

Distribution of Cattle Grazing in a Northeastern Oregon Riparian Pasture

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SUMMARY

Livestock grazing of a northeastern Oregon riparian pasture was monitored using high-frequency GPS tracking of cattle and high-resolution aerial photography. Tracking collars recorded positions, velocity, date, and time at 1-sec intervals. Areas where animals rested and moved were identified and residence times calculated for various locations and plant communities in the pasture. Tracking collars performed well and data from 74 days of continuous 24-hour observation were compiled, more than 10 days of observation on 7 cows. Activity diagrams and daily travel distances were determined for each animal, as was preference for ecological sites. Maps that showed travel routes and stream crossing areas were also produced. Managerial implications of the collected information are discussed.

INTRODUCTION

In 2002 the National Research Council (NRC 2002) conducted a study of riparian areas that found:

“Traditional agriculture is probably the largest contributor to the decline of riparian areas... The primary effects of livestock grazing include the removal and trampling of vegetation, compaction of underlying soils, and dispersal of exotic plant species and pathogens. Grazing can also alter both hydrologic and fire disturbance regimes, accelerate erosion, and reduce plant or animal reproductive success and /or establishment of plants. Long-term cumulative effects of domestic livestock grazing involve changes in the structure, composition, and productivity of plants and animals at community, ecosystem, and landscape scales.”

Modern, rational grazing management systems of riparian areas have been developed and adopted by private ranches and federal and state agencies. These systems were created by university, USDA/Agricultural Research Service, Natural Resource Conservation Service, and Federal agency personnel and are designed to reduce impacts of livestock on critical environmental attributes of riparian systems, such as vegetation along the green line, streamside shrubs, and bank overhang that can negatively impact native plants, fish, and wildlife. Managerial systems typically adjust the timing and/or intensity of grazing such that cattle impacts are controlled while economic benefits to producers are maintained. Knowledge of animal distribution within the context of site preference and site accessibility is central to the development of these grazing management plans and most were developed by experienced managers. Today Geographic Information Systems (GIS) and Global Positioning Systems (GPS)

technologies provide researchers with opportunities to study livestock distribution and movement with greater precision and accuracy than was possible a few years ago. Our study was designed to test the capabilities of GPS collars logging at high frequency for monitoring cow positions in a riparian setting and to determine the relative duration of occupancy on ecological sites.

MATERIALS AND METHODS

Site Description

The study site is located in the Wallowa Mountains of northeastern Oregon approximately 21 mi (36 km) southeast of La Grande Oregon (45.13026°N, 117.70551°W) at an elevation of 3,400 ft (1,036 m). The riparian pasture (Pasture C) is approximately 139 acres (56.40 ha) and extends for approximately 1.44 mi (2.32 km) along Catherine Creek (Fig. 1). Mean annual precipitation for the study site is 23.2 inches (590 mm), most of which falls as snow during the winter months. The study pasture was photographed at high resolution, 7.8-inch (20-cm by 20-cm ground pixel size or 1:706 scale), with an aircraft-mounted Canon® 12.4 megapixel digital camera on 3 September 2008, just after livestock were moved from the unit. Images were corrected for lens curvature, then mosaiced via edge matching to create a composite image. The composited image was geographically registered (geo-rectified) using ground control points.

Geo-rectified images with 100-m (328.083 ft) UTM grid lines were used by ecologists to map vegetative communities in the riparian pasture. Communities were delineated as: 1) cobble (*Bromus tectorum* L.), 2) wet meadow (*Poa pratensis* L., *Phleum pratense* L., *Carex* spp.), 3) dry meadow (*Poa pratensis* L.), 4) Douglas hawthorn (*Crataegus douglasii* Lindl.), 5) riparian shrub (*Populus balsamifera* L. ssp. *trichocarpa* (Torr. & A. Gray ex Hook.) Brayshaw, *Alnus incana* (L.) Moench, *Salix* spp.), 6) gravel bar, and 7) pine (*Pinus ponderosa* C. Lawson). The river was also digitized and became an eighth class as surface water (Fig. 2).

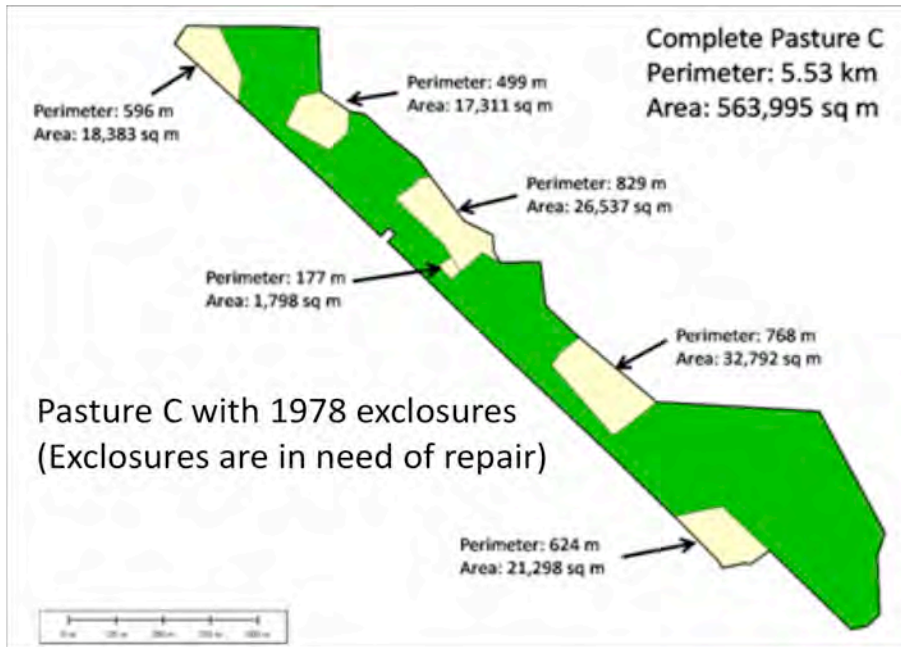


Figure 1. Catherine Creek (Pasture C) study site.



Figure 2. Vegetative communities in the northwestern portion of Pasture C on the Hall Ranch.

GPS Collars

GPS collars were constructed using a Trimble® Lassen® iQ Module, GPS data logger board, SD Card, and batteries that were enclosed in a polycarbonate waterproof case attached to sewn collar belting. Collars were color coded so individual animals could be visually identified at a distance. Collars collected the following data at 1-sec intervals; latitude; longitude [horizontal error: less than 5 m (50 percent), less than 8 m (90 percent)]; velocity (accuracy: 0.06 m/sec); elevation (altitude error less than 10 m (50 percent), less than 16 m (90 percent)); date; time (accurate to better than 0.25 sec); number of satellites used in the positional fix; and an estimate of fix quality. GPS data loggers operated continuously for approximately 6.25 days and automatically restarted if power was interrupted while logging. A reference GPS unit was used as a static test during Trial 1. This unit was placed in a representative area 5 ft (1.5 m) above the ground. During Trial 1 (6.71 days of logging at 1 sec or 579,290 positional fixes) mean XY error was 5.7 ft (1.75 m) with 3.9 ft (1.19 m) standard deviation. Throughout the 6.71-day test, 2,011 points (0.35 percent) were recorded with XY errors greater than 25 ft (7.5 m) and 555 points (0.096 percent) had errors greater than 32 ft (10 m). This stationary reference GPS unit recorded only seven velocities greater than 0.00 mph (0.00 kph) during the test period.

We should note that rapid head movement, such as a collared cow's head toss while fighting flies, can result in a recorded velocity by the GPS collar. This typically occurs as single velocity values in a series of no velocity values. Obviously, "head tosses" during grazing would not be distinguishable from normal grazing velocities.

Animals

Seven Angus and Angus-cross commercial cows from a herd of 33 cows and calves were collared with GPS units that recorded positions at 1 sec intervals. Two trials were run. Trial 1 lasted from when cows entered the pasture on 12 August 2008 to 17 August 2008. Trial 2 lasted from 27 August to 1 September 2008 and ended just before animals left the pasture. A total of 6,378,700 positions were recorded on the collared cows (74 days of continuous 24-hour observation periods). During Trial 2 several cows also carried Vibracorders® to monitor head motion. These units knocked against GPS collars and caused GPS collars to fail.

At the end of each trial data were downloaded from the GPS units and stored in electronic format. Animal positions were grouped by day with only 24-hour continuous observation periods used for analysis. Daily data were sorted by velocity into the following classes based on a 61-sec running average using the Animal Movement Classifier software (Johnson et al. 2008): 1) stationary - no recorded velocity for 61 sec, 2) very slow – mean velocity between 0.0006 mph (0.001 kph) and less than 0.06 mph (0.1 kph), 3) slow - mean velocity between 0.06 mph (0.10 kph) and less than 0.62 mph (1.0 kph), 4) moderate - mean velocity between 0.62 mph (1.00 kph) and less than 2.49 mph (4.00 kph), and 5) fast - mean velocity greater than 2.49 mph

(4.00 kph). Distance traveled for each animal and day was calculated by summing the displacement from each GPS position with a recorded velocity. This typically reduced the number of locations from 86,400 in 24 hours to less than 9,000, which reduced accrued GPS errors. Times when animals had no GPS velocity thus were not used to calculate path distance. Those locations when animals were stationary for 10 min or longer were tallied and a minimum convex polygon was created as an ArcGIS® shapefile® that was attributed with entry date and time, duration in seconds, and surface area of the polygon.

RESULTS AND DISCUSSION

Velocity of GPS-collared cows was plotted to determine daily activity patterns (Fig. 3). The velocity pattern shows that cattle were actively moving beginning between 4:00 and 5:00 local time and continued, with relatively brief inactive periods, until approximately 19:00 hours. Movement, as indicated by velocity, appeared to be more intense during the first day that animals were in the pasture (Fig. 3) but the general active periods were similar through the Trial. As can also be seen in Figure 3, cow 6220 was regular in her activity pattern throughout Trial 1, indicating a stable environment. Night is characterized by fewer, separated velocities but some sustained movement can occur. During this trial civil twilight began at 5:30, sunrise was at 6:02, sunset was at 19:46, and the end of civil twilight occurred at 20:17.

An examination of the classified activity for this animal also indicates that less time was spent in travel toward the end of the grazing period. On August 12, cow 6220 logged 48,122 positions (55.7 percent) classed as stationary, 10,554 positions (12.2 percent) as very slow, 19,916 (23.1 percent) as slow, 7,547 positions (8.7 percent) as moderate, and 248 positions (0.3 percent) as fast. Of a potential 86,400 positions, 86,387 positions (99.98 percent) were recorded for the day. On 31 August 2008 cow 6220 recorded 60,109 positions (69.6 percent) classed as stationary, 12,591 positions (14.6 percent) as very slow, 12,942 (15.0 percent) as slow, 678 positions (0.8 percent) as moderate, and 0 positions (0.0 percent) as fast. Of a potential 86,400 positions, 86,320 positions (99.91 percent) were recorded for the day. This suggests less movement at lower speeds as the grazing period progressed.

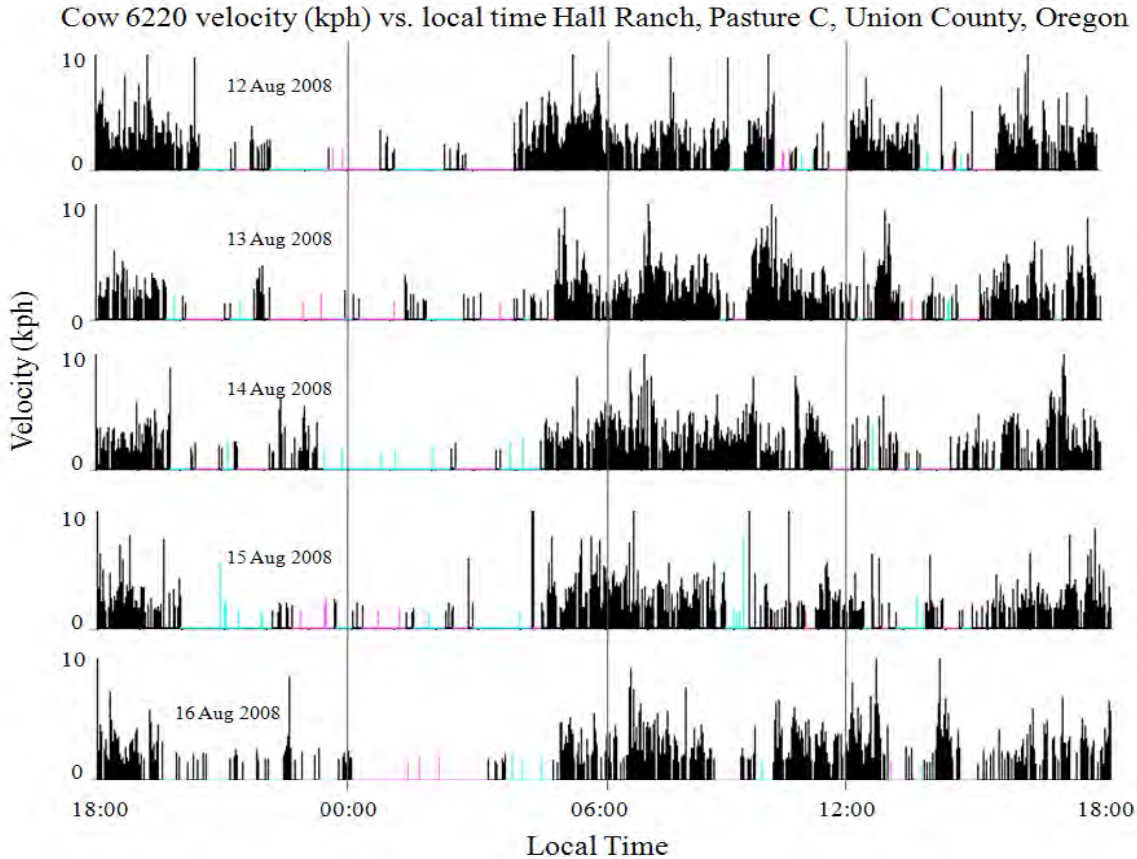


Figure 3. Activity pattern of cow 6220 between 12 and 16 of August 2008. Recording began just after cattle entered the pasture (17:00 hours) and continued for the following 5 days. Gray bands on the time axis represent classified stationary locations with duration longer than 10 minutes.

Travel distance was calculated for each collared animal in the herd (Tables 1 and 2) by calculating X,Y displacement between positions with a recorded velocity. This alleviates most of the pseudo travel that results from summing GPS errors while the animal was actually stationary. Over the duration of both trials the trend in daily distance traveled was to shorter distances ($DDT_{km} = -0.1576x + 6.3171$, $R^2 = 0.5086$), which could indicate that animals learned where the best forage was located and were more efficient foragers as time in the pasture progressed. This trend could be explained by other factors as well.

Cattle distribution in the pasture was not uniform (Fig. 4). The northwestern portions of the pasture were more attractive to cattle than were the brushier, densely wooded or steeper sloped sites in the southeast, thus the bulk of the occupancy was in the northwestern areas. Preferred areas tended to be more open with more grass, which corresponded to meadow areas. Also obvious was that some of the exclosures were in disrepair and fencing did not restrict cow movement. For example, cows freely moved through the northwestern-most exclosure, crossing broken fences at numerous locations.

Table 1. Travel distance (mi/day) for each collared cow during Trial 1, Catherine Creek Pasture, Hall Ranch, Union County, Oregon.

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Cow	12 Aug 08	13 Aug 08	14 Aug 08	15 Aug 08	16 Aug 08	17 Aug 08	18 Aug 08
6220	5.275 mi	4.362 mi	4.064 mi	2.896 mi	3.560 mi	3.250 mi	
6126	3.523	4.058	3.219	2.336	2.678	2.529	3.958
1154	3.921	4.039	4.045	3.766	3.175		
9217	4.232	2.927	3.480	2.691	1.982	2.740	
5223	3.237	3.125	3.393	2.734	2.548	2.417	
4282	5.331	4.312	5.145	3.368	3.592	3.548	
5027	4.430	4.033	3.815	3.157	2.666	3.070	
Mean	4.281	3.83	3.877	2.995	2.883	2.927	3.958

Table 2. Travel distance (mi/day) for each collared cow during Trial , Catherine Creek Pasture, Hall Ranch, Union County, Oregon 2.

	Day 16	Day 17	Day 18	Day 19	Day 20	Day 21
Cow	27 Aug 08	28 Aug 08	29 Aug 08	30 Aug 08	31 Aug 08	1 Sep 08
6220	2.523 mi	4.362 mi	2.113 mi	2.144 mi	1.914 mi	2.175 mi
6126	2.044	2.684	1.510	2.069	1.752	2.734
1154	2.908	3.598	1.964	1.734	2.026	3.020
9217	2.057	0.000	0.000	0.000	0.000	0.000
5223	2.243	2.889	1.423	1.634	1.647	2.678
4282	2.672	3.386	1.684	1.939	2.324	2.852
5027	2.684	0.000	0.000	0.000	0.000	0.000
Mean	2.448	3.386	1.740	1.901	1.932	2.691

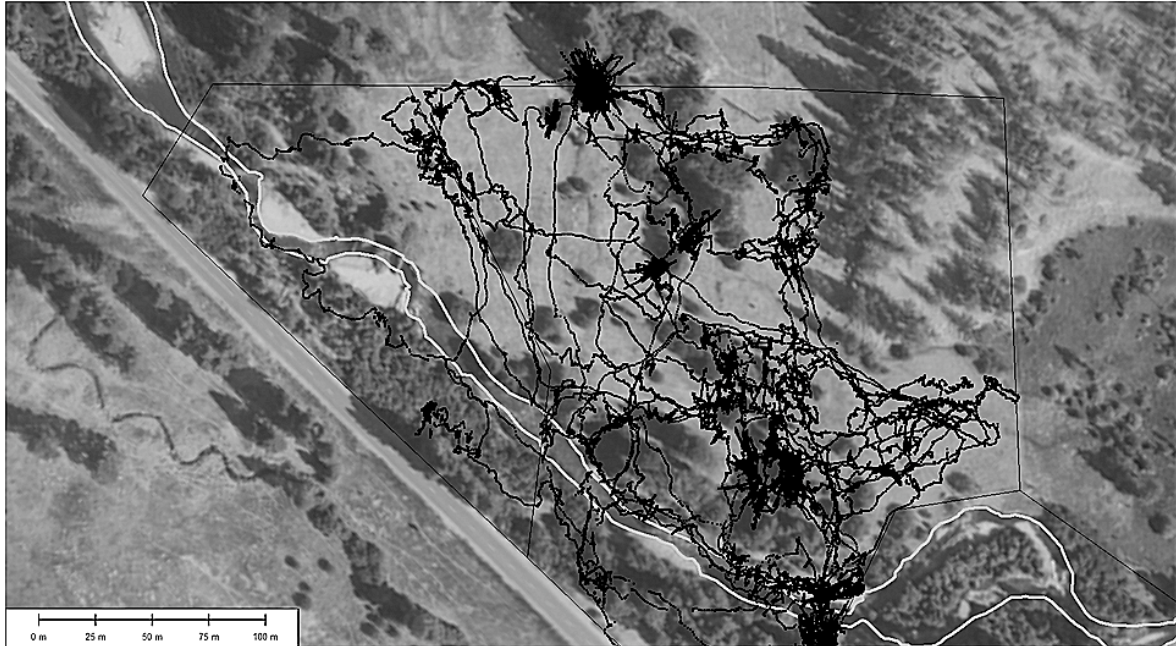


Figure 4. Distribution of collared cattle (black dots) during the August/September 2008 grazing season for the northwestern portion of the Hall Ranch Pasture C. Note the locations that cattle used to cross Catherine Creek (outlined in white) and the meandering travel routes through the brushy areas. Each point represents 1 sec of occupancy.

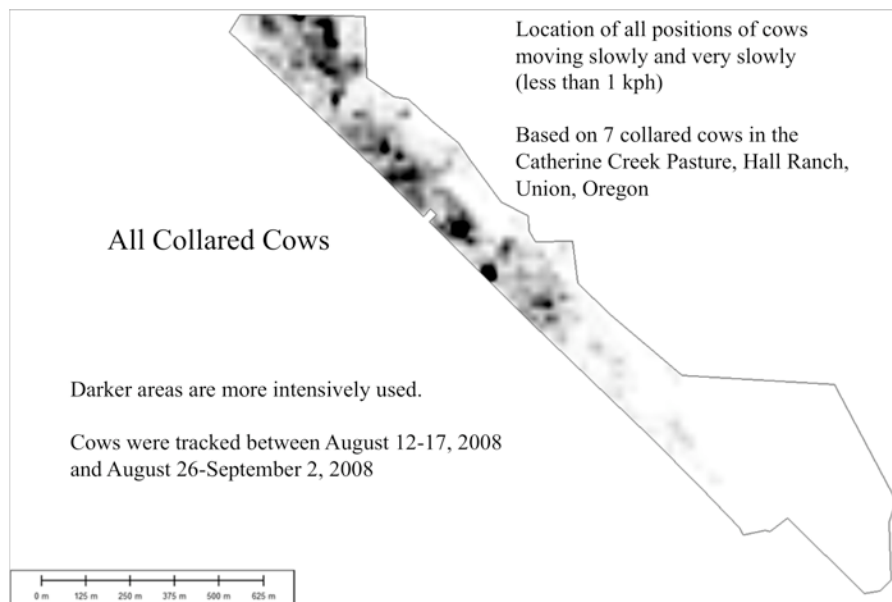


Figure 5. Distribution of collared cattle while moving slowly or very slowly during the August-September 2008 grazing season for the Hall Ranch Pasture C. The pasture was divided into 65-ft by 65-ft (20 m by 20 m) cells and the time (sec) of presence was tallied for all cows and days of observation. Darker gray shading indicates longer occupancy times. The maximum occupancy was 23,000 sec, minimum was 0.

In an attempt to identify where cattle grazed, we extracted those positions that were classified as slow or very slow movement. A 65-ft by 65-ft (20 m by 20 m) grid was created for the pasture and points were tallied to produce a map that shows the duration of occupancy in each cell (Fig. 5). This map contains values from 0 sec occupancy per cell to approximately 23,000. Sites that were preferred tended to center on areas with abundant grass forage. Locations where cows were stationary for more than 10 minutes tended to be near preferred grazing areas and associated with shade trees.

We created preference indices for our vegetation communities map by dividing the percent use (while moving very slowly or slowly) by its relative percentage in the pasture (Table 3). Wet meadows and dry meadows were both preferred as would be expected (Table 3). We did not expect that cobble/BRTE (cheatgrass) sites would also be preferred. Upon examination of the cattle locations plotted on the vegetation communities map, we found that this vegetation type was small (because it represents an old river channel) and perpendicular between two favorite grazing areas. Thus most of the occupancy was during transit between favorite foraging locations. Preference in these communities appears to rank in decreasing order with potential grass production. We hypothesize that forage quality and quantity at the feeding patch/community level is an important factor in determining relative use. Unfortunately standing crop was not measured prior to grazing.

Table 3. Preference of cows grazing the Hall Ranch Catherine Creek Pasture, Union County, Oregon for vegetative communities.

Vegetation community	Total % of area	Total % of use	Preference index
Cobble/BRTE	0.37	1.38	3.68
Wet meadow	0.16	0.60	3.68
Dry meadow	10.24	31.32	3.06
Hawthorn	13.33	29.31	2.20
Riparian shrub	7.28	14.02	1.93
River	3.90	2.78	0.71
Gravel bar	1.59	0.84	0.53
Pine	63.13	18.35	0.29
Total	100	98.60	

MANAGEMENT IMPLICATIONS

The techniques described in this paper were effective in monitoring cattle grazing in a riparian pasture. GPS collars recorded animal position with reliability except when Vibracorders[®] were also carried and we were able to ascertain where and when cattle utilized various vegetative communities and where favorite day and night camps were located. Cow

preference for sites in the pasture was mapped and these locations could be used as key areas for managerial decision making. For example, the standing crop at two or three locations might provide a rancher with an index of how much forage remains to be grazed and when animals should be moved. Although not specifically reported in this paper, we also identified locations where cattle crossed the stream, duration of occupancy, and sites that were used for watering. These areas could be monitored for stream bank or environmental impacts. Obviously, this type of information can be used to rationally assess effects of livestock grazing on pastures with riparian systems. We should also be able to use these types of data to suggest managerial interventions such as off-stream watering, trail building, stream crossing improvement, or fencing configurations to mitigate problems.

Cattle activity in this study was centered on meadow areas and travel routes between them. Extensive portions of the pasture were unused. If the managerial goal is to increase cattle production or increase livestock dispersion, our technologies could suggest ways to do it. For example, meadow areas in this pasture are being invaded and dominated by hawthorn. Hawthorn sites are less preferred than are open meadows and as time passes grazing capacity will diminish as meadows convert to brush. Our technologies could be used to estimate benefits from brush control.

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