

Bird Monitoring and Inventory of Soapstone Prairie Natural Area



2019 TECHNICAL REPORT



Connecting People, Birds and Land

Bird Conservancy of the Rockies

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Technical Report: I-MTP-FCNAP-19

BIRD CONSERVANCY OF THE ROCKIES

Mission: *To conserve birds and their habitats*

Vision: *Native bird populations are sustained in healthy ecosystems*

Core Values: *(Our goals for achieving our mission)*

1. **Science** provides the foundation for effective bird conservation.
2. **Education** is critical to the success of bird conservation.
3. **Stewardship** of birds and their habitats is a responsibility we all share.

Bird Conservancy accomplishes its mission by:

Monitoring long-term trends in bird populations as a scientific foundation for conservation action.

Researching bird ecology and response to anthropogenic and natural processes. Our research informs management and conservation strategies using the best available science.

Educating people of all ages to instill an awareness and appreciation for birds and a conservation ethic.

Fostering good stewardship on private and public lands through voluntary, cooperative partnerships that create win-win solutions for wildlife and people.

Partnering with local, state and federal agencies, private citizens, schools, universities, and other organizations for bird conservation.

Sharing the latest information on bird populations, land management and conservation practices to create informed publics.

Delivering bird conservation at biologically relevant scales by working across political and jurisdictional boundaries in the Americas.

Suggested Citation:

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Cover Photo: *Looking Southwest from the cliffs of Soapstone Prairie Natural Area, photo by E. Youngberg*

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EXECUTIVE SUMMARY

Soapstone Prairie Natural Area is a biological corridor in northern Colorado owned and managed by the City of Fort Collins Natural Areas Department for wildlife habitat and local recreation. This report summarizes the 13th year of annual bird monitoring activities, and the 2nd year of complete property surveys, highlighting our findings of 2019.

The property has historically supported over 18 high-priority grassland and shrubland birds, including Ferruginous Hawk, Swainson's Hawk, Golden Eagle, Northern Harrier, Loggerhead Shrike, Burrowing Owl, Mountain Plover, Prairie Falcon, Common Nighthawk, Virginia's Warbler, Lark Bunting, McCown's and Chestnut-collared Longspur, Long-billed Curlew, Vesper, Grasshopper, Brewer's Sparrow, and more recently; Baird's sparrow.

During the 2019 breeding season we conducted point count surveys at 1182 stations across the entire property. At each station we also surveyed vegetation and recorded observations of other wildlife. During 32 survey days in 2019, we observed 17,367 individual birds of 96 species. We estimated densities of six focal bird species and developed landscape/habitat relationships. In addition we created predictive distribution models to identify priority conservation areas.

We used a focal species approach and identified six focal species; Loggerhead Shrike, McCown's Longspur, Vesper, Brewer's, Grasshopper and Baird's Sparrow. These species integrate ecological processes that contribute to the maintenance of ecosystem function. This will allow management actions aimed at conserving the focal species to also protect a larger number of species occurring in the management area. We show how species density relationships to landscape metrics and habitat variables along with predictive distribution models can be used as an effective tool to assist with management planning. Grassland cohesion, landscape composition and grass structure influenced focal species bird density along both ends of the landscape and vegetation continuum.

Soapstone Prairie Natural Area offers an exceptional opportunity to steward a diverse landscape and sustain populations of several unique species of wildlife that are declining within this disappearing ecosystem. Management should pay particular attention to the shortgrass prairie obligate species that are declining on the property and range-wide. In order to maintain populations of these and other grassland-obligate species, managers should strive to conserve and augment prairie dog populations, maintain and restore native shortgrass prairie through prescribed burns and intensive grazing, minimize disturbance from natural resource development and recreation, and continue monitoring to inform management priorities and actions.

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INTRODUCTION

Soapstone Prairie Natural Area (SPNA) is a unique, high elevation landscape containing some of the last remaining high-quality, extensive shrubland and shortgrass prairie along the Colorado Front Range, literally connecting the Rocky Mountains to the Great Plains. Several Colorado partners have been working since 2004 to protect this biological and scenic corridor through a multi-partner project called The Laramie Foothills Mountains to Plains Project. Bird Conservancy of the Rockies (BCR) has partnered with the City of Fort Collins Natural Areas (FCNA) since 2006 to aid in the conservation and management of this important conservation and recreation destination through bird inventory and monitoring, providing the FCNA with data and management recommendations that benefit the bird and wildlife community in Soapstone and adjacent properties.

The first complete survey of the property was in 2006 & 2007. The goal of this long-term monitoring is to help the FCNA conserve grassland and shrubland bird species and their habitats on Soapstone by understanding the abundance, distribution, trends and habitat requirements of breeding birds in the Natural Area. The area has experienced several cycles of documented sylvatic plague since 2008 that have significantly decreased the Black-tailed prairie dog (*Cynomys ludovicianus*) populations, a keystone species that creates ideal nesting habitat for bird species of concern like Mountain Plover, Burrowing Owl and McCown's Longspur. The decreased grazing activities of the prairie dogs has encouraged more forbs to grow into the areas that were once sparsely vegetated and may create a shift in the avifauna to birds that are more tolerant to forbs and taller grasses. The objectives are to monitor populations of bird species, document the migratory and breeding bird use of the project area and their response to management activities, and to provide recommendations for conservation of sensitive bird species.

We used a focal species approach and identified six focal species; Loggerhead Shrike, McCown's Longspur, Vesper, Brewer's, Grasshopper and Baird's Sparrow. These species integrate ecological processes that contribute to the maintenance of ecosystem function. This will allow management actions aimed at conserving the focal species to also protect a larger number of species occurring in the management area. We show how species density relationships to landscape metrics and habitat variables along with predictive distribution models can be used as an effective tool to assist with management planning.

STUDY AREA & METHODS

Between May 13th and July 11th of 2019, we conducted breeding bird point count surveys on Soapstone Prairie Natural Area in Larimer county of northern Colorado (Appendix A).

Soapstone is dominated by native shortgrass prairie on the eastern half, with the primary species being blue grama (*Bouteloua gracilis*) & buffalo grass (*Bouteloua dactyloides*), edged on the north and west by rolling hills, wide shallow washes, and abrupt rocky outcroppings (Fig 1). Moving west the terrain rises into the foothills that are home to one of the largest contiguous communities of mountain mahogany (*Cercocarpus montanus*) in the state of Colorado

(Rondeau et al. 2011). There is a large patch of old growth ponderosa pine on the far west boundary, limestone cliffs in the middle, running northwest to southeast, and hills dotted with skunkbush (*Rhus trilobata*) and narrow-leaf yucca (*Yucca glauca*).



Fig 1: Looking southeast across Soapstone prairie from a point above the historic Lindenmeier dig Site

Avian Point Count Surveys

Using a systematic 250-m grid of point count stations created in Arc Map 9.3.1 to survey the properties since 2006. There were 1,181 point count stations that were surveyed once between May 13th and July 11th (Fig 2). Point count surveys started one half-hour before sunrise and ended by 11 a.m., often earlier.

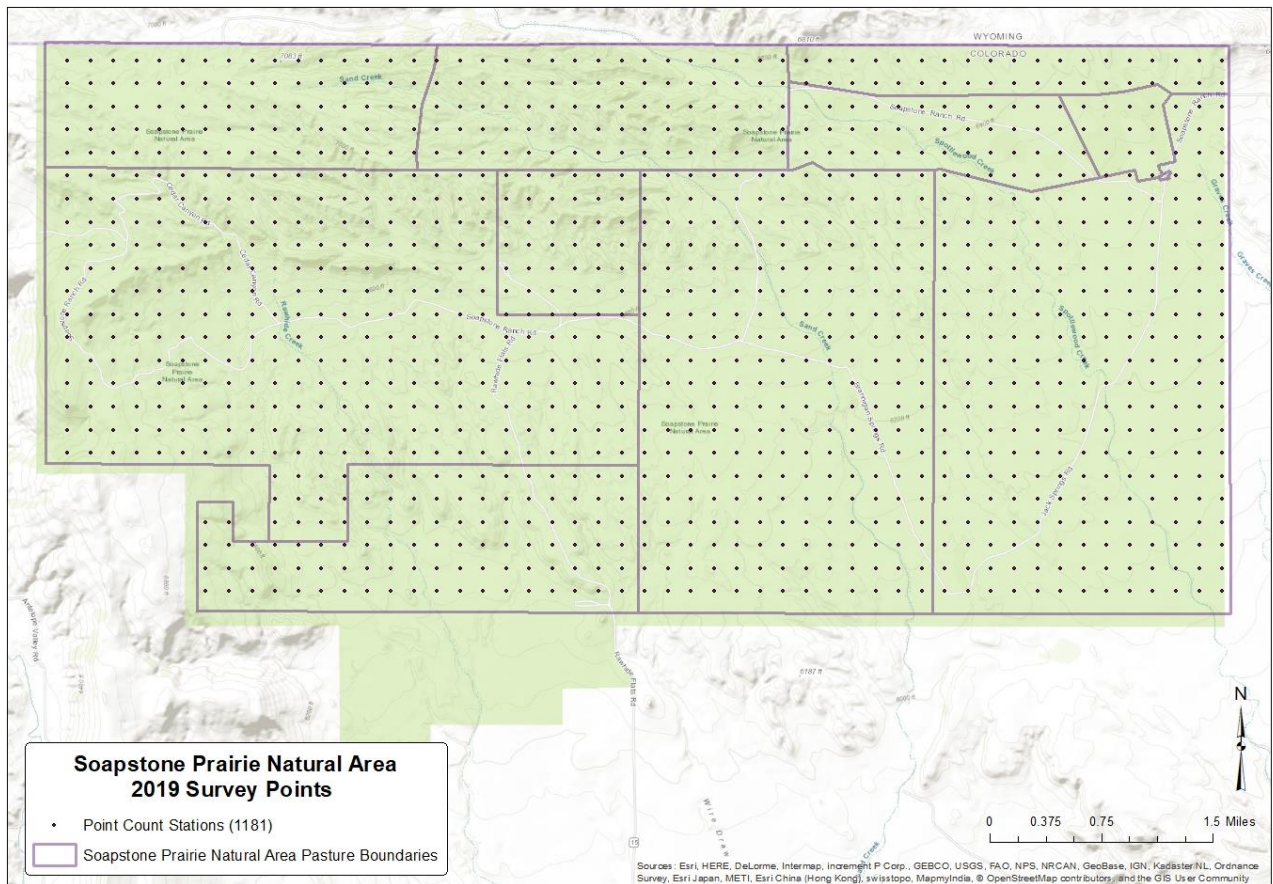


Figure 2: 2019 Survey area and point count stations on Soapstone Prairie Natural Area.

Point count locations were navigated to on foot using a handheld GPS unit. We recorded atmospheric data (temperature, cloud cover, precipitation, and wind speed) and time of day at the start and end of each daily survey effort. All GPS data were logged in Universal Transverse Mercator (UTM) North American Datum 1927. At each station, we conducted a 6-minute point count survey consisting of six consecutive 1-minute intervals. This protocol, which is described more fully by Hanni et al. (2016), uses Distance sampling (Buckland et al. 2001) and removal sampling (Farnsworth et al. 2002). For each bird detected, observers recorded species, sex, how it was detected (call, song, visual, wing beat, other), distance from observer at time of detection, and the 1-minute interval in which it was detected. We measured distances using a Bushnell Yardage Pro laser rangefinder. Point counts were not conducted during periods of heavy snow, rain, or wind greater than 10 mph. Between point count surveys, we recorded the presence of high-priority and other rare or unusual bird species, but we did not use these observations in our analyses. We also noted the presence of any other wildlife or interesting site observations.

Habitat Surveys

After each avian point count survey, we completed a rapid habitat survey by estimating several vegetation parameters. Within 5 m of each point we visually estimated percent cover of grasses, forbs, bare ground, exotic/ non-native plants, cactus, low woody plants (< 30cm), animal scat, rock, and 'other cover' to the nearest 1%. 'Other cover' included other minor ground cover types such as lichen, litter, or categories defined in the notes (i.e. metal scraps, water, etc.). Also

within this radius we measured average grass height with a ruler to the nearest cm and listed the dominant grass species. Within 50 m of each station we documented any shrub (> 30cm) and over-story tree species, estimated the percent cover to the nearest 1%, and the average height of each. We recorded whether point count stations in prairie dog colonies were 'active' or 'inactive'.

ANALYSES

Abundance/Density Estimation

We used a hierarchical distance sampling model described in Sillett et al. (2012). This hierarchical model includes sub-models that allow for the abundance process and the detection process to vary as functions of covariates i.e., grass height. In the abundance component of the model, the number of birds at each point (N_i) was modeled using a Poisson random variable. The expectation for the number of birds at a point count is $E[N_i] = \lambda$. The detection process in the model is based on classical distance sampling methods developed by Buckland et al. (2001). We used a half normal scale parameter and only considered constant models on detection. We estimated parameters of the generalized multinomial mixture model by maximizing the integrated likelihood function in program R software (R Development Core Team 2019) using the 'unmarked' package (Fiske, Chandler & Royle 2010). We assessed the strength of evidence for effect sizes by evaluating the model parameter estimates ($\hat{\beta}$) with respect to zero using standard errors and 95% confidence intervals (Burnham and Anderson 2002). We pooled data from 2006 to 2009 to estimate density except for Baird's Sparrow where we used data from 2016 to 2019. We included a year effect when estimating density for 2019 for species with sufficient detections otherwise we pooled across years.

We used an information theoretic approach to select the top models (Burnham and Anderson 2002). We ranked models by the Akaike Information Criterion (AIC) (Akaike 1973) and considered a set of candidate models to be the best if AIC values were within $\Delta AIC < 2$. If overdispersion was detected we used QAIC ([Burnham & Anderson 2002](#)). We developed distribution models by using the top model to predict abundance/densities throughout Soapstone Natural Area.

Model Covariates

There were two sets of covariates used on density in the models; one for landscape metrics and another using vegetation measurements collected in the field. The detection model was held constant for all models. Within Program R we used the landscapemetrics package ([Hesselbarth et al. 2019](#)) with LANDFIRE existing vegetation type layer (USGS 2014) to derive landscape metrics within the sampling unit (125x125 meters square,(3.8 acres)). The landscape metric covariates were grassland cohesion and landscape composition metric. Covariates collected in the field used in the models were percent cover of grass, grass height, percent cover of woody vegetation and percent cover of bare ground. We developed 12 a priori models to observe bird density response to vegetation covariates.

RESULTS

Avian Surveys

In 2019 we detected 17,367 birds during point count surveys, and observed 96 species within the study area. Of the species detected, 16 are of conservation interest. (Appendix B).

We analyzed data for 6 focal breeding bird species; Baird's Sparrow, Brewer's Sparrow, Grasshopper Sparrow, Vesper Sparrow, Logger-head Shrike and McCown's Longspur and present their mean density in Table 1.

Table 1: Density estimates in 2019 on Soapstone (D = # of birds/ km²), SE = Standard Error, and 95% lower (LCL) and upper (UCL) confidence limits.

Species	D	SE	LCL	UCL
Loggerhead Shrike	0.54	0.08	0.40	0.72
McCown's Longspur	11.35	0.94	9.66	13.35
Grasshopper Sparrow	9.66	1.23	7.53	12.40
Vesper Sparrow	11.62	0.57	10.55	12.80
Brewer's Sparrow	4.54	0.49	3.67	5.63
Baird's Sparrow	0.12	0.07	0.04	0.35

Loggerhead Shrike's top model for habitat selection included grassland cohesion, grass cover, landscape composition, woody cover and grass height (Table 2). Density increased with grass cover, landscape composition, woody cover, grass height and decreased with grassland cohesion (Table 3). Strong positive effects were seen with vegetation diversity, woody cover and grass height (Table 3). Logger-head Shrike occurred in higher densities in the western and north western portion of Soapstone (Figure 3).

McCown's Longspur's top model included the full model (Table 2). Density increased with grassland cohesion, woody cover and decreased with grass cover, landscape composition, grass height and bare ground cover (Table 3). Strong effects were seen for all covariates (Table 3). McCown's Longspur densities increased from west to east corresponding with shortgrass prairie and prairie dog habitat (Figure 4).

Grasshopper Sparrow's top model included the full model (Table 2). Density increased with grassland cohesion, grass cover, landscape composition, grass height and bare ground and decreased with woody cover (Table 3). Strong positive effects were seen for all covariates (Table 3). Grasshopper Sparrow densities were consistently higher in the central and eastern portion of Soapstone with high patchy densities to the west (Figure 5).

Vesper Sparrow's top model included landscape composition and grass height (Table 2). Density increased with landscape composition and grass height (Table 3). Strong positive effects were seen for both of these covariates (Table 3). Vesper Sparrow densities were higher in the western and northern portion of Soapstone (Figure 6).

Brewer's Sparrow top model included grassland cohesion, grass cover, landscape composition, grass height and bare ground cover (Table 2). Density increased with vegetation diversity and grass height and decreased with grassland cohesion, grass cover and bare ground (Table 3). Strong positive effects were seen for landscape composition, grass height and strong negative effects were seen for grassland cohesion, grass cover, and bare ground cover (Table 3). Higher Brewer's Sparrow densities occurred on the western portion of Soapstone (Figure 7).

Baird's Sparrow's top model included grassland cohesion, grass cover, woody cover, grass height and bare ground (Table 2). Density increased with grassland cohesion, grass cover, grass height and decreased with woody cover and bare ground (Table 3). Strong positive effects were seen with grassland cohesion and strong negative effects were seen with woody cover and bare ground (Table 3). Baird's Sparrow densities increased in the eastern pastures on Soapstone (Figure 8).

Table 2: Model selection for the density (λ) of 6 focal species at Soapstone Prairie Natural Area (using data from 2006 - 2019). The model selection metrics are the number of parameters (K), value of the Akaike Information Criterion for small sample size (AICc), difference between model and minimum AICc values (Δ AICc) and the weight of each model (AICcWt). Grass = grass cover, Woody = woody cover, GrassH = grass height, Cohe = grassland cohesion and LandComp = landscape composition.

Loggerhead Shrike				
Model	K	AICc	Delta AICc	AICcWt
Grass+LandComp+Woody+GrassH+Bare	7	1728.34	0.00	0.29
Cohe+Grass+LandComp+Woody+GrassH	7	1728.36	0.02	0.29
Cohe+LandComp+Woody+GrassH+Bare	7	1728.88	0.54	0.22
Cohe+Grass+LandComp+Woody+GrassH+Bare	8	1730.34	2.00	0.11
Cohe+Grass+LandComp+Woody+Bare	7	1730.84	2.50	0.08
Cohe+Grass+Woody+GrassH+Bare	7	1735.93	7.59	0.01
LandComp+GrassH	4	1745.84	17.50	0.00
Cohe+Grass+LandComp+GrassH+Bare	7	1746.12	17.78	0.00
Cohe+Grass+LandComp	5	1747.54	19.20	0.00
Woody+GrassH+Bare	5	1754.01	25.67	0.00
Cohe+GrassH	4	1767.25	38.91	0.00
Null	2	1782.53	54.18	0.00
McCown's Longspur				
	K	AICc	Delta AICc	AICcWt
Cohe+Grass+LandComp+Woody+GrassH+Bare	8	22317.8	0	1
Cohe+Grass+LandComp+GrassH+Bare	7	22333.9	16.06	0
Cohe+LandComp+Woody+GrassH+Bare	7	22353.2	35.43	0
Cohe+Grass+LandComp+Woody+Bare	7	22418.1	100.25	0
Cohe+Grass+LandComp+Woody+GrassH	7	22426.9	109.12	0
Cohe+Grass+LandComp	5	22479.4	161.62	0
Grass+LandComp+Woody+GrassH+Bare	7	23117.9	800.06	0
Cohe+Grass+Woody+GrassH+Bare	7	23158.4	840.63	0
LandComp+GrassH	4	23253.2	935.39	0

Coh+GrassH	4	23267.5	949.74	0
Woody+GrassH+Bare	5	25589.3	3271.54	0
NULL	2	26604.3	4286.47	0
Grasshopper Sparrow				
	K	AICc	Delta_AICc	AICcWt
Coh+Grass+LandComp+Woody+GrassH+Bare	8	5175.8	0	0.98
Coh+LandComp+Woody+GrassH+Bare	7	5183.85	8.05	0.02
Coh+Grass+LandComp+Woody+GrassH	7	5189.03	13.23	0
Coh+Grass+Woody+GrassH+Bare	7	5192.86	17.06	0
Coh+Grass+LandComp+GrassH+Bare	7	5238.82	63.02	0
Coh+Grass+LandComp+Woody+Bare	7	5258.12	82.32	0
Grass+LandComp+Woody+GrassH+Bare	7	5274.77	98.97	0
Woody+GrassH+Bare	5	5287.38	111.58	0
Coh+GrassH	4	5316.44	140.65	0
Coh+Grass+LandComp	5	5356.32	180.52	0
LandComp+GrassH	4	5453.65	277.85	0
Null	2	5476.15	300.35	0
Vesper Sparrow				
	K	AICc	Delta_AICc	AICcWt
LandComp+GrassH	4	14390.06	0	0.51
Grass+LandComp+Woody+GrassH+Bare	7	14392.63	2.57	0.14
Coh+LandComp+Woody+GrassH+Bare	7	14392.65	2.59	0.14
Coh+Grass+LandComp+Woody+GrassH	7	14393.48	3.42	0.09
Coh+Grass+LandComp+GrassH+Bare	7	14394.53	4.47	0.06
Coh+Grass+LandComp+Woody+GrassH+Bare	8	14394.54	4.48	0.05
Coh+Grass+LandComp	5	14408.47	18.41	0
Coh+Grass+LandComp+Woody+Bare	7	14411.57	21.51	0
Woody+GrassH+Bare	5	14540.57	150.52	0
Coh+Grass+Woody+GrassH+Bare	7	14542.22	152.16	0
Coh+GrassH	4	14542.68	152.62	0
NULL	2	14581.88	191.82	0
Brewer's Sparrow				
	K	AICc	Delta_AICc	AICcWt
Coh+Grass+LandComp+GrassH+Bare	7	4683.53	0	0.43
Coh+Grass+LandComp+Woody+GrassH	7	4683.65	0.11	0.4
Coh+Grass+LandComp+Woody+GrassH+Bare	8	4685.39	1.85	0.17
Coh+LandComp+Woody+GrassH+Bare	7	4702.43	18.9	0
Coh+Grass+Woody+GrassH+Bare	7	4708.42	24.89	0
Coh+GrassH	4	4730.87	47.33	0
Coh+Grass+LandComp+Woody+Bare	7	4773.8	90.27	0
Coh+Grass+LandComp	5	4779.04	95.5	0
Grass+LandComp+Woody+GrassH+Bare	7	4876.1	192.57	0

Woody+GrassH+Bare	5	4926.58	243.05	0
LandComp+GrassH	4	4957.16	273.63	0
NULL	2	5252.06	568.53	0
Baird's Sparrow				
	K	AICc	Delta_AICc	AICcWt
Cohe+Grass+Woody+GrassH+Bare	7	921.09	0	0.33
Cohe+Grass+LandComp+Woody+Bare	7	921.1	0.01	0.33
Cohe+LandComp+Woody+GrassH+Bare	7	922.3	1.21	0.18
Cohe+Grass+LandComp+Woody+GrassH+Bare	8	923.07	1.98	0.12
Cohe+Grass+LandComp+Woody+GrassH	7	925.88	4.79	0.03
Woody+GrassH+Bare	5	931.69	10.6	0
Grass+LandComp+Woody+GrassH+Bare	7	931.9	10.81	0
Cohe+Grass+LandComp	5	938.68	17.59	0
Cohe+Grass+LandComp+GrassH+Bare	7	940.72	19.63	0
Cohe+GrassH	4	960.67	39.58	0
LandComp+GrassH	4	981.71	60.62	0
NULL	2	990.24	69.15	0

Table 3: Best model parameter estimates, standard errors (SE) and lower and upper 95% confidence limits (LCL and UCL, respectively) for the density (λ) of focal species.

	Habitat Covariates	Estimate	SE	UCL	LCL
Loggerhead Shrike	(Intercept)	-2.600	0.149	-2.891	-2.309
	Cohesion	-0.116	0.088	-0.288	0.056
	Grass Cover	0.122	0.094	-0.063	0.307
	Land Comp	0.467	0.085	0.300	0.635
	Woody Cover	0.214	0.038	0.139	0.288
	Grass Height	0.167	0.079	0.011	0.322
	McCown's Longspur	(Intercept)	0.736	0.057	0.624
Cohesion		1.630	0.124	1.387	1.872
Grass Cover		-0.121	0.020	-0.160	-0.082
Land Comp		-0.792	0.027	-0.844	-0.739
Woody Cover		0.145	0.030	0.086	0.204
Grass Height		-0.245	0.026	-0.296	-0.194
Bare Ground		-0.193	0.019	-0.230	-0.155
Grasshopper Sparrow	(Intercept)	-1.402	0.098	-1.593	-1.210
	Cohesion	1.129	0.167	0.802	1.456
	Grass Cover	0.179	0.057	0.067	0.290
	Land Comp	0.227	0.052	0.124	0.329
	Woody Cover	-1.038	0.145	-1.322	-0.755
	Grass Height	0.325	0.028	0.270	0.381

	Bare Ground	0.220	0.055	0.112	0.328
Vesper Sparrow	(Intercept)	0.096	0.039	0.019	0.173
	Land Comp	0.294	0.024	0.248	0.339
	Grass Height	0.098	0.022	0.055	0.141
Brewer's Sparrow	(Intercept)	-1.094	0.081	-1.253	-0.935
	Cohesion	-0.481	0.032	-0.544	-0.418
	Grass Cover	-0.229	0.052	-0.330	-0.127
	Land Comp	0.251	0.049	0.155	0.347
	Woody Cover	0.341	0.032	0.278	0.404
	Bare Ground	-0.022	0.047	-0.114	0.071
Baird's Sparrow	(Intercept)	-3.739	0.540	-4.797	-2.680
	Cohesion	1.451	0.577	0.320	2.582
	Grass Cover	0.185	0.173	-0.153	0.524
	Woody Cover	-2.488	0.778	-4.012	-0.963
	Grass Height	0.030	0.112	-0.189	0.249
	Bare Ground	-0.549	0.250	-1.040	-0.059

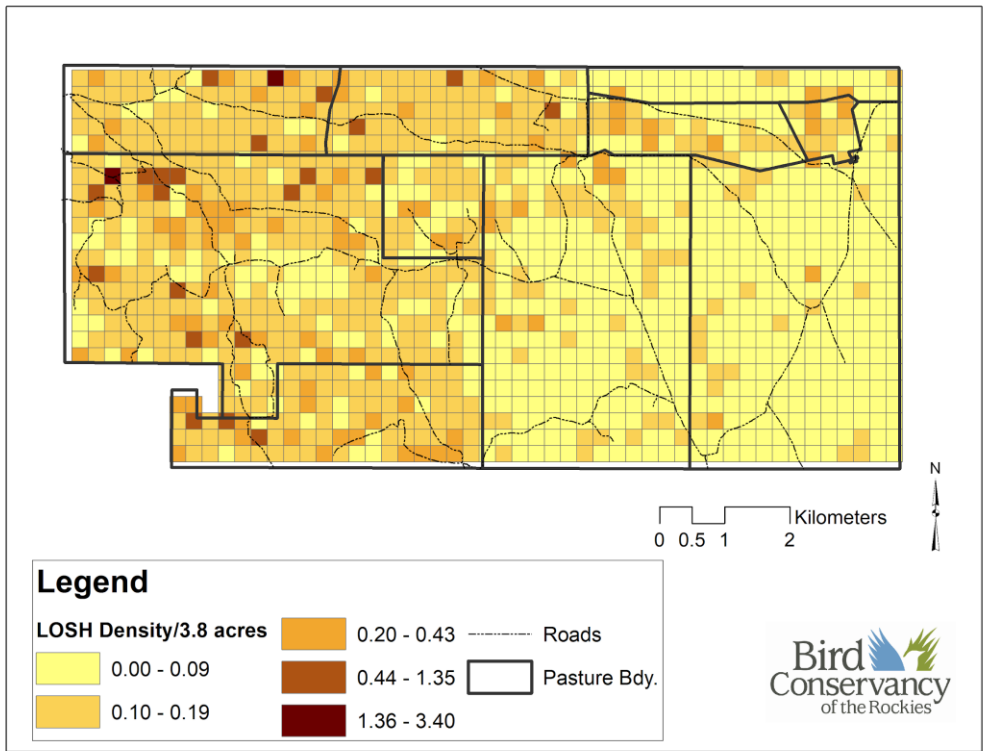


Figure 3: Loggerhead Shrike Density

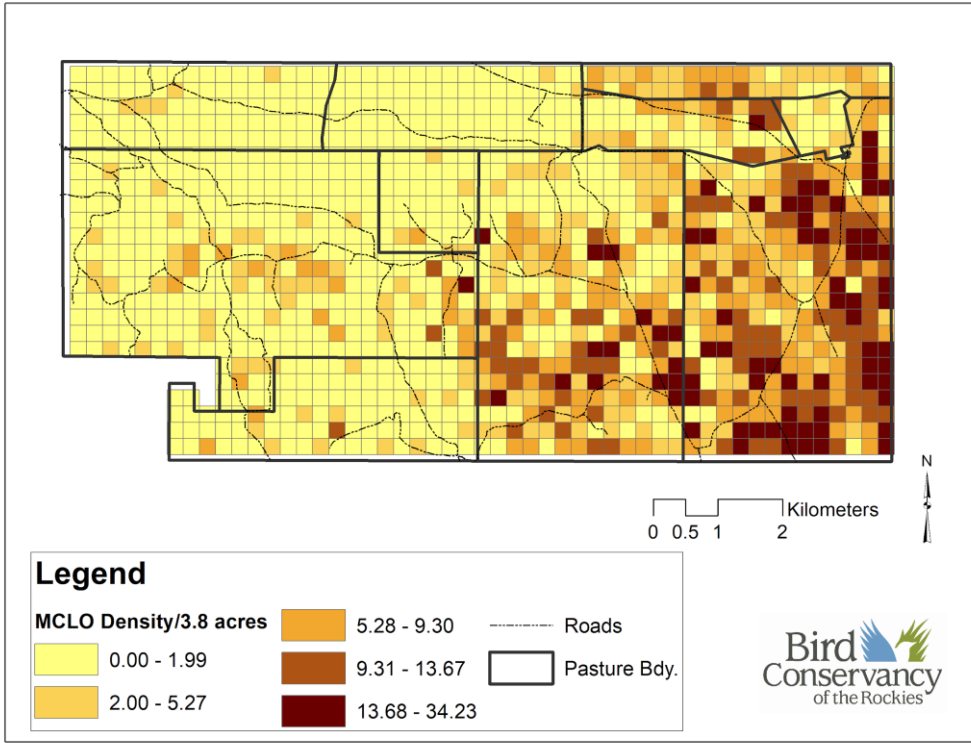


Fig 4: McCown's Longspur Density

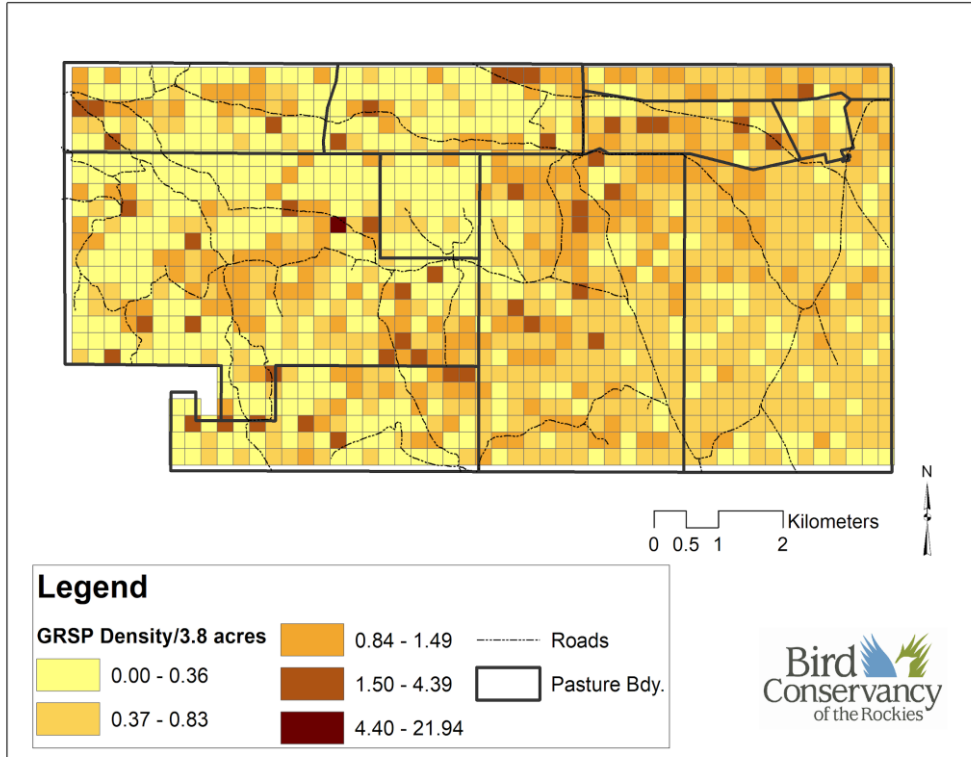


Fig 5: Grasshopper Sparrow Density

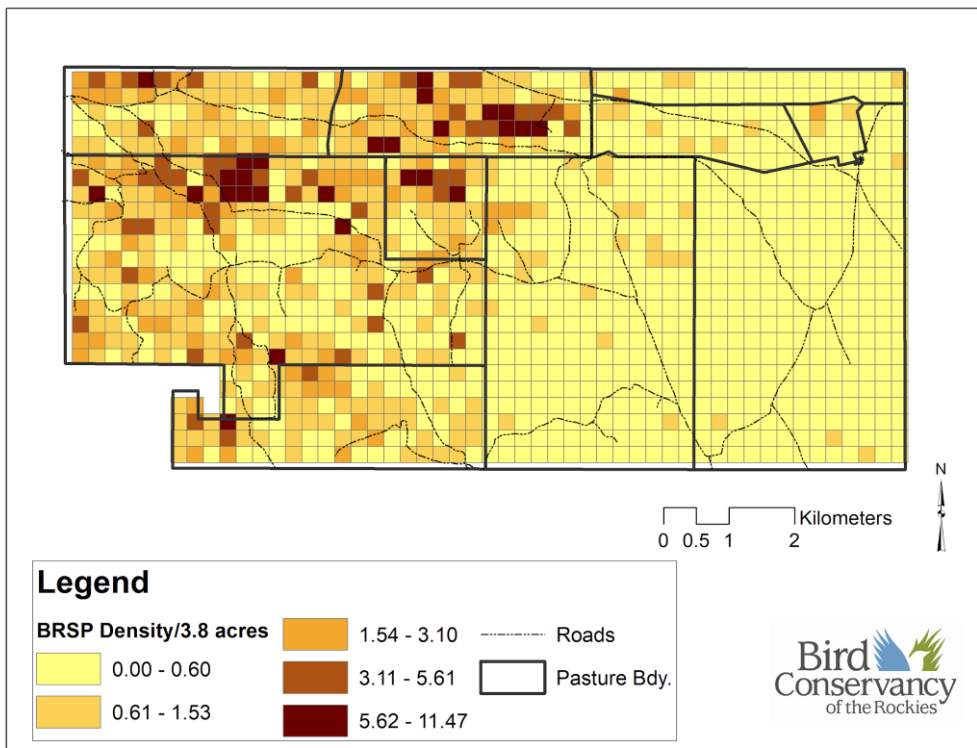


Fig 6: Brewer's Sparrow Density

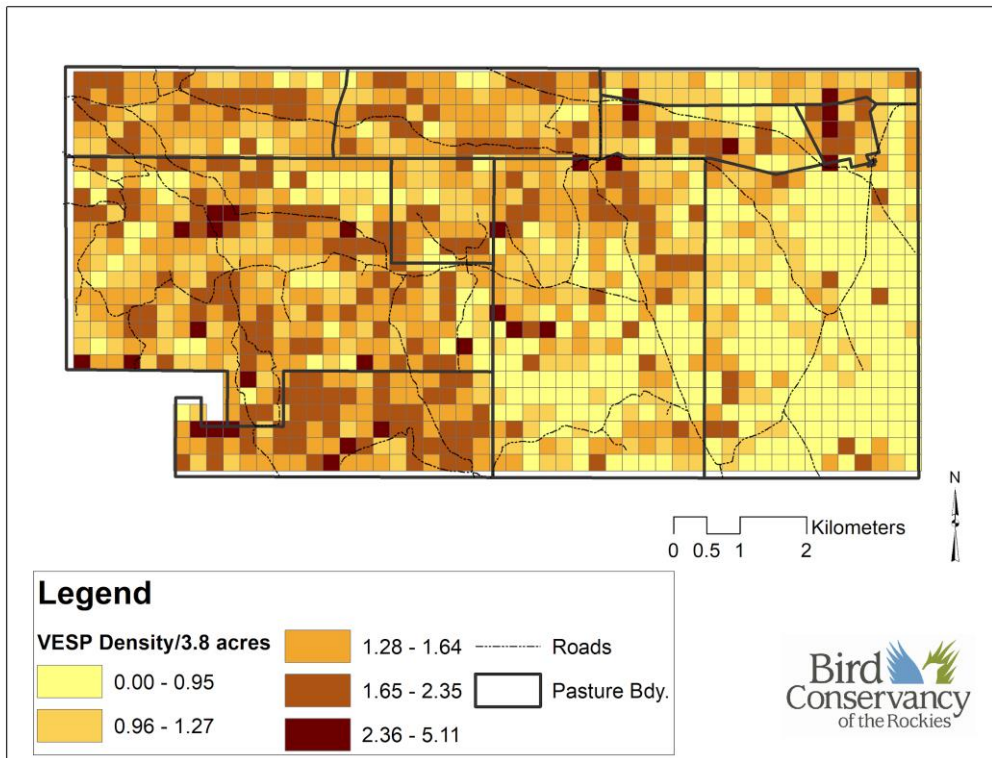


Fig 7: Vesper Sparrow Density

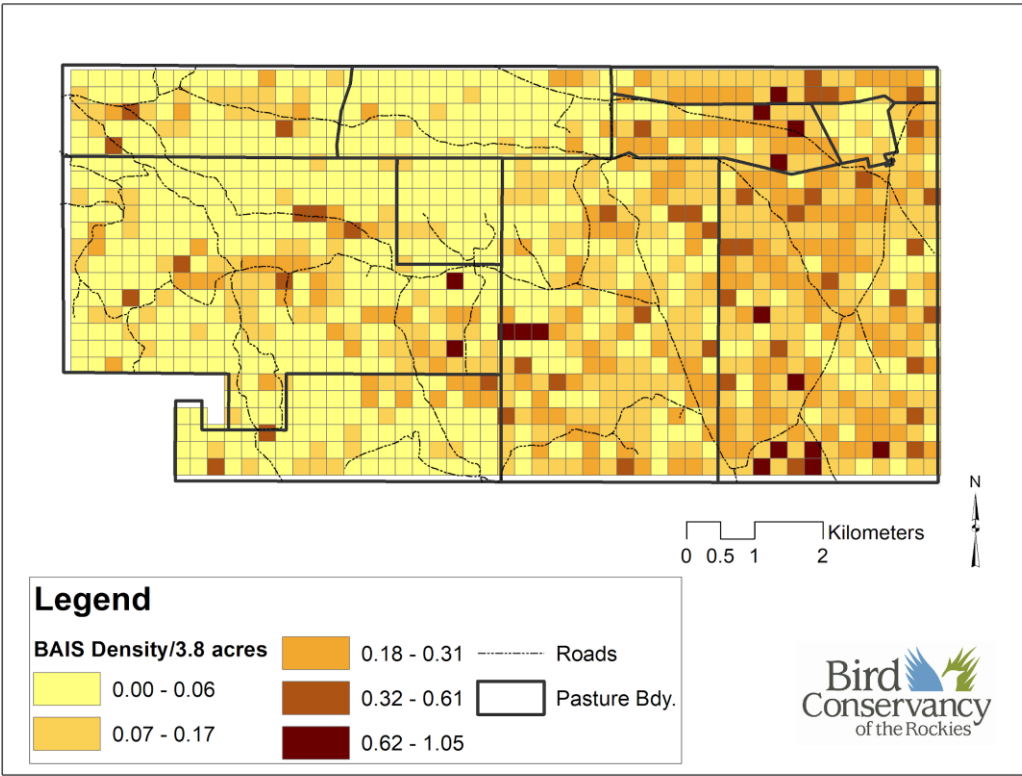


Figure 8: Baird's Sparrow Density

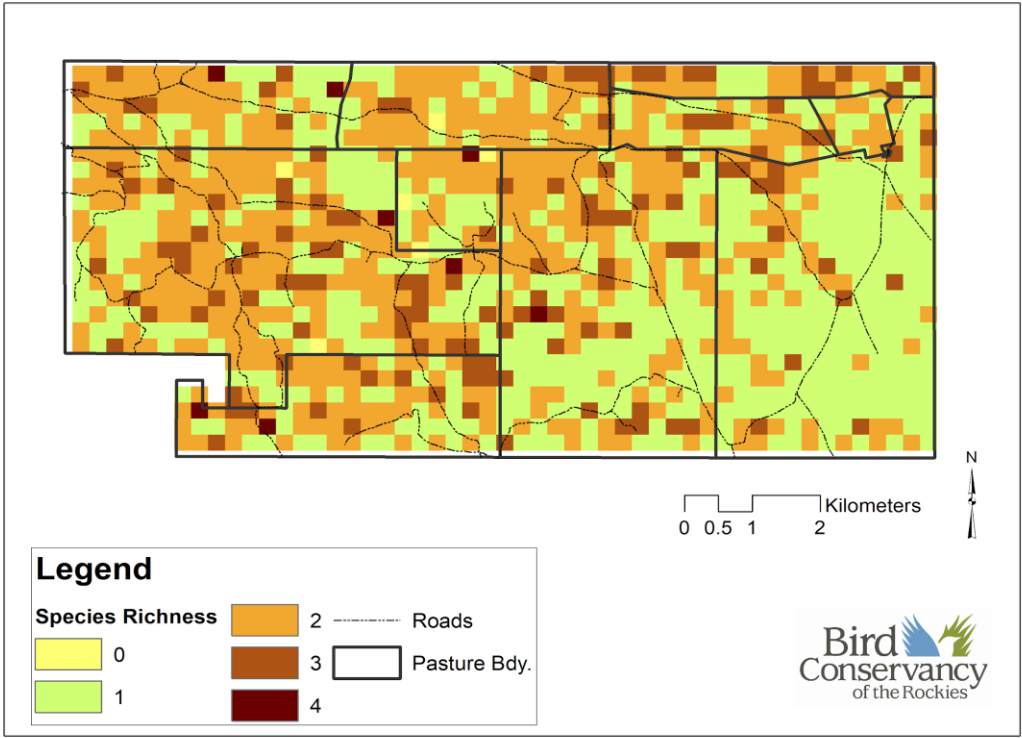


Fig. 9: Species Richness across Soapstone Prairie

Vegetation Surveys:

The average percent ground cover across the property has changed very little since the initial surveys in 2006/ 2007 (Fig 10). The most noticeable change was an increase in forbs from 4% in 2006/ 2007 to 12% in 2019, as well as a large decrease in “Woody” structure (shrubs <30cm tall) from 11% in 2006/ 2007 to 4%. Grass, bare ground, cactus & rock percent cover was fairly consistent. We did a veg percent cover comparison in each pasture for the 2006/ 2007 data and 2019 to see where those changes occurred on the landscape (Appendix C).

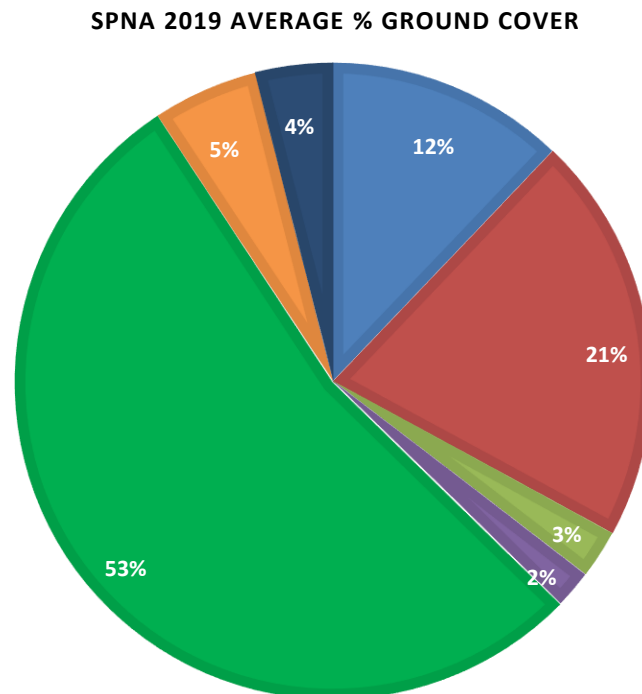
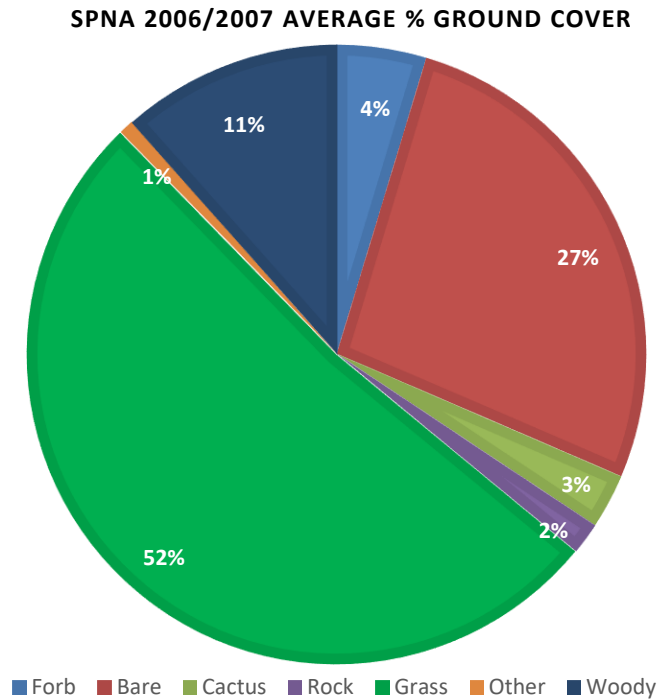


Fig. 10: Average percent ground cover across Soapstone Prairie in 2006/ 2007 (top) and 2019 (bottom).

Discussion and Management Recommendations

Management that focuses on single species outcomes may be too narrow to meet conservation goals (Moilanen 2005). An alternative approach is to identify species that integrate ecological processes that contribute to the maintenance of the ecosystem function while also functioning as focal species (Lindenmayer et al. 2014). This will allow management actions aimed at conserving the focal species to also protect a larger number of species occurring in the management area. We show how species density relationships to landscape metrics and habitat variables along with predictive distribution models can be used as an effective tool to assist with management planning. Grassland cohesion, habitat composition and grass structure influenced focal species bird density along both ends of the landscape and vegetation continuum.

Grassland cohesion characterizes the connectedness of grassland and can be used to meet targeted restoration and management goals. Connectivity brings landscape scale and spatial scale considerations to conservation planning. We found that Baird's Sparrow, Grasshopper Sparrow and McCown's Longspur would benefit from management actions that improve grassland connectivity. Grasshopper Sparrows and Baird's Sparrow have been found to be area sensitive favoring larger grassland tracts (Vickery et al. 1994, Green et al. 2020).

We found that increasing landscape composition benefited Loggerhead Shrike, Brewer's Sparrow, Vesper's Sparrow and Grasshopper Sparrow. Grassland is the dominant habitat on Soapstone followed by a variety of shrubland communities and wet meadows. Within the grassland mosaic patches of shrubland benefits Loggerhead Shrike, Brewer's Sparrow and Vesper's Sparrow. Grassland mosaics with patches of forbs and herbaceous vegetation likely increase Grasshopper Sparrow density. Management actions that increase native habitat composition within the grassland mosaic will increase density for these species.

Grass structure was important for most species and bird density increased with grass height except for McCown's Longspur. This result was expected as McCown's Longspur prefer short grass structure. Grazing management plans can be used to create a mosaic of vegetation structure. Different grazing regimes can be implemented to meet desired conditions and depend on a number of factors ranging from site condition to temporal timing and spatial extent. Different grazing strategies can promote different grass structure simultaneously while benefiting a suite of grassland bird species.

Grasshopper Sparrow had a positive response to grass cover however contrary to our expectations, grass cover didn't have much statistical support for most species. This may be due to the scale at which grass cover was collected. Grass cover would likely have more influence on grassland bird density at a larger scale.

The ability to characterize spatial variation in density at the sampling unit scale across Soapstone will help inform conservation planning and quantify species response to vegetation and habitat covariates.

These models can also be used for adaptive management (Lyons et al. 2008, Conroy et al. 2012) and systematic landscape conservation (Margules and Pressey 2000, Westphal et al. 2007). The distribution models can be used to prioritize management actions and address key questions in conservation planning (Wilson et al. 2007). The predicted distribution maps (population size or density) can be summarized for any area of interest, such as administrative boundaries or management units, and confidence intervals can be computed with the parametric bootstrap (Sillette et al. 2012, Royle et al. 2007).

Spatial variation in species density was seen in the predictive distribution maps and varied by species. There was a west to east gradient in species density with species associated with a shrub component more abundant in the west and higher densities for species associated with more homogenous grassland habitat. Spatial prioritization can be conducted on individual species or using species richness. Species richness was patchy with higher species richness in the West, North and Central portions of Soapstone where vegetation communities transition.

Annual meetings with the Natural Areas Department, ranch managers, the grazing association, and BCR to share data & results and determine management, grazing and conservation goals using birds as indicators would help inform and direct future actions and survey efforts.

ACKNOWLEDGEMENTS

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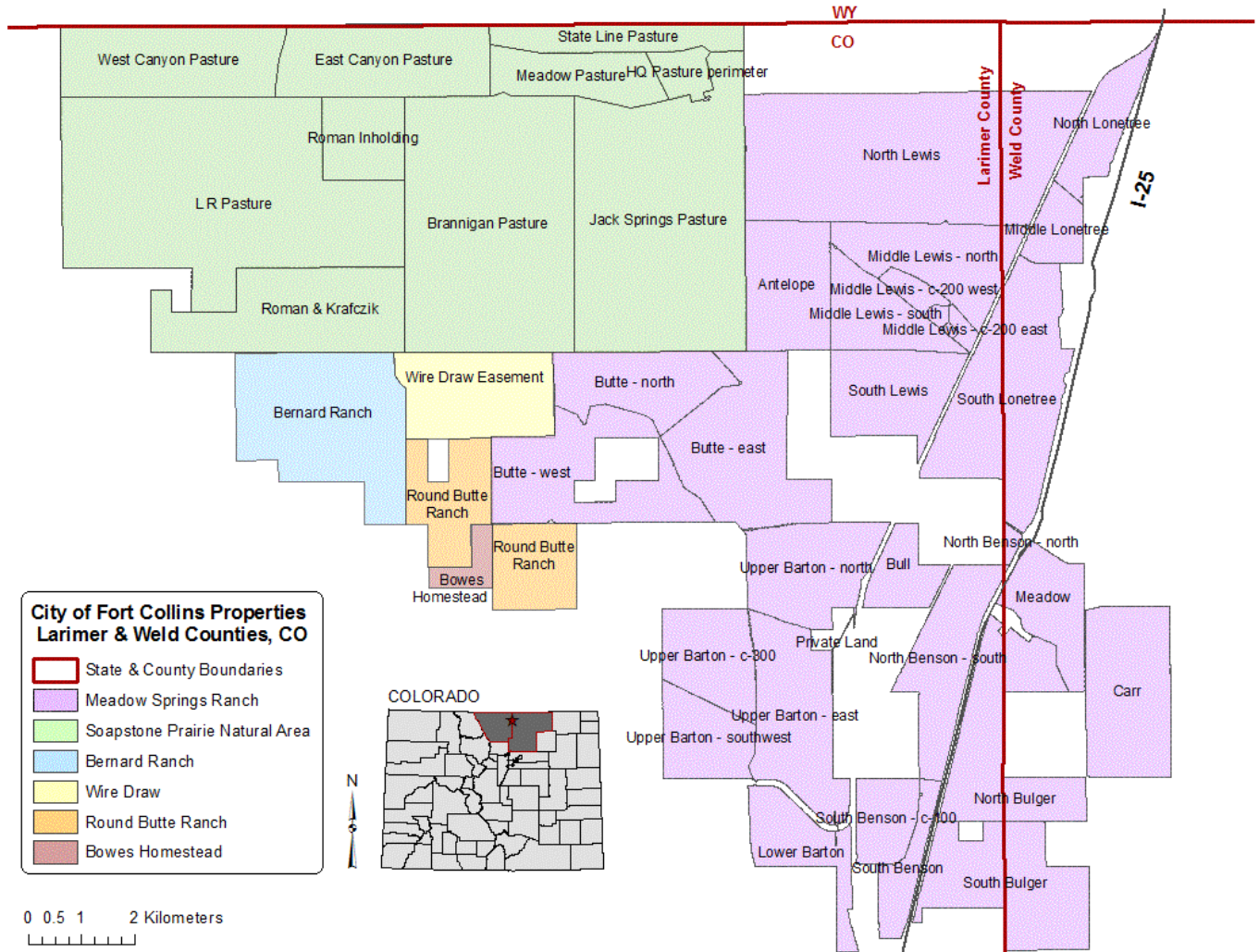
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Appendix (A): Map of Fort Collins Properties

Map of Mountains to Plains properties owned and managed by the City of Fort Collins Natural Areas Program and Utilities: Soapstone Prairie Natural Area, Meadow Springs Ranch, Round Butte Ranch, Bernard Ranch, Wire Draw Easement, and the Bowes Homestead with pasture names.



Appendix (B): Species Detections in the Mountains to Plains Area

Number of individuals (non-truncated detections) of all species during point counts in The Mountains to Plains Area on Fort Collins' Properties from 2006 – 2019.

* Indicates species of special concern and/or high conservation priority status in Canada and the U.S. as determined by Partners in Flight, the USFWS and Colorado Parks & Wildlife.

† Indicates the years Colorado Parks and Wildlife conducted bird monitoring

Common Name	Scientific Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
		800pts	737pts	730pts	1169pts	408pts	531pts (1373 effort)	302pts (604 effort)	507pts (1014 effort)	412pts	522pts	224pts (448 effort)	275pts (550 effort)	223pts	1181pts (SPNA only)	
Canada Goose	<i>Branta canadensis</i>		12	33	13	11	13			20	14	29	27	1	8	181
Gadwall	<i>Mareca strepera</i>						2									2
American Wigeon	<i>Mareca americana</i>										5					5
Mallard	<i>Anas platyrhynchos</i>	6	2	2	18	3	38		5	2	7	7	9	1	17	117
Blue-winged Teal	<i>Spatula discors</i>						2				6					8
Green-winged Teal	<i>Anas crecca</i>						1									1
Cinnamon Teal	<i>Spatula cyanoptera</i>											2				2
Northern Shoveler	<i>Spatula clypeata</i>				2											2
Chukar	<i>Alectoris chukar</i>		2													2
American White Pelican	<i>Pelecanus erythrorhynchos</i>				18	9	6									33
Double-crested Cormorant	<i>Phalacrocorax auritus</i>				20	6	9					4			35	74
Great Blue Heron	<i>Ardea herodias</i>	1			26	4	10				4		1	3		49
Cattle Egret	<i>Bubulcus ibis</i>	1														1
Great Egret	<i>Ardea alba</i>														1	1
Turkey Vulture	<i>Cathartes aura</i>	9	10		5		3		2	1	2	1	2		9	44
Bald Eagle	<i>Haliaeetus leucocephalus</i>								1						1	2
Northern Harrier *	<i>Circus hudsonius</i>	2	1	2	11	8	6	4	5	4	1	4	1	2	1	52

Sharp-shinned Hawk	<i>Accipiter striatus</i>		1				2									3
Cooper's Hawk	<i>Accipiter cooperii</i>		2			2										4
Swainson's Hawk *	<i>Buteo swainsoni</i>	11	6	5	60	9	22	4	7	8	5	18	11	18	12	196
Red-tailed Hawk	<i>Buteo jamaicensis</i>		4	4	31		10	2	3						9	63
Ferruginous Hawk *	<i>Buteo regalis</i>	11	2	2	18	1	32	2	6	1		6	7	8	8	104
Golden Eagle *	<i>Aquila chrysaetos</i>	6	4	4	7	3	5	2	3	1			2	3	2	42
American Kestrel	<i>Falco sparverius</i>	10	6	7	27	15	68	13	10	4	3	19	29	9	10	230
Merlin	<i>Falco columbarius</i>				1		1									2
Peregrine Falcon	<i>Falco peregrinus</i>					1									1	2
Prairie Falcon *	<i>Falco mexicanus</i>	5	5	5	9	10	9	1	2	5	5	5	1	1	17	80
Dusky Grouse	<i>Dendragapus obscurus</i>														2	2
Sora	<i>Porzana carolina</i>												1		3	4
Sandhill Crane *	<i>Antigone canadensis</i>					2			1		1			1		5
American Golden-Plover	<i>Pluvialis dominica</i>									1						1
Killdeer	<i>Charadrius vociferus</i>	90	28	16	123	15	79	10	10	18	24	18	15	20	66	532
Mountain Plover *	<i>Charadrius montanus</i>	6	18	7	42	14	16	30	26	5	6	2	5			177
American Avocet	<i>Recurvirostra americana</i>				4		7				6					17
Greater Yellowlegs	<i>Tringa melanoleuca</i>				1											1
Willet	<i>Tringa semipalmata</i>											1				1
Upland Sandpiper	<i>Bartramia longicauda</i>		2	1			3							2		8
Whimbrel	<i>Numenius phaeopus</i>									2						2
Long-billed Curlew *	<i>Numenius americanus</i>	3		1	11	14	72	11	2	1		6	8			129
Wilson's Snipe	<i>Gallinago delicata</i>	55	11	9	13		30	2	5	3	9	10	13	19	79	258

Wilson's Phalarope	<i>Phalaropus tricolor</i>	2	4		7	3	2				4					22
Red-necked Phalarope	<i>Phalaropus lobatus</i>				7											7
Rock Pigeon	<i>Columba livia</i>	11	2	3	7	3	43		6				11	7	27	120
Eurasian Collared-Dove	<i>Streptopelia decaocto</i>		1	2			1								6	10
Mourning Dove	<i>Zenaida macroura</i>	238	155	104	53	40	137	25	86	26	28	19		48	573	1532
Barn Owl	<i>Tyto alba</i>		1													1
Great Horned Owl	<i>Bubo virginianus</i>	1													4	5
Burrowing Owl *	<i>Athene cunicularia</i>	6	2	5	21	10	54	30	16	3	19	38	59	51	1	315
Short-eared Owl	<i>Asio flammeus</i>		1													1
Common Nighthawk *	<i>Chordeiles minor</i>	67	14	31	24	7	20	11	20	4	2	1	8	17	163	389
Common Poorwill	<i>Phalaenoptilus nuttallii</i>	1	1						1						4	7
White-throated Swift	<i>Aeronautes saxatalis</i>														5	5
Broad-tailed Hummingbird	<i>Selasphorus platycercus</i>	1	3	1	2	1					2			1	15	26
Black-chinned Hummingbird	<i>Archilochus alexandri</i>														2	2
Red-headed Woodpecker	<i>Melanerpes erythrocephalus</i>						1									1
Northern Flicker *	<i>Colaptes auratus</i>			1			11		1		2				4	19
Downy Woodpecker	<i>Dryobates pubescens</i>														1	1
Western Wood-Pewee	<i>Contopus sordidulus</i>	3	3	3	3				2						13	27
Hammond's Flycatcher	<i>Empidonax hammondi</i>														2	2
Dusky Flycatcher	<i>Empidonax oberholseri</i>		2													2
Cordilleran Flycatcher	<i>Empidonax occidentalis</i>		1													1
Say's Phoebe	<i>Sayornis saya</i>	56	14	15	26	8	31	10	14	1	2	1	5	2	48	233

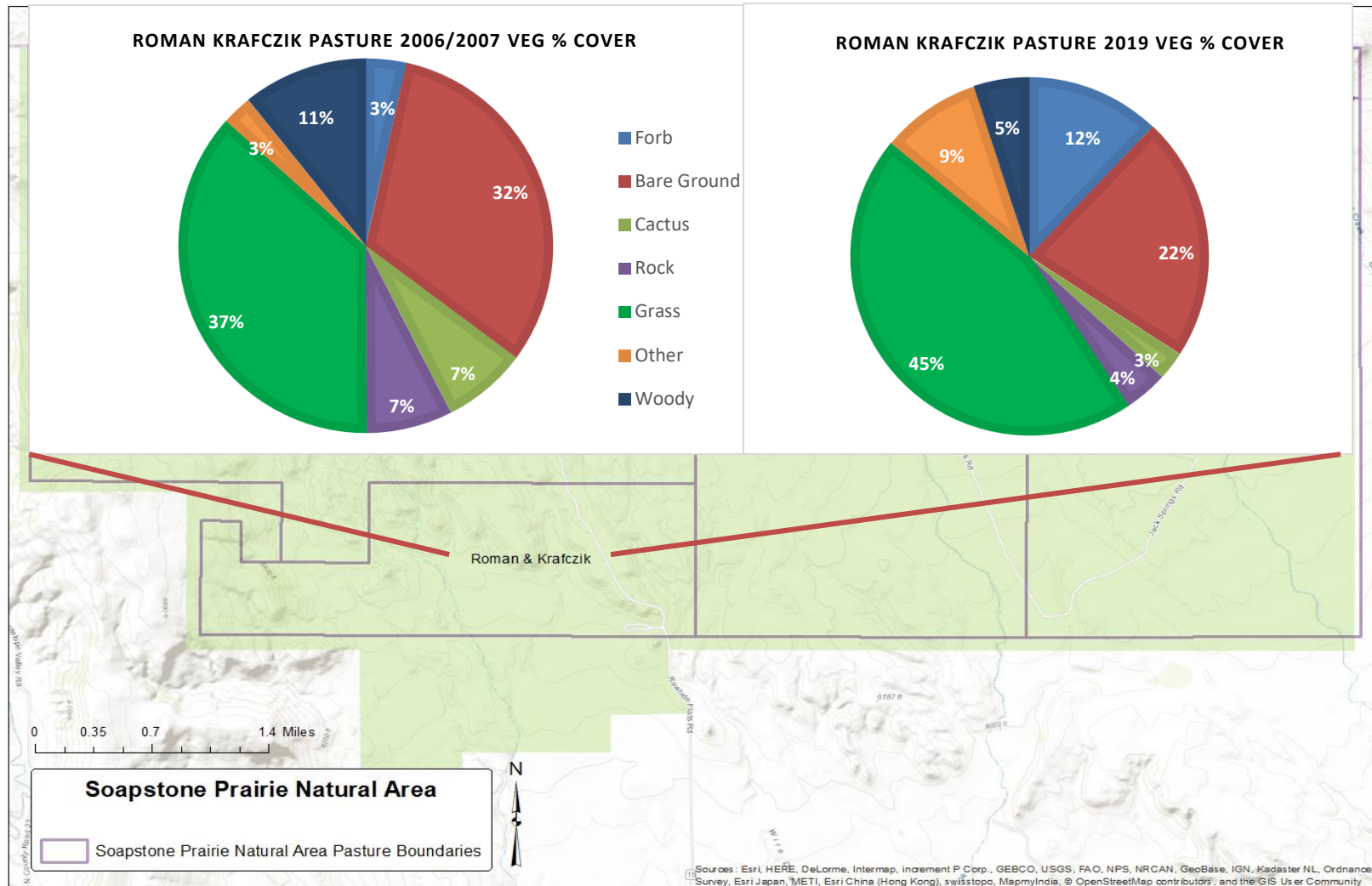
Rock Wren *	<i>Salpinctes obsoletus</i>	103	37	63	13	18	11	13	44	2	1	2	8	18	87	420
House Wren	<i>Troglodytes aedon</i>	1	2				1								3	7
Ruby-crowned Kinglet	<i>Regulus calendula</i>										1					1
Blue-gray Gnatcatcher	<i>Poliophtila caerulea</i>	10	47	1			1		5			1	1		56	122
Mountain Bluebird	<i>Sialia currucoides</i>	1	1						2							4
Western Bluebird	<i>Sialia mexicana</i>				1				1				1		4	7
Eastern Bluebird	<i>Sialia sialis</i>														1	1
Hermit Thrush	<i>Catharus guttatus</i>		1													1
Swainson's Thrush	<i>Catharus ustulatus</i>						2									2
American Robin	<i>Turdus migratorius</i>	23	27	9	7	3	40		1			2			24	136
Gray Catbird	<i>Dumetella carolinensis</i>	6													1	7
Northern Mockingbird	<i>Mimus polyglottos</i>	16	7	1	1		7	3	27		1		4		21	88
Sage Thrasher	<i>Oreoscoptes montanus</i>	8		1			1	22	15		4				4	55
Brown Thrasher	<i>Toxostoma rufum</i>	22	16						13			1	3	7	203	265
Curve-billed Thrasher	<i>Toxostoma curvirostre</i>	1														1
Cedar Waxwing	<i>Bombycilla cedrorum</i>														1	1
European Starling	<i>Sturnus vulgaris</i>	4	4	39	198	11	116	1	2	65	64	9	8	190	71	782
Orange-crowned warbler	<i>Leiothlypis celata</i>														2	2
Virginia's Warbler *	<i>Oreothlypis virginiae</i>		9												19	28
Yellow Warbler	<i>Setophaga petechia</i>	2	14	4	2		7								18	47
Yellow-rumped Warbler	<i>Setophaga coronata</i>		1				2			17					1	21

Common Yellowthroat	<i>Geothlypis trichas</i>	1															1
Wilson's Warbler	<i>Cardellina pusilla</i>	1															1
Yellow-breasted Chat	<i>Icteria virens</i>	1	1				1								11		14
Western Tanager	<i>Piranga ludoviciana</i>						2								7		9
Green-tailed Towhee	<i>Pipilo chlorurus</i>	150	177			7		1	31					2	317		685
Spotted Towhee	<i>Pipilo maculatus</i>	524	288	2		4			183	5	2	8	18	41	1702		2777
Cassin's Sparrow *	<i>Peucaea cassinii</i>			26	13	19	63		54					34			209
Chipping Sparrow	<i>Spizella passerina</i>	11	2		10	5	47		3		26	44		4	17		169
Clay-colored Sparrow	<i>Spizella pallida</i>	31		1	14	4	23		6					2	8		89
Brewer's Sparrow *	<i>Spizella breweri</i>	74	87	111	244	113	95	193	220	31	48	22	17	20	309		1584
Field Sparrow	<i>Spizella pusilla</i>														3		3
Vesper Sparrow *	<i>Poocetes gramineus</i>	369	187	103	102	130	122	210	346	42	139	87	142	153	866		2998
Lark Sparrow	<i>Chondestes grammacus</i>	50	54	36	43	14	138	44	69	12	65	18	12	33	213		801
Bells' (Sage) Sparrow	<i>Amphispiza belli</i>									2							2
Lark Bunting *	<i>Calamospiza melanocorys</i>	451	554	233	3171	119	1212	504	1336	1385	837	122	76	95	556		10651
Savannah Sparrow	<i>Passerculus sandwichensis</i>	93	56	1	34	2	7		1			11	13	17	45		280
Grasshopper Sparrow *	<i>Ammodramus savannarum</i>	1	2	24	150	49	220		11	7	210	102	25	100	321		1222
Baird's Sparrow	<i>Centronyx bairdii</i>										2	39	11	7	31		90
Song Sparrow	<i>Melospiza melodia</i>	1		1			1					1					4
Lincoln's Sparrow	<i>Melospiza lincolnii</i>											10					10
White-crowned Sparrow	<i>Zonotrichia leucophrys</i>						2						1				3

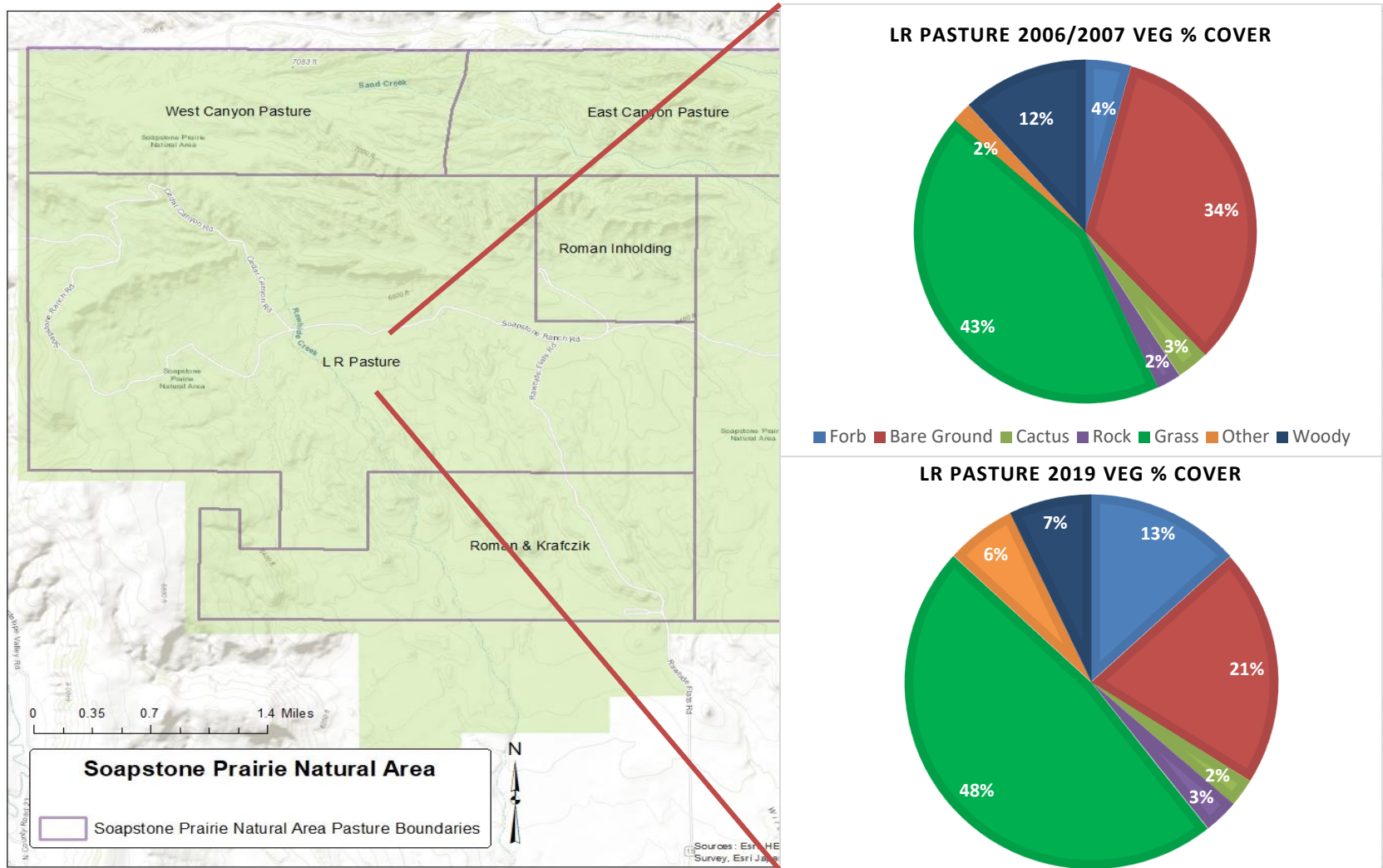
McCown's Longspur *	<i>Rhynchophanes mccownii</i>	1620	725	951	2334	735	1772	480	679	377	564	514	264	661	722	12398
Chestnut-collared Longspur *	<i>Calcarius ornatus</i>	11	1	1	29	78	26	12	10	2	4	1				175
Snow Bunting	<i>Plectrophenax nivalis</i>										5					5
Black-headed Grosbeak	<i>Pheucticus melanocephalus</i>	1	29						4						247	281
Blue Grosbeak	<i>Passerina caerulea</i>		1	2					11						63	77
Lazuli Bunting	<i>Passerina amoena</i>		10				1								6	17
Dickcissel	<i>Spiza americana</i>													3		3
Bobolink *	<i>Dolichonyx oryzivorus</i>					2										2
Red-winged Blackbird	<i>Agelaius phoeniceus</i>	355	84	53	190	29	311	23	65	129	190	65	141	100	488	2223
Eastern Meadowlark	<i>Sturnella magna</i>	1		2		1	2	4	5			2	1			18
Western Meadowlark	<i>Sturnella neglecta</i>	3156	699	581	1693	757	2824	1074	933	672	1208	1335	1558	1847	4527	22864
Yellow-headed Blackbird	<i>Xanthocephalus xanthocephalus</i>		27	4	1						1			3	3	39
Brewer's Blackbird	<i>Euphagus cyanocephalus</i>	197	223	33	112	30	62	12	162	22	157	75	33	60	957	2135
Common Grackle	<i>Quiscalus quiscula</i>	5	9	1	11			32		18	3	1	6	1	25	112
Great-tailed Grackle	<i>Quiscalus mexicanus</i>							48			1					49
Brown-headed Cowbird	<i>Molothrus ater</i>	224	309	25	40	15	21	2	60	43	16	1	11	31	780	1578
Bullock's Oriole	<i>Icterus bullockii</i>	18	35	12	3	2	6	4	15						86	181
House Finch	<i>Haemorhous mexicanus</i>		2		4									2		8
Red Crossbill	<i>Loxia curvirostra</i>		1												3	4
Pine Siskin	<i>Spinus pinus</i>		4											1	1	6
Lesser Goldfinch	<i>Spinus psaltria</i>		11			1	9			4				1	15	41
American Goldfinch	<i>Spinus tristis</i>	50	88	3	1	2	4	3	4			1	1	5	226	388

House Sparrow	<i>Passer domesticus</i>				75		29				1			1		106
Totals	135 species	12012	5339	4110	13808	4099	12024	4513	7172	4398	5560	4590	3859	5791	17367	104642
	# species:	74	86	61	70	57	81	42	65	47	55	52	52	57	96	149

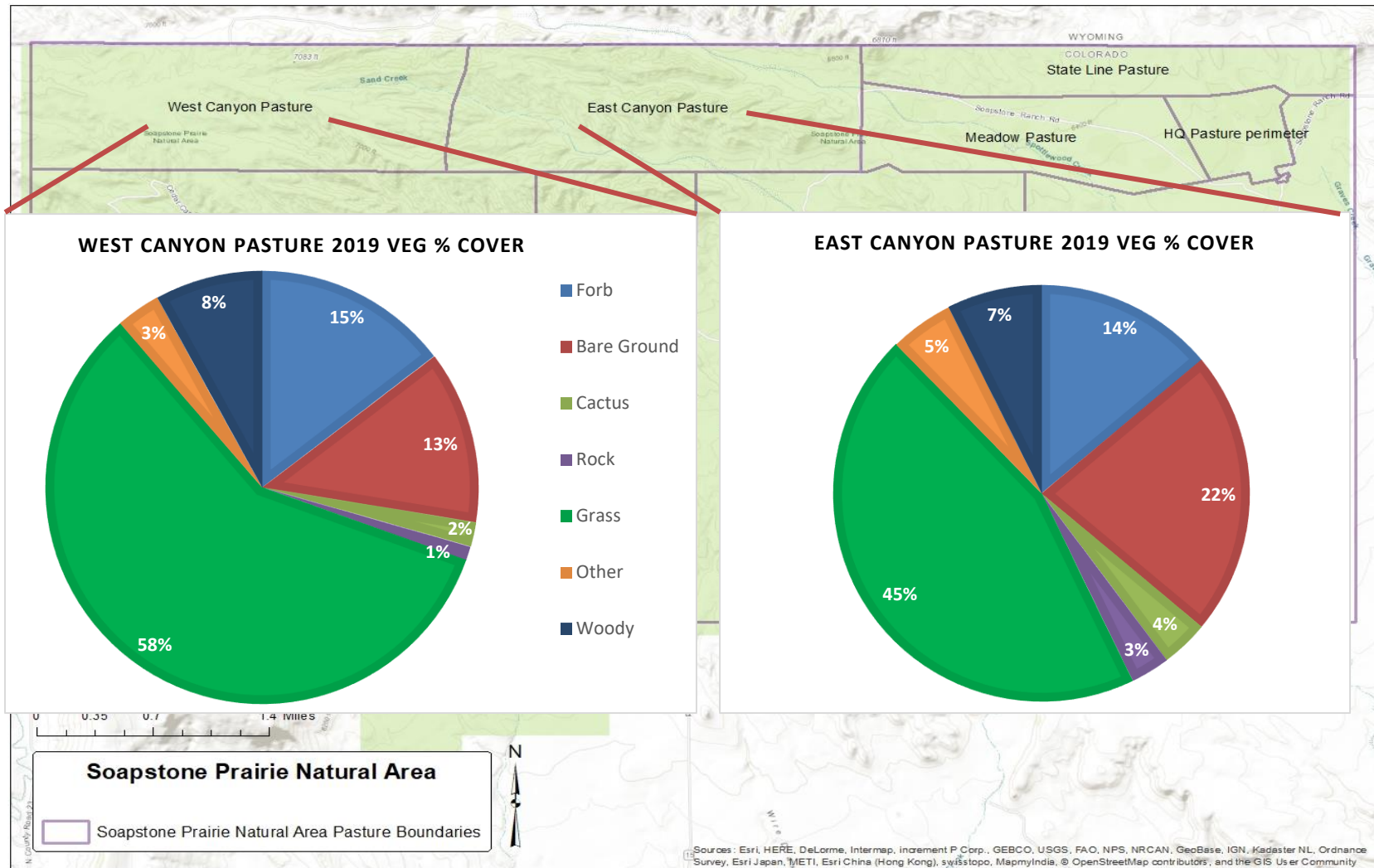
Appendix (C): Average percent ground cover by pasture comparison between 2006/ 2007 and 2019 in Soapstone Prairie Natural Area.



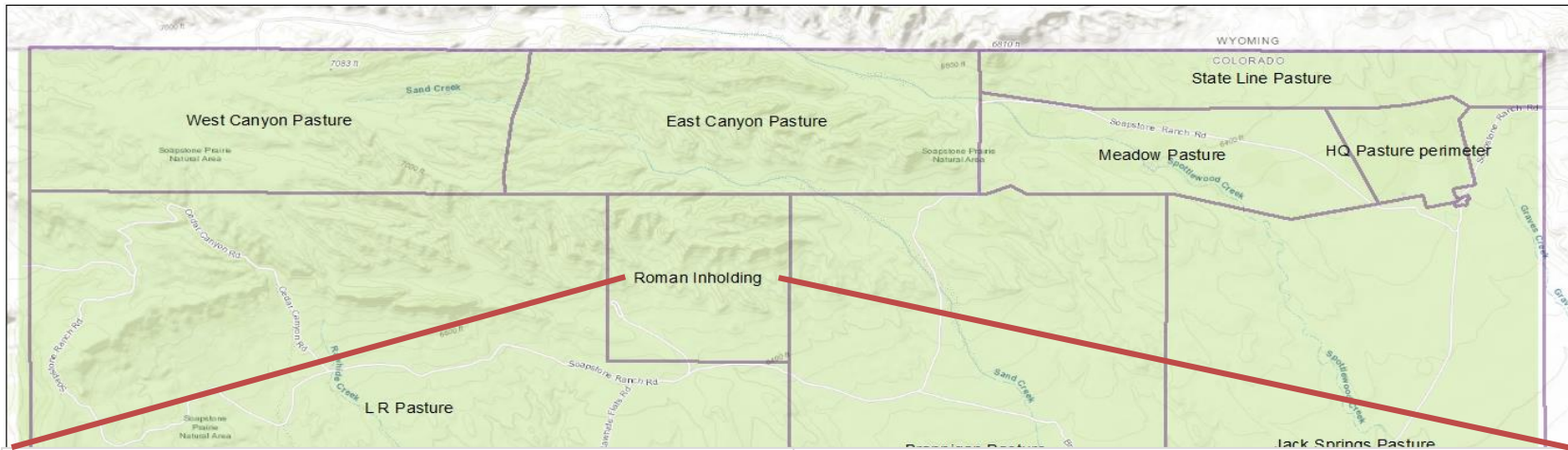
The Roman Krafczik pasture in the southwest part of the property increased grass cover percent average from 37% to 45%, an increase of forb cover (3% to 12%), and showed a 10% decrease in bare ground cover, as well as average decreases in cactus & rock cover overall.



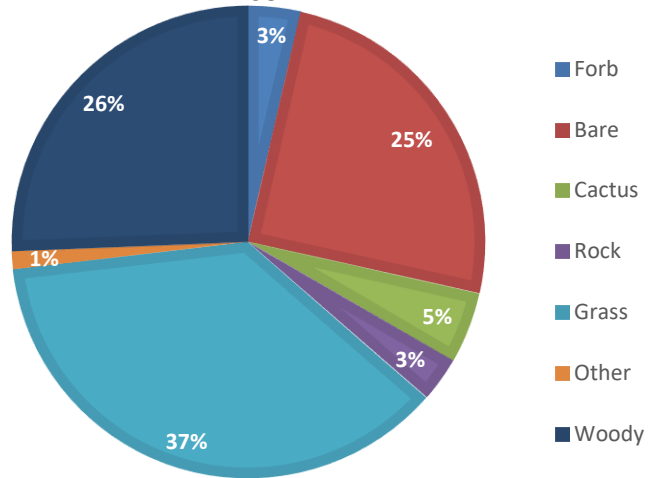
The LR pasture is the largest pasture in SPNA. The biggest change in percent ground cover was the average increase in forbs from 4% to 13%, followed by the average decrease of both woody and bare ground cover (12% to 7%, and 34% to 21%, respectively).



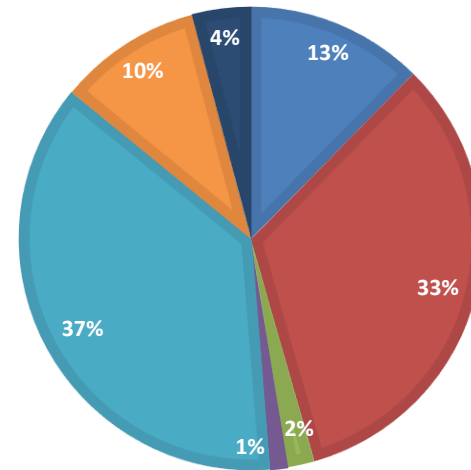
There was no veg data from 2006/ 2007 surveys for the West & East Canyon pastures, but the average percent ground cover for the West & East Canyon pastures are both dominated by grass, bare ground and forb cover, followed by woody, other, cactus and rock.



ROMAN INHOLDING PASTURE 2006/2007 VEG % COVER



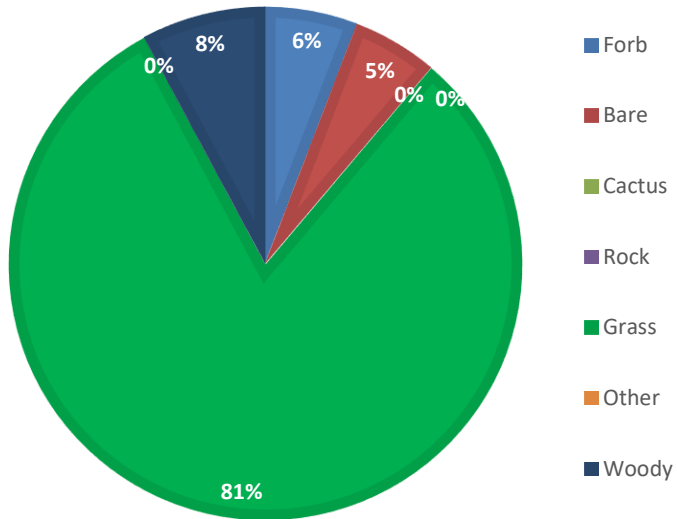
ROMAN INHOLDING PASTURE 2019 VEG % COVER



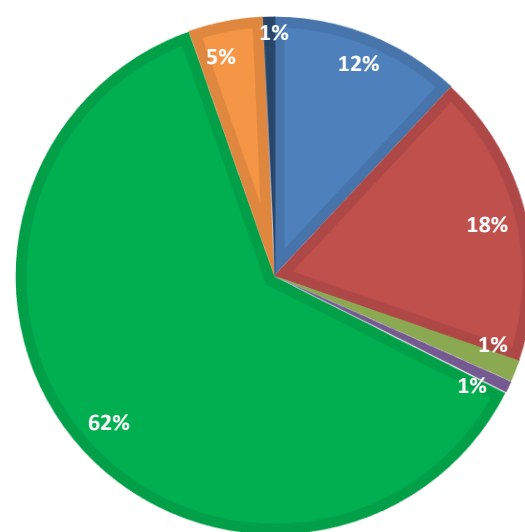
The Roman Inholding pasture has the most overstory of any pasture, the average percent ground cover shows a decrease in low woody cover, a slight increase in bare ground, and an increase in "other" cover. Average percent grass cover remained the same at 37%.



MEADOW PASTURE 2006/2007 VEG % COVER

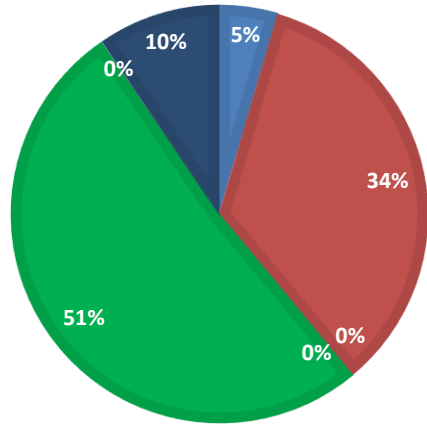


MEADOW PASTURE 2019 VEG % COVER

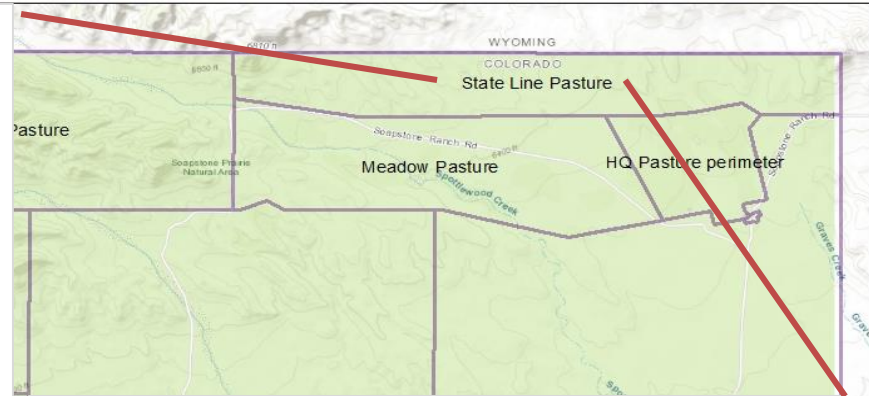


Meadow pasture has Spottlewood Creek running through, making the majority of the ground cover in that pasture grass (81% and 62%). In 2019 there was an increase in average bare ground cover (5% to 18%) and “other” cover (0% to 5%).

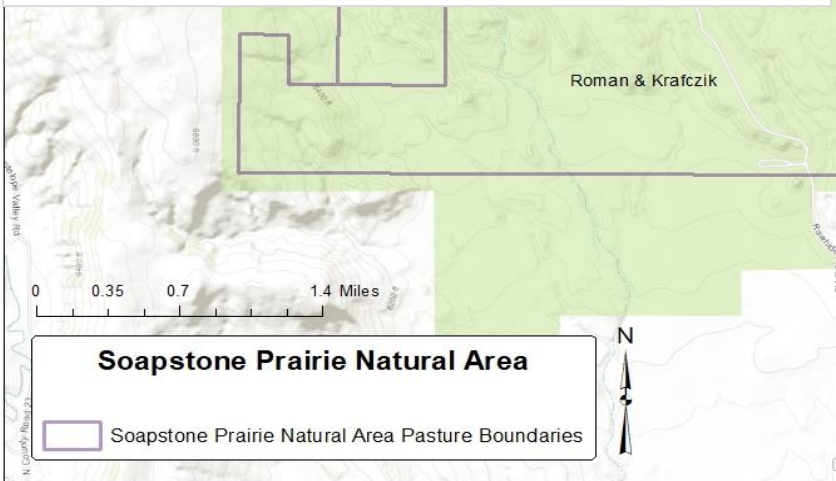
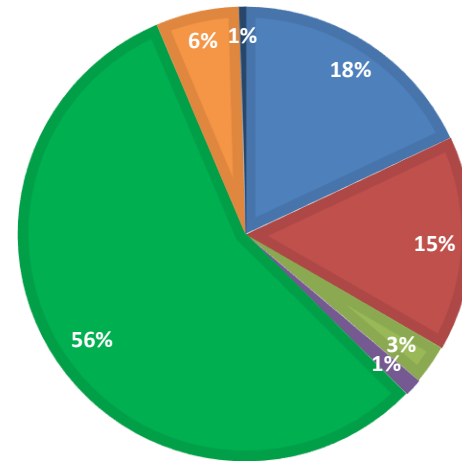
STATE LINE PASTURE 2006/ 2007 VEG % COVER



■ Forb ■ Bare Ground ■ Cactus ■ Rock ■ Grass ■ Other ■ Woody

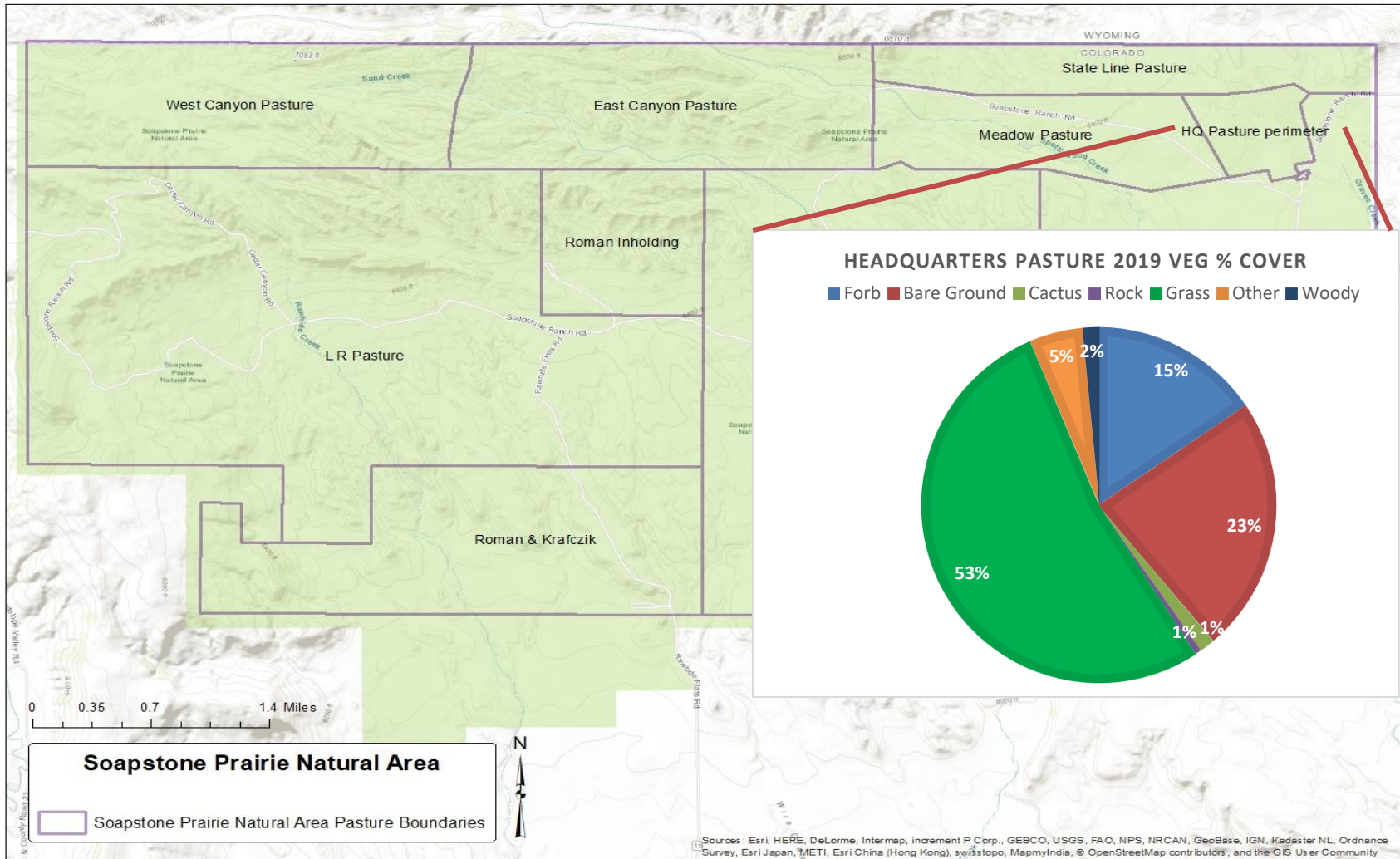


STATE LINE PASTURE 2019 VEG % COVER

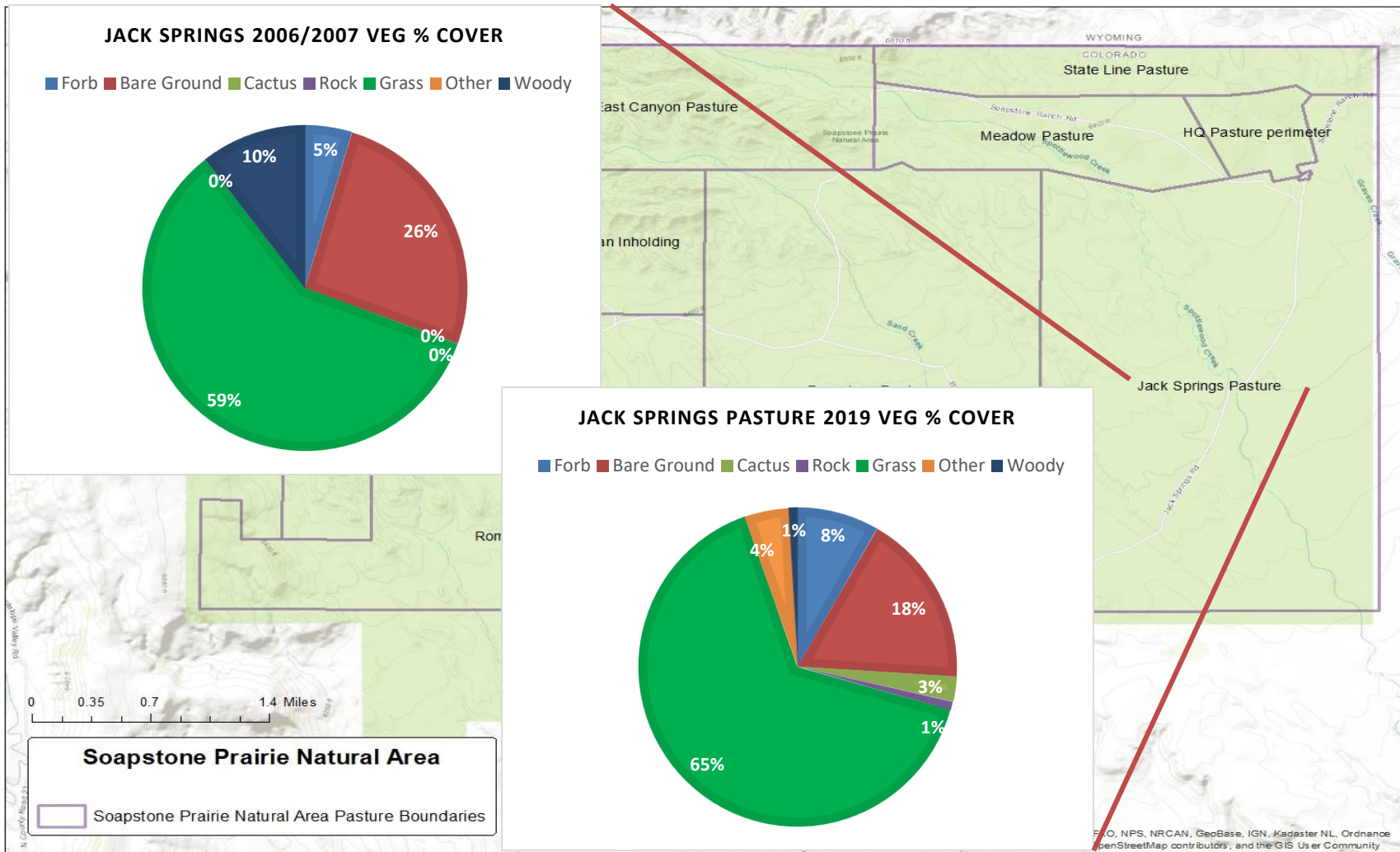


Sources : Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

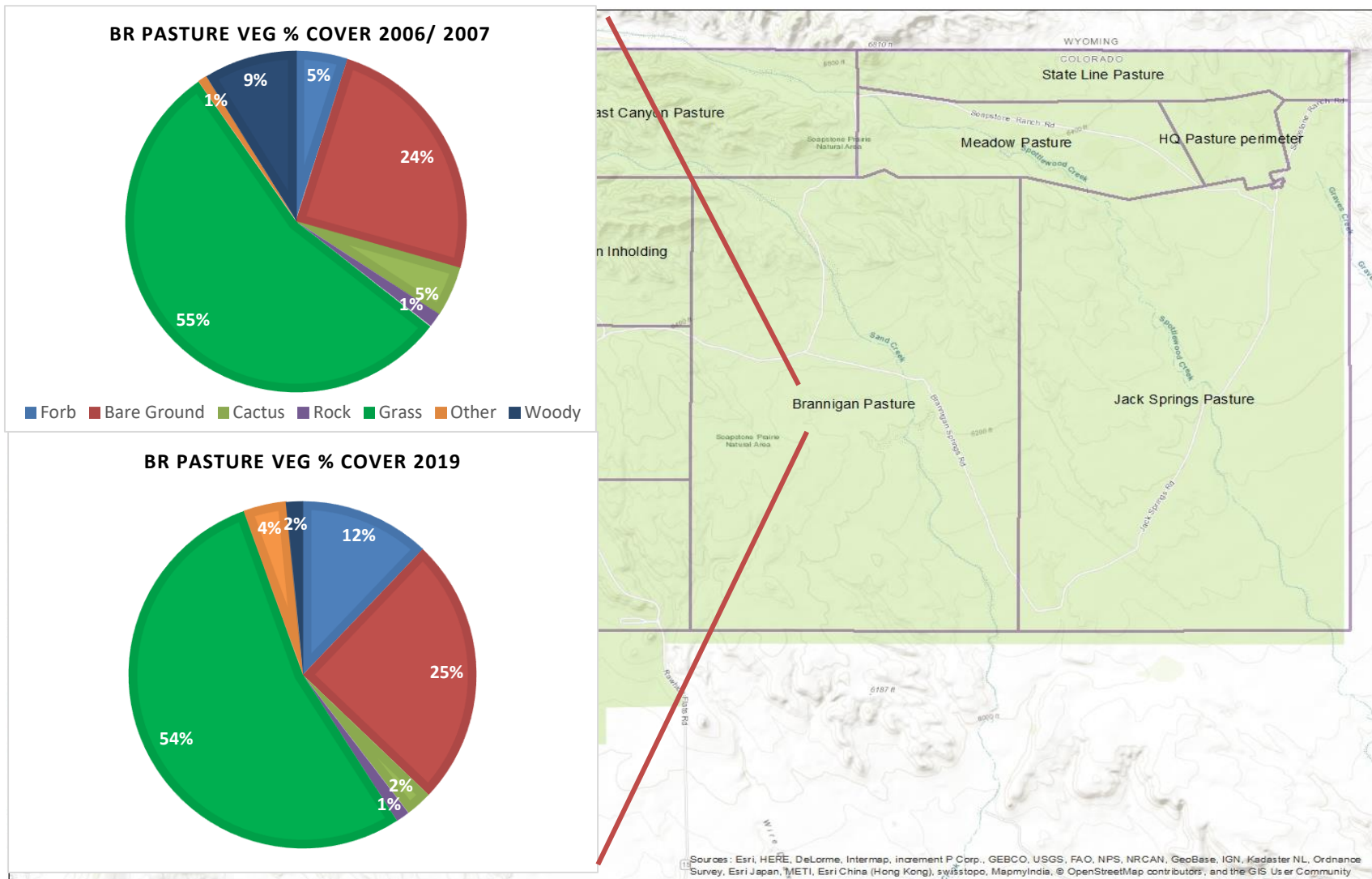
The State Line pasture is the northernmost pasture of SPNA, and the comparison from 2006/2007 to 2019 shows a large reduction of average bare ground cover, and a subsequent increase in forbs. Average grass cover has only increased a small percentage from 51% to 56%.



Headquarters pasture did not have vegetation data from 2006/ 2007. It is also the location of the ranch manager’s home and outbuildings. The highest average percent ground cover was grass at 53%, followed by bare ground at 23%, and then forbs (15%).



Jack Springs pasture is the easternmost pasture, dominated by shortgrass and a large prairie dog colony. From 2006/ 2007 to 2019, average grass cover increased from 59% to 65%, but bare ground decreased from 26% to 18%. Woody percent cover also decreased from 10% to 1%.



The Brannigan pasture did not show large changes in percent ground cover, except for a decrease in woody cover from 9% to 2%.