Sheep and Goat Grazing on Fort Ord National Monument from 1998 – 2019: Implications for Restoration

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Abstract

Since 1960 sheep have been used to reduce fuel accumulation on Fort Ord National Monument (FONM) grasslands. From 1997-2019 BLM's monitoring projects were employed to determine livestock grazing impacts on Coyote Brush, bunchgrasses, and other native and non-native herbaceous vegetation. In 2014, the Bureau of Land Management (BLM) determined that passive sheep grazing was not being effective at reducing fuel loads, and transitioned into using a combination of passive and targeted goat grazing as a management tool. 'Goats R Us' provide BLM livestock to graze grasslands from October – April. Grazing objectives are 1) reduce encroachment of Coyote Brush Scrub into Coastal Grassland, 2) reduce residual dry matter (RDM) to 1200 lb/acre, and 3) increase abundance of native grasses and forbs. Since 2014, BLM has determined that goat grazing can reduce the encroachment of Coyote Brush Scrub, however there has been a concurrent increase in abundance of non-native forbs and annual grasses. BLM and its partners are experimenting with new techniques of goat grazing to reduce biomass of non-native grasses and to promote native grassland diversity. One technique being evaluated is targeted goat grazing select areas of coastal grassland 2-3 times per year. Results suggest that this reduces the cover of non-native grasses, creates open ground for forb and bunchgrass abundance to increase and provides the most reduction in fuel accumulations. This targeted grazing regime gives the BLM an opportunity to manage coastal grassland to both reduce fuel accumulation and increase native plant abundance in FONM Coastal Grassland.

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Objective

This report is a comprehensive summary of sheep and goat grazing on Fort Ord National Monument (FONM). It evaluates all grazing data available to the Bureau of Land Management (BLM) and compiles the individual studies into one comprehensive report. The goals of this paper are to 1) summarize results of the various grazing studies at FONM between 1998-2019, and 2) synthesize and integrate findings into one management document that can inform the development of a comprehensive grazing management plan for FONM.

This report includes the following studies:

1. Passive sheep grazing in coastal grasslands from 1998 – 2015
2. Targeted goat grazing in Pilarcitos Canyon from 2014-2019
3. Passive goat grazing in coastal grasslands from 2016-2017, and 2019
4. Targeted goat grazing in coastal grasslands in 2018

Introduction

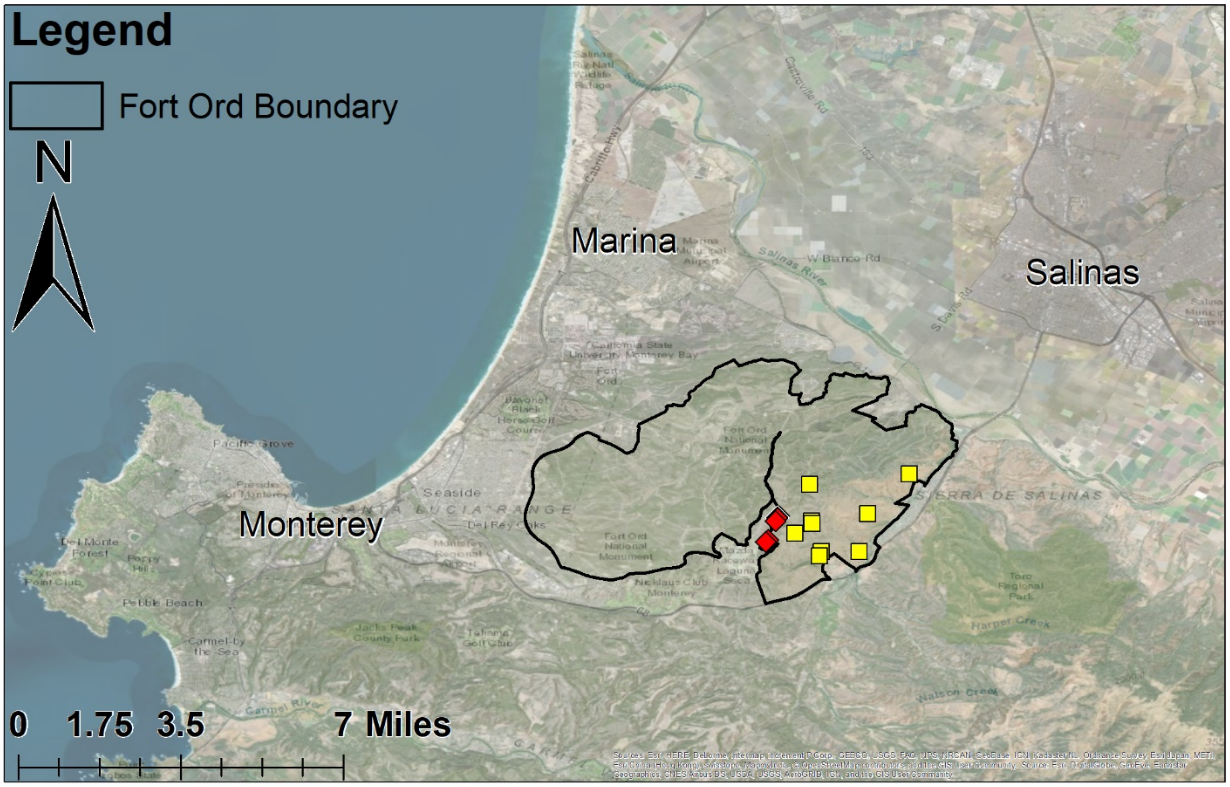

Figure 1: Location of Fort Ord National Monument and the surrounding urban communities. Yellow squares and red diamonds represent monitoring plots.

The Bureau of Land Management (BLM) manages the grasslands of Fort Ord National Monument (FONM) for the ecological health of native bunchgrass and other native herbaceous species while reducing the risk of fire to the surrounding community. FONM is located in Monterey County, California, and contains approximately 14,500 acres of public land. FONM contains different habitats such as coastal scrub, oak woodland, vernal pools, maritime chaparral, and coastal grassland. Prior to being managed by the BLM, the United States Army managed FONM and used high-intensity sheep grazing on the grasslands (aprox 3000 ewes). This type of management has been beneficial to the grassland community and is thought to be responsible for its maintenance of ecological integrity despite frequent military activity (Fossum and Menke 2014).

When BLM began managing FONM in 1993, the U.S. Army had already discontinued the domestic sheep grazing. In 1997, after consulting multiple grassland ecologists, BLM resumed sheep grazing with intent to benefit these grasslands but did not use the same grazing intensity. Between 1997-2015, BLM authorized approximately 650 ewes and 775 lambs to reduce fuel accumulation of annual exotic herbaceous vegetation and to promote the health of perennial native bunchgrass on coastal grasslands (B. Delgado, pers. comm). In 2014, 1,400 domestic goats were introduced to FONM to assess their ability to reverse Coyote Brush Scrub encroachment in Pilarcitos Canyon. BLM began using goats because BLM expected goats to consume coyote brush at a much higher volume than sheep and be more effective managing for BLM's objective of reducing fuel accumulations (BLM staff, pers. comm). BLM introduced goat grazing to grasslands on Dec. 31, 2013, and in 2015 BLM removed sheep entirely. In 2018, BLM increased the number of goats to a total of 1800 goats (comprised of 3 herds with 600 goats each) for grazing throughout FONM grasslands and used 1800-2000 goats annually through 2020. The BLM expects that by using goats to graze the grasslands selectively, they will be able to reduce the abundance of Coyote Brush Scrub while promoting the abundance of native perennial bunchgrass and possibly native forbs found within this coastal grassland habitat.

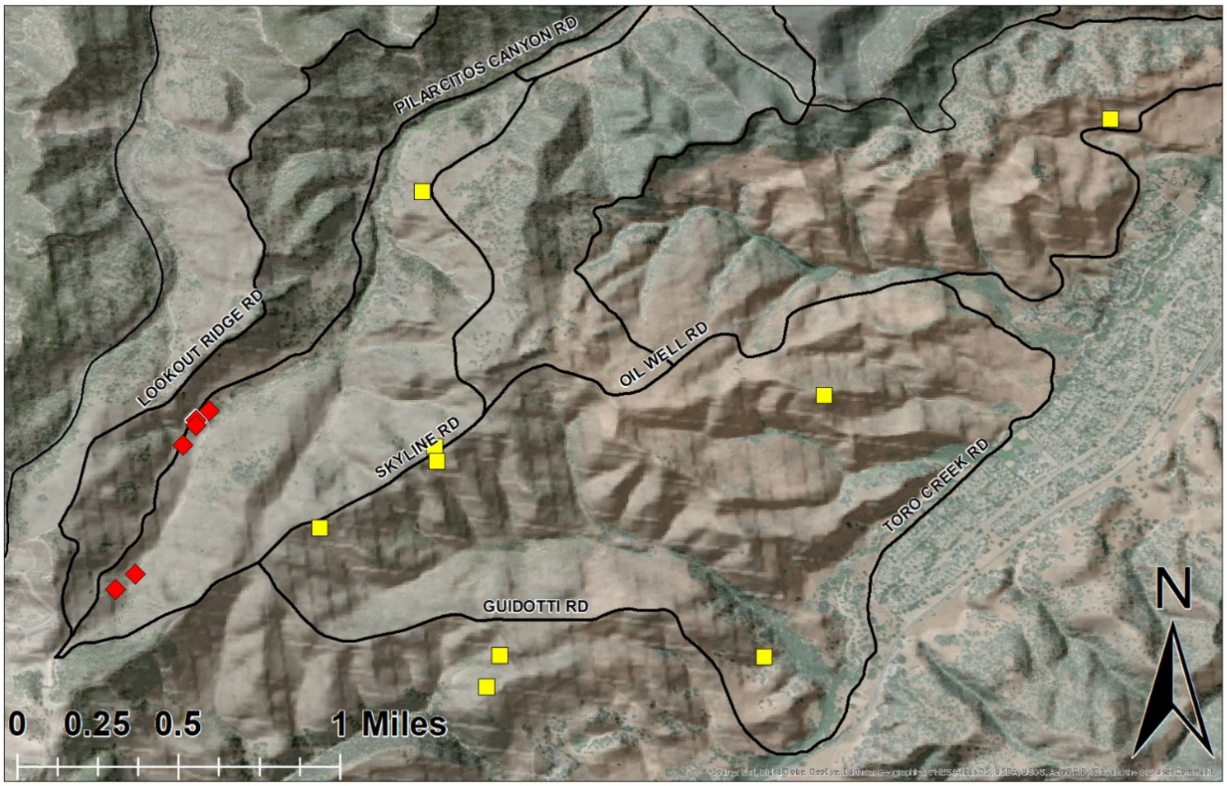

Figure 2: Grazing plot locations on Fort Ord National Monument. Yellow squares represent the nine-paired plots monitoring fuel accumulations in grasslands. Red diamonds represented the six-paired plots monitoring Coyote Brush Scrub encroachment in Pilarcitos Canyon.

Ecology of the Grassland

The coastal grasslands are iconic to California and are a historic ecosystem (Biswell 1956). Urban development, invasive annual grasses, and the expansion and overabundance of *Baccharis pilularis* (coyote brush), a native shrub, threaten the remaining native grassland in the state (Stromberg et al. 2007). Traditional disturbances regimes that would prevent intrusion of *B. pilularis*, such as fire or intense livestock grazing, have been eliminated or reduced to a scale where they are no longer useful (Heady 1977). Like elsewhere, the grasslands on FONM are degrading at a rapid rate by the intrusion of *B. pilularis* and invasive annual grasses.

Stipa pulchra and other bunchgrass species are native to the California coastal grassland, including the grasslands of FONM. Bunchgrass can live for up to 200 years, develop a complex root system that prevents erosion, are drought-tolerant, and grow spaced apart, leaving room for other native forbs (Heady 1977). European invasive annual grass such as *Avena fatua* and

Bromus diandrus appear to outcompete bunchgrasses on FONM. These annual grasses typically grow from December-June and senesce by mid-June. Annual grass in high densities can block out the sun for most other vegetation (Seabloom et al. 2003). The rapid growth of annual grass does not leave room for native forbs to grow, which affects the species that can use the ecosystem (Coleman and Levine 2007). The rapid growth cycle allows these grasses to outcompete native bunchgrass species that typically grow from December-October, and are unable to find soil to germinate seed due to the dense annual grass growth (Hatch et al. 1999). If timed correctly, grazers will prefer the annual grasses over the native grasses as the annual grass grows much earlier in the season and is more desirable for grazers to eat (Harrison et al. 2003). Without such management, annual grass can transform the grassland habitat from being a mosaic of bunchgrass and forbs to an ecosystem that is dominated occupied by non-native annual grass. Removing disturbance regimes from the grassland also allows *B. pilularis* to grow in abundance, which transforms the ecosystem from a grassland community into a Coyote Brush Scrub community.

Grasslands on FONM are adapted to disturbance regimes, such as prescribed fires. Bunchgrass is fire resistant and can rapidly grow after a fire due to the available nutrients released back into the soil and available growing space. Fire favors native forbs since many forbs are fire-adapted, and each forb species requires open space to establish and grow (Biswell 1956). Depending on fire intensity and timing, certain annual grasses will likely be negatively impacted because they only grow for one growing season, and fires will reduce the seed bank after a burn occurs (Hatch et al. 1999). If a prescribed fire is conducted during the early growing season, then bunchgrass and native forbs have a competitive advantage and can begin to outcompete annual grasses (Keeley 2001). When grasslands are not disturbed, they can become converted by the native shrub *B. pilularis* to Coyote Brush Scrub. When *B. pilularis* overtakes the ecosystem, the habitat is transformed from an open, grass-dominated ecosystem to a shrub community. This process changes ecosystem function, and many of the native plants and animals in the grasslands become much less abundant or are entirely displaced. *B. pilularis* abundance is reduced after a prescribed fire as burning removes large shrubs, leaving only smaller ones that do not impact the growth of bunchgrass. This process resets the succession cycle from Coastal Grassland to Coyote Brush Scrub and leaves the grassland ecosystem intact (Heady 1977).

Grazing can reduce the abundance of *B. pilularis*. Selectively grazing the shrubs can reduce their density inside of the grassland. This process opens the habitat and has similar benefits of prescribed fire (Harrison 1999). Grazing annual grass early in the season may promote bunchgrass health. Disturbing the grassland with grazers also removes dead plant material (thatch) that reduces the growth of native bunchgrasses and forbs, and some non-native grasses and forbs. Over time, bunchgrasses can gain a competitive advantage from controlled grazing and be able to outcompete the annual grasses (Perevolotsky and Seligman 1998). Despite the benefits of grazing, there is a risk of spreading or introducing invasive species. Grazers can spread seed from invasive plants and introduce the weeds into new locations. Open habitat can be overtaken by invasive species (e.g., Italian Thistle and other thistles) when removing *B. pilularis* and other shrub species. Grazing also can favor invasive plants if not completed during the right season. Depending on the management of grazers, the disturbance regime will not favor the native species and instead promote the spread of invasive species (Harrison et al. 2003).

Figure 3: Picture of bunchgrass on Fort Ord National Monument

Management Goals

Management goals for FONM grasslands are the following:

1. Reduce encroachment of Coyote Brush Scrub on coastal grasslands.
2. Reduce fuel accumulation of annual herbaceous vegetation in coastal grasslands by having residual dry matter be $\leq$ 1200 lb/acre (Bartolome et al. 2006).
3. Increase abundance of native perennial bunchgrass species on coastal grasslands.
4. Increase abundance of native herbaceous forb species on coastal grasslands.

Types of Grazing on Fort Ord National Monument

Passive sheep grazing

Between 1998 and 2015, passive sheep grazing was performed by having sheep graze Fort Ord National Monument's Coastal Grasslands with no fencing. There were approximately 0.5-1 sheep per acre of land during the months of January-July.

Passive Goat Grazing

Between 2013 and 2019, BLM enclosed goats in 1-3-acre electric pens. Periodically during the day, the goats could “free graze” outside of pen and eat vegetation with minimal herding by goat herders. BLM consulted with goat herder regarding where to where to use electric fencing and free grazing on a month-to-month or more frequent schedule. This combination of electric fencing and free grazing occurred throughout the grassland from November – April. It is passive goat grazing because BLM gave goat herders enough discretion that most of the 2500 acres of Coastal Grassland on FONM received light and inconsistent grazing treatments.

Targeted Goat Grazing

In 2018, BLM began targeted grazed goats in small 0.5 – 2-acre pens. Goats within fenced areas foraged until there until was enough vegetation removed to be considered as meeting BLM’s objectives. Typically, vegetation height was 3-4 inches. Targeted grazing in the sampling plots in 2018 involved a 1.5-acre (~0.6 ha) pasture that placed around the treatment plot and control plot. A herd of 600 goats would graze for an average of 4 hours within the fenced area after the area. Such targeted grazing occurred from November-April and within the wildland-urban interface (within 1000 feet of homes or public roads).

Figure 4: Goats eating Coyote Brush Scrub in Pilarcitos Canyon during targeted goat grazing treatment in November 2019. Photo credit Fred Watson.

Table 1: Summary of the different years of monitoring coastal grasslands fuel accumulations and coyote brush scrub encroachment on Fort Ord National Monument from 1998-2019

Year	Graze Type	Number of Animals	Study Type	Plots Monitored
1998	Passive Sheep	1400	Grassland	1-5
*2003	Passive Sheep	1400	Grassland	1-2
2004	Passive Sheep	1400	Grassland	3-5
2006	Passive Sheep	1400	Grassland	1-2
2008	Passive Sheep	1400	Grassland	1-2
2009	Passive Sheep	1400	Grassland	3-5
2010	Passive Sheep	1400	Grassland	1-2
2011	Passive Sheep	1400	Grassland	3-5
2012	Passive Sheep	1400	Grassland	3-5
Winter 2014	Passive Goat	1400	Coyote Brush	1-6
Spring 2014	Passive Goat	1400	Coyote Brush	1-6
2015	Passive Goat	1400	Grassland	1-9
Spring 2015	Targeted Goat	1400	Coyote Brush	1-6
Spring 2016	Targeted Goat	1400	Coyote Brush	1-4
Spring 2016	Passive Goat	1400	Grassland	1-9
Fall 2016	Passive Goat	1400	Grassland	1-9
Spring 2017	Passive Goat	1400	Grassland	1-9
Fall 2017	Passive Goat	1800	Grassland	1-9
February 2018	Targeted Goat	1800	Grassland	1-9
April 2018	Passive Goat	1800	Grassland	1-9
Spring 2018	Passive Goat	1800	Coyote Brush	1-6
June 2018	Passive Goat	1800	Grassland	1-9
November 2018	Passive Goat	1800	Grassland	1-9
December 2018	Targeted Goat	1800	Grassland	7-8
Spring 2019	Passive Goat	1800	Coyote Brush	1-6
Spring 2019	Passive Goat	1800	Grassland	1-9
Summer 2019	Passive Goat	1800	Grassland	1-9
Fall 2019	Passive Goat	1800	Grassland	1-9

Methods of Monitoring Grazing Effects on Vegetation

Grasslands Plots

In 1997, BLM installed five pairs of monitoring plots (each pair containing a fenced and unfenced plot) to measure residual dry matter (RDM) of dead annual herbaceous vegetation. Fuel accumulation was measured by comparing total RDM of dead annual herbaceous vegetation between fenced (control) and unfenced (grazed) plots. Undergraduate students from California State University Monterey Bay and BLM employees collected and analyzed data periodically from 1998 to 2015. In the summer of 2015, four additional paired plots were added to the study to increase the robustness of the monitoring data after an analysis showed no significant difference between grazed and control plots (Worcester unpub. data, 2015). In 2016, BLM increased the frequency of monitoring and sampled plots every 6-months (e.g., spring, fall) to determine if fuel accumulation reductions are dependent on the growing season and if effects of grazing thru April were muted or reversed by continued plant growth after April. In 2018, BLM and university students sampled plots five-times (February, April, June, November, and December) to assess the effectiveness of targeted goat grazing compared to passive grazing and to quantify the seasonal variation of the plots further. In 2019, BLM sampled plots 3-times a year to measure spring, summer, and fall seasonal effects of goat grazing. These seasons represent the current growing season, post-growing season, and pre-growing season, respectively, and such sampling informs BLM regarding grassland fuel accumulation levels throughout the year.

Figure 5: University students from Cal State University Monterey Bay collecting residual dry matter in grassland plots in November 2019

Each plot used to measure residual dry matter was divided into twelve 0.5 m wide belt transects (Figure 6). Even-numbered transects were used to measure residual dry matter and odd-numbered transects for documenting species composition and quantifying percent cover of grassland species. Within each even-numbered transect, there were three potential 0.33 x 0.5 m subsampling plots per meter comprising a total of 18 potential sampling subplots within a given transect. During sampling, we randomly selected a subplot and placed a 1ft x 1ft (~1000 cm2) quadrat to collect the above-ground plant material. The same subplot was not selected more than once within a calendar year for sampling (Burton unpub. data, 2018). We analyzed goat grazing data collected post-2018 separately from pre-2018 goat grazing data. BLM expected that targeted goat grazing on grassland would significantly decrease fuel accumulation of annual herbaceous vegetation and hoped it might shift species composition in favor of forbs and native perennial grasses.

Preparation of Samples and Estimates of Residual Dry Matter

The biomass samples were air-dried for five days after collection then weighed. Samples were weighed with a Mettler Toledo PL602E Precision Balance accurate to 0.01 grams and dried in a Thelco Precision Incubator (model 51221120) at 60 degrees for approximately 72 hours. We then estimated the RDM (pounds/acre) with the conversion of 1 gram/square foot = 96 pounds/acre (Bartolome, Frost, McDougald, 2006), (Burton unpub. data, 2018).

NW Corner Plot ________ Treatment ________________ Date ________________

Meter	Row	C!	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
	1		1		1		1		1		1		1
1	2		2		2		2		2		2		2
	3		3		3		3		3		3		3
	4		4		4		4		4		4		4
2	5		5		5		5		5		5		5
	6		6		6		6		6		6		6
	7		7		7		7		7		7		7
3	8		8		8		8		8		8		8
	9		9		9		9		9		9		9
	10		10		10		10		10		10		10
4	11		11		11		11		11		11		11
	12		12		12		12		12		12		12
	13		13		13		13		13		13		13
5	14		14		14		14		14		14		14
	15		15		15		15		15		15		15
	16		16		16		16		16		16		16
6	17		17		17		17		17		17		17
	18		18		18		18		18		18		18

Figure 6: Example plot division used for the grassland study. Odd number columns used to assess species composition and percent cover of each species, even number columns used to collect residual dry matter (RDM). The even-column represents locations to collect RDM within each even number column (Burton unpub. data, 2018).

Coyote Brush Scrub Encroachment Monitoring

In addition to the above monitoring, in 2014, BLM established 6-pairs of monitoring plots in Pilarcitos Canyon (ungrazed, grazed), for a total of 12 plots on areas of grassland recently converted to Coyote Brush Scrub. These plots monitor whether or not goat grazing reduces the amount of Coyote Brush Scrub present in grassland and can reverse such shrub encroachment. Each pair of plots were grazed between November-April by goats 1-3 times a year. Goats grazed every plot during the same month, though the grazing treatments varied between years. BLM targeted grazed the plots in 2014 and 2015 with electric fences but passively grazed the plots from 2016-2019. BLM sampled plots in Winter 2014 before grazing treatments took place. Subsequent sampling of plots post grazing treatments occurs every year between April- June.

Figure 7: BLM staff and volunteers monitoring coyote brush encroachment at research plots located in Pilarcitos Canyon in June 2018.

Within each plot, BLM randomly selected two permanent 10-meter transects that are sampled in the same location each year. An additional randomly-placed transect is sampled in a different location each year and is at least 0.5-meters from the permanent transects to avoid trampling any nearby transect. In total, there were 36 transects sampled, which included three transects for each of the 12 plots or 18 transects each for control and grazed treatments. Transects are sampled each year between April - June. At each transect, we utilized line-point intercept sampling to record “hits’ and determine species composition. Each species touching (‘intercepting’) a vertical dowel placed every 0.25 meter along each transect were recorded (N=40 per transect). We record both understory and canopy vegetation classes at each point. Understory vegetation included identifiable vegetative material that is non-woody, or woody and shorter than 4.0 dm (approx. knee height). Canopy vegetation included woody vegetative material that was taller than 4.0 dm or connected to a plant that was taller than 4.0 dm. Some species can be present in both canopy and understory classes depending on plant height. A species recorded in the canopy class can also be recorded in understory class if a separate intercept of the same species is found and meets the proper criteria.

After data is collected, each recorded intercept is placed in one of the following categories: annual grass (AG), coyote brush (BAPI), bare ground (BG), *Cirsium vulgare* (CIVU), bunchgrass (BU), *Quercus agrifolia* (QUAG), *Leymus triticoides* (LETR), dead BAPI (D), Erodium species (ER), *Phalaris aquatica* (PHAQ), *Carduus pycnocephalus* (CAPY), litter (L), other species (O), other native herbaceous species (ONH), other non-native herbaceous species (ONN), other native shrubs (ONS), and *Conium maculatum* (COMA) (Table 2). At each 0.25-meter point, each category can only have one hit even if there is more than one species or more than one individual of that category intercepted, which enabled measurement of percent foliar cover of each given category and comparisons between years. We only focused our analysis on annual grass, coyote brush, bare ground, other native herbaceous species, and other non-native herbaceous species due to lack of hits in the other categories.

Table 2: Species categories of plants found in the coyote brush encroachment monitoring and the associated definition for each category.

Category	Abbreviation	Definition
Annual Grass	AG	Non-native annual grass herbaceous material that is identifiable to observers
Bare-Ground	BG	Rock or soil only, no plant material
Bunchgrass	BU	Any living or dead material attached to a native bunchgrass species
Carduus pycnocephalus	CAPY	Living *Carduus pycnocephalus* (Italian thistle) species
Cirsium vulgare	CIVU	Living *Cirsium vulgare* (bull thistle) species
Conium maculatum	COMA	Living *Conium maculatum* (poison hemlock) species
Coyote Brush	BAPI	Any live or dead part of a living coyote brush individual
Dead BAPI	D	100% dead BAPI individual in either canopy or herbaceous layer
Erodium species	ER	Living erodium (filary) species found in the genus erodium
Leymus triticoides	LETR	Living *Leymus triticoides* (creeping wild rye) species
Litter	L	All dead herbaceous that is unidentifiable or all dead and down woody matter. Recorded if no other hits in the understory.
other	O	Animal scat, fungi, moss, lichen, or living unidentifiable herbaceous plant that does not fit other categories
other native herbaceous species	ONH	Any native annual or perennial non-woody vascular plant excluding bunchgrass species, and *Leymus triticoides*
other native shrubs	ONS	native woody shrubs
other non-native herbaceous species	ONN	Any non-native species that are not annual grasses, or species-specific non-native plants listed in other categories
Phalaris aquatica	PHAQ	Living *Phalaris aquatica* (harding grass) species
Quercus agrifolia	QUAG	Living *Quercus agrifolia* (coast live oak) species

Analysis

Summary statistics(mean, median) were described graphically using box plots. We used bootstrap analysis to test for differences among the treatments (grazed vs. ungrazed); this involved resampling the data (10,000 resamples with replacement) and generating 95% confidence intervals. Significant differences were determined by non-overlapping confidence intervals. Datasets were analyzed using the method for several reasons. First, the datasets violated the assumptions of normality and had low sample sizes, and therefore parametric approaches were inappropriate. Moreover, the methods of data collection across years varied (e.g., one transect each year was randomly established in each plot; additional plots added later in some students, etc.), making repeated-measures approaches inappropriate as well.

Table 3: Summary of variables and treatments used for bootstrap simulation analysis

Study Type	Treatments	Monitoring
Coyote Brush Scrub	Grazed Plots	Percent foliar cover change of BAPI, AG, ONN, BU, ONH
	Ungrazed plots	
Grassland	Grazed Plots	Biomass (lb/acre) dead annual herbaceous vegetation
	Ungrazed plots	

Results

Grassland Results

Sheep Grazing from 1998-2015

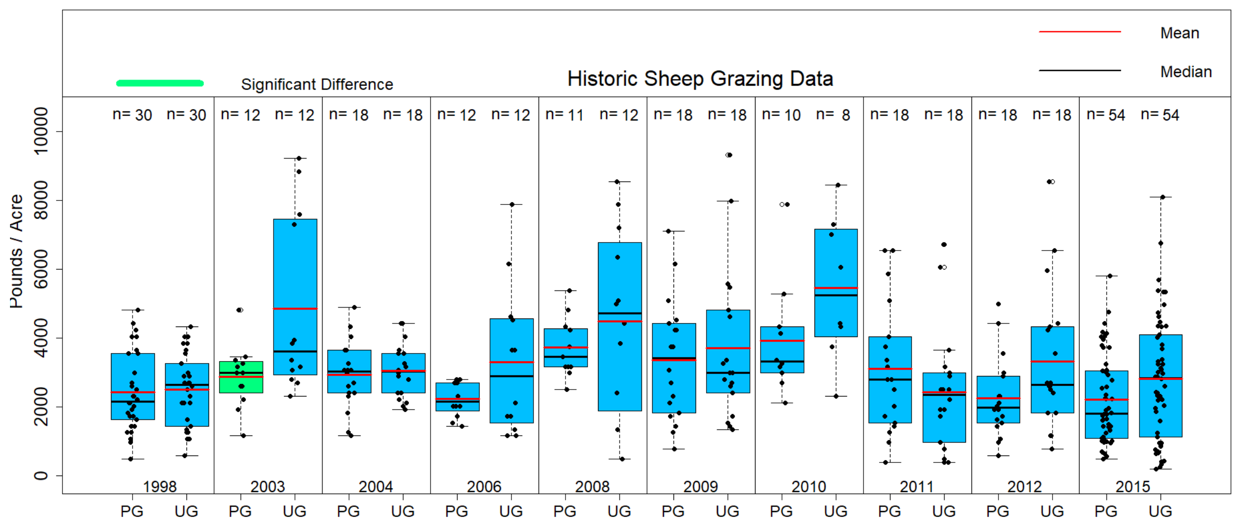

Figure 7: Boxplots of historic sheep grazing data from 1998-2015. PG represents passive sheep grazed plots, UG represents ungrazed (control) plots. A green highlight denotes statistical differences based on bootstrap simulation analysis between the control plot and grazed plot within a given year. Plots were sampled before grazing treatments occurred in 1998. From 2003, 2006, 2008, and 2010 only plots #1 and #2 were sampled. In 2004, 2009, 2011 and 2020 only plots #3, #4 and #5 were sampled. In 2015, BLM added four additional plots and sampled all nine-monitoring plots.

Table 4: Bootstrap simulation analysis results of residual dry matter differences among goat grazing treatments from February 1998 – December 2015. 95% confidence interval shows the expected change in the grazed plot compared to the control plot for each year of the study. The asterisk indicates a significant difference between treatments

Year	Passive grazed mean (lb/acre)	Ungrazed mean (lb/acre)	Expected Change in Grazed Plot versus control plot (lb/acre)
1998 (control)	2426 (2134–2867)	2499 (2029–2835)	No difference
*2003	2872 (2392 –3376)	4840 (3512 – 6320)	-544 – -3536
2004	2923 (2485 –3370)	3045 (2688 – 3408)	No difference
2006	2224 (1952 – 2488)	3304 (2208 – 4552)	No difference
2008	3718 (3272 –4208)	4488 (3080 – 5944)	No difference
2009	3355 (2597 – 4154)	3712 (2789 –4757)	No difference
2010	3917 (2988 – 5112)	5448 (4128 – 6768)	No difference
2011	3093 (2287 – 3957)	2427 (1696 – 3259)	No difference
2012	2240 (1749 – 2779)	3317 (2453 – 4299)	No difference
2015	2206 (1872 – 2552)	2815 (2343 – 3300)	No difference

Based on a bootstrap simulation analysis of the difference in dead annual herbaceous vegetation residual dry matter between passive sheep grazed and ungrazed (control) plots, significant differences in treatments were found in 2003 (Table 4). Between 2003 and 2015, sheep reduce fuel loads from 0 - 1300 lb/acre with an average reduction of 620 lb/acre for any given year compared to areas without passive sheep grazing.

Passive Goat Grazing from 2015-2017

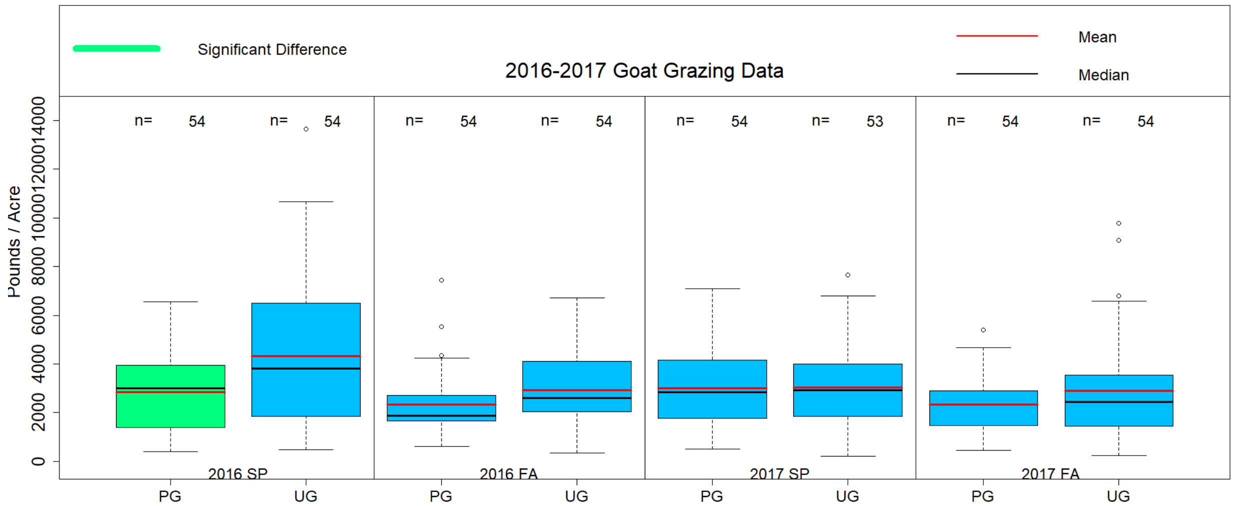

Figure 8: Boxplots of passive goat grazing data from 2016-2017. PG represents passive goat grazed plots, UG represents ungrazed (control) plots. A green highlight denotes statistical differences based on bootstrap simulation analysis between the control plot and grazed plot within a given year.

Table 5: Bootstrap simulation analysis results of residual dry matter differences among goat grazing treatments from Spring 2016 – Fall 2017. 95% confidence interval shows the expected change in the grazed plot compared to the control plot for each year of the study. The asterisk indicates a significant difference between treatments

Year	Passive grazed mean (lb/acre)	Ungrazed mean (lb/acre)	Expected change in grazed plot versus control plot (lb/acre)
*Spring 2016	2845 (2452 – 3247)	4329 (3567 – 5114)	-611 – -2370
Fall 2016	2339 (2032 – 2679)	2934 (2525 – 3353)	No difference
Spring 2017	3009 (2602 – 3436)	3033 (2576 – 3500)	No difference
Fall 2017	2342 (2032 – 2664)	2900 (2379 – 3482)	No difference

Based on a bootstrap simulation analysis of the difference in dead annual herbaceous vegetation residual dry matter between passive goat grazed and ungrazed (control) plots, significant differences in treatments were found in spring 2016 (Table 5). From 2016-2017 goats reduce fuel loads by 0-1400 lb/acre with an average reduction of 670 lb/acre compared to areas without passive goat grazing.

2018 Target Goat Grazing Experiment

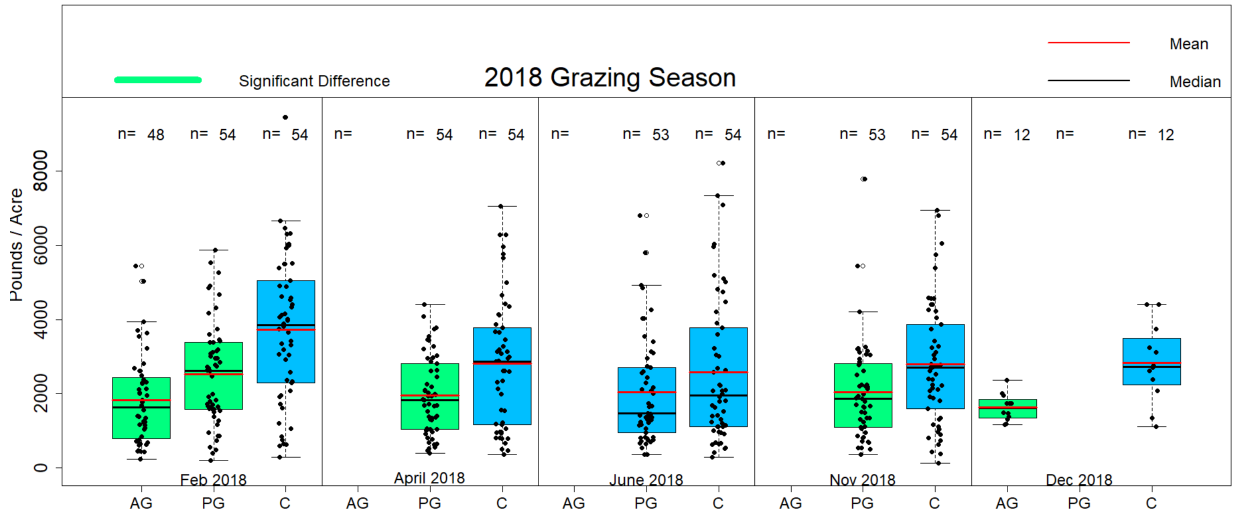

Figure 9: Boxplots of passive goat grazing data in 2018. PG represents passive goat grazed plots; AG represents targeted goat grazed plots, UG represents ungrazed (control) plots. A green highlight denotes statistical differences based on bootstrap simulation analysis between the control plot and grazed plot within a given year.

Table 6: Bootstrap simulation analysis results of residual dry matter differences among goat grazing treatments from February 2018 – December 2018. 95% confidence interval shows the expected change in the grazed plot compared to the control plot for each year of the study. The asterisk indicates a significant difference between treatments

Month	Target grazed mean (lb/acre)	Passive grazed mean (lb/acre)	Ungrazed mean (lb/acre)	Expected change in grazed plot versus control plot (lb/acre)	Expected change in target plot versus control plot (lb/acre)
*February	1828 (1521 – 2156)	2517 (2158 – 2894)	3720 (3201 – 4245)	-567 – -1830	-1286 – -2495
*April	NA	1945 (1670 – 2218)	2809 (2364 – 3278)	-335 – -1403	NA
June	NA	2038 (1675 – 2436)	2571 (2076 – 3109)	No difference	NA
November	NA	2045 (1722 – 2406)	2790 (2369 – 3226)	No difference	NA
*December	1625 (1534 – 1718)	NA	2823 (2355 – 3231)	NA	-732 – -1621

Based on a bootstrap simulation analysis of the difference in dead annual herbaceous vegetation residual dry matter between passive goat grazed and ungrazed (control) plots, significant differences in treatments were found in February, and April. We observed the greatest expected decrease in residual dry matter in February. 95% confidence interval showed that the expected difference between residual dry matter in passive goat grazed plots in February, is 567 lb/acre to 1830 lb/acre lower than the control plots (Table 6).

Based on a bootstrap simulation analysis of the difference in dead annual herbaceous vegetation residual dry matter between targeted goat grazed and ungrazed (control) plots, significant differences in treatments were found in February and December. We observed the greatest expected decrease in residual dry matter in February. 95% confidence interval showed that the expected difference between residual dry matter in targeted goat grazed plots in February, is 1286 lb/acre to 2495 lb/acre lower than the control plots (Table 6).

2019 passive goat grazing

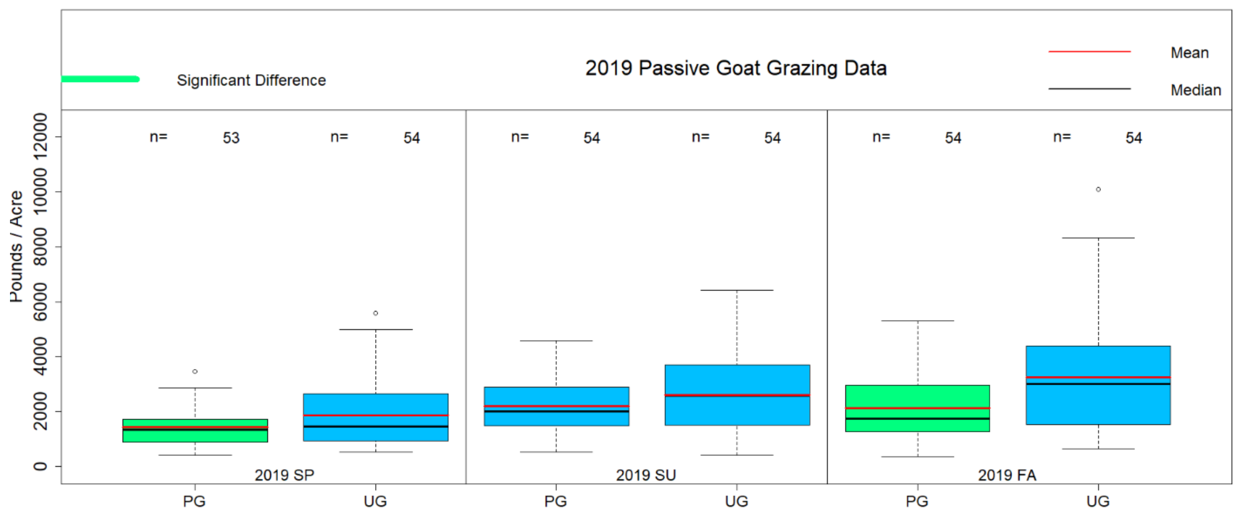

Figure 10: Boxplots of passive goat grazing data in 2019. PG represents passive goat grazed plots, UG represents ungrazed (control) plots. A green highlight denotes statistical differences based on bootstrap simulation analysis between the control plot and grazed plot within a given year.

Table 7: Bootstrap simulation analysis results of residual dry matter differences among goat grazing treatments from Spring 2019 – Fall 2019. 95% confidence interval shows the expected change in the grazed plot compared to the control plot for each year of the study. The asterisk indicates a significant difference between treatments

Season	Passive grazed mean (lb/acre)	Ungrazed mean (lb/acre)	Expected change in grazed plot versus control plot (lb/acre)
*Spring	1419 (1262 – 1589)	1856 (1559 – 2187)	-98 – -787
Summer	2183 (1934 – 2439)	2608 (2232 – 2998)	No difference
*Fall	2131 (1806 – 2474)	3232 (2718 – 3796)	-478 – -1723

Based on a bootstrap simulation analysis of the difference in dead annual herbaceous vegetation residual dry matter between passive goat grazed and ungrazed (control) plots, significant differences in treatments were found in spring and fall (Table 7). In 2019, goats reduced fuel loads by 130-1200 lb/acre, with an average reduction of 660 lb/acre compared to areas without passive goat grazing. Plots grazed in the spring had the lowest reduction of fuel accumulations (1400 lb/acre) but showed a small range of reduction (98 to 787 lb/acre compared to ungrazed plots). Because control plots increased residual dry matter with each iteration of sampling, passive goat grazing in fall had the biggest expected change despite spring goat grazing treatment having the lowest average residual dry matter.

Coyote Brush Scrub Brush Plots Results

BAPI (Coyote Brush) Results

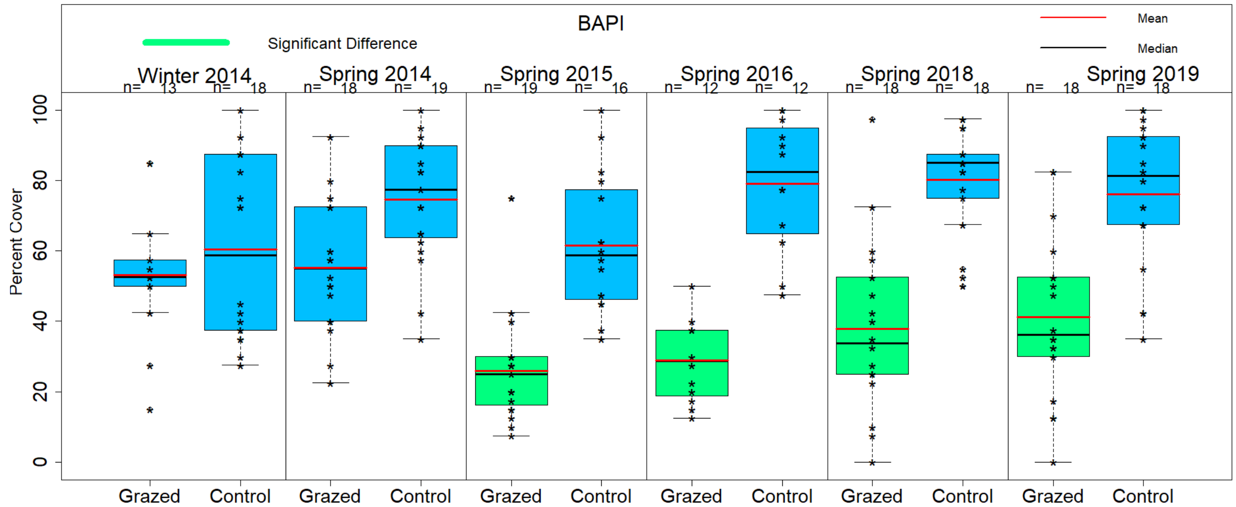

Figure 11: Boxplots Coyote Brush (BAPI) cover differences among goat grazing treatments in Pilarcitos canyon from winter 2014 – spring 2019. Winter 2014 did not receive a grazing treatment before sampling. A green highlight denotes statistical differences based on bootstrap simulation analysis between the control plot and grazed plot within a given year.

Table 8: Bootstrap simulation analysis results of Coyote Brush (BAPI) cover differences among goat grazing treatments in Pilarcitos canyon from winter 2014 – spring 2019. 95% confidence interval shows the expected change in the grazed plot compared to the control plot for each year of the study. The asterisk indicates a significant difference between treatments

Species	Year	Grazed Mean (% Cover)	Control Mean (% Cover)	Expected Change in Grazed Plot versus control plot
BAPI	Winter 2014 (no treatment)	53 (37.5–70)	60.5 (47.5–77.5)	No difference
BAPI	Spring 2014	55.5 (40–70)	74.5 (62.5–87.5)	No difference
*BAPI	Spring 2015	26 (10–37.5)	61.5 (47.5–77.5)	-17.5% – -57.5%
*BAPI	Spring 2016	29 (15–42.5)	79 (65–90)	-30% – -67.5%
*BAPI	Spring 2018	38 (22.5–52.5)	80 (67.5–92.5)	-22.5% – -60%
*BAPI	Spring 2019	41 (27.5–57.5)	76 (62.5 – 90)	-15% – -55%

Based on a bootstrap simulation analysis of the difference in Coyote Brush (BAPI) percent coverage between grazed and control plots, significant differences in treatments were found from spring 2015-spring 2019. Spring 2016 had the most reduction of coyote brush percent coverage. 95% confidence interval showed that the expected difference between coyote brush percentage coverage in grazed plots in spring 2016, is 30% to 67.5% lower than the control plots. Spring 2019 had the least reduction in coyote brush percent coverage. 95% confidence interval showed that the expected difference between coyote brush percentage coverage in grazed plots in spring 2019, is 15% to 55% lower than the control plots (Table 8).

Annual grass Results

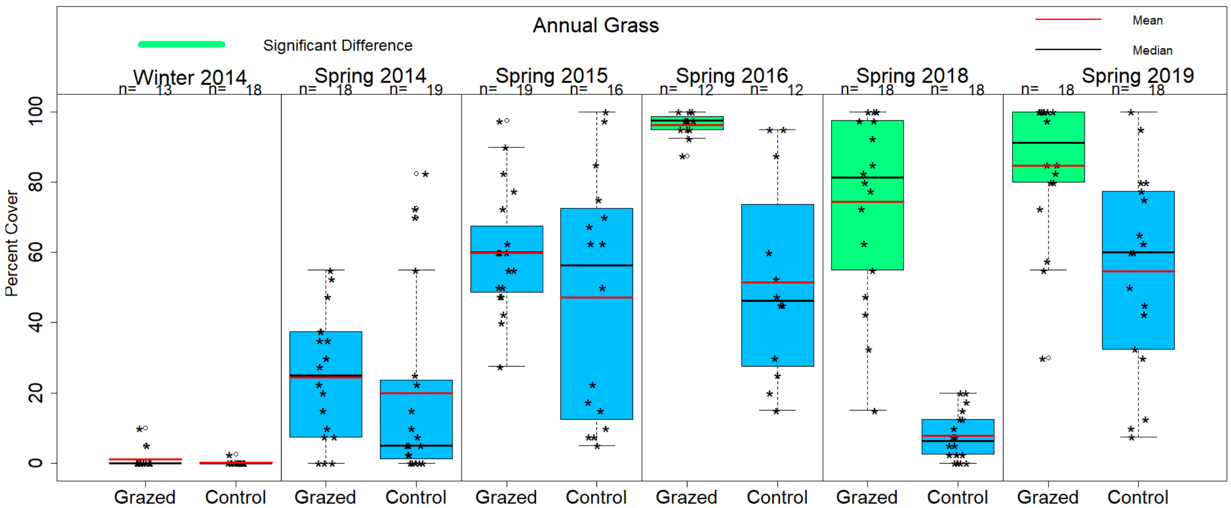

Figure 12: Boxplots annual grass cover differences among goat grazing treatments in Pilarcitos canyon from winter 2014 – spring 2019. Winter 2014 did not receive a grazing treatment before sampling and occurred before the growth of most annual grasses. A green highlight denotes statistical differences based on bootstrap simulation analysis between the control plot and grazed plot within a given year.

Table 9: Bootstrap simulation analysis results of annual grass (AG) cover differences among goat grazing treatments in Pilarcitos canyon from winter 2014 – spring 2019. 95% confidence interval shows the expected change in the grazed plot compared to the control plot for each year of the study. The asterisk indicates a significant difference between treatments

Species	Year	Grazed mean (% cover)	Control mean (% cover)	Expected change in grazed plot versus control plot
AG	Winter 2014	1 (0 –5)	2.5 (0 –7.5)	No difference
AG	Spring 2014	25 (12.5– 40)	20 (7.5 – 32.5)	No difference
AG	Spring 2015	65 (50–80)	45.5 (30 – 60)	No difference
*AG	Spring 2016	96 (90–100)	51 (35–67.5)	27.5% – 60%
*AG	Spring 2018	74 (60–87.5)	8 (0–17.5)	50% – 82.5%
*AG	Spring 2019	84 (72.5–95)	54 (40–70)	10% – 47.5%

Based on a bootstrap simulation analysis of the difference in annual grass (AG) percent coverage between grazed and control plots, significant differences in treatments were found from spring 2016-spring2019. Spring 2018 had the most increase in annual grass percent coverage. 95% confidence interval showed that the expected difference between annual grass percentage coverage in grazed plots in spring 2018, is 50% to 82.5% higher than the control plots. Spring 2019 had the least increase in annual grass percent coverage. 95% confidence interval showed that the expected difference between annual grass percentage coverage in grazed plots in spring 2019, is 10% to 47.5% higher than the control plots (Table 9).

Other non-native herbaceous species results

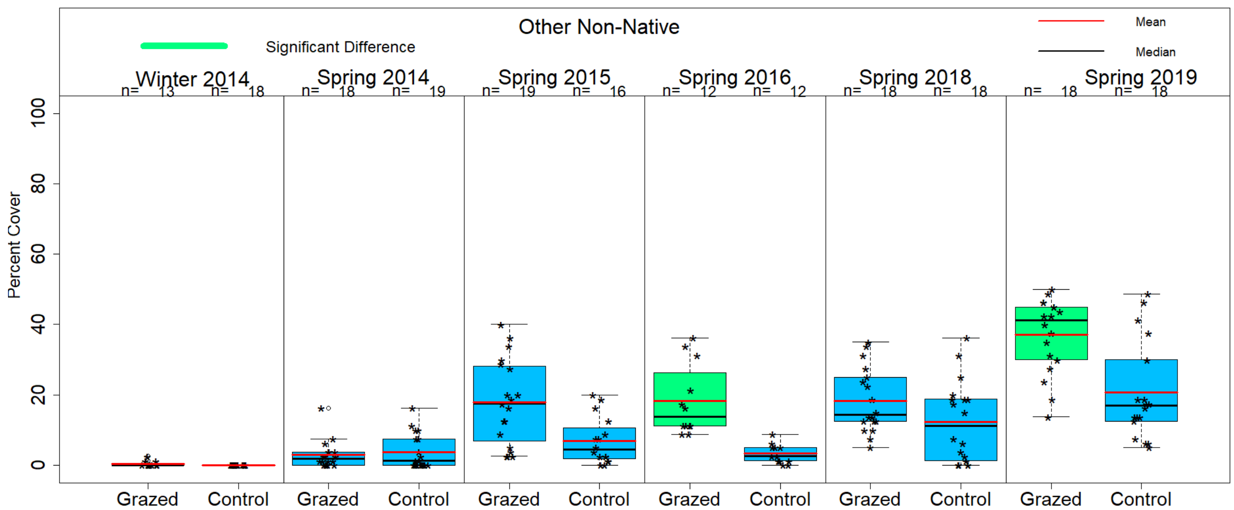

Figure 13: Boxplots other non-native herbaceous species cover differences among goat grazing treatments in Pilarcitos canyon from winter 2014 – spring 2019. Winter 2014 did not receive a grazing treatment before sampling and occurred before the growth of most other non-native herbaceous species. A green highlight denotes statistical differences based on bootstrap simulation analysis between the control plot and grazed plot within a given year.

Table 10: Bootstrap simulation analysis results of other non-native herbaceous species (ONN) cover differences among goat grazing treatments in Pilarcitos canyon from winter 2014 – spring 2019. 95% confidence interval shows the expected change in the grazed plot compared to the control plot for each year of the study. The asterisk indicates a significant difference between treatments

Species	Year	Grazed mean (% cover)	Control mean (% cover)	Expected change in grazed plot versus control plot
ONN	Winter 2014	1 (0–5)	0 (0–0)	No difference
ONN	Spring 2014	6 (0–15)	6 (0–15)	No difference
ONN	Spring 2015	35 (20–50)	17 (7.5–30)	No difference
*ONN	Spring 2016	36 (22.5–50)	6 (0–15)	12.5% – 47.5%
ONN	Spring 2018	37 (22.5–52.5)	25 (12.5–37.5)	No difference
*ONN	Spring 2019	74 (60–87.5)	41 (27–57.5)	12.5% – 52.5%

Based on a bootstrap simulation analysis of the difference in other non-native herbaceous species (ONN) percent coverage between grazed and control plots, significant differences in treatments were found in spring 2016 and spring 2019 (Table 10).

Bunchgrass Results

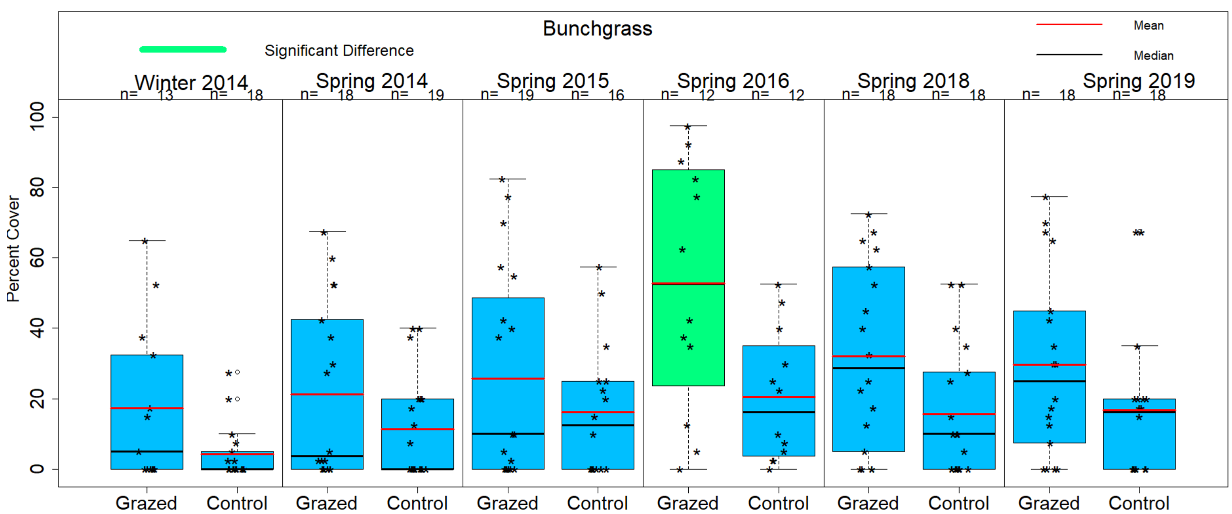

Figure 14: Boxplots of bunchgrass species cover differences among goat grazing treatments in Pilarcitos canyon from winter 2014 – spring 2019. Winter 2014 did not receive a grazing treatment before sampling. A green highlight denotes statistical differences based on bootstrap simulation analysis between the control plot and grazed plot within a given year.

Table 11: Bootstrap simulation analysis results of bunchgrass (BU) differences among goat grazing treatments in Pilarcitos canyon from winter 2014 – spring 2019. 95% confidence interval shows the expected change in the grazed plot compared to the control plot for each year of the study. The asterisk indicates a significant difference between treatments

Species	Year	Grazed mean (% cover)	Control mean (% cover)	Expected change in grazed plot versus control plot
BU	Winter 2014	17.5 (7.5–30)	4 (0–10)	No difference
BU	Spring 2014	21 (10–35)	11.5 (2.5–20)	No difference
BU	Spring 2015	26 (17.5–45)	16 (5–27.5)	No difference
*BU	Spring 2016	52.5 (37.5–67.5)	20.5 (10–32.5)	12.5% – 52.5%
BU	Spring 2018	32 (17.5–47.5)	15.5 (5–27.5)	No difference
BU	Spring 2019	29.5 (15–45)	16.5 (5–30)	No difference

Based on a bootstrap simulation analysis of the difference in bunchgrass (BU) percent coverage between grazed and control plots, significant differences in treatments were found in spring 2016 (Table 11).

Other native herbaceous species Results

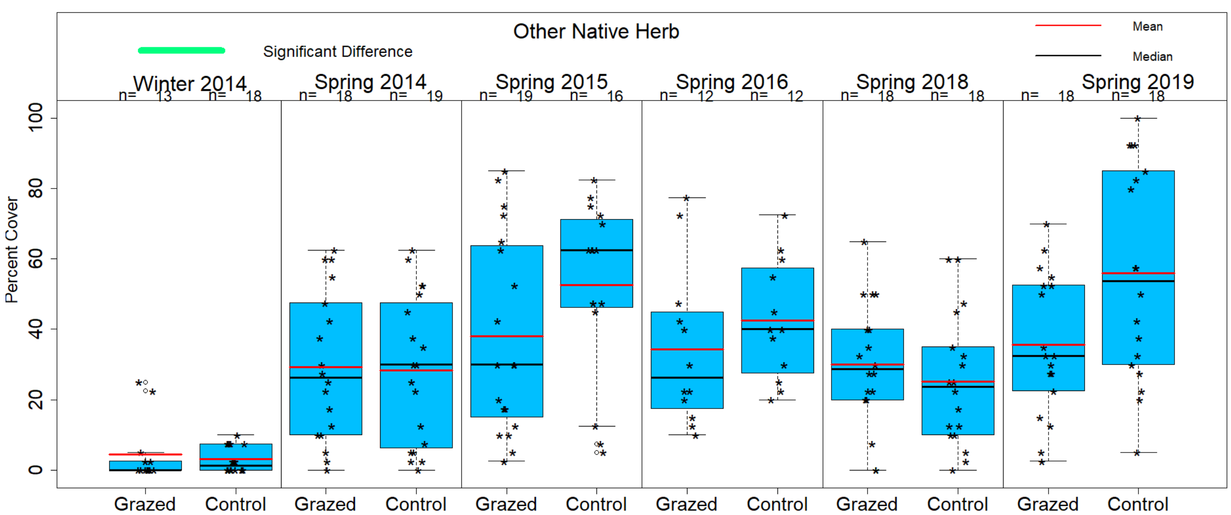

Figure 15: Boxplots other native herbaceous species cover differences among goat grazing treatments in Pilarcitos canyon from winter 2014 – spring 2019. Winter 2014 did not receive a grazing treatment before sampling and occurred before the growth of most other native herbaceous species. A green highlight denotes statistical differences based on bootstrap simulation analysis between the control plot and grazed plot within a given year.

Table 12: Bootstrap simulation analysis results of other native herbaceous species (ONH) cover differences among goat grazing treatments in Pilarcitos canyon from winter 2014 – spring 2019. 95% confidence interval shows the expected change in the grazed plot compared to the control plot for each year of the study. The asterisk indicates a significant difference between treatments

Species	Year	Grazed mean (% cover)	Control mean (% cover)	Expected change in grazed plot versus control plot
ONH	Winter 2014	4.5 (0–12.5)	3 (0–7.5)	No difference
ONH	Spring 2014	29.5 (17.5–45)	28.5 (12.5–40)	No difference
ONH	Spring 2015	38 (22.5–52.5)	52.5 (37.5–67.5)	No difference
ONH	Spring 2016	34.5 (20–50)	42.5 (27.5–57.5)	No difference
ONH	Spring 2018	30 (17.5–45)	25 (12.5–40)	No difference
ONH	Spring 2019	35.5 (20–50)	56 (40–70)	No difference

Based on a bootstrap simulation analysis of other native herbaceous species (ONH) percent coverage between grazed and control plots, no significant differences in treatments were found (Table 12).

Discussion

Grasslands

The management goal for the grasslands is to reduce the residual dry matter (RDM) of annual herbaceous vegetation to 1200 lbs/acre to reduce the risk of fire to the surrounding urban community around Fort Ord National Monument. Throughout all years of the sheep monitoring study, we were unable to reduce RDM within grazed plots to management objectives. Despite passive sheep grazing not reducing fuel accumulation levels to BLM management goals, in most years, sheep reduced fuel loads by up to 1300 lb/acre, which may reduce the risk of fire (or fire severity) to the surrounding community. Though sheep were not meeting the BLM management goals, they were more effective at reducing fuel accumulations compared to not having any grazing present on the monument.

Passive goat grazing in 2016-2017, and 2019 also did not meet management goals. This trend suggests that passive goat grazing in the grassland has a similar effect on coastal grasslands as passive sheep grazing. Passive goat grazed plots have lower fuel accumulations on average than control plots indicating that goats are removing dead herbaceous vegetation. However, this trend is not present when goats are not grazing the grasslands during the summer fire season. Passive goat grazing does not meet the management goal of 1200 lb/acre of RDM and only reduces fuel accumulations when goats are present on the monument.

In 2018, BLM experimented using both targeted and passive goat grazing. Both passive goat grazing and targeted goat grazing significantly reduced RDM between grazed and ungrazed plots. However, neither grazing strategy met management goals of 1200 pounds per acre of dead, annual herbaceous vegetation. Targeted goat grazing in spring came closest to meeting management goals, and we observed the greatest expected decrease in fuel accumulations. When goats repeatedly grazed the same plot through targeted goat grazing treatments, there was a greater reduction in fuel accumulations compared to passive goat grazing. Our results found that targeted goat grazing was the most effective grazing method at reducing fuel loads. However, these effects only occurred while the goats were active on the monument. We no longer observed these effects during the summer fire season when BLM removed goats in late April.

Overall, grazing coastal grasslands with passive sheep grazing or passive goat grazing reduced fuel accumulations compared to not using a grazing treatment but did not meet management goals of 1200 pounds per acre of dead annual herbaceous vegetation. Passive sheep grazing was as effective as passive goat grazing and are equivalent management methods for fuel accumulation reduction. The advantage of goat grazing is that the goat herding operation used an electric fence to target graze high priority areas. In contrast, the sheep operation was unwilling to graze the grassland with electric fencing. While neither targeted goat grazing or passive goat grazing reduces fuel accumulations to 1200 lb/acre of residual dry matter, targeted grazing reduces more residual dry matter than passive goat grazing. Results suggest that goat grazing is only effective when goats are present on the monument and that there is no reduction to fuel loads during the summer fire season when goats are absent in late April. However, there is more RDM reduced by targeted goat grazing than passive goat grazing, and targeted goat grazing is a viable management strategy for BLM to use when goats are present on the monument. To meet fuel accumulation goals, then BLM must use targeted goat grazing on high priority areas and maintain fuel accumulation reduction with passive goat grazing throughout the year. While goat grazing does not meet the specific goal of 1200 lb/acre of dead annual herbaceous vegetation, goats are having a significant effect at reducing fuel accumulations compared to not using any grazing treatment.

Coyote Brush Scrub

Coyote Brush (BAPI)

Coyote brush is reduced most in 2015 after the study area was targeted grazed in 2014 and 2015. When the grazing management changed, and the area was passively grazed in subsequent years, then the difference becomes less apparent over time. Results suggest that coyote brush foliar cover is reduced with targeted goat grazing but returns when the grazing treatment changes to passive goat grazing. Therefore, to reduce coyote brush encroachment, BLM must target goat graze areas with high-density of Coyote Brush Scrub every year.

Annual grass and other non-native herbaceous species

Annual grass and other non-native herbaceous species abundance increased throughout the study in the grazed plot compared to the control plot. Results indicate that annual grass and other non-native herbaceous species benefit from goat grazing. As goat grazing removes coyote brush plants from the grazed plot, annual grass and other non-native herbaceous species increase in foliar cover. Data suggests an inverse relationship between coyote brush and annual grass as well as other non-native herbaceous species. If there is high coyote brush foliar cover, then there is low annual grass and other non-native herbaceous species foliar cover. If there is low coyote brush foliar cover, then there are high annual grass and other non-native herbaceous species foliar cover.

Bunchgrass (BU)

Goats are not affecting bunchgrass foliar cover and neither having a negative or positive effect on their distribution. Bunchgrass may be slow to respond to goat grazing, and a change in bunchgrass foliar cover may not be observed during the short period of monitoring in this study. It is also possible that observer bias is underestimating the new growth of bunchgrass when there is abundant annual grass growth. Annual grasses can grow over bunchgrasses and make it difficult for the observer to identify specific bunchgrass leaves during monitoring. Since annual grasses increased foliar cover in the last few years of the study, it’s likely that new bunchgrass growth was not accurately recorded in grazed plots with high annual grass cover.

Other native herbaceous species

Results are variable for other native herbaceous species. While there was no significant difference between grazed and control plots during any year of the study, the grazed plot foliar cover of other native herbaceous species changed depending on the year sampled and was generally lower in the grazed plot. This variation may be due to other native herbaceous species category, including both annual plants, which have variable growth between years and perennial plants that are slow to regrow quickly once grazed by goats. It is likely that when goats graze perennial forbs, then there is a decrease in foliar cover. However, if this occurs during a year with high annual forb growth, then there is no observed difference in foliar cover. Whereas in years with low annual forb growth, there is an observed decline in other native herbaceous species foliar cover. When the coyote brush canopy is removed from the grazed plots, forbs become the desired vegetation by the goats, and we would expect this category to decline over time, especially on years with low annual forb growth.

Overall, goat grazing in Pilarcitos Canyon has reduced coyote brush foliar cover, increased annual grasses, and non-native herbaceous species foliar cover does not affect bunchgrass foliar cover and is variable for native herbaceous species foliar cover. Grazing effects on coyote brush coverage is variable, where targeted goat graze priority areas see the most reduction in coyote brush foliar cover. However, coyote brush is slow to grow back with passive goat grazing, and it may be possible to intensely target-graze priority area every three-five years with passive grazing maintenance to see results desired results. Despite increasing annual grass and non-native herbaceous species, data supports that the area is slowly being transitioned into coastal grassland as most grassland on Fort Ord has a high foliar cover of non-native species.

Conclusion and Next Steps

Grasslands

Passive sheep, passive goat, and targeted goat grazing were unable to meet management goals of 1200 pounds per acre of dead herbaceous vegetation. This management goal is unobtainable to reach with current livestock grazing and may not be the most appropriate goal for the grassland. BLM established 1200 lb/acre as the minimum amount of biomass that needs to be present on the grassland to avoid overgrazing the grasslands. Therefore BLM should consider revising this goal and adjust to a range of 1200-2100 lb/acre of dead annual herbaceous vegetation (Bartolome et al. 2006) to avoid overgrazing the grasslands. Targeted goat grazing is a more desirable management practice because it has a greater effect on reducing fuel accumulations. The downsides to grazing are that fuel reductions are not observed during the summer months, even with the use of targeted goat grazing due to the absence of goats from May-October. Sheep grazing would likely have the same drawback had monitoring been conducted during the summer months when sheep were present, making goat grazing the better management practice. Extending the length of time goats are on the monument will not remove further fuel accumulations. BLM has not observed goats eating grasses (Ripgut Brome and Wild Oats) in the mature seed stage, which occurs after mid-April (B. Delgado, pers. comm). Therefore, increasing the intensity of grazing will not meet management goals if grasses continue to grow after goats are removed in early April. Alternatively, BLM can consider using a different management method on high priority areas (such as targeted grazing with specific types of cattle grazing, or mastication of vegetation with heavy equipment) during the summer months to achieve BLM's objectives. Presently the goats are reducing fuel accumulations and reducing the risk of fire to the surrounding urban community when they are present on the monument but do not have a substantial impact after their departure in April.

Coyote Brush Scrub

Goats are slowly reducing areas of Coyote Brush Scrub encroachment into coastal grasslands. Data suggests that targeted goat grazing reduced Coyote Brush Scrub with repeated grazing treatments in future years. However, the growth of annual grass and other non-native vegetation warrant new management practices if BLM's objectives include improvement of habitat for native grasses and forbs. BLM needs to find an effective way to convert coastal grassland infested with annual grasses into coastal grassland with high native species diversity. Such management, in conjunction with the current use of targeted goat grazing in areas of Coyote Brush Scrub encroachment, may reduce annual grass foliar cover if goats graze annual grasses as soon as they begin producing fertile seeds (Harrison et al. 2003). However, BLM is not conducting monitoring that reveals the overall plant composition of the grassland and measures the change of species composition from alternative management practices. Therefore, the recommended next steps are to continue to use targeted grazing with goats in Pilarcitos Canyon for the next several years and add additional monitoring plots on grasslands that do not have Coyote Brush Scrub. Such monitoring will address an information gap between the grassland study and the coyote brush encroachment study and inform managers on the expected change of plant diversity through targeted goat grazing in both grassland with and without coyote brush presence.

From 1997-2019 BLM's monitoring projects were employed to determine livestock grazing impacts on Coyote Brush, bunchgrasses, and other native and non-native herbaceous vegetation. Passive sheep and goat grazing were both ineffective at having a significant reduction in fuel accumulation levels and reducing the risk of fire to the urban communities surrounding Fort Ord National Monument. Targeted goat grazing had the most reduction in fuel accumulations of all three grazing treatments but was not able to meet management goals of 1200 lb/acre of residual dry matter. However, targeted goat grazing was an effective grazing technique for removing the intrusion of coyote brush scrub on coastal grassland communities despite increasing the foliar cover of non-native forbs and annual grasses. As the BLM continues to graze coastal grasslands with targeted goat grazing, they must establish additional monitoring plots that measure plant diversity in grasslands without coyote brush scrub to ensure that they are increasing the cover of bunchgrasses and native forbs. Despite its drawbacks, targeted goat grazing is the best available grazing technique available to the BLM. Until an alternative management technique can be introduced to reduce fuel accumulations further, BLM should continue to target goat graze the grasslands. This targeted grazing regime gives the BLM an opportunity to manage coastal grassland to both reduce fuel accumulation and increase native plant abundance in FONM Coastal Grassland.

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