Determining Methods to Evaluate Relations Between Livestock and Wildlife Grazing and Water Quality

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EXECUTIVE SUMMARY

The goal of this project was to assimilate information that may be used to design research that will evaluate relations between wildlife and livestock grazing on water quality in Wyoming. This report summarizes the published and unpublished literature on relationships between livestock grazing, wild ungulate grazing, and water quality in streams in order to provide technical assistance to the Wyoming Department of Environmental Quality and the U.S. Environmental Protection Agency. The emphasis in on the impacts of large hooved mammals on riparian systems and their contribution to non-point source pollution.

Specific objectives include:

1. Collect data currently available in both published and unpublished form on the impact of both livestock and wildlife grazing on water quality and riparian habitat.
2. Determine if such data are sufficient to develop a decision model that considers livestock AUM's and wildlife herd levels on a seasonal basis for the purpose of assessing non-point pollution when considering livestock and wildlife densities and their management.
3. Summarize data on wildlife foraging behavior, seasonal movement, winter feeding programs, and both natural and man-induced winter concentration of wildlife that might affect water quality.

4. Compare foraging behavior of various wildlife species in different riparian habitat types from available data in order to determine their relative influence on water quality.
5. Design field experiments based on data from Objectives 1-4 that could assess the impact of wildlife grazing on water considering:
   (a) seasonal and diurnal movements,
   (b) presence and absence of livestock grazing, and
   (c) various riparian habitat types present in Wyoming.
6. Recommend potential study sites in different riparian habitats that could be used to carry out field experiments.

Published and unpublished data regarding the impact of both livestock and wildlife grazing on water quality and riparian habitat were summarized. There are numerous reports that summarize impacts of livestock grazing on water quality, but few reports address the impacts of wild ungulates on water quality. The major non-point source pollutants that result from ungulate grazing are sediment, bacteria, and nutrients. Sedimentation is generally the most detrimental non-point source pollutant, whereas increased bacteria levels and nutrient loads from grazing may not have the far reaching impact on the stream ecosystem as sedimentation does. Ungulates grazing on riparian zones remove and trample vegetation which causes three types of change to water quality: (1) increased summer water temperatures, (2) reduced allochthonous inputs, (3) changes to the physical feature of the stream channel.

Results vary on water quality impacts related to livestock densities. Low densities generally yield little impact to riparian zones and water quality. Light to moderate densities yield variable results in the degree of water quality or riparian zone impacts. Several studies found that moderate to heavy densities resulted in measurable non-point source pollution. The majority of literature available on the impacts of wild ungulates to water quality and riparian zones pertained to elk (Cervus elaphus). Physical and behavioral characteristics of elk heighten the likelihood that they may cause impacts to water quality and riparian areas in Wyoming.

Published and unpublished data were summarized to evaluate the potential for the development of predictive models of the relationship of herd levels to non-point source pollution. The information available on both livestock stocking levels and wildlife herd levels was insufficient for designing predictive models of the relationship of animal densities to non-point source pollution.

The information on the affects of wild ungulates on water quality was too limited to determine how foraging behavior, seasonal movement, or winter feeding concentrations may influence water quality. It was not possible to assess the relative influence of wild ungulates and livestock on water quality in different riparian habitats with the information currently available.

RESEARCH DESIGN

Determination of the relations between livestock and wildlife grazing and water quality can be approached using two different experimental designs: (1) comparison of multiple field sites with differing levels of wildlife and livestock grazing, or (2) controlled experiments with known kinds and numbers of animals held in confined areas.

Comparison of several sites to determine relations between grazing and water quality is not a reasonable approach to research due to several limitations, the most severe being the ability to measure the past and present grazing intensity without error. The most scientifically sound approach to determining the relations between livestock and wildlife grazing and water quality is the use of controlled experiments. Such experiments will require extensive funding and long time periods to complete, but they are the only feasible approach to obtaining sound information.

State and federal agencies were contacted to identify potential field study sites and experimental sites for research. Thirty sites throughout the state were visited and evaluated according their potential as field or experiment sites. Seven field study sites and five experimental study sites were identified as potentially good areas to conduct future research.

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INTRODUCTION

The national concern about water quality due to non-point sources of pollution caused by various land uses has encouraged widespread research on the efficacy of current land management practices. In the West, and specifically in Wyoming, both livestock grazing and wildlife foraging are widespread land uses, and the interactions of these two uses of land on water quality is the focus of heated controversy among interest groups (Phinney et al. 1989, Platts 1979). The controversy is amplified by concerns over the degradation of riparian zones and fisheries habitat (Crouse 1989, and Behnke 1977, Armour et al. 1990).

A major requirement of each state's Non-point Source Management Plan is the inclusion of best management practices (BMP) for each category of land use (Wilkinson and Anderson 1989). A consideration in drafting grazing BMP's relative to non-point source pollution is properly factoring the influences of native ungulate grazing when calculating the impact of livestock density on water quality. This consideration involves evaluation of the use of seasonal ranges by native ungulate species both in competitive and non-competitive situations. Determination of the influence of native wildlife on water quality over a several year period can provide much needed data for establishment of BMP's associated with grazing and for the control of non-point source pollution.

The types of data available to correlate grazing practices with different land use practices are difficult to assess because wild ungulate grazing and livestock grazing usually occur in the same area (Thomas et al. 1978). Thus, the individual impact of one or the other cannot be separated. Coupled with this problem is the fact that livestock grazing may influence the behavior of wild ungulates, thereby altering the impact of wild ungulates on water quality (Crumpacker 1981). Seasonal concentrations of wildlife associated with changing weather patterns may also alter the impact of wildlife grazing on water quality.

GOALS AND OBJECTIVES

The goal of this project was to assimilate information that may be used to design research that will evaluate relations between wildlife and livestock grazing on water quality in Wyoming. We have summarized available literature and information on the impact of both livestock and wild ungulate grazing on water quality for the purpose of providing technical assistance to the Wyoming Department of Environmental Quality and the National Environmental Protection Agency. This information will be used to define quantitative relationships between ungulate and livestock grazing and water quality.

Specific objectives include:

1. Collect data currently available in both published and unpublished form on the impact of both livestock and wildlife grazing on water quality and riparian habitat.

2. Determine if data are sufficient to develop a decision model that considers livestock AUM's and wildlife herd levels on a seasonal basis for the purpose of assessing non-point pollution when considering livestock and wildlife densities and their management.
3. Summarize data on wildlife foraging behavior, seasonal movement, diurnal movement, winter feeding programs and both natural and man-induced winter concentration of wildlife that might affect water quality.
4. Compare foraging behavior of various wildlife species in different riparian habitat types from available data in order to determine their relative influence on water quality.
5. Design field experiments based on data from Objectives 1-4 that could assess the impact of wildlife grazing on water considering,
   (a) seasonal and diurnal movements,
   (b) presence and absence of livestock grazing, and
   (c) various riparian habitat types present in Wyoming.
6. Recommend potential study sites in different riparian habitats that could be used to carry out field experiments.

METHODS

We assimilated information from both the published and unpublished literature that address the known impacts of grazing on water quality. This was done to identify gaps in current knowledge and to determine specific research needs.

Two sources of information were used, published literature and the experience of professional managers. Published literature was identified through two data bases available through the U.S. Fish and Wildlife Service and several data bases available through the University of Wyoming. Searches of all pertinent data bases were conducted using a suite of key words. Additionally, Wildlife and Fisheries Review was searched. Pertinent articles were collected into a reference library and the information in them was abstracted on computer files for summarization. Personnel from all State and Federal resource management agencies in Wyoming that have responsibility for natural resources were contacted. Pertinent information that they identified, such as file data or project reports, were collected and summarized. Both published and unpublished information was used to address Objectives 1-4. Potential study sites were evaluated according to location, accessibility, willingness of management agency to permit research on the site, species of wild ungulates that utilize the site and the season of use, livestock grazing history, observed impacts on water quality caused by livestock or wild ungulate grazing, and size of the study area. Based on the literature review and evaluation of possible study sites, field experiments were designed to evaluate impacts of wildlife grazing on water quality.

ORGANIZATION OF REPORT

This report is organized into two chapters. Chapter 1 summarizes published and unpublished literature regarding the impact of livestock and wild ungulate grazing on riparian zones and water quality and addresses Objectives 1-4. Species of domestic and wild ungulates that may be affecting water quality are identified and specific impacts that may be occurring are discussed. Chapter 2 involves the design of experiments and addresses Objectives 5 and 6. Applicable study designs to assess the relations between livestock and wildlife grazing and water quality are discussed. A description and rating of potential study sites is given for each site that we evaluated. Sites with the highest potential for research are identified.

CHAPTER 1

Evaluation of Relations Between Wildlife and Livestock Grazing and Water Quality

The national concern over non-point source pollution has stimulated research on the efficacy of current land management practices. In the west, specifically Wyoming, grazing by livestock and wild ungulates are major land uses. Because grazing is a source of non-point source pollution, much controversy has arisen among interest groups over the interaction of these two land uses on water quality (Phinney et al. 1989, Platts 1979). The debate has become more heated because of heightened concern over the degradation of riparian areas (Crouse 1989, Behnke 1977, and Armour et al. 1990).

Each state is required to develop best management practices (BMP) for each category of land use as part of its Non-point Source Management Plan (Wyoming Department of Environmental Quality 1989). A consideration in drafting BMPs for grazing is properly factoring the influences of wild ungulates when calculating the impacts of livestock densities on water quality. This consideration evaluates seasonal ranges of wild ungulates in both competitive and non-competitive situations. Natural and human induced densities of wildlife must also be considered. Determining wildlife influences on water quality over a multi-year period will provide necessary data for establishment of BMPs associated with grazing and for the control of non-point source pollution.

Unfortunately, the data available to correlate grazing practices with water quality are difficult to assess because livestock and wild ungulates commonly use the same areas (Thomas et al. 1978). For example, the tendency of cattle to concentrate in riparian areas that are also used by ungulates makes it difficult to assess the respective impacts. An associated problem is the influence livestock have on the behavior of wild ungulates, thus altering the impact of wild ungulates on water quality (Crumpacker 1981).

There are numerous reports that summarize impacts of livestock grazing on water quality, but very few address the impact of wild ungulates (Platts 1979a, 1982a). A thorough literature review was needed to provide information for the design of field studies that can measure the impacts of livestock and wildlife grazing on water quality and the relative contributions of each to the nonpoint water pollution problems in riparian habitats (Nelson and Peek 1981).

In this chapter four of the project objectives are addressed:

1. Collect published and unpublished data on the impact of both livestock and wildlife grazing on water quality and riparian habitat.

2. Determine if the data are sufficient to develop a predictive model that considers seasonal livestock animal unit months (AUMs) and wildlife herd levels for assessing the contribution of grazing to nonpoint source pollution.
3. Summarize data on wildlife foraging behavior, seasonal movement, diel movement, winter feeding programs, and both natural and human-induced winter concentration of wildlife that might affect water quality.
4. Compare foraging behavior of wildlife species in different riparian habitat types from available data to determine their relative influence on water quality.

Two methods were used to gather the pertinent published and unpublished literature for the data summarization aspect of this report. The published literature was identified from data base searches, including Fisheries Review, Wildlife Review, and Fish and Wildlife Reference Service of the U. S. Fish and Wildlife Service. The data bases of the Habitat and Technical Support (HATS) Division of the Wyoming Game and Fish Department and the Wyoming Water Bibliography of the Wyoming Water Research Center were also searched. The reference sections of these articles were reviewed to identify other pertinent articles. Articles were collected into a reference library and the information was abstracted onto computer files for summarization. Others have published reviews of grazing and riparian literature (Cuplin 1987, Thomas and Wentzell 1986, and U. S. Environmental

Protection Agency 1979). These works were reviewed for pertinent articles.

The unpublished literature was obtained by soliciting professionals from federal and state agencies, societies, and other departments at the University of Wyoming for relevant information.

SECTION I - SUMMARY OF IMPACTS

Summary of Impacts of both livestock and wildlife grazing on water quality and riparian habitat (Objective 1).

Influence of Large Ungulates on Water Quality

Any pollutant that enters a stream from other than a discernible, confined and discrete source is considered nonpoint source pollution (Wyoming Department of Environmental Quality 1990). The impacts of range livestock and free roaming wildlife on water quality are considered nonpoint sources of pollution. The impacts caused by feedlot situations are point source pollution and will not be addressed in this report.

Because nonpoint source pollution is not discrete it is difficult to determine cause, especially in areas with multiple-land-use practices. Natural processes of erosion and sedimentation also contribute to changes in water quality and unless their levels are quantified, it is difficult to assess the contribution of other sources.

The major nonpoint source pollutants that result from grazing are sediment, bacteria and nutrients. Sedimentation is most detrimental in terms of associated biological and economic problems (Chesters and Schierow 1985, Crosson 1987, Robinson 1988). Increased bacteria levels and nutrient loads from grazing are of short duration and do not seriously impact water quality, except in situations of obvious overgrazing by livestock (Van Haveren et al. 1985).

Sediment

Sediment is detrimental to water quality and streams for many reasons (Lynch et al. 1977). Increased sediment loads cause changes in physical properties of the water, impacting habitat for stream flora and fauna. Increased sediment loads also alter stream morphology. Sediment functions as a reservoir for bacteria, nutrients, and chemicals. Sediment also interferes with human uses of water.

Sediment affects stream organisms while it is in the water column as suspended solids (turbidity), and after it has settled to the bottom (Lynch et al. 1977). Excessive levels of sediment can change species densities, species diversity, and community structure of a stream.

Groups of organisms in the food chain are affected by suspended solids (Cordone and Kelley 1961). Suspended solids decrease light penetration, effectively reducing photosynthetic rates of phytoplankton and periphyton, thus reducing the numbers of these primary producers. Decreased numbers of primary producers influences the populations of secondary consumers, ultimately changing the community structure of the stream (Windell 1983). Suspended solids also influence the thermocycles of the water column. Ellis (1936) found that as suspended sediments settle they interfere with the heat transmission of the water. The metabolic rates of aquatic organisms may be affected by change in these cycles.

Suspended solids have direct and indirect impacts on fish. Physiologically, the function of the gills is inhibited by the amounts of suspended solids in the water column. Vision is impaired by turbidity, thus affecting a fish's ability to capture prey items. Suspended solids also affects the drift behavior of macroinvertebrates (Gammon 1970) which are prey for fish.

Once sediments have settled, they cause different impacts on stream organisms than suspended solids. Sediment changes the complexion of the substrate as interstitial spaces become imbedded with fine sediment material (Cordone and Kelley 1961). Sediment covers gravel substrates, rendering these areas unsuitable as fish spawning habitat. When sediment covers redds the amount of gas exchange for the eggs is impaired, decreasing egg survival (Armour 1977). Duff (1977) found survival of chinook salmon and steelhead eggs was reduced when gravel interstices were filled with fines. Cover used by young of the year fish is reduced causing a decrease in the total population (Alexander and Hansen 1986). Imbeddedness also alters macroinvertebrate community structure because the habitat required for some species is lost (Nuttall and Bielby 1973, Alexander and Hansen 1983).

Sediment, in association with discharge and gradient, is a major component influencing stream morphology (Miller 1987). Although streams have the ability to adjust for changes in flow regimes and sediment loads, excessive sediment loads can damage a stream's ability to maintain its state of dynamic equilibrium (Apmann and Otis 1965). Changes in stream morphological characteristics, including channel width and bed form can result from excessive sediment loads.

Scour and deposition processes alter streams banks, thus altering stream width. In alluvial rivers the bank material, which is primarily wash load (fines transported with the same velocity as that of the water), is constantly being scoured and deposited (Einstein 1972). A stream channel is in equilibrium relative to sediment level when scour and deposition rates are equal. A stream not in equilibrium with its wash load will scour sediment from the banks if the wash load is low, and deposit sediments when the flow is insufficient to carry the load (Apmann and Otis 1965). Channel width change through scour and deposition is dependent on flow rates. When flow rates are low relative to stream width, aggradation at the banks results and the stream becomes narrower (Andrews 1982). Bank encroachment results in greater habitat uniformity. Restriction of flow to a narrower channel causes many habitat features such as undercut banks to be lost.

The stream bed form is also altered by excessive sediment. When sediment loads are in excess of the water velocity's ability to flush the stream system, deposition results (Foster and Meyer 1977). Sediment deposited along the bottom alters the contour of the bed form by filling in pools and backwaters. This process creates a more physically uniform stream and reduces habitat diversity.

Another detrimental characteristic of sediment is it acts as a reservoir of bacteria, nutrients and organic matter (Windell 1983). Sediment is derived from run-off and land erosion. Because of its source, sediment is high in organic material, and in areas that are grazed, bacteria and organic wastes contained in animal feces will enter the stream (Cole et al. 1986).

Kittrel and Furfari (1963) found that coliform organisms tend to adhere to suspended sediments and settle to the bottom. Acting as a sink for bacteria sediment may cause prolonged and heightened levels of bacteria in streams. Bacteria levels within the water column may diminish rapidly. But a storm event can causes re-suspension of bottom sediment triggering increased bacteria levels (Stephenson and Rychert 1982).

Sediment may act as a sink for organic matter and nutrients (phosphorous and nitrogen). Fredriksen (1972) found that a significant portion of nutrients entering streams are attached to eroded soil particles. Animal wastes are washed into streams as in run-off and may settle out of the water into sediments. Presence of these components accelerate the eutrophication process.

Sediment loads in streams also act as sinks for chemical substances (Ellis 1936, Auer and Auer 1990). The interface between the water column and the substrate is important for biochemical processes that take place in the stream ecosystem. At this interface, chemicals are often harmful because they can impact oxygen levels. Unsaturated chemicals result in oxygen depletion (Ellis 1936). Decomposition of organic matter at the water column substrate interface depletes oxygen causing toxic reduced chemical species to be produced including ammonia and hydrogen sulfide. Fish embryos in contact with contaminated sediments may have reduced viability (Auer and Auer 1990).

Sediment in streams is costly to humans both economically and socially (Crosson 1987). Both problems motivate the development of best management practices.

The economic problems created by excessive sediment loads include decreased water storage and reduction of sport fishing and recreation opportunities. Sediment loads inhibit water storage by filling in reservoirs, lakes, and irrigation ditches (Holochek 1980). Building sediment storage areas into reservoirs and sediment dredging processes are costs incurred from excessive sediment delivery. Revenues generated by sport fishing and associated economic benefits of tourism decrease when fishing opportunities are reduced by the destruction of fish habitat (Tiner 1984). Other recreational opportunities are lost when sedimentation from high water turbidity renders waters undesirable for body contact watersports (Fanning 1986).

Bacteria

Grazing animals increase levels of bacteria in streams from feces delivery (Tiedemann et al.1988, Gary et al. 1983, Milne 1976). Bacteria do not broadly impact stream ecology as sedimentation does. But they are detrimental to water quality. The major problem with high levels of bacteria are the dangers posed to human health. The presence of excessive levels of pathogenic bacteria renders water unsuitable to human consumption or contact (Hammer and MacKichan 1981).

Nutrients

As with bacteria levels, nutrient loading in streams results from inputs of ungulate excreta (Doran et al.1981, Schepers and Francis 1982). Nutrient loading does not have the far reaching impact on the stream ecosystem as sedimentation does (Johnson et al. 1978, Smeins 1975). The more significant impact of nutrient enrichment from grazing is the downstream cumulative impacts of eutrophication (Likens and Bormann 1974, Cole et al. 1986). Nutrients (primarily phosphorous and nitrogen) from animal excreta entering the stream may pass through the stream system with little impact, but provide increased nutrients to downstream bodies of water. Excess nutrient loading provided to aquatic vegetation results in increased photosynthetic rates followed by will diminish light transmission through the water. Decreasing light decreases photosynthetic rates, causing plants to consume oxygen for respiration, leading to oxygen depletion of the water (U. S. Environmental Protection Agency 1979). Decomposition of increased plant biomass also requires greater amounts of oxygen. Oxygen depletion from eutrophication impacts the ecological balance of the body of water (U. S. Environmental Protection Agency 1979) .

Riparian Zone

The preceding discussion of the major nonpoint source pollutants addresses grazing impacts in both the upland and the riparian zones. Large ungulate grazing in the riparian zone as well as the upland areas influences the quantities of sediment, and bacteria and nutrients from animal excreta that enter the stream. But some impacts to water quality and stream ecosystems are unique to grazing impacts on the riparian zone (Skovlin 1984). Riparian zones are defined as having a high water table and distinct vegetation and soils (Kauffman and Krueger 1984, Hansen 1988). They form transitional zones between the terrestrial and aquatic ecosystems (Ewel 1978). Because of their unique position as an ecotone between the two systems they are particularly important to the maintenance of water quality (Odum 1978). Animals grazing in riparian zones remove and trample vegetation (Severson and Boldt 1978). These activities promote the following three types of changes to water quality and the stream ecosystem: changes in water temperature, alteration of allochthonous inputs, and changes to the physical features of the channel.

Shading provided by riparian vegetation is important for regulating solar energy inputs to streams (Miller 1987). Removal or damage to vegetation overhanging the stream reduces shading, thus increasing water temperature (Meehan et al. 1977). Warmer water temperatures can reduce habitat for sensitive organisms such as salmonid species. Overhanging vegetation also provides cover to fish (Boussu 1954). Loss of this type of cover is equivalent to loss of fish habitat (Wesche et al. 1987).

Streamside vegetation is an important source of allochthonous detrital inputs to the stream, particularly in heterotrophic headwater streams (Knight and Bottorff 1984). Allochthonous inputs provide nutrition for fungi, bacteria and macroinvertebrates and are important for the energy flows within stream. Loss of these materials results in changes to the community structure of macroinvertebrates which are an important food source for fish (Armour 1977). Also, streamside vegetation supports many terrestrial insects that are important food sources to fish once they fall into streams (Armour 1977). These populations are impacted when streamside vegetation is altered by grazing.

Streamside vegetation removal and trampling alters bank stability, instream vegetation, and quantity of large woody debris that influence the physical features of the stream. Loss of streamside vegetation weakens bank structure because the binding of root systems no longer provides bank stability (Groeneveld and Griepentrog 1985). When vegetation is lost, banks are more susceptible to breakdown from animal movements and from erosional forces of the stream flow. Destablization of streambanks can result in breaking and sloughing of bank material into the stream (Marcuson 1969, Groeneveld and Griepentrog 1985). Stream morphology is changed by the resulting stream width increase and stream sediment contribution (Platts et al. 1985).

Another feature of riparian zones are overhanging banks. Overhanging banks provide cover for fish and influences stream morphological processes. In a study of eight small streams in southeast Wyoming, Wesche et al. (1987) found that overhanging banks were the most important cover type for trout. Also, vegetation on overhanging banks slows water flow and promotes deposition (Clifton 1989). Thus loss of overhanging banks from breaking and sloughing not only reduces an important component of fish habitat but also influences factors of stream morphological processes.

Large woody debris is an important component influencing stream morphology (Swanson et al. 1982). Sediment trapping, stream bank protection, routing of water and sediment, and creation of instream habitat structures such as plunge pools are functions of large woody debris in streams (Keller and Swanson, 1979). Loss of large woody debris in the stream may result in morphological changes.

Riparian vegetation is important as a buffer strip between the upland areas and the stream ecosystem (Meehan et al. 1977, Odum 1978, Miller 1987). It decreases the levels of sediment that reach the stream and is also a sink for nutrients (Omernik et al. 1981). Loss of riparian vegetation allows for greater delivery of sediment to the stream. The riparian zone functions in denitrification processes and in phosphorous demobilization

(Green and Kauffman 1989). Water quality is influenced by these biogeochemical functions of the riparian ecosystem. As the preceding discussion demonstrated impacts to stream water quality from large ungulate grazing, particularly sediment, bacteria and nutrients, have many ramifications for the stream ecosystem and for the socio-economic uses for human beings. To maintain water quality, standards have been established.

Water Quality Standards

Nonpoint source pollution standards for various streams in Wyoming differ based on the stream's classification. All streams are organized into a four class system based on water quality potential with 1 being the highest quality and 4 being the lowest (Wyoming Department of Environmental Quality 1990). The type of fishery that is supported by the particular water, warmwater or coldwater, and the level of body contact with the water are other rating categories used in conjunction with the four class system to define Wyoming waters.

Water quality standards that are associated with ungulate grazing impacts include those for: turbidity, settleable solids, fecal coliform bacteria, and dissolved oxygen. The standards set for each of these nonpoint source pollutants qualifies that the standards are set for degradation levels that are "attributable to or influenced by the activities of man" (Wyoming Department of Environmental Quality 1990).

The water quality standards for turbidity and settleable solids address the problems of sedimentation. Standards set for Class 1 and 2 coldwater fisheries type waters require that human activities not increase the turbidity more than 10 nephelometric turbidity units. In Class 3 waters and Class 1 and 2 warmwater fisheries waters, increases of 15 nephelometric turbidity units are allowable. The standards for settleable solids are less quantitative. In all Wyoming waters, sludge formation and bank or bottom deposition from human activities are not allowed if they affect the aesthetic value or other human uses of the water. Also, these impacts may not adversely affect the aquatic organisms, plant life, or wildlife.

The standards used to address the problem of bacterial loads that can be caused by grazing animals vary by water class and by rating of body contact. In all Class 4 waters levels of the indicator bacteria (fecal coliform bacteria) may not exceed a geometric mean of 200 bacterial groups per 100 ml sample year round. In waters classified as full body contact recreation waters the same standard applies for during the recreation season. For waters classified as secondary contact recreation waters, fecal coliform groups may not exceed a geometric mean of 1000 per 100 ml sample.

Dissolved oxygen levels can be impacted from ungulate grazing because of nutrients contributing to the process of eutrophication. The Department of Environmental Quality has designated specific standards for dissolved oxygen levels for Class 1 and 2 coldwater fisheries, and Class 3 and Class 2 warmwater fisheries. These standards are based on dissolved oxygen levels necessary for viability of different life stages. The standard deems that human activities may not introduce wastes harmful to aquatic organisms into waters.

Grazing may influence water temperature by the removal of vegetation that shades the stream. The Wyoming standards prohibit changing natural water temperatures by human activities. In Class 1 and 2 coldwater fisheries changes of more than 1.1 °C are not allowed. A change of more than 2.2 °C is not allowed in Class 3 waters or in Class 1 and 2 warmwater fisheries.

<u>Mechanisms of Impact by Grazing</u>

The degree of degradation by sediment, bacteria and nutrients to water quality is dependent upon delivery processes, primarily erosion and run-off (White et al. 1983, Cole et al. 1986). Coupled with the mobilization of nonpoint source pollutants are the actions of grazing animals that alter landscape features, thus, enhancing the delivery of pollutants to the stream (Marcuson 1977a). Before mobilization and the influence of grazing animals on nonpoint source pollution can be discussed, the importance of the riparian zone to maintenance of water quality must be reviewed.

Riparian Zone

By virtue of the riparian zone's proximity to the aquatic and the upland area it has the ability to directly influence stream water quality and to buffer streams from upland impacts (Meehan et al. 1977, Odum 1978).

Riparian zones directly influence instream water quality by their function in water storage, stabilizing banks, and sediment removal (Hansen 1988). Riparian areas store water during periods of increased flow and help to maintain water flow during low water periods. The bank storage function decreases the magnitude of flooding reducing the likelihood of excessive bank erosion. Riparian vegetation binds bank soils, enhancing bank stability and reducing bank erosion. When riparian vegetation is inundated by high stream flows it will trap sediment, increasing riparian soil and improving water quality (Clifton 1989). Also greater channel roughness is achieved helping to control water velocity. The slowing of water velocity by riparian vegetation hanging within the stream channel allows for deposition and helps to reduce erosion of the stream channel (Lowrance et al. 1985, Clifton 1989).

Sediment movement is regulated by riparian vegetation. Eroded materials contained in run-off from upland areas are effectively filtered by the riparian vegetation before entering the stream (Meehan et al. 1977). Riparian areas also act as sinks for nutrients from the uplands (Lowrance et al. 1985).

Besides water quality maintenance, riparian areas are integrated with nonpoint source pollution problems due to their relationship with large ungulates. Riparian areas are of disproportionate importance to both wildlife and livestock (Thomas et al. 1979). The greater abundance and palatability of forage, proximity to water, and availability of cover and shade increase the that 37 to 43 percent of Wyoming terrestrial wildlife species are to some degree dependent on riparian habitat for survival. Livestock preference for riparian areas over upland areas has been noted by many authors (Ames 1977, Kennedy 1977, Hansen 1988). Because the riparian zone is important in maintaining water quality and important for wild and domestic ungulates, a potential for negative impacts to water quality exists when animals overuse riparian areas.

Erosion

The primary mechanism by which sediment is delivered to streams is overland flow of precipitation (Foster and Meyer 1977, Meehan et al. 1977). This run-off mobilizes eroded soil particles and carries them into streams. Subsurface flow can deliver sediment but because velocities are low, this process is of little consequence (Statham 1977).

Many factors influence the quantities of soil that will erode and be mobilized by run-off, including climate, topography, ground cover, and soil (Foster and Meyer 1977). The activities of large ungulates alters the functions of ground cover in protecting water quality and also changes soil properties.

Vegetation influences hydrological processes including infiltration, interception of surface run-off erosion and deposition of soil components (Smeins 1975). Ground cover acts to protect the soil from the erosional forces of rainfall (Branson and Owen 1970, Buckhouse 1984a). Vegetation protects the soil by either preventing precipitation from reaching the soil or by buffering the impact of the rain drops. Upland vegetation can trap sediment mobilized by run-off. Bare soil not bound by vegetation nor protected from rainsplash by vegetation or litter, is more susceptible to erosion. The impact of rainsplash is higher on soils that are not protected by vegetation (Barrett 1984). The velocity of run-off is slowed by vegetation allowing more time for absorption. Vegetation also increases soil permeability allowing more water to penetrate (Statham 1977).

Soil properties also determine its erodibility. Moisture content, bulk density, and soil infiltration rates affect how efficiently precipitation will be absorbed rather than becoming surface run-off (Buckhouse 1984a). Trampling by large grazing ungulates compacts the soil, increasing bulk density of soil.

The resulting lowered infiltration rates cause increased run-off and erosion.

Bacteria

The mobilization of bacteria and nutrients from animal excreta is also due to run-off (Cole et al. 1986). Fecal material is eroded by precipitation and mobilized by run-off. The amount of mobilization depends on whether feces were deposited in a location where it would be susceptible to erosion (Cole et al. 1986). Also bacteria and nutrients associated with the soil will be eroded along with the soil. Thus the same factors that influence sediment delivery will also influence bacteria and nutrient loads. Omernik et al. (1981) states that many nutrients may eventually reach the stream by subsurface flow.

SECTION II - POTENTIAL FOR DEVELOPMENT OF A PREDICTIVE MODEL

Potential for development of a predictive model that considers livestock and wildlife contributions to non-point source pollution from available data (Objective 2).

Livestock

Study results vary on water quality impacts related to livestock densities. Low stocking levels generally yield less impacts to water quality. In the studies reviewed, stocking levels were commonly expressed in two ways, animal unit months (AUMs) or the proportion of available forage that is removed by animals. An

AUM is precisely defined as the amount of forage needed to support one cow and calf unit for one month, conversely, stocking levels are expressed as light, moderate, or heavy amounts of forage removal. These categories depend on geographic location. For example, an area that supports 5 AUMs at a moderate grazing level, may be considered as a heavy grazing level in a more arid region. Describing grazing levels as light, moderate, and heavy is a more broad definition that has common meaning across geographic locations.

Several studies found that moderate to heavy stocking levels resulted in measurable non-point source pollution. In central Idaho, heavy cattle stocking (0.26-0.43 ha/AUM) lead to bank instability and reduced streamside vegetation and undercut banks (May and Somes 1982). In northeastern Oregon, Kauffman et al. (1983b) found that cattle stocking at 1.3-1.7 ha/AUM in a riparian zone caused significantly increased streambank erosion, although riparian vegetation was not severely impacted. In south-central Utah, similar stocking levels of 1.2 ha/AUM resulted in increased stream widths and sedimentation, and decreased pool quality and overhanging banks in (Starostka 1979).

Studies with light to moderate stocking densities yielded variable results in the degree of water quality or riparian zones impacts. In northeastern Oregon, after 1 year of grazing at 3.2 ha/AUM, Buckhouse et al. (1977) found that sediment production was insignificant and fecal bacteria counts in run-off were acceptable , although infiltration rates were decreased. In another northeastern Oregon study, Buckhouse et al. (1981)

assessed the impacts to streambank degradation due to a moderate grazing level (3.2 ha/AUM); significant streambank loss could not be attributed to livestock grazing at this level. In southeastern Utah, Buckhouse and Gifford (1976) found fecal bacteria counts did not change significantly in fun-off at a grazing level of 2 ha/AUM compared to an ungrazed area. In southwestern Wisconsin, Sartz and Tolsted (1974) found that a moderate cattle grazing level resulted in increased run-off compared to an ungrazed pasture. Soil bulk density was higher in the grazed area.

Generally, heavy grazing levels result in damage to riparian zones and affect water quality. High grazing levels are likely to alter the hydrologic qualities of the soil including soil loss, infiltration rates, and bulk density (Dunford 1949, Rodgers 1981, Blackburn et al. 1982).

Light and moderate grazing levels results were variable. It is difficult to make comparisons of studies that use AUMs because of environmental differences among areas. Also, some studies did not indicate if the grazing level was considered to be light or moderate a review by Blackburn et al (1982) concluded that light and moderate grazing levels are not significantly different from on another in their impacts on hydrologic qualities of the soil, while Rauzi and Hanson (1966) found a linear relationship between the level of grazing and the amount of run-off produced and water intake rates. In western South Dakota, Hanson et al. (1970) found that infiltration rates were significantly higher in the lightly grazed pasture versus the moderately and heavily grazed pastures.

Because of the importance of vegetation in maintaining water quality by providing soil stability, reducing erosion, trapping sediment, and protecting soil from eroding forces, the amount of vegetation remaining after livestock grazing has been used as a management indicator of water quality. Several authors have recommended that light to moderate grazing levels (at least 70% if the plant cover must be left unutilized), is effective in minimizing soil erosion and maintaining soil infiltration rates (Packer 1953, Smeins 1975). Heavy grazing (> 35% of the vegetation removed) is significantly more detrimental by decreasing infiltration rates and increasing erosion (Dunford 1949, Rauzi and Hanson 1966).

Translating levels of unutilized vegetation into AUMs would require knowledge of the consumption of forage by livestock a particular area. The impact of any given stocking level depends on a particular area's ability to withstand grazing pressure.

Amounts of available to livestock differ from place to place. This causes difficulties in predicting stocking levels that would minimize non-point source pollution.

The timing to grazing also influences the level of impacts on water quality and riparian zones. Grazing levels that maintain water quality and minimize impacts in one season may not have the same affect at another time due to seasonal trends in soil moisture (Marlow et al. 1987, Pogacnik and Marlow 1983). A particular grazing level may have less impact during the late dry season than the same level during wetter times of the year. Time of year and duration of grazing in the riparian zone may be more important than the actual number of grazing animals (Marlow and Pogacnik 1985, Marlow et al. 1989).

The proportion of riparian zone in an area also influences the grazing level that is appropriate. A grazing level in an allotment where livestock have access to a riparian zone versus an allotment where access to the riparian zone is limited may result in varying level of water quality and riparian zone degradation. Also, preference of different types of riparian areas by livestock varies, putting more pressure on certain vegetation types (Kauffman et al. 1983a).

Cattle prefer riparian zones, causing difficulties in defining stocking levels. The amount of available forage, the time of foraging, and desirability of the riparian zone influence the likelihood of cattle congregating in the riparian zone (Hayes 1978). Setting an adequate grazing level that will maintain infiltration rates and minimize erosion in the upland portion of an allotment may still result in negative impacts to water quality if livestock are permitted to spend large amounts of time in the riparian portion of an allotment (Platts and Nelson 1985d).

An alternative to recommending AUM levels for minimizing impacts to water quality is to use levels of forage removal (Gifford and Hawkins 1978). Treating riparian zones as separate or unique portions of an allotment when prescribing stocking levels that consider the amount of stream length accessible per AUM may have greater utility as management criteria for controlling non-point source pollution than the method of using AUMs (Kauffman et al. 1983b).

Wildlife

Information currently available on the impacts caused to water quality by wildlife is insufficient for generating predictive models of the relationship of herd levels to non-point source pollution. The small amount of literature found on the subject does not the numbers of animals present in either natural or human-induced situations.

The information on the affects of wild ungulates on water quality is too limited to make speculations on how their foraging behavior, seasonal movement, and winter feeding concentrations might be influencing water quality. Also, it is not possible to assess the relative influence of wild ungulates on water quality in different types of riparian habitats with the information available. The majority of the literature reviewed on the impacts of wild ungulates to water quality and riparian zones pertained to elk. Although quantitative data was not available, several authors have described impacts to riparian vegetation caused by elk (Weinstien 1979, Patten 1988, Skates 1988). Physical and behavioral characteristics of elk heighten the likelihood that they could cause impacts. Their gregariousness, seasonal preference for wet meadows and riparian habitats, and large size make them a species of interest when considering wild ungulate species that would be likely to cause impacts to water quality and riparian areas in Wyoming.

SECTION III - SUMMARY OF INFORMATION ON IMPACTS OF LIVESTOCK AND WILDLIFE

Summary of information on the affects of seasonal movement, diel movement, winter feeding programs, and winter concentrations by wildlife on water quality (Objective 3). Foraging behavior of wildlife in different riparian habitats and the influence on water quality (Objective 4).

Objectives 3 and 4 have been addresses in a single section because of the overlapping nature of the two objectives. Wildlife foraging behavior, seasonal movement, diel movement, and winter concentrations of most of the species in Wyoming involve riparian habitats. Combining the two objectives avoids substantial redundancy in the presentation.

Activities of large ungulates grazing in both upland areas and in the riparian area influence the quantities of sediment, bacteria, and nutrients in streams (Skovlin et al. 1977). Grazing animals impact the landscape by three mechanisms: consumption of forage, trampling, and deposition of excreta (Smeins 1975).

Consumption and trampling by large ungulates reduces plant vigor and vegetative production (Winegar 1977). Decreasing vegetation negates the functions that vegetation preforms in preventing soil loss (Packer 1953). The ability of vegetation to binding soil, reduce rainsplash, and trap sediment is reduced by large ungulates.

Soil structure is changed by trampling of large ungulates (Bohn and Buckhouse 1985b). The weight of ungulates causes soil compaction which increases the bulk density of the soil and reduces infiltration rates (Rauzi and Hanson 1966). Run-off rates are altered by these changes to soil. The combination of trampling and vegetation removal by grazing ungulates changes the amount of bare soil exposed to precipitation (Packer 1953). This can result in increased amounts of soil loss to erosion (Toy and Hadley 1987).

The riparian zone impacts from ungulate activities are more profound than in the uplands because it is the last terrestrial area that run-off crosses before entering the stream (Bohn and Buckhouse 1985a). Trampling and vegetation consumption reduces the effectiveness of the riparian vegetation's ability to trap sediment from upland runoff.

When activities of ungulates make soil available for transport in the riparian zone, the soil particles have a shorter physical distance before they reach the stream, thus they are more likely to enter the stream. As in the upland, trampling in the riparian zone compacts soil, reducing infiltration rates. But because riparian soils tend to be moister due to the high water table, flatness of the floodplain, and water received from the upland, they are more prone to compaction (Bohn and Buckhouse 1985b). Soil compaction can interfere with the water storage function of riparian zones (Lowrance et al. 1985).

As with sediment delivery, dung deposition in the riparian zones means a short physical distance that it must be mobilized. Thus increasing the likelihood that it will contribute to bacteria and nutrient levels of the stream. During periods of high run-off, streams that have exceeded bank full conditions wash dung from the riparian zone, increasing the amount of bacteria (Skinner et al. 1984) and nutrients delivered to the stream.

Information regarding water quality impacts and related degradation processes caused by large ungulates (livestock and wildlife) was presented in general terms as both may cause similar impacts in upland and riparian areas and subsequently affect water quality (Claire and Storh 1977). The level of impact and processes by which impacts occur do vary depending on the type of ungulate. Specific information available on each of the major large ungulates in Wyoming is presented.

Impacts of Livestock

Studies that assess the impacts of large ungulates on water quality are more numerous for livestock than for wildlife species. In Wyoming, livestock of greatest concern regarding impacts to water quality are cattle (Bos taurus), sheep (Ovis aries) and horses (Equus caballus). Most studies are concerned with impacts caused by cattle. The terrain and diet that cattle prefer and other behavioral characteristics influence the magnitude of their impacts on water quality.

Cattle

Cattle prefer flat or gently sloping terrain (Mueggler 1965, Stevens 1966, Mclean and Williams 1982). Bryant (1982) reported that cattle prefer slopes of less than 35%, and as slope increases cattle use decreases. In a study in north-central Montana, Allen (1968) reported that cattle utilized bottomlands in all seasons.

Cattle primarily graze on graminoid species when available (Hansen and Reid 1975, Hubbard and Hansen 1976). Hurd and Pond (1958) identified Idaho fescue (Festuca idahoensis), bluegrasses (Poa spp.), and sedges (Carex spp.) as the important species in the diets of cattle in the Big Horn Mountains, Wyoming. In a study in the Piceance Basin, Colorado, Hubbard and Hansen (1976) identified seven graminoids and one shrub species as the principle forage species of cattle. A study in Douglas Mountain, Colorado (Hansen et al. 1977) rated needlegrasses (Stipa spp.), wheatgrasses (Agropyron spp.) , and brome (Bromus spp.) as the major forage species of cattle.

Shrub species are also important in cattle diets. As the palatability of herbaceous species decreases through the season, use of shrub species increases (Roath and Krueger 1982). Allen (1968) found that browse species were more prevalent in cattle diets during the winter, probably because snow cover decreased availability of preferred grasses.

In general, cattle prefer riparian areas because of the topography, variety of forage, and availability of shade, water, and thermal cover (Ames 1977, Gillen et al. 1985). The combination of cattle preference for riparian areas and the importance of these areas for maintaining water quality accentuates the problems caused to water quality.

The affinity of cattle for flat or gently sloping terrain corresponds to their disproportional occupation of riparian zones (Severson and Boldt 1978, Platts and Nelson 1985b). Gary et al. (1983) determined that cattle spent 65 % of their time within 100 m of the stream in a study in the Front Range of Colorado. Roath and Krueger (1982) noted that cattle utilized the riparian zone rather than slopes through the grazing season even though forage became progressively reduced. Goodman et al. (1989) noted heavy use of riparian areas by cattle, but determined that riparian use never exceeded 45 % of the available grazing area.

Cattle prefer riparian vegetation to upland vegetation (Ames 1977, Dwyer et al. 1984). Riparian zones have greater plant biomass and species diversity (Bedell 1984). Also, the vegetation stays green longer and has a higher water content, making it more palatable for a greater period of time (Ames 1977, Schmidly and Ditton 1978, Bedell 1984). Platts and Nelson (1985b) found that (92 % of observations) streamside vegetation use by cattle was twice as heavy as that of the adjacent range.

Cattle usage of riparian zones differs by season (Kinch 1989, Clary and Webster 1989). The summer growing season is the time of greatest use of the riparian zone because forage palatability and variety are at their peak (Goodman et al. 1989). Shade and water are most critical to cattle during the warmest part of the season. In southwestern Montana, Marlow and Pogacnik (1985, 1986) found that riparian zone use by cattle increased over upland use from late June to August with the last half of the season being equal between the two areas.

Cool season grass species in the uplands are more palatable in the fall, thus, cattle may shift usage to the upland in this season (Kinch 1989). Also shade and water are less important in the fall than in the summer. In a study in southwestern New Mexico, Goodman et al. (1989) determined that cattle moved from the riparian zone after the vegetation became dormant and the only green vegetation was upland evergreen species.

Winter usage of riparian zones by cattle often is decreased because of deep snow that cattle avoid (Platts and Raleigh 1984, Knopf and Cannon 1982). Also, the micro-climate of the riparian zone may be colder in winter. Conversely, Allen (1968) found that cattle used the bottomland most in the winter. An explanation would be that vegetation is dormant in the winter, but there may still be available browse species in the riparian zone. Thus, winter usage is dependent on snow depth, temperature, and plant communities.

Spring usage of riparian zones by cattle may be highly variable. Cattle may be distributed between the riparian zone and the upland because of forage availability in the uplands and spring flooding may preclude usage of the riparian zone (Kinch 1989). Other parameters that dictate cattle usage of the riparian zone are their need for water and shade, and their general lack of dispersal behavior (Bryant 1982). This causes cattle to congregate in riparian zones, increasing the likelihood of impacting water quality.

Many authors state that over-utilization of riparian zones by cattle results in damage to the riparian habitat and to water quality (Platts 1981a, Platts and Nelson 1985a, Mizell and Skinner 1986, Thomas 1986). Many of the statements that attribute cattle grazing to riparian degradation and water quality degradation are based on comparison studies of grazed versus non-grazed areas. Observations of recovery of areas from which cattle have been removed have been used to make inferences regarding damage caused by cattle.

Livestock grazing is related to run-off, erosion, and sediment (Packer 1953, Van Haveren et al. 1985, Platts and Meehan 1977). The parameters that influence run-off, including soil bulk density, infiltration rates, and ground cover are also affected by cattle grazing and trampling (Rauzi and Hanson 1966). In a northern Colorado riparian zone, Leininger and Trlica (1986) found that bulk densities averaged 21 % higher in areas grazed by livestock versus protected areas. Buckhouse et al. (1977) and Sartz and Tolsted (1974) noted improved infiltration rates.

A study by Rauzi and Hanson (1966) evaluated the influences of grazing levels and vegetation cover on water run-off in mixed prairie in South Dakota. They found that water intake rate decreased as grazing intensity increased and that annual run-off was greatest from heavily grazed watersheds and least from lightly grazed watersheds. Differences in soil bulk density and soil pore space between the grazing levels were significant. The authors concluded that heavy grazing can change soil properties including decreasing the pore spaces and increasing bulk density.

Because of alteration of soil properties by cattle grazing, run-off levels and soil erosion are affected. In a study of different grazing levels in a Colorado pine-bunchgrass range, Dunford (1949) noted an increase of 210 and 325 % in moderate and heavy grazing areas,respectively, compared to a control area. The amount of soil eroded from control areas was approximately half the amount yielded from the heavily grazed area, but no change from the control area was noted in the moderately grazed area.

In the Badger Wash Basin of western Colorado, Lusby (1970) found that run-off was directly related to the amount of bare soil.

Grazed watersheds were compared to watersheds where cattle and sheep were removed. After 2 years, the grazed watersheds averaged 30 % more run-off than the ungrazed. Also the ungrazed watersheds yielded 45 % less sediment. The greatest differences in sediment were noted after 3 yr of cattle exclusion, with the grazed watersheds averaging 51 % more run-off than the ungrazed watersheds (Lusby et al. 1971). In a southwestern Wisconsin study, Sartz and Tolsted (1974) also reported reduced run-off levels following 3 years of cattle exclosure.

Duff (1977) documented differences between stream sections within an area exclosed from livestock and two grazed areas in northeastern Utah. Both grazed stream sections had increased sediment loads possibly because of grazing in upstream areas. In a canyon section of Buffalo Creek, Wyoming, Rockett (1974) observed that the number of silt bars increased, and silt covered riffle gravel and filled in pools, in an area grazed by cattle. Streambanks were in poor condition due to overgrazing and trampling by cattle.

Impacts to stream channels and streambanks can result from cattle grazing in the riparian zones (Kauffman et al. 1983b, Marlow et al. 1987). In a comparison study in Rock Creek, Montana, Marcuson (1977a) reported 80% more stream channel instability in an area grazed by cattle at 0.27 acres/AUM than an ungrazed area. The general channel morphology of the ungrazed area was unchanged, while the grazed area was unstable and constantly shifting.

Duff (1977) reported alteration of stream width, stream depth, and pool depth due to cattle and sheep grazing in Big Creek, northeastern Utah. While average stream depth within the areas exclosed to cattle and sheep decreased, the stream width within the grazed area increased in each year of the 2 yr study. The exclosed area had mean a depth of 33 cm in the four years of the study as compared to 8 cm in the grazed areas. Likewise, pools within exclosed area had decreased depth because of channel movement and siltation caused by livestock grazing and trampling.

Van Velson (1979) reported the results of a recovery study in which changes to the stream were noted after cattle were removed from Otter Creek, Nebraska. Decreases in stream width were noted as well as increased velocity which helped to flush accumulated sediment from spawning gravel. The stream channel became more variable with more riffle/pool sequences. Similar results were reported by Smith (1982).

In a study by Platts et al. (1983), differences between cattle grazed and ungrazed stream sections in western Nevada were compared. In the ungrazed areas the channel width was narrower and the water depth was greater than in the grazed area. Also bank undercuts were more abundant in the ungrazed areas, indicating a greater degree of bank stabilization. Similar results were noted in a study on Big Creek, Utah (Platts and Nelson 1985c).

Cattle also impact riparian vegetation, reducing its effectiveness in maintaining water quality. In a study of western streams, Platts and Nelson (1985c) found that cattle consistently used forage in the riparian areas more than the upland and that this use was frequently heavy (76 to 100% forage removal). Although sheep were also present in the study area, cattle were the primary users of the riparian zone. Similar results were reported by Platts et al. (1983) in Tabor Creek, Nevada.

In a Colorado riparian willow community, cattle were observed to find shade under the willows causing breakage of lower branches (Knopf and Cannon 1982). Lower branches are also removed by grazing. Rickard and Cushing (1982) noted negative grazing impacts on the riparian willows in south central Washington from cattle, sheep and horses. Young willow shoots were persistently grazed, leading to a generally sparse and discontinuous vegetation in the riparian corridor.

Duff (1977) described the riparian vegetation as almost completely eliminated by cattle along Big Creek, Utah. No instream shade or cover was provided and bank stability was poor.

In another Big Creek study, Platts and Nelson (1985a) indicated that bank stability and riparian vegetation and overhanging vegetation were rated significantly higher in the ungrazed area than the grazed section. Others have reported improvements to riparian vegetation after cattle have been removed (Van Velson 1979, Rinne 1988).

Cattle grazing alters stream habitat characteristics including width, depth, pools, and substrate size (Hubert et al. 1985). Impacts to stream habitat from cattle grazing will ultimately impact fish populations. Keller and Burnham (1982) reported trout species preferred the habitat in ungrazed areas compared to grazed areas in all habitat types sampled.

A study of Rock Creek, Montana showed that a grazed area had an inferior fishery compared to an ungrazed area (Marcuson 1977b). In estimates of trout biomass, the ungrazed area yielded 317 % the trout biomass per acre than the grazed area. The grazed areas actually supported greater numbers and more biomass because of the large numbers of whitefish and suckers present.

Prior to exclusion of cattle, rough fish composed 88% of the fish population of Otter Creek, Nebraska (Van Velson 1979). After exclusion, rainbow trout composed 97% of the population. Similarly, ratios of brown trout to rough fish steadily improved by the removal of grazing animals and streambank improvements in

Blue Creek, Montana (Marcuson 1969).

Cattle grazing on rangeland generally does not cause high enough levels of fecal inputs into streams to affect water quality degradation. Levels of contamination are dependent on the intensity and duration of cattle grazing. Grazing at low to moderate levels did not result in high bacteria levels in streams (Buckhouse and Gifford 1976, Buckhouse et al. 1977, Gary et al. 1983).

Also, proximity of cattle to the stream determines the level of impacts to water quality. Cattle grazing adjacent to streams causes greater impacts to water quality (Buckhouse and Gifford 1976, Milne 1976). Unless animals are defecating directly into the stream or adjacent to the streambed, bacterial contamination is unlikely (Buckhouse and Gifford 1976). A study of a western Montana stream concluded that in a cattle and sheep winter grazing situation little bacterial impact existed on stream sections that were unaccessible to the livestock (Milne 1976).

Run-off affects delivery of animal wastes to streams (Jawson et al. 1982). In a study by Saxton et al. (1983), fecal coliform and fecal streptococcal bacteria increased from a cattle grazed area with run-off levels in the spring after animals were removed. In Big Creek, Utah, Duff (1977) noted that bacteria levels from grazed stream reaches were generally low except during a period of heavy rains which increased run-off levels.

Nutrients levels in streams are not increased significantly within rangelands where cattle grazing occurs (Milne 1976, Gary et al. 1983). As with bacteria, Duff (1977) found nitrate and phosphate levels associated with cattle grazing in the bottomlands to increase with run-off, but water quality remained acceptable.

In the studies reviewed, it is clear that levels and intensity of cattle grazing influence water quality degradation (Rauzi and Hanson 1966, Buckhouse et al. 1981, Buckhouse 1984a). Definitions of grazing level are variable because of climatic and vegetative factors. A general rating for cattle grazing levels defines light grazing as 67 % of the previous years growth remaining (1 AUM/6 acres), moderate 33 % to 66 % of the previous year's growth remaining (AUM/1.35 acres), and heavy as < 33 % of the previous year's growth remaining (1 AUM/fraction of an acre) (Kirsch 1969).

Heavy grazing can severely impact riparian areas (Dahlem 1979, Rodgers 1981, Wood and Blackburn 1981), but the impacts of moderate and light grazing are poorly defined. Several authors have noted impacts caused at light and moderate grazing levels are not significantly different (Gary et al. 1983), and only heavy grazing causes detrimental impacts to riparian zones and water quality (Platts 1981a).

To control livestock use of the landscape and reduce over use of forage, different types of grazing strategies have been developed, but primarily for upland areas (Platts and Nelson 1985d, Platts 1989). The usefulness of different strategies in reducing the impacts to riparian zones is variable (Platts 1984, Clary and Webster 1989). Literature on the major types of grazing strategies and the level of protection from impacts has been extensively reviewed by Bryant et al. (1982), Gifford and Hawkins (1976) Meehan and Platts (1978), and Platts (1981a). If designed without consideration of cattle affinity for riparian areas, grazing strategies do not enhance protection of riparian zones and water quality (Platts 1986).

Sheep

The second class of livestock of concern to riparian integrity and water quality are sheep. Because of their behavior, size, and management, sheep do not cause the same degree of impacts to riparian zones and water quality as cattle (May and Somes 1982). Sheep do not have as great a preference for riparian areas as cattle. They prefer steeper slopes and tend to spend more time in upland areas (May and Somes 1982). This behavior causes them to be less intrusive to the riparian zone.

Like cattle, sheep diets consist primarily of graminoid species, but forbs are also important food items (McMahan 1964, MacCracken and Hansen 1981). Sheep also utilize browse species. Olsen and Hansen (1977) report that saltbush was the most important species to sheep in all seasons except summer in the Red Desert, Wyoming. Sheep will browse on the new willow growth in riparian areas when forage in the upland is less palatable (Kinch 1989).

Because of their small size, sheep cause less trampling damage to soil and ground cover. The way they forage, by nibbling, prevents pulling and dislodging of entire plants as cattle and horses tend to do. Sheep also are not prone to breaking down willow as cattle (Kinch 1989).

Sheep are managed differently than cattle. When properly herded, sheep do not have the opportunity to spend great amounts of time in the riparian zone. Thus, the likelihood of damage to the riparian zone is limited (Platts 1981a, May and Somes 1982, Kinch 1989).

Sheep have not been addressed as thoroughly in the literature regarding riparian zone and water quality impacts as cattle. In a study by Platts (1981a) an Idaho riparian area heavily grazed by sheep resulted in impacts similar to those caused by heavy riparian cattle grazing. Significant changes to streambanks, channel, and riparian habitat were reported. Fish density and biomass also declined. In the same study, sheep under herding had only periodic and limited access to the riparian zone. No significant changes to the stream ecosystem were reported.

Horses

Little information on the impacts of either domestic or wild horses to riparian areas and water quality is available. Perhaps horse grazing has not been noticed as a problem because they do not congregate as cattle and sheep do (Kinch 1989). Also, large horse operations are not as common as cattle and sheep ranching. In a study in central Wyoming, Hubert et al. (1985) noted the good condition of the riparian zone and the stream in a pasture grazed by horses and wildlife.

Impacts of Wildlife

Because the riparian zone is important to large wild ungulates (Gerhart and Olsen 1982, Thomas et al. 1979), concern has arisen that these animals may also impact riparian zones and water quality. If large wild ungulates use the landscape in a manner similar to livestock, impacts to riparian zones and water quality would be likely. For instance, trails caused by wildlife would be as susceptible to erosion as livestock trails (Clark 1980). Presently, literature which substantiates damage to riparian zones and water quality caused by large wild ungulates is limited.

Generalized comments that wild ungulates impact riparian zones and water quality have been made. Mizell and Skinner (1986) stated that wildlife grazing and browsing can accelerate erosion and streambank loss. Skinner (1986) suggested that livestock have merely replaced wildlife. He also stated that prior to settlement of the West by europeans, herds of wild grazing ungulates were impacting streams and that riparian systems of today are more vast than at that time. Bedell (1984) commented that the impacts caused to riparian areas are similar between livestock and wild ungulates, but information pertaining to wildlife was not presented. Buckhouse (1984b) noted that riparian areas receive heavy browsing and grazing pressure from both wild and domestic ungulates, especially in semiarid and arid regions.

General statements that wildlife do not cause impacts to riparian zones or water quality have also been made. Meehan et al. (1977) stated, "Wild ungulates also use the riparian zone, but their presence is much less noticeable than that of cattle and sheep." While livestock were reported as removing 29 - 40 % more vegetation from the riparian zone that from uplands, Platts and Nelson (1985d) reported that "wildlife use was trivial".

Limited information is available on the impacts caused by large wild ungulates. Wildlife are typically addressed in antidotal comments made during livestock impact studies, where the intent was not to quantify wildlife impacts.

In a study to assess the impacts of cattle grazing on riparian plant communities, Kauffman et al. (1983a) stated that use of willow-dominated gravel bars by cattle ranged from 27-48% removal and succession appeared to be retarded. In the same area, wild ungulates utilization was always < 5 %.

During a study of the influence of different grazing levels on trout streams, Hubert et al. (1985) observed that a study area accessible to wild ungulates and horses had a heavily vegetated riparian zone with stable, vegetated banks. Likewise, Van Velson (1979) found that recovery of riparian vegetation, after exclosure of livestock, made the area more attractive to wildlife. The increased use of the riparian area by large wild ungulates, did not result in observable degradation of the riparian area.

While trying to locate undisturbed sites within Wyoming to study riparian habitat, Olsen and Gerhart (1982) noted wildlife concentrations had effected the pristine nature of some sites, but evidence of livestock grazing was present in almost all of the sites.

Several studies have attempted to assess impacts caused by large wild ungulates. In a study of bank retreat from grazing of livestock and big game, Bohn and Buckhouse (1986) found that livestock grazing areas accessible to big game had significantly greater bank retreat than areas where big game was exclosed. They stated numerous limitations of the study including the lack of quantitative data on big game animal numbers and small experimental areas.

Another study by Bohn and Buckhouse (1985b) attempted to assess impacts of cattle and big game on riparian soils. Soil compaction increased significantly in the areas that were accessible to big game. The study design was problematic because pastures accessible to big game had less riparian area for use by livestock than the pasture from which big game were exclosed. They stated that comparisons based on big game may not be valid because the pasture sizes were not equivalent in terms of the amount of riparian area available. Also, big game numbers were not measured.

Several studies have attempted to measure changes in bacteria levels caused by large wild ungulates using ratios of fecal coliform to fecal streptococci. Although the ratios can distinguish between livestock, human recreation, and wildlife contributions, the technique is of questionable value as these indicator bacteria may not reflect behavior of the pathenogenic bacteria (Bohn and Buckhouse 1985a). While increased levels of indicator bacteria have been attributed to wildlife (Skinner et al. 1974, Doran et al. 1981), it is not possible to determine the contribution of large wild ungulates because the ratio includes the contributions of all wildlife including small mammals and birds.

Habitat use, diet, and behavior influence the degree of impact wild ungulates have on water quality and riparian zones. The degree of competition between large wild ungulates and livestock, both dietary and behavioral (Julander 1958), may affect impacts that wildlife may have on water quality and riparian zones. In Wyoming, large wild ungulates that may cause impacts to water quality and riparian zones are: elk (Cervus elaphus), mule deer (Odocoileus hemionus), white-tail deer (Odocoileus virginianus), and pronghorn antelope (Antilocapra americana). Of lesser concern are bison (Bison bison), moose (Alces alces), and bighorn sheep (Ovis canadensis).

Elk

Elk occur throughout Wyoming (Clark and Stromberg 1987). They are most typical of mountain meadows and prefer coniferous forests for cover (Nelson and Burnell 1975). Generally, elk are gregarious (Mackie 1970). In the winter they form herds, while in the summer they travel either singly or in small groups. Elk are migratory animals with winter being the time of greatest movement and summer being the least. Thus their use of the landscape varies with the seasonal pattern of their movements.

In general, the seasonal physiographic areas used by elk are upland summer range, mid-level transitional range during spring and fall, and lowlands in the winter (Skovlin 1975). In summer, elk use ridges and plateaus, but as summer progresses and vegetation becomes increasingly dry and temperatures increase, elk will use forest understory and moist meadows. Wet meadows and riparian habitats are preferred in summer (Campbell and Knowles 1978, Roberts and Becker 1982). The use of forests increases through the fall. In winter, elk congregate into larger herds and their use of cover diminishes.

Elk prefer slopes of > 10 ° with use of slopes up to 30 to 40° (Skovlin 1975, Mackie 1970). Although elk prefer slopes regardless of season (Skovlin 1975), they also use riparian habitat in late summer because of forage availability. Riparian areas are important as travel routes. Gerhart and Olsen (1982) state that elk use a variety of riparian habitats and that they commonly forage in riparian zones. In a study of tame elk in northern Utah, Collins et al. (1978) stated the preference that elk had for riparian areas. Riparian wet meadow areas within a lodgepole pine (*Pinus contorta*) habitat were used by elk for foraging and resting.

Another behavior that may influence seasonal use of riparian zones is wallowing, a rutting-season behavior of bulls (Lyon and Ward 1982). This behavior could be damaging to streambeds, but because this event is limited to a few animals within a herd and only in the fall it is doubtful that a sustained impact occurs. Skovlin (1975) reviewed literature on the proximity of elk to water. Although most studies show that distribution is under 1.2 km, the relationship of elk proximity to water and use of riparian zone is unknown.

Elk diets are variable; consuming grasses, forbs, and shrubs depending on availability. Spring diets are primarily grasses, while summer diets consist of both grasses and forbs. Shrubs are used in all seasons, particularly in winter when grass availability is low (Clark and Stromberg 1987).

Elk are grazers at most times of the year (Kufeld 1973). In winter, grasses or shrubs are used most depending on availability. Spring diets consist mainly of grasses. Forbs gain importance in the summer. In the fall, grass regains primary importance and shrub use becomes more frequent (Kufeld 1973, Miller and Vavra 1982). A survey of elk diet studies (Kufeld 1973) ranked the most used summer forbs as <u>Agoseris glauca</u> and <u>Geranium viscossimum</u>. The most valuable grasses were <u>Agropyron spicatum</u>, <u>Carex geyeri</u>, <u>Festuca idahoensis</u>, <u>Festuca scabrella</u>, and <u>Poa</u> sp.
Elk browsed more frequently in the aspen, willow, and wet meadow communities than in other vegetation types (Hobbs et al. 1981). Browse species of greatest importance to elk include <u>Amelanchier alnifolia</u>, <u>Ceanothus sanguineus</u>, and <u>Ceanothus velutinus</u>, <u>Populus</u>

tremuloides, Prunus virginiana, Purshia tridentata, Quercus gambellii and Salix spp. (Kufeld 1973).

Several studies have described the impacts to vegetation caused by elk. The Gros Ventre drainage in western Wyoming is used by elk as a winter feeding ground, where elk diets are artificial supplemented to reduce elk mortality. Riparian vegetation is absent along Flat Creek within the refuge because of grazing by wintering elk (Skates 1988). The elk heavily impact the aspen ecosystem by browsing and removing bark in early and late winter (Debyle 1979, Gruell 1979). Aspen regeneration and community successional processes are being hindered. Similar damage to aspen stands were reported by Weinstein (1979) along Pacific Creek in Grand Teton National Park, Wyoming, in an area relatively far from the winter feeding grounds. In the upper Gallatin River drainage, Montana, Patten (1988) used photo documentation to demonstrate changes to riparian vegetation caused by elk browsing during winter. Damage to streams or water quality has not been measured in any of these studies.

Skovlin (1984) stated that of the large wild ungulates elk cause the most problems to riparian habitats by their grazing and trampling activities. No data or references were given to describe the damages they cause. Platts and Raleigh (1984) noted that while elk were in riparian meadows in Idaho, riparian damage was not noticeable. They contend that trampling impacts from elk would be minimal in the riparian zone because elk tend to use the riparian zone in winter when snow depth precludes their use of shorter vegetation. Frozen soil is not as susceptible to compaction, thus, impacts are minimized. Although, usage of the riparian shrubs may be significant in spring and early summer, because the animals are dispersed by that time impacts are minimal.

Another reason that impacts from normal (not human induced) concentrations of elk may be minimal is their high mobility. Ward (1973) noted that elk seemed to have a "natural rotation pattern" of grazing through their summer range. They never stay in a particular area for more than a day or two at a time. Eng and Mackie (1982) also commented on the high mobility of elk allowing them to use preferred areas.

Little evidence was found that elk are impacting water quality and riparian zones. The most substantiated reports were in situations where human-induced populations were present. Situations may exist where elk and livestock compete by using the same areas. Overlap of diets and behavioral interactions may be influencing how the animals partition resources. These interactions could influence the degree to which wild large ungulates have access to and impact riparian zones.

Dietary overlap of elk with livestock may indicate a source of resource competition (Skovlin et al. 1968, Lyon 1985). Cattle and elk, as well as sheep and elk, have been found to have similar diets (Cooperrider 1982, Berg and Hudson 1982).

Several studies have found high degrees of dietary overlap between elk and cattle. In northwestern Colorado, Hansen et al. (1977) found that elk and cattle diets overlapped 47 %. In southern Colorado, Hansen and Reid (1975) reported cattle and elk dietary overlap varied from 30 to 51 % in the summer. In the Red Desert, Wyoming, Olsen and Hansen (1977) found dietary overlap between elk and cattle to be greatest in the winter at 46 %. Gordon (1968) identified the potential for competition between cattle and elk in elk winter range in the Crow Creek drainage, Elkhorn Mountains, Montana. Both cattle and elk used Agropyron spicatum which is the critical winter forage species for elk in this area.

Pickford and Reid (1943) stated that elk and sheep were using the same forage in eastern Oregon. MacCracken and Hansen (1981) found that elk diets were similar to sheep in a study of winter range in south-central Colorado, with mean dietary overlap of 30 %. In the Red Desert, Wyoming, Olsen and Hansen (1977) found overlap between sheep and elk was also greatest in the winter at 53 %. The idea that forage overlap is indicative of interspecific competition is questionable (Mackie 1978, Lyon 1985). Because unless forage becomes limiting, direct competition is not likely.

Another factor that influences the degree of interspecific competition between large wild ungulates and livestock is how animals behaviorially partition themselves through the landscape. Berg and Hudson (1982) reported that although dietary overlap between elk and cattle was significant, little spatial and temporal overlap existed in southwestern Alberta, because cattle tended to concentrate in lowlands while elk selected uplands. Allen (1968) stated that the potential for cattle and elk interactions was small in northwestern Montana because elk use the bottomland very little, especially in winter and spring. However, cattle used bottomland most during the winter, but usage was also high for the other seasons.

Komberec (1976) stated that both cattle and elk used areas with slopes of 0 - 10° in the spring and winter in eastern Montana. Skovlin et al. (1968) found that elk used steeper, rockier areas, while the cattle grazed the flatter areas. Drainage bottoms were not of as great importance to elk as they were to cattle (Stevens 1966, Knowles 1975)

As with dietary overlap, it is likely that behavioral interactions between livestock and wildlife modify the use of the landscape by wildlife. This is important because the use of riparian zones by wildlife could be influenced by livestock.

A second type of behavioral interaction between livestock and elk that could influence the degree of impacts on riparian zones by elk are social interactions. Several studies have found that elk avoid livestock and human activities. Lyon and Ward (1982) noted that elk will avoid sheep herds, especially if a herder is present. Stevens (1966) also noted the avoidance of sheep by elk. A study by Knowles and Campbell (1982) found that elk avoid pastures being grazed by large concentrations of cattle. Even after cattle were removed the elk avoided the heavily grazed pastures.

In the Pole Mountain area, Wyoming, Ward (1973) and Ward et al. (1973) found that elk and cattle appeared to be compatible when forage was adequate. Elk were observed grazing in close proximity to cattle and using the same salt licks. Most other studies show that elk are repelled by cattle.

The outcome of studies on the behavioral relationships between elk and livestock have varied (Lyon 1985). In a review of literature from the Missouri River breaks areas of Montana, Eng and Mackie (1982) concluded that evidence for livestock influence of wildlife behavior was inconclusive.
Assessing livestock influences on the use of riparian zones by elk is difficult and studies addressing this issue have not found. Social interactions coupled with stocking levels and habitat or forage availability must all be considered when trying

to determine effects of livestock on use of riparian zones by large wild ungulates.

Mule deer

Mule deer are found throughout Wyoming in grasslands, shrublands, riparian zones, and desert (Hoover and Wills 1984, Clark and Stromberg 1987). They are not considered highly gregarious or solitary. Mule deer typically occur individually or in small groups, although habitat limitations may force large numbers of onto winter feeding grounds. Like elk, mule deer are migratory in the winter and spring.

Mule deer are intermediated feeders, consuming browse, grasses, and forbs (Hoover and Wills 1984). Because mule deer inhabit many different habitat types, the importance of forage classes, by season, has been found to vary from location to location (Hansen and Reid 1975, Knowles 1975, Hansen et al. 1977, Miller 1982,). In southern Colorado, Hansen and Reid (1975) found that mule deer diets consisted mostly of browse in the summer and early winter. Forbs were consumed in small amounts in spring and summer only.

Mule deer use a variety of riparian habitats in Wyoming (Gerhart and Olsen 1982). Collins and Urness (1983) reported tame mule deer prefer wet meadows for forage. Skovlin (1984) stated that mule deer are dependent on riparian areas for forage and water.

Mackie (1970) found that water did not seem to be significant in determining mule deer distribution in the Missouri River Breaks, Montana.

Mackie (1970) found that 50 % of the mule deer observed were on slopes between 11 - 45°. They made greater use of gentle slopes during the winter and spring, while in summer they used steeper timbered sites. Komberec (1976) found that mule deer used slopes of < 10 ° in winter and spring.

As with elk, very limited information is available on the impacts of mule deer on riparian zones and water quality. In a study of aspen (Populus tremuloides) along Pacific Creek, Wyoming, Weinstein (1979) found that aspen were damaged by ungulate browsing and regeneration was being hindered. Elk were identified as the most abundant browser, but mule deer and moose also used the area.

Interspecific competition between mule deer and livestock may influence the degree of impacts that mule deer have on riparian zones. Mule deer diets overlap very little with either cattle or sheep (MacCracken and Hansen 1981). At Douglas Mountain, Colorado, Hansen et al. (1977) found that cattle dietary overlap with mule deer was very low (4 %). Hubbard and Hansen (1976) noted a dietary overlap of < 11 % in the Piceance Basin, Colorado.

Besides the use of different forage, mule deer and livestock also differ spatially. McLean and Williams (1982) stated that mule deer preferred the steeper terrain than cattle. Allen (1968) stated that competition with mule deer would be insignificant because mule deer use uplands while cattle prefer bottomlands. Berg and Hudson (1982) reported similar results.

Mule deer appear to be repulsed by the presence of cattle and prefer to forage in areas not grazed by cattle (Austin et al. 1983, Austin and Urness 1986). McIntosh and Kraussman (1982) reported that mule deer observations decreased when cattle were introduced. Dusek (1975) noted the avoidance of cattle by mule deer in areas of duel usage. Cattle may limit deer usage of an area by removing needed cover (Crouch 1982, Bowyer and Bleich 1984).

White-tailed deer

White-tailed deer also occur throughout Wyoming. They use most habitat types except dry lowlands and dense coniferous forests (Clark and Stromberg 1987). White-tail deer prefer deciduous riparian habitat with dense cover (Gerhart and Olsen 1982). Because of their affinity for riparian habitats, the possibility that they could cause impacts to the riparian area and water quality exists.

White-tail deer are primarily browsers, but they also consume forbs and some grasses (Hoover and Wills 1984). In the Missouri River breaks area, Montana, Allen (1968) found that browse formed 45, 81, 65, and 43 % of their diet in summer, fall, winter, and spring, respectively. The remaining portion of the diet was primarily forbs, with grasses forming a minor percentage. Allen (1968) found that dietary overlap of white-tail deer and cattle was high, particularly in the winter. Because both animals have a strong affinity for bottomlands the possibility for competition for habit is high.

Behaviorally, white-tail deer avoid cattle. In an study of white-tail deer and cattle, deer avoided encounters with cattle at a watering facility (Prasad and Guthery 1986). Deer may avoid riparian areas where cattle have reduced the amount of cover for deer, by trampling and breaking of vegetation (Loft et al. 1987).

Although white-tailed deer use riparian habitat to obtain forage and cover, no literature concerning their impact on riparian zones or water quality was found. They are not gregarious, thus large numbers do not congregate in a riparian area.

Pronghorn

Pronghorn are found throughout Wyoming, preferring high plains and arid shrub grassland (Clark and Stromberg 1987). They are not associated with riparian areas, preferring open sagebrush and grasslands (Gerhart and Olsen 1982).

Browse is the major component in pronghorn diets, with forbs having secondary importance (Bayless 1969, O'Gara and Greer 1970, Clark and Stromberg 1987). In the Red Desert, Wyoming, Severson and May (1967) found that pronghorn diets consisted mainly of big sagebrush (Artemisia tridentata) and douglas rabbitbrush (Chrysothamnum viscidiflorus var. pumilis). Olsen and Hansen (1977) reported that pronghorn diets consisted of 95 % sagebrush in winter and 77 % in the spring in the Red Desert.

The degree of forage overlap between livestock and pronghorns varies depending on the geographic region (Severson and May 1967). The possibility of competition for forage is greatest with sheep (Olsen and Hansen 1977, Schwartz and Ellis 1981, McNay and O'Gara 1982). Clary and Holmgren (1982) and Clary and Beale (1983) reported pronghorns avoiding areas grazed by sheep in western Utah. Low levels of dietary overlap were recorded between cattle and pronghorn (8 % in winter and 25 % in spring) by McInnis and Vavra (1987) in southeastern Oregon.

Although it has been shown that proximity to water is a critical need for pronghorns (Sundstrom 1968), literature concerning impacts to riparian zones or water quality was not found.

Moose

In Wyoming, moose are found in spruce-fir, willow, and riparian communities (Gerhart and Olsen 1982, Clark and Stromberg 1987).

They require access to water and are primarily browsers (Clark and Stromberg 1987) with aquatic and phreatophytic plants forming most of the diet (Hoover and Wills 1984). In southwest Montana, Dorn (1970) reported that moose occupied the willow communities in wet lowland areas along streams 84 % of the time in summer and 93 % in winter. Diet was almost entirely browse in both seasons. Literature concerning impacts to riparian areas or water quality by moose was not found. Weinstein (1979) mentioned that moose were browsing in habitats where aspens were being damaged. The damage was attributed to elk because elk were the only species numerous enough to cause impacts. Although moose use the riparian zones a majority of the time, there solitary nature may prevent damage to the riparian zone.

Big Horn Sheep

Big horn sheep inhabit mountainous regions of Wyoming. They forage on grasses, forbs, and browse (Clark and Stromberg 1987). Because they occupy rugged terrain, they are not considered to be associated with riparian zones (Gerhart and Olsen 1982). Literature on impacts to water quality or riparian zones as caused by big horns was not found.

Bison

Bison are of very minor concern to the issue of riparian impacts as they only occur in the national parks in northwestern Wyoming and on a few private ranches. Historical accounts of bison impacts to the riparian zones have been recorded (Skinner 1986), but these occurred when bison numbers were in the millions.

Conclusion

Overgrazing of riparian areas by wildlife may occur, but this situation is likely only if the wildlife do not have adequate upland forage or numbers are very high (Claire and Storh 1977). In both instances, improper land management may be the issue, not the behavior of the wildlife.

CHAPTER 2

Design of Field Experiments

This chapter addresses Objective 5 -- Design field experiments based on data from Objectives 1-4 that could assess the impact of wildlife grazing on water considering, (a) seasonal and diurnal movements, (b) presence and absence of livestock grazing, (c) various riparian habitat types present in Wyoming -- and Objective 6 -- Recommend potential study sites in different riparian habitats that could be used to carry out field experiments. The purpose of this section is to describe and evaluate potential study sites throughout Wyoming. As stated in Objective 5, the design of field experiments is based on information gathered for Objectives 1-4, as well as consideration of the following (Objective 5):

(a) seasonal and diurnal use of elk, deer, antelope,

(b) presence and absence of livestock grazing, and

(c) various riparian habitat types in Wyoming.

Wild ungulates will utilize different elevations and habitat types during the year. Animals generally migrate to lower elevations during winter in search of food and thermal cover. Many of these natural and man-induced wintering areas have high concentrations of animals which are located in valley bottoms and basins with perennial streams. The possibility of degradation to riparian habitat and water quality in this scenario is high.

Animals will generally disperse and migrate to higher elevations during late spring and early summer. Riparian habitat may not used as intensively during this time of year.

EVALUATION PROCEDURE

Information considered when evaluating potential study sites included:

1. Location and accessibility of site because topography may limit access to the site. Feasible access would be that in which a short hike or vehicle could be used to get to the site.
2. Administrative agency for the site, of the managing agency the management function of the site for, and willingness to permit research on the site.
3. Seasonal and diurnal use by wild ungulates.
4. Livestock grazing history of the site.
5. Classification of the wetland features based the system of classification used by the U.S. Fish and Wildlife and is described in, Classification of Wetlands and Deepwater Habitats of the United States (Cowardin 1979).
6. Description of site in terms of the vegetative structure of riparian and upland habitat.
7. Land improvements, including types and times of land management practices (prescribed burning, fertilizing, seeding, etc.) that may increase the quality or quantity of forage for wildlife.

8. Observed impacts on water quality caused by wildlife or livestock grazing.
9. Potential as a field study site for comparison among several sites where the extent of wildlife grazing is known and no recent livestock grazing has occurred.
10. Potential as experimental site where pristine or nearly pristine conditions exist so that impacts from wildlife could be assessed by manipulating numbers and species over a period of time.
11. Administrative contact to the agency responsible for management of the site.

Personnel from the Wyoming Game and Fish Department, U.S Bureau of Land Management, U.S. Forest Service, National Park Service, University of Wyoming, and the U.S Fish and Wildlife Service were contacted to discuss potential study sites. Criteria needed for consideration as a potential field study site or experimental site included: (1) site must be at least 5 acres in size, and (2) site must have minimal or no livestock use. Visits were made to identified sites with agency personnel. Notes were taken from observation and discussion about the general landscape, species of wildlife that utilize the site, seasons of use by wildlife, approximate numbers of ungulates that utilize the site, grazing history of the site, types of land treatments implemented on the site, vegetative composition, and types of wildlife impacts occurring on the site. Photographs of the sites were taken and can be used as references for future planning.

RESULTS

Photographs and notes regarding location, accessibility, species of wild ungulates on site, season of use, livestock grazing history, wetland classification, vegetative structure, rangeland improvements on site, and observed impacts were taken at each of the thirty sites visited. A brief description is given for each site visited (Appendices I-XXX). Each appendix is listed in alphabetical order by site by county. Each site was evaluated and given a ranking as a field study site and experimental site (Table 1). Table 1 lists each potential study site in alphabetical order by site and county and gives it a ranking. The ranking system used is as follows: 0 = no potential due to several limiting factors, such as, degraded riparian habitat and water quality due to flooding, drought, natural erosion, past livestock grazing impacts and other factors, such as, poor accessibility, limited size, topography, fencing, and human activity; 1 = some potential, but some limiting factors mentioned above may generate uncontrolled variability; 2 = high potential, none or very few limiting factors exist.

DESIGN OF FIELD EXPERIMENTS

Determination of the relations between livestock and wildlife grazing and water quality can be approached using two different experimental designs: (1) comparison of multiple sites with differing levels of wildlife and livestock grazing, or (2) controlled experiments with known kinds and numbers of animals held in confined areas. The basic experimental design, problems, and feasibility of both approaches are discussed.

Comparison of Multiple Sites

This approach would involve field study of numerous sites. The design assumes a functional relationship between livestock and/or wildlife grazing and water quality. Measures of livestock and/or wildlife grazing intensity are evaluated for their relation to measures of water quality among several study sites.

Linear-regression and multiple-regression analyses are the statistical methods for determining if statistically significant relationships may exist between grazing intensity (independent variable) and water quality (dependent variable). The null hypothesis is that no relation exists between independent variable(s) and the dependent variable. Regression analysis may indicate relationship, but it does not confirm cause and effect or define physical/biological mechanisms causing the observed relationship. Additionally, regression analysis is based on four assumptions (Sokal and Rohlf 1981):

(1) The independent variable (grazing intensity) is measured without error,

(2) the relation of the dependent (water quality) and independent variable is a linear function (straight line),

(3) for any given value of the independent variable, the measurements of the dependent variable are normally distributed, and

(4) the variance of both the independent and dependent variables is independent of their magnitude.

These assumptions may be hard to achieve in field studies.

In order for a regression analysis approach to be used, several sites with <u>similar</u> climatic, geomorphic, geologic, and vegetative features would have to be found. If the influence of wildlife grazing on water quality were being examined, an accurate measure of the magnitude of grazing would be needed at each site (Assumption 1 above).

Problems

There are numerous problems associated with a regression analysis design for determining the relation between grazing and water quality:

(1) Identification of several sites with similar features is extremely difficult. For example, if the focus was to assess water quality in second order streams within a riparian area dominated by willows, then study sites with many similarities would be needed. The sites would have to have similar climates (elevation, precipitation, etc.) and be in drainages of similar sizes and with similar geomorphic features. Additionally, the history of management and use would have to be similar.

(2) The assumption that the independent variable (magnitude of grazing) is measured without error would be violated. Accurate estimates of wildlife use (numbers, forage utilization, season of use, etc.) are difficult to obtain with extensive amounts of work.

(3) Other uses of the various drainage areas besides wildlife and livestock grazing are difficult to measure and are likely to confound a regression approach. Much unaccounted for variability in water quality is likely to occur due to other anthropogenic activities such as construction of roads and buildings, timber harvest, water development, or past histories of mining, logging, and livestock grazing.

Feasibility

Comparison of several sites to determine relations between grazing and water quality is not a reasonable approach to research. Sufficient numbers of suitable sites will be very difficult to locate. The most severe limitation is the ability to measure the past and present grazing intensity in potential study areas. Determination of the magnitude of grazing by wildlife cannot be measured without error, the first assumption necessary for regression analysis.

<u>Controlled Experiments</u>

This approach would involve large-scale experiments at specific study sites. The basic experimental design would entail measurement of the water quality under known, controlled levels of grazing. While simple in statistical design, this approach would provide numerous logistic hurdles due to the magnitude of an experiment site.

Two statistical approaches could be used to design and analyze data from controlled experiments: (1) linear/multiple regression, or (2) analysis of variance. Both designs have unique advantages and disadvantages.

Regression

Within this design, several know levels of grazing intensity (independent variable) could be assessed for their relation to a measure of water quality. For example, 10 identical pastures could be stocked each with a different number of mule deer. The suspended solids in runoff from each pasture could be measured. Linear-regression analysis could be used to determine if the density of mule deer was related to suspended solids in runoff.

Because this is a controlled experiment, the assumptions required for regression analysis can be met through the research design. For example, the assumption that the independent variable (magnitude of grazing) is measured without error can be met by the researchers' manipulation of the number of mule deer in each pasture.

Analysis of Variance

This design also entails controlled manipulation of a single variable, such as grazing intensity. Within this design specific treatments (magnitude of grazing) are defined and the effect of the treatments on a variable (water quality) are assessed with replicates of each treatment.

A example of a simple experiment might entail the influence of mule deer grazing on suspended sediment in runoff from upland prairie. To conduct the experiment a gently sloping grassland site is selected and nine 1-acre pastures are fenced to hold the deer. There levels of grazing will be evaluated -- 0,5, and 10 mule deer per acre for the same 3-month summer period -- with three replicates of each. Surface runoff will be collected during storm events within sumps at the lowest elevation point within each pasture and suspended sediment in the water will be determined.

Analysis of variance is the statistical method for testing if the null hypothesis should be rejected. In the example, the null hypothesis is that there is no difference in suspended sediment among the three levels of grazing intensity. The example is a one-way analysis of variance, but more complex designs, such as two-way analysis of variance could be used.

A fundamental set of assumptions for analysis of variance includes: (1) Sampling of individuals is random (For example, if three levels of grazing by mule deer were to be measured on three pastures each, the three levels of grazing would be randomly allocated among nine pastures.), (2) The error term of each expected value of a variate is a random normal variable, and (3) The error terms have identical variance. Within controlled experiments these assumptions can be met in most cases; therefore, the statistical approach is valid in this situation.

Problems

Controlled experiments do not pose the statistical problems that are encountered in comparison among multiple sites using regression analysis. While the experimental design is sound, the physical construction of an experimental facility poses many problems. Fencing, water collection and water quality monitoring devices, and other components of the physical facility are expensive. Siting of a facility is difficult because an area of sufficient size with similar topography, vegetation, and grazing history may be difficult to find. The actual experiment will likely alter vegetation and soil features at a site so that repeated use following completion of the initial experiment may not be feasible.

Controlled experiments will require long periods of time to complete. It is likely that several years will be required to complete an experiment at a particular site because treatment effects are likely not to be observed until vegetation changes occur.

Numerous problems in obtaining and holding large mammals will be encountered. Permits will have to be obtained from the state game and fish agency.

Because the animals are held in confinement an unnatural situation is created. Behaviors of animals associated with seasonal movements, reproduction, diurnal variation in habitat use, and seasonal availability or use of specific forage plants can be simulated, but the complexity of the experimental design is increased. The limited mobility of the animals is likely to have effects that might not be seen with free-ranging animals.

A particular experiment will be limited to a single species in a particular habitat type, such as elk in mountain meadows or mule deer in upland sagebrush habitat. Numerous experiments will be needed to ascertain the effects of all the large mammal species on the array of different habitat types found in the state.

The limitations associated with finding suitable sites, the cost of establishing a facility, and the availability of test animals, will limit both the number of treatments and replicates that can be managed in any given experiment. Simple experimental designs will have to be used as a result.

The use of controlled experiments will be very costly and time consuming. It is estimated that a single experiment on one species in one habitat type will cost in excess of $500,000 and require more than 4 years to complete.

Feasibility

The use of controlled experiments seems to be the only scientifically sound approach to determining the relations between livestock and wildlife grazing and water quality. Such experiments cannot be conducted with ease because they will require extensive funding and long time periods to complete, but they are the only feasible approach to obtaining factual information. Controlled experiments can be manipulated to simulate seasonal and diurnal movements in presence of livestock, but the complexity of the work is increased. Separate experiments will have to be conducted on various riparian habitat types to assess the effects of wildlife in each.

POSSIBLE STUDY SITES

Only seven field study sites were identified that had high potential. Each site is listed in order of greatest potential based on criteria used to evaluate each site: (1) Flat

Creek/National Elk Refuge, (2) Horse Creek, (3) Beaver Creek, (4) Fence Creek, (5) Blacktail Creek, (6) Wagonhound Creek, and (7) Camp Creek.

The potential for using a multiple-site, regression analysis approach is quite limited because only seven sites were identified. This is probably not a sufficient sample size to allow statistical inference to be obtained.

Only five experimental study sites were identified that had high potential. Each site is listed in order of greatest potential based on criteria to evaluate each site and relative pristine condition of the site: (1) Torrey Creek, (2) Labonte Creek, (3) Johnson Creek, (4) Bear Creek, and (5) Green River/Seedskadee National Wildlife Refuge. All of these sites have good potential for controlled experiments.

SUMMARY OF ACCOMPLISHMENTS FOR EACH OBJECTIVE

1. Collect published and unpublished data on the impact of both livestock and wildlife grazing on water quality and riparian habitat.

   Accomplishment: Published and unpublished information was collected from the U.S. Fish and Wildlife Service Reference Service database, University of Wyoming Library database, and from personal contacts with Personnel from Federal and State natural resource management agencies.

2. Determine if such data are sufficient to develop a decision model that considers livestock AUM's and wildlife herd levels on a seasonal basis for the purpose of assessing non-point pollution when considering livestock and wildlife densities and their management.

   Accomplishment: The information reviewed on both livestock stocking levels and wildlife herd levels is insufficient for designing predictive models of the relationship of animal densities to non-point source pollution.

3. Summarize data on wildlife foraging behavior, seasonal movement, diurnal movement, winter feeding programs and both natural and man-induced winter concentration of wildlife

that might affect water quality.

Accomplishment: Data on wildlife foraging behavior was collected for elk, mule deer, whitetail deer, pronghorn, bighorn sheep, and moose was summarized. Information on seasonal movement, diurnal movement, winter feeding programs and both natural and man-induced winter concentrations was summarized but was limited mainly to elk.

4. Compare foraging behavior of various wildlife species in different riparian habitat types from data available in order to determine their relative influence on quality.

   Accomplishment: Foraging behavior was compared among elk, mule deer, whitetail deer, pronghorn, bighorn sheep, and moose.

5. Design field experiments based on data from Objective 1-4 that could assess the impact of wildlife grazing on water quality considering,

   (a) seasonal and diurnal movements,

   (b) presence and absence of livestock grazing, and

   (c) various riparian habitat types present in Wyoming.

   Accomplishment: Our analysis indicates that the only scientifically sound approach to assess the impact of wildlife grazing on water quality is through controlled experiments with known numbers of animals held in captivity.

Such studies will be very expensive and time consuming.

6. Recommend potential study sites in different riparian habitats that could be used to carry out field experiments. Accomplishment: Out of 30 potential study sites visited, 7 were identified as possible sites for field studies, and 4 were identified as possible locations for controlled experimental studies.

Table 1. The following table shows the rating system of each site as a field study site. Rating values are as follows: 0 = no potential, 1 = some potential, but several limiting factors, 2 = high potential, few limiting factors.

Site	Field Study	Experimental Study
Fence Creek	2	1
Johnson Creek	1	2
Labonte Creek	1	2
South Crow Creek	0	0
Cedar Creek	0	0
Cumberland Creek	1	0
Littlefield Creek	1	1
Muddy Creek/Baldy	0	0
Muddy Creek/Sulfer	0	0
Wagonhound Creek	2	1
Bear Creek	1	2
Torrey Creek	1	2
Blue Creek	1	1
Middle Powder River	0	0
Fontenelle Creek	1	1
Blacktail Creek	2	0
Elk Fork River	1	1
Lamar River	1	1
Slough Creek	1	1
Sunlight Creek	1	1
Tongue River	0	0
West Pass Creek	0	0
Fall Creek	0	0
Bone Draw Creek	1	1
Green River	1	2
Beaver Creek	2	1

Camp Creek	2	1
Flat Creek/Refuge	2	1
Flat Creek/South	1	1
Horse Creek	2	1

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Appendix I

FENCE CREEK, MEDICINE BOW NATIONAL FOREST, ALBANY COUNTY

Location and Accessibility

Fence Creek is located on the south side of Sheep Mountain on the Medicine Bow National Forest. The potential study area is located 5 miles east of Albany, Wyoming (T 14N, R 77W, S 10, 15). The potential study area includes approximately 1.5 miles of stream and riparian meadow. The site is accessible by foot or horseback from spring until late fall.

Land Administrator

The potential study area is located on the Medicine Bow National Forest which is managed by the U.S. Forest Service. There is no cattle grazing, logging, or motorized vehicle use on this portion of the Medicine Bow National Forest.

Livestock Grazing History

Cattle grazing has been excluded from this portion of Medicine Bow National Forest since 1945. There is some occasional recreational horse grazing during summer and fall.

Wetland Classification

According to the classification system used by the U.S. Fish and Wildlife Service, Fence Creek is classified as; SYSTEM Riverine, SUBSYSTEM Upper Perennial.

Description of Site

The elevation of the potential study site is approximately 9,150 feet. Fence Creek flows through a montane meadow which is dominated by grass, sedges, and willows. Upland vegetation consists of mainly lodgepole pine and limber pine. Upland soils are very granitic and loose.

Rangeland Improvements

There have been no rangeland improvement practices or treatments in the Fence Creek area.

Observed Impacts

There is heavy use by elk along Fence Creek, especially during spring when elk are migrating to higher elevations. Willows have been browsed down to uniform height, probably due to the snow depth at the time when elk were in the area. Some sloughing of streambanks is occurring at points along the stream. Streambanks are vegetated mainly by grasses and sedges. There is a tremendous amount of elk feces throughout the riparian meadow and along the stream. There are several springs which feed the stream. Water from these springs saturate much of the dung-covered ground and flows directly into Fence Creek.

Potential as Field Study Site

Fence Creek holds great potential as a field study site. Utilization by elk is moderate to heavy with high potential of fecal contamination of the stream during spring.

Potential as Experimental Site

Fence Creek holds little potential as an experimental site because of impacts on water quality that already exist from wild ungulate grazing.

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Appendix II

JOHNSON CREEK, SYBILLE WILDLIFE RESEARCH UNIT, ALBANY COUNTY

Location and Accessibility

The potential study area on Johnson Creek is located on the Sybille Wildlife Research Unit, approximately 32 miles southwest of Wheatland, Wyoming, north of highway 34 (T 21N, R 72W, S 18, 19, 20, 30). Approximately 3 miles of Johnson Creek, on the north side of Highway 34, is located on 2,700 acres. The site is accessible by four-wheel drive from early spring to late fall.

Land Administrator

The Wyoming Game and Fish Department manages the area within the unit and is utilized by the public for recreational purposes and by the Wyoming Game and Fish Department for wildlife research projects.

Seasonal and Diurnal Use by Wild Ungulates

Approximately 100-250 mule deer utilize the unit year-round with heaviest utilization occurring during winter months. Some whitetail deer utilize the riparian zone of Johnson Creek. A small number of elk will occasionally use the unit during summer and fall while some antelope will utilize the unit during winter.

Livestock Grazing History

The portion of Sybille Wildlife Research Unit north of Highway 34 has not been grazed by livestock since 1979. Light fall cattle grazing may be implemented in the near future.

Wetland Classification

According to the classification system used by the U.S. Fish and Wildlife Service, Johnson Creek is classified as; SYSTEM Riverine, SUBSYSTEM Upper Perennial.

Description of Site

The elevation of the potential study site is approximately 6,500 feet. Associated riparian vegetation includes grass, sedges, willow, cottonwood, and aspen. Upland vegetation consists of mainly grass, sagebrush, antelope bitterbrush, and mountain mahogany. Vegetative biomass has greatly increased since the exclusion of cattle grazing in 1979.

Rangeland Improvements

There have been no rangeland improvements or treatments other than periodic spraying of noxious weeds.

Observed Impacts

The streambanks of Johnson Creek are well vegetated and stable. There is some trespass cattle use along the stream near the northern boundary of the unit. Deer feces was observed on upland ridges which receive heaviest utilization by mule deer. Very little deer feces was observed along the stream. Overall, wildlife seem to have few impacts on the riparian zone.

Potential as Field Study Site

Johnson Creek holds little potential as a field study site because of cattle grazing upstream adjacent to the unit. Also, use by wild ungulates on the unit is mainly from mule deer which utilize upland ridges and hillsides more than the riparian area, therefore, impacts on water quality from deer use may be limited.

Potential as Experimental Site

Johnson Creek could be used as an experimental site despite the fact that there is cattle grazing upstream adjacent to the unit. Impacts on water quality could be measured above the unit where cattle grazing is permitted and below the experimental site which has exclusive grazing by wildlife.

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Appendix III

LABONTE CREEK WILDLIFE UNIT
MEDICINE BOW NATIONAL FOREST, ALBANY COUNTY

Location and Accessibility

Labonte Creek Wildlife Unit is located on the Medicine Bow National Forest approximately 25 miles southwest of Douglas, Wyoming (T 28N, R 73W, S 9,10,11). Approximately 3 miles of Labonte Creek is located on the 3,320 acre unit. The site is accessible by four-wheel drive from spring until late fall.

Land Administrator

Labonte Creek Wildlife Unit is located on Medicine Bow National Forest and is managed by the U.S. Forest Service. The primary objective of the wildlife unit is to provide big game wildlife habitat.

Seasonal and Diurnal Use by Wild Ungulates

Approximately 50-100 elk and some mule deer utilize the wildlife unit and surrounding area from late spring to late fall. Approximately 10-15 bighorn sheep utilize Labonte Creek area year-round.

Livestock Grazing History

Labonte Creek Wildlife Unit has not had authorized livestock grazing since the establishment of the unit in 1968. There is minimal cattle grazing above the unit in Curtis Gulch and Big

Bear Canyon.

Wetland Classification

According to the classification system used by the U.S. Fish and Wildlife Service, Labonte Creek would be classified as; SYSTEM Riverine, SUBSYSTEM, Upper Perennial.

Description of Site

The elevation of the potential study area is approximately 6,800 feet. Associated riparian vegetation includes grass, sedges, willow, aspen, spruce, and fir. Upland vegetation consists of grass, sagebrush, aspen, and fir. Interspersions of conifers and grass meadows are associated with the riparian zone.

Rangeland Improvements

There have been no rangeland improvements or treatments on the Labonte Creek Wildlife Unit or surrounding area.

Observed Impacts

The riparian zone is in excellent condition. Streambanks are stable and well vegetated by sedges and willows. On upland sites, aspen look healthy with good regeneration. Feces from elk and deer were rarely observed along the stream while some feces was observed on upland sites. Overall, the unit is in good shape with few impacts on water quality from wild ungulates.

Potential as Field Study Site

Labonte Creek Wildlife Unit holds some potential as a field study site. Impacts on water quality from wildlife grazing are minimal.

Potential as Experimental Site

Labonte Creek Wildlife Unit has good potential as an experimental site. Conditions within the unit are nearly pristine and access is good. Impacts on water quality from light cattle grazing above the unit could be measured and compared to impacts from wild ungulate grazing within the unit.

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Appendix IV

SOUTH MIDDLE CROW CREEK
MEDICINE BOW NATIONAL FOREST, ALBANY COUNTY

Location and Accessibility

South Middle Crow Creek is located on the Medicine Bow National Forest, 16 miles southeast of Laramie, Wyoming. Three exclosures, approximately 33 acres each, are located on 1.5 miles of South Middle Crow Creek, 2 miles east of Vedauwoo Campground (T 14N, R 71W, S 25,26,27). The site is accessible by vehicle from early spring until late fall.

Land Administrator

Three exclosures were built through mitigation processes involved with the development of the Cheyenne Stage II Water Project. The U.S. Forest Service manages the land inside the exclosures while personnel from the Stage II Water Project maintain the fences and water that is diverted into South Middle Crow Creek. The objective of the U.S. Forest Service is to increase riparian habitat within the exclosures.

Seasonal and Diurnal Use by Wild Ungulates

Approximately 30-40 elk and 50 mule deer utilize the area which includes South Middle Crow Creek. Elk and deer utilize the area mainly during spring, summer, and fall but may also use the area during mild winters.

Livestock Grazing History

Cattle grazing is permitted on Medicine Bow National Forest but has been excluded from inside the exclosures since they were built in 1984. The area between exclosures on South Middle Crow Creek serve as water gaps for cattle. Cattle use along these water gaps is moderate to heavy.

Wetland Classification

Stream flow is maintained from water that is piped from Rob Roy Reservoir to South Middle Crow Creek. According to the classification system used by the U.S. Fish and Wildlife Service, South Middle Crow Creek would be classified as; SYSTEM Riverine, SUBSYSTEM Upper Perennial.

Description of Site

The elevation of the potential study site is approximately 7,900 feet. Associated riparian vegetation includes grass, sedges, willow, and aspen. Upland vegetation would be considered a semi-open coniferous forest with grass, aspen, spruce, fir, lodgepole pine, and limber pine as the main types of vegetation.

Rangeland Improvements

There have been no rangeland improvements or treatments on South Middle Crow Creek Drainage or the surrounding area.

Observed Impacts

The streambanks are well defined and stable in the upper and lower exclosures. In the middle exclosure, the streambanks are less defined with water flowing openly across the ground. Vegetative biomass within the exclosures is high. There is a noticeable difference in the quantity and quality of vegetation inside and outside of the exclosures. Cattle use outside the exclosures is moderate to heavy. A small amount of elk and deer feces were observed inside the exclosures. Some feces were observed outside the exclosures on upland sites.

Potential as Field Study Site

The exclosures on South Middle Crow Creek hold little potential as a field study site. From general observations, use by elk and deer on South Middle Crow Creek is minimal. Fecal contamination of the stream would come mainly from cattle use outside the exclosures or possibly from other sources above Rob Roy Reservoir which feeds South Middle Crow Creek.

Potential as Experimental Site

The exclosures on South Middle Crow Creek would not be feasible as an experimental site for the reasons mentioned above.

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Appendix V

CEDAR CREEK, BIGHORN NATIONAL FOREST, BIGHORN COUNTY

Cedar Creek is located approximately 25 miles east of Greybull, Wyoming. This area was not evaluated in detail because topography and accessibility limit the potential as an experimental site or field study site. The upper portion of Cedar Creek is a designated wildlife use area which requires a 3-4 mile hike to reach. The lower portion of Cedar Creek is located in a narrow and rocky canyon which is difficult to hike.

Appendix VI

CUMBERLAND CREEK, PENNOCK BIG GAME WINTER RANGE CARBON COUNTY

Location and Accessibility

Pennock Big Game Winter Range is located 3.5 miles east of Saratoga, Wyoming (T 17N, R 82W, S 5,6; T 18N, R 83W, S 26,35,36). Approximately 4.5 miles of Cumberland Creek is located on the 9,806 acre unit. The site is accessible by vehicle from early spring until winter.

Land Administrator

The Wyoming Game and Fish Department purchased Pennock Big Game Winter Range in 1962. The primary objective of the department is to manage the winter range for winter elk use.

Seasonal and Diurnal Use by Wild Ungulates

Approximately 600 elk utilize the unit from late fall until early spring. Seventy-five mule deer and 50 antelope utilize the area throughout the year.

Livestock Grazing History

Pennock Big Game Winter Range has not had authorized livestock grazing since 1965. Prior to 1965, the potential study area was heavy utilized by cattle.

Wetland Classification

According to the classification system used by the U.S. Fish and Wildlife Service, Cumberland Creek is classified as; SYSTEM Riverine, SUBSYSTEM Upper Perennial.

Description of Site

The elevation of the potential study site is approximately 7,200 feet. Associated riparian vegetation includes grass, serviceberry, chokecherry, willow, aspen, and cottonwood. Upland vegetation consists of grass, big sagebrush, antelope bitterbrush, and some conifers. The potential study area is included in a low annual precipitation zone.

Rangeland Improvements

A total of 500 acres have been burned over the past 3 years on the winter range. Six-hundred acres are scheduled to be burned in the near future. There is irrigation of a small grass meadow on the southeast portion of the unit.

Observed Impacts

Possible impacts from past intense livestock grazing may still be evident on some portions of the unit. Grass production is low on some upland sites. Bare soil makes up a high percentage of the ground throughout much of the range. Streambanks on Cumberland Creek are fairly well vegetated and stable with some bank sloughing occurring at certain points along the stream. Some elk and mule deer feces was observed along the stream and on upland sites.

Potential as Field Study Site

Cumberland Creek holds little potential as a field study site because of existing poor range conditions which may be attributed to past livestock grazing. Stream sediment loading and fecal contamination of the stream may be accelerated and more profound due poor range conditions.

Potential as Experimental Site

Cumberland Creek holds little potential as an experimental site for the same reasons as mentioned above.

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Appendix VII

LITTLEFIELD CREEK EXCLOSURE, CARBON COUNTY

Location and Accessibility

Littlefield Creek exclosure is located approximately 27 miles southwest of Rawlins, Wyoming (T 17N, R 89W, S 15). The exclosure is 7 acres in size and encloses approximately 300 yards of Littlefield Creek. The potential study site is accessible by vehicle from early spring until early winter.

Land Administrator

The U.S. Bureau of Land Management erected the exclosure in 1982 to improve stream quality and increase habitat for the Colorado Cutthroat Trout. The U.S. Bureau of Land Management plans to enclose another 1300 acres of riparian pasture which will include the existing exclosure.

Seasonal and Diurnal Use by Wild Ungulates

The potential study area on Littlefield Creek serves primarily as transition range for elk, mule deer, and antelope. Some elk and mule deer may be found in the area during summer and fall.

Livestock Grazing History

The land within the exclosure has had periodic trespass cattle use since it was built in 1982. The amount of utilization by cattle has been minimal. During the past year, the pasture surrounding of the exclosure was rested from livestock grazing except for some light spring use by sheep.

Wetland Classification

According to the classification system used by the U.S. Fish and Wildlife Service, Littlefield Creek is classified as; SYSTEM Riverine, SUBSYSTEM Upper Perennial.

Description of Site

The elevation of the potential study site is approximately 7,000 feet. Associated riparian vegetation includes grass, sedges, and willow. Upland vegetation consists of big sagebrush and some grass. Jerry Jech of the U.S. Bureau of Land Management in Rawlins, Wyoming noted that the riparian vegetation within the exclosure has greatly increased during the past year. Sedges have encroached on the stream, which has help stabilize and narrow the streambanks.

Rangeland Improvements

Willow and Chokecherry were planted along the stream within the exclosure to increase streambank stability and provide overhanging cover. At this point, there is no evidence that willow and chokecherry have established along the stream.

Observed Impacts

There was very little evidence of use within the exclosure by wild ungulates. Some deer feces was observed on the hillside adjacent to the stream within the exclosure. Cattle dung from previous use was observed along the stream within the exclosure.

Potential as Field Study Site

Littlefield Creek exclosure holds little potential as a field study site because utilization and impacts from wild ungulates use within and outside the exclosure is minimal.

Potential as Experimental Site

Littlefield Creek exclosure holds some potential as an experimental site mainly because of existing fences that enclose 7 acres of riparian habitat. Also, the U.S. Bureau of Land Management has proposed to enclose an additional 1300 acres of riparian habitat which may possibly be livestock free for 5 years after the exclosure is built.

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Appendix VIII

BALDY BUTTE EXCLOSURE, MUDDY CREEK, CARBON COUNTY

Location and Accessibility

Baldy Butte exclosure is located on Muddy Creek, approximately 40 miles southwest of Rawlins, Wyoming, 2 miles east of Highway 789 (T 17N, R 92W, S 11). The site is accessible by vehicle year-round.

Land Administrator

The U.S. Bureau of Land Management built the 300 acre exclosure in 1985 to see how the riparian system would respond to the absence of livestock grazing.

Seasonal and Diurnal Use by Wild Ungulates

The potential study area serves mainly as winter range for antelope. Some antelope and mule deer are found in the area year-round. The amount of utilization by wild ungulates within the exclosure is minimal.

Livestock Grazing History

There has not been authorized grazing inside the exclosure since it was built in 1985. There has been some occasional trespass cattle use inside the exclosure.

Wetland Classification

According to the classification system used by the U.S. Fish and Wildlife Service, Muddy Creek is classified as; SYSTEM Riverine, SUBSYSTEM Intermittent. Muddy Creek usually has perennial flows except during drought years such as this past year. The stream bottom is unconsolidated and consists of mainly sand and mud.

Description of Site

The elevation of the potential study site is approximately 6,700 feet. The potential study area is a desert type environment with the average annual rainfall being less than 12 inches per year. Associated riparian vegetation consists of sedges, willow, rabbitbrush, and sagebrush. Upland vegetation includes mainly rabbitbrush and sagebrush.

Rangeland Improvements

There have been no rangeland improvements or treatments within the exclosure or surrounding area. There has been an attempt to fill a large downcut section of the stream with large boulders.

Observed Impacts

According to Jerry Jech of the U.S. Bureau of Land Management in Rawlins, Wyoming, willow have been declining along the stream due water stress from recent drought years. Streambanks have been eroding away year by year as a result of high water flows during spring and the lack of deep rooted vegetation along the streambanks. There is significant downcutting occurring. Impacts from wild ungulate and cattle use inside the exclosure are minimal. Most of the stream quality problems, mainly stream sediment loading, are most likely occurring due to impacts from intense cattle grazing upstream and severe flash flooding.

Potential as Field Study Site

Baldy Butte exclosure on Muddy Creek holds no potential as a field study site. Impacts from wild ungulate grazing within the exclosure and surrounding area are minimal. Impacts from cattle grazing upstream and flash flooding have possibly caused existing water quality problems such as stream sediment loading.

Potential as Experimental Site

Baldy Butte exclosure holds little potential as an experimental site for the same reasons mentioned above.

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Appendix IX

SULFUR SPRINGS EXCLOSURE, MUDDY CREEK, CARBON COUNTY

Location and Accessibility

Sulfur Springs exclosure is located on Muddy Creek approximately 36 miles southwest of Rawlins, Wyoming (T 17N, R 89W, S 18). Approximately 300 yards of Muddy Creek flows through the 5 acre exclosure. The exclosure is accessible by vehicle year-round.

Land Administrator

The U.S. Bureau of Land Management erected the exclosure in 1986 to see how the riparian system would respond to the absence of livestock grazing.

Seasonal and Diurnal Use by Wild Ungulates

The potential study area receives summer and fall use by antelope and mule deer and some winter use by elk.

Livestock Grazing History

The land inside the exclosure has not had authorized livestock grazing since it was built in 1986. There is evidence of some trespass cattle use on the east end of the exclosure.

Wetland Classification

According to the classification system used by the U.S. Fish and Wildlife Service, this portion of Muddy Creek is classified as; SYSTEM Riverine, SUBSYSTEM Lower Perennial.

Description of Site

The elevation of the potential study site is approximately 7,200 feet. The exclosure is located in a desert type environment with a low average annual rainfall. Associated riparian vegetation includes grass, sedges, and some willow. Upland vegetation includes sagebrush and some grass.

Rangeland Improvements

In 1989, the U.S. Bureau of Land Management planted different species of willow along the stream. Some of the willows have established but are still very small and do not provide much cover or bank stability.

Observed Impacts

The willows that are present are being utilized by either trespass cattle or elk, or a combination of both. Sedges have established along the streambanks which has increased streambank stability. There is evidence of past flooding which has eroded some of the stream channel. Cattle, elk, and mule deer feces were present along the stream and on upland sites inside and outside the exclosure.

Potential as Field Study Site

Sulfur Springs exclosure on Muddy Creek holds little potential as a field study site. Problems related to cattle grazing, flash flooding, and soil types (mainly fine sediment), are most likely impacting water quality and would be difficult to differentiate from wild ungulate impacts on water quality. The amount of utilization by wild ungulates inside the exclosure is relatively low.

Potential as Experimental Site

Sulfur Springs exclosure holds little potential as an experimental site for the same reasons as mentioned above.

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Appendix X

WAGONHOUND CREEK, WICK WILDLIFE HABITAT UNIT, CARBON COUNTY

Location and Accessibility

The Wick Wildlife Habitat Unit is located 40 miles northwest of Laramie, Wyoming, along Interstate Highway 80. Approximately 6.5 miles of Wagonhound Creek are located along the western boundary of the habitat unit (T 19N, R 79W, S 5,6,8,17,18,19,20,30,31). The site is accessible by vehicle from late spring until late fall.

Land Administrator

The Wick Wildlife Habitat Unit, which was purchased in 1964, is comprised of 10,344 acres of Wyoming Game and Fish Department deeded land, 2,440 acres of leased state land, and 286 acres of land owned by the Bureau of Land Management. The habitat area is managed to provide year-round habitat for all wildlife species and to provide public access.

Seasonal and Diurnal Use by Wild Ungulates

The Wick Habitat Unit provides crucial winter range for elk and mule deer and summer range for antelope. Approximately 600 elk, 200 mule deer, and 200 antelope utilize the unit throughout the year. The majority of the elk move from the higher summer ranges on to the southern portion of the unit by early December.

Livestock Grazing History

Authorized livestock grazing has been excluded from the unit since October of 1988. Prior to that date the University of Wyoming had 800 AUM's of cattle on the unit.

Wetland Classification

According to the classification system used by the U.S. Fish and Wildlife Service, Wagonhound Creek is classified as; SYSTEM Riverine, SUBSYSTEM Intermittent. During drought years the upper portion of Wagonhound Creek, along the southern boundary of the unit, may flow very little water or completely dry up. The lower portion of the stream has several beaver dams which have kept the water table high and provided a source of perennial water flow.

Description of Site

The elevation of the potential study area is approximately 7,500 feet. Associated riparian vegetation includes grass, sedges, willow, chokecherry, aspen, and cottonwood. Upland vegetation consists primarily of grass, big sagebrush, black sagebrush, mountain mahogany, antelope bitterbrush, and aspen.

Rangeland Improvements

There have been several rangeland improvements done to improve wildlife habitat on the unit. Prescribed burning, fertilization, range pitting, herbicide spraying, clearcutting, and salt blocks have been used since 1967 to improve wildlife habitat and animal distribution on the unit.

Observed Impacts

The riparian vegetation along Wagonhound Creek looks very healthy and vigorous. Streambanks on the upper portion of the stream look stable while most of the lower portion of the stream is comprised of several beaver dams which have increased the water table and spread water out of the stream channel. Most elk and deer feces were observed on upland hillsides and ridges adjacent to the stream. Overall, the riparian zone along Wagonhound Creek looks very healthy.

Potential as Field Study Site

Wagonhound Creek holds some potential as a seasonal (late spring and early summer) study site. The fact that Wagonhound Creek may flow intermittently along the southern portion of the unit may present problems for conducting research. Research might be conducted from early spring to early summer when the stream is holding water and big game animals are still utilizing the area.

Potential as Experimental Site

Wagonhound Creek has good potential as an experimental study site. Research might be conducted lower on the stream where water is present year-round and wild ungulate use is not as heavy.

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Appendix XI

BEAR CREEK, EAST FORK WILDLIFE HABITAT UNIT, FREMONT COUNTY

Location and Accessibility

The East Fork Wildlife Habitat Unit is located 16 miles northeast of Dubois, Wyoming (T 42N, R 105W, S 4,5,9,16,17,19). Approximately 3 miles of Bear Creek is located on the 17,000 acre unit. The unit is accessible by vehicle from early spring until late fall.

Land Administrator

The Wyoming Game and Fish Department manages the unit for big game winter use. The unit was initially purchased in 1946 but there have been several additions to the unit since then. The last addition to the unit was in 1978 and included 7,000 acres.

Seasonal and Diurnal Use by Wild Ungulates

The number of elk utilizing the unit during winter ranges from 1,300 to 1,900 animals, depending on the severity the winter. A small number of elk utilize the higher elevations of the unit during late summer and fall. The majority of mule deer in the area are found below the unit at lower elevations during winter months. Moose are occasionally found on the unit throughout the year.

Livestock Grazing History

The entire unit has not had authorized livestock grazing since the last addition to the unit in 1978. Other portions of the unit have not had authorized livestock grazing since there addition to the unit. There has been some occasional use by trespass cattle throughout the years.

Wetland Classification

According to the classification system used by the U.S. Fish and Wildlife Service, Bear Creek is classified as; SYSTEM Riverine, SUBSYSTEM Upper Perennial.

Description of Site

The elevation of the potential study area is approximately 7,300 feet. Associated riparian vegetation includes, grasses, sedges, willow, chokecherry, aspen, cottonwood, and spruce. Upland vegetation includes grass, sagebrush, spruce, lodgepole pine, and some aspen. Several irrigated grass meadows are located adjacent to the stream on the unit.

Rangeland Improvements

Several rangeland treatments, including planting, fertilizing, range pitting, and prescribed burning, have been implemented to improve the quantity and quality of forage on the unit. Salt and mineral blocks have also been used to distribute the animals throughout the unit.

Observed Impacts

Overall, the riparian and upland habitat is in good shape. There is evidence of some light browsing on shrubs along the stream but browsing has not been significant enough to cause a species composition shift in the riparian zone. There are periodic problems with stream quality related to sediment loading from upstream sources. The problem has not yet been attributed to any particular cause, but the Wyoming Game and Fish Department is addressing the issue. Elk feces was found mainly off of the riparian zone on upland hillsides. Elk distribute throughout the unit and spend most of the time utilizing open slopes and ridges.

Potential as Field Study Site

Impacts on water quality from wild ungulate use may be difficult to assess due to the existing water quality problems caused from upstream sources. Within the unit, the majority of utilization by wild ungulates occurs off of the riparian zone on upland slopes. The animals are well distributed throughout the unit, therefore, utilization is relatively uniform and impacts on water quality may be minimal.

Potential as Experimental Site

East Fork Wildlife Habitat Unit could be used as an experimental site if erosion problems from above the unit are identified and solved. The unit is large enough that a small-scale or large-scale study could be conducted.

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Appendix XII

TORREY CREEK, WHISKEY BASIN HABITAT UNIT, FREMONT COUNTY

Location and Accessibility

The potential study site on Torrey Creek is located on the Whiskey Basin Wildlife Habitat Unit, 9 miles south of Dubois, Wyoming (T 40N, R 106W, S 14,22). Approximately 1 mile of Torrey Creek is located on the 16,980 acre unit. The site is accessible by vehicle year-round.

Land Administrator

The Wyoming Game and Fish Department initially purchased the unit in 1954. There have been several additions to the unit since 1954 with the last purchase occurring in 1989. The Wyoming Game and Fish Department manages the unit for big game winter use.

Seasonal and Diurnal Use by Wild Ungulates

Approximately 1,000 bighorn sheep and 250 elk utilize the unit throughout the winter. The majority of sheep utilize rocky cliffs and high ridges above Torrey Creek. Most elk utilization occurs on open wind swept slopes on the west side of the unit away from Torrey Creek. Some mule deer and moose are occasionally found along the stream throughout the year.

Livestock Grazing History

Whiskey Basin Wildlife Habitat Unit has not had authorized livestock grazing since 1954. There is no livestock grazing along Torrey Creek above the unit.

Wetland Classification

According to the classification system used by the U.S. Fish and Wildlife Service, Torrey Creek is classified as; SYSTEM Riverine, SUBSYSTEM Upper Perennial.

Description of Site

The elevation of the potential study site approximately 7,500 feet. The riparian zone is in nearly pristine condition with exception to some very light utilization by moose. Associated riparian vegetation includes grass, sedges, and willow. Upland vegetation includes grass, sagebrush, juniper, spruce, and lodgepole pine. Torrey Creek runs through a glacial valley with steep rocky cliffs on both sides of the stream. Due to the rocky terrain adjacent to the stream, stream sediment loading from natural erosion and animal use is minimal.

Rangeland Improvements

Rangeland improvements, such as, planting, fertilizing, prescribed burning, range pitting, and spraying have been used to improve the quantity and quality of forage and better distribute animals to minimize interspecific competition between bighorn sheep and elk.

Observed Impacts

The riparian zone along Torrey Creek is in nearly pristine condition. Utilization by wild ungulates along the stream is minimal. Most utilization by bighorn sheep occurs on rocky outcroppings and ridges away from the stream. Elk utilization occurs on open wind swept slopes on the opposite side of the mountain from Torrey Creek. Stream quality related to soil erosion and fecal coliform contamination would be minimal within and above the unit the topography and geography of the area.

Potential as Field Study Site

Torrey Creek holds little potential as a field study site because of minimal use by wild ungulates. Most utilization occurs away from the stream on rocky ridges and open slopes. Wild ungulates would have minimal impact on stream quality.

Potential as Experimental Site

Torrey Creek holds good potential as an experimental site. Riparian vegetation and stream quality are in excellent condition. Impacts from wild ungulate use could be assessed exclusively because of the lack of livestock use and minimal sediment loading occurring above the unit.

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Appendix XIII

BLUE CREEK ALLOTMENT, HOT SPRINGS COUNTY

Location and Accessibility

Blue Creek Allotment is located approximately 20 miles southwest of Grass Creek townsite in Hot Springs County (T 44N, R 101W, S 3,4,9; T 45N, R101W, S 33,34,35). The allotment includes all of Blue Creek and approximately 6 miles of Cottonwood Creek. The potential study area is accessible by four-wheel drive from late spring until late fall.

Land Administrator

Blue Creek Allotment is managed by the U.S. Bureau of Land Management under a Coordinated Land Resource Plan (CLRP) which includes the Wyoming Game and Fish Department, U.S. Soil Conservation Service, and 14 private land owners. The primary objective of the CLRP is to improve the range condition from "poor" to "good" and "excellent" status. The secondary objective is to provide critical winter range for elk.

Seasonal and Diurnal use by Wild Ungulates

Approximately 350 elk utilize Blue Creek Allotment during late winter and early spring. Some elk, mule deer, and moose also utilize the area during summer and fall.

Livestock Grazing History

Blue Creek Allotment received heavy livestock use until 1983 when the CLRP was put into effect. Livestock have been excluded since 1983, but will be reintroduced back on the allotment within the next 1-2 years.

Wetland Classification

According to the classification system used by the U.S. Fish and Wildlife Service, Blue Creek and Cottonwood Creek are classified as; SYSTEM Riverine, SUBSYSTEM Upper Perennial.

Description of Site

The elevation of the potential study site is approximately 7,600 feet. Associated riparian vegetation includes grass, sedges, willow, cottonwood, aspen, fir, and spruce. Upland vegetation consists of big sagebrush, fir, spruce, and limber pine. According to Ken Stinson of the U.S. Bureau of Land Management in Worland, Wyoming, streamside vegetation has greatly increased since the exclusion of livestock in 1983. Willow production has increased and streambanks are becoming more stable. Grass production on upland sites greatly increased after annual prescribed burns starting in 1985.

Rangeland Improvements

The U.S. Bureau of Land Management has prescribed spring and fall burns since 1985. More burning is planned in the future.

Observed Impacts

Streambanks were severely eroded by high stream flows during spring of 1991. Stream sediment loading from wild ungulate use would be difficult to assess due to natural bank erosion. Moose feces was observed occasionally along the creek while most elk and deer feces was limited to upland sites. Some fecal contamination may be occurring lower on the allotment during spring when water runoff and elk concentrations are highest.

Potential as Field Study Site

Blue Creek Allotment holds little potential as a field study site because of water existing quality problems caused by natural erosion. Also, reintroduction of livestock on to the allotment is planned in 1992 or 1993.

Potential as Experimental Site

There is little potential as an experimental site for the same reasons as mentioned above.

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Appendix XIV

MIDDLE FORK POWDER RIVER, ED O'TAYLOR WILDLIFE HABITAT UNIT
JOHNSON COUNTY

The Ed O'Taylor Wildlife Habitat Unit is located approximately 25 miles west of Kaycee, Wyoming. The unit was not evaluated in detail because topography and accessibility limit the potential as an experimental site or a field study site. The middle fork of the Powder River on the unit is located at the bottom of a large, steep, and rocky canyon that is accessible by foot in limited areas.

Appendix XV

FONTENELLE CREEK, BRIDGER NATIONAL FOREST, LINCOLN COUNTY

Location and Accessibility

The potential study area on Fontenelle Creek is located in the Bridger National Forest, 35 miles north of Kemmerer, Wyoming (T 27N, R 116W, S 22,27). Approximately 2.5 miles of Fontenelle Creek is located on a 5,000 acre allotment which is designated for wildlife use. The lower portion of the stream is accessible by four-wheel drive from late spring until late fall and the upper portion of the stream is accessible by foot or horse.

Land Administrator

The U.S. Forest Service manages the allotment for wildlife use.

Seasonal and Diurnal Use by Wild Ungulates

Elk, mule deer, and moose utilize the area from early spring until early winter. The potential study area includes prime elk calving habitat and borders crucial elk and mule deer winter range.

Livestock Grazing History

The wildlife use area has not had authorized livestock grazing since 1989 when the livestock grazing permit was not re-issued. There is some trespass cattle use on the southern end of the allotment where there is no fencing. Domestic sheep and cattle grazing is permitted on Fontenelle Creek above and below the designated wildlife use area.

Wetland Classification

According to the classification system used by the U.S. Fish and Wildlife Service, Fontenelle Creek is classified as; SYSTEM Riverine, SUBSYSTEM Upper Perennial.

Description of Site

The elevation of the potential study site is approximately 7,700 feet. Associated riparian vegetation includes grass, sedges, and willow. Upland vegetation includes grass, sagebrush, aspen, spruce, fir, and lodgepole pine. Fontenelle Creek flows through a narrow valley that has steep and timbered slopes rising up from the stream.

Rangeland Improvements

There have been no rangeland improvements or treatments done on the allotment. There has been some logging in areas adjacent to the allotment.

Observed Impacts

Impacts on water quality from ungulate use is limited. Streambanks are well vegetated and stable. Two moose and some moose feces were observed along the stream. Some elk and deer feces were observed on upland slopes.

Potential as Field Study Site

Fontenelle Creek holds little potential as a field study site because utilization from sheep and cattle above the allotment may be impacting water quality. Feasibly, there could be cattle use throughout the wildlife area due to the potential of cattle entering the allotment on the southern end where fences are absent.

Potential as Experimental Site

Fontenelle Creek holds some potential as an experimental site. Personnel from the U.S. Forest Service mentioned that they might be able to put up an electric fence on the bottom end of the allotment which is currently not fenced. The electric fence would enclose 5,000 acres of forest which is designated for wildlife use.

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Appendix XVI

BLACKTAIL DEER CREEK, YELLOWSTONE NATIONAL PARK, PARK COUNTY

Location and Accessibility

Blacktail Deer Creek is located in north-central Yellowstone National Park, approximately 6 miles east of Mammoth Hot Springs (T 57N, R 113W, S 7,18). Three miles of Blacktail Deer Creek is included in the potential study area south of the Grand Loop Road. There is access by vehicle to the northern part of the site and good access by foot to the southern end of the site.

Land Administrator

The National Park Service manages the natural resources of Yellowstone National Park to maintain, rehabilitate, and perpetuate their (natural resources) inherent integrity. Ecological processes should be permitted to proceed as they did under pristine conditions and modern man must be restricted to generally non-consumptive uses of these areas.

Seasonal and Diurnal Use by Wild Ungulates

The Northern Range, which includes Blacktail Deer Creek, is approximately 247,000 acres in size and has provided critical winter range for elk, mule deer, bison, bighorn sheep, antelope and moose since before the establishment of Yellowstone National Park in 1872. Douglas (1983) estimated that approximately 12,000 elk utilize the Northern Range during winter months, 83% of which winter inside the Park boundary. It has also been estimated that 2,000 deer, 500 bighorn sheep, 260 bison, 200 moose, and 150 antelope winter on the Northern range. Animals disperse and migrate to higher elevations during late spring and summer.

Livestock Grazing History

Livestock grazing has been excluded from the Northern Range since 1952. Specifically, Blacktail Deer Plateau has not had livestock grazing since 1942. From 1935 to 1942, 25-30 semi-domesticated bison summered on a small pasture near Antelope Creek. From the late 1870s to 1930s, several hundred horses and cattle periodically grazed throughout Blacktail Deer Plateau.

Wetland Classification

According to the classification system used by the U.S. Fish and Wildlife Service, Blacktail Deer Creek is classified as; SYSTEM Riverine, SUBSYSTEM Upper Perennial.

Description of Site

The elevation of the potential study site is approximately 6,800 feet. Blacktail Deer Creek is a small perennial stream that starts above Blacktail Deer Plateau and flows northward into the Yellowstone River. Vegetation associated with the riparian zone includes grass, sedges, willow, and cottonwood. Upland vegetation is primarily a sagebrush steppe with interspersions of conifers occurring in small stands at lower elevations and more continuous at higher elevations.

Rangeland Improvements

There have been no rangeland improvements or treatments on the Northern Range including Blacktail Deer Creek.

Observed Impacts

Streambank sloughing occurs at some points along Blacktail Deer Creek where streamside vegetation is absent possibly due to years of intense grazing by wildlife. Shrubs have been browsed heavily along the creek and adjacent uplands. Some elk and deer feces were observed along the stream and upland sites.

Potential as Field Study Site

Blacktail Deer Creek has good potential as a field study site. Impacts by wildlife, mainly elk, seem quite significant.

Potential as Experimental Site

Blacktail Deer Creek holds little potential as an experimental site because moderate to large numbers of ungulates have utilized the area and may have caused changes in vegetative composition and stream quality.

<u>Administrative Contact</u>

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Appendix XVII

ELK FORK RIVER, SHOSHONE NATIONAL FOREST, PARK COUNTY

Location and Accessibility

The potential study area on the Elk Fork River is located 27 miles west of Cody, Wyoming on the south side of highway 20 (T 52N, R 106W, S 31,32; T 51N, R 106W, S 6,7). The last 5 miles of the river above highway 20 is considered crucial elk winter range. The potential study area is accessible by foot or horse.

Land Administrator

The U.S. Forest Service manages the Elk Fork drainage and surrounding area for wildlife and non-motorized recreational use. The upper portion of the Elk Fork River is located in designated wilderness area.

Seasonal and Diurnal Use by Wild Ungulates

During severe winters, as many as 800 elk will utilize the lower portion of the Elk Fork River. During mild winter, elk will utilize a larger portion of the drainage and not concentrate on the lower portion of the river as much. Elk will utilize the upper portion of the river in the wilderness area from late spring until late fall. Moose and mule deer utilize the potential study area from early spring until late fall.

Livestock Grazing History

The entire Elk Fork River watershed has not had authorized cattle or sheep grazing since the early 1940's. There is some recreational horse use from hunters and outfitters.

Wetland Classification

According to the classification system used by the U.S. Fish and Wildlife Service, the Elk Fork River is classified as; SYSTEM Riverine, SUBSYSTEM Upper Perennial.

Description of Site

The elevation of the potential study site is approximately 6,500 feet. Riparian vegetation includes grass, sedges, willow, aspen, cottonwood, spruce, and fir. Upland vegetation consists of grass, sagebrush, juniper, spruce, and fir. The Elk Fork River flows through a relatively straight and narrow canyon with steep semi-open slopes adjacent to the river. Vegetative cover on upland slopes is low with thin and loose volcanic soils being exposed. Approximately 2 miles up the river are remnants of 3 experimental exclosures. The U.S. Forest Service erected these exclosures in 1941 to assess impacts from winter elk use and to rest a heavily utilized hillside. The Elk Fork River is a relatively large river that has periodic spring flooding which may be causing downcutting and channel scouring.

Rangeland Improvements

Trenching and some grass planting was done on a heavily utilized hillside inside the largest exclosure during the late 1940's.

Observed Impacts

U.S. Forest Personnel said that there was a noticeable difference in vegetative biomass and composition inside and outside the exclosures during the early 1980's. Today, there is a minimal difference in vegetative biomass and composition inside and outside 2 exclosures which have either been taken down or not maintained for several years. There are several game trails crossing open slopes and ridges. Streambanks are rocky, bare, and unstable and could be easily eroded during flooding events. Elk feces was observed on open slopes and ridges. Some moose and deer feces were observed along the river and on upland sites.

Potential as Field Study Site

The Elk Fork River holds little potential as a field study site because of potential water quality problems that may exist which may be mostly attributable to loose volcanic soils and spring flooding events. Impacts from wild ungulate use may be difficult to differentiate from impacts due existing soil types and flooding.

Potential as Experimental Site

The Elk Fork River holds little potential as an experimental site for the same reasons as mentioned above.

Administrative Contact

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Appendix XVIII

LAMAR RIVER, YELLOWSTONE NATIONAL PARK, PARK COUNTY

Location and Accessibility

The potential study area on the Lamar river is located 12 miles east of Tower Falls Junction, south of the Northeast Entrance Road (T 57N, R 111W, S 22,23,25,26,36). The potential study area, known as the Lamar Valley, is located on the upper portion of the Northern Range which provides crucial winter range for elk, mule deer, bison, moose bighorn sheep, and antelope. The site is accessible by vehicle from late spring until late fall.

Land Administrator

The National Park Service manages the natural resources of Yellowstone National Park to maintain, rehabilitate, and perpetuate their (natural resources) inherent integrity. Ecological processes should be permitted to proceed as they did under pristine conditions and modern man must be restricted to generally non-consumptive uses of these areas.

Seasonal and Diurnal Use by Wild Ungulates

The Northern Range, which includes a large portion of the Lamar River, is approximately 247,000 acres in size and has provided critical winter range for elk, mule deer, bison, bighorn sheep, antelope, and moose since before the establishment of Yellowstone National Park in 1872. It has been estimated that approximately

12,000 elk utilize the Northern Range during winter months. As many as 5,000-6,000 elk may be using the upper portion of the Northern Range which includes the Lamar Valley. There have been estimations of 2,000 mule deer, 500 bighorn sheep, 260 bison, 200 moose, and 150 antelope that also winter on the Northern Range.

Livestock Grazing History

The Lamar Valley has not had domesticated livestock grazing since 1951. From 1940 to 1951, a small number of horses were raised on Rose Creek. During the late 1800's a small number of cattle and horses grazed throughout the Lamar Valley.

Wetland Classification

According to the classification system used by the U.S. Fish and Wildlife Service, the Lamar River is classified as; SYSTEM Riverine, SUBSYSTEM Upper Perennial.

Description of Site

The elevation of the potential study site is approximately 6,600 feet. The Lamar Valley is very wide (up to 1,000 yards) and is composed primarily of grass and some cottonwood trees. Sedges and willow are limited along the river, possibly due to natural channel erosion. Upland vegetation consists of grass, sagebrush, spruce, fir, lodgepole pine, and some willow.

Rangeland Improvements

There have been no rangeland improvements or treatments on the potential study area in the Lamar Valley.

Observed Impacts

The Lamar River has been identified as a major contributor of suspended sediment in the upper Yellowstone River Basin. In response to a local concern that Yellowstone Park's Northern Range is over-grazed, monitoring of suspended sediment in the upper Yellowstone River Basin began 1985. Results indicate that 90% of suspended sediment is transported during snowmelt runoff. Major sources of sediment are: erosion in high elevation volcanic rocks; loosely consolidated glacial moraine in steep cirque basin; landslides and scarps in soft cretaceous shale and mudstones; and large scale channel erosion of various sediments. The Lamar River is a large river that has some channel movement which may be contributing to stream sediment loading. Wild ungulate feces were rarely observed along the river.

Potential as Field Study Site

The Lamar River, in this portion of the Northern Range, holds little potential as an experimental site because of existing water quality problems related to suspended sediment. Recent studies by Park officials have not identified wild ungulate grazing as a major contributor of sediment to streams and lakes in the upper Yellowstone River Basin.

Potential as Experimental Site

The Lamar River holds little potential as an experimental site for the same reasons as mentioned above.

Administrative Contact

Chief of Research
National Park Service
Yellowstone National Park, Wyoming 82190

(307) 344-7381

Appendix XIX

SLOUGH CREEK, YELLOWSTONE NATIONAL PARK, PARK COUNTY

Location and Accessibility

The potential study area on Slough Creek is located approximately 8 miles east of Tower Falls Junction, north of the Northeast Entrance Road (R 111W, T 57N, S 7,8,18; R 112W, T 57N, S 13). Approximately 6 miles of Slough Creek are located in the upper portion of the Northern Range which provides crucial winter range for elk, mule deer, bison, moose, bighorn sheep, and antelope. The site is accessible by vehicle from late spring until late fall.

Land Administrator

The National Park Service manages the natural resources of Yellowstone National Park to maintain, rehabilitate, and perpetuate their (natural resources) inherent integrity. Ecological processes should be permitted to proceed as they did under pristine conditions and modern man must be restricted to generally non-consumptive uses of these areas.

Seasonal and Diurnal Use by Wild Ungulates

The Northern Range, which includes a portion of Slough Creek, is approximately 247,000 acres in size and has provided crucial winter range for elk, mule deer, bison, bighorn sheep, antelope and moose since before the establishment of Yellowstone National

Park in 1872. It has been estimated that approximately 12,000 elk utilize the Northern Range during winter months. As many as 5,000-6,000 elk may be utilizing the upper portion of the Northern Range which includes Slough Creek. It has also been estimated that 2,000 mule deer, 500 bighorn sheep, 260 bison, 200 moose, and 150 antelope winter on the Northern Range.

Livestock Grazing History

Slough Creek has not had authorized livestock grazing since 1920-1937 when a small number of horses were utilizing the area. During the late 1800's a small number of cattle and horses grazed throughout the Lamar Valley which includes the potential study area on Slough Creek.

Wetland Classification

According to the classification system used by the U.S. Fish and Wildlife Service, Slough Creek is classified as; SYSTEM Riverine, SUBSYSTEM Upper Perennial.

Description of Site

The elevation of the potential study site is approximately 6,250 feet. Riparian vegetation consists of grass, sedges, willow, aspen, and cottonwood. Upland vegetation includes grass, sagebrush, aspen, spruce, fir, lodgepole pine, and some willow. Slough Creek is located at the lower portion of the Lamar Valley which a relatively flat and wide (up to 1,000 yards) valley.

Rangeland Improvements

There have been no rangeland improvements or treatments in the Lamar Valley which includes Slough Creek.

Observed Impacts

Slough Creek has been identified as a major contributor of suspended sediment in the upper Yellowstone River Basin. In response to a local concern that Yellowstone Park's Northern Range is over-grazed, monitoring of suspended sediment in the upper Yellowstone River Basin began in 1985. Results indicate that 90% of suspended sediment is transported during snowmelt runoff. Major sources of sediment are: erosion in high elevation volcanic rocks; loosely consolidated glacial moraine in steep cirque basins; landslides and scarps in soft cretaceous shale and mudstones; and large scale channel erosion of various sediments. Game trails were observed throughout the riparian zone and along the stream. Willows have been heavily browsed throughout the riparian zone. Elk and bison feces were observed along the stream and on upland sites.

Potential as Field Study Site

Slough Creek holds little potential as a field study site because of existing water quality problems related to suspended sediment. Recent studies by Park officials have not included wild ungulate grazing as a major contributor of sediment to streams and lakes in the upper Yellowstone River Basin.

Potential as Experimental Site

Slough Creek holds little potential as an experimental site for the same reasons mentioned above.

Administrative Contact

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Yellowstone National Park, Wyoming 82190

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Appendix XX

SUNLIGHT CREEK, SUNLIGHT BASIN WILDLIFE HABITAT UNIT PARK COUNTY

Location and Accessibility

The potential study area is located on Sunlight Basin Wildlife Habitat Unit which is approximately 35 miles northwest of Cody, Wyoming and 5 miles west of Highway 296 (T 56N, R 106W, S 13,14; T 56N, R 105W, S 7,17,18,19,). Approximately 1 mile of Sunlight Creek is located on the 1,200 acre unit. The site is accessible by four-wheel drive year-round.

Land Administrator

The Wyoming Game and Fish Department manages Sunlight Basin Wildlife Habitat Unit for big game use and access for public fishing.

Seasonal and Diurnal Use by Wild Ungulates

Approximately 1,000 elk utilize the unit from late fall until early summer. Some moose utilize the unit year-round and some mule deer are found on the unit from late spring until late fall.

Livestock Grazing History

There has been no authorized livestock grazing on the unit since it was purchased by the Wyoming Game and Fish Department in 1961. There is some occasional trespass cattle use and horse use on the unit. Cattle grazing is permitted on Forest Service land above the unit and private land surrounding the unit.

Wetland Classification

According to the classification system used by the U.S. Fish and Wild Service, Sunlight Creek is classified as; SYSTEM Riverine, SUBSYSTEM Upper Perennial.

Description of Site

The elevation of the potential study site is approximately 6,700 feet. Riparian vegetation includes grass, sedges, willow, aspen, cottonwood, spruce, and fir. Upland vegetation includes grass, sagebrush, spruce, fir, and lodgepole pine. Much of the area inside and outside the unit burned during the wildfires of 1988. Vegetative cover on upland slopes is low, with loose and thin volcanic soils being exposed. Two intermittent streams, Trail Creek and Painter Creek, flow into Sunlight Creek on the unit.

Rangeland Improvements

Approximately 880 acres, which consisted of mainly sagebrush on upland slopes, were burned in 1978. There are 200 acres of irrigated grass meadow adjacent to Sunlight Creek. Approximately 20 acres of decadent willows along Sunlight Creek were sheared to increase willow regeneration.

Observed Impacts

There is evidence of severe flooding and high spring runoff on Trail Creek and Painter Creek. Streambanks are unstable and are easily eroded. Snow melting on upland slopes could erode thin and loose volcanic soils which might be contributing sediment to Sunlight Creek. There has been moderate utilization of cottonwood and willow along Sunlight Creek. Streambanks along Sunlight Creek are well vegetated and stable. Elk feces were observed along the stream and on upland hillsides and ridges. Some moose and deer feces were observed along the stream.

Potential as Field Study Site

Sunlight Creek holds little potential as a field study site because of potential water quality problems that be attributable to loose and thin volcanic soils and high spring runoff. It may be difficult to differentiate impacts from wild ungulate grazing from impacts caused by natural processes.

Potential as Experimental Site

Sunlight Creek holds little potential as an experimental site for the same reasons as mentioned above.

Administrative Contact

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Appendix XXI

TONGUE RIVER, AMSDEN BIG GAME WINTER RANGE, SHERIDAN COUNTY

Amsden Big Game Winter Range is located 1 mile west of Dayton, Wyoming. The unit was not evaluated in detail because topography the lack of water on the unit limit the potential as an experimental or field study site. A small section of the Tongue River is located in a narrow canyon with nearly vertical cliffs on both side of the river. Utilization by elk on this portion of the unit is limited. Most utilization occurs to the north of the river on open slopes where water is limited.

Appendix XXII

WEST PASS CREEK, KERN'S BIG GAME WINTER RANGE, SHERIDAN COUNTY

Kern's Big Game Winter Range is located approximately 20 miles west of Ranchester, Wyoming. The unit was not evaluated in detail because topography, accessibility, and the lack of perennial water on the unit limit the potential as an experimental site or field study site. A small section of West Pass Creek is located in a deep, narrow, and dense timbered canyon on the south side of the unit. Utilization by elk on this portion of the unit is limited. Most utilization occurs on the northern part of the unit where intermittent streams flow water only during spring.

Appendix XXIII

FALL CREEK, FALL CREEK FEEDGROUND, SUBLETTE COUNTY

Location and Accessibility

The potential study site is located on Fall Creek Feedground, 8 miles east of Pinedale, Wyoming (T 33N, R 108W, S 1,SE1/4 2,NE1/4 11,N1/4 12). Approximately 1 mile of Fall Creek is located land deeded to the Wyoming Game and Fish Department from the U.S. Bureau of Land Management. The site is accessible by four-wheel drive from late spring until late fall.

Land Administrator

The Wyoming Game and Fish Department manages Fall Creek Feedground for supplemental winter feeding of big game animals, primarily elk.

Seasonal and Diurnal Use by Wild Ungulates

Approximately 650 elk utilize Fall Creek Feedground and the surrounding area from late fall until late spring. Moose and some mule deer utilize the area throughout the year.

Livestock Grazing History

Summer and fall cattle grazing is permitted on Fall Creek Feedground and the surrounding area.

Wetland Classification

According to the classification system used by the U.S. Fish and Wildlife Service, Fall Creek is classified as; SYSTEM Riverine, SUBSYSTEM Upper Perennial.

Description of Site

The elevation of the potential study site is approximately 7,100 feet. Riparian vegetation includes grass, sedges, willow, aspen, and lodgepole pine. Upland vegetation includes grass, sagebrush, aspen, and some lodgepole pine. The area can be described as a sagebrush steppe with interspersions of conifers along the streams.

Rangeland Improvements

There have been no rangeland improvements on Fall Creek Feedground. Elk will utilize native winter range on Half Moon Mountain which is located approximately 4 miles northwest of Fall Creek Feedground. Half Moon Mountain attracts elk because of wildfires and prescribed burnings which have increased grass production on the mountain.

Observed Impacts

Fall Creek Feedground has very pronounced impacts from cattle and wildlife use. Shrubs, mainly willow and aspen, have been heavily utilized in the riparian zone and on upland sites. Aspen regeneration is virtually non-existent. Lodgepole pine trees along the stream have been heavily barked, primarily by elk during the winter. Grass in the riparian zone and on upland sites is moderately grazed by cattle during the summer and fall. Streambanks are not well vegetated and have been trampled by the hooves of ungulates in some areas. Elk feces was abundant along the stream and on upland sites. Cattle dung was observed along the stream and on upland sites.

Potential as Field Study Site

Fall Creek Feedground holds little potential as a field study site because cattle and wildlife both utilize the site. It would be difficult to differentiate the impacts of cattle use from wild ungulate use. Fall Creek holds good potential as a field study site to research the impacts of both cattle grazing and wild ungulate grazing on water quality.

Potential as Experimental Site

Fall Creek Feedground holds little potential as an experimental site because of moderate to heavy utilization by cattle and wild ungulates which have impacted water quality and vegetative biomass, age structure, and species composition.

Administrative Contact

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Appendix XXIV

BONE DRAW EXCLOSURES, SWEETWATER COUNTY

Location and Accessibility

Two exclosures are located on Bone Draw Creek approximately 7 miles southwest of Eden, Wyoming (T 24N, R 107W, S 32,33). The lower exclosure (exclosure A) is approximately 42 acres in size and is located directly above the confluence of Bone Draw Creek and Big Sandy River. The upper exclosure (exclosure B) is 37 acres in size and is located approximately 300 yards above exclosure A. The exclosures on Bone Draw Creek are accessible by four-wheel drive year around.

Land Administrator

The U.S. Bureau of Land Management in cooperation with the Wyoming Game and Fish Department manage the exclosures on Bone Draw Creek. The primary management objective is to protect spawning habitat for fish and the secondary management objective is to provide a livestock free control area to show contrasts between grazed and ungrazed riparian.

Seasonal and Diurnal Use by Wild Ungulates

Utilization inside exclosure A is limited to a small number of mule deer, mainly during spring, summer, and fall. Occasionally, up to 200 antelope will inhabit the area within exclosure B during late fall while migrating to winter grounds.

Livestock Grazing History

The area within the exclosures has not been grazed by livestock, with exception to an occasional trespass cow, since the construction of the exclosures in 1980. The area outside the exclosures is extensively grazed by cattle.

Wetland Classification

Bone Draw Creek in exclosure A is classified by the U.S. Fish and Wildlife Service as; SYSTEM Riverine, SUBSYSTEM Upper Perennial. Bone Draw Creek within exclosure B would be classified as; SYSTEM Riverine, SUBSYSTEM Intermittent.

Description of Site

The elevation of the potential study site is approximately 6,500 feet. It is possible that water from irrigated cropland above Bone Draw seeps into shallow aquifers and feeds Bone Draw Creek. Associated riparian vegetation includes grass, sedges, and some big sagebrush. Upland vegetation would be considered desert type with big sagebrush and rabbitbrush being the dominate shrubs.

Rangeland Improvements

There have been no rangeland improvements or treatments within the exclosures or on land adjacent to Bone Draw Creek.

Observed Impacts

The riparian zone inside the exclosures looks very healthy.

Sedges have created stable banks and filtered sediment from upstream sources. Outside the exclosures, streambanks are severely trampled and streamside vegetation is virtually non-existent. The stream is very shallow, muddy and slow moving. Cattle use along the stream outside the exclosures is moderate to heavy.

Potential as Field Study Site

Bone Draw exclosures hold little potential as a field study site because of minimal wild ungulate use within the exclosures and cattle use outside of the exclosures which may be impacting water quality.

Potential as Experimental Site

Bone Draw exclosures hold little potential as an experimental site for the same reasons mentioned above.

Administrative Contact

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Appendix XXV

GREEN RIVER, SEEDSKADEE WILDLIFE REFUGE, SWEETWATER COUNTY

Location and Accessibility

Seedskadee Wildlife Refuge is located approximately 22 miles north of Green River, Wyoming, east of Highway 312. Approximately 30 miles of the Green River is located on the 13,816 acre refuge. The potential study are is accessible by vehicle year-round.

Land Administrator

The U.S. Fish and Wildlife Service manages Seedskadee Wildlife Refuge for all species of wildlife with a higher priority on waterfowl. Seedskadee Wildlife Refuge was established in 1965.

Seasonal and Diurnal Use by Wild Ungulates

Approximately 50 mule deer, 50 antelope, and 35 moose utilize the refuge throughout the year.

Livestock Grazing History

Livestock grazing has been excluded from most of the refuge since the late 1960's. Eight water gaps are located along the Green River on the refuge for cattle and sheep use. Livestock grazing is permitted on land surrounding the refuge.

Wetland Classification

According to the classification system used by the U.S. Fish and Wildlife Service, the Green River is classified as; SYSTEM Riverine, SUBSYSTEM Upper Perennial.

Description of Site

The elevation of the potential study site is approximately 6,200 feet. Riparian vegetation includes grass, sedges, willow, chokecherry, and cottonwood. Upland vegetation is mainly a sagebrush-grassland. Seedskadee Wildlife Refuge includes approximately 30 miles of stream and riparian zone which contains excellent cover and forage for a wide diversity of wildlife species.

Rangeland Improvements

The U.S. Fish and Wildlife Service has used prescribed burning on some areas of the refuge to increase grass production and reduce decadent woody vegetation.

Observed Impacts

The number of wild ungulates per unit area on the refuge is low, therefore, impacts from wild ungulate use within the refuge are minimal. There is some utilization of willow and chokecherry by moose throughout the unit. Streambanks are relatively well vegetated and stable with exception to water gaps along the river which are utilized by livestock.

Potential as Field Study Site

The Green River on Seedskadee Wildlife Refuge holds little potential as a field study site because of minimal wild ungulate use on the refuge.

Potential as Experimental Site

The Green River on Seedskadee Wildlife Refuge holds good potential as an experimental site because the area within the refuge is large and in relatively good condition and impacts on water quality are few with exception to livestock utilizing water gaps on the river.

Administrative Contact

Refuge Supervisor
Seedskadee Wildlife Refuge
Highway 312
Green River, Wyoming 82935

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Appendix XXVI

BEAVER CREEK, GRAND TETON NATIONAL PARK, TETON COUNTY

Location and Accessibility

The potential study site on Beaver Creek is located 3 miles northwest of Moose, Wyoming in Grand Teton National Park (T 43N, R 116W, S 14,15). The Potential study area includes approximately 1.5 miles of Beaver Creek. There is good access to the lower end of site by vehicle and upper end of the site by foot.

Land Administrator

The National Park Service manages the natural resources of Grand Teton National Park to maintain, rehabilitate, and perpetuate their (natural resources) inherent integrity. Ecological processes should be permitted to proceed as they did under pristine conditions.

Seasonal and Diurnal Use by Wild Ungulates

Elk and some mule deer are found in the area during late spring, summer and fall. Moose inhabit the area year around. Elk and deer generally migrate to lower elevations, including the National Elk Refuge, during late fall and winter.

Livestock Grazing History

While cattle grazing and some horse grazing is allowed in the Park, it has been limited to areas east of the Snake River.

Prior to 1950, cattle grazing was allowed on both sides of the Snake River but most likely did not include the potential study area on Beaver Creek.

Wetland Classification

According to the classification system used by the U.S. Fish and Wildlife Service, Beaver Creek is classified as; SYSTEM Riverine, SUBSYSTEM Upper Perennial.

Description of Site

The elevation of the potential study site is approximately 7,500 feet. Beaver Creek divides into three forks roughly 0.6 miles west of Grand Teton Park Road. The north and south forks have perennial flows while the middle fork has potential for intermittent flows during late summer and fall. Associated riparian vegetation consists of grass, sedges, willow, spruce, and fir. Upland vegetation consists of spruce, fir and lodgepole pine. The ridge immediately north of Beaver Creek burned in 1985 and is now vegetated by sapling lodgepole pine, huckleberry, and serviceberry. Many large dead and down logs are scattered over the ridge.

Rangeland Improvements

There have been no rangeland improvements or treatments in the Beaver Creek area.

Observed Impacts

Tremendous trampling and sloughing of streambanks occur where upland game trails have converged at certain sites along the stream. Elk use the riparian zone heavily, especially in fall during the breeding season. Trampled areas have exposed fine soils which could contribute to stream sediment loading. Feces from elk, moose, and deer were found along the creek and adjacent upland sites.

Potential as Field Study Site

Beaver Creek has good potential as a field study site. Research of wildlife impacts on water quality could be measured exclusively without effects from livestock grazing.

Potential as Experimental Site

Beaver Creek holds little potential as a experimental site because of moderate to heavy utilization by wildlife that already exists and the need to enable animal migration through the area, thereby making fencing impractical.

Administrative Contact

Pete Hayden
Chief of Resource Management
Science and Resource Management
Grand Teton National Park
Moose, Wyoming 83102

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Appendix XXVII

CAMP CREEK, CAMP CREEK FEEDGROUND, TETON COUNTY

Location and Accessibility

The potential study site is located on Camp Creek Feedground, 14 miles south of Jackson, Wyoming, east of highway 187 (T 29N, R 115W, S 29). Approximately 0.75 miles of stream are located on Camp Creek Feedground. Camp Creek is accessible by vehicle from early spring until late fall.

Land Administrator

The Wyoming Game and Fish Department manages Camp Creek Feedground for supplemental winter feeding of big game animals, primarily elk.

Seasonal and Diurnal use by Wild Ungulates

Approximately 900 elk utilize the feedground and surrounding area during winter and early spring. An occasional moose may be found on the feedground and some mule deer may utilize the feedground year-round.

Livestock Grazing History

There is no authorized livestock grazing permitted on the feedground or on the surrounding National Forest. A portion of Teton National Forest, which includes the Camp Creek area, has been cattle and sheep free since 1918. There is some recreational horse grazing from hunters and outfitters throughout the area.

Wetland Classification

According to the classification system used by the U.S. Fish and Wildlife Service, Camp Creek is classified as; SYSTEM Riverine, SUBSYSTEM Intermittent.

Description of Site

The elevation of the potential study site is approximately 7,500 feet. Camp Creek is a small intermittent stream that flows during spring and dries up during summer. Associated riparian vegetation consists grass, willow, and aspen. Upland vegetation consists of grass, big sagebrush, willow, aspen, and some conifers.

Rangeland Improvements

There have been no rangeland Improvements or treatments on Camp Creek Feedground.

Observed Impacts

Grass production looks good while the willow and aspen component looks poor. Willow and aspen have been heavily browsed and regeneration is low. Willow establishment along the stream is poor and streambanks are relatively unstable. Shallow rooted grasses have established up to the streams edge. Elk feces is abundant along the riparian zone and adjacent uplands. The potential for fecal bacteria contamination of the stream is very high, especially during spring when water flows openly across the wide and relatively flat riparian zone.

Potential as Field Study Site

Camp Creek holds some potential as a field study site. A small scale study regarding fecal contamination of the stream might be feasible during the spring when elk are still utilizing the area and the stream is flowing.

Potential as Experimental Site

It would not be feasible to use Camp Creek as an experimental site because of the heavy utilization by elk and possible impacts on water quality that already exist.

Administrative Contact

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Star Rt.
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Appendix XXVIII

FLAT CREEK, NATIONAL ELK REFUGE, TETON COUNTY

Location and Accessibility

The potential study area on Flat Creek is located on the National Elk Refuge north of Jackson, Wyoming (T 41N, R 115W, S 4,5,6; T 41N, R 116W, T 1,E1/4 2,11,NW1/4 14,E1/2 15,22,SW1/4 23; T 42N, R 116W S 34,350). Approximately 9 miles of Flat Creek are located on the National Elk Refuge. The site is accessible by vehicle year-round.

Land Administrator

The U.S. Fish and Wildlife Service manages the National Elk Refuge, which was established in 1912, for winter elk use. A small portion of Flat Creek on the National Elk Refuge provides crucial nesting habitat for Trumpeter Swans which have low priority management by the U.S. Fish and Wildlife Service on the refuge.

Seasonal and Diurnal Use by Wild Ungulates

The National Elk provides 24,700 acres of winter range for approximately 7,500 to 9,000 elk which utilize the refuge from November through May. Approximately 100 bison and a small number of mule deer will utilize the National Elk Refuge throughout the winter.

Livestock Grazing History

The National Elk Refuge has been excluded from livestock grazing since the early 1900's when the refuge was established. A portion of Teton National Forest adjacent to the refuge has been excluded from livestock grazing, other than some recreational horse grazing, since 1918.

Wetland Classification

According to the classification system used by the U.S. Fish and Wildlife Service, Flat Creek on the northern portion of the refuge is classified as; SYSTEM Riverine, SUBSYSTEM Upper Perennial. Flat Creek on the southern portion of the refuge is classified as; SYSTEM Riverine, SUBSYSTEM Lower Perennial.

Description of Site

The elevation of the potential study site is approximately 6,300 feet. Associated riparian vegetation includes grass, sedges, willow and cottonwood. Upland vegetation can be described as a sagebrush-grassland which includes some aspen.

Rangeland Improvements

Several rangeland improvements and treatments have been used to increase the quantity and quality of forage on the refuge and better distribute the animals. Rangeland treatments on the refuge include prescribed burning, aspen clearcutting, seeding, fertilization, and irrigation.

Observed Impacts

Woody vegetation, mainly willow, aspen, and cottonwood, has been heavily utilized on the refuge. Streamside vegetation is limited to grasses and sedges with little establishment of woody vegetation along the stream. Water diverted from the Gros Ventre River to Flat Creek on the northern part of the refuge has increased stream flow of Flat Creek by three times. Streambanks on Flat Creek below the diversion have eroded due to the large amount of water added to the stream. Elk are generally divided into four separate feed herds on the refuge during supplemental feeding. Two herds are located on the southern portion of the refuge in close proximity to Flat Creek. At these locations, the amount of elk feces on the ground is high and the chance of fecal contamination of Flat Creek is high.

Potential as Field Study Site

Flat Creek on the National Elk Refuge holds good potential as a field study site. Fecal contamination of the stream is very probable, especially where elk concentrate close to the stream. It may be difficult to differentiate sources of suspended sediment due to elk use and increased stream load.

Potential as Experimental Site

Flat Creek on the National Elk Refuge holds little potential as an experimental site because of the large number of elk utilizing the area which may have caused changes in vegetative composition and stream quality.

Administrative Contact

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National Elk Refuge
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Jackson, Wyoming 83001

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Appendix XXIX

FLAT CREEK, SOUTH PARK FEEDGROUND, TETON COUNTY

Location and Accessibility

Flat Creek on South Park Feedground is located approximately 5 miles south of Jackson Wyoming, west of Highway 187 (T 40N, R 117W, S 28,29,33). Approximately 0.75 miles of Flat Creek is located on the 1,223 acre feedground. The site is accessible by vehicle year-round.

Land Administrator

The Wyoming Game and Fish Department established South Park Feedground in 1939 and manages the feedground for supplemental winter feeding of big game animals, primarily elk.

Seasonal and Diurnal Use by Wild Ungulates

Approximately 900 elk utilize South Park Feedground and a limited area adjacent to the feedground from late fall until spring. Moose may occasionally utilize the unit throughout the year.

Livestock Grazing History

South Park Feedground has not had authorized livestock grazing since it was established by the Wyoming Game and Fish Department. Cattle grazing is permitted on private land adjacent to the unit.

Wetland Classification

According to the classification system used by the U.S. Fish and Wildlife Service, Flat Creek is classified as; SYSTEM Riverine, SUBSYSTEM Upper Perennial.

Description of Site

The elevation of the potential study site is approximately 6,100 feet. Associated riparian vegetation includes grass, sedges, willow, and cottonwood. Upland site which have not been developed consist of mainly grass and some sagebrush. Housing has developed along a 3-4 mile stretch of Flat Creek between Jackson and South Park Feedground.

Rangeland Improvements

Native grass meadows are sub-irrigated and left standing for winter elk use.

Observed Impacts

Riparian vegetation along Flat Creek is in good condition. Streambanks are well vegetated and fairly stable. Flat Creek flows through the town of Jackson and through several miles of urban development above the feedground. It may be difficult to differentiate impacts due to wild ungulate use from impacts due to housing development, road development, livestock, and human activity above the feedground.

Potential as Field Study Site

Flat Creek, on South Park Feedground, holds little potential as a field study site due to possible impacts on water quality other than wild ungulate use.

Potential as Experimental Site

Flat Creek, on South Park Feedground, holds little potential as an experimental site for the same reasons mentioned above.

Administrative Contact

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Appendix XXX

HORSE CREEK, HORSE CREEK WINTER FEEDGROUND, TETON COUNTY

Location and Accessibility

Horse Creek Feedground is located 11 miles south of Jackson, Wyoming, 2 miles east of Highway 187 (T 39N, R 115W, S 18). Approximately 0.5 miles of Horse Creek is located on the 301 acre feedground. The site is accessible by vehicle year-round.

Land Administrator

The Wyoming Game and Fish Department established Horse Creek Feedground in 1968 and manages the unit for supplemental winter feeding of big game animals, primarily elk.

Seasonal and Diurnal Use by Wild Ungulates

Approximately 1,100 elk utilize Horse Creek Feedground and the surrounding area during the winter. Some mule deer utilize the area during summer and fall while a few moose may be found in the area year-round.

Livestock Grazing History

There is no authorized livestock grazing permitted on the feedground or surrounding National Forest. A portion of Teton National Forest, including Horse Creek, has been cattle and sheep free since 1918. There is some recreational horse grazing from hunters and outfitters in the area. Supplemental feeding of elk started in the early 1940's by private land owners.

Wetland Classification

According to the classification system used by the U.S. Fish and Wildlife Service, Horse Creek is classified as; SYSTEM Riverine, SUBSYSTEM Upper Perennial.

Description of Site

The elevation of the potential study site is approximately 6,200 feet. Riparian vegetation includes grass, sedges, cottonwood, and some willow. Upland vegetation includes grass, balsamroot, sagebrush, aspen, spruce, and fir. Horse Creek Feedground is located in a wide valley bottom with semi-open slopes and ridges rising up from both sides.

Rangeland Improvements

Hay meadows on the feedground are irrigated and the crop is left standing for elk to utilize during winter.

Observed Impacts

The most direct impact on water quality from wild ungulate use on the feedground is fecal contamination of the stream. During late winter and early spring when elk concentrations in the area are high, small tributaries and snowmelt runoff is yellowish-brown due to the large amount of elk feces that is being washed away. A large number of elk concentrate in a small area which compounds the impact of fecal contamination in that area. Willows and other bank stabilizing plants are not well established along the streambank. There are some occasional areas along the stream that have been trampled by elk and have sloughed off. On upland slopes, aspen have been heavily utilized and regeneration is low. A possible indirect impact from heavy elk utilization is a species composition shift from grasses to deep tap root species such as arrowleaf balsamroot.

Potential as Field Study Site

Horse Creek Feedground holds good potential as a field study site. With the large number of elk utilizing a relatively small area, there are most likely significant impacts on water quality, especially fecal contamination.

Potential as Experimental Site

Horse Creek Feedground holds little potential as an experimental site because of the moderate to heavy utilization by elk in the area and possible water quality problems that already exist.

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