

RURAL ECONOMY

The Economics of Riparian Management: A Literature Review

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Project Report 00-06

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Background

Concerns Associated with Grazing Cattle in Riparian Areas

The effects of grazing cattle in many riparian areas have greatly affected the associated landscapes over the past 50 years (Adams and Fitch, 1998). The riparian areas of streams and rivers provide numerous ecological services, and it has been demonstrated that cattle grazing can disrupt this zone, negatively affecting these services. The benefits of healthy riparian zones include, but are not restricted to, shelter and forage for wildlife, controlling the flow and volume of stream discharge, and filtering of chemicals and sediment in runoff from fields and pastures (Adams and Fitch, 1998). Each of these services will have both market and non-market economic effects that are of interest to both private (ranchers and farmers) and public interests. However, these economic impacts have rarely been included in studies to date.

The riparian zone is also, in many situations, the most productive zone for forages, as a result of its higher water table (Adams and Fitch, 1998). The economic benefit to ranchers of using this zone can be considerable, and may be necessary to the economic viability of ranch operations. While this may not always be true, there is potential for conflict between the public and private interests from the use of the riparian area for grazing.

The ranch costs and benefits of riparian area management are not well documented in the research. The key objective of this study is to list the published research on the economics of riparian area management. The issues concerning riparian area management are first reviewed. An overview of Alberta's riparian area situation is then presented. A brief discussion of the costs and benefits presented in research studies completes the synopsis of the problem. The last section presents a list of literature related to the economics of riparian area management.

The Problem

One early, widely quoted overview of riparian health is Kauffman and Krueger (1984). This paper reviewed the results of over 100 papers published between 1940 and 1980, concerning livestock impacts on riparian ecosystems. As well, it provided an outline of the many services from healthy riparian areas impacted by grazing. The four major categories outlined were: i) impacts causing changes in streamside vegetation, ii) impacts which changed the shape of the stream channel, iii) impacts which influenced water quality and flow rates, and

iv) impacts which changed the soil portion of the streambank. The presence of grazing cattle also can negatively affect wildlife. Negative effects include direct competition, and alterations to the habitat necessary for wildlife.

Some recent work suggests that the quality of the science in the studies regarding cattle grazing impacts is insufficient. Larsen et al (1998) carried out a literature review of over 1500 articles about livestock influences on riparian zones and fish habitat. The authors classified the articles into 3 groups; papers with original data, commentary papers, and reports about methodology. Of the total papers reviewed, 428 were directly related to riparian zones and fish habitat, but only 89 were classed as experimental. They concluded that many studies in this area have inadequate descriptions of the grazing management practices involved, weak study designs, and lack of pre-treatment data.

Other recent studies suggest that the environmental impacts from grazing are highly variable, and depend mainly on geographical location, the soil and water component of the range, and the grazing management system used (e.g., Clark, 1998).

From an economic viewpoint, the area of interest for any management plan, or change to the current situation, is the distribution of benefits and losses. Do the benefits outweigh the costs for the party obligated to pay for improvements in riparian zones? If not, are there other interested parties who will benefit, and who will also be willing to pay? In particular, if the rancher receives less income due to a modified riparian grazing regime, is society as a whole willing to pay to carry out the changes and compensate the rancher?

The Alberta Situation

In other North American jurisdictions (mainly south of the border), questions surrounding the grazing of livestock have spawned legal challenges, political debates, and increased media attention (Adams and Fitch, 1998). Alberta's grazed riparian areas may also come under scrutiny. Some of the areas of concern are in the foothills regions, where numerous streams and small rivers support an active trout fishery. This has also been an area of extensive free-range cattle grazing. Certain watersheds exhibit definite damage to riparian zones, in that their appearance and vegetation (plant species vigor) are not what would naturally occur (Willoughby and Alexander, 2000). Given the concern over fisheries in the province, and the decline of sport

fish populations throughout, any plan that would improve the situation for sport fish has gained recent attention.

Summary of Possible Benefits and Costs of Riparian Area Grazing Management

The existing literature does provide good coverage of the physical effects of grazing cattle in riparian areas. As well, there are studies that outline either actual or assumed changes to the environment when cattle grazing is modified, either by complete exclusion, or seasonal exclusion. Literature on the costs of specific activities also exists, though not necessarily directly related to the present study. The following list shows certain riparian factors that can be improved through management systems:

1. Streambank physical characteristics
2. Streambank vegetation
3. In-stream vegetation
4. Stream bed characteristics
5. Water flow volume
6. Water quality
- 6a. Sediment

If animals overgraze riparian areas, streambanks can be damaged (Wagstaff, 1986). Trampled banks can fall into the stream. This is known as bank failure. Combined with erosion from water and ice, this can cause widening of the stream. According to Clark (1998), a faster flow (which can result from stream widening) increases erosion. Erosion of stream banks leads to sediment deposition in the stream. In slower reaches of the stream, this will cause higher siltation, possibly covering spawning beds (Wagstaff, 1986). Erosion can also cause flash flooding, and irregular volume of flow.

Wet soil can be compacted by livestock as well (Wagstaff, 1986). The trampling and elimination of streamside vegetation could result in faster run-off after precipitation; further increasing erosion and sediment loads. Another major problem associated with livestock grazing in riparian areas is the deposition of fecal matter in streams (Wagstaff, 1986). This can endanger downstream users of waterways (not to mention aquatic organisms). Fecal matter in surface

water leads to negative public perceptions of agricultural activities. If structural work is required to repair streambanks, then rehabilitation costs will be much higher. Wagstaff (1986) stated that natural processes could correct some problems cheaply. However, these processes often work too slowly.

Any rehabilitation program can have a major effect on ranching. This is because many rehabilitation plans involve the exclusion or controlled use of livestock (Wagstaff, 1986). For example, fence construction will increase costs. A producer may be able to compensate for this added cost with improved livestock production. Corridor fencing, which excludes livestock grazing along streams, can be expensive, especially if the riparian area covers much of the grazing land. A more cost-effective solution may involve more intensive livestock management (Wagstaff, 1986). Though these systems may save on fencing costs, they will increase livestock management costs, through labour for handling and moving animals.

Wagstaff (1986) suggested that a rancher might see adverse effects on livestock performance by controlling grazing. For example, a rancher may have to keep animals off the riparian area when vegetation (forages) reaches its best stages for animal weight gain. This means that animals would not gain weight as they would with season-long grazing. A rancher may have to find outside sources of forages in cases such as this. This can be an added cost to the ranch (Wagstaff, 1986).

According to Wagstaff (1986), many benefits of streambank physical improvement involve fisheries and aquatic habitat. Healthier aquatic habitat will result from the decreased water temperature provided by better streambank cover. A streambank's strength will also be increased through improved vegetation. With increased vegetation comes increased shade and cover for fishes in the salmon family (Wagstaff, 1986). Increased fish population can lead to increased recreational use of a stream or river. Certain wildlife species are dependent on healthy vegetation for nesting, cover, or food. More wildlife along a rehabilitated stream can also increase usage by the public. These are non-market benefits that are not easily measured (Wagstaff, 1986). Increased vegetation along a stream can be a result of a higher water table. This can mean increased forage production for livestock producers (Wagstaff, 1986).

According to Clark (1998), damage due to livestock tends to be localized, site-specific, and manageable. As well, Clark suggested that the contribution to downstream water pollution might be less than that caused by cropping and confined livestock operations. There are also a

number of factors that affect the impact of livestock on riparian areas. These include climatic region, soil type and drainage, flow velocity, vegetation cover, etc. (Clark, 1998). The site-specific management used to correct problems due to livestock grazing will almost invariably increase farm expenses through increased labour, fencing, and loss of grazing potential (Wagstaff, 1986). It is therefore the producer's responsibility to choose management systems that promote riparian recovery at least cost. The literature suggests that healthy riparian areas can translate to increased production of higher-quality forages. This will lead to higher livestock productivity. However, research quantifying the economic benefits and costs of riparian area grazing management is limited.

Literature Search

A bibliographical search was conducted for past work that related directly to the economic effects of cattle grazing on riparian areas. The search was conducted using the following databases: AGRICOLA, CAB International, and Bio-Abstracts. Keywords were chosen that related to the main points listed above. The keywords used are listed in Table 1. Overall, less than 25 articles were found with titles related to the full range of keywords. The economic aspect was the keyword most often missing. Of those articles that met the criteria, the majority were either a listing of a limited number of potential impacts, or hypothetical examinations of what the economic effects would be, given a number of assumed situation variables. Less than 5 examined real situations, with actual costs or benefits.

Given the paucity of the existing literature, a further search was initiated that would provide information on at least portions of the economic issues, such as the cost of fence construction, feed prices in Alberta, or water quality benefit/cost analysis. With these, more objective scenarios could be modeled, that would provide clues to what the results would be, from specific projects undertaken in the region.

Table 1: Keywords Used In Literature Search

Search Number	Keyword(s) Used
1	Riparian AND Cost
2	Riparian AND Livestock
3	Graz* AND Economi* AND Riparian
4	Riparian AND Economics
5	Riparian AND Cattle
6	Cattle AND River
7	Riparian AND Cattle AND Graz*

Literature Listed

- Adams, B. and Fitch, L. 1998. Caring for the Green Zone: Riparian Areas and Grazing Management. 2nd Edition. Alberta Riparian Management Partnership and the Canada-Alberta Environmentally Sustainable Agriculture Agreement, Lethbridge, Alberta.
- Barrett, H. 1984. Rangeland erosion: A question of measurement. Range watersheds, riparian zones, and economics: interrelationships in management and use: Proceedings, 1984 Pacific Northwest Range Management Short Course, Oregon State University, Corvallis, Oregon. 75-77.
- Bedell, T.E. 1984. Livestock grazing and the riparian zone. Range watersheds, riparian zones, and economics: interrelationships in management and use: Proceedings, 1984 Pacific Northwest Range Management Short Course, Oregon State University, Corvallis, Oregon. 60-66.
- Belsky, A.J., A. Matzke, and S. Uselman. 2000. Survey of livestock influences on stream and riparian ecosystems in the western United States. *Journal of Soil and Water Conservation*. First Quarter: 419-431.
- Blackwell, Hogan, and Maltby. 1999. The use of conventionally and alternatively located buffer zones for the removal of nitrate from diffuse agricultural runoff. *Water Science Technology* 39 (12): 157-164.
- Buckhouse, J.C. 1984. Infiltration and erosion: identifying potential hazards in the rangelands of Oregon. Range watersheds, riparian zones, and economics: interrelationships in management and use: Proceedings, 1984 Pacific Northwest Range Management Short Course, Oregon State University, Corvallis, Oregon. 31-34.
- Castle, G. 1993. Agricultural Waste Management In Ontario, Wisconsin, and British Columbia: A Comparison of Policy Approaches. *Canadian Water Resources Journal* 18 (3): 217-227.
- Chow, T.L., H.W. Rees, and J.L. Daigle. 1999. Effectiveness of terraces/grassed waterway systems for soil and water conservation: A field evaluation. *Journal of Soil and Water Conservation*. Third Quarter: 577-583.
- Clark, E.A. 1998. Landscape variables affecting livestock impacts on water quality in the humid temperate zone. *Canadian Journal of Plant Science* 78 (2): 181-190.
- abstract:* The potential for impact by grazing livestock on unprotected watercourses may vary with climate, landscape level factors (including the landform within which the pasture is located), biophysical characteristics of the watercourse itself, and with pasture and grazing management practices. Policies seeking to implement cost-effective measures to protect downstream water quality need to acknowledge large-scale as well as

small-scale processes which can moderate or exacerbate potential sources of pollution. Evidence suggests that unrestricted livestock access accounts for a relatively modest share of watercourse pollution in humid temperate regions. This is compared with such watershed-specific factors as leaking septic tanks and confinement feeding systems. A wide variety of evidence suggests that the degree of compatibility of grazing livestock with a healthy riparian ecosystem should be viewed as a hypothesis that is testable on a site-specific basis. Greater understanding of the factors causal to livestock behavior in, and impact on, watercourses may help to better focus prevention and remediation efforts by both producers and policymakers.

Crouse, M.R. and R.R. Kindschy. 1984. A method for predicting riparian vegetation potential of semiarid rangelands. Range watersheds, riparian zones, and economics: interrelationships in management and use: Proceedings, 1984 Pacific Northwest Range Management Short Course, Oregon State University, Corvallis, Oregon. 18-24.

Dickard, M. 1998. Management Strategies for Improved Cattle Distribution and Subsequent Riparian Health. M.S. Thesis. University of Idaho, Moscow, Idaho.

summary: This was a Masters thesis in two chapters. The first chapter outlined riparian ecosystems. It included discussions of grazing distribution and behaviour. The author discussed the roles of habitat type, water, and shade. Dickard then discussed management strategies and opportunities. These included off-stream water and salt placement. The second chapter outlined a research project by the author, which involved assessing off-stream water and salt as management strategies, for improved cattle distribution and subsequent riparian health. Sixty cow/calf pairs were allotted to three pastures, with three grazing strategies: 1) stream access, with access to off-stream water and salt, 2) stream access, with no access to off-stream water and salt, and 3) ungrazed control. Overall, the author found that cattle distribution was affected by the presence of off-stream water and salt. However, no changes were noted for grazing activity, travel distances, forage utilization, or water quality (in any of the three treatments).

Elmore, W. and P. Cuplin. 1984. Use of color infrared photography in stream habitat inventories. Range watersheds, riparian zones, and economics: interrelationships in management and use: Proceedings, 1984 Pacific Northwest Range Management Short Course, Oregon State University, Corvallis, Oregon. 6-12.

Findley, J. 1984. Riparian monitoring using large scale color infra-red aerial photography in Southeastern Oregon. Range watersheds, riparian zones, and economics: interrelationships in management and use: Proceedings, 1984 Pacific Northwest Range Management Short Course, Oregon State University, Corvallis, Oregon. 13-17.

Fitch, L. and B.W. Adams 1998. Can cows and fish co-exist? Effects of agriculture on the riparian ecosystem. Proceedings of a symposium held at Lethbridge, Alberta, Canada, 1996, Canadian Journal of Plant Science 78 (2): 191-198.

abstract: An ecological perspective on the interrelationship between livestock grazing and

riparian areas was provided in a review of topical literature. The Alberta Riparian Habitat Management Project (also known as "Cows and Fish") was described. Three decades of riparian investigation quantified the effect that unmanaged livestock grazing can have on range productivity and watershed function. It was considered that suitable grazing strategies for riparian areas would be developed, by understanding the function of riparian systems. Then, range management principles could be applied to develop riparian grazing strategies. It was concluded that unmanaged grazing results in overuse and degradation of riparian areas. Strategies suitable for riparian areas in Southern Alberta, which should maintain ecological function and sustained use, were described. These included control of animal distribution and access to water, control of grazing intensity, control of grazing frequency and rest periods, and control of grazing dates.

Kauffman, J.B. and W.C. Krueger. 1984. Livestock impacts on riparian ecosystems and streamside management implications...a review. *Journal of Range Management* 37 (5): 430-438.

summary: State of the knowledge up to 1984, review of bio-physical interactions between cattle and the environment in riparian zones.

Kindschy, R.R. 1984. A line-intercept method for monitoring riparian vegetation trend. Range watersheds, riparian zones, and economics: interrelationships in management and use: Proceedings, 1984 Pacific Northwest Range Management Short Course, Oregon State University, Corvallis, Oregon. 25-30.

Konynenbelt, R. D. 1993. A stream restoration project along the North Raven River," in Tellman, B. et al, Riparian Management: common threads and shared interests: A western regional conference on river management strategies. Feb 4 - 6, 1993, Albuquerque, New Mexico. General Technical Report RM-226, USDA Forest Service, Fort Collins, Colorado. 294-304.

summary: This was a good description of an actual project. It included a background summary of the initial situation, remediation work carried out, and a brief benefit/cost analysis of the project.

Lambert, D.K. 1984. The economics of range investments: public and private perspectives. Range watersheds, riparian zones, and economics: interrelationships in management and use: Proceedings, 1984 Pacific Northwest Range Management Short Course, Oregon State University, Corvallis, Oregon. 86-98.

Larsen, R.E. et al. 1997. Livestock Influences on Riparian Zones and Fish Habitat: A Bibliography. EM 8660, Oregon State University Extension Service, Oregon State University, Corvallis, Oregon.

abstract: This bibliography contained 1521 entries. Very few of them related to the economics of riparian management. The authors found that many of the cited papers had inadequate sample size, and lacked statistical reliability. As well, citations included both

non-refereed and refereed journal articles. The authors were able to make only broad generalizations pertaining to riparian management.

Larsen, R.E. et al. 1998. Livestock influences on riparian zones and fish habitat: literature classification. *Journal of Range Management* 51 (6): 661-664.

abstract: A key was used to classify articles about livestock influences on riparian zones and fish habitat into 3 classes: papers that contained original data, those that were commentary, and reports about methodology such as classification systems, policies, and monitoring criteria. Four hundred and twenty-eight of the total articles were directly related to grazing impacts on riparian zones and fish habitat. Only 89 of these grazing impact articles were classified as experimental, where treatments were replicated and results were statistically valid. This analysis revealed several limitations of riparian grazing studies that included: (1) inadequate description of grazing management practices or treatments, (2) weak study designs, and (3) lack of pre-treatment data. More long-term, replicated treatment studies are needed in the future.

Lowrance, R. 2000. REMM: The Riparian Ecosystem Management Model. *Journal of Soil and Water Conservation*. First Quarter: 27-34.

Masters, L., Swanson, S., and Burkhardt, W. 1996. Riparian grazing management that worked: I. Introduction and winter grazing. *Rangelands* 18 (5): 192-195.

abstract: A review was presented of traditional and alternative grazing strategies for riparian ecosystems. Rotation and rest strategies were highlighted, in addition to other herd management techniques; such as animal selection, riding, slating, and water development. Winter grazing was discussed in relation to the resulting improvement of livestock distribution and plant response. Wickiup Creek and Meadow Valley Wash (both in Nevada) were discussed as examples of the success of this management type. These sites contrasted in elevation, vegetation, precipitation patterns, and their historical uses. However, winter grazing proved successful in restoring streamside vegetation, maintaining healthy conditions, and building new stream channels in both areas.

Masters, L., Swanson, S., and Burkhardt, W. 1996. Riparian grazing management that worked: II. Rotation with and without rest and riparian pastures. *Rangelands* 18 (5): 196-200.

abstract: Rest-rotation grazing was discussed in general. Rotation strategies were compared and contrasted, with and without rest, on 3 different streams. Riparian pastures were compared and contrasted on 2 streams at 5 sites in northern Nevada (Strawberry Creek, Wildcat Creek, Van Duzer Creek, Goosey Lake Flat Creek and Pie Creek). It was concluded that to assure success, rotation or rest-rotation grazing strategies should be specifically designed for the unique conditions of an allotment or watershed. It was suggested that 3-pasture rest-rotation might succeed with moderate stocking rates, seasonal use matched to the climate, and maintained (rather than *improved*) woody and herbaceous vegetation. It was suggested that 4- or 5-pasture rotation schemes with no rested pasture might be more suitable to areas that require increased streambank

vegetation. It was also suggested that movement of livestock out of sensitive areas (salt-lick placement, etc) might improve cattle distribution during sensitive periods.

Newton, J. Fifteenmile Creek riparian recovery, Wasco County, Oregon. 1984. Range watersheds, riparian zones, and economics: interrelationships in management and use: Proceedings, 1984 Pacific Northwest Range Management Short Course, Oregon State University, Corvallis, Oregon. 80-83.

Obermiller, F. 1994. A Framework for Evaluating the Economic Benefits, Costs and Trade-offs Associated with Riparian-Area Management Practices and Strategies. *Natural Resources and Environmental Issues*. 1: 15-18.

summary: This paper presented a good overview of riparian area management in the western United States. The original conflict between ranchers and other land users was discussed. The paper outlined the scope and diversity of the western riparian areas. The author constructed a timeline of knowledge building, regarding livestock grazing in riparian areas. Items discussed included the Federal Land Policy and Management Act, National Research Council findings, education commissioned by the EPA, etc. Obermiller outlined some grazing systems and other riparian management practices. The author discussed efficiency, equity, and sustainability; as applied to riparian area economics. Riparian economics was then discussed from the private and social perspectives. In conclusion, Obermiller noted that if private benefits did not outweigh private costs, then riparian area management schemes would not be adopted on private land. No real economic analysis (data analysis) was used in this paper.

Pacific Northwest Range Management Short Course (Corporate Author). 1984. Range watersheds, riparian zones, and economics: interrelationships in management and use: Proceedings, 1984 Pacific Northwest Range Management Short Course, Oregon State University, Corvallis, Oregon.

Phillips, W.E. and T.S. Veeman. 1987. Alternative Incentives and Institutions for Water and Soil Conservation. *Canadian Water Resources Journal* 12 (3): 27-33.

Platts, W.S. 1984. Compatibility of livestock grazing strategies with riparian-stream systems. Range watersheds, riparian zones, and economics: interrelationships in management and use: Proceedings, 1984 Pacific Northwest Range Management Short Course, Oregon State University, Corvallis, Oregon. 67-74.

Platts et al. 1989. Cattle and fish on the Henry's fork. *Rangelands* 11: 58-62.

summary: This was a case study of one particular remediation effort in Idaho. It included a 'guesstimate' of the recreational fishing value involved, by using a previous study from a different geographic location.

Platts, W. 1990. Fish wildlife, and livestock: protection of riparian areas. *Western Wildlands* 16 (2): 16-19.

summary: This was a descriptive narrative of various effects cattle can have when grazed in riparian areas, and anecdotal tales of remediative efforts.

Platts, W.S. 1984. Compatibility of livestock grazing strategies with riparian-stream systems. Range watersheds, riparian zones, and economics: interrelationships in management and use: Proceedings, 1984 Pacific Northwest Range Management Short Course, Oregon State University, Corvallis, Oregon. 67-74.

Qiu, Z. and T. Prato 1998. Economic evaluation of riparian buffers in an agricultural watershed. Journal of the American Water Resources Association 34 (4): 877-890.

abstract: This study determined the most cost-effective spatial pattern of farming systems for improving water quality, and evaluated the economic value of riparian buffers in reducing agricultural nonpoint source pollution in a Midwestern agricultural watershed. Economic and water quality impacts of alternative farming systems were evaluated using the CARE and SWAT models, respectively. The water quality benefits of riparian buffers were estimated by combining experimental data and simulated water quality impacts of farming systems obtained using SWAT. The net economic value of riparian buffers in improving water quality was estimated by total watershed net return with riparian buffers, minus total watershed net return without riparian buffers, minus the opportunity cost of riparian buffers. Exclusive of maintenance cost, the net economic value of riparian buffers in reducing atrazine concentration from 45 to 24 ppb was \$612,117, and the savings in government cost was \$631,710. Results strongly supported efforts that encouraged farmers to develop or maintain riparian buffers adjacent to streams.

Sanderson, H.R. and T.M. Quigley 1984. A coordinated and comprehensive approach to range Management. Range watersheds, riparian zones, and economics: interrelationships in management and use: Proceedings, 1984 Pacific Northwest Range Management Short Course, Oregon State University, Corvallis, Oregon. 84-85.

Shannon, R.E. 1990. Grazing fees on public lands: A system under siege. Western Wildlands 16 (2): 7-11.

Stillings, A. 1997. The Economic Feasibility of Offstream Water and Salt to Reduce Grazing Pressure in Riparian Areas. M.S. Thesis. Oregon State University, Corvallis, Oregon.

summary: This paper has not been reviewed by the authors. However, it discusses the economic feasibility of a project similar to that of Dickard (see above). According to the related abstract, Stillings' off-stream water and salt dispersion project had annual expected net returns of \$5,517, \$7,358, and \$11,054 at low, medium, and high cattle prices, respectively, for a 300-cow operation in northeast Oregon.

Stringham, T.K. 1984. Importance of publicly owned rangeland to the Oregon cattle industry. Range watersheds, riparian zones, and economics: interrelationships in management and use: Proceedings, 1984 Pacific Northwest Range Management Short Course, Oregon State University, Corvallis, Oregon. 45-58.

Thomas, J.W. 1984. Bridging the management gap. Range watersheds, riparian zones, and economics: interrelationships in management and use: Proceedings, 1984 Pacific Northwest Range Management Short Course, Oregon State University, Corvallis, Oregon. 59.

Vavra, M. 1984. Livestock production possibilities on streamside meadows. Range watersheds, riparian zones, and economics: interrelationships in management and use: Proceedings, 1984 Pacific Northwest Range Management Short Course, Oregon State University, Corvallis, Oregon. 35-44.

Wadman, K. 1984. Soil erosion on range watersheds: a question of measurement. Range watersheds, riparian zones, and economics: interrelationships in management and use: Proceedings, 1984 Pacific Northwest Range Management Short Course, Oregon State University, Corvallis, Oregon. 78-79.

Wagstaff, F.J. 1986. Economic issues of grazing and riparian area management. Trans-North American Wildlife and Natural Resources Conference, Wildlife Management Institute, Washington, D.C. 272-279.

summary: This paper provided a good overview of the economic consequences of changes in the range management regime to protect the riparian zone. No real cost analyses were used.

Watson, M.C. and A.W. McIntosh. 1999. Aquatic ecosystems in agricultural landscapes: A review of ecological indicators and achievable ecological outcomes. Journal of Soil and Water Conservation. (Fourth Quarter): 636-643.

Willoughby, M. and Alexander, M. 2000. A Range Condition Dilemma. Rangelands 22 (1): 23-26.

Winward, A.H. 1984. An ecosystem classification for intermountain riparian areas. Range watersheds, riparian zones, and economics: interrelationships in management and use: Proceedings, 1984 Pacific Northwest Range Management Short Course, Oregon State University, Corvallis, Oregon. 1-5.

Wuerthner, G. 1990. Grazing the western range: what costs, what benefits? Western Wildlands 16 (2): 27-29.

summary: This was a descriptive outline of the biophysical effects of grazing in one locale.