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# GRAZING AND FISHES IN THE SOUTHWEST: CONFOUNDING FACTORS FOR RESEARCH

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ABSTRACT: Little information on the relationships and interactions of livestock grazing and fishes exist for the southwestern United States. This situation is much in need of remedy. However, based on several case studies in the Southwest, certain factors render research in this area difficult and results suspect. These are 1) species of fish under consideration, 2) temporal-spatial factors, 3) habitat influences and 4) fishery management practices. The probability of acquiring valid, defendable research on grazing/fish relationships must address these factors and be done in partnership with land managers.
KEY TERMS: Fish; grazing; research; management

## INTRODUCTION

Grazing of domestic livestock is one of the multiple uses of National Forest lands. Livestock grazing has been a component of the southwestern landscapes for centuries (Jemison et al. in press). Cattle and sheep were already ubiquitous on the landscapes of Arizona and New Mexico when the United States Forest Service was established in 1902. The 1930 Taylor Grazing Act was the first legislation directed at controlling livestock grazing on pubic lands. More recently, the Multiple Use and Sustained Yield Act of 1960 and National Forest Management Act of 1976 further addressed multiple use management on National Forest lands including livestock grazing.

Management of forested landscapes for timber, recreation, mining, and livestock all potentially and ultimately affect riparian-stream areas (Debano and Schmidt 1989). Riparian-stream areas and their encompassing watersheds are intimately related and condition of the former can serve as an indicator of condition of the latter (Lafayette and Debano 1990, Rinne 1990). In the arid American Southwest, availability of water is highly variable in time and space. Riparian-stream areas are more often ephemeral and intermittent than perennial, however, these aquatic habitat provide critical habitat for an assemblage of native fishes, many of which are threatened and endangered species (Rinne 1994, 1995, Rinne and Minckley 1991). Accordingly,

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Forest Service management must know the relationships of fish, th habitats and land use practices in order to properly manage the fish resource. Understanding and managing these relationships becomes m critical because of the threatened and endangered status of many fish species on National Forest lands in the Southwest (Rinne and Medina 1995).

A more comprehensive review of state-of-the knowledge for fish/grazing relationships throughout the West is available in Rinne (in press). The primary objective of this paper is to identify some of the confounding factors that affect research on relationships of livestock grazing and fishes based on one research case history in the Southwest conducted by the author in the 1980s. Suggestions are offered as to a plausible course that Forest Service management and research should follow to address these factors, and to insure acquisition of valid, defendable data; and ultimately, the sustainability of native fishes in southwestern riparian-stream ecosystems.

## STATE OF KNOWLEDGE

Most of the information on the relationship of domestic livestock grazing and fishes in the United States has been generated in the northern Rocky Mountain, Inter-mountain and Pacific Northwest regions (Rinne in press). Dr. W.S. Platts, a former U.S. Forest Service researcher, recently summarized much of what is known about the effects of grazing on fishes in the above-listed geographic regions (Pl 1991). This state of knowledge review provides some generalizat about grazing effects on fishes and their habitats. The reader is referred to this document for further information on specific grazing strategies and fish habitat and the influence of grazing on fish populations.

The general consensus is that livestock grazing has an irrefutable, negative impact on fishes, and their habitats. Over two decades ago, Behnke and Zarn (1976) identified livestock grazing as "the greatest threat to the integrity of trout stream habitat in the western United States." Saltzman (1977) also suggested that overgrazing and irrigation are the most serious and least understood ecological problems in the western states." Meehan and Platts (1978) were unable to identify any widely-used grazing strategy that is compatible with the environmental needs of aquatic ecosystems.

Two decades ago, the same paradigm was expounded for the Southwest. Gallizioli (1977) suggested overgrazing by livestock was "the single most important range-management problem limiting fish and wildlife benefits in Arizona." Davis (1977) stated that "management of the riparian habitat for wildlife could best be accomplished by the total exclusion of domestic livestock." However, despite these statements suggesting that livestock grazing in the Southwest has a negative impact on wildlife and fishes and their habitats, no definitive, scientifically-based data are yet available to support such conclus Platts (1991) correctly stated that "because published, evaluations of grazing strategies as related to fishery productivity lacking and because we do not completely understand cause and effect in livestock grazing and fishes, controversy exists." As we come to the

close of the 20th Century, almost seven decades after the Taylor Grazing Act and two to three decades after significant legislation on management of Forest lands mandating acquisition of research and monitoring information of our multiple use strategy, we yet lack sound, reliable information on two of these resources and their interrelationships--fishes and livestock grazing. Because of this state-of-knowledge, controversy exists as evidenced by the recent plethora of legal issues and current agency initiatives addressing grazing/fish relationships in the Southwest.

My review of the literature on the relationships of grazing, riparian areas, and fishes throughout the West revealed a low proportion of studies documenting the effects of livestock grazing on fishes. Of the 200 papers reviewed, only a third (33%) addressed the relationship of fishes in riparian habitats (Table 1). Of the 66 papers discussing fishes and riparian, 47 (72%) considered salmonid species, and 19 (28%) addressed other than salmonids. Of these 19 papers, I categorized 13 (68%) as "fish general." Further, of these 19 papers, 11 (59%) were opinion, summary or review papers that discussed previous study results and presented no new data. Unfortunately, these papers did little more than serve to promote the litany or current dogma on the effects of grazing on fishes. Finally, and to address the intent of this paper, only 8 of the 19 papers were from the Southwest. Of these 8 papers, only 3 (17%) were data-based.

TABLE 1. Comparison and analyses of 200 literature references on riparian, fishes and grazing.

| | |
|---|---|
| Total references | 200 |
| Fish related references | 66 (of 200) |
| Salmonids | 47 (of 66) |
| Non-salmonids | 19 (of 66) |
| Fish general | 13 (of 19) |
| Fish (opinion, review) | 11 (of 19) |
| Studies in Southwest | 8 (of 19) |
| Data based studies, Southwest | 3 (of 8) |

## CONFOUNDING FACTORS

Between 1983 and 1997 the author has conducted research on the effects of livestock grazing on fishes and their habitats on several streams at three study areas in Arizona and New Mexico. The Rio de las Vacas is a montane riparian area with exclosures to grazing for a period of 10 years prior to research commencing. It is located in northern New Mexico on the Santa Fe National Forest (Rinne 1988). The West Fork Allotment on the Apache Sitreaves National Forest encompasses three montane riparian-stream areas. This adaptive management study was initiated because of a biological opinion on the threatened Apache trout, *Oncorhynchus apache*. Finally, studies of native cypriniform fishes and grazing on the Verde River, Prescott National Forest, Arizona were recently initiated. From data collected in the first study certain factors can be demonstrated to potentially and dramatically affect conclusions relative to the effect of grazing on fish populations.

These are:

1. species of fish (salmonid vs non-salmonid)
2. temporal and spatial variation of data
3. stream habitat influences
4. fishery management activities

Additional factors and a more detailed discussion of information available on grazing and fish relationships and its reliability can be found in Rinne (in press).

## Species of Fish

As stated above and illustrated in Table 1, most of the information on grazing and fishes is based on salmonid species. The question becomes "Would one expect differential effects of grazing on salmonids versus non-salmonids such as suckers and chubs (i.e. cypriniform species) in the Rio de las Vacas and the Verde River?" Van Velson (1979) reported an inverse relationship between these two groups of fishes in one creek in Nebraska. Rinne (1988) noted an inverse relationship of numbers of trout and Rio Grande chubs (*Gila pandora*) in the Rio de las Vacas. Accordingly, biological interactions between these two groups of fishes alone could affect conclusions relative to response to grazing.

Based on five years of sampling (Table 2) over a period of seven

TABLE 2. Mean Density (n per km) and biomass (kg per km) of fish (n = 6) in the Rio de las Vacas, 1982-85. Trout include rainb (Oncorhynchus mykiss), Rio Grande cutthroat, (*O. clarki virginalis* their hybrids, and brown trout (*Salmo trutta*).

| (Year of Sample) | Rio Grande Sucker | | Rio Grande Chub | | Trout | | Total Fish | |
|---|---|---|---|---|---|---|---|---|
| Treatment | n | bio | n | bio | n | bio | n | bio |
| (1982) | | | | | | | | |
| Ungrazed | 1940 | 25.4 | 860 | 10.5 | 260 | 19.5 | 3060 | 55.4 |
| Grazed | 3700 | 22.4 | 3420 | 25.6 | 40 | 1.1 | 7160 | 49.1 |
| (1983) | | | | | | | | |
| Ungrazed | 1100 | 12.8 | 840 | 12.1 | 140 | 9.5 | 2080 | 34.4 |
| Grazed | 1140 | 12.2 | 1560 | 16.3 | 80 | 4.5 | 2780 | 33.0 |
| (1984) | | | | | | | | |
| Ungrazed | 1120 | 17.3 | 520 | 8.3 | 180 | 12.7 | 1820 | 38.4 |
| Grazed | 1920 | 24.7 | 1920 | 21.6 | 220 | 18.7 | 4060 | 65.0 |
| (1985) | | | | | | | | |
| Ungrazed | 560 | 10.3 | 380 | 7.8 | 140 | 14.7 | 1080 | 32.8 |
| Grazed | 560 | 9.2 | 560 | 8.9 | 60 | 8.0 | 1180 | 26.1 |
| (1988) | | | | | | | | |
| Ungrazed | 500 | 13.4 | 280 | 4.9 | 360 | 32.0 | 1140 | 50.3 |
| Grazed | 780 | 15.8 | 760 | 9.0 | 220 | 19.7 | 1760 | 44.[illegible] |

years in the Rio de las Vacas, several interpretations of the effects of grazing on fishes can be developed based on fish species alone. First, although numbers vary in Table 2, there are no significant differences in estimated fish density and biomass between grazed and ungrazed reaches of stream in most of the years (Rinne 1988). However, if one individually examines the various fish statistics for suckers, chubs, trout, and total fish, one can arrive at, or certainly present several different conclusions relative to grazing effects.

First, the Rio Grande sucker (*Catostomus plebeius*) occurred in greater abundance per unit length of stream in 1982 and 1984. One could select either of these years, or both, and state that grazing has no negative effect on Rio Grande sucker. In fact, one might go beyond that conclusion and state that grazing enhanced sucker populations. In terms of biomass, however, only the 1984 sample estimate of sucker density could perhaps be concluded to be significantly greater in grazed reaches of streams. In the other three sample years, densities were the same or similar between grazed and ungrazed sample reaches. Based on biomasses there were no statistical (ANOVA) or even apparent differences between grazed and ungrazed reaches of stream.

Next, if we evaluate Rio Grande chub densities relative to grazing, markedly greater populations were present in grazed reaches all years sampled. By contrast, biomasses also were much greater in the grazed reaches in 1982,1984, and 1988. Overall, selecting this species, one could conclude that grazing either has no negative effect on Rio Grande chub, or as suggested for suckers, even enhances chub populations.

In contrast to the two cypriniform species, greater density and biomass of trout occurred in ungrazed reaches of stream in all but 1984. Finally, if one selects total fish densities in ungrazed and grazed reaches of stream in the Vacas, grazed reaches always contained more fishes. It is obvious that if one does not consider statistical analyses (as commonly has been the case; Rinne in press), and selects cypriniform and total fish density and biomass as indicators, grazing certainly cannot be unequivocally demonstrated to have a negative influence on fishes. Indeed, one might interpret this multiple use to be beneficial to minnows, suckers and total fish population in this montane stream. By contrast, the opposite conclusion could be drawn for trout populations.

## Temporal-Spatial Variation

Temporal interpretation of fish data is a another critical, confounding factor that has not been properly addressed in grazing/fish studies. Table 2 suggests a basic problem that pervades the literature on grazing and fish interactions studies--there is a tendency to not replicate collection of data in time. This approach results in only a snapshot of the status of fish populations in a given year (Rinne in press). To further confound and add to this deficiency, broad, generalized statements on the effects of grazing on fish are then offered. Finally, and most damaging, management decisions may be made based on such data.

Multiple-year data on the Rio de las Vacas demonstrates that temporal variation in fish populations are the norm. If fish populations on the Vacas had been sampled only in exceptional years

i.e. 1985 and 1988 for chubs and suckers, and 1984 for trout) different conclusions could be reached than if sampled in 1982-84. Again, single year data on fish populations is simply that. In absence of additional years of information, or worse, lack of pretreatment information (which is the norm in most fish/grazing studies; Rinne, in press), valid conclusions on grazing effects are precluded and, if offered, should be highly suspect.

Spatial variation is an equal or greater problem. Replication in space of most fish grazing studies occurs less than half the time (Rinne in press). When present, it is most often achieved in a contiguous, upstream-downstream design (Rinne 1988). Although vegetation and streambanks may respond quickly to grazing removal, parallel changes in water quality, substrate and suspended sediment, and certainly fishes between adjacent stream sections subjected to differing grazing strategies do not readily occur. Because there is no impediment to exchange of these factors between reaches of stream under differing grazing treatments, benefits accrued in terms of water quality, fish habitat and populations in ungrazed reaches readily influence reaches immediately down- and for fishes, even upstream. Accordingly, assume grazing removal is viewed as beneficial and the "white" of the stream, and grazing is harmful or the "black" of the stream, then the interactions and mixing of factors between the two becomes the "gray." This is one reason (as Platts stated) controversy yet exists in definition of fish/grazing relationships.

Another spatial influence may confound research efforts. Frequently there is a lack of contiguous or proximate study reaches available for study. In the Rio de las Vacas, downstream grazed reaches were over 4 km removed from upstream, ungrazed reaches (Rinne 1988). Linear changes in channel types (Rosgen 1994) and in fish habitat (Calamusso 1996) typically will result as one progresses along a riparian-stream system. In turn, fish populations and species composition will change as discussed in the next section.

## Habitat Influences

Extensive study of fishes and their habitats have been conducted, however the habitat component is not properly addressed in fish/grazing studies. This situation can be illustrated in the Rio de las Vacas study design. Grazed sample reaches were over 4 km downstream from ungrazed reaches, separated by private lands and therefore disjunct not only spatially, but also in habitat type (Rinne 1985, 1988). Recent, detailed studies on Rio Grande sucker habitat use indicate it occupies lower gradient (< 3%) reaches characterized by pool and glide habitat (Calamusso 1996). In retrospect, the downstream, "grazed" reaches sampled between 1982 and 1988 were comprised of these habitat types. Accordingly, greater sucker density might be expected which was the case (Table 2). The influence of habitat availability and preference on both salmonids and non salmonids are further evident from the Apache trout on the West Fork allotment in the White Mountains (Rinne and Neary 1996) and in studies of cypriniform populations in the Verde River (Rinne and Neary 1997, Rinne in press).

## Fisheries Management

Finally, fishery management is a key, critical component to be considered when it comes to evaluation of any land management effect on fish populations. In fact, many of the problems that may be associated with habitat loss and degradation in the West and Southwest have been mitigated by stocking of nonnative, sport fishes such as rainbow, brown and brook trout (Platts and Rinne 1985). In concept, and by charge, land management agencies are responsible for managing and caring for the habitat. State Game and Fish agencies are responsible for managing the species (i.e. the fishes, Sponholtz et al. in press). Stocking practices and angling activity can have marked effects on interpretations of results of research focused only on grazing effects.

For example, on the Rio de las Vacas (Table 2), a marked increase in trout populations was observed based on density and biomass estimates in the grazed reaches between 1982 and 1984. Such an increase largely could be attributable to extensive stocking of brown and rainbow trout in 1982-83 (Rinne 1988). Further, if populations of native trout such as the Apache trout in headwater streams in the White Mountains are very low as documented by Rinne and Neary (1996), sport angling may potentially and dramatically affect trout density and ultimately estimates of population size. Indeed, fishery management activities (Platts and Rinne 1985) probably have as great (or greater) impact on fish populations than does grazing.

## FUTURE DIRECTION OF MANAGEMENT AND RESEARCH

First, a conscious effort must be made to address the above four factors in any future fish/grazing relationship studies. Equally important, future studies in this area should include an approach that involves interagency, collaborative management and research. The West Fork ungulate study on the Apache Sitgreaves National Forest, now in its fifth year, is an example of such cooperation and collaboration. The Forest along with the permittee have established the grazing strategies in time and space on this allotment. The Arizona Game and Fish Department has expended many thousands of dollars to construct both elk proof and standard livestock fences to facilitate study design. The Rocky Mountain Research Station designed the study and collects and analyzes the data. At two-year intervals analyses, evaluation, and interpretation of data facilitate any needed adjustments to management to achieve management goals and at the same time obtain the most reliable information for future management of riparian and fishery resources.

Finally, the time has come to remove ourselves from promoting and sustaining the "litany" or "dogma" on effects of grazing on fishes and embrace collection of sound, defendable information that can be used by land managers. Rinne (in press) documents that most often qualitative, non-scientific data are collected. Although the reliability of such data is low, its use, and adoption for management has been high. Hawkins (1997) conducted an analyses on the status, quality and reliability of all types of data collected relative to grazing effects on riparian areas. Again, of hundreds of studies analyzed, there was an "alarming paucity" of well-designed studies that produced unequivocal results. He suggested the "outlook for moving from opinion-based to

fact-based decision making is bleak unless we quickly adopt a research strategy that incorporates adequate replication at the spatial and temporal scales most relevant to the natural and anthropogenic processes that operate within riparian landscapes."

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