Upland Water and Deferred Rotation Effects on Cattle Use in Riparian and Upland Areas

By John Carter, James C. Catlin, Neil Hurwitz, Allison L. Jones, and Jonathan Ratner

On the Ground

- Our experience shows that land management agencies rely on upland water and deferred rotation grazing systems to reduce riparian use and improve conditions, rather than addressing stocking rate and requiring herding of cattle.
- Range scientists have published studies showing that cattle prefer to linger in riparian areas and that stocking rate is more important than grazing system.
- We collected 4 years of data on upland and riparian residual vegetation, riparian stubble height, and bank alteration prior to implementation of the upland water developments and deferred rotation scheme and compared that with 4 years of data collected after implementation.
- As a result of this change in management, post-grazing riparian stubble heights decreased; bank alteration was unchanged; upland residual grasses were reduced; there was no change in residual herbaceous vegetation in the riparian zone; and utilization remained excessive in both upland and riparian areas.
- Range science shows that to reverse this outcome and improve conditions, changes must be made. These include
  - setting stocking rates based on currently available preferred forage species and todays consumption rates of livestock,
  - enforcing utilization rates of less than 30% in upland and riparian areas,
  - enforcing riparian stubble heights of $>$15.2 cm across the aquatic influence zone and floodplain,
  - enforcing bank alteration levels of $<$20%,
  - using riders to limit riparian use and distribute livestock, and
  - providing rest, not deferment, so that sensitive native grasses recover vigor and productivity prior to being grazed again.

Keywords: utilization, bank alteration, stubble height, riparian, upland water, deferred rotation.

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In 2007, a U.S. Bureau of Land Management (BLM) National Environmental Policy Act process for the Duck Creek allotment resulted in the installation of six large-capacity upland water troughs that would "draw" livestock away from riparian areas. New fences were built to divide the allotment into four pastures so grazing could be managed under a deferred rotation system. This would reduce livestock access to individual riparian areas from 4 months to 1 month, provide alternating periods of growing season rest, and correct a distribution problem. Similarly, uplands would experience fewer defoliations due to shorter grazing periods and alternating periods of growing season rest. The expected results were reduced use of the riparian areas, no measurable increase in use of the uplands, and improved conditions for both.[1]

We collected data for parameters used by BLM to assess compliance with objectives for upland and riparian utilization and greenline stubble height. Bank alteration, although not an annual indicator or objective used by BLM, was also measured. This data was collected for 4 years prior and 4 years after implementation of the upland water and deferred rotation grazing system. Our intent was to measure changes in use; we expected that if the changes in the grazing system and upland water resulted in less use of the riparian area, then riparian utilization, greenline stubble height, and bank alteration would decline. Similarly, for the uplands, we were interested in whether measurable changes in utilization would occur. We did not measure changes in plant species, ground cover, stream channel width, or other long-term condition parameters.

Reviews of season-long grazing versus grazing systems found no discernible difference between the two, regardless of the dependent variables compared. Grazing systems showed limited or no benefit in arid systems, while rest and deferment were not sufficient to overcome the effects of periodic heavy use on primary forage plants.[2] In both the semi-arid and desert range types, rotational grazing systems generally showed no advantage over continuous or season-long grazing.[3] A recent comprehensive review analyzed outcomes of over 30 separate studies comparing rotational grazing to continuous grazing. Eighty-nine percent of the experiments reported no difference in plant production or standing crop between rotational and continuous grazing with similar stocking rates. Stocking rate emerged as the most consistent variable influencing vegetation response.[4]

Water and slope limited cattle use and distribution in a Wyoming study, with the majority of use within 366 m of water and 79% of use on slopes less than 7%.[5] In a study of continuous and deferred-rotation grazing systems in northeast Oregon's Blue Mountains, small riparian meadows were the preferred sites. The deferred grazing system increased cattle use of riparian areas.[6] In a companion study of vegetation production and cattle presence in small riparian meadows, standing crop of herbaceous vegetation "at the end of the grazing season was similar under continuous grazing and the early and late grazing periods of a two pasture deferred rotation grazing system."[7] In the Starkey Experimental Forest and Range in Oregon with water and salt available in upper elevation areas, the majority of summer use was in areas of less than 35% slope and in the riparian zone. Salt and upland water did not reduce use of the riparian areas.[8] A controlled experiment at the Hall Ranch Unit of the Eastern Oregon Agricultural Research Center using off-stream water and supplements found no significant difference between supplemented and nonsupplemented pastures in erosion index or mean cattle hoof prints along the stream margin.[9]

Study Area Description

The Duck Creek allotment is located in Rich County in northeastern Utah (Fig. 1). This area is part of the Middle Rocky Mountain Physiographic Province. The allotment is located in the Bear River Plateau, which contains nearly level to steep uplands dissected by numerous small drainages.[10] It is a semi-arid cold desert sagebrush-grassland, or sage-steppe type, in which the majority of the precipitation falls as snow during late fall to early spring, while summers are dry.[11]

Annual precipitation varies from approximately 30.5 cm at lower elevations to 40.6 cm at higher elevations.[10] Precipitation averages 34.5 cm, and temperatures range from a minimum monthly average of −16.7°C in January to a maximum monthly average of 27.8°C in July. During the 32-year period of 1983 to 2014, the Randolph climate station (14 km south) recorded 12 years with below average precipitation out of 24 with a complete record.[12] Annual precipitation during the period 2005 to 2013 is shown in Figure 2.

Elevations on the Duck Creek allotment range from 1,920 to 2,220 m. The allotment contains 9,053 ha, including BLM-managed land, private land, and state-managed lands. Perennial streams within the allotment include Duck Creek, Six Mile Creek, and North Fork Sage Creek.[1]

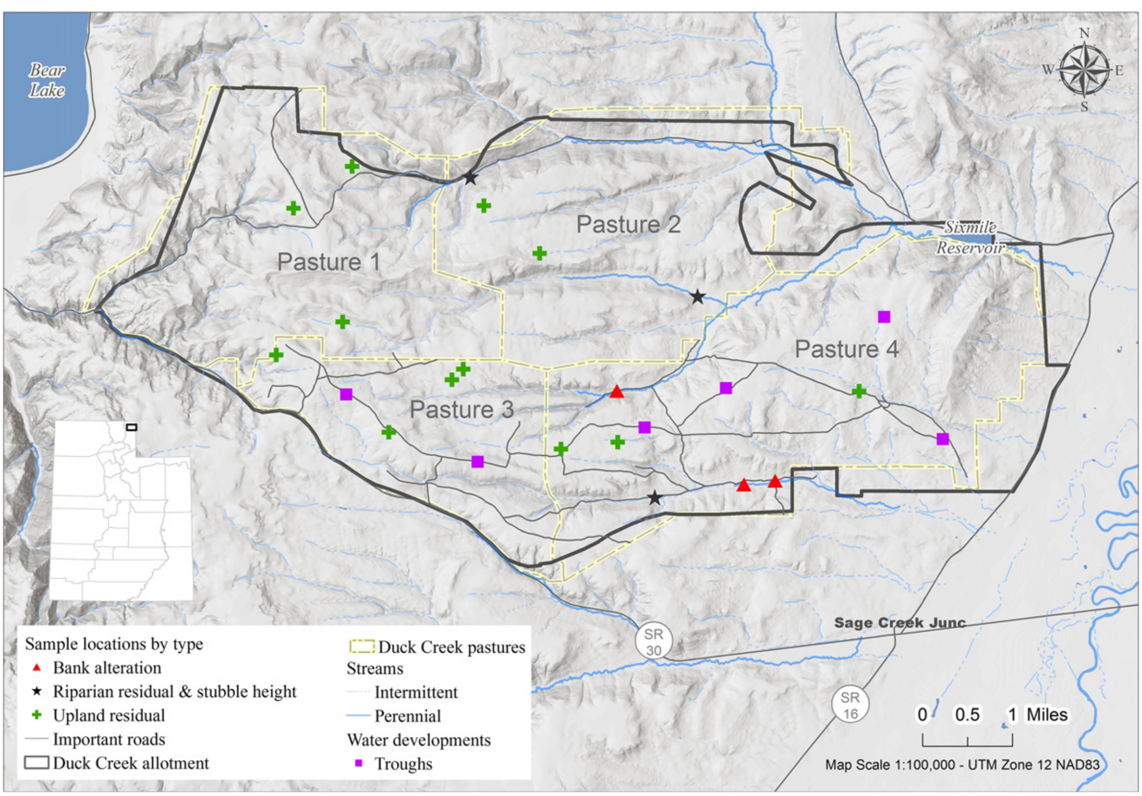

Figure 1. Map of the Duck Creek Allotment.

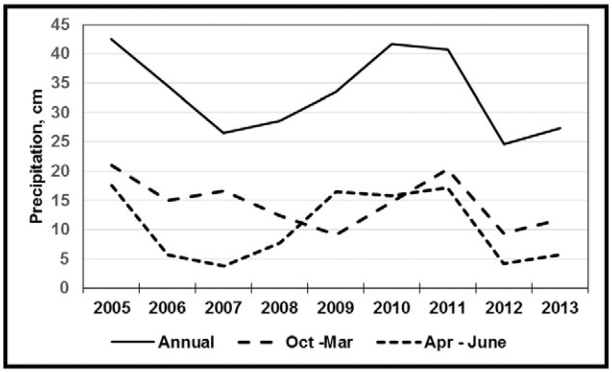

Figure 2. Precipitation at the Randolph, Utah Climate Station.

The plant community consists of shrubs dominated by sagebrush, including Wyoming big sagebrush (*Artemisia tridentata wyomingensis)*, low sagebrush (*Artemisia arbuscula*), black sagebrush (*Artemisia nova*), low rabbitbrush (*Chrysothamnus viscidiflorus*), antelope bitterbrush (*Purshia tridentata*), Utah serviceberry (*Amelanchier utahensis*), snowberry (*Symphoricarpos occidentalis*), and winterfat (*Krascheninnikovia lanata*). Small groves of aspen (*Populus tremuloides*) and Utah juniper (*Juniperus osteosperma*) are present. Willow (*Salix* spp.) are rare in riparian areas, which are dominated by Kentucky bluegrass (*Poa pratensis*) and Nebraska sedge (*Carex nebrascensis*). Perennial upland grasses present include bluebunch wheatgrass (*Pseudoroegneria spicata*), Indian ricegrass (*Achnatherum hymenoides*), western wheatgrass (*Pascopyrum smithii*), and Sandberg's bluegrass (*Poa sandbergii*). Broad-leaved flowering plants include buckwheat (*Eriogonum* spp.), spiny phlox (*Phlox hoodii)*, and yarrow (*Achillea millefolium*). Some areas on south-facing slopes are invaded by cheatgrass (*Bromus tectorum*). Noxious weeds such as Canada thistle (*Cirsium arvense*), black henbane (*Hyoscyamus niger*), hounds tongue (*Cynoglossum officinale*), and others are also present.[1]

Eight range sites are included on the allotment, including mountain loam, semidesert loam, semidesert stony loam, upland loam, upland shallow loam, upland shallow loam (juniper), upland stony loam, and woodland (aspen). These are dominated by soils with high or very high erosion hazard.[10] Riparian areas are not described in the soil survey but are associated with the springs and streams. Many stream reaches have become incised and have lost access to their historical floodplains. Some springs have ceased flowing.

Livestock, including cattle, sheep, and horses, have grazed the Duck Creek allotment since settlement of the area in the 1800s. Currently, six individual permits allow 400 cow/calf pairs, 14 horses, and 765 ewe/lamb pairs to graze on BLM-managed lands, with an additional 241 cattle and 305 sheep (ewe/lamb pairs) allowed to graze under exchange of use with private- and state-managed lands within the allotment boundary. The grazing season for cattle is May 10 through September 7. Sheep graze under two permits: during spring, from May 10 to July 1 and in fall, from September 20 until December 1. Total animal unit months (AUMs) under Active Use are 2,134 with an additional 1,176 allowed under Exchange of Use, for a total permitted use of 3,310 AUMs. The deferred rotation schedule is shown in Table 1 and the pasture arrangement in Figure 1. After 4 years, the rotation is repeated. Table 2 provides a summary of BLM billing records that provide numbers of each class of livestock and AUMs for each year.[1]

Structural range facilities include the allotment boundary fence and two internal pasture fences that divided the allotment into four pastures in 2009. Prior to that time, the allotment lacked internal pasture fences. Water developments on BLM lands prior to the installation of the new troughs included 14 troughs, 11 spring developments, and six excavated ponds.[1] During the study, upland ponds were dry, while existing water troughs were in valley bottoms adjacent to their source springs. As a result, the upland plateau above the valleys lacked water during the grazing season prior to installation of the new troughs and pipeline in 2009. Salt is placed along roads in the uplands on this plateau.

Data Collection

Greenline Stubble Height

Stubble height of Nebraska sedge was measured along the greenline of three perennial stream reaches to assess compliance with a 12.7-cm BLM resource management objective incorporated into the 2007 decision. Heights were measured on both sides of the stream at approximately 1-m intervals extending for 30 m up- and downstream from riparian utilization cages.[13]

Bank Alteration

The Multiple Indicators Method was used for collecting bank alteration data along both sides of three stream reaches.[14] Bank alteration is the displacement of the soil from livestock trampling (hoof prints). It is measured using a marked frame at approximately 2-m intervals along each side of the stream. The

Table 1. Grazing rotation for cattle and sheep

	Pasture 1	Pasture 2	Pasture 3	Pasture 4
Year 1	First	Second	Third	Fourth
Year 2	Fourth	First	Second	Third
Year 3	Third	Fourth	First	Second
Year 4	Second	Third	Fourth	First

Table 2. Summary of annual livestock use

Year	Number Cattle	Number Sheep	Total AUMs	BLM AUMs
2006	544	1,070	2,887	1,798
2007	655	1,070	3,319	2,142
2008	655	1,070	3,319	2,142
2009	655	1,070	3,319	2,142
2010	655	1,070	3,270	2,142
2011	604	1,070	3,067	1,939
2012	655	1,070	3,473	2,142
2013	655	1,070	3,270	2,142

frame is equally divided into five marked segments, and displacement or alteration of the bank from trampling hooves is recorded based on the number of these marked segments in contact with hoof prints (hits). Steel rebar markers were placed at each end of the 110-m long stream sections.

Residual Plant Measures

Upland herbaceous vegetation residual biomass (air dry) was measured at 12 locations. These locations were typically in Wyoming big sagebrush ecological sites. An adaptation of the paired plot method was used.[13] Wire mesh cages with welded steel frames (1.2 m^2) were placed in upland locations prior to the start of livestock grazing. These cages excluded herbivory by rabbits and larger animals. Sampling sites were chosen to represent soil map units that covered a majority of the allotment, key range sites identified by BLM, and Utah Division of Wildlife Resources wildlife survey sites. At each location, a sample frame (0.8 m^2) was used inside the cage footprint and on the 10 grazed locations. The frames in grazed areas were placed at 15.2 and 30.5 m along five transects with headings of 72 degrees apart radiating outward from the cage. All herbaceous species in each sample plot were collected and separated into forbs and grasses to avoid the uncertainty of collecting only certain forage species that may be difficult to identify when grazed and may not be representative of the community as a whole. Cages were moved to a new location following sampling.

Riparian herbaceous vegetation was also sampled. Initially, a single cage was placed at each of the three riparian sample locations. These were the same design as the upland cages; however, livestock damage necessitated using a stronger design constructed of welded wire panels beginning in 2007. Two cages were installed at each location to prevent loss of data in the event one cage was damaged. These cages were 0.9 m^2 and excluded rabbits and larger animals. A 0.8 m^2 sample frame was used for plots inside the utilization cages and in two plots 15.2 and 30.5 m upstream and downstream from the cages for four grazed plots at each of three locations.

Sampling was conducted after the end of the cattle grazing period, typically in late September or early October and to account for any regrowth. It did not capture fall use by domestic sheep, which graze from September into December. Samples, including forbs and grasses, were clipped with scissors to approximately 2 cm, or just above the root crown, then placed in plastic bags, transported to the lab, and air dried. Typically, this required only

Figure 3. Measuring bank alteration and stubble height.

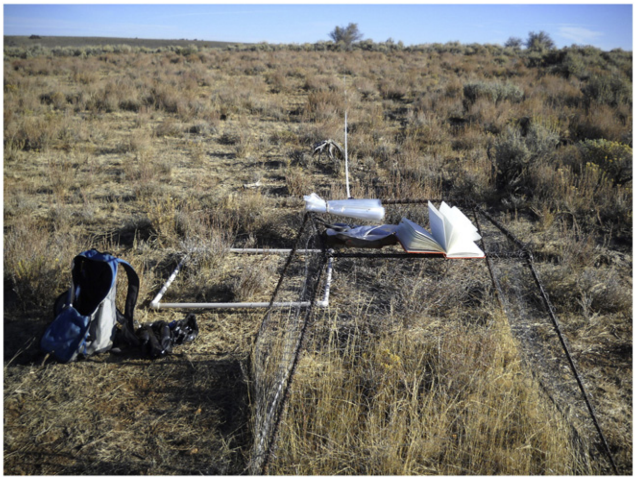

Figure 4. Upland residual sampling.

Figure 5. Riparian residual sampling.

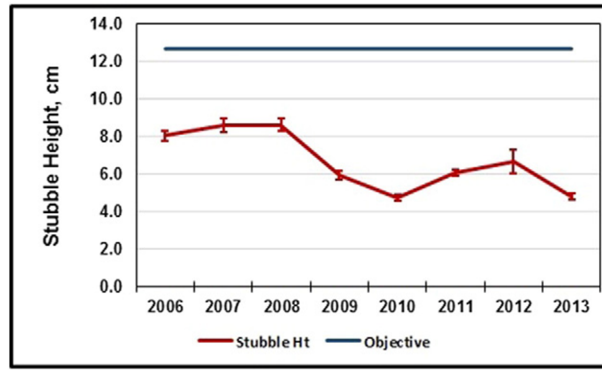

Figure 6. Riparian greenline stubble height, Nebraska sedge.

opening the bag for upland samples, which were already dry or nearly so when clipped. Larger riparian samples were placed in paper bags to dry, while smaller samples could be dried in the open plastic bags. Samples were then weighed on an electronic balance to the nearest 0.1 g. Due to the difficulty of separating forbs and grasses in the dense growth and our observations that cattle consume them together in riparian areas, we based the analysis for riparian areas on the combined grasses and forbs, which we designated as herbaceous vegetation. Figures 3, 4, and 5 are photographs taken during monitoring following the grazing season (September) and in years following implementation of the upland water and deferred rotation system. These illustrate the general topography and post-grazing conditions.

Data Analysis

Data for each parameter were pooled by year and analyzed with Microsoft Excel (2013). To compare the means of habitat measurements in the pre- and post-grazing system implementation periods, we aggregated the observations across all years and performed a version of Student's *t* tests that pools variance estimates to account for unequal sample sizes and variances between two populations.[15]

Results

Riparian Greenline Stubble Height

To determine whether the new grazing system had an impact on the residual greenline stubble height in riparian zones, we examined the mean stubble heights of samples taken in the years before and after the new grazing system was implemented. Mean stubble heights on Nebraska sedge ranged from 8.6 to 4.7 cm, compared with BLM's objective of 12.7 cm. Stubble heights were significantly greater in the pre-implementation period as compared with the post-implementation period (Table 3, Fig. 6).

Bank Alteration

We followed a similar path of analysis to determine whether the new grazing system had an impact on stream bank alteration by examining hoof print counts on the banks pre- and post-implementation. Bank alteration remained nearly constant across all years at 4.0 to 4.1 hits (80%-82%). There was no significant difference in bank alteration between the pre- and post-implementation periods. BLM has no standard for annual bank alteration but uses it as part of the Multiple Indicator Monitoring method for assessing long-term changes. All measures greatly exceeded levels (15%-20%) known to restore streambanks and channel width[16] (Table 3, Fig. 7).

Table 3. Results of *t* tests: 2-tailed, unpaired, unequal variance

	2006–2009			2010–2013			*t* test	
	N	Mean	Std. Dev.	N	Mean	Std. Dev.	d.f.	*P* value
Upland residuals	470	74.0	58.6	450	45.4	33.1	747	<0.0001
Riparian residuals	58	125.3	98.3	49	144.5	199.3	67	0.54
Stubble height	366	7.5	3.1	606	5.6	3.9	893	<0.0001
Bank alteration	239	4.1	0.9	950	4.0	1.2	468	0.80

d.f., degrees of freedom; Std. Dev., standard deviation.

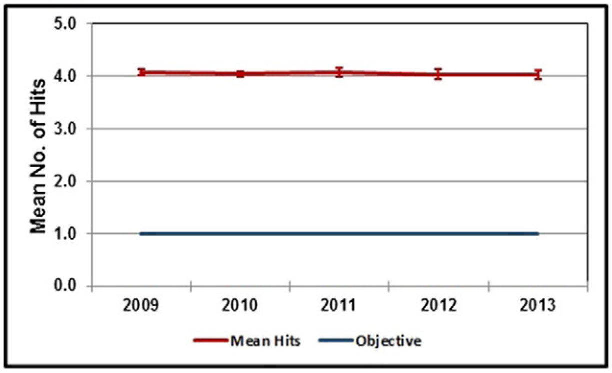

Figure 7. Riparian bank alteration.

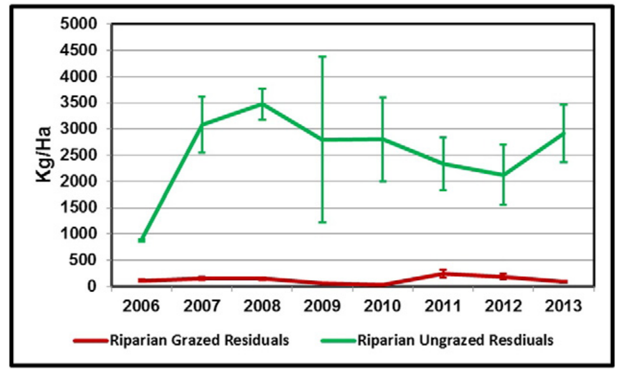

Figure 9. Riparian grazed and ungrazed residual herbaceous vegetation.

Upland Residual Grasses

We were interested in whether the new grazing system and upland water resulted in a measurable change of use in the upland plant communities. Grasses are the preferred forage component, so we used the residual grasses remaining after the grazing season as the parameter to test. Over the 8 years of data, grass residual amounts varied between 32.0 and 90.7 kg/ha for grazed plots and 141.2 to 264.1 kg/ha for ungrazed plots. When the pre-implementation data were pooled for comparison with the post-implementation data, a significant difference was found with post-implementation grazed residuals being significantly less than pre-implementation residuals (Table 3, Fig. 8).

Riparian Residual Herbaceous Vegetation

Grazed riparian herbaceous vegetation ranged between 22.9 and 241.3 kg/ha, while ungrazed riparian herbaceous vegetation ranged between 882.6 and 3478.5 kg/ha over the 8 years. When the pre-implementation data were pooled for comparison with the post-implementation data, no significant difference was found (Table 3, Fig. 9).

Utilization

Grazed and ungrazed upland and riparian residuals were used to determine utilization. Upland utilization ranged from 58.3% to 81.4%, while riparian utilization ranged from 86.4% to 99.2% (Table 3, Fig. 10). BLM objectives were not to exceed 50% utilization in upland and riparian areas.[1] This level was exceeded throughout the study period for both upland and riparian areas.

Discussion

The measures of riparian stubble height, bank alteration, upland residual grasses, riparian residual herbaceous vegetation, and utilization bear out the research over the past few decades showing that rotational grazing systems cannot overcome the effects of overstocking in arid or semi-arid systems such as the Duck Creek allotment. Upland water developments and supplements do not overcome the propensity of cattle to linger in riparian areas, resulting in overgrazing and stream damage, and therefore do not lead to recovery of these damaged systems.

Riparian greenline stubble height never met the objective of 12.7 cm. This was the case prior to implementation of the upland water and deferred rotation system, as well as after its implementation. Post-implementation stubble height was significantly less than pre-implementation levels, likely as a result of concentrating all the animals in one pasture of the allotment without herding them away from riparian areas. Agency research shows that at least 15.2 cm of residual herbaceous plant growth at the end of the grazing season typifies riparian areas in excellent, good, or rapidly improving condition. This corresponds to utilization of 24% to 32% in the riparian area.[17] That research concluded that the grazing system is not of dominant importance, but control of use in riparian areas is critical.

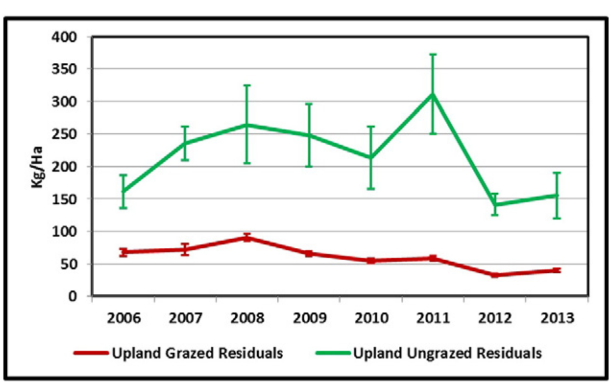

Figure 8. Upland grazed and ungrazed residual grasses.

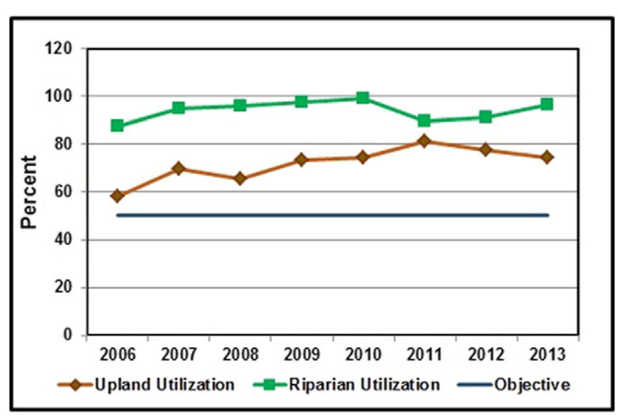

Figure 10. Upland and riparian utilization.

Stream bank alteration was 80% or greater in both pre- and post-implementation periods. Essentially, all available stream banks were trampled each season. This is similar to the levels found prior to implementing bank alteration measures as requirements in the Beaverhead National Forest (NF).[16] Their study found that even when the utilization (45%) and stubble height (10 cm) requirements were met in a majority of situations, bank alteration was not. The only streams showing improvement in width-depth ratios were those in which levels below 20% were achieved by using riders to herd cattle away from the riparian zone. These levels resulted in decreases in channel width of approximately 50% in less than a decade.

Upland residual grass biomass measurements showed that significantly less remained in uplands after implementation of the upland water and grazing system. This was reflected in an increase in utilization in uplands, up to 81.4% post-implementation. While the utilization objective for the Duck Creek allotment is 50%, this was exceeded in all years. In degraded arid or semi-arid systems such as this, utilization of 25% to 30% by livestock is recommended.[11,18] Rest is an indispensable factor as well, because many native species such as bluebunch wheatgrass and Idaho fescue require sufficient rest to recover vigor and productivity following grazing. In the absence of adequate rest, these species may be lost. In degraded states, the amount of rest required can be several years.[19,20] The deferment system does not provide that time. Riparian herbaceous residuals were not significantly different pre- and post-implementation, and riparian utilization remained between 80% and 90% during the entire 8 years, far exceeding BLM's 50% objective.

Conclusion and Recommendations

Overstocking and lack of adequate science-based standards, quantitative monitoring, and enforcement result in overuse and degraded conditions in the Duck Creek allotment. Sensitive native bunchgrasses are being replaced with increasers and annual forbs. High amounts of erodible bare soil are subject to accelerated erosion, stream channels are incised, and willows are lost. Implementation of the upland water and deferred rotation grazing system demonstrably failed to reduce riparian use by livestock while further increasing upland utilization rates. Restoring the degraded conditions and sustaining native plant species will require a change in management, including

- setting stocking rates based on current levels of preferred forage species and current forage consumption rates of livestock
- enforcing sustainable utilization rates of less than 30% in both upland and riparian areas
- enforcing riparian stubble heights of greater than 15.2 cm, applicable to the entire aquatic influence zone and floodplain
- enforcing bank alteration levels of less than 20%
- providing adequate rest based on the needs of the preferred native grasses and forbs, typically multiple years following each grazing period
- using riders to disperse cattle away from riparian areas

References

1. Bureau of Land Management, 2007. Environmental Assessment UT-020-2007-003. Duck Creek Allotment. Salt Lake Field Office, Bureau of Land Management.
2. Holechek, J., H. Gomes, F. Molinar, and D. Galt. 1998. Grazing intensity: Critique and approach. *Rangelands* 20:15-18.
3. Holechek, J., H. Gomez, F. Molinar, and D. Galt. 1999. Grazing studies: What we've learned. *Rangelands* 21:12-16.
4. Briske, D., J. Deerner, J. Brown, S. Fuhlendorf, W. Teague, K. Havstad, R. Gillen, A. Ash, and W. Wilms. 2012. Rotational grazing on rangelands: Reconciliation of perception and experimental evidence. *Rangeland Ecology and Management* 61:3-17.
5. Pinchak, W., M. Smith, R. Hart, and J. Waggoner. 1991. Beef cattle distribution patterns on foothill range. *Journal of Range Management* 44:267-275.
6. Gillen, R., W. Krueger, and R. Miller. 1984. Cattle distribution on mountain rangeland in northeastern Oregon. *Journal of Range Management* 37:549-553.
7. Gillen, R., W. Krueger, and R. Miller. 1985. Cattle use of riparian meadows in the Blue Mountains of Northeastern Oregon. *Journal of Range Management* 38:205-209.
8. Bryant, L. 1982. Response of livestock to riparian zone exclusion. *Journal of Range Management* 35:780-785.
9. McInnis, M., and J. McIver. 2001. Influence of off-stream supplements on streambanks of riparian pastures. *Journal of Range Management* 54:648-652.
10. USDA, 1982. Soil Survey of Rich County, Utah.
11. Holechek, J., R. Pieper, and C. Herbel. 2004. Range management: Principles and practices. 5th ed. New Jersey, USA: Upper Saddle River.
12. Western Regional Climate Center, Randolph Coop Station 472165. Available at: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ut7165 Accessed 12 January 2017.
13. Bureau of Land Management, 1996. Utilization Studies and Residual Measurements. Interagency Technical Reference. TR 1734-3.
14. Burton, T., S. Smith, and E. Cowley. 2008. Monitoring streambanks and riparian vegetation – multiple indicators. Version 5.0. Boise, ID, USA: U.S. Department of Interior, Bureau of Land Management, Idaho State Office.
15. McDonald, J. 2008. Handbook of biological statistics. Baltimore, MD, USA: Sparky House Publishing.
16. Bengeyfield, P. 2006. Managing streams with cows in mind. *Rangelands* 28:1-6.
17. Clary, W., and B. Webster. 1989. Managing grazing of riparian areas in the intermountain region. USDA Forest Service. GTR-INT-263.
18. Galt, D., F. Molinar, J. Navarro, J. Joseph, and J. Holechek. 2000. Grazing capacity and stocking rate. *Rangelands* 22:7-11.
19. Mueggler, W. 1975. Rate and pattern of vigor recovery in Idaho fescue and Bluebunch wheatgrass. *Journal of Range Management* 28:198-204.
20. Hormay, A., and M. Talbot. 1961. Rest-rotation grazing – A new management system for perennial bunchgrass ranges. USDA Forest Service Production. Research Report No. 51.

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