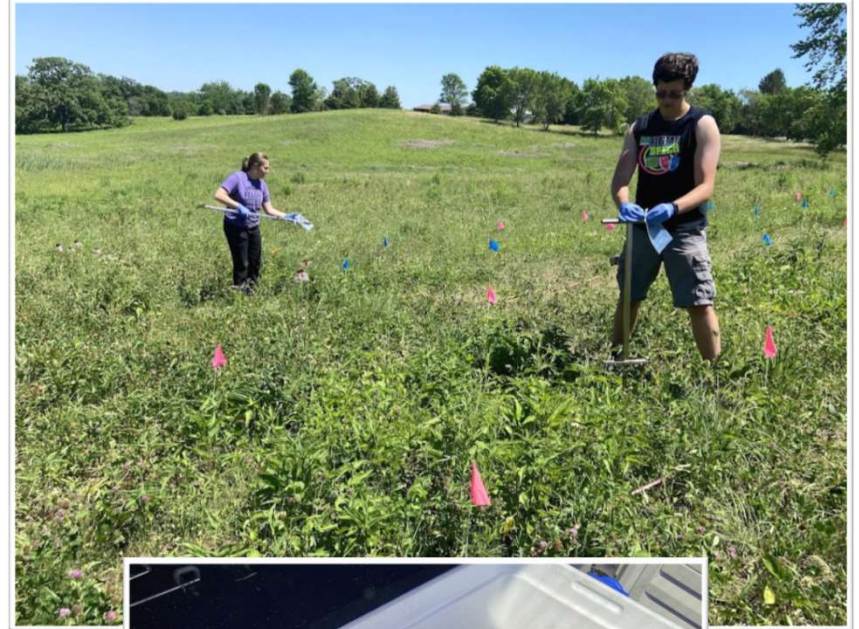How are <u>soil nutrients</u> effected by varying amounts of manure?

1. pH

2. % organic matter

3. Phosphorous

4. Nitrogen

- Baseline (before initial manure application)
- 1 day after initial application
- 1 day after final application of 1st season
- 1 day after final application of 2nd season

Data Collection: Plants

How are <u>floral availability, height, and community composition</u> effected by varying amounts of manure?

1. Floral abundance (number of blooming flowers)

2. Height (length)

3. Surface ground cover (% forb, grass, litter, bare)

4. Aboveground biomass (visual obstruction)

5. Mortality

- **Weekly** sampling until first killing frost = 16 samples/season

Data Collection: Insects

How are <u>insect community and population abundance</u> effected by varying amounts of manure?

- **Biweekly** sampling until first killing frost

  = 9 samples /season

- Sampling occurred **4 – 6 days post-manure application**

  Two beneficial insect guilds = two methods

  1. Pollinators: vacuum

  2. Predators: pitfall traps

2 minutes/plot

1 trap/plot
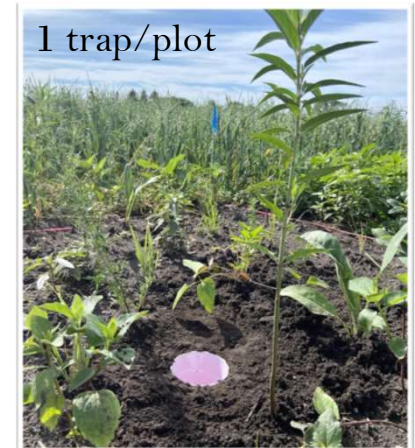
Data Collection: Insects

Statistical Analysis

R

Generalized additive model (GAM)

Response = *f* (Treatment * Year**)**

Smoothed with thin plate spline by **week**

Random effect: plot replications (1–4)

Significance p < 0.05

Pairwise contrasts

Correlation matrix

By the Numbers...

2 years

2 field sites

32 experimental plots

2,068 plants planted

24 trips to dairy farm

4 treatment levels

3,224 gallons of manure (12,200 L)

480 plant heights

55,722 flowers counted

576 pitfall traps
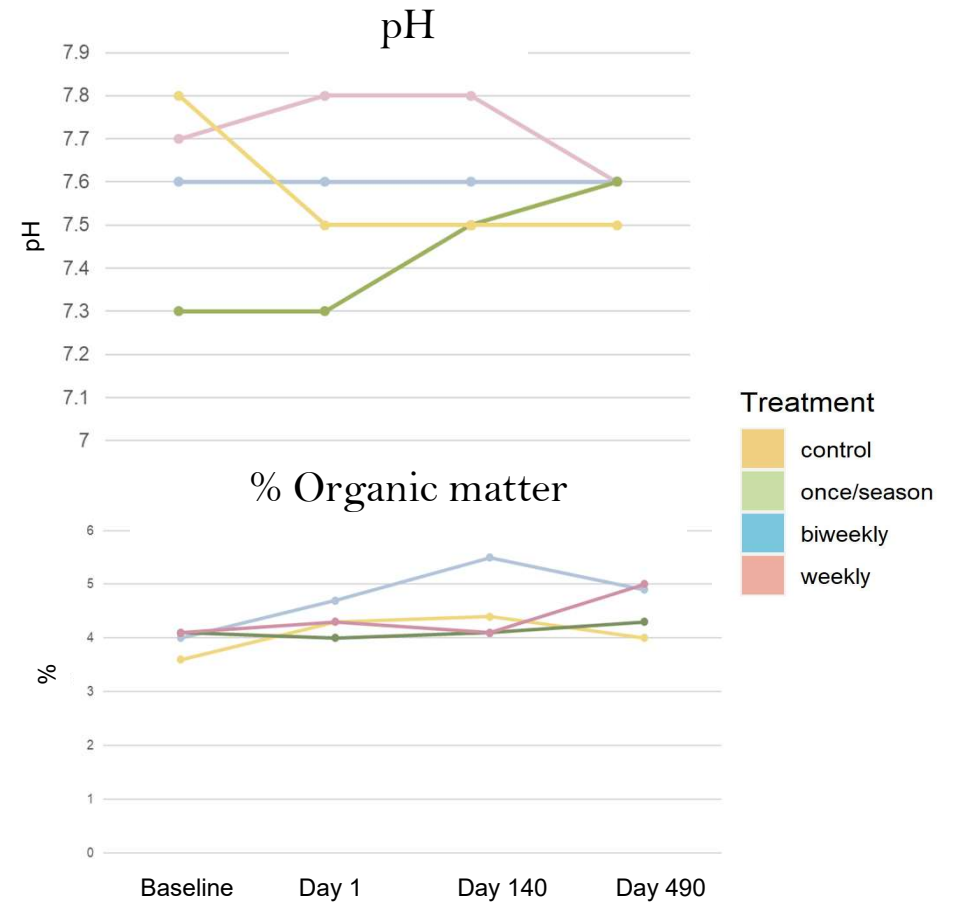
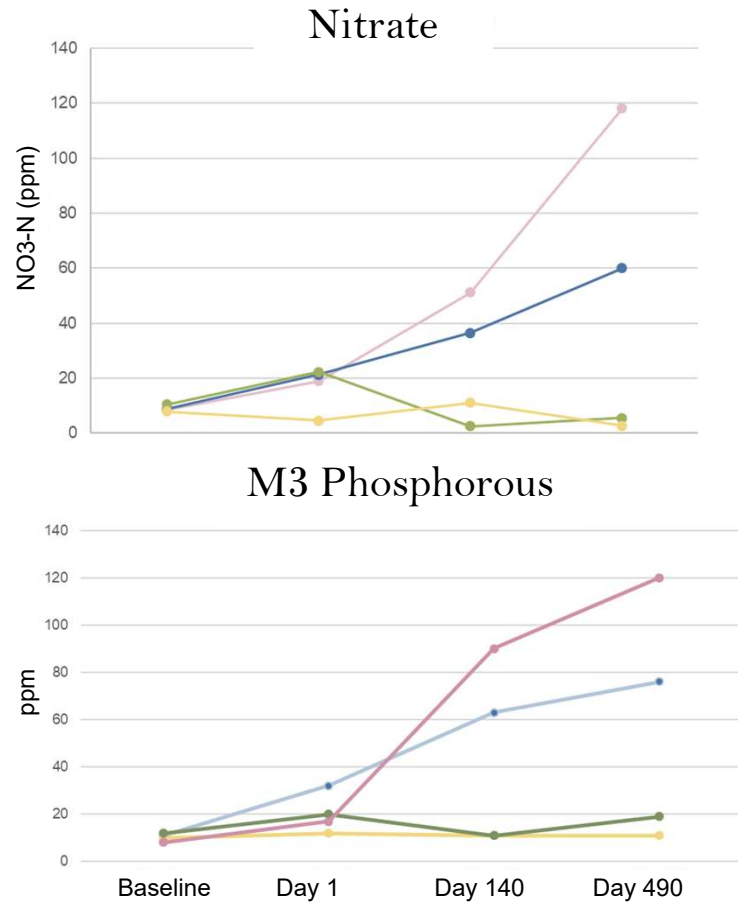**576** vacuum samples

10,619 insects identified

Results

Results: Soil

How are <u>soil nutrients</u> effected by varying amounts of manure?

Nitrate

pH

M3 Phosphorous

% Organic matter

Treatment
- control
- once/season
- biweekly
- weekly

Results: Plants | Floral abundance

1) Experimental plants

Treatment	# flowers 2021	# flowers 2022	Total
control	6	257	**263**
once/season	4	266	**270**
biweekly	6	639	**645**
weekly	12	541	**530**
total	28	1,703	**1,731**

2) Total flowers (experimental plants + existing plants)

Treatment	# flowers 2021	# flowers 2022	Total
control	2,518	2,778	**5,296**
once/season	2,501	3,069	**5,570**
biweekly	3,273	7,463	**10,736**
weekly	3,370	7,273	**10,643**
total	11,662	20,583	**32,245**

purple coneflower (*Echinacea purpurea*)
yellow coneflower (*Ratibida pinnata*)
Philadelphia fleabane (*Erigeron philadelphicus*)
purple fleabane (*Erigeron purpuratus*)
common milkweed (*Asclepias syriaca*)
butterfly milkweed (*Asclepias tuberosa*)
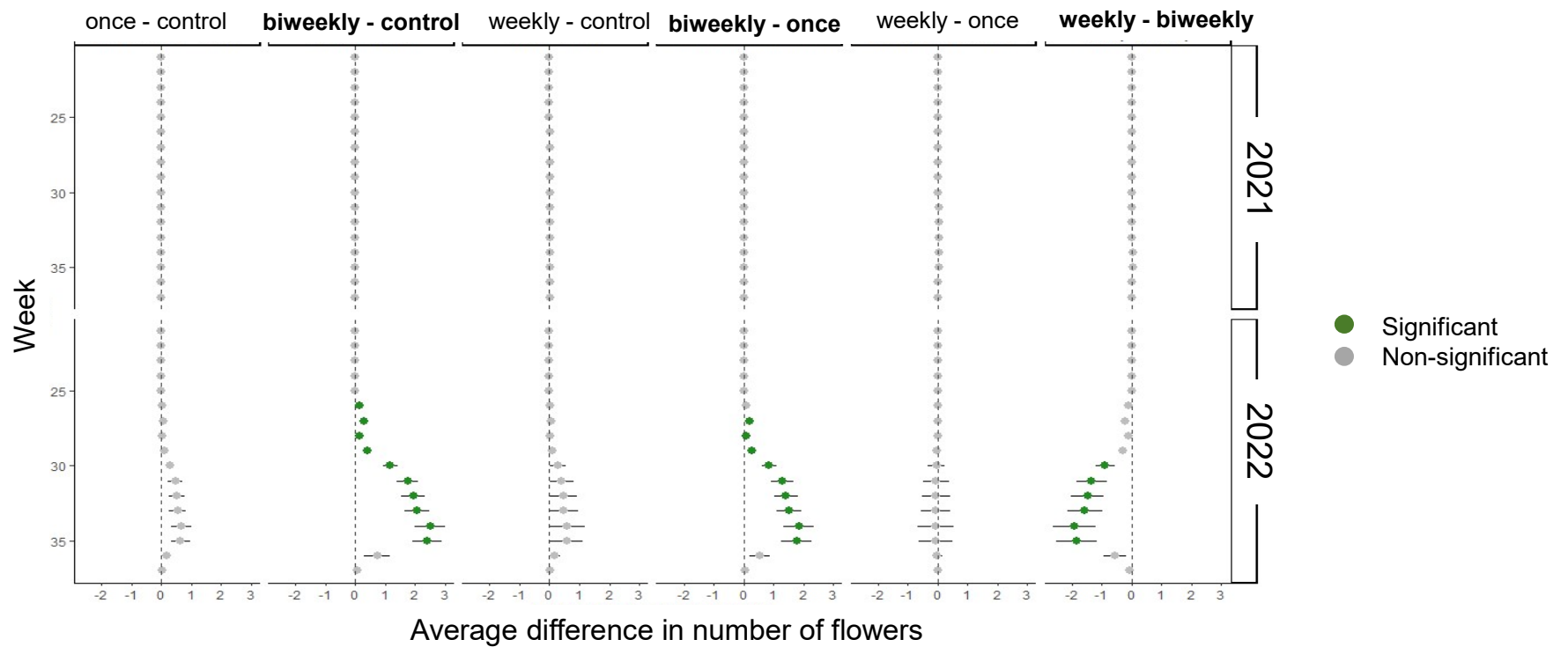Canada goldenrod (*Solidago canadensis*)

Floral abundance

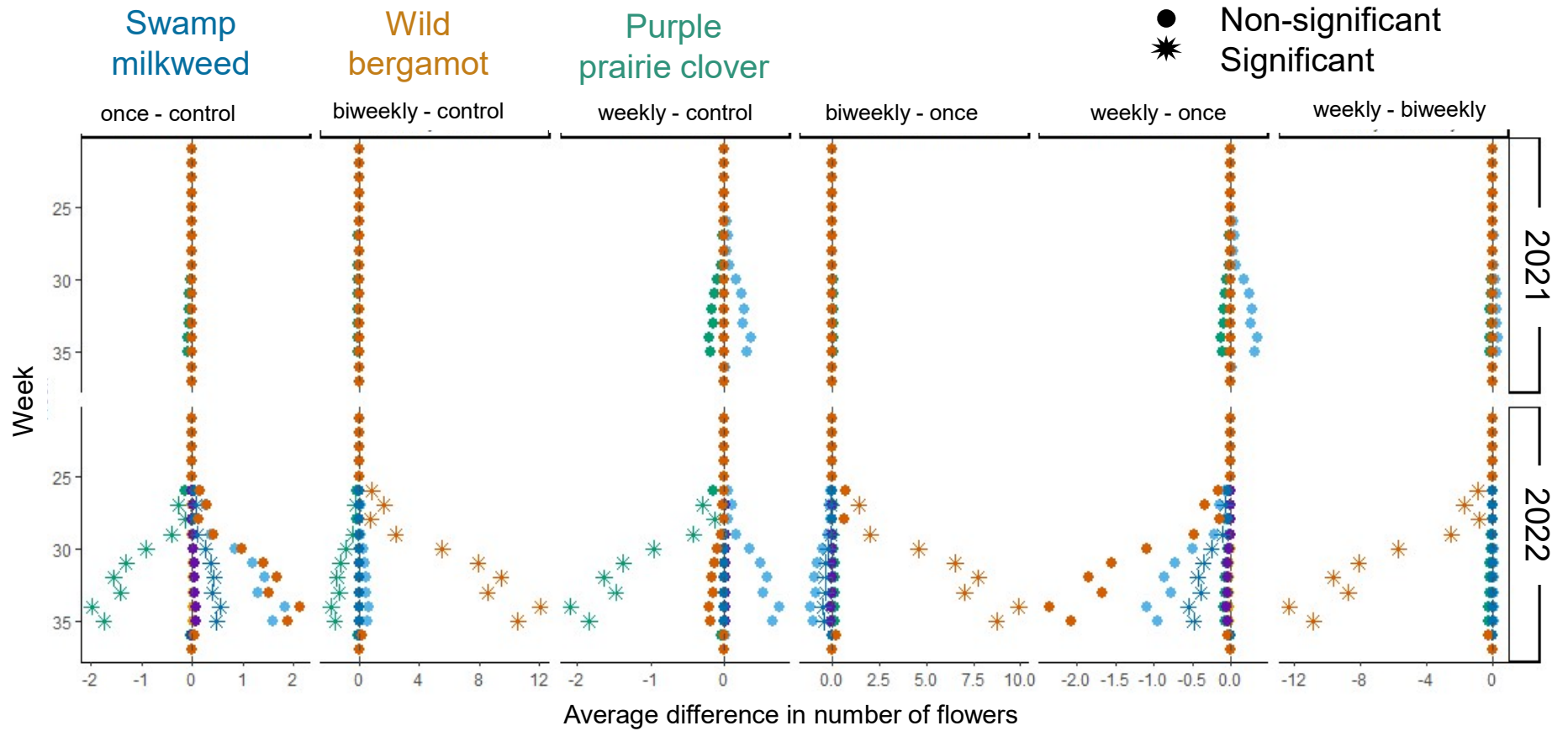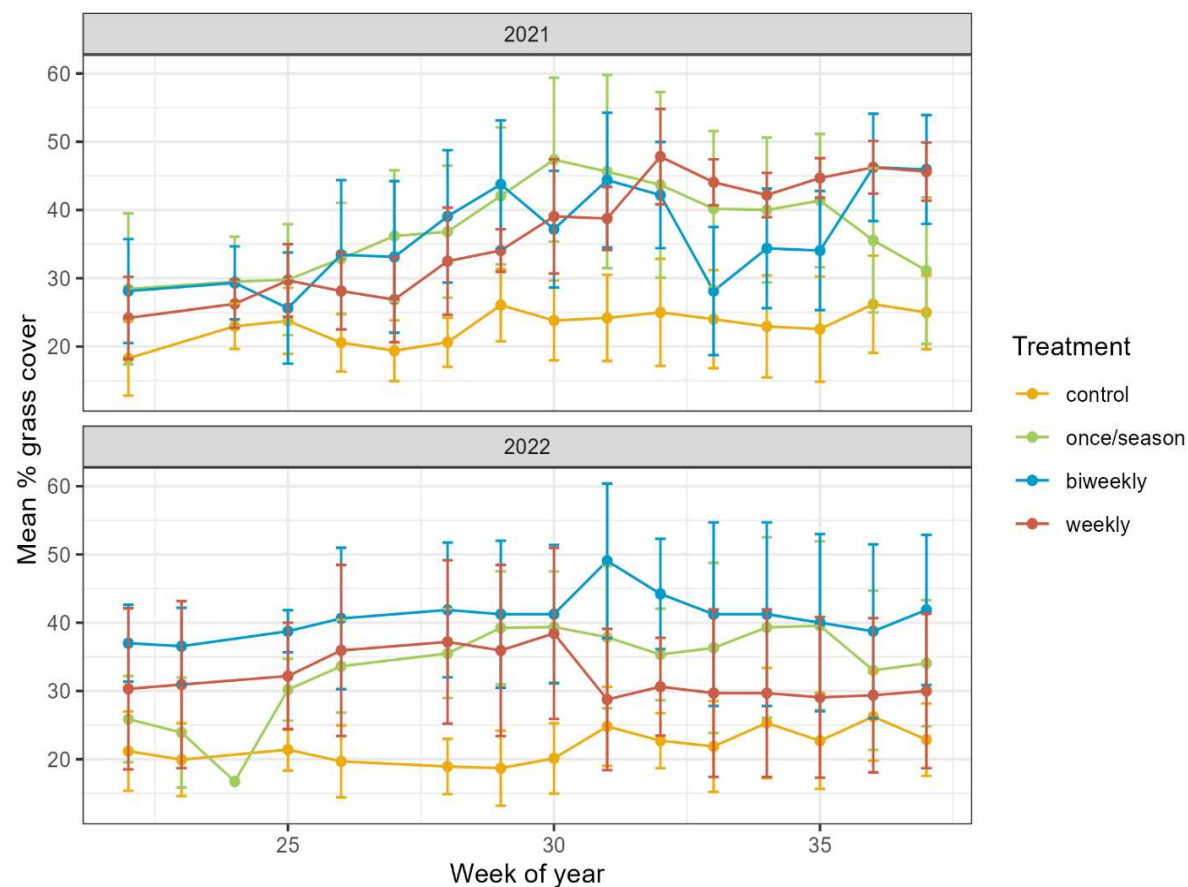**Total flowers** (experimental plants + existing plants)
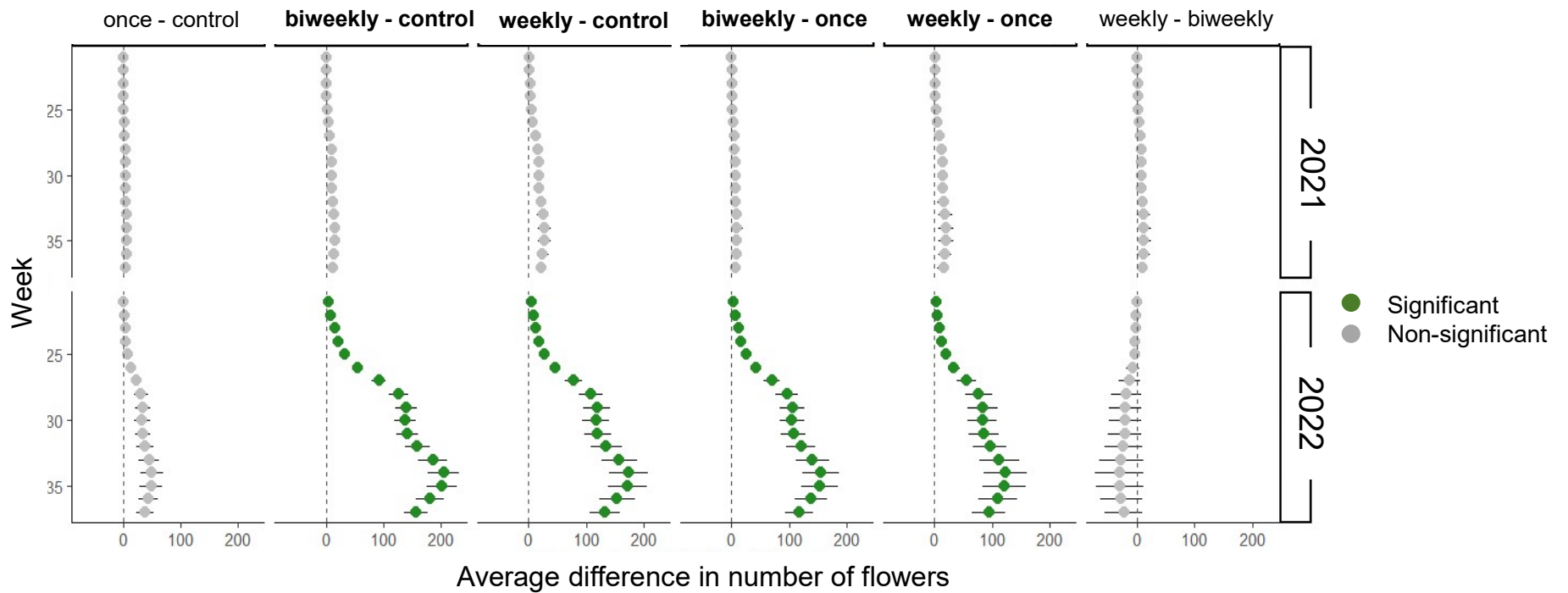
Experimental plants

Ground cover: grass

Mean % grass cover

Treatment	2021	2022
control	23 ± 11.6	22 ± 10.4
once/season	36 ± 19.7	34 ± 17.2
biweekly	36 ± 17.0	41 ± 18.6
weekly	36 ± 12.5	31 ± 20.8

Year	Significant treatment contrast	Estimate (% grass)
	once/season – control	13.87
2021	biweekly – control	12.87
	weekly – control	13.01
	once/season – control	12.25
	biweekly – control	19.13
2022	biweekly – once/season	6.87
	weekly – control	10.019
	weekly – biweekly	-9.11

Ground cover: forbs

Mean % forb cover

Treatment	2021	2022
control	47.5 ± 13.7	69.1 ± 11.3
once/season	42.2 ± 15.0	65.1 ± 11.6
biweekly	46.8 ± 10.7	51.4 ± 18.4
weekly	44.7 ± 7.6	58.6 ± 18.9
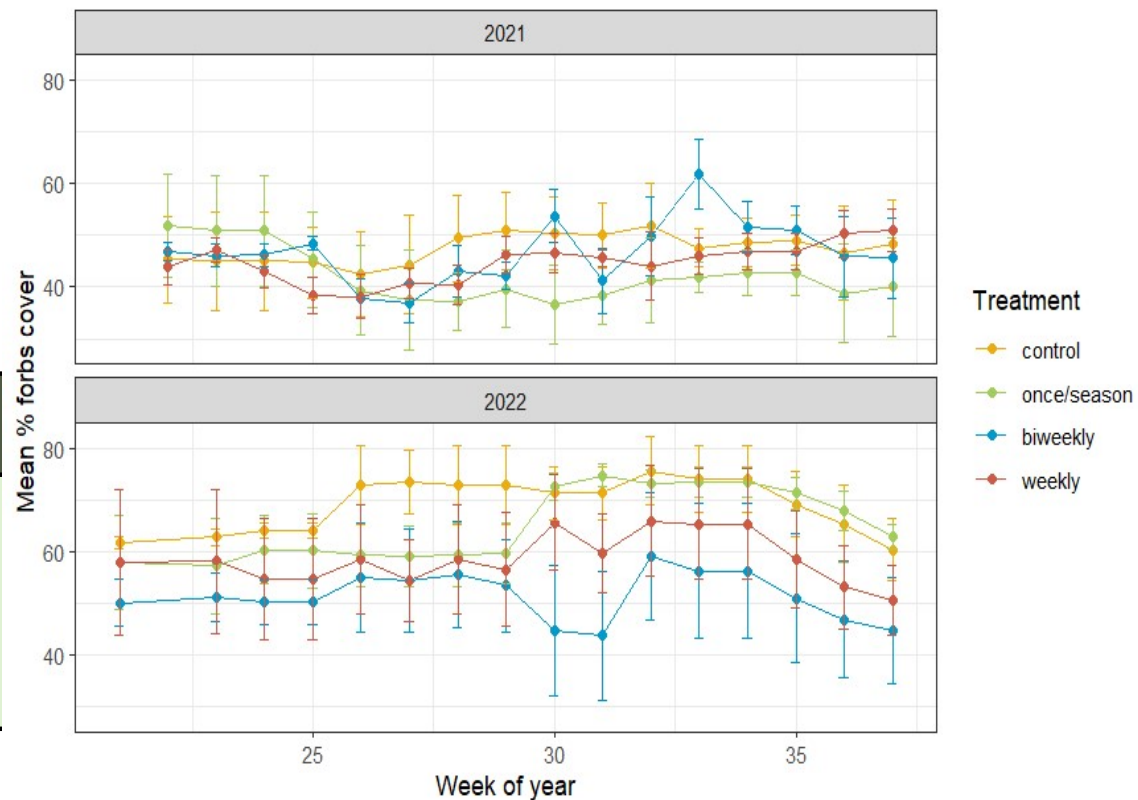
Year	Significant treatment contrast	Estimate (% forbs)
2022	biweekly – control	-17.7
	biweekly – once/season	-13.7
	weekly – control	-10.5
	weekly – once/season	-6.5
	weekly – biweekly	7.2

Visual obstruction (aboveground biomass)

Treatment	Mean VOR (cm) + sd
control	20 ± 11.6
once/season	36 ± 8.7
biweekly	47 ± 22.3
weekly	102 ± 51.8

Significant treatment contrast	Estimate (cm)
weekly – control	81.9
weekly – once/season	65.9
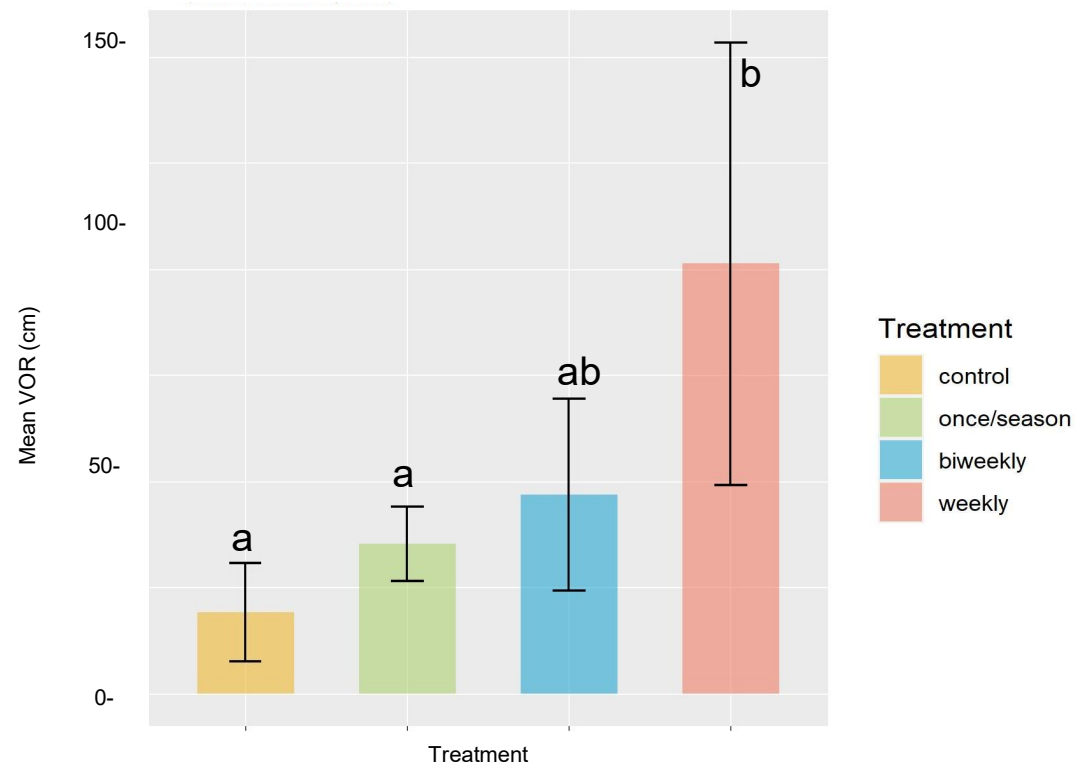
Maximum length

Species	Sig. contrast (2022)	Estimate (cm)	Manure effect
Wild bergamot	biweekly - control	35	
	weekly - once	-31	
	weekly - biweekly	-49	
Swamp milkweed	weekly - once	-26	**–**
Stiff goldenrod	once - control	48	**+**
	biweekly - control	44	
	weekly - control	33	
Purple prairie clover	biweekly - control	-43	**–**
	biweekly - once	-33	
	weekly - control	-54	
	weekly - once	-44	
Ox-eye sunflower	biweekly - control	34	**+**
	weekly - control	32	
Golden Alexander	weekly - control	-54	**–**
	weekly - once	-38	
	weekly - biweekly	-39	

Scaled difference in maximum length
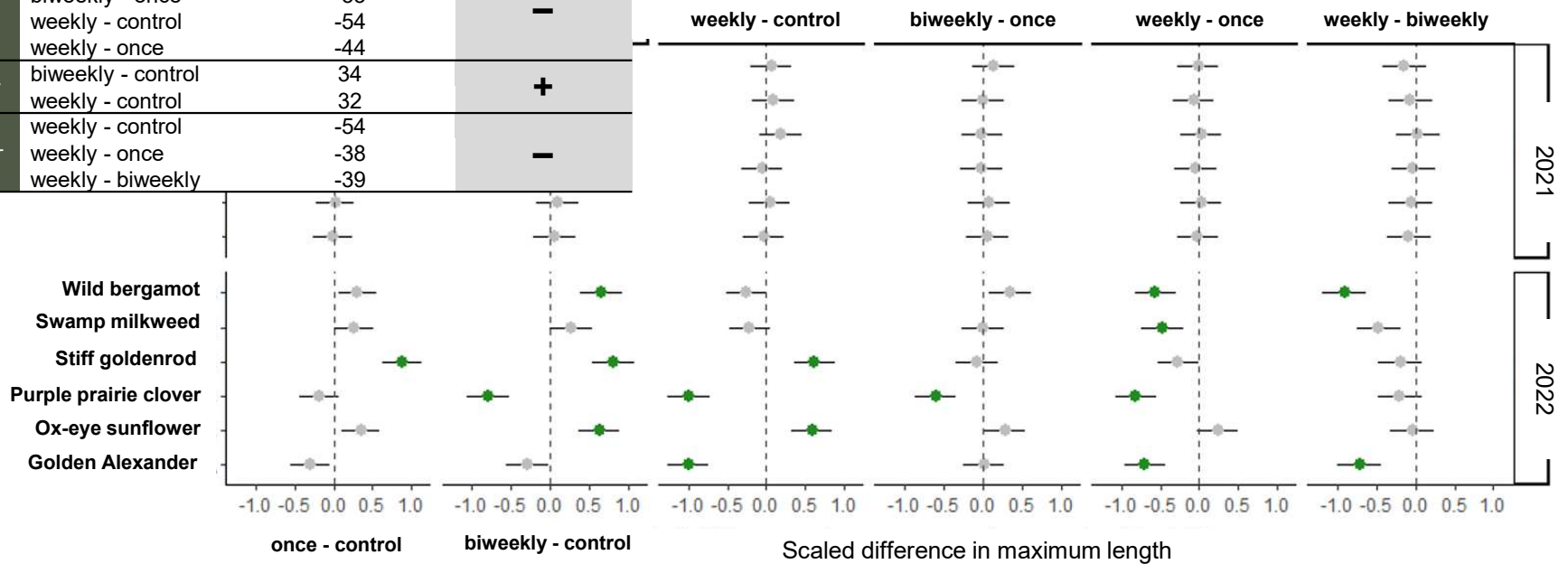
Mortality

Treatment	# dead plants 2021	# dead plants 2022	Total
control	7	9	**16**
once/season	2	12	**14**
biweekly	4	18	**22**
weekly	6	32	**38**
total	**19**	**71**	**90**

Significant treatment contrast	Estimate (# dead plants per plot)
weekly – control	2
weekly – once/season	2

Total plants planted: 780

Results: Insects

How are **insect community and population abundance,**
namely pollinator and ground beetles,
effected by varying amounts of liquid manure application?

1) Total abundance (activity density)

2) Pollinator abundance
    (Order: Hymenoptera – bees & wasps)
    - Family abundance

3) Predator abundance
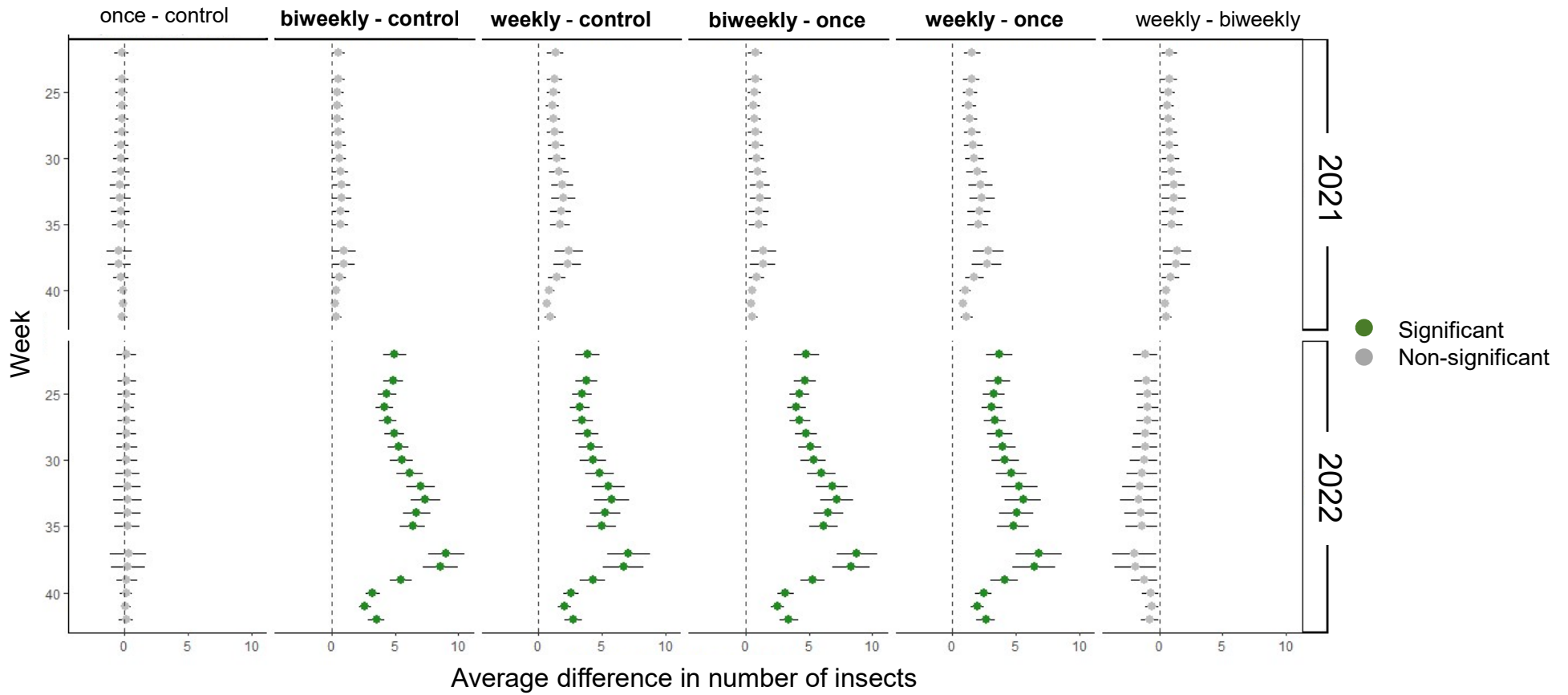   (Order: Coleoptera, family: Carabidae – ground beetles)
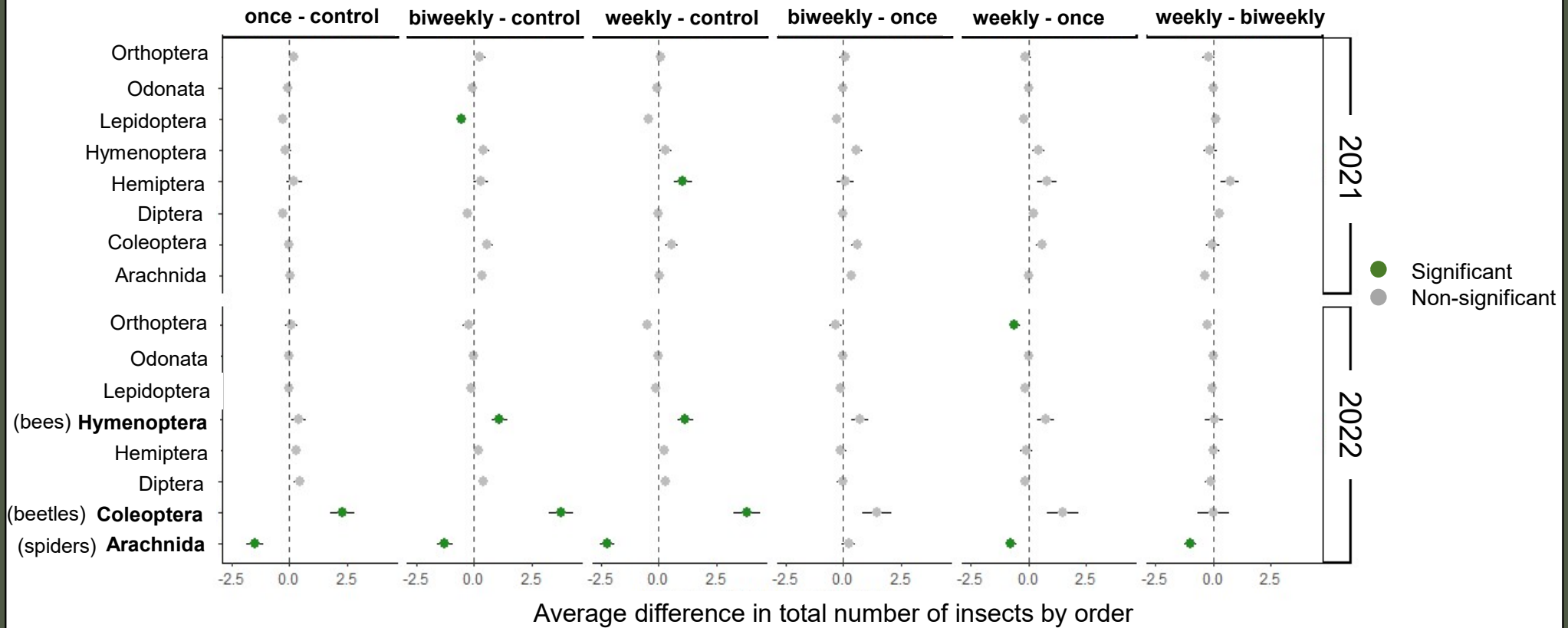
Total abundance – vacuum

Treatment	# insects 2021	# insects 2022	Total
control	361	273	**634**
once/season	348	339	**687**
biweekly	378	394	**772**
weekly	400	403	**803**
total	**1,487**	**1,409**	**2,896**

Total abundance – vacuum

Total abundance by order – vacuum

Order Hymenoptera (bees): vacuum

Treatment	# insects 2021	# insects 2022	Total
control	36	29	65
once/season	29	49	78
biweekly	53	65	118
weekly	56	70	126
total	174	213	387

Hymenopteran families – vacuum

Hymenoptera families	control	once/season	biweekly	weekly	Total
Halictidae	27	36	56	52	171
Apidae	31	28	33	31	123
Ichneumonidae	4	1	4	16	25
Andrena	0	0	10	3	13
Vespidae	0	1	4	7	12
Hyaleus	0	1	5	3	9
Colletidae	0	3	1	3	7
Megachilidae	0	1	2	4	7
Crabronidae	0	2	0	1	3
Scoliidae	0	0	0	2	2
Thynnidae	0	0	1	0	1
Tiphiidae	0	0	1	0	1
Pompilidae	0	0	0	0	0
Total	**62**	**73**	**117**	**122**	**374**

> 75%, Common

Uncommon

Hymenoptera families, common : uncommon – vacuum
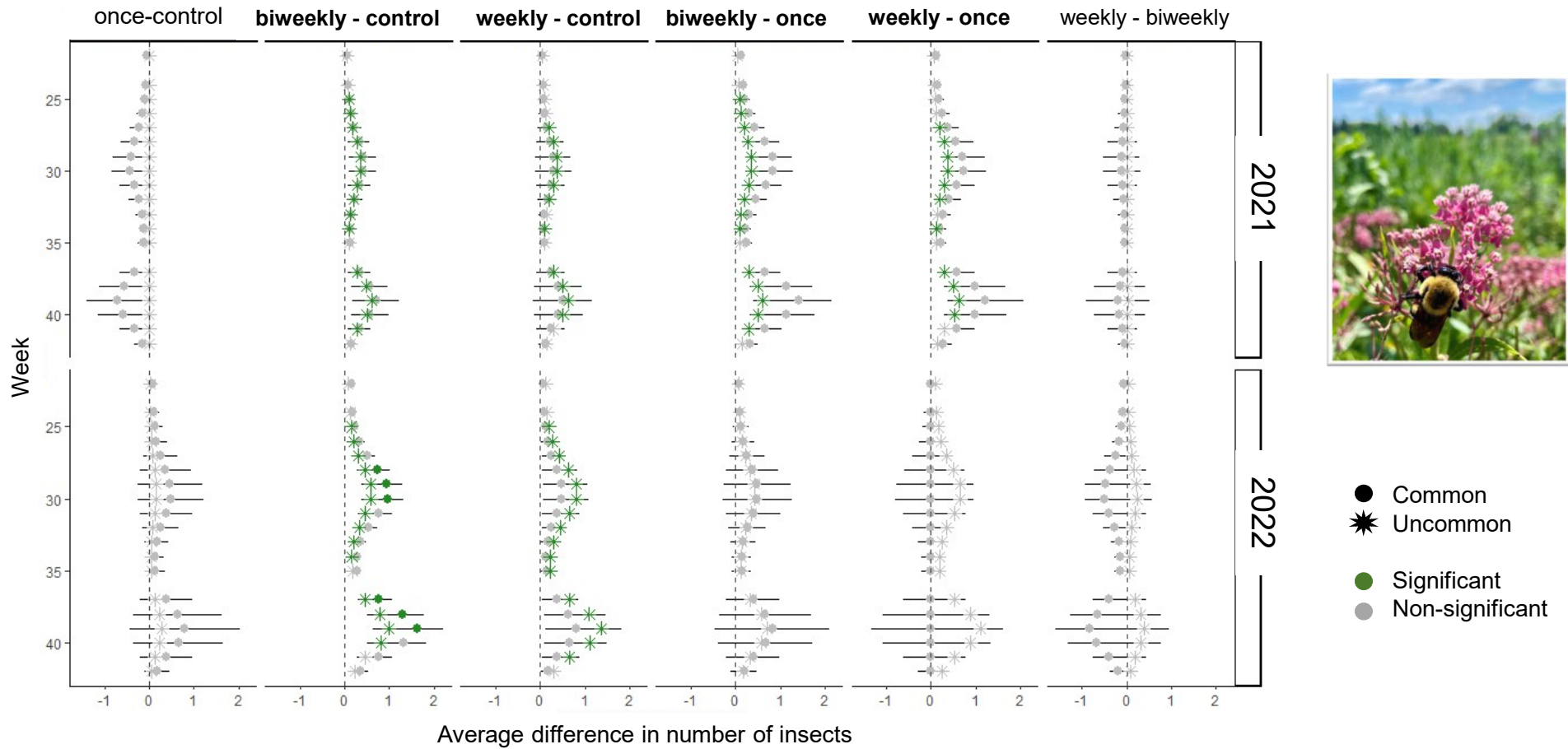
Total abundance – pitfall traps

Treatment	# insects 2021	# insects 2022	Total
control	238	249	**487**
once/season	482	318	**800**
biweekly	384	232	**616**
weekly	591	199	**790**
total	**1,695**	**998**	**2,693**

Total abundance by order – pitfall trap

Average difference in number of insects
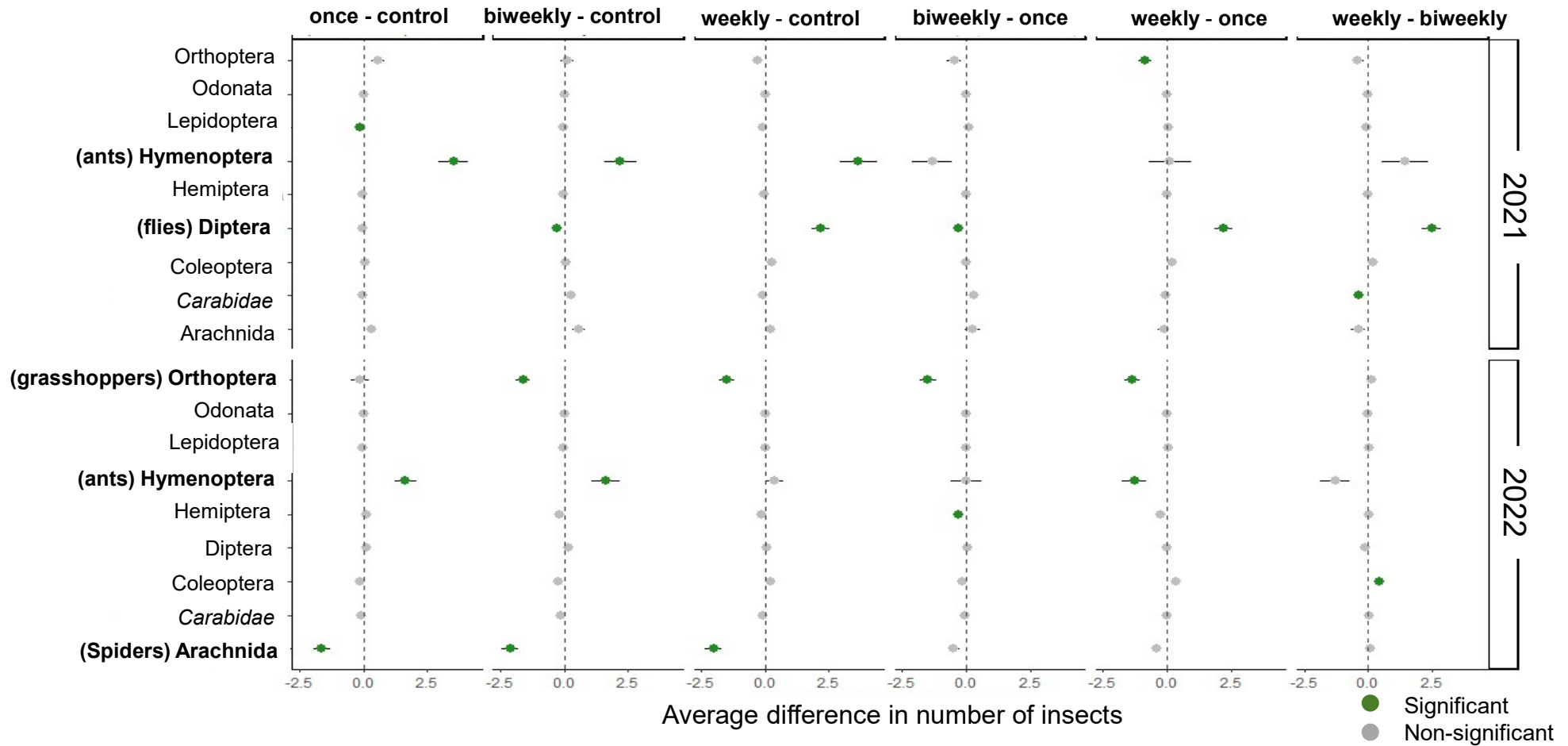
Carabidae abundance by week – pitfall trap
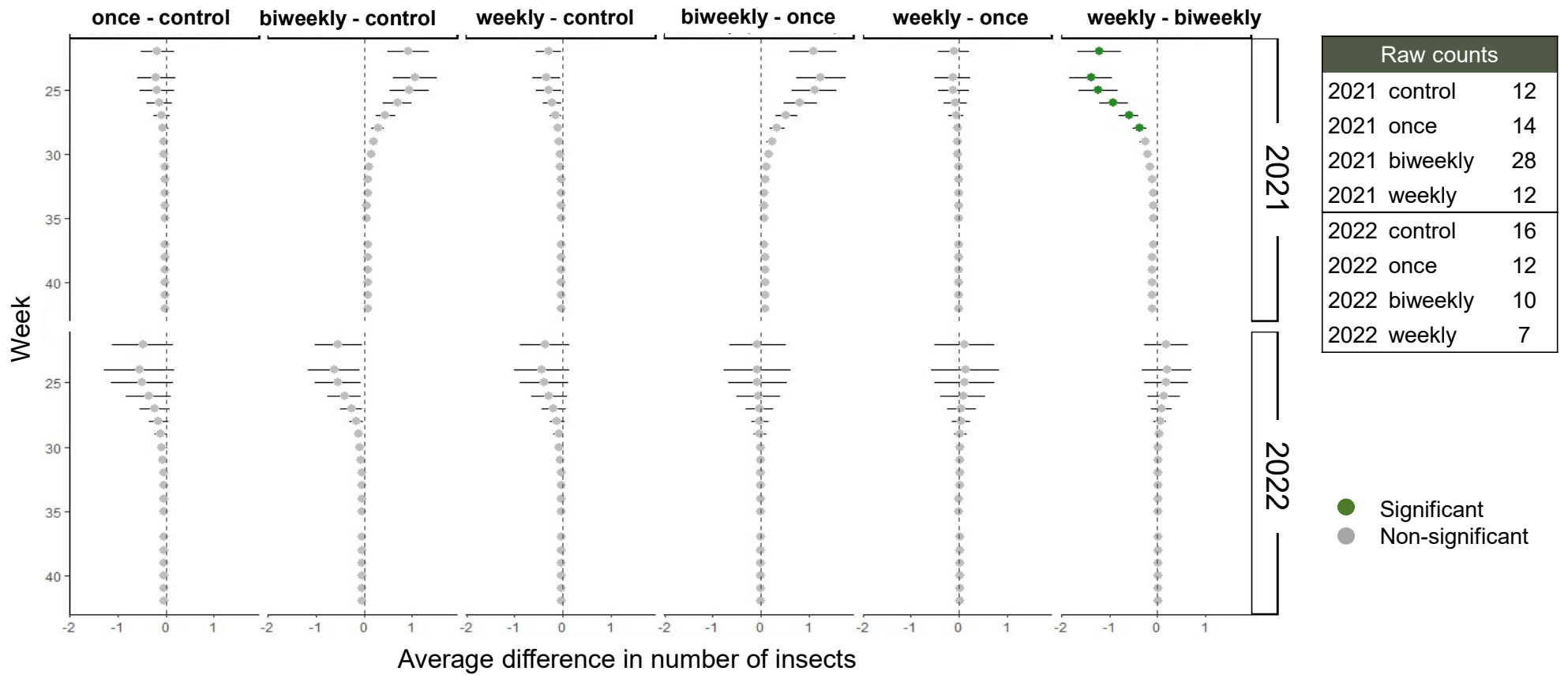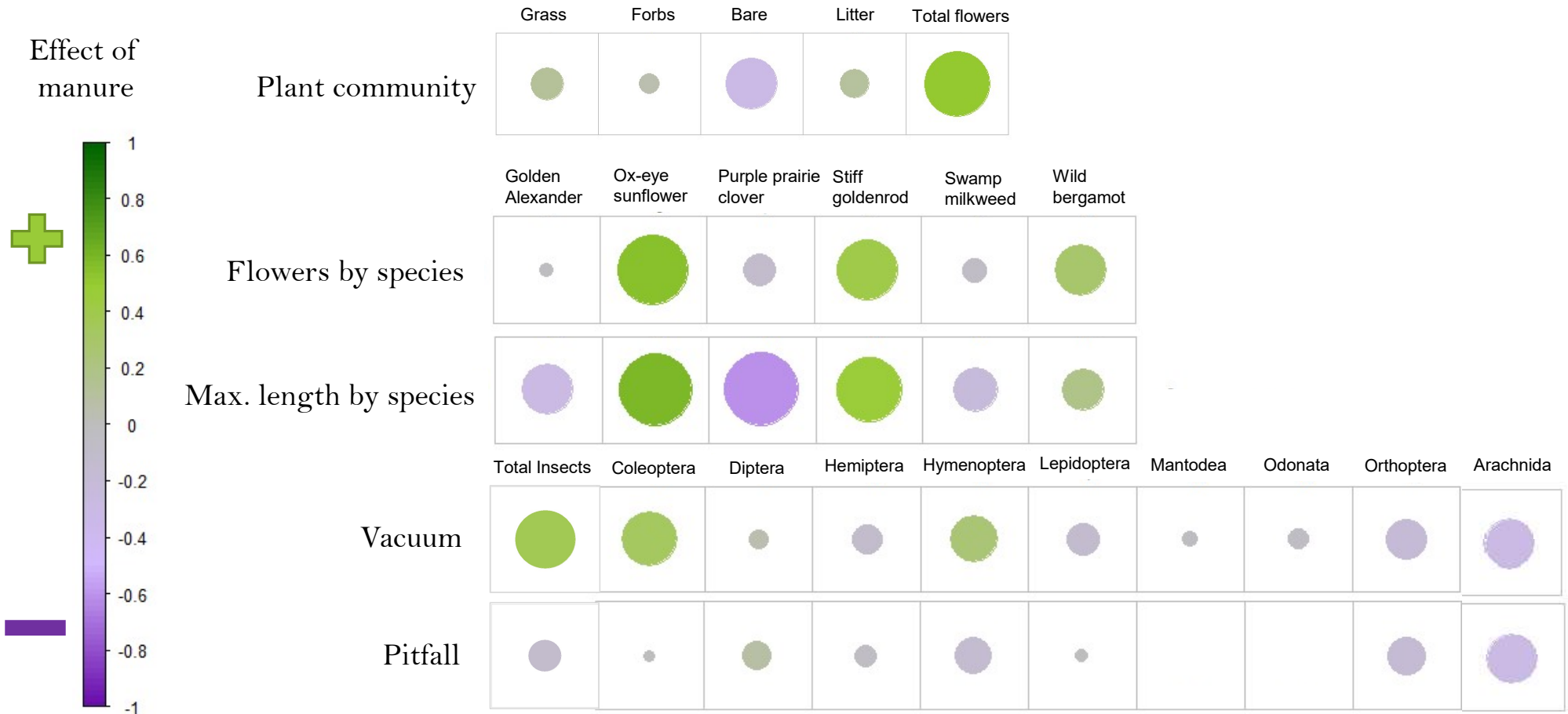
Raw counts		
2021	control	12
2021	once	14
2021	biweekly	28
2021	weekly	12
2022	control	16
2022	once	12
2022	biweekly	10
2022	weekly	7

● Significant
● Non-significant

Primary Research Objective:

**How do prairie plant and insect communities respond to incremental manure application?**

- Soil nutrients - trends of increase N and P, slightly OM

- Floral availability, height, and community composition – increased # flowers, varying height effects, more grass & less forbs, increased biomass, increased mortality

- Insect community/population abundance – increased insects (vac), increased bees (+uncommon!)

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STRIPS
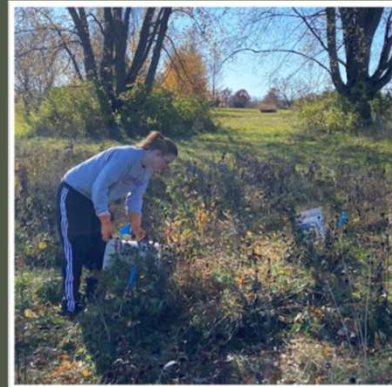
Thank you!!
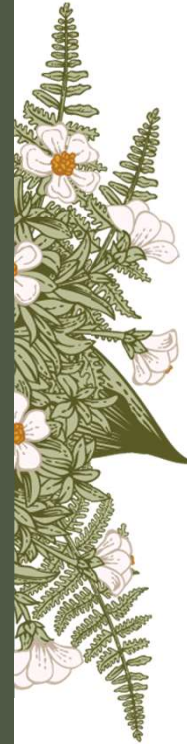
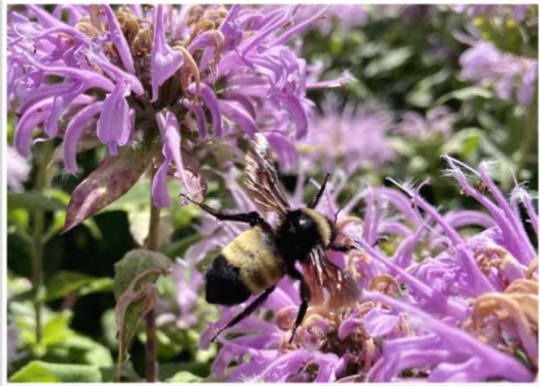|	
Haleigh Summers	Meyer Bohn
Maura Speck	Gabe Johnson
Andres Vargas	Carmen Frederick
Morgan Kaardal	Laura Alt
Jess Nelson	Paige Hollenberg
Rachel Perry	Abigail Enos
Kelsey Karnish	Eryn Blatt
Cait Current	Fernando Miguez
Sam Blair	Dan Andersen
Ben Kolbe	

Technicians: Maura Speck and Fatima Najar
Committee Members:
John Tyndall, Matt O'Neal, Lisa Schulte Moore

~95 % water
Nitrogen mean: 24.56 lb N/1,000 gallons (sd 2.57)
Phosphorous mean: 10.19 lb P/1,000 gallons (sd 2.02)

Table 1. Nutrient content of liquid dairy manure, ISU Dairy Farm, Ames, IA.*

Year	Nitrogen lb N/1,000 gal		Phosphorus as P_2O_5 lb P/1,000 gal		Potassium as K_2O lb K/1,000 gal	
	Fall	Spring	Fall	Spring	Fall	Spring
2017	23.00	26.30	9.00	12.50	20.00	20.90
2016	20.50	23.40	11.70	11.70	20.00	22.50
2015	19.60	25.45	8.80	10.90	21.70	16.70
2014	25.00	26.70	9.20	10.00	20.90	18.40
2013	25.00	25.00	9.20	7.00	20.90	18.00
2012	21.70	26.00	8.40	8.00	20.50	16.00
2011	24.40	29.00	8.20	14.00	18.20	20.00
2010	22.50	28.00	9.00	11.00	16.00	20.00
2009	26.00	na	13.00	na	16.50	na
Seasonal						
Mean	23.08	26.23	9.61	10.64	19.41	19.06
Max.	26.00	29.00	13.00	14.00	21.70	22.50
Min.	19.60	23.40	8.20	7.00	16.00	16.00
Std. dev.	2.20	1.74	1.62	2.29	2.03	2.19
Overall						
Mean	24.56		10.19		19.25	
Max.	29.00		14.00		22.50	
Min.	19.60		7.00		16.00	
Std. dev.	2.57		2.02		2.11	

*Values are the average of two samples at each pumping season after agitation.
Liquid dairy manure stored in an open top glass-lined tank after processing through a solids separator.

Iowa State University, Ag Engineering/Agronomy, Central Iowa, and BioCentury Research Farms   ISRF17-16, 30