STATE: **MONTANA**

AGENCY: **MONTANA STATE UNIVERSITY**

GRANT: **GROUSE FOOD, POLLINATOR, AND DUNG BEETLE ECOLOGY - GRAZING**

MT TRACKING: **MT #W-164-R-1**

ANNUAL REPORT

FOOD ARTHROPODS, POLLINATORS, AND DUNG BEETLES - GRAZING

APRIL 1, 2017 – MARCH 31, 2018

SUBMITTED BY:

RANGELAND ENTOMOLOGY LAB

DEPARTMENT OF ANIMAL & RANGE SCIENCES

MONTANA STATE UNIVERSITY

PRESENTED TO: MONTANA DEPARTMENT OF FISH, WILDLIFE, AND PARKS

PRINCIPAL INVESTIGATORS: HAYES GOOSEY, MARNI ROLSTON, LORELLE BERKELEY, MELISSA FOSTER, JOHN ENSIGN

GRADUATE STUDENTS: GABRIELLE BLANCHETTE

MARCH 2018

THE EFFECTS OF LIVESTOCK GRAZING ON FOOD ARTHROPODS OF GROUSE AND SONGBIRDS, RANGELAND POLLINATORS, AND DUNG BEETLES IN SAGEBRUSH STEPPE AND NORTHERN MIXED GRASS HABITATS.

ANNUAL REPORT

EXECUTIVE SUMMARY. Livestock grazing, a dominant pressure on approximately 70% of native rangelands in Montana, can modify wildlife habitats in positive or negative directions, depending on the grazing program. One component of healthy rangelands is healthy arthropod populations. Arthropods are invertebrate animals possessing an exoskeleton with the largest representing groups being insects and arachnids. Arthropods function within ecosystems by serving as food for higher trophic levels, such as grouse, pollinating all the forbs, including wildlife food sources and nitrogen fixing species, and recycling plant detritus and large ungulate manure into soils. Based on the importance of arthropods in the food-webs of rangeland wildlife and agricultural cycles, it is essential for land and wildlife managers to understand how these invertebrates function within these systems.

Arthropods are drivers of ecosystems from the bottom up perspective yet are influenced by how various grazing systems alter plant communities and subsequently reproductive, thermoregulation, security sites, feed resources, and feeding times. Conversely, it is of equal importance to know, from the top down, how grazing influences different predatory guilds of arthropods which, through hunting strategy alone, can produce a trophic cascade thus altering the arthropod community. Arthropods affect the detritus which in turn influences soil nutrients, which affects the vegetation all of which, in turn, impact wildlife and their habitats. Our project is based on gathering data on a structural foundation of how, within grazing systems, arthropod communities react.

We present here the 2017 annual report of two intertwined projects investigating how rest-rotation grazing influences arthropod communities in sage-grouse and sharp-tailed grouse habitats. Project 1 investigates the Montana Department of Fish, Wildlife and Parks (MT FWP) recommended three-pasture rest-rotation grazing program as implemented on the Buxbaum Ranch south east of Sidney, MT. Project 2 investigates the NRCS Sage-Grouse Initiative (SGI) rest-rotation grazing program as implemented on multiple ranches northwest of Roundup, MT. Data from the sampling season 2016 are presented here as an initial report. We sampled again in 2017 and are nearing completion of the sample process. Entomological collections are processed on the MSU campus during late summer and winter months. This process is tedious and time consuming. During the 2016 field season, we collected and processed 244,937 specimens from both research locations.

In association with Project 1, we sampled five treatments weekly over a seven-week period as part of the MT FWP three-pasture rest-rotation program implemented on the Buxbaum Ranch, south east of Sidney, MT. Treatments sampled, as part of the MT FWP easement, are designated as Fall Graze, Spring Graze, Winter Graze, and Rested. An additional reference pasture (Off-Easement), which is not part of the MT FWP easement, was also sampled (Fig. 1).

In association with Project 2, we sampled three treatments weekly over a five-week period as part of the NRCS SGI rest rotation grazing program which is implemented on multiple private

ranches, state, and federal lands north west of Roundup, MT. Treatments sampled are SGI (i.e., lands enrolled in the NRCS SGI program), Non-SGI (i.e., lands not enrolled in the NRCS SGI program), and Lake Mason National Wildlife Refuge (LMWR; i.e., United State Fish and Wildlife Service [USFWS] land) which has not experienced domestic livestock grazing in over seven years (Fig. 1).

Report Commonalities.

- The summary of Project 1 (Sidney, MT) can be found on pages 5 – 14. It is organized following Objectives 1a – 1de, Objective 2, and Objective 3.
- The summary of Project 2 (Roundup, MT) can be found on pages 15 – 22. It is also organized following project 2 Objectives 1a – 1e, to Objective 2, then Objective 3.
- Throughout this report, the reader should keep in mind the means, medians, rank abundance, percentages, and statistical analyses are generated off only one year's data, the 2016 field season. It is for this reason that we have minimized the Discussion, Conclusions, and Implications of these data. Our team is near completion of processing all of 2017 field season samples. Once this is completed, a comprehensive two-year report will be completed.

Statistical Analyses.

- All statistical analyses were conducted using the Proc Mixed procedures of SAS, Version 9.2, with replicate as the random variable. This Mixed procedure approach deploys true mixed-model technology by building the random effects parameters into the statistical model through the covariance structure.

Sampling methods at the Sidney and Roundup sites were identical and are as follows.

- To collected ground and vegetation dwelling arthropods, pollinators, and dung beetles associated with Objectives 1a – 1e, sampling was deployed in: 1) each phase of the MT FWP three pasture re-rotation, 2) winter grazed pasture, and 3) on adjacent pastures.
- Ground-dwelling arthropods were sampled using pitfall traps. Ten traps were deployed along a predetermined trapping transect oriented on a random compass bearing and filled with propylene glycol, a non-toxic killing agent.
- Vegetation-dwelling arthropods were sampled using a standard 35cm diameter sweep net to collect specimens along a transect oriented along a random compass bearing. Each sample consisted of all specimens collected from 100 sweeps.
- Pollinators were collected using nine colored pan traps deployed in each replicate. Traps were filled with a non-toxic killing agent and deployed along a transect oriented along a random compass bearing. Pan trap colors were white, yellow, and blue which take advantage of the visual capabilities of pollinators and capture a more representative set of species than one color trap alone.
- Dung beetles were collected using five baited pitfall traps per replicate. Baits consisted of 100 g of organic cow dung collected at the MSU Bozeman Agricultural Research and Teaching Farm. Fresh manure was collected weekly, returned to the MSU campus, and used to fill small containers with approximately 100 g, then frozen for later use.
- Samples were collected weekly from approximately mid-May through July.

PROJECT 1 PROJECT 2

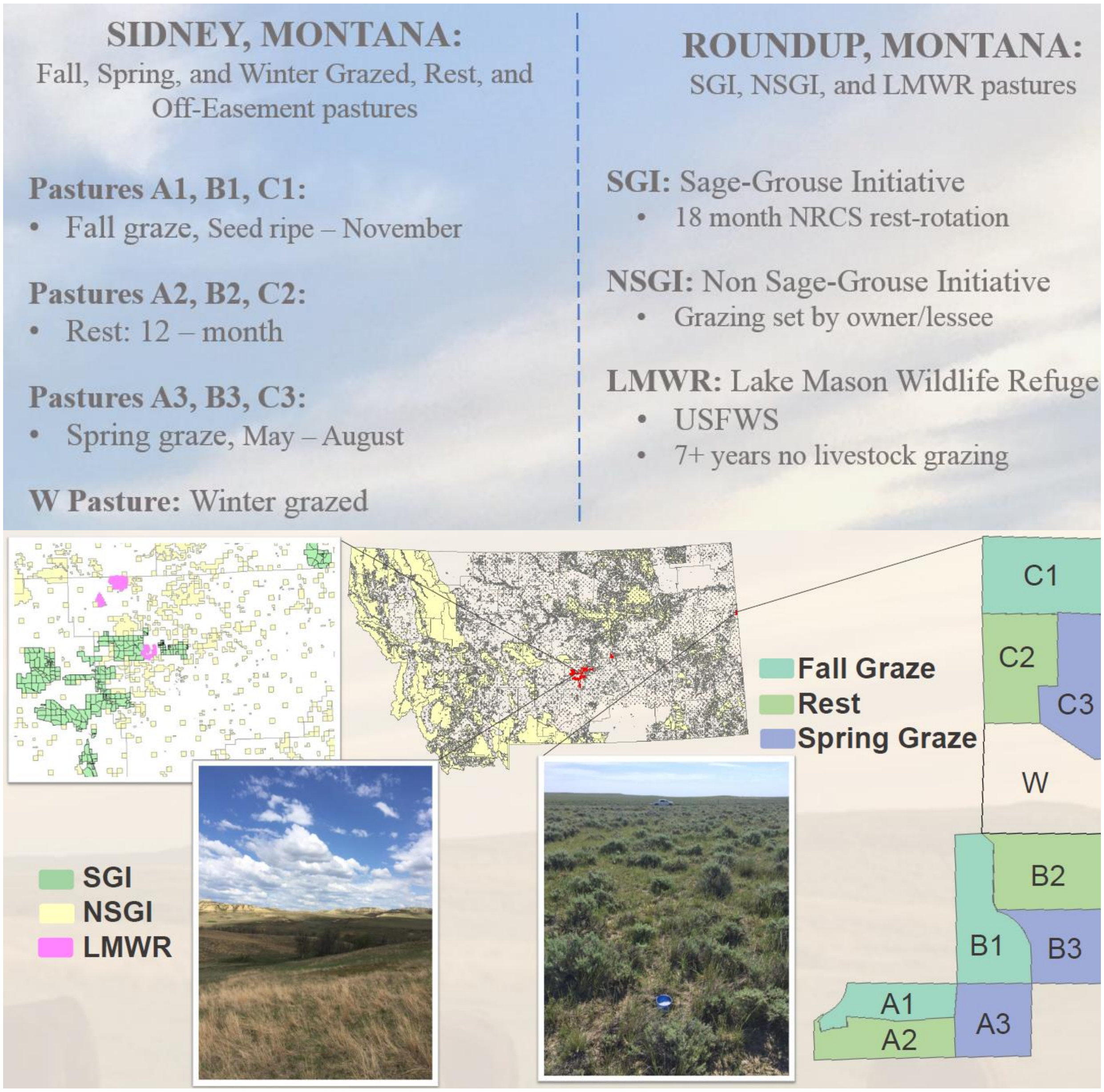

Fig. 1. Treatment designation with a brief explanation during the 2016 field season and Project 1 and 2 study site locations in Montana.

PROJECT 1: SHARP-TAILED GROUSE

OBJECTIVE 1: Quantify the influence of the MT FWP three pasture rest-rotation grazing, deferred grazing, and season-long grazing on; a) the relative abundance and diversity of ground-dwelling arthropods serving as food items for sharp-tailed grouse, b) the relative abundance and diversity of above ground and plant-dwelling arthropods serving as food items for songbirds, c) the relative abundance and diversity of wild pollinators, d) the relative abundance and diversity of dung beetles, and e) the vegetative community biomass and diversity and percent bare ground.

During the 2016 field season, we collected 80,627 total arthropods at site 1 south east of Sidney, MT collected. Treatments sampled were 1) Fall Graze, 2) Pasture Rest, 3) Spring Graze, 4) Winter Grazed, and 5) Reference Pastures (i.e., not part of the FWP rest-rotation grazing program).

Fall and Spring grazing treatments refer to the MT FWP three pasture grazing treatments. The Rest treatment refers to deferred grazing while the Reference treatment refers to season-long grazing. These rest pastures were not grazed the entire year, rather grazing rotations were not dictated by the MT FWP plan, rather were dictated independently by the landowner. Reference pastures were not grazed during the time we sampled to negate the effects of grazing on our arthropod sampling. Winter grazed pastures are defined as those pastures where livestock are kept, closer to the main ranch buildings, during winter months, fed more pre-harvested and baled hay, and allowed to calve.

Total treatment catches did not differ ($p = 0.53$) during 2016 (Fig. 2). Total treatment catches are values of the summed catches between pitfall trapping (ground dwelling arthropods) and sweep net sampling (vegetation dwelling arthropods) which include all specimens of Coleoptera (Beetles), Diptera (Flies), Hemiptera (True Bugs), Homoptera, Lepidoptera (Butterflies and Moths), Araneae (Spiders), Neuroptera (Net-Winged Insects), Hymenoptera (Bees, Ants, Wasps), Orthoptera (Grasshoppers, Crickets), Mesostigmata (Predatory Mites), Trombidiformes (non-Predatory mites), Chilopoda (Centipedes), and Diplopoda (Millipedes).

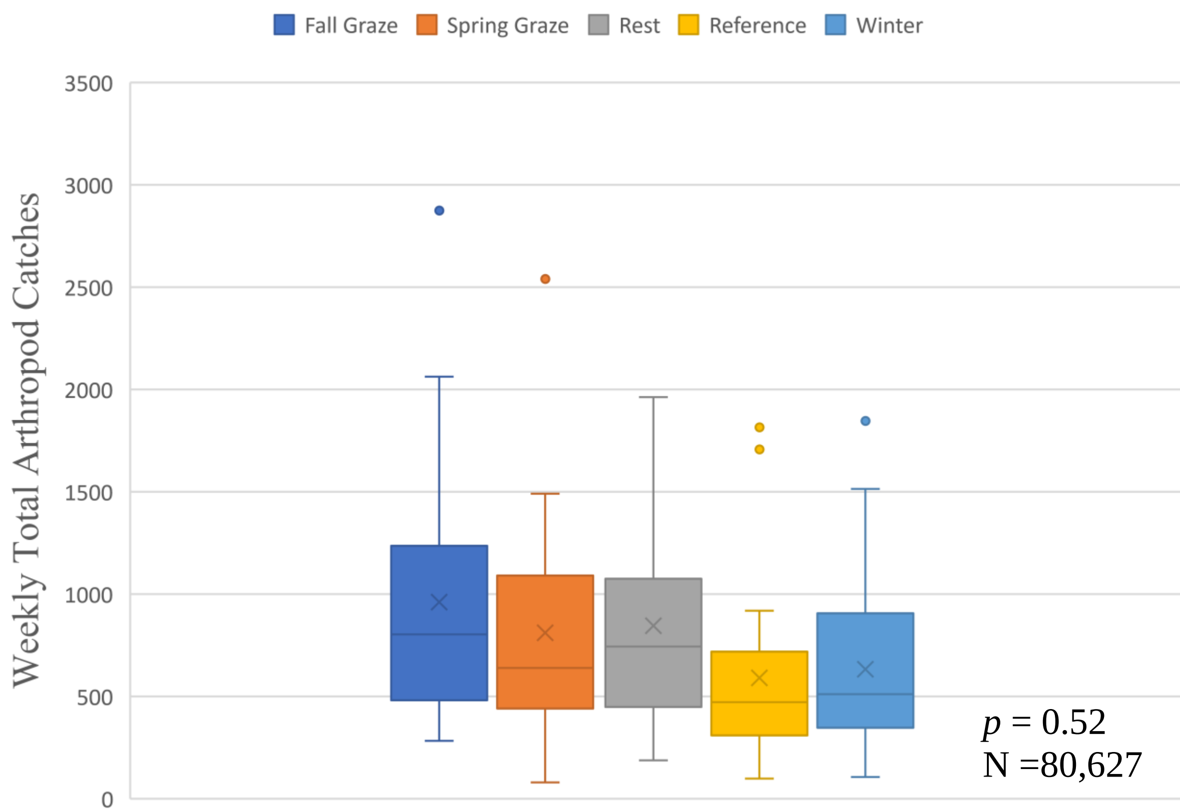

Fig. 2. Box plots of weekly 2016 total catches (N = 80,627 specimens) of both ground and above ground (vegetation) dwelling arthropods southeast of Sidney, MT. Catches did not differ ($p = 0.52$). Box plot upper and lower whiskers represent the high and low catch values, upper and lower box limits represent the first and third quartiles, X represents the arithmetic Mean, and the horizontal line represent the Median.

OBJECTIVE 1A. The relative abundance and diversity of ground-dwelling arthropods serving as food items for sharp-tailed grouse.

Treatment level samples collected at site 1 south east of Sidney, MT during the 2016 field season indicates that grouse food catches (N = 39,947 specimens) were greatest and did not differ ($p > 0.14$) among Fall Grazed, Rested and Spring Grazed pastures. Grouse food catches were greater ($p < 0.01$) in Fall Grazed and Rest pastures when compared to Off-Easement Reference and Winter Grazed pastures. Grouse food catches in Spring Grazed pastures did not differ ($p > 0.22$) from Off-Easement Reference and the Winter Grazed pastures (Fig. 3).

Fall grazed and Rest pasture are both non-grazed, deferred pastures. Previous team research has suggested that non-grazing deferment may benefit arthropod populations. This may be what we are recording at site 1; however, we need to complete processing 2017 data and include these into a comprehensive two field season analyses. Grouse good captures were lowest in off-easement and winter grazed pastures suggesting that managerial approach may have some influence on arthropod abundance.

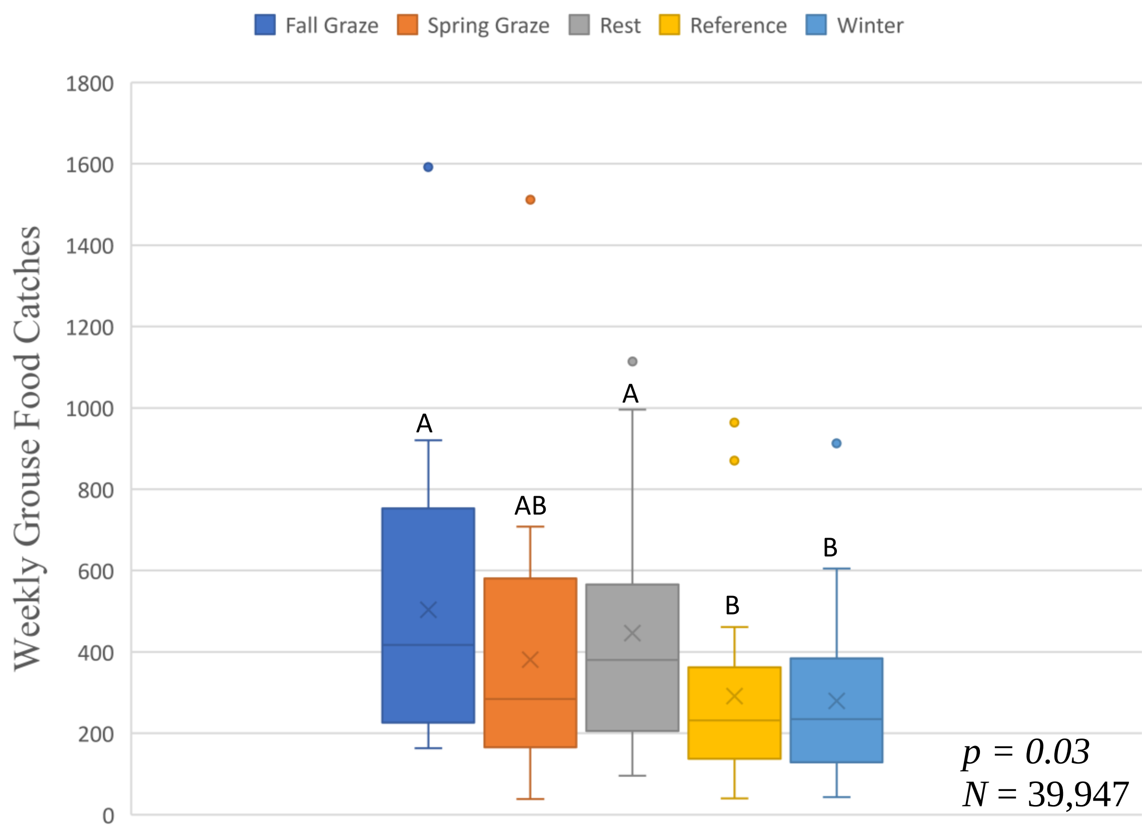

Fig. 3. Box plots of weekly 2016 grouse food catches (N = 39,947 specimens) from the Sidney, MT research site. Catches were greatest in the Fall Grazed and Rested pastures which did not differ from Spring grazed ($p > 0.14$) but did differ ($p < 0.01$) from the Off-Easement Reference pasture and the Winter Grazed pasture. Catches of grouse food in Spring grazed pastures did not differ ($p > 0.22$) from catches in the Off-Easement Reference Pastures and the Winter grazed pasture. Box plot upper and lower whiskers represent the high and low catch values, upper and lower box limits represent the first and third quartiles, X represents the arithmetic Mean, and the horizontal line represent the Median

OBJECTIVE 1B. The relative abundance and diversity of above ground and plant-dwelling arthropods serving as food items for songbirds.

Proc Mixed (SAS, Version 9.2) analyses of 2016 Order level songbird catches (N = 29,288) suggests that catches did not differ among Fall Grazed and Rest pastures ($p = 0.45$), Rest and Spring grazed pastures ($p = 0.18$), and Spring Grazed, Off-Easement Reference, and Winter grazed pastures ($p > 0.34$). Songbird food catches were greatest ($p < 0.01$) in Fall Grazed and Rest pastures which did not differ from each other ($p = 0.45$). Catches in Rest pastures were greater ($p < 0.05$) than catches in both Off-Easement and Winter Grazed pastures but did not differ ($p = 0.18$) from Spring Graze pasture catches (Fig. 4).

As with the grouse food captures, we are recording that songbird food arthropods are more abundant in the fall and rest pastures. These are non-grazed, deferred pastures and as indicated previously, our team had recorded in past years that grazing may decrease the abundance of arthropods. We have not collected data that would suggest this effect is lasting over multiple years, rather that it is a direct cause and effect measurable only within one year. Songbird food catches are also lowest in the off-easement reference and winter grazed pastures.

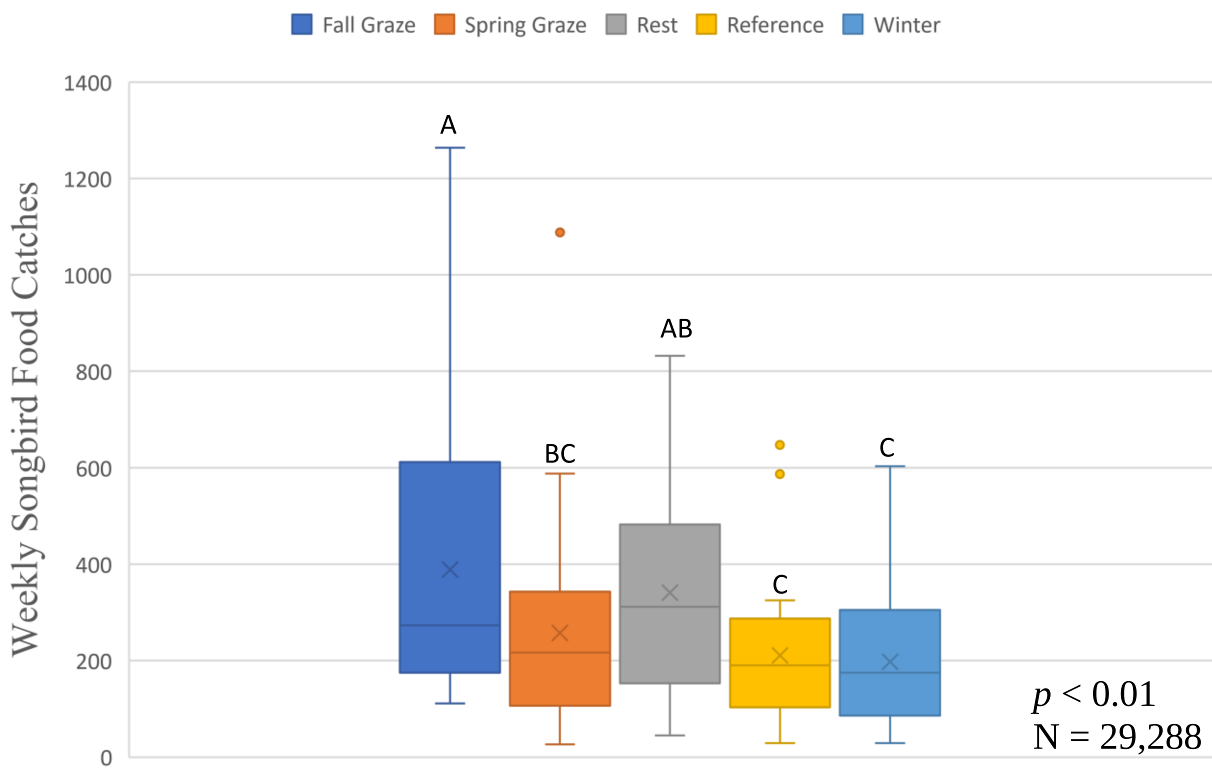

Fig. 4. Box plots of weekly 2016 songbird food catches (N = 29,288 specimens) from the Sidney, MT research site. Catches did not differ among Fall Grazed and Rest pastures ($p = 0.45$), Rest and Spring grazed pastures ($p = 0.18$), and Spring Grazed, Off-Easement Reference, and Winter grazed pastures ($p > 0.34$). Songbird food catches were greatest ($p < 0.01$) in Fall Grazed and Rest pastures which did not differ from each other ($p = 0.45$). Catches in Rest pastures were greater ($p < 0.05$) than catches in both Off-Easement and Winter Grazed pastures but did not differ ($p = 0.18$) from Spring Graze pasture catches. Box plot upper and lower whiskers represent the high and low catch values, upper and lower box limits represent the first and third quartiles, X represents the arithmetic Mean, and the horizontal line represent the Median.

OBJECTIVE 1C. The relative abundance and diversity of wild pollinators.

Wild pollinators are classified as Families of Hymenopteran native bees, Syrphid Flies, and Butterflies. Catches of these select groups were analyzed using Proc Mixed (SAS, Version 9.2) methods of 2016 pollinator (N = 15,600) data. Analysis outputs indicate that treatment level catches did not differ ($p = 0.93$) at the Sidney research site (Fig. 5). This suggests that treatment floral resources, architecture, reproductive galleries and microhabitats were similar.

Thirty-one native pollinator *Genera* and *sub-Genera* were collected from the Sidney research site. Rank abundance of the top five *sub-Genera* in order from largest to smallest is: 1) *Lasioglossum* (*Dialictus*), 2) *Agapostemon*, 3) *Halictus*, 4) *Mellisodes and* 5) *s.str.)* (Fig. 6).

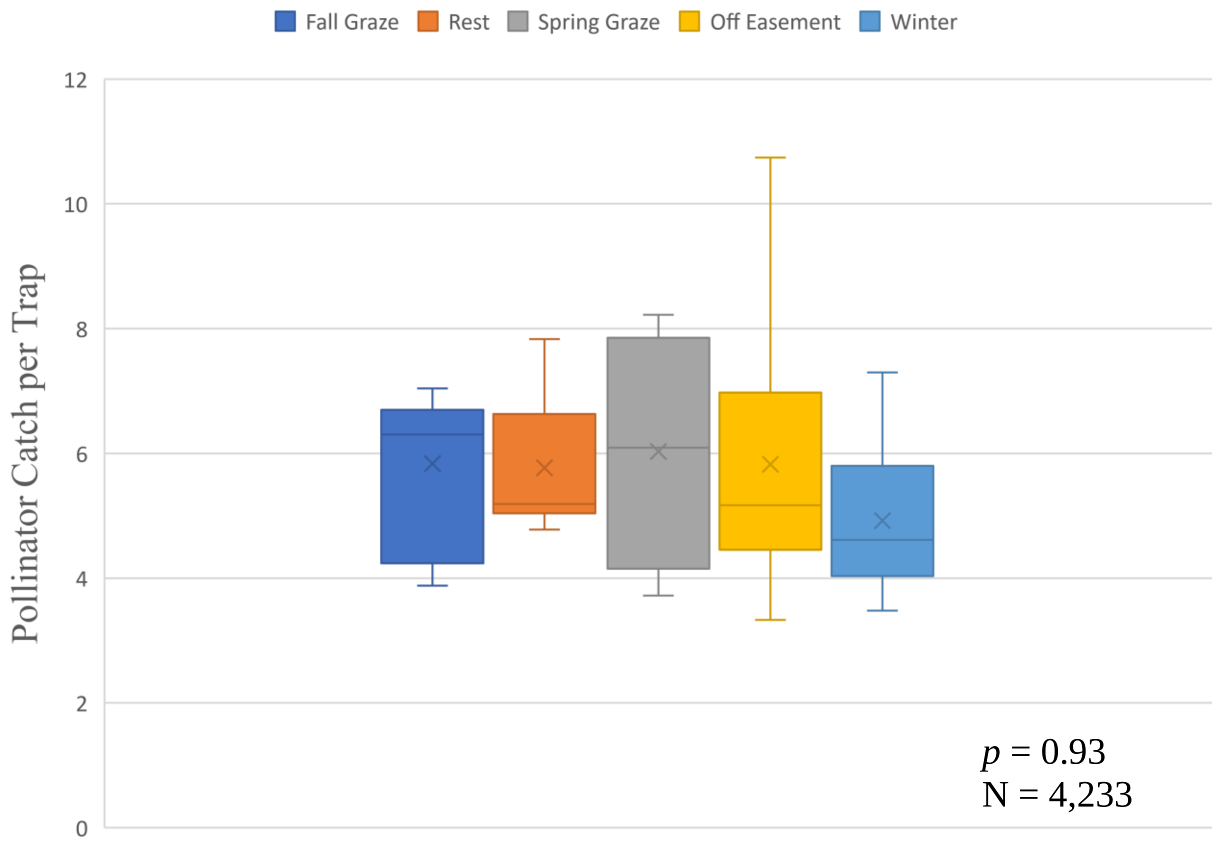

Fig. 5. Box plots of 2016 pollinator catches per trap (N = 4,233 specimens) from the Sidney, MT research site. Treatment level catches did not differ ($p = 0.93$). Box plot upper and lower whiskers represent the high and low catch values, upper and lower box limits represent the first and third quartiles, X represents the arithmetic Mean, and the horizontal line represent the Median.

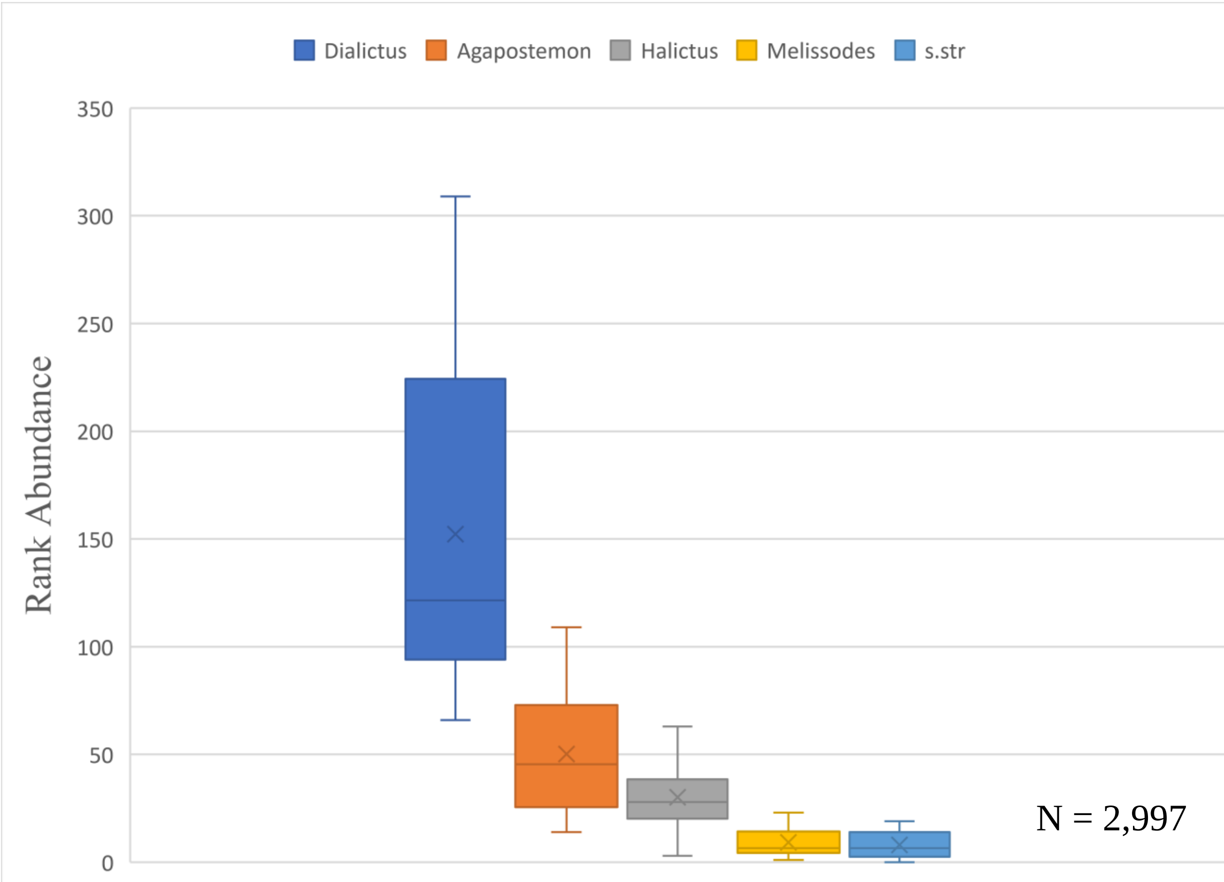

Fig. 6. Box plots of 2016 catches (N = 2,997) representing the rank abundance diversity of the five most common native pollinator *sub-Genera* collected from the Sidney, MT research site. Box plot upper and lower whiskers represent the high and low catch values, upper and lower box limits represent the first and third quartiles, X represents the arithmetic Mean, and the horizontal line represent the Median

Sweat bees are typically abundant Hymenopteran pollinators that are unaffected by livestock grazing. Our one year's data supports other findings on this subject. Native bees differ in their response to livestock grazing and further analyses and specimen collections will supplement these 2016 findings. The interactions between grazing livestock and native rangeland pollinators is of growing interest in land management programs. At the Entomological Society of American 2017 annual meetings, it was recognized that the largest gap in pollinator literature is that of native rangelands. This project is helping to address that deficiency.

OBJECTIVE 1D. The relative abundance and diversity of dung beetles.

Proc Mixed (SAS, Version 9.2) analyses of 2016 total Dung beetles captures (N = 28,485) indicates that treatment level catches (Fig. 7) did not differ ($p = 0.67$). Additional Proc Mixed analyses of location level collections indicates that total dung beetle captures were greatest ($p < 0.01$) in the C pastures, equal ($p < 0.18$) in the A, B, and Off-Easement Reference pastures, and least ($p < 0.01$) in Winter Grazed pasture (Fig. 8). Of the 28,485 dung beetles captured, 285 were only identified to the subfamily Aphodiinae, and 85 were only identified to the subfamily Melolonthinae which represent 0.30% and 0.91% of the total captures, respectively (Table 1). We are consulting additional dung beetle specialists to help with correct identification of the 285 Aphodiinae species. The 85 Melolonthinae species are not true dung beetles and so we are satisfied with the subfamily level of identification. Of the remaining 28,115 dung beetles, the five most abundant species with rank percentage were: 1) *Onthophagus Hecate* (7,251; 25.45%), 2) *Aphodius (Aphodius) fimetarius* (6,819; 23.94%), 3) *Onthophagus nuchicornis* (4,489; 15.76%), 4) *Aphodius (Oscarinus) pseudabusus* (3,021; 10.61%), and 5) *Aphodius (Colobopterus) erraticus* (2,331; 8.18%) (Table 1).

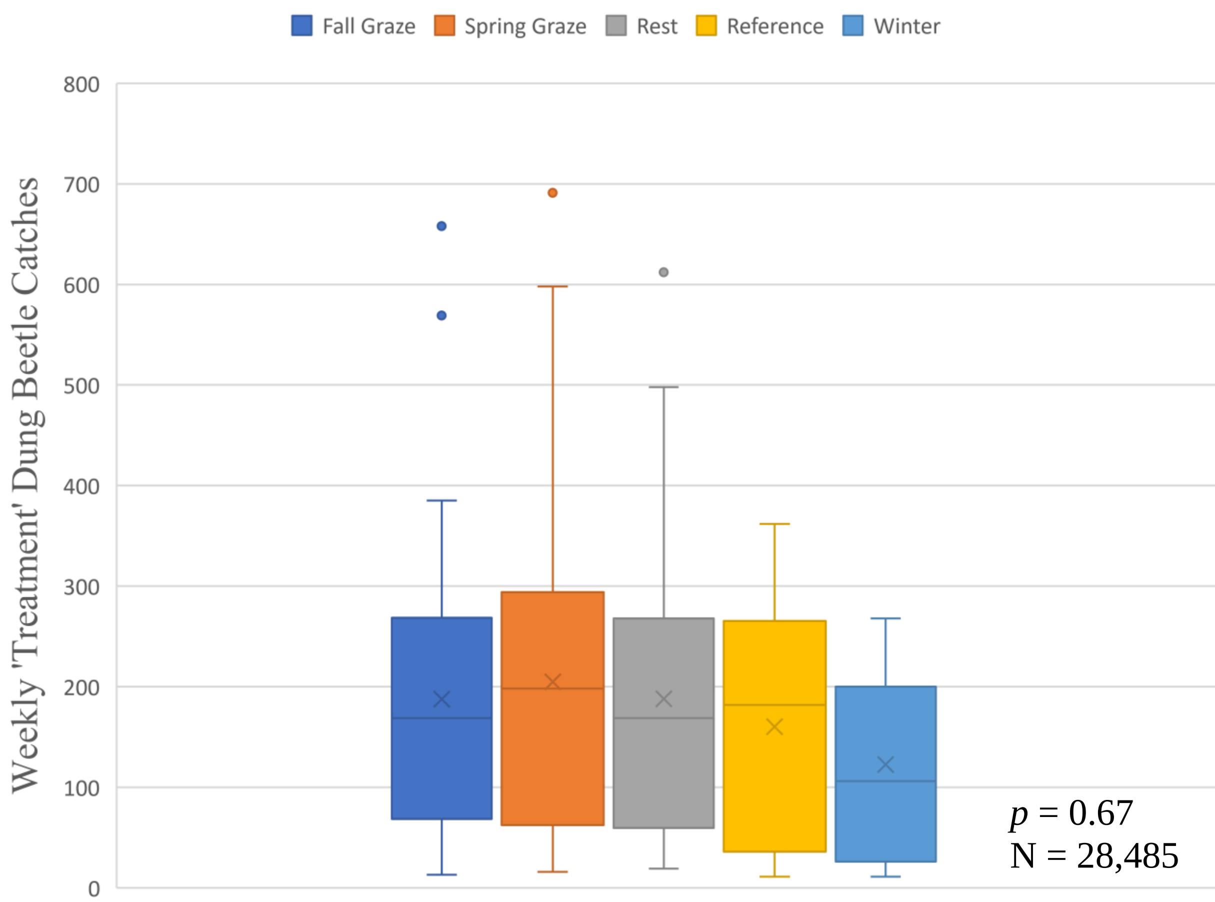

Fig. 7. Box plots of 2016 total weekly treatment level dung beetle catches (N = 28,485 specimens) from the Sidney, MT research site. Treatment level catches did not differ ($p = 0.67$). Box plot upper and lower whiskers represent the high and low catch values, upper and lower box limits represent the first and third quartiles, X represents the arithmetic Mean and the horizontal line represents the Median.

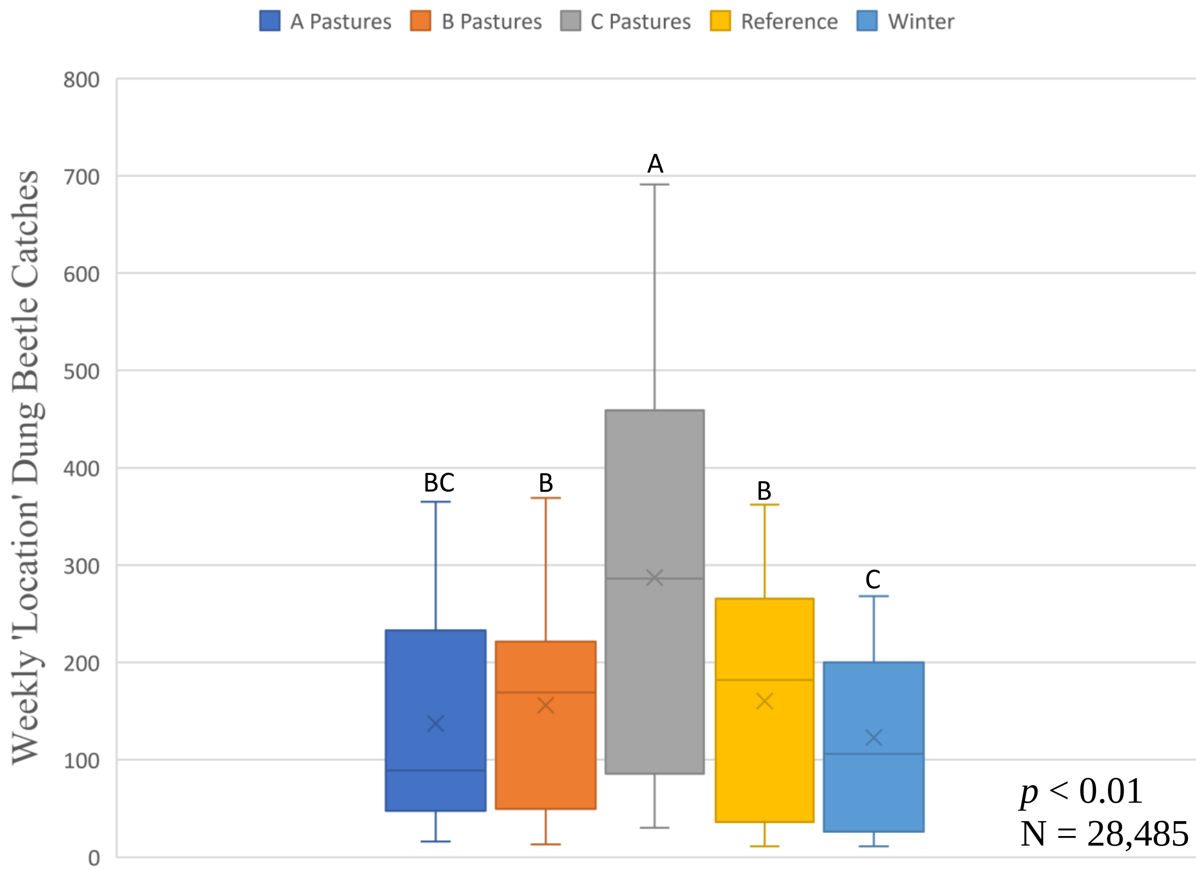

Fig. 8. Box plots of 2016 total weekly location level dung beetle catches (N = 28,485 specimens) from the Sidney, MT research site. Location level beetle captures were greatest ($p < 0.01$) in the C pastures, equal ($p > 0.18$) in the A, B, and Off-Easement Reference pastures, and least ($p < 0.01$) in Winter Grazed pasture (Fig. 8). Box plot upper and lower whiskers represent the high and low catch values, upper and lower box limits represent the first and third quartiles, X represents the arithmetic Mean, and the horizontal line represent the Median.

Interestingly, our team did not record any treatment level differences. One theory is that dung beetles are dung obligates and evolved keen senses to detect dung. Sampling in rest pastures, where there are no livestock and subsequent dung pats, may be inadvertently drawing dung beetles from downwind and non-rest pastures because of the acute dung detection capabilities of dung beetles.

We did record statistically greater numbers of dung beetles captured in C pastures (Fig. 8). Groups of pastures (A, B, W, C) are oriented south to north (Fig. 1., lower right corner) and this may represent the quality of dung excreted by the livestock. Personal observation during field seasons 2016 and 2017 support that dung beetles were more active on dung pats in the C pastures. This could be due to parasiticide residue levels in the dung as part of a production internal parasite management program.

We are currently processing the 2017 dung beetle field samples and specimens. When complete, these will incorporate those into a two-year analysis to determine if these one-year findings hold true over multiple field seasons.

Table 1. Dung beetles captured during the 2016 field season at site 1, south east of Sidney, MT identified to species and presented as a rank percentage and a rank abundance of the total captures.

Dung Beetle Species	Rank Percentage	Rank Abundance
Onthophagus hecate	25.45	7251
Aphodius fimetarius[1]	23.94	6819
Onthophagus nuchicornis	15.76	4489
Oscarinus pseudabusus[1]	10.61	3021
Colobopterus erraticus[1]	8.18	2331
Melanopterus prodromus[1]	5.45	1554
Otophorus haemorrhoidalis[1]	2.42	691
Chilothorax distinctus[1]	2.12	604
Aphodiinae spp. unknown	1.82	518
Pseudagolius coloradensis[1]	1.21	345
Teuchestes fossor[1]	1.21	345
Aphodiinae spp. Unknown	0.91	259
Canthon pilularius	0.61	173
Melolonthinae sp.	0.30	85
Totals	100%	28,485

[1]Classified in the genus *Aphodius* previous to Gordon and Skelley (2007).

Gordon, R.D. and P.E. Skelley. 2007. A monograph of the Aphodiini inhabiting the United States and Canada (Coleoptera: Scarabaeidae: Aphodiini). Memoirs of the American Entomological Institute. 79: 1-580.

OBJECTIVE 1E. The vegetative community biomass and diversity and percent bare ground.

- During 2016, Daubenmire Frame samples were taken weekly at pitfall trap, sweep sample, and pollinator pan trap sampling location. Data collected were: Grass, forb, flowering forb, lichen, bare ground, and detritus. We are also working collaboratively with the Montana State University Range Science Faculty and Staff to visit each sampling location and collect species level plant data. These methods were followed in 2017 and will be repeated in 2018.

OBJECTIVE 2. Transfer knowledge to wildlife and land management agencies at the federal and state levels through local and regional meetings and to private individuals and landowners at the stakeholder level through agricultural associations.

- Our team continues to attend relevant local and regional meetings including but not limited to, 1) The Entomological Society of America, 2) The MT FWP sage-grouse oversight committee meeting, The MT FWP annual landowner appreciation dinner, and 4) The Western Association of Fish and Wildlife Agencies.

OBJECTIVE 3. Disseminate the results to the scientific community by publishing results in topic specific peer-reviewed journals.

- No peer-reviewed publications have yet been submitted. We anticipate one submission in 2018 and two submissions in 2019.

PROJECT 2: SAGE-GROUSE OBJECTIVES

OBJECTIVE 1. Quantify the influence of the NRCS SGI rest-rotation grazing and non-SGI season long grazing on: a) the relative abundance and diversity of ground-dwelling food arthropods at sage-grouse nesting and songbird survey locations b) the relative abundance and diversity of above ground and plant-dwelling arthropods at sage-grouse nesting and songbird survey locations, c) the relative abundance and diversity of wild pollinators, and d) the relative abundance and diversity of dung beetles.

The USFWS LMWR was added as an additional treatment to our sampling in 2016 and 2017. All the specimens collected from 2017 are still being processed so this 2017 annual report only contains data collected during the field 2016 field season. These treatments were identified and sampled as a large-scale approach to better understand how land management practices influence sage-grouse food arthropod abundance and diversity. Treatment level sampling during 2016 collected 91,7104 total arthropods at site 2 from three treatments including: 1) LMWR – which designates sampling to the upper unit of the USFWS Lake Mason National Wildlife Refuge, 2) Non-SGI – which designates sampling to lands that are enrolled in the NRCS Sage-grouse initiative rest-rotation grazing program and 3) SGI – which designates sampling to lands enrolled in the NRCS Sage-grouse initiative rest-rotation grazing program.

United States Fish and Wildlife Service LMWR lands refer to federally owned lands located in the upper LMWR unit. These lands have not experience domestic livestock grazing in approximately seven years. Non-SGI lands refer to lands that are part of active 'for profit' cow-calf or ewe-lamb agricultural operations. On these lands the owner or operator sets the grazing program. SGI lands refer to lands that are enrolled in the sage-grouse initiative rest-rotation grazing program. On these lands the owner or operator works collaboratively with the local NRCS office to establish the program grazing protocol on their land. The owner or operator then moves livestock grazing in accordance with a contract they have agreed upon with the NRCS.

Proc Mixed (SAS, Version 9.2) analyses of total treatment catches did not differ ($p = 0.45$) during 2016 (Fig. 9). Total treatment catches are values of the summed catches between pitfall trapping (ground dwelling arthropods) and sweep net sampling (vegetation dwelling arthropods) which include all specimens of Coleoptera (Beetles), Diptera (Flies), Hemiptera (True Bugs), Homoptera (), Lepidoptera (Butterflies and Moths), Araneae (Spiders), Neuroptera (Net-Winged Insects), Hymenoptera (Bees, Ants, Wasps), Orthoptera (Grasshoppers, Crickets), Mesostigmata (Predatory Mites), Trombidiformes (non-Predatory mites), Chilopoda (Centipedes), and Diplopoda (Millipedes).

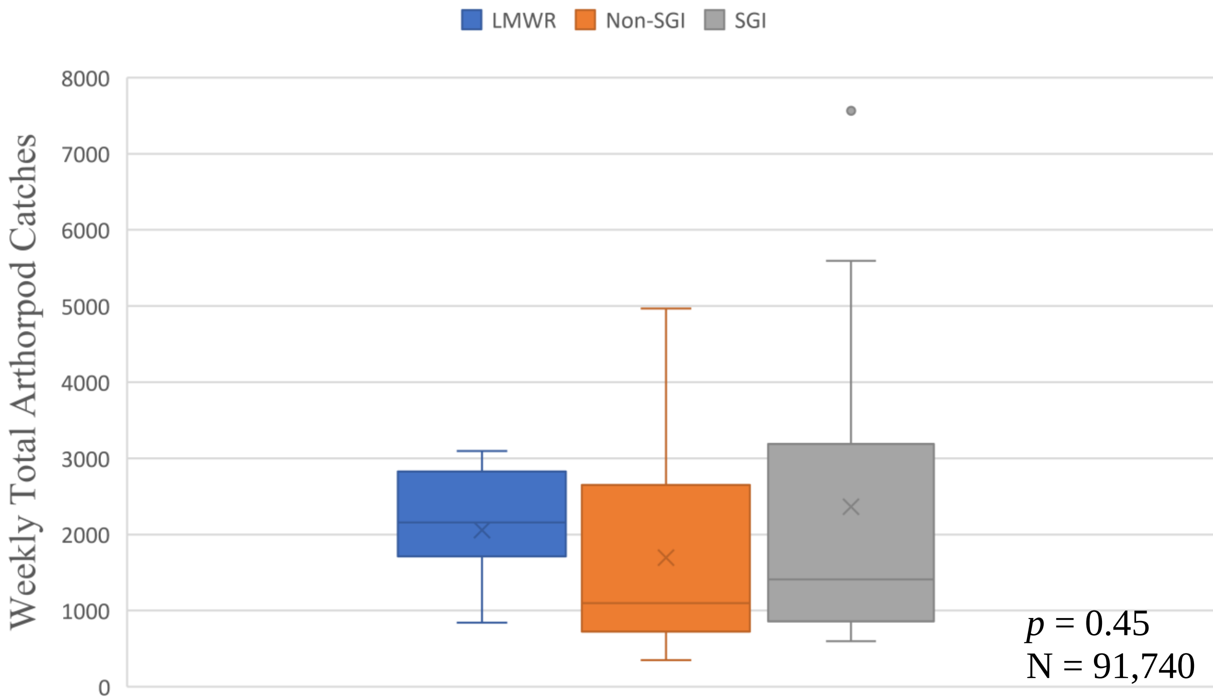

Fig. 9. Box plots of weekly treatment level total catches (N = 91,740 specimens) during 2016 field season of both ground and above ground (vegetation) dwelling arthropods at site 2 northwest of Roundup, MT. Treatment level catches did not differ ($p = 0.45$). Box plot upper and lower whiskers represent the high and low catch values, upper and lower box limits represent the first and third quartiles, X represents the arithmetic Mean, and the horizontal line represent the Median.

Our team is compiling and entering data for the 91,740 specimens collected from project 2. Abundances do not differ between treatments; however, a thorough two-year analyses analysis at the Family level is needed to determined diversity differences between treatments. We are near completing all 2017 Family level identifications which are needed for the complete two-year analyses.

OBJECTIVE 1A. The relative abundance and diversity of ground-dwelling food arthropods of sage-grouse.

During field seasons 2016 and 2017 our team elected to sample ground-dwelling arthropods associated with sage-grouse on three areas that have been for the past seven years managed differently in terms of livestock grazing. We sample Sage-grouse initiative lands that have been enrolled in the rest-rotation grazing program for seven years. We also sample lands that are adjacent to the SGI lands but are not enrolled in the SGI program and are managed according to the landowner or his/her agent. Our third treatment was the upper unit of the USFWS LMWR where livestock grazing has been absent for seven plus years.

Our sampling locations on both SGI and Non-SGI lands were strategically placed in non-grazed, deferred pastures. Previous research indicates that grazing decreases the abundance of arthropods and our objective was to sample arthropods on lands managed under different grazing programs. Since the LMWR has not had grazing in seven plus years, it is scientifically prudent to only sample non-grazed, deferred SGI and Non-SGI pastures as a comparison.

Proc Mixed analyses (SAS, Version 9.2) of box plots representing weekly treatment level grouse food catches (N = 27,614 specimens) during the 2016 field season at site 2 northwest of Roundup, MT (Fig. 10). Treatment catches did not differ ($p = 0.24$).

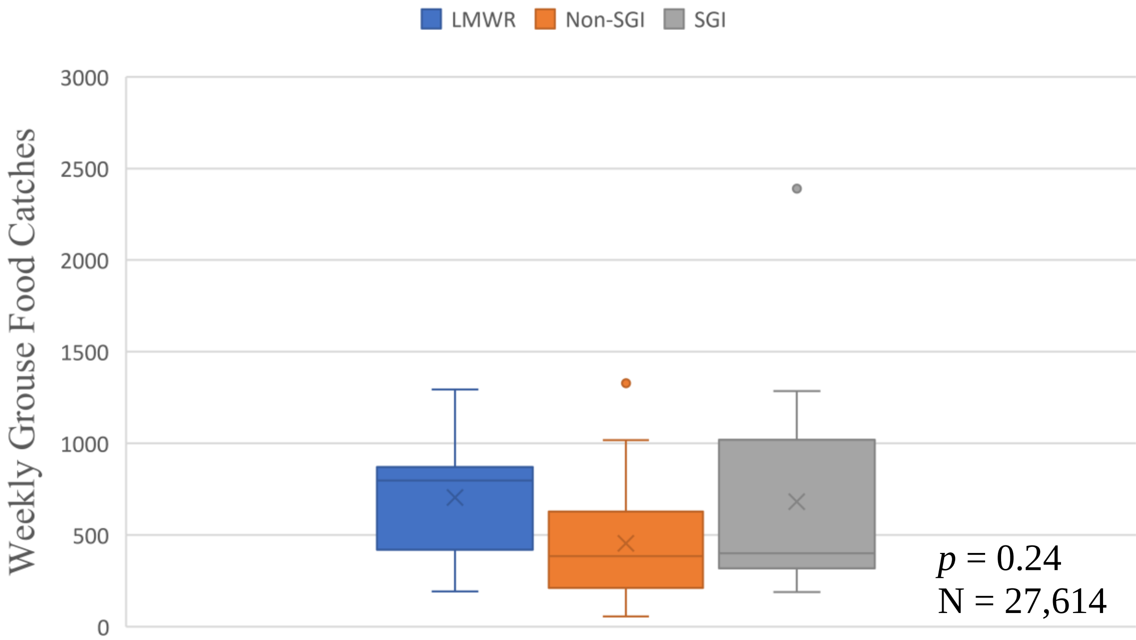

Fig. 10. Box plots of weekly treatment level grouse food catches (N = 27,614 specimens) during the 2016 field season at site 2 northwest of Roundup, MT. Catches did not differ ($p = 0.24$). Box plot upper and lower whiskers represent the high and low catch values, upper and lower box limits represent the first and third quartiles, X represents the arithmetic Mean, and the horizontal line represent the Median.

OBJECTIVE 1B. The relative abundance and diversity of above ground and plant-dwelling arthropods associated with songbird diets.

As stated previously, our sampling locations on both SGI and Non-SGI lands were strategically placed in non-grazed, deferred pastures. Previous research indicates that grazing decreases the abundance of arthropods and our objective was to sample for relative arthropod abundance on lands managed under different grazing programs. Since the LMWR has not had grazing in seven plus years, it is scientifically prudent to only sample non-grazed, deferred SGI and Non-SGI pastures as a comparison.

Proc Mixed (SAS, Version 9.2) analyses of weekly treatment level songbird food catches (N = 17,034 specimens) during the 2016 field season at site 2 northwest of Roundup, MT (Fig. 11). Catches from the Lake Mason National Wildlife Refuge and SGI lands enrolled in the NRCS sage-grouse initiative rest-rotation grazing program were greatest and did not differ ($p = 0.41$). Captures on SGI lands and Non-SGI lands did not differ ($p = 0.14$) Captures on Non-SGI lands were numerically lowest and differed ($p = 0.03$) from the Lake Mason National Wildlife Refuge.

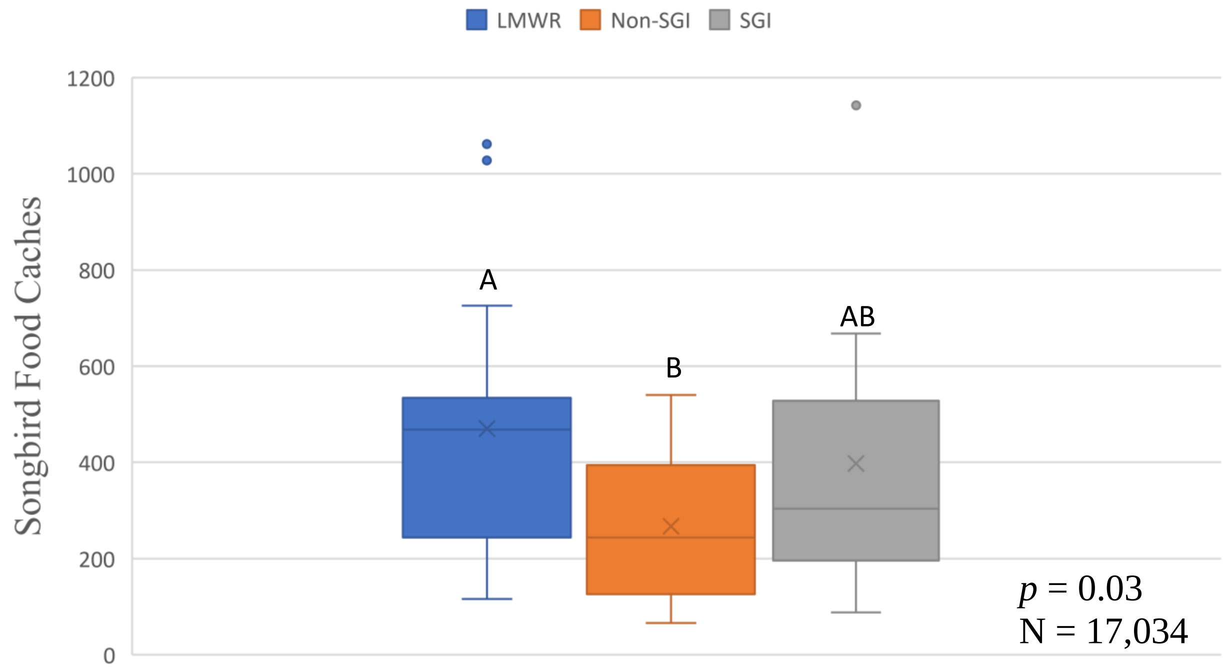

Fig. 11. Box plots of weekly treatment level songbird food catches (N = 17,034 specimens) during the 2016 field season at site 2 northwest of Roundup, MT. Catches from the Lake Mason National Wildlife Refuge and SGI lands enrolled in the NRCS sage-grouse initiative rest-rotation grazing program were greatest and did not differ ($p = 0.41$). Captures on SGI lands and Non-SGI lands did not differ ($p = 0.14$). Captures on Non-SGI lands were numerically lowest and differed ($p = 0.03$) from the Lake Mason National Wildlife Refuge. Box plot upper and lower whiskers represent the high and low catch values, upper and lower box limits represent the first and third quartiles, X represents the arithmetic Mean, and the horizontal line represent the Median.

OBJECTIVE 1C. The relative abundance and diversity of wild pollinators.

Proc Mixed (SAS, Version 9.2) Pollinator catches differed ($p < 0.04$) at Roundup (Fig. 12) suggesting differences exist among treatment floral resources, architecture, reproductive galleries and/or microhabitats.

Pollinator catches on Non-Sage-grouse Initiative lands and lands enrolled in the SGI rest-rotation grazing program did not differ ($p = 0.33$). Native pollinator catches on SGI lands and the upper unit of the USFWS Lake Mason National Wildlife Refuge did not differ ($p = 0.08$) but did show a trend that pollinators were less abundant on the USFWS LMWR upper unit. Pollinator catches on Non-SGI lands were greater ($p = 0.01$) than those recorded on the USFWS LMWR upper unit.

Twenty-three native pollinator *Genera* and *sub-Genera* were collected from the Roundup research site. Rank abundance of the top five *sub-Genera* in order from largest to smallest is: 1) *Lasioglossum* (*Dialictus*), 2) *Agapostemon*, 3) *Eucera*, 4) *Halictus and* 5) *Anthophora)* (Fig. 13).

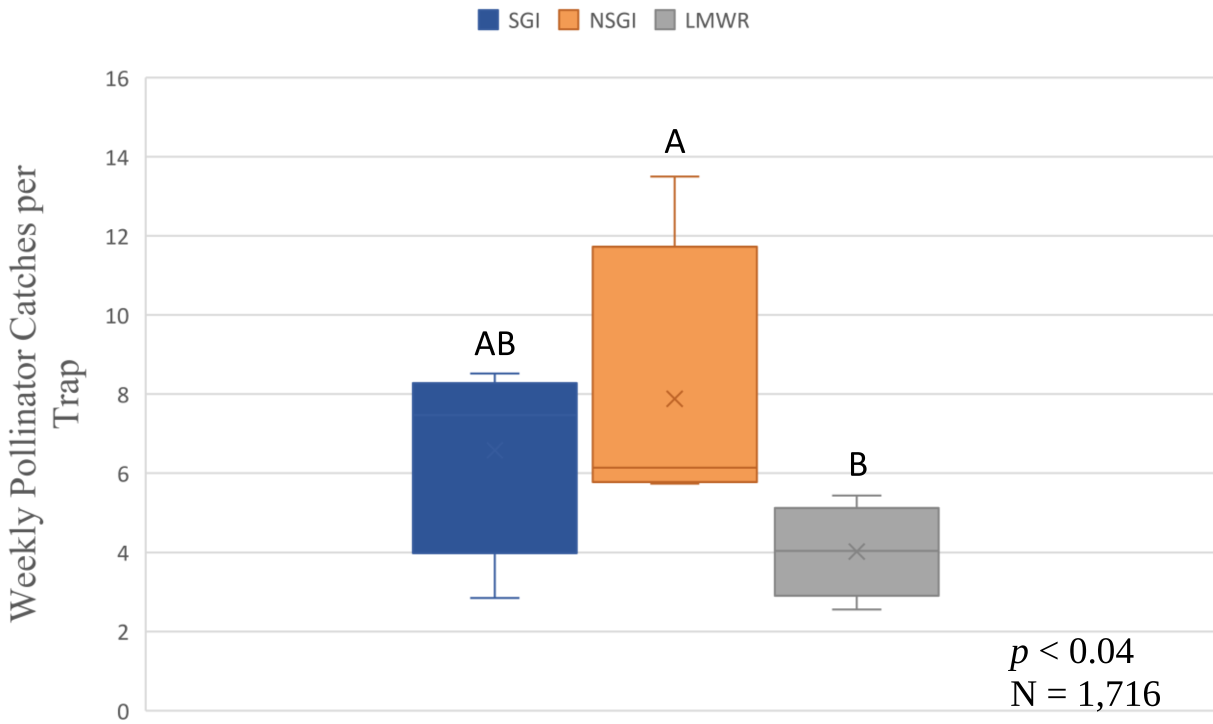

Fig. 12. Box plots of treatment level pollinator catches per trap (N = 1,716 specimens) during the 2016 field season at site 2 northwest of Roundup, MT. Pollinator catches on Non-Sage-grouse Initiative lands and lands enrolled in the SGI rest-rotation grazing program did not differ ($p = 0.33$). Native pollinator catches on SGI lands and the upper unit of the USFWS Lake Mason National Wildlife Refuge did not differ ($p = 0.08$) but did show a trend that pollinators were less abundant on the USFWS LMWR upper unit. Pollinator catches on Non-SGI lands were greater ($p = 0.01$) than those recorded on the USFWS LMWR upper unit. Box plot upper and lower whiskers represent the high and low catch values, upper and lower box limits represent the first and third quartiles, X represents the arithmetic Mean, and the horizontal line represents the Median.

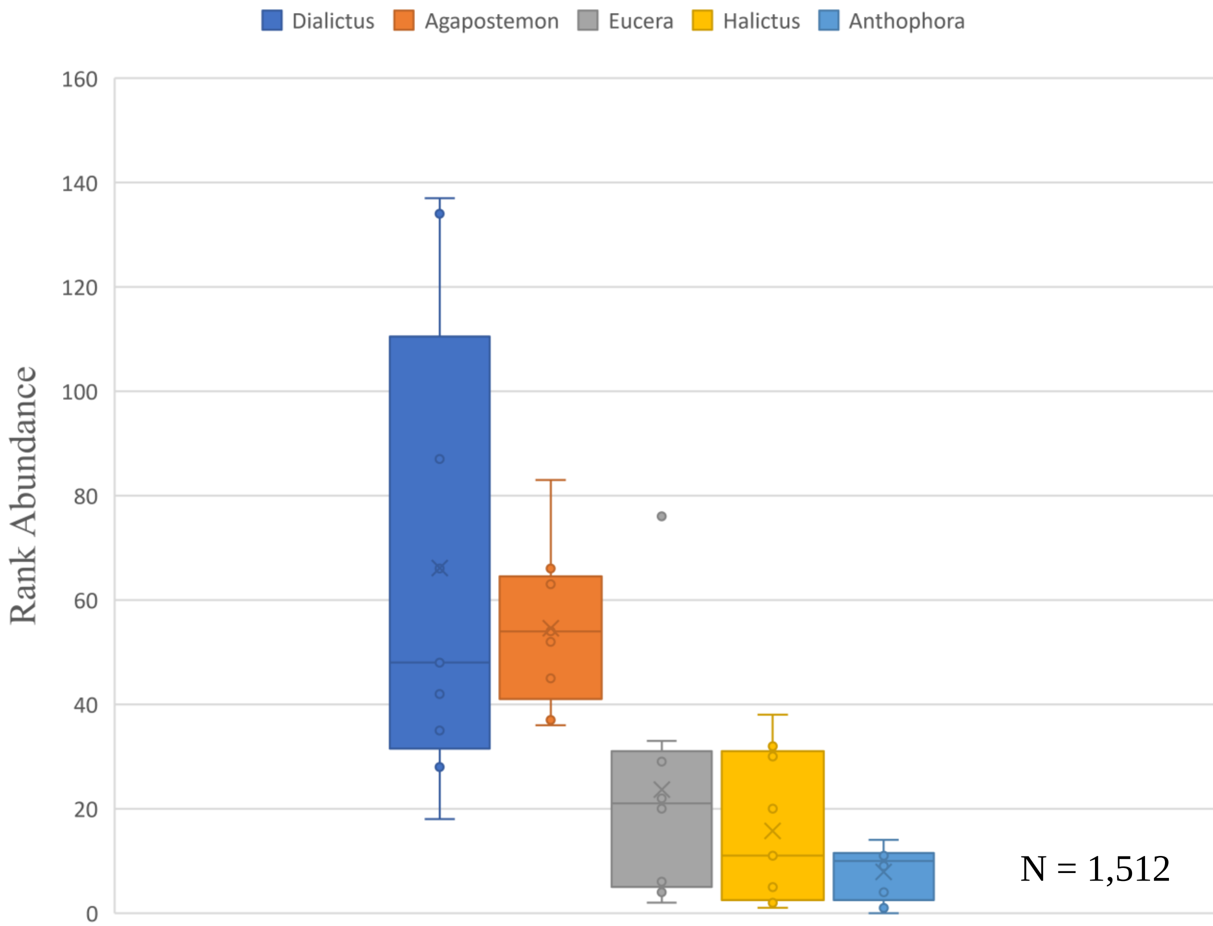

Fig. 13. Box plots representing the rank abundance and diversity of the top 5 native pollinator *sub-Genera* (N = 1,512) collected during the 2016 field season from site 2, northwest of Roundup, MT. Box plot upper and lower whiskers represent the high and low catch values, upper and lower box limits represent the first and third quartiles, X represents the arithmetic Mean, and the horizontal line represent the Median.

Sweat bees are typically abundant Hymenopteran pollinators that are unaffected by livestock grazing. It is unclear and generally unknown if the families of native Hymenopteran pollinators that comprise the 'sweat bee' group respond negatively to lack of ungulate grazing. Bison grazing and other large ungulate grazing was a dominant land use and potentially a selective pressure for millions of years. In theory, it is possible that certain groups of Hymenopteran pollinators evolved to take advantage of the disturbances caused by large scale grazing and therefore would be found in relatively few numbers on areas like the LMWR were large ungulate grazing is absent.

OBJECTIVE 1D. The relative abundance and diversity of dung beetles.

Proc Mixed (SAS, version 9.2). Dung beetle catches were greatest on the United States Fish and Wildlife Service Lake Mason National Wildlife Refuge upper unit and differed ($p < 0.01$) from catches on lands enrolled (SGI) and not enrolled (Non-SGI) in the NRCS Sage-grouse Initiative rest rotation grazing program. Dung beetle catches from Non-SGI and SGI lands did not differ ($p = 0.68$).

It is interesting that dung beetle adults would be relatively more abundant on LMWR lands where there are no large ungulates grazing and depositing dung. Dung beetle adults will feed on detritus in absence of dung, it is only the egg and larval stages of development that a dung obligates. Internal parasite management programs are nearly universal across livestock operations and potentially lethal levels are in dung. A second years data is needed to confirm these results.

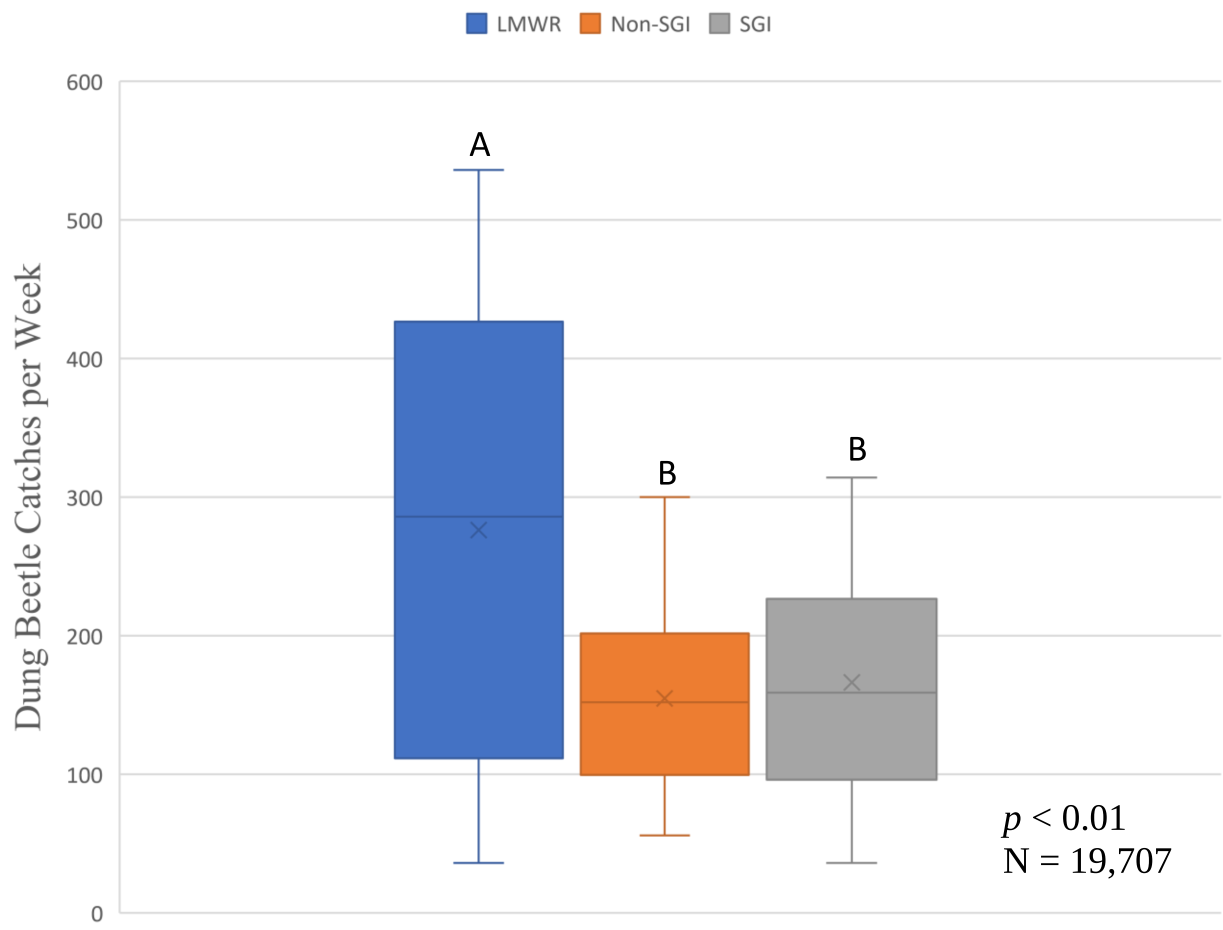

Fig. 14. Box plots of the weekly treatment level dung beetle catches (N = 19,707 specimens) during the 2016 field season from site 2 northwest of Roundup, MT. Catches were greatest on the United States Fish and Wildlife Service Lake Mason National Wildlife Refuge upper unit and differed ($p < 0.01$) from dung beetle catches on lands enrolled (SGI) and not enrolled (Non-SGI) in the NRCS Sage-grouse Initiative rest rotation grazing program. Dung beetle catches from Non-SGI and SGI lands did not differ ($p = 0.68$). Box plot upper and lower whiskers represent the high and low catch values, upper and lower box limits represent the first and third quartiles, X represents the arithmetic Mean, and the horizontal line represent the Median.

OBJECTIVE 1E. The vegetative community biomass and diversity and percent bare ground.

- During 2016, Daubenmire Frame samples were taken weekly at pitfall trap, sweep sample, and pollinator pan trap sampling locations. Data collected were: Grass, forb, flowering forb, lichen, bare ground, and detritus. We are also working collaboratively with the Montana State University Range Science Faculty and Staff to visit each sampling location and collect species level plant data. These methods were followed in 2017 and will be repeated in 2018.

OBJECTIVE 2. Transfer knowledge to wildlife and land management agencies at the federal and state levels through local and regional meetings and to private individuals and landowners at the stakeholder level through agricultural associations.

- Our team continues to attend relevant local and regional meetings including but not limited to, 1) The Entomological Society of America, 2) The MT FWP sage-grouse oversight committee meeting, The MT FWP annual landowner appreciation dinner, and 4) The Western Association of Fish and Wildlife Agencies.

OBJECTIVE 3. Disseminate the results to the scientific community by publishing results in topic specific peer-reviewed journals.

- No peer-reviewed publications have yet been submitted. We anticipate one submission in 2018 and two submissions in 2019.