Rangeland Ecology & Management 73 (2020) 224–226

Contents lists available at ScienceDirect

Rangeland Ecology & Management

journal homepage: http://www.elsevier.com/locate/rama

Animal Track Accumulation on Streambanks of Four Eastern Oregon Streams

Larry L. Larson [a,*], P.A. Larson [b]

[a] Retired Professor, Department of Animal & Rangeland Sciences, Oregon State University, Corvallis, OR 97331, USA
[b] Natural Resource Specialist, Oregon Cattlemen Association, Salem, OR 97301, USA

ARTICLE INFO

Article history:
Received 12 July 2019
Received in revised form 18 November 2019
Accepted 22 November 2019

Key Words:
bank alteration
riparian
sequential
systematic
tracks

ABSTRACT

A 2-yr study of livestock/wildlife tracking was conducted on four streams in eastern Oregon. Binomial sampling of tracks proved to be an effective statistical method for monitoring the proportion of samples containing tracks on stream greenlines and testing the observed value against an established standard. Study results indicate that tracks are related to variables outside of the control of livestock grazing management.

Introduction

Livestock trampling on a streambank is thought to break down banks (streambank alteration) to the extent that soil is displaced, allowing harmful particles to move into the stream channel, settle in the substrate, and in some circumstances smother fish eggs through oxygen deprivation (Bjorn and Reisner 1991). Streambank alteration has been identified if the hoof of an ungulate left an imprint 13 mm deep or the print within the plot sheared or trampled the bank or terrace wall (Burton et al. 2011). Streambank alteration has been identified as a "take" on endangered species critical habitat streams. A range of 15–35% fine sediment (Bryce et al. 2008) has been recommended in streambed composition coupled with a limitation on wildlife and livestock streambank alteration set at 20% (Bengeyfield 2006).

Trampling impacts from wildlife and livestock before, during, and after a grazing season require frequent site inspections to avoid an Endangered Species Act (USDC National Marine Fisheries Service 1998) "take" due to the accumulation of wildlife and livestock streambank alteration. In addition, managers need reliable information to make decisions on the basis of a point-in-time evaluation when the result is near a management standard or threshold (Turner and Clary 2001; Heitke et al. 2008).

Confidence in point-in-time evaluations requires random selection of sampling units to ensure each plot location is independent of the other plots (Schumacher and Chapman 1948; Steele and Torrie 1980). Turner and Clary (2001) investigated a binomial sampling procedure for stubble height monitoring. They found it provided statistically defensible answers in a short amount of time and was a theoretically sound method to make accurate and objective decisions of whether an area is above or below a standard using simple yes-no answers at each observation. They suggested their binomial sampling would also be applicable for estimates of trampling on streambanks where standards have been established for riparian management.

The objective of this study was to use binomial sampling to evaluate the amount and timing of wildlife and livestock tracking on the near stream greenline of monitoring sites established by the US Forest Service. Data sets were analyzed to address the following questions: Did the amount of tracking exceed the bank alteration standard? Did the amount of tracking observed before livestock grazing occurred change between years? Did the tracking change during the period of livestock grazing?

Materials and Methods

Study Area

The study areas were located in eastern Oregon in the John Day and Blue Mountain Ecological Provinces of eastern Oregon (Anderson et al. 1998). The provinces encompass a number of ecological sites and in practice can be described in terms of vegetation differences caused by local geology, geomorphology, and climate. The riparian areas surveyed occurred as narrow,

* Correspondence: Larry L. Larson, 61931 Cottonwood Rd, La Grande, OR 97850, USA.
E-mail addresses: lllarson@eoni.com, ranchfun@eoni.com (L.L. Larson).

https://doi.org/10.1016/j.rama.2019.11.007

interrupted bands of vegetation along geologically constrained tributary streams with channel widths of 1–4 m and channel substrates consisting of cobbles, gravels, and smaller fragmented materials. Riparian areas within the mountainous regions of eastern Oregon often form a narrow interface that is 1–2 m wide between aquatic and terrestrial ecosystems (Table 1).

The annual average precipitation of the Blue Mountain Province is 57 cm (22.4 in), and the John Day Province is 39 cm (15.4 in). Approximately 28–32% of the annual precipitation falls between April and July during the active growing season. The streams and riparian areas in the study are in the Wallowa Whitman National Forest in Union (45.324′N, 118.087′W) and Baker County (44.774′N, 117.834′W) and the Malheur National Forests in Grant County (44.415′N, 118.953′W) in mixed conifer and Ponderosa pine (*Pinus ponderosa* Dougl.) forests. The livestock grazing that occurs in the allotments is managed to protect the habitat for wildlife and listed endangered fish species. The livestock grazed allotments supported herd sizes of 300–400 cow-calf pairs using a rest-rotation pasture management with pasture grazing periods of 35–40 d.

Methods

The study was conducted over a 2-yr period in four different livestock grazing units. Sites 1, 2, and 4 were grazed by livestock and wildlife for the 2-yr period. Site 3 was only grazed by wildlife. The study was located at permanent US Forest Service monitoring sites that had an established bank alteration standard of 20%. Sampling occurred along the stream greenline (Winward 2000) until the required number of samples was achieved and was not restricted to established US Forest Service transects.

Sampling was conducted annually to assess the amount, when and where tracking was occurring. Data collection occurred before livestock grazing (i.e., early June) and after livestock were removed (i.e., late September). Within each collection period, data sets from randomly (random number generation of each pace distance) located plots (0.1 m^2) were collected 0–0.3 m (near) and 0.3–0.6 m (far) from the bankfull stream edge.

Within riparian areas, the impact of livestock and wildlife bank alteration are entangled and typical monitoring protocols lack the rigor to distinguish between ungulate impacts. To address this issue, sampling objectives and methodologies were partitioned to conduct sampling before livestock use and after livestock were rotated out of the units. While not a perfect partitioning, this approach separated periods of dominant livestock and dominant wildlife use.

The amount of bank alteration from wildlife and livestock tracking was assessed in the field using a sequential sampling procedure (Wald 1947; Dixon and Massey 1957; Turner and Clary 2001) to determine when an adequate number of samples had been collected and if the accumulated bank alteration exceeded the bank alteration standard of 20%. The term *sequential sampling* describes any method of sampling that reads an ordered frame of N sampling units and selects the sample with specified probabilities or specified expectations. Data for the assessment was accumulated in sets of 25 randomly selected plots. At the conclusion of 50 accumulated plots, a bank alteration decision was made to determine if the accumulation of tracks exceeded the 20% bank alteration standard.

Table 1
Summary of study sites monitored at four different livestock grazing units.

Site	Elevation (m)	Rosgen (1996) classification	Forest type
1	1 249	B3	Mixed conifer
2	1 341	B3	Mixed conifer
3	1 453	B3	Ponderosa pine
4	1 260	B3	Ponderosa pine

The standard was exceeded (sample adequacy confidence of 95%) if more than 12 plots were observed in a 50-plot data set.

Chi-square tests ($P \leq 0.05$) were performed to determine differences that occurred between early (early June before livestock grazing) and late (late September after the grazing) sampling periods, years, and distance (0–0.3 m [near] and 0.3–0.6 m [far]) from the bankfull stream edge. The purpose of the analyses was to provide an assessment of changes in the overall occurrence of tracks within the riparian area and their location within the near-stream landscape. Data sets for each sampling period contained fifty 0.1-m^2 plots.

Results and Conclusions

Johnson et al. (2016) conducted a 5-yr study tracking Global Positioning System (5-min recording interval) collared cows across four allotments in northeastern Oregon for 5 yr. They observed livestock presence in riparian areas varied substantially with somewhat frequent use occurring on some perennial streams and little or no use occurring on others. Overall, cattle occupancy within 30 m and 60 m of streams was 1–2% and 1–4% respectively ($n =$ 3.75 million points over 5 yr). They also observed livestock had preferred access points along streams and found that large percentages (75–95%) of the length of streams had minimal (< 2 hr/yr) occupancy by livestock. In other words, stream access and occupancy by livestock were selective, being influenced by multiple factors such as obstacles (topography, shrubs and brush, steep banks); trailing patterns; and off-site water. Furthermore, established pathways from favorite grazing areas to streams, roadways, and jeep trails that parallel streams affected cattle travel routes within the allotments and influenced where cattle could water along the stream. These observations indicate that track patterns are nonrandom and that their measurement will reflect seasonal ungulate activity and landscape attributes that occur along streambanks.

Streambank Alteration Pattern

Binomial sampling of bank alteration (data not shown) along the lineal length of the stream identified variable alteration. Sites 1 and 2 had open low terrace meadow environments, unimpeded animal access, and minimal animal concentration. Sites 1 and 2 had only one exceedance of the bank alteration standard during the study. Sites 3 and 4 contained scattered shrub colonies and terrace heights, which tended to concentrate animal access to specific areas. Bank alteration was exceeded two times on Sites 3 and 4. In each case the exceedance occurred before livestock access and was sustained through the period of livestock grazing.

Streambank Impact Accumulation Before Livestock Grazing

The accumulation of streambank impacts before the livestock grazing season showed that tracking by wildlife increased on sites 3 and 4 in the second yr of the study (Table 2). The difference between sites 1 and 2 verses 3 and 4 was likely associated with an extended period of high water on the floodplains of all sites in yr 1. The impact of that event delayed wildlife access to the near-stream location on all sites. Sites 1 and 2 are open low terrace meadow environments in which ungulates seeking water have unimpeded access. As a result, the access restriction imposed by high water would have limited impact on areas of concentrated animal access. By contrast, sites 3 and 4 contained a landscape dominated by shrub colonies and variable terrace heights, which concentrate animal access and alterations. In that landscape, decreasing the amount of time when animals access wetted streambank soils in yr 2 decreased the bank alterations.

Table 2
Track accumulation before livestock grazing season in yr 1 and 2.

Site	Distance (m)	Yr 1	Yr 2	Significance
1	0.0-0.3	7	11	Ns[1]
	0.6-0.6	5	4	Ns
2	0.0-0.3	2	2	Ns
	0.6-0.6	1	2	Ns
3	0.0-0.3	4	22	[2]
	0.6-0.6	3	10	[2]
4	0.0-0.3	5	15	[2]
	0.6-0.6	3	10	[2]

[1] Ns, nonsignificant.
[2] $P \leq 0.05$.

Streambank Impact Accumulation During Livestock Grazing

Track observations in this study were restricted to the area contained within 0.6 m of the stream channel. Table 3 displays the bank alteration during the grazing season at distances 0–0.3 m and 0.3–0.6 m from the streambank in each year. The pattern of animal tracks that accumulated during the livestock grazing season was variable. Accumulation of bank alteration in the 0–0.3 and the 0.3–0.6 near-stream locations was similar in pregrazing and postgrazing seasons on most sites and showed a minimal increase in track occurrence during the grazing season. The exception to that statement occurred in the open landscape of site 2 in both yr, where an increase in track occurrence was observed during the grazing season in both streambank locations. Site 3 also showed an increase in track occurrence during yr 1 at the 0.3–0.6 location. Because Site 3 was closed to livestock grazing, the increase was solely attributed to wildlife.

Considerations for Management

The site-specific nonrandom nature of bank alterations on riparian areas requires clearly stated objectives and a random sampling strategy. Sampling must occur across a sufficiently large sampling area to take into account site characteristics that influence ungulate access. In addition, hoofed wildlife access to saturated riparian soils had a direct impact on the accumulation of tracks. This was particularly obvious on site 3 (no livestock grazing), where all tracks could be assigned to wildlife activities because cattle were excluded from the allotment during the 2-yr study.

In this study we monitored the occurrence of tracks to estimate the proportion of streambank containing tracks. We did not observe erosional patterns that suggested a direct link between bank alteration occurrence and increased streambank erosion during the study. Past literature has suggested that bank alteration is related to increased substrate fines in streams (Bjorn and Reisner 1991; Platts 1991). However, subsequent research has not demonstrated a direct link between animal hoof prints and fine sediments within streams. Lucas et al. (2009) in a grazing study did not find significant changes to channel widths or large erosion of streambanks. They concluded many smaller-scale changes were part of the normal geomorphological adjustments made by streambanks and did not contribute to lasting streambank morphological change. Similarly, a 3-yr study conducted on cool-season grass pastures by Bear et al. (2012) compared livestock stocking rates with erosion but attributed runoff and streambank erosion to natural climate events.

Table 3
Track accumulation during the livestock grazing season in yr 1 and 2.

Site	Distance (m)	Livestock season 1			Livestock season 2		
		Pre	Post	Significance	Pre	Post	Significance
1	0.0-0.3[1]	7	6	Ns[1]	11	13	Ns
	0.3-0.6[1]	6	9	Ns	4	7	Ns
2	0.0-0.3	2	6	[2]	2	8	[2]
	0.3-0.6[2]	1	8	[2]	2	6	[2]
3	0.0-0.3	4	7	Ns	22	18	Ns
	0.3-0.6	3	9	[2]	10	9	Ns
4	0.0-0.3	5	3	Ns	15	15	Ns
	0.3-0.6	3	5	Ns	10	5	Ns

[1] Ns, nonsignificant.
[2] $P \leq 0.05$.

Summary and Conclusions

It may seem plausible that tracks on the stream greenline impact streambank erosion, but the tracking patterns observed in this study suggest that the concentration of tracks is site specific and can be influenced by a number of variables outside the control of livestock grazing management. For the measurement of streambank alteration to be meaningful to livestock management, the monitoring objective must be clear and the sampling strategy must reflect both the objective and limitations imposed by site conditions on ungulate access and track formation.

In this study random sampling provided a statistically valid method of establishing whether a threshold bank alteration standard had been achieved. Random selection of each plot location allowed for dispersion of samples in the study area and encouraged the sampling of a sufficiently large area to take into account site characteristics that influence ungulate access. Credible data is critical for effective communication between the agencies and livestock grazers. More research is needed to establish a clear definition of alteration and to fully understand the relationship between hoof prints and streambank alteration.

References

Anderson, E.W., Borman, M.M., Krueger, W.C., 1998. Ecological provinces of Oregon. SR 990. Oregon Agriculture Experiment Station, Corvallis, OR, USA.
Bear, D.A., Russell, J.R., Tufekcioglu, M., Isenhart, T.M., Morrical, D.G., Kovar, J.L., 2012. Stocking rate and riparian vegetation effects on physical characteristics of riparian zones of Midwestern pastures. Rangeland Ecology & Management 65, 119–128.
Bengeyfield, P., 2006. Managing cows with streams in mind. Rangelands 26, 3–6.
Bjornn, T.C., Reiser, D.W., 1991. Habitat requirements of salmonids in streams. In: Meehan, W.R. (Ed.), Influences of forest and rangeland management on salmonid fishes and their habitats. Special Publication 19. American Fisheries Society, Bethesda, Maryland, USA, pp. 83–138.
Bryce, S., Lomnicky, G., Kaufmann, P., McAllister, L., Ernst, T., 2008. Development of biologically based sediment criteria in mountain streams of the western United States. North American Journal of Fisheries Management 28, 1714–1724.
Burton, T.A., Smith, S.J., Cowley, E.R., 2011. Riparian area management. Multiple indicator monitoring (MIM) of stream channels and streamside vegetation. Technical Reference 1737-23. BLM/OC/ST-10/003 = 1737. US Department of the Interior, Bureau of Land Management, National Operations Center, Denver, CO, USA, p. 155.
Dixon, W.J., Massey, F.J., 1957. Introduction to statistical analysis. McGraw-Hill, New York, NY, USA, p. 488.
Heitke, J.D., Henderson, R.C., Roper, B.B., Archer, E.K., 2008. Evaluating livestock grazing use with streambank alteration protocols; challenges and solutions. Rangeland Management & Ecology 61, 647–655.
Johnson, D.E., Larson, L.L., Wilson, K.D., Clark, P.E., Williams, J., Louhaichi, M., 2016. Cattle use of perennial streams and associated riparian areas on a northeastern Oregon landscape. Journal of Soil and Water Conservation 71 (16), 484–493.
Lucas, R.W., Baker, T.T., Wood, M.K., Allison, C.D., VanLeeuwen, D.M., 2009. Streambank morphology and cattle grazing in two montane riparian areas in western New Mexico. Journal of Soil and Water Conservation 64 (3), 183–189.
Platts, W.S., 1991. Livestock grazing. In: Meehan, W.S. (Ed.), Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society, Bethesda, MD, USA, pp. 389–424.
Schumacher, F.S., Chapman, R.A., 1948. Sampling methods in forestry and range management. Duke University, Durham, NC, USA, p. 222.
Rosgen, D., 1996. Applied river morphology. Wildland Hydrology Books, Pagosa Springs, CO, USA, p. 350.
Turner, D.L., Clary, W.P., 2001. Sequential sampling protocol for monitoring pasture utilization using stubble height criteria. Journal of Range Management 54, 132–137.
Steele, R.G.D., Torrie, J.H., 1980. Principles and procedures of statistics. McGraw-Hill, New York, NY, USA, p. 633.
Wald, A., 1947. Sequential analysis. Wiley, New York, NY, USA, p. 212.
Winward, A. 2000. Monitoring the vegetation resources in riparian areas. USDA FS Gen. Tech. Rep. RMRS-GTR-47.