History of Rangeland Research on Catherine Creek

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Oregon State University acquired the Hall Ranch in 1941 and has maintained it as a forested rangeland research center since. The early studies on the Hall Ranch included classification of the soils and vegetation and mapping range use patterns of the University cattle herd. Forest grazing integrated with forest harvest practices was the early rangeland research focus of the station. The meadow associated with Catherine Creek was grazed heavily season long. Range surveys in the 1960's consistently indicated utilization was very heavy and range condition was poor. Some attempts were made to improve the forage production mostly through fencing and mechanical control of hawthorne (*Cratagus douglasii*) in 1958 and again in 1974 and 1975. Even though condition was poor the productivity of the forage in the meadow was much higher per acre than any of the upland sites. In 1971 Dr. Martin Vavra began working at the Eastern Oregon Experiment Station. In the middle 1970's, he collaborated with Dr. Ralph Phillips in a study of nutrition and production of cows and calves on the upland pastures and the meadow in pasture C, which is the riparian pasture dissected by Catherine Creek. In those studies, they discovered that grazing the meadow (riparian zone) in late fall improved cow and calf productivity over leaving them on the uplands as the forage began to mature in mid-August. Cows grazing the Catherine Creek meadow maintained their weight while the cows on the forested uplands were losing weight. At the same time the calves on the meadow gained 1 to 1.5 pounds per day more than calves on the uplands. Consequently, the cows in the meadow went into winter in better condition, and total calf weights were 25 to 40 pounds greater for calves grazing the meadow compared to those grazing the uplands in the late season. The distinct livestock production advantage of late-season grazing in the Catherine Creek meadow precipitated a change in management to using it exclusively in mid-to late August for about three weeks depending on the year and forage availability. We anticipated that this change in management would also improve the range condition of the riparian meadow.

When the change in management was made in 1977, there was no evidence whether there were positive or negative impacts to a variety of environmental aspects that could relate to late season grazing in the riparian zone. So Dr. Vavra and Dr. Bill Krueger developed a research program to evaluate the impacts of the late-season cattle grazing on the soils, vegetation, and wildlife associated with Catherine Creek. In 1978, a series of five exclosures were constructed along Catherine Creek so that approximately half of the stream banks along the 1.6 miles of the creek and the riparian zone within the adjacent 50 yards were excluded from cattle grazing (Figure 1). Since 1977 the grazing program has been maintained with grazing by cows and calves from mid-August to mid-September, usually for three weeks. Duration of grazing has been adjusted based on forage growth each year. Cattle are removed when the stubble height of Kentucky bluegrass (*Poa pratensis)* is at 1 inch. The only deviation from this grazing strategy was in 1992, when the pasture was grazed most of May, and again in early August for about two weeks. The same stubble height criteria was observed in the fall grazing.

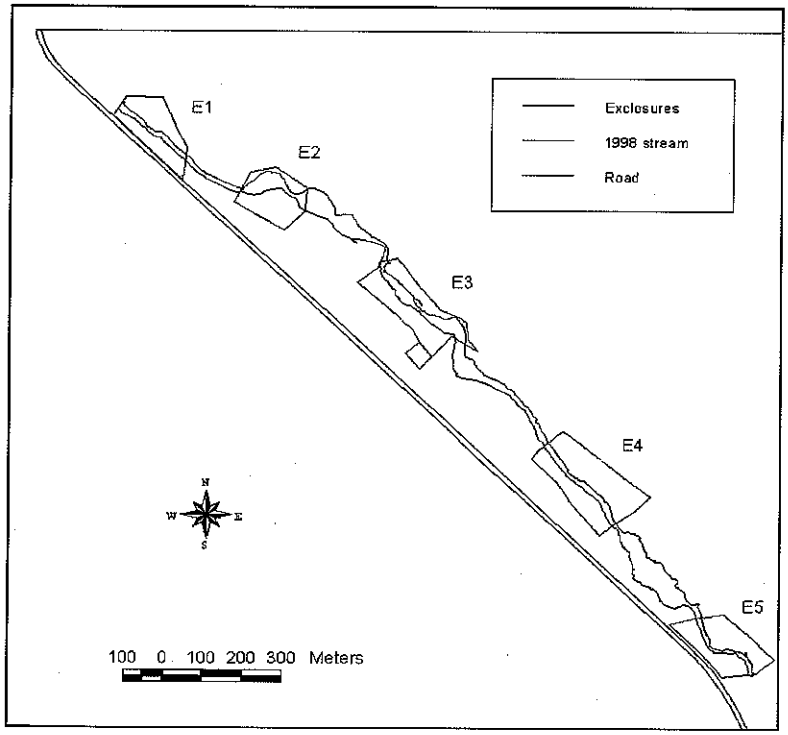

Figure 1. Layout of the study area locating the five exclosures and outline of Catherine Creek in 1998.

Much of the field research on Catherine Creek has been conducted by graduate students, beginning with John Boone Kauffman who finished an MS thesis in 1982 with major professor Dr. Krueger. He was followed by Douglas M. Green, who finished a PhD thesis in 1991 with major professor Dr. Kauffman; Edwin J. Korpela, who finished a PhD thesis in 1992 with major professor Dr. Krueger; Teena Ballard, who finished an MS thesis in 1999 with major professor Dr. Krueger; Mark P. Reynolds, who finished an MS thesis in 1999 with co-major professors Drs. Johnson and Krueger; and Andrea Laliberte, who finished an MS thesis in 2000 with Dr. Johnson as major professor.

The initial studies from 1978 to 1980 were the basis for Kauffman's thesis. The initial survey of the pasture, in a band 50 meters wide along the stream, indicated there were 256 individual stands of plant communities representing 60 discrete plant communities. Twenty species of mammals and 81 species of birds were found in the study area. Ten plant communities representing the range of community types were intensively sampled to contrast changes between areas excluded from cattle grazing and those grazed with the late season grazing strategy. Three of the 10 plant communities studied developed differently in the grazed areas compared to exclosures. There was substantial variability among and within community types. Wet meadows tended to increase the relative abundance of mesic forbs and sedges in the excluded areas compared to grazed areas; drier meadows with hawthorne tended to increase productivity, especially in abundance of Kentucky bluegrass, under exclusion; shrubs were grazed sufficiently on gravel bars to significantly reduce their rate of growth compared to those in exclosures. No differences in productivity were found for the other 7 plant communities studied in detail. Biodiversity was measured with standard indices including richness, species diversity, and equitability. No differences were found in biodiversity between grazed and excluded areas after two seasons of study. We also noted that the most productive meadow types would cycle in productivity between years when they were not grazed because of the heavy mulch left from about 7,000 to 8,000 kg/ha of vegetation residue in the exclosures. The reaction of individual species was dependent on the plant community they were in. For example, Kentucky bluegrass declined in exclosures in wet meadows and increased in exclosures in hawthorne types.

The impact of cattle grazing on short term erosion rates was significant. In 1979, after the first winter, streambanks were protected from cattle grazing in the exclosure. There was more total bank erosion in grazed areas compared to excluded areas during the grazing season. There were no differences in erosion losses based on vegetation types or for position on the meander bends. Over-winter erosion was not different between grazed and ungrazed locations, so erosion losses occurred during the grazing season and did not carry over into winter runoff losses. The experimental design, fencing out half of the streambanks, doubled the number of animal days per length of streambank from 48-50 meters of available streambank/animal unit month to 25-30 meters of available streambank/animal unit month. Grazing the pasture at 48-50 meters of available streambank had few impacts on the vegetation and, we suspected, would have much less impact on the streambank as well. When the status of streambank erosion, morphology, and bank undercuts are important considerations in making management decisions, it may be more useful to measure intensity of use with the numbers of animals per length of streambank rather than density of animals per unit area.

The third aspect studied was difference in abundance of birds and small mammals in exclosures compared to late season grazing by cattle. There were few short-term impacts on birds and a significant decrease in small mammals following the late season grazing. By the year following grazing, the small mammals had fully colonized the grazed areas to yield essentially the same species composition and densities.

In 1987 and 1988 the initial work was followed up by Doug Green to evaluate changes in 8 of the major plant communities under grazing exclusion or grazed with the late season strategy. He found that species diversity was similar after 10 years. Woody vegetation on gravel bars was less under grazing compared to exclusion. Most of the parameters studied did not change differently in grazed or excluded areas, but what did change resulted in more uniformity within the exclosures compared to the grazed areas. It may be that prior to historical introduction of livestock, diversity and species richness was lower than occurs under livestock grazing now. The vegetation in this riparian zone probably requires some level of disturbance to maintain optimum diversity.

This study also had a focus on the underground aspects of plant community ecology, including depth to water table, soil temperatures, and a variety of soil chemical attributes. The soils under *Glyceria* communities were anaerobic with high levels of nitrates. These wetter sites are efficient at denitrification of the soil and may be important to maintaining water quality parameters. The soil chemistry was distinct for each plant community, indicating that the plant soil associations were important in determining what will grow at any particular area.

In 1998, Dr. Douglas Johnson supervised evaluation of the changes over 20 years which was the basis for Andrea Laliberte's MS thesis. This approach used remote sensing and geographic information systems techniques to evaluate changes in the vegetation and morphology of Catherine Creek and to determine if the changes that occurred were a result of cattle grazing, topography, or climate.

Aerial photos from 1979 and 1998 (scale of 1:4000) were geo-referenced with ground control points, and various stream features were digitized using a GIS. Stream length, stream width and areas of change were identified for both years. Although stream length remained the same, stream width decreased in both grazed and exclosed areas (Table 1). The area of change (3.65 ha) was slightly larger than the area of no change (3.2 ha). The number of islands and island perimeter decreased, while the island area increased. Exclosures and grazed areas responded similarly, and it was concluded that the topography and stream dynamics had a greater influence on ecological

change than the grazing regime in this study of 20 years of change in Catherine Creek and the riparian zone associated with the creek.

Table 1. Catherine Creek mean stream widths excluding islands for 1979 and 1998 in exclosures (E) and grazed areas (G). Stream width was measured every 0.5 m.

	1979	1998	Change
	(m)		(%)
E2	18.91	14.36	-24.06
E3	19.43	12.33	-36.54
E4	15.04	12.38	-17.69
E5	20.35	8.65	-57.49
G1	17.30	10.56	-38.96
G2	16.54	13.32	-19.47
G3	15.82	13.68	-13.35
G4	16.83	14.26	-15.27
Mean E	18.67	11.85	-36.54
Mean G	16.62	12.96	-22.06

These three studies of ecological changes over time illustrate the extreme complexity of riparian and stream systems. It is difficult to look at short-term changes and then predict what will happen in the longer term. In every period, the changes that were related to the grazing program were small or there were no differences between grazed and ungrazed study sites. As more time progressed some level of change, especially related to biodiversity, became more obvious. The increased biodiversity after 10 years of late-season grazing compared to exclusion of grazing suggests grazing increases biodiversity. This was the case, but this may not be satisfactory to all management objectives since in some plant communities there was an increase of plant species that tend to be more suited to disturbed areas. In some other areas, there was essentially no difference in vegetation between grazed and excluded sampling units. The response of vegetation and physical attributes of the riparian zone and creek after 20 years seems to be more a function of the weather patterns and natural attributes resulting from the topography. From this, we conclude that Catherine Creek is functioning for producing sustainable levels of production of both cattle and natural products that depend on a properly functioning ecosystem.

In 1984 and 1985 we decided to evaluate the riparian meadow specifically as it related to cattle use and production. This was the basis for Ed Korpela's PhD thesis. Productivity and seasonal trends of the five major plant community types were modeled using correlation and path analysis techniques. Wet meadows produced the greatest amount of biomass followed by moist bluegrass meadows, gravel bars, forests, and dry bluegrass meadows in descending order. Production was related to soil moisture in the dry meadows and depth to the water table in the wetter sites.

Streamflow levels had the greatest influence on production of the gravel bars. Preference for each plant community type was monitored and then modeled to evaluate forage preference, intake, and vegetative and nutritional characteristics of available forage. Relationships among variables were evaluated and the cattle behavior indicated they initially favored plant communities with highly digestible forage, specifically Kentucky bluegrass. Late in the period, in early September, cattle preference was less specific and communities were grazed at random. At the end of the season, daily grazing time declined. Intake was related to digestibility and the amount of time spent grazing but not related to amount of available forage. The key to livestock production on riparian zone at Catherine Creek is highly associated with the distribution and production of Kentucky bluegrass.

We conducted a methods study in 1996 and 1997 to evaluate the use of GIS technology for measurement of shrub utilization. This was the basis of Mark Reynolds' 1999 MS thesis. A point frame, photographs, and a canopy analyzer to evaluate obstruction of light were used to define level of utilization. Black cottonwood (*Populus trichocarpa*) and Douglas hawthorne were artificially defoliated and level of defoliation was determined for each technique. Analysis of photographs was the most reliable, followed by point frame analysis. The canopy analyzer was least reliable of the three techniques. Time invested in the point frame and photographic measurements (about 2 hours) were equivalent while the canopy analyzer was rapid (about 5 minutes). The photographic technique was determined to be the most useful of those tested.

Since chinook salmon (*Oncorhynchus tshawytscha*) spawn in the research area and they are listed as threatened, we decided to evaluate the long-term effects of cattle grazing on the spawning habitat in Catherine Creek and the direct relationships between cattle grazing and salmon behavior. In 1997 Dr. Bob Ellis (Fisheries Biologist) and Drs. Johnson and Harris in the Department of Rangeland Resources collaborated on an extensive study evaluating the long term (19 years) changes in spawning habitat in Catherine Creek and comparing it to conditions in the Little Minam River in the Eagle Cap Wilderness area that has been ungrazed for decades. The physical and biological attributes of both streams are similar.

Stream bank stability was similar between the grazed and exclosed plots after 19 years of application of the late-season grazing program on Catherine Creek (Table 2). Overall, the reference reach in the wilderness had about 20% more stable banks than either the grazed or exclosed areas on Catherine Creek. Vegetation cover and canopy density were not different for the grazed areas compared to the excluded areas on Catherine Creek. The canopy density and cover was significantly higher on both the grazed and ungrazed areas of Catherine Creek when compared to that on the Little Minam River in the wilderness.

Table 2. Percentage of streambank in each of four stability categories for both grazed and excluded areas of Catherine Creek and the Little Minam River.

Treatment	Covered and Stable	Uncovered and Stable	Covered and Unstable	Uncovered and Unstable
Exclosed	71.8	2.3	14.0	11.7
Grazed	61.5	9.7	20.6	8.1
Reference (L. Minam R.)	89.0	5.0	5.9	0.1

Most of the differences that were calculated from total inventories of the study area (i.e. streambank cover, pool quality, pool quantity, and spawning habitat area) were small (Table 3). The major unexpected exception was spawning habitat area, which was much larger in the grazed treatment. Pool frequency was higher in the grazed treatment primarily because grazed plots G-2 and G-4 had relatively long lengths of side channel habitat, where pools occurred more frequently than in the main channel. Most differences between means determined from transect data (i.e., width/depth ratio, mean bankfull channel width, mean low flow channel width, and percent fine sediments) were found to be non-significant.

Overall, the combined results indicate that variability within treatments was high and that any detrimental effects attributable to grazing impacts were small and probably biologically insignificant with respect to fish use. When compared with the pristine conditions of the Little Minam River reference reach, Catherine Creek habitat appears to be moderately degraded with respect to residual pool depth, width to depth ratio, undercut bank cover, and density of large woody material. However, little difference was found between the Little Minam River and Catherine Creek with respect to percentage of fines in potential spawning substrate. The Catherine Creek study area had better canopy cover and better bank cover than the Little Minam River meadow reach.

This case study demonstrated that after 19 years of cattle grazing under a late-season grazing management program, grazing impacts on stream habitat were minimal and within the range of natural variation compared with areas where cattle grazing was excluded. In conclusion, it appears that the relatively low intensity of cattle grazing on the riparian shrub/tree vegetation has allowed plant succession to advance similarly in both grazed and excluded areas. The stream channel throughout the study reach appears to be in a long-term process of recovery from historic effects of land use.

Table 3. Summary of habitat measurements for grazed and exclosed treatments, difference between treatments, direction of change relative to the grazed plots and consistency of the direction of change with that expected for grazing related impacts.

Habitat Characteristic	Grazed	Exclosed	Difference	Direction of Change	Consistent with Expected Direction of change (yes or no)
Streambank Cover					
%Undercut Bank	9.4%	5.3%	4.1%	+	No
%Overhanging Veg.	5.3%	7.4%	2.1%	–	Yes
Pool Quality					
Pool Rating Score	3.8	3.6	0.2	+	No
Residual Pool Depth	0.38m	0.47 m	0.09m	–	Yes
Pool Quantity					
% Channel Length	20.7%	28.5%	7.8%	–	Yes
Pool Frequency	52/mile	42/mile	10/mile	+	No
Width/Depth Ratio	58.2	50.2	8.0	+	Yes
Mean Bankfull Width	24.7 m	22.3 m	2.4 m	+	Yes
Mean Low Flow Width	13.5 m	12.4 m	1.5 m	+	Yes
Spawning Habitat					
Area of Medium + High Quality Habitat	267 m^2	120 m^2	147 m^2	+	Yes
% Fine Sediments	3.8%	3.6%	0.2%	+	Yes

The behavior of cows and calves in riparian pastures and their direct interaction with spawning chinook salmon was studied by Teena Ballard in 1996 and 1997. Cattle were stocked in the Catherine Creek pasture when salmon began to spawn each year. She followed individual cows and recorded thirteen different activities during the three weeks they grazed in the middle of August and early September. During the same period, she observed individual salmon redds and recorded nine different activities of the salmon.

Cattle spent approximately 94% of their time in the terrestrial habitats (meadow, disturbance, low shrub, tall shrub, and trees) that supported herbivory-type activities (travel, graze, and rest); the remaining time was spent in stream habitats, which consisted of gravel bar (5%) and in aquatic (<1%) habitats (Table 4). Cattle spent approximately 88% of their time on nonherbivory-type activities while in the aquatic habitat. Individual cows were observed during the daylight hours for 18 of 28 days each year they were in the pasture and were never observed in direct contact with a redd. Cattle spent over half of their time drinking and <0.01% of their time defecating while they were in the aquatic habitat. Defecation was proportional to time spent in each habitat; so about 2% of the manure was directly deposited in the stream.

Table 4. Percent of time cattle occupied each terrestrial and stream habitat in 1996 and 1997 compared to the area of the habitat.

Habitat	Dominant Species	Pasture % of Area	1996 Percent Time	1997 Percent Time
Meadow	Kentucky Bluegrass	38	26.9**[1]	28.2**
Disturbed	Cheatgrass	2	1.4	0.1
Low shrub	Snowberry	8	17.1*	12.3
Tall shrub	Black Hawthorn Thinleaf Alder	16	32.8**	26.1**
Tree	Grand Fir Ponderosa Pine Black Cottonwood	13	14.7	27.9**
Gravel bar	Willow Black Cottonwood Thinleaf Alder	8	5.4	5.0
Aquatic	Not Applicable	15	1.5**	0.4**

[1]Significant differences between the availability of the habitat and time spent in each habitat in each year are noted for $P \leq 0.05$ as * and $P \leq 0.01$ as **.

The second part of the study addressed the occurrence of spawning in the study area and two potential impacts of cattle behavior during chinook salmon spawning: 1) disruption of spawning behavior by the presence of cattle near the redd, and 2) the frequency of actual cattle contact with redds. Frequency of salmon redds was not significantly different in the stream reaches accessible to cattle compared with excluded reaches. The selection of spawning sites was proportional to the relative occurrence of suitable spawning gravel in the exclosed and grazed areas of the riparian area and creek. Salmon continued preexisting patterns of behavior while cattle were within visible range of a redd (Table 5). Cattle were seldom close to a redd (12% of the time) and the chance for direct interaction to occur was minimal. When cattle were visibly near an active redd, cattle remained greater than 3.0 m from the active redd 84% of the time. Of the total time redds were observed, cattle contacted the redds <.01% of the time. Previous studies have shown salmon that are harassed during spawning can retain eggs and even go completely unspawned. All salmon fully spawned in the study area in both years of the study.

Table 5. Percent time spring chinook salmon spent on each activity in the presence of cattle visible to a human observer and in the absence of cattle, averaged over years. There were no significant differences between time spent on activities when cattle were present compared to when cattle were absent.

	CATTLE PRESENT	CATTLE ABSENT
SALMON ACTIVITIES	% of time	% of time
Spawning	0.90	0.66
Working	4.45	8.36
Swimming around redd	5.92	10.32
Under cover	34.70	30.54
Resting in redd	52.31	43.47
Darting to cover	0.37	0.12
Protecting the redd	0.30	0.19
Absent from redd	1.13	6.41

Summary

These studies of the various aspects of ecology, cattle grazing, salmon spawning and behavior, and effects of management were case histories of a typical riparian zone found on private land in northeastern Oregon. The meadow is larger than most of the riparian meadows adjacent to streams in the National Forest. The applicability of the results of this study to other riparian areas is unknown. We conducted the research with stocking densities and utilization levels that are similar to those of private lands in the area and much heavier than those on public lands. Since most of this research is related to specific interactions of cattle with salmon and their redds and specific aspects of ecology and stream geomorphology, use of the information from these case studies in other areas should consider the grazing behavior of cattle. If cattle are not forced to spend time in the aquatic zone because of topography and availability of forage more than 3 meters from the creek, they would probably behave similarly to those in this case study. If topography, lack of usable forage, or other factors concentrate animals near the stream edge or in the stream for long periods, the conditions of the interactions of cattle and salmon, plant succession, or stream geomorphology as affected by cattle grazing could be different and the results would not be applicable. The early short-term studies indicated some grazing influences that we would expect to have a long-term cumulative effect on structure of the vegetation and geomorphology of the stream. However, as the study continued, the short-term impacts of cattle grazing were insignificant as the natural forces of weather and succession overwhelmed the system and determined the structure and function of Catherine Creek and the riparian area adjacent to the creek.

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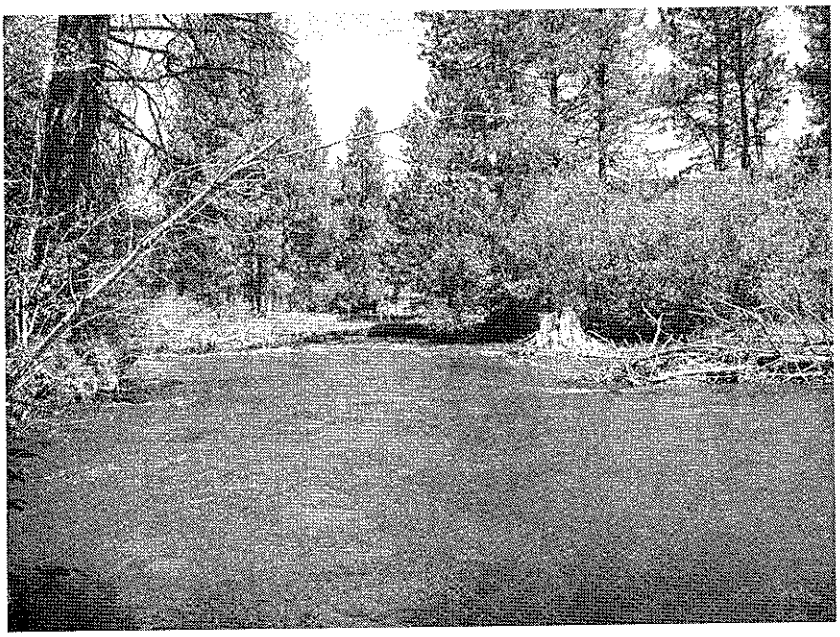
Catherine Creek riparian pasture near peak production. The foreground is a Kentucky bluegrass site, middle is a wet meadow, and a corner of an exclosure is visible as the site transitions to a tall shrub community dominated by hawthorne.



Catherine Creek at high flow.