AN ABSTRACT OF THE THESIS OF

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Title: SYNECOLOGICAL EFFECTS OF CATTLE GRAZING RIPARIAN ECOSYSTEMS

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In 1978, a ten year project was begun to examine the synecological effects of livestock grazing riparian ecosystems. A multitude of biotic and physical factors, many which were unique to riparian ecosystems, interacted to form a complex and diverse riparian ecosystem. A total of 256 stands of vegetation representing 60 discrete plant communities were identified. Twenty species of mammals and 81 species of birds were sited utilizing the area from May-October.

Approximately one-half of the riparian vegetation bordering Catherine Creek was excluded from livestock grazing. Ten plant communities were intensively sampled in grazed and exclosed areas during three growing seasons to determine some of the impacts a late season grazing scheme has on riparian vegetation. Three plant communities displayed significant species composition and productivity differences. These communities were within the meadow and Douglas Hawthorne (Crataegus

douglasii) vegetation types and were utilized more heavily by livestock than any other communities sampled. In addition succession appeared to be retarded by grazing on gravel bars dominated by black cottonwood (*Populus trichocarpa*) saplings and willows (*Salix* spp.). Few differences were recorded in other plant communities sampled.

Late season grazing had few short term impacts on avian populations censused from May-October. There was a significant decrease in small mammal populations after grazing in all communities sampled. However, by the following August small mammals had recolonized the grazed plant communities in essentially the same species composition and densities.

Grazed areas had significantly greater streambank losses than areas that were not grazed. While overwinter losses accounted for much of the streambank erosion, the erosion and disturbance caused by livestock grazing and trampling was enough to create significantly greater streambank losses in grazed areas compared to ungrazed areas.

Positive characteristics of a late season grazing scheme on the riparian zone included increased late season livestock production, good plant vigor and productivity, minimal soil disturbance, and minimal short term disturbance to wildlife populations dependent on riparian ecosystems.

Synecological Effects of Cattle Grazing Riparian Ecosystems

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INTRODUCTION

Riparian zones, particularly those associated with lotic systems could be described as unique assemblages of plant, animal and aquatic communities whose presence can be directly attributed to factors that are stream induced or water related. Though varying considerably in size and vegetation complex, all riparian zones have the following in common: (1) they create well-defined habitat zones within the much drier surrounding areas; (2) they make up a minor portion of the overall area; (3) they are generally more productive in terms of biomass - plant and animal, than surrounding uplands; (4) and they are a critical source of diversity (Thomas et al. 1979).

Riparian zones are recognized as among the most biologically diverse and most productive of all ecosystems in North America (Johnson et al. 1977, Odum 1978, Thomas et al. 1977). Vegetation along streamsides is an important component of the riparian/stream ecosystem in that it provides the detritial substrate on which much of the instream system is based; it cycles nutrients and it modifies the aquatic environment (Jahn 1978, Campbell and Franklin 1979). The riparian/stream ecosystem is also recognized as the single most productive terrestrial wildlife habitat type (Ames 1977, Hubbard 1977, Miller 1951, Patton 1977, Winegar 1977). And finally, riparian zones are important to livestock as a forage and water supply (Cook 1966, Reid and Pickford 1946).

In the past riparian zones were considered sacrifice areas (Oregon-Washington Interagency Wildlife Council 1978). Reid and Pickford stated that the highly palatable vegetation in meadows adjacent to streams is often sacrificed in order to utilize a much larger acreage of forested range.

Damages to vegetation induced by livestock grazing are the result of compaction of soils, which result in increased runoff, lowered plant vigor, higher soil temperatures, thus increased evaporation, and physical damage to vegetation by browsing, trampling, and rubbing (Severson and Bolt 1978). Excessive livestock grazing in riparian areas can severely impact terrestrial wildlife habitat causing a subsequent decrease in wildlife species and numbers (Ames 1977, Townsend and Smith 1977, Tubbs 1980, Wiens and Dyer 1975). Livestock grazing and excessive trampling have degraded streambank integrity in the form of decreased bank undercuts, increased channel widths, and bank steepness (Dahlem 1978, Duff 1979, Gunderson 1969, Heede 1977).

Because of the values riparian ecosystems and associated stream environments have for resident and anadromous fish populations, terrestrial wildlife, water quality and quantity, livestock production, recreation and aesthetics, it is important that they be managed in such a way as to provide suitable habitat values and/or requirements for all the important uses.

Management schemes discussed for riparian zone rehabilitation and/or maintenance included exclusion of livestock, alternative grazing schemes, changes in the kind and class of animals, managing riparian zones as special use pastures, instream structures and several basic range practices.

Recently many riparian ecosystems in the western United States have been fenced and managed as special use pastures. Rather than indefinite exclusion of grazing, several grazing schemes have been suggested to utilize the riparian forage resource while preserving the integrity of the riparian/stream ecosystem (Claire and Storch in press, Platts 1977). One such system is a late season grazing scheme in which utilization is deferred until late in the growing season just prior to movement of livestock to winter range or feedlots. This study was initiated to examine some of the synecological effects of a late season grazing scheme on the riparian plant communities, riparian wildlife communities and streambank physiognomy and character.

LITERATURE REVIEW

Historically, riparian vegetation has been defined as vegetation rooted at the water's edge (Campbell and Franklin 1979). Quite often, however, the stream influences vegetation well beyond the water line. Therefore, riparian zones could best be defined as those areas associated with streams, lakes and wet areas where vegetative communities are predominantly influenced by their association with water (Carter 1978).

Riparian zones can vary considerably in size and vegetation complexity because of the many combinations that can be created between water sources and physical characteristics of a site (Claire and Storch in press, Odum 1971, Platts 1979). Such characteristics include gradient, aspect, topography, soil type of streambottom, water quality, elevation and plant community (Odum 1971). However, riparian zones, particularly those bordering streams or rivers, have several characteristics in common. They are ecotonal in nature with high edge to area ratios (Odum 1978). As functional ecosystems they are very open with large energy, nutrient and biotic interchanges with aquatic systems on the inner margin (Cummins 1974, Odum 1978, Sedel et al. 1974) and upland terrestrial ecosystems on the other margin (Odum 1978).

Thomas et al. (1979) stated that all riparian zones within managed rangelands of the western United States have the following in common: (1) they create well-defined habitat zones within the much drier surrounding areas; (2) they make up a minor proportion of the overall area; (3) they are generally more productive in terms of biomass - plant and animal - than the remainder of the area; and (4) they are a critical source of diversity within rangelands. These points will be discussed in detail in the review.

Importance of Riparian/Stream Ecosystems

Importance to Instream Ecosystems

Vegetation along small streams is an important component of the riparian/stream ecosystem (Campbell and Franklin 1979, Jahn 1978). It provides the detrital substrate on which much of the instream system is based; it cycles nutrients and it modifies the aquatic environment (Campbell and Franklin 1979). Riparian vegetation produces the bulk of the detritus that provides up to 90 percent of the organic matter necessary to support headwater stream communities (Cummins and Spengler 1978). Berner (in Kennedy 1977) found that even in large streams such as the Missouri River, 54 percent of the organic matter ingested by fish is of terrestrial origin.

Ninety-nine percent of the stream energy input is imported from terrestrial surroundings (i.e., it is heterotrophic) with only one percent derived from stream photosynthesis by mosses (Cummins 1974). The riparian zone vegetation functions both in light attenuation and as the source of allochthonous inputs, including long term structural and annual energy supplies (Cummins 1974).

Channel and floodplain obstructions such as branches, logs and rocks enhance detention and concentration of organic matter, thereby facilitating its use locally rather than washing downstream (Jahn 1978). In addition, wood debris in channel bottoms appear to play an important role in the dynamics of stream morphology. Trees falling in the channel produce log steps which dissipate energy, thereby reducing the frequency of gravel bars and associated sediment movement (DeBano 1977).

Floodplain vegetation also acts as a roughness element that reduces the velocity and erosive energy of overbank flow during floods (Li and Shen 1973). The result is a higher flood peak than a channel without riparian vegetation but lower erosional factors acting on the floodplain and bank (Schumm and Meyer 1979). A healthy riparian vegetation may help reduce streambank damage from ice, log debris and animal trampling (Platts 1979).

Streamside vegetation strongly influences the quality of habitat for anadromous and resident coldwater fishes (Duff 1979, Marcuson 1977, Meehan et al. 1977). Riparian vegetation provides shade, preventing adverse water temperature fluctuations (Claire and Storch in press, Meehan et al. 1977). The roots of trees, shrubs and herbaceous vegetation stabilize streambanks providing cover in the form of overhanging banks (Marcuson 1977, Meehan et al. 1977). Streamside vegetation acts as a "filter" to prevent sediment and debris from man's activities from entering the stream (Meehan et al. 1977). Riparian vegetation also directly controls the food chain of the ecosystem by shading the stream and providing organic detritus and insects for the stream organisms (Claire and Storch in press, Cummins 1974, Meehan et al. 1977).

Importance to Wildlife

It is believed that on land, the riparian/stream ecosystem is the single most productive type of wildlife habitat, benefiting the greatest number of species (Ames 1977, Hubbard 1977, Miller 1951, Patton 1977). When it comes to wildlife, the riparian zone provides an almost classic example of the ecological principle of edge effect (Odum 1978). Both density and diversity of species tends to be higher at the land/water ecotones than in the adjacent uplands, especially where regional climates are arid or are characterized by dry periods (Odum 1978). Riparian habitat provides living conditions for a greater variety of wildlife than any other type of habitat found in California (Sands and Howe 1977), the Great Basin of southeast Oregon (Thomas et al. 1979), the Southwest (Hubbard 1977) and the Great Plains (Tubbs 1980).

Examples of the wildlife values of riparian habitat are numerous (Carothers et al. 1974, Carothers and Johnson 1975, Henke and Stone 1978, Hubbard 1977, Thomas et al. 1979). Hubbard (1977) reported that 16-17 percent of the entire breeding avifauna of temperate North America occurs in two New Mexico river valleys over the course of a few score miles. Johnson et al. (1977) reported that 77 percent of the 166 nesting species of birds in the Southwest are in some manner dependent on water related (riparian) habitat and 50 percent are completely dependent on riparian habitats. Thomas et al. (1979) stated that of the 363 terrestrial species known to occur in the Great Basin of southeastern Oregon, 288 are either directly dependent on riparian zones or utilize them more than any other habitats.

When riparian vegetation is eliminated several wildlife species dependent on riparian ecosystems may be either severely reduced or may disappear altogether. Henke and Stone (1978) found 93 percent fewer bird numbers and 72 percent fewer avian species on two riprapped plots from which riparian vegetation had been removed, and 95 percent fewer birds and 32 percent fewer species on cultivated lands previously occupied by riparian forests.

The influence of riparian ecosystems on wildlife is not limited to those animal species that are restricted in distribution to the streamside vegetation. Population densities of birds in habitats adjacent to the riparian type are influenced by the presence of a riparian area (Carothers 1977). When a riparian habitat is removed or extensively manipulated, not only are the riparian species of the area adversely influenced, but wildlife productivity in the adjacent habitat is also depressed (Carothers 1977).

Riparian ecosystems are valuable to wildlife as a source of water, food and cover (Stevens et al. 1977, Thomas et al. 1979). They also provide nesting and brooding habitat (Carothers et al. 1974, Johnson et al. Tubbs 1980). By furnishing abundant thermal cover and favorable micro-climates, especially when surrounded by non-forested ecosystems, they facilitate the maintenance of homeostasis, particularly for big game (Thomas et al. 1979). Riparian ecosystems also serve as big game migration routes between summer and winter range (Thomas et al. 1979), and provide routes and nesting cover for migrating avian species (Stevens et al. 1977, Wauer 1977).

Importance to Livestock

Range grazing is the most extensive form of land use in the interior Pacific Northwest (Skovlin et al. 1977). Cattle tend to congregate on meadows and utilize the vegetation much more intensively than the vegetation of adjacent ranges (Reid and Pickford 1946).

The moist meadow soils of riparian ecosystems are generally so highly productive that an acre of mountain meadow has a potential grazing capacity equal to 10-15 acres of forested range (Reid and Pickford 1946). Although riparian meadows cover only about 1-2 percent of the summer range area of the Pacific Northwest, potentially they can produce 20 percent of the summer range forage (Reid and Pickford 1946, Roath 1980). However, Roath (1980) stated that because of livestock concentrations, limits on livestock movements imposed by steep slopes, and erratic dictribution of watering areas away from the creek, the riparian zone (covering about two percent of a Blue Mountain grazing allotment) accounted for 81 percent of the total herbaceous vegetation removed.

Cattle exhibit a strong preference for riparian zones for a number of the same reasons other animals prefer and use these areas. The main attributes that attract and hold cattle to riparian areas are the availability of water, shade and thermal cover, and the quality and variety of forage (Ames 1977, Severson and Boldt 1978). In addition, sedges (Carex spp.) tend to retain relatively constant crude protein levels until the first killing frost. Several sedges common to riparian zones of the Pacific Northwest outrank key upland forage species in sustained protein and energy content (McClean et al. 1963, Paulsen 1969, Skovlin 1967). If the surrounding country is rough and rocky, livestock tend to concentrate along the level riparian areas (Ames 1977).

Livestock-Riparian Relationships

The impact of livestock on riparian zones in public grazing lands of the western states has received much attention recently. Several studies are presently underway examining the impact of livestock grazing on stream ecology, water quality, channel stabilization, salmonid fish habitat and physiology, terrestrial riparian wildlife populations and riparian vegetation.

Quite often existing literature on the impacts that livestock exert on riparian ecosystems has depended too much on observational data with no consideration given to variability, replication, or any other assumptions of statistical design. These shortcomings would include, for instance, only one year's data, only one exclosure, or no statistical analysis of data. In addition, several results and conclusions of these studies are confounded by the failure to report intensity of use, levels of utilization or season of use by the grazing animal. Neither proponents nor opponents of livestock grazing in riparian ecosystems are immune from this apparent bias in the literature.

General

The quality of the riparian habitat and its associated aquatic environment, both formed over geologic time, are fragile ecosystems which serve as focal points for management of livestock, recreation, and fisheries (Behnke et al. in press). It has been reported that inappropriate management results in grazing overuse and subsequent degradation of the riparian/stream ecosystem (Behnke et al. in press, Behnke and Raleigh 1978, Clair and Storch in press, Oregon-Washington Interagency Wildlife Council 1978, Platts 1979).

Livestock grazing can affect all four components of the aquatic system - streamside vegetation, stream channel morphology, shape and quality of the water column and the structure of the soil portion of the streambank (Behnke and Raleigh 1978, Claire and Storch in press, Marcuson 1977, Platts 1979). Improper livestock use of riparian ecosystems can affect the streamside environment by changing, reducing, or eliminating vegetation bordering the stream (Ames 1977, Behnke and Raleigh 1978, Claire and Storch in press, Platts 1979). The channel morphology can be changed by widening and shallowing of the streambed, gradual stream channel trenching, or braiding, depending on soils and substrate composition (Behnke and Raleigh 1978, Gunderson 1968, Marcuson 1977, Platts 1979). The water column can be altered by increasing water temperatures, nutrients, suspended sediments, bacterial counts and by altering the timing and volume of water flow (Behnke and Raleigh 1978, Claire and Storch in press, Johnson et al. 1978, Rauzi and Hanson 1966, Platts 1979). Overgrazing can cause bank slough-off creating false setback banks, accelerated sedimentation and subsequent silt degradation of spawning and invertebrate food producing areas (Behnke and Raleigh 1978, Claire and Storch in press, Platts 1979). Impacts of abusive livestock practices also result in decreased fish biomass and in percent of salmonid fishes in the total fish composition (Behnke and Raleigh 1978, Claire and Storch in press, Duff 1979, Gunderson 1968, Marcuson 1977).

Livestock abuse of riparian areas can severely impact terrestrial wildlife habitat causing a subsequent decrease in wildlife species and numbers (Ames 1977, Townsend and Smith 1977, Tubbs 1980, Wiens and Dyer 1975).

Improper grazing can have a considerable effect on vegetation, resulting in lowered vigor, biomass and a degradation of species composition and diversity (Ames 1977, Bryant et al. 1972, Evans and Krebs 1977, Pond 1961).

While various other management activities have caused serious losses or reductions in habitat productivity, livestock grazing has been the major factor identified in numerous studies throughout the 11 western states (Oregon-Washington Interagency Wildlife Council 1978). Conversely, Busby (1979) stated that it was not reasonable to conclude that livestock grazing is the only, nor necessarily the major cause of impacts to riparian ecosystems.

Impacts of Livestock on the Instream Ecology

A healthy instream environment is vital for the aquatic life forms inhabiting the stream, as well as for various human needs that are directly dependent on high water quality. High concentrations of suspended solids or other sediment loads, and fecal coliforms or fecal streptococci are usually associated with the degree of impact of man's activities, and can have a major impact in altering an existing stream ecosystem or even creating an entirely new ecosystem (Johnson et al. 1977, Johnson et al. 1978, McKee and Wolf 1963).

During the grazing season, Johnson et al. (1978) could not find any differences in physical and chemical properties of streamwater (suspended solids, total dissolved solids and orthophosphates) between an area grazed at 1.2 ha/AUM and an ungrazed area. After the grazing season, however, there was a significant increase in total dissolved solids which indicated that some livestock waste products may have eventually reached and enriched the stream, probably from the action of rain showers. The presence of cattle significantly elevated the fecal coliform and fecal streptococci for about nine days after cattle were removed.

Winegar (1977) found sediment loads were reduced 48-79 percent while flowing through 3.5 miles of a stream protected from grazing.

Rauzi and Hanson (1966) found a nearly linear relation between runoff and infiltration to the degree of grazing intensity. They found that runoff from a heavily grazed watershed (1.35 ac/AUM) was 1.4 times greater than from a moderately grazed watershed (2.42 ac/AUM), and nine times greater than from a lightly grazed watershed (3.25 ac/AUM).

Changes in water temperature have been shown to have drastic effects on fisheries and aquatic insect populations (Johnson et al. 1977). Changes in average temperature or daily fluctuations can in effect create an entirely new aquatic ecosystem (Johnson et al. 1977).

Van Velson (1979) found average water temperatures dropped from 74° F to 71° F after one year of livestock exclusion on a creek in Nebraska. Claire and Storch (in press) compared stream temperatures between an area that had been grazed season long (June 1 - October 15) and an area that had been rested for four years and, thereafter, grazed only after August 1. The maximum water temperatures outside and downstream from the exclosure averaged 12° F higher than those sampled within the exclosure. Daily fluctuations of water temperatures averaged 27° F outside the exclosure as compared to 13° F inside the exclosure. Winegar (1980) observed much the same results in an exclosure along Beaver Creek in central Oregon.

The effects of livestock grazing have been shown to vary greatly depending upon several factors, in particular, the nature of the stream studied. Duff (1979) stated that introduction of livestock into an ungrazed area resulted in a 14 percent decrease in streambank stability within six weeks. In contrast, after six weeks of mid-summer grazing by cattle, Roath (1980) gave an ocular estimate of 90 percent bank stability with little indication that trampling was contributing to or causing erosion. He attributed nearly all erosion present to geologic erosion caused by the actions of streamflow.

Buckhouse et al. (1981) could find no particular relationship between streambank erosion and various grazing treatments (including non-use) in northeastern Oregon. There appeared to be no significant patterns of accelerated streambank deterioration due to moderate livestock grazing (3.2 ha/AUM). Most bankcutting losses in this system were associated with over-winter periods where ice flows, high water and channel physiognomy were critical factors involved in the erosional process.

Hayes (1978) found that stream channel movement did not occur more frequently in grazed meadows under a rest-rotation grazing scheme. Rather, streambank degradation appeared to occur more often and to a greater magnitude along ungrazed streams. However, Hayes stated that soughoff increased as forage removal was above 60 percent. High forage removal, high amount of foraging time along banks, high percentages of palatable sedges along the bank were shown to significantly increase the probability of soughoff occurring during the grazing season.

Marcuson (1977) found the average channel width to be 53 meters in an area grazed season long at 0.11 ha/AUM and an average channel width of only 18.6 meters in the ungrazed areas. Marcuson (1977) also recorded 224 meters of undercut bank/ha in the grazed area and 685 meters of undercut bank/ha in the ungrazed area. Heavy grazing and trampling by cattle were suggested to cause the excessive erosion.

Duff (1979) found the stream channel width in a grazed area was 173 percent greater than the stream channel not grazed for eight years inside an exclosure. Similar results have been reported (Behnke and Zarn 1976, Dahlem 1979, Gunderson 1968, Heede (1977) where over-grazing and excessive trampling caused a decrease in bank undercuts, increases in channel widths and a general degradation of fish habitat.

The production of game fish in headwater streams can be used as a biological indicator of the quality of land management that is occurring within the watershed and/or streamside (Claire and Storch in press). Over-grazing, causing a reduction in vegetative cover and the caving in of overhanging banks was suggested as one of the principle factors contributing to the decline of native trout in the west (Behnke and Zarn 1976).

Van Velson (1979) found rough fish made up 88 percent of a fish population before relief from grazing and only one percent of the population after eight years' rest. Rainbow trout (Salmo gairdneri) made up one percent of the fish population before cessation of grazing and 97 percent of the population after relief from grazing. Marcuson (1977) found that an overgrazed section (.11 ha/AUM) of Rock Creek, Montana, supported only 71 kg of brown trout (*Salmo trutta*) per hectare whereas an ungrazed section produced 238.8 kilograms of brown trout per hectare. Claire and Storch (in press) in the Blue Mountains of Oregon found game fish were 24 percent of the total fish population in an area grazed season long, contrasted to a 77 percent game fish composition within a livestock exclosure.

Chapman and Knudsen (1980) found eight sections of streamside vegetation in western Washington judged to be moderately to heavily affected by livestock, had significant reductions in total biomass for Coho salmon (*Oncorhychus kisutch*), Cutthroat trout (*Salmo clarki*) and all salmonids compared to those areas that had not been grazed. Similar relationships between livestock grazing and salmonid fish populations have been reported by Dahlem (1979), Duff (in press), Gunderson (1968), and Keller et al. (1979).

Impacts of Livestock on Terrestrial Wildlife

Riparian zones are the most critical wildlife habitats in managed rangelands (Thomas et al. 1979). It is readily apparent that riparian ecosystems are of paramount importance in producing and maintaining a large degree of the biotic diversity of the Southwest (Hubbard 1977) and, perhaps, the entire North American continent (Johnson et al. 1977).

Changes in plant vigor, growth form and species composition due to grazing have frequently been related to the increase or decline of various species of birds (Townsend and Smith 1977). Several studies have shown a negative impact on avian populations due to grazing (Dambach and Good 1940, Overmire 1963, Owens and Meyers 1973, Reynolds and Trost 1980, Smith 1940). The tendency for livestock to congregate and linger around ponds and streambanks, results in the elimination of food and cover plants and reduces nest sites and habitat diversity (Buttery and Shields 1975, Behnke and Raleigh 1978, Crouch 1978, Evans and Krebs 1977).

Grazing may improve habitat for some avian species (Burgess et al. 1965, Kirch and Higgins 1976). In areas of higher precipitation (or productivity), grazing may be highly desirable to open up "roughs" and provide more diversity and patchiness (Ryder 1980). Grazing effects on breeding avifaunas are not uniform nor easily defined, primarily because grazing varies so much in its local intensity and because of the general difficulties in unraveling cause-effect relationships in rangeland faunas

(Wiens and Dyer 1975).

Several studies have shown wildlife numbers improved when a riparian area that was abused by improper grazing practices was fenced and allowed to recover (Claire and Storch in press, Duff 1979, Van Velson 1979, Winegar 1975, 1977). Duff (1979) reported a 350 percent increase in small mammal, songbird and raptor use after eight years' rest from grazing. Van Velson (1979) reported increased pheasant (Phasianius colchicus) production, increased deer populations and that waterfowl production occurred for the first time in the rested area.

When properly managed, the grazing of domestic livestock is generally compatible with wildlife, and may even increase the numbers of some species (Tubbs 1980). Nongame wildlife which are dependent on riparian ecosystems have several intangible values which are very hard to evaluate (Peterson 1980). It has been demonstrated that livestock can graze streamsides without causing serious damage. The capability to achieve positive on-site livestock control appears to be the limiting factor (Claire and Storch in press).

Impacts of Livestock on Riparian Vegetation

Recently there has been much published research and opinion on the effects of livestock in riparian ecosystems. Specifically these reports have dealt with soil compaction and its relationship to root growth, plant succession and productivity, and species diversity and vegetation structural diversity. Roath (1980) stated that there was no evidence that heavy cattle grazing affected productivity of a riparian zone, or that they caused bank deteriorations by trampling. Conversely, Ames (1977) stated that grazing only a few days can seriously impair a riparian zone's reproductive capability.

Damage to riparian vegetation induced by livestock can basically be separated into: (a) compaction of soil which increases runoff and decreases water availability to plants; (b) herbage removal which allows soil temperatures to rise and increases evaporation to the soil surface; and (c) physical damage to vegetation by rubbing, trampling and browsing (Severson and Boldt 1978).

Impacts of Trampling

The impacts of livestock trampling on soil compaction bulk density, and its subsequent effects on forage growth is well documented. Alderfer and Robinson (1949), Bryant et al. (1972), Orr (1960), and Rauzi and Hanson (1966) all found soil compaction increased linearly with increases in grazing intensity.

Alderfer and Robinson (1949) found grazing and trampling Kentucky bluegrass (Poa pratensis) upland pastures to a one-inch stubble height reduced vegetation cover, lowered yields, decreased non-capillary porosity and increased the volume weight of the 0-1 inch layer of soil.

Rauzi and Hanson (1966) found water intake rates on silty clay and silty clay loam soils to be 2.5 times greater in an area grazed at 1.35 acres/AUM compared to an area grazed at 3.25 acres/AUM. After 22 years of grazing at this intensity, not only had species composition been altered but possibly the soil properties had been changeed as well.

In a riparian zone continuously grazed season long, Orr (1960) found bulk density and macropore space to be significantly greater in grazed areas over exclosures. Differences in total pore space (both macro- and micropores) between grazed and exclosed areas were small due to a transformation of macropore spaces to micropore spaces due to trampling. Macropore space is a more sensitive indicator of compaction or recovery from compaction than either micro or total pore space (Orr 1960).

Bryant et al. (1972) found increasing trampling pressure had an adverse effect on Kentucky bluegrass swards, particularly during the months of June and September. After one overwinter period, there was a significant difference in soil compaction between an area trampled by 120 cow trips over bluegrass plots and an area that was untrampled.

Impacts of Herbage Removal

Impacts of herbage removal can be divided into two categories according to vegetation structure: (1) utilization of herbaceous vegetation and subsequent impacts on species composition, species diversity, and biomass produced and (2) utilization of woody vegetation and subsequent impacts on foliage cover, structural height diversity and stand reproduction.

Perhaps the greatest vegetation change to take place in mountain riparian systems is the replacement of native bunchgrass with Kentucky bluegrass. It has successfully established itself as a dominant species in native bunchgrass meadows as a result of overgrazing by herbivores and subsequent site deterioration (Volland 1978).

Pond (1961) found clipping native bunchgrass meadows every two weeks for four years caused a marked reduction in native sedges (Carex spp.), tufted hairgrass (Deschampsia caespitosa) and fostered the appearance of Kentucky bluegrass where it was not present before.

Evenden and Kauffman (1980) compared a fenceline contrast that was heavily grazed on one side and protected from grazing on the other. The grazed site was dominated by Kentucky bluegrass and Baltic rush (Juncus balticus), while the ungrazed site was dominated by panicled bullrush (Scirpus microcarpus). Twenty herbaceous plants were recorded in the grazed area with 12 herbaceous plants recorded in the ungrazed area. Dobson (1973) also found an increase in species numbers in a riparian zone due to grazing. He concluded the effect of grazing had been to open up the vegetation, creating more niches in which weeds could establish themselves. Hayes (1978) also observed that the abundance of forb species appeared to be higher in grazed areas than in pristine areas.

The impact of cattle on herbaceous productivity in riparian zones has been examined along several streamsides in the western United States. Duff (1979), Gunderson (1968), Marcuson (1977), McClean et al. (1963), and Pond (1961) found either decreases in biomass due to herbage removal or increases in biomass due to cessation of grazing in riparian ecosystems. Conversely, Volland (1978) could find no significant differences in biomass between a Kentucky bluegrass meadow grazed annually and one that had been rested for eleven years.

Effects of herbivory on shrub and tree production is a critical impact in riparian ecosystems, because of the importance of the woody vegetation to wildlife habitat and its dominant influence in altering the riparian microclimate. While mature vegetation approaches senescence, excessive grazing pressures have prevented the establishement of seedlings, thus producing an even-aged non-reproducing vegetative community (Carothers 1977, Glinski 1977).

The effects of excessive herbivore use on woody vegetation bordering streamsides can generally be termed as negative. Marcuson (1977) found shrub production to be 13 times greater in an ungrazed area than in a severely overgrazed area. Cover was 82 percent greater in the natural area. On a stream rested from continuous grazing for ten years, Claire and Storch (in press) found alders (*Alnus* sp.) and willows (*Salix* spp.) provided 75 percent shade cover over areas that had been devoid of shrub canopy cover before exclosure. Similar herbivore-woody vegetation relations has been reported by Crouch (1978), Duff (1979), Evenden and Kauffman (1980) and Gunderson (1968).

Management of Riparian Ecosystems

Recognizing and understanding the impacts on the streamsides which resulted from all previous land use practices is a prerequisite to streamside planning (Claire and Storch in press). Because of their small extent riparian zones in the past were considered "sacrifice areas" (Oregon-Washington Interagency Wildlife Council 1978, Skovlin et al. 1977). Riparian vegetation has been intensively used by livestock over several decades causing a reduction in the productivity of fish and wildlife habitats and degrading water quality as well as promoting increases in flow fluctuations (Oregon-Washington Interagency Council 1978).

Platts (1979) indicated that riparian ecosystems are the most critical zones for multiple use planning and offer the most challenge for proper managment; therefore, stream habitats should be identified as separate management units from the surrounding upland ecosystems. Even among riparian zones the need to identify and classify them adequately is important for proper stewardship of these systems (Claire and Storch in press, Platts 1978, 1979). The riparian habitat is the most productive and possibly most sensitive of North American habitats, and should be managed accordingly (Johnson et al. 1977).

Land management agencies responsible for managing livestock grazing have not adequately considered the influence of grazing on the other uses and users of riparian ecosystems (Platts 1979). Often what is good range or timber management (in economic terms) is not good riparian or stream management (Platts 1979). On the other hand, proper stream management practices that protect stream banks from damage, also improve the potential for riparian zones to enhance wildlife and livestock uses (Gunderson 1968, Marcuson 1977).

Methods discussed for riparian zone rehabilitation include exclusion of livestock grazing, alternative grazing schemes, changes in the kind or class of animals, managing riparian zones as "special use pastures," in-stream structures and several basic range management practices.

The use of instream structures as a method of riparian rehabilitation has been met with some success where instream structures are combined with rest from livestock grazing (Duff in press, Heede 1977). Heede (1977), combining rest from grazing with construction of check dams, obtained vegetation cover improvements, a change from an ephemeral stream flow to a perennial flow and a stabilization of gully erosion.

After losing 23 out of 26 instream structures in a grazed area Duff (in press) found that stream improvement structures can not work effectively to restore pool quality and streambank stability as long as livestock grazing continued. Keller et al. (1979) found that rest from grazing negated the need for artificial instream structures intended to enhance trout production for stream ecosystems. Kimball and Savage (in Swan 1979) found aquatic ecosystems can be restored through intensive livestock management at a lower cost than through installation of instream improvement structures.

Grazing systems have achieved some success in riparian rehabilitation and much success in riparian ecosystem maintenance. The damage caused by heavy season or yearlong grazing is well documented (Evans and Krebs 1977, Gunderson 1968, Marcuson 1977, Severson and Boldt 1978). It appears that rest-rotation grazing schemes and/or specialized grazing schemes in which riparian zones are treated as special use pastures have been the most successful.

Hayes (1978) stated that species composition appeared to be improved under a rest-rotation grazing system and bank sloughoff occurrences were not increased if utilization was under 60 percent.

Claire and Storch (in press) found a rest-rotation system to be favorable for achieving desired streamside management objectives if one year's rest out of three is included in the scheme. A rest-rotation system obtained a very favorable response for vegetation surrounding a livestock pond in South Dakota (Evans and Krebs 1977).

Criticism of rest-rotation systems includes reports that objectives for herbaceous vegetation were not being achieved within desired time limits (Storch 1979), and that rest-rotation systems may increase trailing and trampling damage, causing streambank erosion and instability (Meehan and Platts 1978).

Fencing and managing riparian zones separately from terrestrial upland sites as special use pastures was an adequate multiple use system of riparian zone management (Claire and Storch in press). Grazing a fenced riparian zone annually after August 1, had no measureable effect on production or species composition in mountain meadows, contrasted to decreased production and composition in a simulated season long scheme in northcentral Wyoming (Pond 1961).

Another grazing system for fenced riparian zones includes winter grazing, where possible, to minimize damage (Severson and Boldt 1978). For Kentucky blue-grass meadows, Volland (1978) recommended an initial year's rest, then late spring grazing alternated with late fall grazing to discourage flowering, increase tiller development, maintain plant vigor, and maximize productivity.

The most successful riparian management alternative on public lands to date, has been intensive livestock management by permit holders (Storch 1979). Herding livestock on a somewhat daily basis has been successful in limiting the number of livestock that visit streambottoms and improving utilization of upland areas. Proper stewardship of riparian ecosystems is, in effect, money in the bank for the floodplain rancher (Marcuson 1977).

Proper management of riparian zones means decreased streambank erosion and floodplain losses (Duff 1979, Gunderson 1968, Marcuson 1977), increased forage production (Evans and Krebs 1977, Pond 1961, Volland 1978), and an increased wildlife and fisheries resource (Buttery and Shields 1975, Duff 1979, Tubbs 1980, Van Velson 1979).

In conclusion, public grazing lands must be managed on a true multiple use basis that recognizes and evaluates the biological potential of each ecological zone in relation to the present and future needs of our society as a whole (Behnke et al. in press). Management strategies that recognize all resource values must be designed to maintain or restore the integrity of riparian communities (Behnke et al. in press).

CHAPTER I

Synecology of the Riparian Area Associated with Catherine Creek

SYNECOLOGY OF THE RIPARIAN AREA ASSOCIATED WITH CATHERINE CREEK

Abstract

In 1978, a ten year project was begun to examine the synecology of a riparian area along Catherine Creek in northeastern Oregon. A multitude of biotic and physical factors, many of which are unique to riparian environments, interact to form an extremely complex ecosystem. A total of 258 stands of vegetation representing 60 communities were identified. At least twenty species of mammals and 81 species of birds utilize the area during the months of May - October.

The observed factors responsible for much of the diverse mosaic of riparian communities include soil characteristics, streamflow dynamics, climate, plant community interactions and animal effects. Analysis of the ten most common communities in the study area showed significant impacts by each of these factors in riparian community composition and structure.

Introduction

Riparian zones are those areas associated with streams, lakes and wet areas, where vegetation communities are predominantly influenced by their association with water (Carter 1978). This "association," particularly in lotic systems, is not only responsible for increased water availability, but also for the soil deposition, unique microclimate, increased productivity and the many consequential, self-perpetuating biotic factors associated with riparian zones. Therefore, along streambanks (such as Catherine Creek) riparian ecosystems could be defined as assemblages of plant, animal and aquatic communities, whose presence can be either directly or indirectly attributed to factors that are stream-induced or related.

Riparian zones, though varying considerably in size and vegetation complex, have the following in common: (1) they create well-defined habitat zones within the much drier surrounding areas; (2) they make up a minor portion of the overall area, usually only one-two percent; (3) they are generally more productive in terms of biomass - plant and animal, than surrounding uplands; and (4) they are a critical source of diversity (Thomas et al. 1979).

Riparian zones are recognized as among the most biologically diverse and most productive of all ecosystems in North America (Johnson et al. 1977, Odum 1978, Thomas et al. 1977). Ganskopp (1978) found 44 vegetation communities in a 49 hectare riparian zone. Evenden and Kauffman (1980) described 30 different plant communities in a 400 meter section of a riparian zone in central Oregon.

Vegetation along streams is an important component of the riparian/stream ecosystem (Jahn 1978, Campbell and Franklin 1979). It provides the detritial substrate on which much of the instream system is based; it cycles nutrients and it modifies the aquatic environment (Campbell and Franklin 1979).

The riparian/stream ecosystem is recognized as the single most productive terrestrial wildlife habitat type (Ames 1977, Hubbard 1977, Miller 1951, Pattom 1977, Winegar 1977). Streamside vegetation strongly influences the quality of habitat for anadromous and resident cold water fish populations (Duff 1977, Marcuson 1977, Meehan et al. 1977).

Riparian zones are very important for livestock as a forage and water supply (Cook, 1966, Reid and Pickford 1946). Riparian zones have been reported as supplying up to 81 percent of the total forage intake by livestock on a Blue Mountain grazing allotment in eastern Oregon

(Roath 1980).

Because of the many values and uses of riparian ecosystems, whether consumptive or nonconsumptive, a thorough synecological understanding of the area is desirable for land management decisions. Therefore, the objectives of this research were to describe, both in a qualitative and quantitative manner, the riparian ecosystem adjacent to Catherine Creek and to determine factors important in riparian community development, structure and composition.

Description of the Study Area

Location

The study area is located on the Hall Ranch, a unit of the Eastern Oregon Agriculture Research Center. The Hall Ranch is located in the southwestern foothills of the Wallowa Mountains, 19 km southeast of Union, Oregon. The specific location of the study area is Township 5, South, Range 41, East of the Willamette Meridian.

The study area is roughly a 50 meter by three kilometer strip of riparian vegetation adjacent to Catherine Creek. Approximately one half of the area has been excluded from grazing by the construction of five exclosures built in 1978. Uplands are dominated by mixed conifer and ponderosa pine (*Pinus ponderosa*) habitat types.

Geology

Diastrophic processes during the late Tertiary-Quaternary lifted the Wallowa Mountains to their present heights. The upthrust of the high Wallowas influenced lower areas such as the Hall Ranch through structural faulting. Catherine Creek is thought to follow a fault line. The land area to the east of Catherine Creek is underlain by lava flows tilted to the southwest, while the area to the west is situated on a 900 m fault escarpment (Hampton and Brown 1963, Wagner 1955).

Climate

The majority of precipitation occurs in the form of snow during the months of November to May. Summers are typically warm and dry with temperatures rarely exceeding 38° C. Freezing or near-freezing temperatures are possible every month. The Catherine Creek basin serves as a cold air drainage for high elevations resulting in frequent morning frosts during the summer months. The 17 year precipitation mean for a weather station located on the Hall Ranch (station number 424) was 60 cm. Mean monthly precipitation patterns and monthly precipitation for the three study years are summarized in Figure 1. Mean temperatures and monthly temperatures for the three years of the study are summarized in Figure 2.

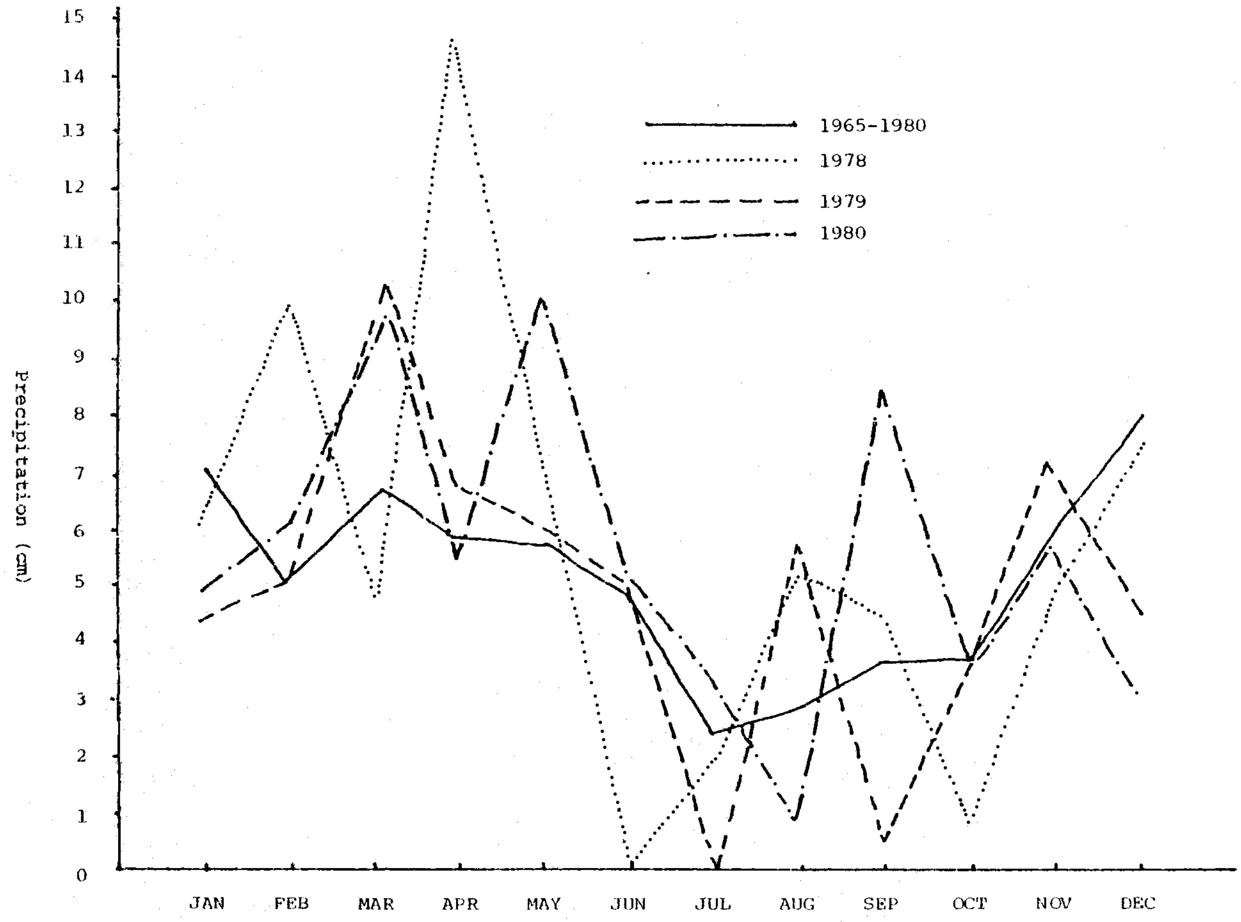

Figure 1. Precipitation deviations between a 16 year average and the years 1978-1980.

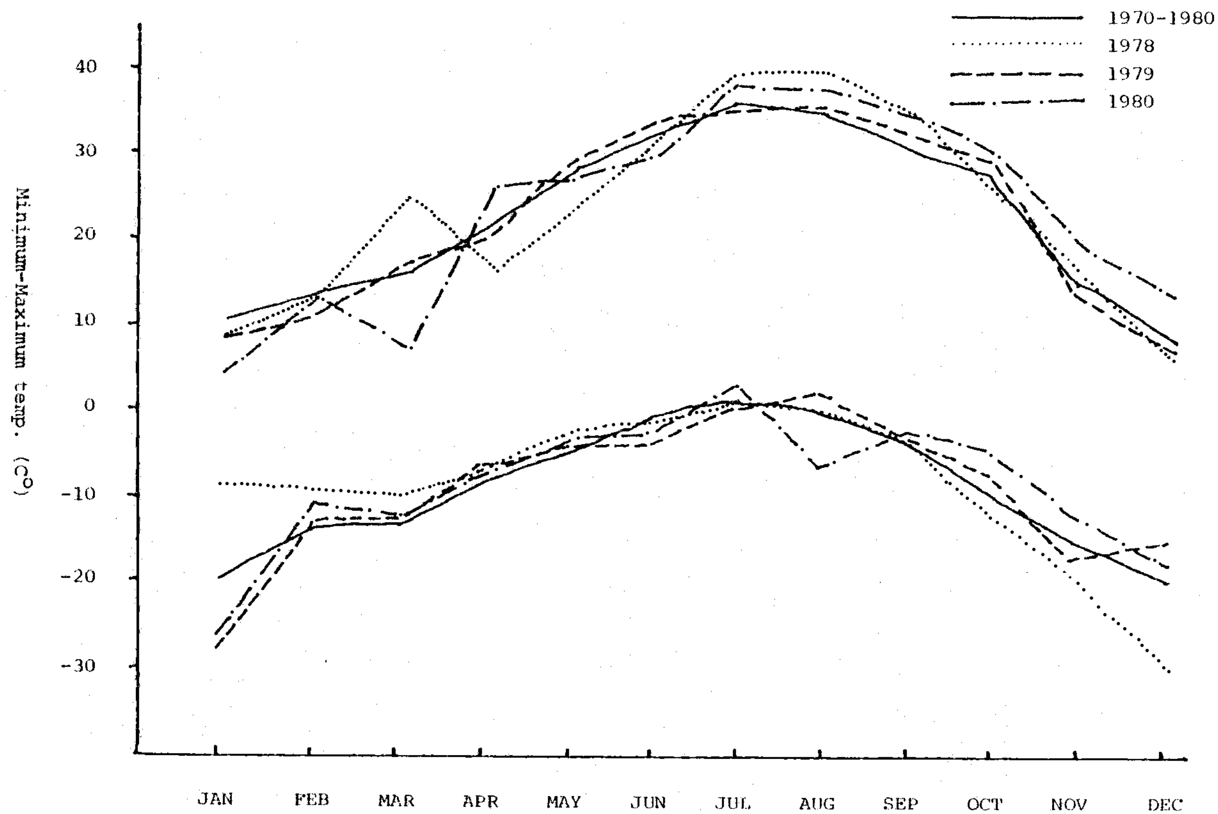

Figure 2. Temperature deviations between an 11 year average and the years 1978-1980.

Catherine Creek

Catherine Creek is a third order tributary of the Grande Rhonde River. The major tributaries of Catherine Creek above the study area are the North, Middle and South Fork of Catherine Creek.

A gaging station (station number 13320000) located ten km downstream from the study was used to acquire streamflow data for the creek. At this station, Catherine Creek has an average discharge of 119 CFS (3.370 m^3/s) or 86,220 acre-ft/yr (106 hm^3/yr) (USGS 1980). Peak annual flows occur in late April, May, and early June. During the spring runoff period, discharges of over 500 CFS are not uncommon. Comparisons between annual discharges for water years 1978-80 and a 17 year mean (1964-80) are summarized in Figure 3.

Methods and Procedures

Plant Communities

Plant Community Description and Mapping

Initial mapping of plant communities was accomplished by ocular reconnaissance. All vegetation stands which had a diameter of three meters or greater were mapped and the species composition was identified with an ocular prominance rating similar to that of Winward

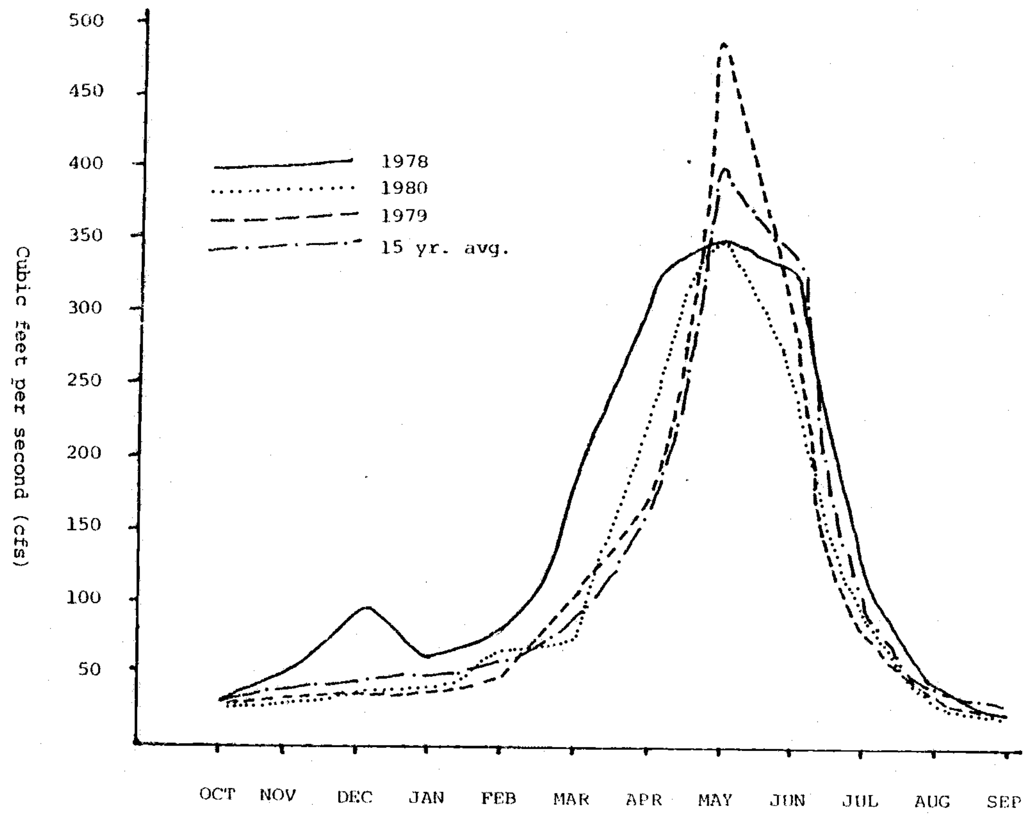

Figure 3. A comparison between a 15 year average streamflow and streamflow for Catherine Creek during the three years of the study.

and Youtie (1976). The revised ocular ratings for riparian vegetation range from dominants (5) to rare plants (1) and are as follows:

(5) Dominant: Plants showing the highest degree of dominance or influence on the site.

(4) Moderately Abundant: Plant species usually dominant or co-dominant, or found in sufficient density to exert significant influence on the site.

(3) Plants uniformly scattered throughout the stand, but in low abundance.

(2) Plants encountered occasionally or in patches and exerting little influence on the site.

(1) Rare: Found only through intensive search.

A classification and marking system was designed to ensure that all stands could be pinpointed to their exact location. Each vegetation stand described was numbered and a small notation on size, geographical location and other pertinent information was recorded (See Appendix G).

Frequency

Once ocular reconnaissance was completed, frequency data was accumulated for all plant species in the more common and recurring communities of the study area. A

0.25 meter^2 quadrat was used for frequency readings. A 0.0625 m^2 nested plot was also used to determine a more precise composition of the dominant plants which would normally have a frequency of 100 percent in the 0.25 meter^2 plot.

Frequency measurements were accomplished by sampling 30 plots per stand with 6-18 stands of each community measured. Usually half of the stands sampled were in grazed areas and half of the stands sampled were in ungrazed areas.

Standing Phytomass

Standing phytomass was estimated for the ten dominant communities. Standing phytomass information was collected with a 0.25 m^2 quadrat. Six stands of each community (three grazed and three ungrazed) were measured by clipping ten plots in each stand.

All forbs and grasses that had their stem base within the plot were clipped at ground level. Current year's growth of woody vegetation was measured by clipping an estimated fraction of the plant. Measurements were taken in late July to early August, at the time of maximum standing phytomass.

Shrub Composition, Density and Height

Shrub density, height and composition were measured with ten one $meter^2$ plots, permanently established in 30 vegetation stands, 28 of which were shrub or tree dominated and two which were located in dry meadows [Kentucky bluegrass (Poa pratensis) communities].

Density and height measurements were recorded for all shrub species with a stembase occurring totally within the plot. Because of the rhizomatous nature of many of the woody species, density estimates were recorded as rooting stem density and not as individual plant density. Measurements were taken late in the growing season prior to leaf abscission.

Quantitative Community Descriptions

Plant species diversity and equitability data were generated from frequency data which, when sampled within discrete community boundaries is a valid index of species abundance. The AIDN program (Overton 1974) was used to generate the quantitative data.

The Shannon-Weaver Information formula was used to calculate diversity (H'), where $H'=\Sigma pi \log_e pi$. Here, pi is the frequency of the ith species (i=1,2,...5) (Shannon 1948). This diversity measure has two components, species richness (S) and equitability (J') or distribution of numbers between species (Lloyd and Ghelardi 1964). Species richness is simply the number of species found in a particular plant community. Equitability is expressed as J'=H'/H' max, where H' max is equal distribution of units between a given number of classes. H' max is calculated as $\log_e S$.

Soils

Soils were described for all communities sampled. Ten auger samples and one soil pit were used to obtain a qualitative description of soils in all communities except in snowberry-Wood's rose (*Symphoricarpos albus* - *Rosa woodsii*) and Kentucky bluegrass - cheatgrass (*Poa pratensis* - *Bromus tectorum*) communities. Profile descriptions include soil surface characteristics, depth and structure of each horizon, presence of gleyed horizons, depth to water tables, depth to root restrictive layers and notes on general solum characteristics which appeared to be important in plant community development (U.S.-S.C.S. 1975). These characteristics would include presence of a layer restricting percolation or presence of aerated horizons.

Wildlife Communities

Avian and small mammal populations were estimated in the three most dominant vegetation types occurring in the riparian zone. Vegetation (or community) types are defined as general assemblages of vegetation communities with similar dominant plant species. There can be many discrete communities in one vegetation type. The vegetation types censused were dry-moist meadow communities usually dominated by Kentucky bluegrass, hawthorne (Crataegus douglasii) communities and black cottonwood (Populus trichocarpa) - mixed conifer communities.

Avian Populations

Avian communities were censused by the fixed circular plot technique (Anderson (1970). Size of the plots used were determined by the maximum horizontal distance possible for detection of birds. For the hawthorne and cottonwood communities, a radius of 20 meters was determined to be the mean distance within stands sampled for detection of birds. In the meadow communities, a plot size with a 40 meter radius was selected, not necessarily for the vegetation density inhibiting detection, but because there were few communities larger than this size. Some stations were not of this size and density estimates had to be adjusted for their particular size.

Avian populations were censused late Spring (May, 1980), early Summer (June, 1979), late Summer (August, 1978, 1979) and early Autumn (September-October, 1978, 1979). A total of eight stations per community type were censused. Half of these stations were in grazed communities and half were in ungrazed communities. Each station was sampled five times during the census period for a total of 40 observations per community type per census period.

Each station was censused for ten minutes. The areas were sampled each morning, usually beginning an hour after sunrise, which corresponded to the peak of daily avian activity.

Bird species diversity and equitability information was obtained from the AIDN program. Shannon's information measure was used to calculate bird species diversity and equitability.

Small Mammal Populations

Small mammal populations were estimated in cottonwood (*Populus trichocarpa*) - mixed conifer, hawthorne (*Crataegus douglasii*) / Kentucky bluegrass and in moist meadow [Kentucky bluegrass - timothy (*Phleum pratense*)] communities. Population size was estimated by the removal method in which a certain number of kill traps are set over several trapping periods (Zippin 1958).

Each community was sampled during late Summer (August, 1979) and early Autumn (September, 1978, 1979). Moist meadows were also sampled during early Summer (June, 1979).

A total of 50 unbaited traps were set in a 25 x 50 meter plot. The trapping period lasted for three trap nights.

The Zippin technique (Zippin 1958) was utilized to obtain density estimates. Relative abundance is expressed as the percent composition of a particular species captured to the total captured population. Diversity indices were obtained using the Shannon-Weaver index.

Descriptive Ecology of Catherine Creek

The several biotic, environmental and other abiotic factors interacting in the riparian environment have created a disproportionate number of niches compared to other ecosystems in the area. As an example, more than 265 plant species were found in the riparian zone. Of these, 10 tree species, 22 shrub species, 57 graminoids and 127 forb species have been identified (Appendix A).

Wildlife species diversity, like plant species diversity is very rich. At least twenty species of mammals are known to have utilized the riparian area during the first three years of the study. Eighty-one species of birds have been sighted using the riparian area between the months of May-October. Thus far, 34 species are known to use the area as nesting/brood habitat.

The high wildlife diversity can at least be partially attributed to the high community and structural diversity of the area. Within the study area, there were 258 stands of vegetation representing 60 plant communities. Community interspersion created a significant amount of edge, particularly in areas where one could find a mosaic of tree, shrub, and meadow type communities. This combination is further enhanced by the presence of aquatic systems such as seeps, wet meadows with standing water, and the stream ecosystem.

Not only are there extreme spatial differences in community types along the area, quite often there are extreme temporal differences in community types. Through a single season, several communities, each with their own unique structure, may exist on one area.

For example, an area in early Spring could be classified as a *Poa pratensis* - *Ranunculus acris* - mixed forb community; a *Veratrum californicum* / *Poa pratensis* - *Phleum pratense* community during mid-Summer and a *Poa pratensis* - *Phleum pratense* - mixed forb community by early Autumn. Analysis of the same area throughout the year has shown significant differences in species composition, species diversity and standing biomass.

Several factors, some unique to riparian areas, interact to form the high community diversity of the area. Some of the factors observed contributing to community development, structure and composition, include differences in soil type, depth to the water table, microrelief, natural biotic impacts, man caused impacts, streamflow dynamics and the natural erosive action of the creek.

Soil Characteristics Contributing to Community Development and Composition

Soils of the study area are mapped as the Veazie Series (Anderson pers. comm.). This series consists of deep, well-drained soils that formed in alluvium from mixed sources. This is not an accurate description of the soils in the study area except those found in dry meadows. Soils on the area vary from well-drained loamy soils greater than 100 cm deep to unconsolidated sands, gravels and cobbles.

An apparent factor in community development is the presence of an aerated horizon. Aerated horizons consisting of coarse sands to cobbles are apparently necessary for cottonwood and ponderosa pine communities to develop (Anderson pers. comm. 1980).

Ponded soils with finer textured A horizons underlain by a coarse textured IIC horizon forming a restrictive layer to water percolation were correlated to sedge or wet-moist meadow communities. Well drained, shallow soils were usually correlated with shrub dominated communities.

The physical properties of soils that were observed as being important to community development include soil texture, structure, depth to root restrictive layer, infiltration-percolation characteristics, and aerated horizons. In addition, soil characteristics interacted with other physical factors such as microrelief and depth to the water table in the formation of vegetation communities. Hydric plants occurring in lower lying areas were replaced by less mesic plants with only minute upward changes in microrelief. Along with minute upward changes in microrelief and depth to the water table, a change in soil texture to coarser materials usually occurred.

Plant Interactions

Floristic effects in altering the microclimate and physical characteristics of an area were important in community development. Competitive interactions among plants, shading effects on understory layers and habitat modification by plants were evident.

Shading plays an important role in determining species composition and plant morphology of understory layers. For example, in hawthorne communities, species richness of forbs was much greater in shrub understories than in the inter-shrub spaces. The understory composition was composed of more mesic plant species than the inter-shrub areas. Conversely, standing biomass, particularly that of Kentucky bluegrass, was less in the shrub understory.

Kentucky bluegrass morphology was greatly altered in tree and shrub dominated communities, particularly those with dense overstories. In meadow communities, tillering and subsequently percent cover and standing biomass was greater than in forested communities. In forested communities, Kentucky bluegrass density was less and leaf length was greater than in meadow communities. Similar differences in morphology were noted for other plant species [e.g. miner's lettuce (*Montia perfoliata*), leafybract aster (*Aster foliaceus*) and western yarrow (*Achillea millefolium*)].

Animal Effects on Community Development and Composition

The faunal inhabitants of the riparian ecosystem play a significant role in the ecological processes of the area. Animals of the order Rodentia, cattle (Bos taurus), big game, and avian species all play a role in community development. Insects, particularly grasshoppers (Arphia and Trimerotropis spp.) occurred in high densities for the three years of the study and, undoubtedly had some effects on plant composition and physiology, but these effects were not measured.

The beaver (Castor canadensis) played a dominant role in the riparian ecosystem. In places, beavers have almost completely removed cottonwood sapling communities (DBH < 15 cm). They altered the riparian ecosystem by the removal or thinning of the overstory, resulting in community composition and structure changes. Subsequently, the critical use of these communities for many of the avian inhabitants of the area, particularly as nesting habitat, was decreased.

The potential effect of cottonwood removal on the stream environment includes a decrease in shade cover over the creek, a short term increase, but long term decrease in the detritus input, alterations in runoff and streamflow dynamics and changes in bank physiognomy.

The burrowing action of rodents especially the Columbian ground squirrel (Cittelus columbianus) and the northern pocket gopher (Thomomys talpoides) had an effect on community composition and succession. In dry meadows with deep well-drained soils, up to 40 percent of the surface area was lightly disturbed during the early part of the growing season. The disturbance caused by these rodents created a niche for several pioneer species of forbs and annual grasses, many of which are found exclusively on these areas (e.g., Nemophila spp.). This action served to increase the species diversity and richness of the community but also allowed for invasion of such highly competitive species as cheatgrass (Bromus tectorum).

Avian species probably played only a minor role in the ecological processes of riparian communities. However, their effects on seed dispersal and consumption of herbivorous insect populations may be important. Avian impacts on insect populations are well documented (Baldwin 1968, Koplin 1978, Otvos 1979). Their primary role is more to control high peaks of insect numbers that occur in unregulated populations rather than definitive control (Otvos 1979). Consequently, if birds are able to keep their insect prey in check, the nutritive condition of rangeland plants may be indirectly affected by bird-insect predator-prey relationships (Wiens and Dyer 1975).

The historical impacts of herbivores in riparian zones is great, in that the native bunchgrass meadows have largely been replaced by Kentucky bluegrass swards as a result of overgrazing (Volland 1978). There have been many alterations and impacts on the riparian ecosystem of Catherine Creek due to herbivory. Cattle, mule deer (Odocoileus hemionus hemionus) and Rocky Mountain elk (Cervus elaphus nelsoni) all utilize the area. However, big game do not use the area in great numbers. Utilization by deer and elk could only be detected on the most palatable shrub and forb species. Big game use was highest during Spring and Fall migrations between Winter and Summer ranges.

Cattle grazing along Catherine Creek had a significant impact on community structure, composition and standing biomass. Impacts by livestock on the riparian/stream ecosystem was generally attributed to forage removal, trampling, compaction and disturbance of soils, and physical damage inflicted on the riparian vegetation.

The effects of herbivory on the 60 plant communities present is neither constant nor uniform. Grazing enhances species richness in many communities. Grazing has apparently halted or slowed succession in several communities, particularly in gravel bars dominated by willows and in moist meadows.

In some communities grazing creates a drier atmosphere, decreasing the abundance of mesic plants and increasing those species more naturally suited to drier environments. Trampling moist, finer textured soils, removal of forage causing increased evaporation from the soil surface and the lack of litter layer in grazed areas may cause these communities (particularly moist meadows) to be under a drier moisture regime than what would naturally occur.

Cattle effects on the riparian ecosystems will be discussed in greater detail in the next chapter.

Stream Effects on the Synecology of the Area

Riparian vegetation is present primarily because of its association with Catherine Creek. Actions of the creek have deposited the substrate in which soil development of the riparian zone has occurred. Water availability and water table depths are directly related to streamflow dynamics. The creek is a primary dispersal mechanism for germplasm transport which is responsible for the formation or creation of many streamside communities.

However, as the creek plays a creative role in riparian community development, so does it also play a destructive or degradative role in riparian communities. Channel changes or natural geologic erosion of streambanks reclaim and washout areas occupied by mature plant communities, leaving the old channel composed of unconsolidated materials to start the process of primary succession.

During the first three years of the study, entire thin leaf alder (*Alnus incana*) and willow dominated stands have been reclaimed by the creek. Other degradative impacts on the riparian/stream ecosystem are due to the scouring of streambanks by ice flows, high water, or large debris (logs, stumps, etc.). Scars from the results of these high streamflow events are evident on many woody species bordering the channel.

Man's Influence on the Riparian Ecosystem

Influences of man on the area can be witnessed in many places along the creek. Logging, old irrigation ditches and the ditch spoils and brush clearing are all part of the historical impacts on the area.

Most of the large conifers were probably logged off the area prior to the 1930's. Stumps in excess of one meter in diameter can be found on the area. Logs were floated down Catherine Creek to supply a water powered mill midway between the Hall Ranch and Union (Hug 1961). The effects of log drives can only be conjectured, but probably severely damaged streambank integrity.

Irrigation ditches were built through the study area probably in the 1890's to supply water to areas in cropland located across State Highway 203. An old ditch and rock dam is still intact. The bottom of the ditch now supports an alder-willow community. There are many areas with little topsoil and severe disturbance that are related to early irrigation canal building. These long, linear disturbance areas, running perpendicular to the creek and ending at the highway, display no evidence that these were once natural channel bottoms. Areas like this are low producing areas primarily dominated by cheatgrass and annual forbs.

The study area was periodically cleared of brush up through the 1950's. Several old brushpiles scattered throughout the area today have created communities dominated by snowberry, Wood's rose, nettle (*Urtica gracilis*) and cheatgrass.

Descriptions of the Major Community Types

Sixty discrete plant communities were identified on the study area (Table 1.). Of these, ten major plant communities were intensively sampled. These communities were thinleaf alder / Kentucky bluegrass - mixed forbs (*Alnus incana* / *Poa pratensis* - mixed forbs), Douglas hawthorne / Kentucky bluegrass - mixed forbs (*Crataegus douglasii* / *Poa pratensis* - mixed forbs), cheatgrass - mixed forbs (*Bromus tectorum* - mixed forbs), Kentucky bluegrass - mixed forbs (*Poa pratensis* - mixed forbs), ponderosa pine / Kentucky bluegrass - mixed forbs (*Pinus*

TABLE 1. Partial listing of community life forms, vegetation types, and plant communities identified in the Catherine Creek Riparian Ecosystem.

I. Meadow Communities

A) *Poa pratensis* Vegetation Type

Poa pratensis-*Achillea millefollium*
Poa pratensis-*Agropyron repens*
Poa pratensis-*Agrostis alba*
Poa pratensis-*Bromus racemosus*
Poa pratensis-*Bromus tectorum*-Mixed Forbs
Poa pratensis-*Erodium cicutarium*
Poa pratensis-*Juncus balticus*
Poa pratensis-*Lupinus leucophyllus*
Poa pratensis-*Phleum pratense*-Mixed Grasslikes and Forbs

B) *Bromus tectorum* Vegetation Type

Bromus tectorum-Mixed Forbs
Bromus tectorum-*Achillea millefolium*
Bromus tectorum-*Bromus racemosus*
Bromus tectorum-*Erodium cicutarium*
Bromus tectorum-*Poa sandbergii*
Verbascum thapsus/*Bromus tectorum*

C) *Carex* Vegetation Type

Carex aquatilis-*Phleum pratense*-*Poa pratensis*
Carex aquatilis-*Scirpus microcarpus*
Carex aquatilis-*Carex stipata*-*Poa pratensis*
Carex rostrata
Mixed *Carex* spp.-*Phleum pratense*-*Poa pratensis*
Mixed *Carex* spp.-*Juncus balticus*

D) Forb Dominated Vegetation Type

Arnica chamissonis-*Poa pratensis*-*Juncus balticus*
Ranunculus acris-*Poa pratensis*-*Agrostis alba*
Veratrum californicum/*Poa pratensis*-Mixed Grasslikes

E) Other Herbaceous Vegetation Types and Communities

Bromus racemosus-Mixed Forbs
Glyceria elatius-*Juncus balticus*

TABLE 1. (continued)

II. Low Shrub Communities

F) *Rosa woodsii* Vegetation Type

Rosa woodsii/*Poa pratensis*-Mixed Forbs

G) *Symphoricarpos albus* Vegetation Type

Symphoricarpos albus/*Bromus tectorum*
Symphoricarpos albus/*Geum macrophyllum*-*Poa pratensis*
Symphoricarpos albus/*Poa pratensis*
Symphoricarpos albus-*Rosa woodsii*

III. Tall Shrub Dominated Communities

H) *Alnus incana* Vegetation Type

Alnus incana-*Crataegus douglasii*/*Poa pratensis*
Alnus incana/Mixed Grasslikes and Forbs
Alnus incana/*Poa pratensis*-Mixed Forbs
Alnus incana-*Populus trichocarpa*
Alnus incana/*Symphoricarpos albus*
Alnus incana/*Scirpus microcarpus*

I) *Crataegus douglasii* Vegetation Type

Crataegus douglasii/*Poa pratensis*-Mixed Forbs
Crataegus douglasii-*Prunus virginiana*/*Poa pratensis*-Mixed Forbs
Crataegus douglasii/*Veratrum californicum*/*Poa pratensis*-Mixed Forbs

IV. Tree Dominated Communities

J) *Abies grandis* Vegetation Type

Abies grandis/*Bromus tectorum*

K) *Pinus ponderosa* Vegetation Type

Pinus ponderosa/*Alnus incana*/*Poa pratensis*-Mixed Grasslikes-Forbs
Pinus ponderosa/*Bromus tectorum*

TABLE 1. (continued)

K) *Pinus ponderosa* Vegetation Type (continued)

Pinus ponderosa/*Crataegus douglasii*/*Poa pratensis*-Mixed Forbs
Pinus ponderosa/*Hordeum pussillum*
Pinus ponderosa/*Poa pratensis*-Mixed Forbs
Pinus ponderosa/*Rosa woodsii*
Pinus ponderosa/*Symphoricarpos albus*

L) *Populus trichocarpa* Vegetation Type

Populus trichocarpa/*Alnus incana*
Populus trichocarpa/*Alnus incana*-*Crataegus douglasii*/*Rosa woodsii*
Populus trichocarpa-Mixed Conifer
Populus trichocarpa-*Pinus ponderosa*
Populus trichocarpa/*Poa pratensis*
Populus trichocarpa/*Symphoricarpos albus*-*Rosa woodsii*

V. Gravel Bar Communities

Bryophytes-Mixed Grasses-Mixed Forbs

M) *Salix* spp. Vegetation Type

Populus trichocarpa/Mixed Grasses-Mixed Forbs
Salix rigida/Mixed Grasses-Mixed Forbs
Mixed *Salix* spp./Mixed Grasses/Mixed Forbs

VI. Disturbance Communities (old brush piles, land fills, mechanical damage, etc.)

Symphoricarpos albus/*Urtica gracilis*/*Bromus tectorum*
Bromus tectorum

ponderosa / *Poa pratensis* - mixed forbs), Kentucky bluegrass - cheatgrass (*Poa pratensis* - *Bromus tectorum*), Kentucky bluegrass - timothy - mixed grasslikes and forbs (*Poa pratensis* - *Phleum pratense* - mixed grasslikes and forbs), black cottonwood - mixed conifer (*Populus trichocarpa* - mixed conifer), snowberry - Wood's rose (*Symphoricarpos albus* - *Rosa woodsii*) and gravel bar communities usually dominated by at least one species of the Salicaceae family.

Gravel Bars (*Salix* spp. - mixed forbs)

Gravel bar communities are located along the stream channel or on small islands. They are located in areas that were the old stream channel. Soils are composed of unconsolidated alluvium, ranging from finer textures to stone sized materials. The communities are usually inundated during Spring runoff.

Upon creation of a gravel bar, the first species to invade the area are field horsetail (*Equisetum arvense*), black cottonwood and many annuals. Black cottonwood quickly sprouts in new gravel bars, primarily from stems and branches which were washed downstream during Spring runoff and deposited within the alluvium. These cottonwoods behave much like other salicacious plants, retaining a shrub-like physiognomy. Annual scouring of the gravel bar is one of many forces which may be responsible for this inhibition of growth form.

After establishment of cottonwoods, willows, particularly Mackenzie willow (Salix rigida) and coyote willow (Salix exigua) begin to appear.

Species richness on gravel bars is high. Ninety-eight species of plants were identified in this community. Several species which are common only to higher elevations were also found here. Lodge pole pine (Pinus contorta), blackhead (Rudbeckia occidentalis) and others are found only on gravel bars at this elevation. In addition there are many hydric plants found only on gravel bars (Rumex spp., Veronica spp., Carex spp., etc.) which enhance the species diversity. Over 40 plant species collected on gravel bars, occur almost exclusively on these areas. Species diversity indices for areas sampled are 3.2-3.5, the highest of any community sampled.

The gravel bars sampled were dominated by black cottonwoods, Mackenzie willow, bluegrasses (Poa spp.), oval head sedges (Carex spp.), white clover (Trifolium repens), mullein (Verbascum thapsus), and many species of shrubs, grasses, grasslikes and forbs. Standing phytomass on gravel bars varies greatly depending on age since its creation. Gravel bars sampled ranged from 1400-2800 kg/ha.

Shrub density can be very high. Mean shrub densities for stands sampled ranged up to 28.8 stems/m^2 (288,000/ha). Black cottonwood densities averaged 14-23/m^2 (140,000-320,000/ha). Willow species density ranged from 1-4/m^2.

Big game use of gravel bars was apparent only on cottonwood, willows and white clover. Utilization by big game was usually less than 8 percent on all stands sampled. The majority of the utilization occurs during Spring and Autumn migrations. Other wildlife use of gravel bars was light except by avian species of aquatic feeding guilds and particularly the spotted sandpiper (*Actitis macularia*) which nested only on gravel bars.

Alnus incana / *Poa pratensis* - mixed forbs

Thin leaf alder / Kentucky bluegrass - mixed forb communities were generally located parallel to the creek, bordering the streamchannel or in areas of high water tables. There is usually free standing water in the community during Spring runoff.

Soils can be characterized as shallow and rocky with a water table depth of less than 50 cm, usually around 18 cm.

General profile descriptions include a shallow A horizon, 0-18 cm, loamy in texture and high in organic matter. These are usually underlain by a IIC horizon consisting of unconsolidated sands and cobbles.

Thin leaf alder communities were dominated by thin leaf alder alone, or in co-dominance with hawthorne, willow, or black cottonwood. All communities that were intensively sampled were dominated solely by alders.

Alder stands varied in understory composition. A midstory layer dominated by snowberry and/or Wood's rose was common in some stands. Quite often, under one contiguous stand of alders, there are several distinct understory communities present. In general, forb or grass layers were dominated by Kentucky bluegrass in the drier section of a stand and by mixed grasslikes, particularly panicled bullrush (Scirpus microcarpus) or sawbeak sedge (Carex stipata) in the more mesic section of a stand. Sampling locations usually were located in the drier portions of the stands (e.g., those with an understory of Kentucky bluegrass).

Species richness and diversity was great in these communities. A total of 100 species were sampled while collecting frequency measurements in these communities. Species diversity for stands sampled varied from 2.7 to 3.3. The variance in range of species diversity in all communities sampled was due to the particular nature of the stand sampled. Stands on either the most mesic or xeric end of the community's range of environmental tolerance, were usually lower in species diversity than those stands in the middle of the range. Equitability ranged from .77-.86.

In the communities sampled, Kentucky bluegrass, sawbeak sedge, panicled bullrush, timothy, mannagrass (Glyceria sp.) and Baltic rush (Juncus balticus) were dominant graminoids present. Common forbs would include leafy bract aster, common dandelion (Taraxacum officinale), largeleaf avens (Geum macrophyllum), rough bedstraw (Galium asperrimum), tall buttercup (Ranunculus acris), white clover, western yarrow, and self heal (Prunella vulgaris).

In comparison to other communities found on the area, annual standing phytomass of the understory layers was low. Standing phytomass ranged from 960 kg/ha to 1600 kg/ha. Density for alders ranged from 1.5-3.0 stems/m^2 during 1978 and 1979.

These areas are used by many avian species as nesting/brood habitat and as resting/roosting habitat. The catkins and buds produced are a valuable forage source for many birds utilizing these communities. Beaver, muledeer, elk and cattle utilized alder as a forage source.

Alder are second only to black cottonwood - mixed conifer communities in providing shade for the creek. The detritial input to the creek from alder communities is probably of importance to the instream environment.

The alder communities are a relatively early-seral plant community, and may be successional to willow / mixed forb dominated communities. Because of their streamside location and unconsolidated substrate, these communities are highly susceptible to destruction by abrupt channel changes during Spring runoff. Annual channel changes that were associated with Spring runoff often destroyed substantial portions of alder stands. In areas where the communities are protected, evidence that alders are being replaced by cottonwoods was apparent. Alder communities here, appear to be seral to cottonwood dominated communities.

Populus trichocarpa - mixed conifer

There was evidence that these communities replace alder communities on some sites. Black cottonwood sapling communities were also observed to be successional to willow dominated communities without a seral stage of alder between them. It appeared that there were at least two seres leading to cottonwood communities.

Soils in which cottonwood-mixed conifer communities were situated, were similar to those of alder communities. A horizons of cottonwood communities varied from 15-30 cm. Textures were loamy (silt-sandy loams). A horizons had high organic matter contents and, like alder communities, were very dark (< 10 YR 3/3). A horizons were underlain by an aerated horizon ranging from coarse sands to larger unconsolidated cobble material. The water table in cottonwood communities was usually less than 60 cm, averaging 18 cm in late May.

These communities were the most structurally diverse communities sampled. Some cottonwood stands contained five layers of vegetation, excluding the crytogram layer. The layers included a cottonwood dominated layer; a conifer layer usually dominated by ponderosa pine; a tall shrub-low tree layer usually dominated by either thin leaf alder, Douglas hawthorne or water birch (Betula occidentalis); a low shrub layer dominated by snowberry or Wood's rose; and a field layer dominated by many understory communities, most commonly by Kentucky bluegrass. Sampling took place in those areas dominated by a Kentucky bluegrass - mixed forb understory.

Seventy-three plant species were sampled within cottonwood communities during the three years of the study. The most common understory species found in cottonwood communities included Kentucky bluegrass, blue wildrye (Elymus glaucus), sedges, common dandelion, tall buttercup, golden ragwort (Senecio pseudareus), wild sweet anise (Osmorhiza chilensis) and miner's lettuce. Species diversity (H') ranged from 2.7-3.1. Equitability

(J') varied among stands from .76-.85.

There were high variations in standing phytomass estimates, primarily due to site variations among stands, and the annual differences in environmental parameters critical for understory growth. Standing phytomass of the understory ranged from under 1000 kg/ha to almost 2700 kg/ha. Cottonwood communities provided more shade cover over the creek than any other.

Cottonwood communities were important habitats for many species of wildlife. Species richness for both avian and mammalian populations was greater here than in any other community. Cottonwood - mixed conifer communities provided nesting brood habitat for 23 species of birds. These communities provided habitat for 9 of the 15 ecological foraging guilds utilizing the area.

There were great annual and seasonal fluctuations in avian populations in cottonwood communities, just as in the study area as a whole. Seasonal population peaks were usually correlated with the nesting season and Autumn migration, while densities were lowest prior to these seasons. Winter populations were not censused.

Mean densities of up to 48 birds/ha were recorded for stands in this community. Densities in Autumn reflected a high migratory population of birds utilizing the area. Species richness was highest during the nesting/brood season when 26 species were observed utilizing the area. This season (early Summer) also corresponded to a time of high densities, high bird species diversity (2.4-2.8) and high equitability indices (.81-.94). A total of 56 avian species were sited utilizing the study area during the growing season (Appendix B.).

Many species which utilize cottonwood-mixed conifer communities, particularly cavity nesters, and those species of the timber searching and timber drilling guilds were dependent on these areas. Species of the family Picidae and Sittidae were rarely censused out of these communities. Game birds such as the ruffed grouse (Bonasa umbellus) and mourning dove (Zenaidura macronura) utilized these habitats more than any other.

Only four species of mammals were censused utilizing the field layer of cottonwood communities. Highest density estimates were obtained during early Autumn at the end of the growing season. Densities here were as high as 254 mammals/ha and as low as 216 mammals/ha.

During this season the mountain vole (Microtus montanus) was the most common species captured with a relative abundance of 70 percent. The deer mouse (Peromyscus maniculatus), yellow pine chipmunk (Eutamias amoenus) and vagrant shrew (Sorex vagrans) made up the other 30 percent of the population estimate.

The population structure the previous year, which was a much drier year, was skewed towards the deer mouse and vagrant shrew populations (relative abundance of 44 and 38 percent respectively). Mountain vole densities were low in 1978 relative to 1979.

Although species richness of small mammal populations were highest in cottonwood communities, densities were lower than for other communities sampled, and species composition was different from other communities.

Poa pratensis - mixed forbs

Kentucky bluegrass communities were among the most widespread communities found on the study area. Historically, these communities were probably dominated by native bunchgrasses, sedges and rushes. Overgrazing by herbivores has been suggested as being the chief factor responsible for this drastic change in species composition (Volland 1978). The significance of a change from a native graminoid composition to a bluegrass sward on the synecology of the area, particularly to the wildlife component, is unknown.

Dry meadow communities were found on some of the more developed soil profiles of the area. Soils were characterized as deep well drained loamy soils. A horizons were dark (< 10 YR 3/3), almost exclusively of a loam texture and averaging 30-40 cm deep. Mottling usually occurred beginning at the lower end of the A horizon. Depth to a restrictive layer to root growth ranged from 70-150 cm, with a mean of 80 cm. The water table was usually greater than 70 cm from the soil surface in late May.

Dry meadow communities varied from almost a monotypic stand of Kentucky bluegrass, to communities with a very diverse species composition. Common species found in dry meadows include Kentucky bluegrass, redtop (Agrostis alba), stork's bill (Erodium cicutarium), western yarrow, white clover, chickweed (Cerastium viscosum), common dandelion, velvet lupine (Lupinus leucophyllus), tall buttercup, and many others. Species richness, compared to other communities within the study area was moderate, with a total of 78 species recorded during frequency sampling. Species diversity ranged from less than 1.0 in the near monotypic stands of Kentucky bluegrass to almost 3.3 in the communities with a high forb and graminoid composition.

Standing phytomass was high in dry meadow communities. Mean standing phytomass ranged from 2600-4200 kg/ha for the three years sampled. Kentucky bluegrass accounted for greater than 75 percent of the standing phytomass estimate, and in some cases accounted for over 96 percent of the late Summer estimate. Earlier in the growing season, the forb constituency of the community made up a greater portion of standing phytomass. These communities were preferred foraging sites by both domestic livestock and big game.

Some small mammal species were endemic only to dry meadow communities, or were present in their greatest numbers. The Columbian groundsquirrel was observed almost exclusively utilizing dry meadows. They appeared to be a good indicator of deep loamy soils which were almost all supporting dry meadows. Other small mammal species included the mountain vole, the vagrant shrew, the deermouse and the northern pocket gopher.

The effects of trails and soil disturbance by small mammals was apparent and had a discernible effect on plant species composition by creating sites for the invasion of many forbs and other pioneer species.

Avian use of meadow vegetation was heaviest during nesting/brooding season. Densities of up to 28 birds/ha were observed utilizing meadow communities during early summer. At this time the highest bird species diversities (2.0-2.2) and species richness (15-20) were observed for meadow communities. With the exception of raptorial birds, avian use of meadow communities at all other seasons of the year was light.

The American robin (Turdus migratoris), Brewer's blackbird (Euphagus cyanocephalus) and rough winged swallow (Stelgidopteryx rufficollis) utilized meadow communities in the highest densities of avian species, primarily in search of insects. Only three of the nine ground nesting avian species utilized dry meadows as nesting habitat.

Poa pratensis - *Phleum pratense* - mixed grasslikes (Moist Meadows)

Moist meadows occurred in low lying areas away from the stream channel. Generally there was standing water during Spring to early Summer. Some of these moist meadows and most wet meadows were ponded with no external drainage. Wet meadows, in contrast to moist meadows, were usually dominated only by sedges with a minor composition of hydric grass species.

Poorly drained, finer textured soils characterized moist and wet meadow communities. In moist meadows, A horizons varied from silty clay loams to silty clays. Infiltration and percolation is slow in these communities often due to a coarse sand horizon overlain by the finer textured A horizons. Mottling occurs at approximately 18 cm and gleyed horizons can sometimes be found at 28 cm or deeper.

Water table depths in late May ranged from 20-30 cm. Water availability to plants through the growing season is enhanced by the presence of the standing water and a shallow water table. In some years water is never a limiting factor and growth continued season long.

Sixty-four plant species were recorded in stands of moist meadow vegetation from frequency measurements. Plant species diversity for individual moist meadow stands ranged from 2.1-3.3. It appeared that species diversity and the mesic nature of some moist meadows were negatively correlated. The most mesic-hydric communities had a lower species richness and plant species diversity than the less mesic meadows. Often, meadows in the most hydric environments were almost complete monotypic stands of sedges (*Carex aquatilis*, *Carex vesicaria* or *Carex rostrata*).

Moist meadows were dominated by a combination of Kentucky bluegrass, timothy, Baltic rush, oval head sedges (*Carex athostachya*, *Carex microptera* or *Carex comosa*) and large sedges (*Carex aquatilis*, *Carex stipata* or *Carex rostrata*). Common forbs included tall buttercup, leafy bract aster, northwest cinquefoil (*Potentilla gracilis*), western yarrow and many mesic forbs. In a few areas, very palatable native bunchgrasses such as tufted hairgrass (*Deschampsia caespitosa*) and tall mannagrass (*Glyceria elata*) were present in the composition.

Standing biomass was greater in moist meadows than in any other community on the study area. One stand yielded an estimated 14,970 kg/ha in 1980. Mean estimates of standing phytomass ranged from 3500 kg/ha - 9200 kg/ha. Greater than 90 percent of the phytomass was produced by the graminoid component.

High preferences by cattle and big game for moist meadows were observed. Utilization by big game was apparent, particularly on timothy and a few selected palatable forbs. However, this utilization was scattered and light.

High densities of small mammal populations were estimated in moist meadows. These populations were similar in composition to those of dry meadow communities. The highest densities of the mountain vole were found in moist meadow communities.

Peak density estimates obtained in meadows were Summer populations ranging from 468-568 mammals/ha. Here, the mountain vole had a relative abundance of 70 percent. The northern pocket gopher, deer mouse and vagrant shrew made up the rest of the small mammal population estimate with relative abundance indices of 15, 7.5 and 7.5 percent, respectively.

The forage intake of up to 600 mammals/ha was not estimated, but may have a significant impact on community composition and standing biomass. In some communities, utilization of timothy by small mammals was estimated as high as ten percent of the total yield.

Avian populations utilized moist meadows primarily for insect predation during the nesting/brooding season. Three species of birds including the common snipe

(*Capella gallinado*) utilized these areas exclusively for nesting habitat.

Crataegus douglasii / *Poa pratensis* - mixed forbs

Douglas hawthorne communities are widespread throughout the riparian study area. Hawthornes have among the widest ecological range of any shrub species on the study area. They are present in all but the most hydric community types.

Soils in hawthorne dominated communities contained unique characteristics which may facilitate development of these communities. A horizons consisted of silt loam-loamy textures and are relatively thick (33-43 cm). Mottling occurs at 33-38 cm. All hawthorne stands sampled had A horizons underlain by a coarse textured (loamy sand - coarse sand) IIC horizon. Sometimes these horizons had clay balls interspersed throughout the coarse textured materials. Depth to a root restrictive rock layer, varied from 69-100 cm, usually less than 75 cm. The combination of soil characteristics which separate soils of hawthorne communities from others were the deep silt loam A horizons underlain by a coarse textured IIC horizon. And, the soil depth, which is deeper than that of all soils except for meadow communities.

Species richness in hawthorne dominated communities were high, particularly in the understories of the shrubs. A total of 86 species were recorded during frequency measurements. Plant species diversity in this community is among the highest recorded for any community on the study area (2.4-3.4).

Field layers of hawthorne stands were varied ranging from those stands dominated by cow parsnip (*Heracleum lanatum*) / Kentucky bluegrass - mixed forbs to sparse stands dominated by Kentucky bluegrass - cheatgrass. Stands sampled for frequency and standing phytomass were in the middle of this spectrum, dominated by Kentucky bluegrass and mixed forbs. Common species found in the field layers included Kentucky bluegrass, red top, western yarrow, common dandelion, hook violet (*Viola adunca*), white clover, leafy bract aster, American vetch (*Vicia americana*), black medic (*Medicago lupulina*) and tall buttercup.

Standing phytomass of the field layer in hawthorne communities ranged from 1500-2500 kg/ha. The stands with a dense canopy cover of hawthorne were not as productive in the understory layers as those with a more open canopy cover. Kentucky bluegrass accounted for 61-87 percent of the standing phytomass estimate. Mean density of hawthornes in 1979 was 3.4 rooting stems/m^2.

Wildlife use of hawthorne communities was heavy. Hawthorne stands were preferred habitat for many species of wildlife. Hawthornes were moderately palatable for browsing species and evidence of hedging was apparent on many of the small shrubs. The flowers and berries also were observed being extensively utilized by many wildlife species. Adequate horizontal cover, and a good understory composition facilitated the use of these communities for heavier use by big game than any other community type. High densities of small mammals were also estimated.

Avian utilization of hawthorne communities was estimated as being heaviest during the nesting/brood season at the time of berry ripening. Because of their thorny, multistemmed physiognomy, these shrubs provide valuable nesting/brooding habitat for at least 14 species of birds. Warblers (Dendroica and Oporornis spp.), the American robin and the cedar waxwing (Bombycilla cedrorum) were among the most common nesters in hawthorne communities. Mean densities of avian species during the nesting/brooding season ranged from 27-31 individuals/ha. Bird species diversity and species richness were 2.35 and 16-18, respectively.

In years that hawthornes produced a good berry crop, late summer utilization by birds appeared to have increased. During 1979, a high yielding year for hawthorne berries, late summer avian densities were as high as 17 individuals/ha compared to densities of 6-9 individuals/

ha in late Summer 1978.

Small mammal density estimates were high in hawthorne communities. The highest densities recorded for small mammals in the riparian zone was the late Summer 1979 census in which 700-800 individuals/ha were estimated to be inhabiting hawthorne communities.

The mountain vole accounted for over 80 percent of the population estimate. Early Autumn densities ranged from 140-200 individuals/ha. The 800 individuals/ha estimate is probably reflective of an explosion in vole numbers. Trap success of over 60 percent was experienced the first two trap nights.

Pinus ponderosa / *Poa pratensis*

Ponderosa pine communities in the riparian zone differ from ponderosa pine communities found in uplands due to the presence of an understory consisting of Kentucky bluegrass and many forb species that are riparian obligates. Understories in ponderosa pine stands varied greatly in composition and structure.

Midstories, when present, were dominated by hawthorne, alder, snowberry, or Wood's rose alone, or in combination. Understories were dominated by Kentucky bluegrass, cheatgrass or little barley (*Hordeum pussillum*).

Minor soil differences existed between ponderosa pine communities with a midstory and those communities that were void of a midstory shrub layer. However, the similarities of soil profiles in all ponderosa pine communities were more evident than the differences.

Ponderosa pine communities in the study area had O horizons 8-23 cm in thickness which consisted of decaying pine needles and other plant materials. A horizons, 20-58 cm thick with loamy textures were characteristic of all stands of ponderosa pine sampled. Most A horizons were approximately 38 cm thick and underlain by a thin coarse textured IIC. Another C horizon of coarse sands with unconsolidated gravels and pebbles could usually be found underlying the first C horizon. These C horizons were aerated horizons, and apparently necessary for ponderosa pine communities to develop in riparian areas (Anderson pers. comm. 1980). Water tables in May were greater than 81 cm below the soil surface.

A species richness of 64 was recorded during frequency sampling. Species diversity ranged from a low of 2.0 in those stands with a combination of a dense canopy cover and a thick mat of pine needles, to 3.0 in those stands with a more open canopy and weak O horizons.

In communities sampled, Kentucky bluegrass, blue wildrye and cheatgrass were the dominant graminoids. Common forbs included sandwort (*Arenaria macrophylla*), western yarrow, common dandelion, tall buttercup, white clover, leafy bract aster, golden ragwort and blueleaf strawberry (Fragaria virginiana).

O horizons appeared to inhibit growth and production of understory species. Standing phytomass estimates were low in ponderosa pine stands relative to other communities in the riparian zone. Mean annual standing phytomass estimates ranged from 1400-2000 kg/ha.

Wildlife use in ponderosa pine communities was similar to use in the uplands dominated by ponderosa pine types. Species common in upland pine communities such as the porcupine (Erethizon dorsatum) and chickaree (Tamiasciurus douglasi) were common in the riparian zone only in this community.

Because of the unpalatable growth form and low yield of Kentucky bluegrass in this community, estimated use by big game was light, with the only discernible utilization on preferred forbs and shrubs.

Heavy avian use of ponderosa pine communities was noted during the nesting season. Cavity nesters and species commonly nesting in upland forested communities were observed nesting here. Utilization by species of the foliage-seed foraging guilds was heavy during seed ripening of pines.

Symphoricarpos albus - Rosa woodsii

Snowberry - Wood's rose communities characteristically were found in small stands of less than ten meters in diameter. These stands varied in composition from stands of Wood's rose with only scattered individuals of snowberry to almost pure stands of snowberry. These communities appeared to be an indicator of past disturbance in dry sites of the riparian zone.

The soils of snowberry - Wood's rose communities were not extensively studied. Generally these communities were found on shallow, rocky and well-drained soils. In many stands the soils have been disturbed either by man caused practices or natural perturbations caused by Catherine Creek.

Species richness for snowberry - Wood's rose communities was 64 species from frequency data. Species diversity ranged from 2.7-3.1. These communities were dominated by snowberry and Wood's rose in the low shrub layer and by Kentucky bluegrass in the field layer. Other common species include redtop, bald brome (*Bromus racemosus*), cheatgrass, white clover, common dandelion, western yarrow, leafy bract aster, tall buttercup and largeleaf avens.

Standing phytomass for 1978-1979 ranged from 3200-4000 kg/ha. Snowberry accounted for 30-48 percent of the standing phytomass. Kentucky bluegrass accounted for 24-57 percent of the standing phytomass.

Wildlife utilization of snowberry - Wood's rose communities was light. Neither snowberry nor Wood's rose were browsed significantly by big game. Utilization of berries and rose hips by wildlife was common. Big game and avian species both were observed foraging on rose hips during late Summer - early Autumn. Some utilization of Wood's rose as a nesting site was observed.

Bromus tectorum - mixed forbs

Cheatgrass dominated communities were found in old channels, usually well away from the present course or in old dredge piles from irrigation ditches. Soils were weakly developed or totally structureless, rocky to the surface with low water-holding capacities. The soils are excessively drained causing droughty conditions to prevail. Field observations suggested that organic matter contents were low relative to other communities. Depth to this water table was greater than 90 cm.

Species richness was poor in these communities. Fifty species were recorded during frequency measurements and greater than 30 percent of these were annuals. Species diversity was comparatively low (2.0-2.5).

Cheatgrass, stork's bill, western yarrow, Autumn willow-weed (Epilobium paniculatum), Douglas knotweed (Polygonum douglasii), collomias (Collomia spp.) and microsteris (Microsteris gracilis) were common plant species found in the community. Several annual aliens may be common in any one year, but their annual recurrence is not uniform.

Maximum standing phytomass in cheatgrass communities was present during late May - early June, about the time cheatgrass was in anthesis. By July phytomass was much lower ranging from 970-2000 kg/ha. At this time most of the forbs were no longer present, and the cheatgrass was usually in a leached state.

Wildlife use was minimal on the communities except for seasonal insect predation by some avian species. Big game may utilize the area during Spring growth when cheatgrass is palatable, or during Autumn, if regrowth is present.

Poa pratensis-Bromus tectorum

Kentucky bluegrass-cheatgrass communities were very similar to dry meadow communities except for the co-dominance of cheatgrass. These communities were present in areas where there were small patches of gravelly soils interspersed and intergrading with deep loamy soils.

Disturbance causing these communities can be attributed to the natural processes of the creek and past disturbances caused by irrigation canals. It is possible that soil disturbance caused by small mammals and large herbivores created areas in dry meadows for invasion and establishment of cheatgrass as a co-dominant. Whether or not these biotic effects have a dominant role in this community's development is hard to quantify.

Besides Kentucky bluegrass and cheatgrass, bald brome, stork's bill, western yarrow, chickweeds (Caryophyllaceae family) and common speedwell (*Veronica arvensis*) are also common.

Species richness was poor with only 49 species sampled in two years of frequency analysis. Plant species diversity ranged from 1.2-2.6.

Biomass estimates range from 2000-3300 kg/ha. Kentucky bluegrass and cheatgrass contributed over 90 percent of this standing phytomass.

Wildlife utilization of these communities was light. Avian species utilized the area somewhat for insect predation and seed consumption. Utilization by big game on Kentucky bluegrass and cheatgrass (when succulent) was observed, though very light.

Discussion

The community data presented here and summarized in Table 2., could be misleading, in that it appears species diversity, standing phytomass, and even species composition are similar among many of the communities sampled. This is not entirely true. These data represent the ranges of three years' measurements. The years 1978 and 1980 were very productive with high species richness, and standing phytomass estimates. The year 1979 was drier and warmer than the other years of the study and is reflected in lowered biomass, species richness and species diversity. These data are summarized in Appendix D.

In addition to year effects, the wide ranges in Table 2 also reflected the difficulties in community delineation within riparian zones. Quite often, variation among stands within one community was higher than the variation among certain communities. Even with 56 plant communities described and separated, it was apparent that among stands of each community, discrete differences in composition and structure existed.

There are intangible factors associated with a particular vegetation stand's geographical location on the study area, and many complex intercommunity interactions occuring between these stands. Because of these

TABLE 2. General community descriptions of selected riparian plant communities sampled along Catherine Creek, 1978 - 1980.

Community	Soils	Dominant Species in the field layer	Diversity (H') Equitability (J') Species Richness (S)	Phytomass Kg/ha	Miscellaneous
Gravel Bars (*Salix* spp.-mixed forbs)	Unconsolidated materials ranging from silts - rocks	*Agrostis* sp., *Trifolium repens*, *Taraxacum officinale*, *Verbascum thapsus*, and many forbs, grasses and grasslikes.	H' = 3.2 - 3.5 J' = .83 - .84 S = 98	1400 - 2800	Ecologically young community, susceptible to severe damage or destruction during spring runoff.
Twinleaf alder/Kentucky bluegrass-mixed forbs	Shallow, loamy A horizons underlain by unconsolidated materials, shallow water tables.	*Poa pratensis*, *Carex* sp., *Scirpus macrocarpus*, *Juncus balticus*, *Taraxacum officinale*, *Aster foliaceus* and many forbs, grasses and grasslikes.	H' = 2.7 3.3 J' = .77 - .86 S = 100	960 - 1600	Usually located immediately adjacent to the stream channel; susceptible to destruction by spring runoff and channel changes.
Black cottonwood-Mixed Conifer communities	Shallow loamy A horizons, usually deeper than those of Alder communities; underlain by aerated horizons; soils deeper than in Alder communities.	*Poa pratensis*, *Elymus glaucus*, *Carex* sp., *Taraxacum officinale*, *Senecio pseudaureus*, *Osmorhiza chilensis*.	H' = 2.7 - 3.1 J' = .76 - .85 S = 73	1000 - 2700	Most structurally diverse communities on the area; very valuable for avian populations, particularly as nesting/breeding habitat.
Douglas hawthorne/Kentucky bluegrass	A horizons consist of silt-loam textures; underlain by coarse textured horizons. Deep, well drained soil profiles.	*Poa pratensis*, *Agrostis alba*, *Achillea millefolium*, *Taraxacum officinale*, *Viola adunca*, *Aster folaceus*, *Vicia americana*.	H' = 2.1 - 3.4 J' = .76 - .85 S = 86	1500 - 2500	Important wildlife habitat; preferred foraging community by cattle.
Kentucky bluegrass-Mixed Forbs (Dry Meadows)	Among the more well developed soil profiles, deep solum (70-150 cm). Deep, loamy A horizons. Usually possess B horizons.	*Poa pratensis*, *Agrostis alba*, *Erodium cicutarium*, *Achillea millefolium*, *Lupinus leucophyllus*, *Ranunculus acris*.	H' = 1.0 - 3.3 J' = .58 - .81 S = 78	2600 - 4200	Valuable forage areas for cattle; historical dominance of bunch grasses and grass-likes, now in a zootic climax of Kentucky bluegrass.
Kentucky bluegrass-Timothy-Mixed Grasslikes and Forbs. (Moist Meadows)	Poorly drained profiles with a restrictive layer to water percolation, overlain by A horizons with SICL-CL textures. Gleyed horizons common.	*Poa pratensis*, *Phleum pratense*, *Carex aquatilis*, *Carex stipata*, other *Carex* sp., *Ranunculus acris*, *Aster foliaceus*, *Potentilla gracilis*, many mesic forbs.	H' = 2.1 - 3.3 J' = .80 - .84 S = 64	3500 - 15,000	Highest standing phytomass of all communities on the area, valuable forage producing communities, susceptible to trampling.
Cheatgrass-Mixed Forbs	Structureless, rocky to the surface, profiles appear to be excessively drained.	*Bromus tectorum*, *Erodium cicutarium*, *Achillea millefolium*, *Polygonum* sp., *Collomia* sp., and many annual aliens.	H' = 2.0 - 2.5 J' = .66 - .85 S = 50	970 - 2000	Communities appear almost exclusively on disturbed soils caused by old stream channels or old dredge piles from irrigation canals.
Kentucky bluegrass-Cheatgrass	Deep well drained soils, similar to dry meadows with the exception of gravelly areas and increased disturbance.*	*Poa pratensis*, *Bromus tectorum*, *Bromus racemosus*, *Erodium cicutarium*, *Achillea millefolium*, *Veronica arvensis*.	H' = 1.2 - 2.6 J' = .57 - .73 S = 49	2600 - 3300	Cheatgrass and bluegrass usually occur in almost pure patches depending on soils and soil disturbance factors.
Snowberry-Wood's rose	Shallow, well drained soils, on old disturbed areas.*	*Poa pratensis*, *Agrostis alba*, *Bromus racemosus*, *Bromus tectorum*, *Trifolium repens*, *Geum macrophyllum*, *Taraxacum officinale*.	H' = 2.7 - 3.1 J' = .77 - .81 S = 64	3200 - 4000	Occur primarily on disturbed sites, old brush piles, etc.
Ponderosa pine/Kentucky bluegrass	O horizon usually present; thick A horizons up to 60 cm, underlain by IIC and IIIC horizons of unconsolidated coarse materials forming an aerated horizon. Deep water tables.	*Poa pratensis*, *Elymus glaucus*, *Bromus tectorum*, *Arenaria macrophylla*, *Achillea millefolium* *Taraxacum officinale*, *Ranunculus acris*.	H' = 2.0 - 3.0 J' = .67 - .81 S = 64	1400 - 2000	Structurally similar to upland *P. ponderosa* types; but with an understory dominated by riparian obligates.

* No profile descriptions taken.

interactions, each of the 258 stands is actually an assemblage of plant and animal species with many distinguishing characteristics; making each of them a unique entity unto themselves.

The artificial grouping of similar assemblages of plant species into communities, three years' measurements in which the environmental effects were different each year, and the complex interactions of geographical location and intercommunity interactions all contributed to wide ranges in the community parameters measured. In addition, these measurements were made in stands of vegetation in which half were grazed and half were ungrazed. The two treatments probably served to broaden stand differences among communities to an even greater extent.

Conclusion

Riparian ecosystems are recognized as among the most diverse and complex of all habitats. Many environmental factors that contribute to that diversity and complexity were examined on the riparian zone along Catherine Creek.

Factors demonstrated to have significant effects on community development included the interactions of soil morphology, depth to water tables, streamflow dynamics, microclimate, and biotic interactions. These are by no means all the ecological processes which interact in riparian community development. The complexity of these ecosystems is due to many ecological interactions, many of which are readily apparent and many which may not even be discovered until years of intense study are completed, if ever. Two hundred and fifty-eight stands of vegetation representing 60 plant communities were identified. As a foundation to understand some of the ecological processes involved in community development, structure and composition, ten common plant communities were quantitatively described using a variety of techniques.

Variation of and within plant communities in the 15 hectare study area was probably greater than the variation of all upland communities which drain into this area.

Standing phytomass in the riparian zones ranged from almost 15,000 kg/ha in moist meadows to practically 0 kg/ha on recently formed gravel bars.

Species richness and species diversities were high in several communities, many of which contain well over 100 species. Conversely, some dry meadows and cheatgrass disturbance areas were practically monotypic vegetation stands.

Wildlife use of the area was very high. Eighty-one species of birds utilized the area during the months of May - October. At least 34 species of birds utilized the area as nesting habitat. During the nesting/brooding season densities of over 30 avian species/ha were not uncommon.

Twenty species of mammals were casually observed utilizing the riparian study area. Under intense observation, there is no doubt that this list would increase. Many species examined appear to have significant impacts on the community composition and plant succession. Those animals shown to have the greatest impact include cattle, beaver, northern pocket gopher and Columbian ground squirrel.

Proximity to water, high diversity of species and communities, high productivity and favorable microclimate are a few reasons these areas are extremely valuable to many wildlife species. Livestock prefer riparian areas for much the same reasons. Recreationists utilize riparian zones extensively for many outdoor activities. Water quality and quantity for downstream users is of paramount importance for health and food production. Because these important uses of riparian ecosystems are expected to increase, a better understanding of the ecological processes within riparian ecosystems is imperative for long-term land use planning.

CHAPTER II

Synecological Effects of Livestock on Riparian Plant Communities

SYNECOLOGICAL EFFECTS OF LIVESTOCK ON RIPARIAN PLANT COMMUNITIES

Abstract

A study to evaluate impacts of a late season grazing scheme on riparian vegetation was begun in 1978. Livestock impacts on community composition, structure and productivity were evaluated. After almost three years' cessation from grazing, three plant communities out of ten sampled displayed significant species composition and productivity differences. These were within meadow and Douglas hawthorne (*Crataegus douglasii*) community types which were utilized more heavily than any other communities sampled. Shrub use was relatively light except on willow (*Salix* spp.) dominated gravel bars. On gravel bars, succession appeared to be retarded by livestock grazing. Few differences were recorded in other plant communities sampled, particularly forested plant communities.

Positive characteristics of a late season grazing scheme on the riparian zone include increased livestock production, maximum plant vigor and productivity, minimal soil disturbance and minimal short-term disturbance to the critical values of riparian ecosystems such as wildlife habitats.

Introduction

The impacts of livestock grazing in riparian ecosystems has received much attention recently. Riparian ecosystems have been identified as critical zones of management because of their values as wildlife habitat (Ames 1977, Hubbard 1977, Patton 1977), as a modifier of the aquatic environment and fisheries habitat (Cummins 1974, Duff 1974, Meehan et al. 1977), as a major constituent in maintenance of water quality and quantity (Horton and Campbell 1974), and as a valuable forage resource for livestock (Cook 1966, Reid and Pickford 1946). It has been stated that the riparian habitat is the most productive and possibly the most sensitive of North American habitats and should be managed accordingly (Johnson et al. 1977).

In the past riparian zones were considered sacrifice areas (Oregon - Washington Interagency Wildlife Council 1978). Reid and Pickford (1946) stated that the highly palatable vegetation in meadows adjacent to streams is often sacrificed in order to utilize a much larger acreage of forested range. Riparian vegetation has been intensively utilized by livestock over several decades and has been reported to cause a reduction in the productivity of fish and wildlife habitats, and degradation of water quality as well as promotion of increases in streamflow fluctuations (Oregon - Washington Interagency Council 1978). In addition, improper grazing practices in riparian zones can have a considerable effect on vegetation, resulting in lowered vigor, biomass, and a degradation of species composition and diversity (Ames 1977, Bryant et al. 1972, Evans and Krebs 1977). Overgrazing has also resulted in erosion of stream channels causing a lowering of the water table, and thus channels are deepened to such a degree that subirrigation is destroyed (Reid and Pickford 1946).

These damages induced by livestock grazing are considered to be the result of compaction of soils which results in increased runoff and decreased water availability; herbage removal which has lowered plant vigor and allowed soil temperatures to rise and thus increased evaporation; and physical damage to vegetation by rubbing, trampling and browsing (Severson and Bolt 1978).

Riparian ecosystems are the most critical zones for proper management (Platts 1979). Management schemes discussed for riparian zone rehabilitation and/or maintenance include exclusion of livestock, alternative grazing schemes, changes in the kind and class of animals, managing riparian zones as special use pastures, instream structures and several basic range practices (e.g. salting, upland water developments, herders).

Recently many riparian ecosystems in the western United States have been fenced and managed as special use pastures. Rather than indefinite exclusion of grazing, several grazing schemes have been suggested to utilize the riparian forage resource while preserving the integrity of the riparian/stream ecosystem (Claire and Storch in press, Platts 1978). One such system is a late season grazing scheme.

Objectives of this study were to compare differences in succession, composition, productivity and structure between riparian plant communities that were ungrazed and riparian plant communities that were grazed under a late season grazing scheme (late August - mid September).

Description of the Study Area

Location

The study area is located on the Hall Ranch, a unit of the Eastern Oregon Agriculture Research Center. The Hall Ranch is located in the southwestern foothills of the Wallowa Mountains, 19 km southeast of Union, Oregon. The specific location of the study area is Township 5, South, Range 41, East of the Willamette Meridian.

The study area is roughly a 50 meter by three kilometer strip of riparian vegetation adjacent to Catherine

Creek. Uplands are dominated by mixed conifer and ponderosa pine (*Pinus ponderosa*) habitat types. Elevation along the creek is approximately 1030 meters.

Geology

Diastrophic processes during the late Tertiary - Quaternary lifted the Wallowa Mountains to their present heights. The upthrust of the high Wallowas influenced lower areas such as the Hall Ranch through structural faulting. Catherine Creek is thought to follow a fault line. The land area to the east of Catherine Creek is underlain by lava flows tilted to the southwest, while the area to the west is situated on a 900 m fault escarpment (Hampton and Brown 1963, Wagner 1955).

Climate

The majority of precipitation occurs in the form of snow during the months of November to May. Summers are typically warm and dry with temperatures rarely exceeding 38° C. Freezing or near freezing temperatures are possible every month. Catherine Creek serves as a cold air drainage for high elevations, resulting in frequent morning frosts during the summer months.

The 17 year precipitation mean for the study area was 60 cm. Mean monthly precipitation and temperature data can be found in greater detail in Chapter one.

Soils

Soils of the study area were mapped as a Veazie soil (Anderson person. comm.). The Veazie series consists of deep, well drained soils, that formed in alluvium from mixed sources (Strickler 1966). This is not an accurate description of any of the soils in the study area except those found in dry meadows (*Poa pratensis* - mixed forb communities). Soils on the area vary from well drained loamy soils greater than 100 cm deep to unconsolidated sands, gravels and cobbles. General descriptions of soils of the most prevalent communities in the study area can be found in Chapter one.

Methods

Plant Community Mapping

Initial mapping of plant communities was accomplished by ocular reconnaissance. All vegetation stands which had a diameter of at least three meters were mapped and the species composition was estimated using an ocular prominance rating as described in Chapter one. From the data, the ten most prevalent communities were intensively sampled using species frequency, standing phytomass and, where appropriate, shrub density and height measurements. The ten communities sampled were dry meadow (Poa pratensis - mixed forbs), moist meadow (Poa pratensis - Phleum pratense - mixed grasslikes and forbs), Kentucky bluegrass - cheatgrass (Poa pratensis - Bromus tectorum), cheatgrass (Bromus tectorum), Douglas hawthorne / Kentucky bluegrass (Crataegus douglasii / Poa pratensis), snowberry - Wood's rose (Symphoricarpos albus - Rosa woodsii), gravel bars (Salix spp. - Populus trichocarpa sapling - mixed graminoids - mixed forbs), thin leaf alder / Kentucky bluegrass (Alnus incana / Poa pratensis), ponderosa pine / Kentucky bluegrass (Pinus ponderosa / Poa pratensis), and black cottonwood - mixed conifer (Populus trichocarpa - mixed conifer).

Exclosures

Upon completion of community descriptions of the riparian study area, five livestock exclosures were constructed alternating with grazed portions of the study area. Exclosures were constructed in such a manner as to minimize alterations in normal livestock movements. This was accomplished by construction of two exclosures at both ends of the study area and construction of three exclosures in the wider portions of the study area.

Approximately one half of the streambank and riparian vegetation within 50 meters was excluded from grazing. Exclosed and grazed areas contained an adequate number of similar vegetation stands for meaningful comparisons to be made. Plant community distribution and locations of exclosures can be found on the map (Appendix G).

The Grazing System Utilized on the Hall Ranch

Eighty-five to 104 spring calving cow-calf pairs grazed the Hall Ranch each grazing season from June 1 - October 1. Cattle grazing begins on irrigated pasture and proceeds through two ponderosa pine upland pastures grazed on a deferred rotation system until late summer. Livestock then move into the riparian ecosystem studied which is fenced separately from the uplands. Grazing began about August 25 and continued for three - four weeks depending on the amount of forage produced and livestock numbers grazing. The stocking rate on the riparian study area was approximately 0.4 - 0.5 AUM/ha. Then livestock are usually moved to north slope pastures or upland pastures with adequate forage availability for the remaining few weeks of the grazing season.

Frequency

As a method of determining changes in species composition, richness, diversity and community equitability, frequency percents of all species were measured in the field layers of the ten communities previously mentioned. A one quarter meter^2 quadrat was used for frequency measurements. A one sixteenth meter^2 nested plot was also used to determine frequency more precisely for the dominant plants which would normally have a frequency of 100 percent in the larger plot.

Frequency measurements were accomplished by sampling 30 plots per vegetation stand with 6-18 stands of each community measured. Usually half of the stands sampled were in grazed areas and half of the stands were in ungrazed areas.

Frequency was measured when Kentucky bluegrass was in anthesis (late June - early July). At this time, most perennial species were in an identifiable phenological state and the highest seasonal species diversity for most plant communities was expressed.

Shrub Composition Density and Height

Shrub density, height and composition was measured using transects of ten one-meter^2 plots, permanently established in 30 vegetation stands. Twenty-eight were in shrub or tree dominated communities and two were in dry meadows. Half of these transects were in grazed stands and half were in exclosed stands. Density and height measurements were recorded for all shrub species with a rooting stem base occurring totally within the plot. Because of the rhizomatous nature of many of the woody species, density estimates were recorded as rooting stem density and not as individual plant density.

Standing Phytomass and Utilization

Standing phytomass was estimated in the field and low shrub layers for the ten communities intensively sampled. Standing phytomass was determined using a one quarter meter^2 plot. Three stands of each community in both grazed and exclosed areas were measured by clipping ten plots in each stand for a total of 30 plots in each community for each treatment.

All forbs and graminoids that had their stem base within the plot were clipped, oven dried and then weighed to obtain individual species dry weight estimates. Current year's growth of woody vegetation available to herbivores was measured by clipping an estimated fraction of the plant to prevent total defoliation and subsequent death of the shrubs.

Measurements were taken in late July to mid-August just prior to the onset of grazing. This season reflected the time of maximum standing phytomass and was a good measure of the amount of forage available to livestock.

Estimation of utilization was accomplished by an ocular estimate of 10-15 plots in each stand that was sampled for standing phytomass. Stubble heights of key forage species in meadow and Douglas hawthorne communities were estimated by randomly measuring one grazed plant per plot.

Quantitative Community Analysis

Plant species diversity, equitability and McArthur's difference values were generated from frequency data which, when sampled within discrete community boundaries appeared to be a valid index of species abundance. The AIDN program was used to generate the quantitative data (Overton 1974).

The Shannon-Weaver Information theory formula was used to calculate diversity (H'), where $H' = \Sigma pi \log_e pi$. Here pi is the frequency of the ith species (i=1,2,...S) (Shannon 1948). This diversity measure has two components, species richness and equitability or distribution of numbers between species (Lloyd and Ghelardi 1964). Species richness (S) is the number of species found in a particular community. Equitability is expressed as $J' = H'/H'max$, where H'max is equal distribution of units between a given number of classes. H'max is calculated as $\log_e S$.

McArthur's difference value is a measure of community resemblance that was utilized to measure quantitative differences in plant communities under the different grazing treatments. The range varies from 1-2 with values increasing as differences between two communities increase. McArthur's difference value (DIFF) is expressed as $e^{H''_T - H''}$ where H'' is the sum of H' for the two communities to be compared multiplied by 0.5 and H''_T is the sum of pi for both communities times 0.5 times the $\log_e$ of this number (Overton 1974).

Statistical Analysis

Changes in individual species frequency was tested with chi-square statistics. Standard analysis of variance and student-Newman-Keul's test were used to compare standing phytomass estimates of plant communities among both treatments and years. Changes in shrub density and heights between grazed and exclosed areas was tested using a student's t test (Steele and Torrie 1960).

Multivariate analysis of variance (MANOVA) was also used to test for differences in plant community composition (Morrison 1976). Population parameters used in the MANOVA were species diversity, species richness, community equitability and standing phytomass. Wilk's lambda (Λ) was the test statistic used to detect significant differences with the MANOVA (Neter and Wasserman 1974). When a significant Λ was obtained, student-Neuman-Keul's test was used to determine where differences occurred.

Discriminant analysis was also used to indicate which variate(s) were most sensitive in indicating treatment effects. Fiducial limits for all statistical analyses procedures were set at $P \leq 0.05$ level.

Results

Patterns of Utilization by Domestic Livestock

Utilization by livestock on the study area varied greatly, not only from community to community but quite often from stand to stand within particular communities. Generally those communities containing an overstory layer were less preferred than meadow or grassland vegetation types.

Dry meadows (Kentucky bluegrass - mixed forbs), moist meadows (Kentucky bluegrass - timothy - mixed *Carex* spp.) and wet meadows (*Carex* spp.) were most preferred and cattle utilized these communities more heavily than the other communities sampled. Greater than 60 percent of the forage was removed by livestock in these communities.

In the dry meadow community Kentucky bluegrass was utilized 55, 77 and 79 percent in 1978, 1979, and 1980, respectively. Average stubble heights for Kentucky bluegrass were 3.4 cm in 1978 and 4.1 cm after the 1980 grazing season. Utilization of forbs in the dry meadow community was moderate to light, with utilization estimates of 33 percent in 1979 and 15 percent in 1978 and 1980. Utilization estimates for dry meadows and all other communities sampled are summarized in Appendix E.

Kentucky bluegrass utilization in the moist meadow community was moderate to heavy, with an estimated utilization of 67, 78, and 68 percent in 1978, 1979 and 1980, respectively. Mean stubble heights were measured at 3.5 cm in 1979 and 7.1 cm in 1980. Timothy was utilized 76, 76, and 60 percent and sedges were utilized 65, 81, and 65 percent in 1978, 1979 and 1980, respectively. Mean stubble heights for timothy was 8.8 cm in 1979 and 14.5 cm in 1980. Mean stubble heights for all sedges was 7.7 cm in 1979 and 20.7 cm in 1980. The only forb utilization of any consequence in moist meadows was that of northwest cinquefoil (Potentilla gracilis) and white clover (Trifolium repens). In many stands northwest cinquefoil utilization estimates were greater than 70 percent. White clover was generally utilized 60 percent or greater.

Another community that was apparently preferred by cattle as a forage source included the hawthorne community, particularly those stands with a relatively open canopy. Utilization in hawthorne stands ranged from 25-47 percent with the more open stands of hawthorne receiving the heaviest utilization. Stubble heights of Kentucky bluegrass in hawthorne communities were less than 8.4 cm. Mean stubble heights for selected graminoids in hawthorne, dry meadow and moist meadow communities are summarized in Table 3.

On gravel bars utilization estimates were light - moderate with less than 40 percent of the total available forage utilized. A preference for willows, black cottonwood saplings and white clover was observed. Utilization estimates for shrubs varied from 31 percent in 1979 to 54 percent in 1978. Average height of black cottonwood saplings after the 1979 grazing season was 10 cm compared to a height of 30 cm in exclosures.

Because of the lateral growth form of white clover around rocks and cobbles on the gravel bars, a high percentage of the standing phytomass of clover was unavailable to grazers. Because of this phenomenon, actual utilization of the available white clover was higher than estimated. Utilization percent estimates of total standing phytomass of white clover was 24, 28 and 59 percent in 1978, 1979, and 1980, respectively.

TABLE 3. Mean stubble heights (cm) of selected graminoids in the three plant communities most preferred by livestock and the estimated utilization percent of that species.

	1979				1980			
	Grazed		Exclosed		Grazed		Exclosed	
Communities	Stubble Ht. (cm)	Util. (%)	Stubble Ht. (cm)	Util. (%)	Stubble Ht. (cm)	Util. (%)	Stubble Ht. (cm)	Util. (%)
Poa pratensis-Mixed forbs								
Poa pratensis	3	79.4	29	1.0	4	77.3	34	*
Juncus balticus	12	50.2	-	-	10	40.0	-	-
Carex sp.	4	90.0	-	-	-	-	-	-
Phleum pratense	-	-	23	10.0	-	-	74	*
Bromus marginatus	-	T	23	14.4	-	-	20	*
Agropyron repens	4	90.0	-	-	-	-	-	-
Poa pratensis-*Phleum pratense*-Mixed grasslikes								
Poa pratensis	4	80.2	29	2.1	7	67.9	48	T
Phleum pratense	9	76.0	37	3.4	14	59.7	66	2.2
Carex sp.	8	80.9	34	3.4	20	64.6	66	T
Juncus balticus	12	43.0	29	T	-	-		-
Crataegus douglasii/*Poa pratensis*-Mixed forbs								
Poa pratensis	6	58.9	33	10.0	8	47.7	33	2.9
Juncus balticus	14	17.0	-	-	4	85.0	-	-
Phleum pratense	-	-	-	-	9	37.5	51	T

\- Indicates particular species was not measured in the analysis
* Indicates no discernable utilization by livestock or big game was detected during analysis
T Indicates a trace of utilization was detected (usually less than 2%)

Utilization of those plant communities containing a dense canopy cover (black cottonwood, Ponderosa pine and thin leaf alder communities) was light. It appeared that the growth form of Kentucky bluegrass in forested communities was not as palatable as the growth form in meadow communities. Observations in forested communities indicated that number of tillers per plant was less, leaf blade length was greater and plant density was less than the Kentucky bluegrass layer found in meadow or more open communities. Lodging was also a more common occurrence in communities possessing an overstory canopy. Utilization by cattle occurred almost exclusively on plants that were not lodged.

Utilization estimates for ponderosa pine, black cottonwood and thin leaf alder communities was always less than 30 percent and usually less than 17 percent. Sixty to 100 percent of the total phytomass utilized by livestock in forested communities was Kentucky bluegrass except in a few communities where substantial shrub utilization occurred. Shrub utilization varied greatly among stands within communities, ranging from 0 to 36 percent.

Forested communities in the riparian zone were primarily sought out by cattle as shade and resting cover. Because of the high use by livestock in many stands as resting areas, trampling of vegetation in these stands was common.

The cheatgrass community was the least preferred of all communities. During the 1978 grazing season, Fall regrowth of cheatgrass was present. This regrowth was the only detectable forage utilized in cheatgrass stands. Utilization in 1978 was 14 percent while less than two percent of the total available standing phytomass was utilized in 1979 or 1980.

In general, shrub utilization for the entire riparian ecosystem was neither constant from year to year nor from community to community. Shrub utilization for all shrub species was lower in 1979 than 1978 or 1980. Precipitation and subsequently forage production was lower in 1979 than 1978 or 1980. Examination of three years' data indicate that in years of high forage production (both shrub and herbaceous vegetation), utilization of shrubs increased.

Utilization of palatable shrubs such as blue elderberry (Sambucus cerelua) and goosecurrents (Ribes spp.) was heavy, particularly in meadow communities. Utilization often was greater than 100 percent of the current year's growth. Douglas hawthorne shrubs with a height of less than one meter were preferred by cattle, particularly when occurring in low density hawthorne stands or as solitary shrubs in meadow communities. Utilization often exceeded 50 percent of the current year's growth on many individuals. Douglas hawthornes exceeding two meters in height were rarely browsed as heavily as the smaller hawthorne shrubs.

Utilization by Wildlife

Utilization of shrubs by big game was apparent in many communities. Solitary shrubs in meadow communities were observed as receiving the heaviest utilization. Big game utilization in cattle exclosures was estimated at 75 percent of current year's growth for goosecurrents, 30 to 50 percent of current year's growth for Douglas hawthorne and 10 to 15 percent of current year's growth for Wood's rose in 1978. Utilization on willows was light, usually less than 10 percent.

Utilization on the herbaceous component of riparian plant communities was very light and undetectable, except for the most palatable species. Most of the utilization on the herbaceous component in exclosures was attributed to trespass cattle, small mammals and insects.

Grasshoppers (*Arphia* and *Trimerotropis* spp.) defoliated some communities heavily enough to obtain utilization estimates of their use. Leafy bract aster (*Aster foliaceus*), snowberry and bull thistle (*Cirsium vulgare*) each had over 20 percent of their standing phytomass removed in some vegetation stands, for all three years of the study. Insect utilization estimates of over ten percent of the standing phytomass of timothy, quackgrass (*Agropyron repens*), common dandelion (*Taraxacum officinale*) and white clover were not uncommon.

Impacts of Livestock on Species Composition

Significant changes in species richness and in species composition has occurred in some of the riparian plant communities. However, these changes in species composition and richness between grazed and ungrazed areas were not the same for all communities. In fact, changes in vegetation stands of the same community were not always constant.

Generally the most substantial changes in species composition occurred in areas that were most altered or impacted by cattle. These included areas of heavy utilization and concentration by livestock and those vegetation stands that were disturbed by trampling.

One vegetation type in which cessation of grazing for three years has brought about changes was the moist meadow community. Species composition differences between the two treatments were evident. Phenology and temporal differences in the growing season have occurred. The onset of the growing season, anthesis, and dormancy in exclosed areas occurred as much as two weeks later in the year compared to grazed areas.

Significant increases in mesic/hydric species such as lineleaf indianlettuce (Montia linearis) and sedges have occurred in some exclosed stands of moist meadows while significant decreases were apparent in timothy and many forbs more attuned to drier environments. Changes in species composition were more apparent in standing phytomass than from frequency data and shall be discussed in greater detail later in this chapter. Species frequency differences between a grazed portion and an ungrazed portion of a particular moist meadow stand are summarized in Table 4.

Those areas which are susceptible to trampling damage have also experienced changes in species composition due to cessation of grazing. In an area with gravelly, loosely structured soils, cheatgrass dominates the portions of the stand utilized by livestock while quackgrass now dominates the area within an exclosure. In the exclosure, perennial and biennial forbs are invading and colonizing the area while outside the exclosure the stands are basically dominated by annuals. A well developed litter layer is forming in the exclosed area. Communities such as this are not utilized by cattle due to the unpalatable nature of annual forbs and cheatgrass during late summer. Because of the unpalatable nature of the cheatgrass and forbs, trampling impacts were

TABLE 4. 1980 Average Percent Frequency of grazed and ungrazed portions of a *Poa pratensis* - *Phleum pratense* - Mixed grasslike and forb community bisected by an exclosure fence (C-142).

Species	1978	Exclosure 1980	Grazed 1980
GRAMINOIDS			
Poa pratensis	97	100	100
Phleum pratense	100	27	93
Carex aquatilis	90	90	93
oval sedges*	47	23	37
Juncus balticus	--	20	20
Agrostis diegoensis	33	13	--
Festuca elatior	23	--	10
Melica bulbosa	--	--	3
FORBS			
Ranunculus acris	100	77	83
annual *Caryophyllaceae* spp.	7	63	67
Montia linearis	--	47	10
Taraxacum officinale	33	30	39
Stellaria graminea	--	7	27
Cirsium vulgare	--	17	--
Cerastium viscosum	7	10	--
Veronica arvensis	--	7	3
Potentilla glandulosa	--	7	--
Trifolium repens	13	3	3
Fragaria vesca	--	3	--
Brassicaceae spp.	--	3	--
Epilobium glaberrimum	--	3	3
Rumex occidentalis	--	3	3
Mimulus guttatus	--	3	3
Medicago lupulina	--	3	--
Trifolium pratense	3	--	--

1978 - sampled August 1
1979, 1980 - sampled June 25, 26

believed to be the reason for the species composition present outside the exclosure. Data from this area now supporting two discrete communities are summarized in Table 5.

Some gravel bar stands have also experienced changes in composition and structure due to cessation of grazing. Mackenzie willow (Salix rigida) may be increasing in exclosed areas on gravel bar communities. Density measurements of Mackenzie willow increased from 2.6 rooting stems per meter^2 after one year of rest to 3.77 rooting stems per meter^2 after two years of cessation from grazing in 1979. However, this difference was not significant.

Significant increases in density were measured for cottonwood saplings which behave much like willows on gravel bars in that they generally retain a shrub-like physiognomy. Density in exclosures after two years rest was 23.7 rooting stems per meter^2, compared to 13.1 rooting stems per meter^2 in grazed areas. In exclosures the mean height of black cottonwoods significantly increased from 19 cm in 1978 to 30 cm in 1979. Mean height of black cottonwoods in grazed areas was not significantly different between years (a change from 12-10 cm. Shrub density and height measurements were not estimated in 1980.

On gravel bars, observed changes in shrub

TABLE 5. Average percent frequency of a grazed and ungrazed plant community occurring on gravelly soils after three years cessation from grazing (C-60).

Species	Percent Frequency Exclosure	Percent Frequency Grazed
GRASSES		
Bromus tectorum	5	100
Agropyron repens	100	--
Poa pratensis	20	25
Bromus racemosus	--	20
FORBS		
Epilobium paniculatum	50	40
Veronica arvensis	15	5
Microsteris gracilis	55	70
Taraxacum officinale	5	--
Collomia linearis	50	5
Lactuca serriola	35	--
Rumex acetosella	10	10
Achillea millefolium	10	--
Collinsia parviflora	10	--
Erodium cicutarium	5	10
Polygonum douglasii	--	15
Fragaria virginiana	--	5
chickweeds (*Caryophyllaceae* sp.)	--	25
unknowns	10	--

composition included increased density and height of willows and alders in the ungrazed area while the grazed area remains dominated by a low cover of black cottonwoods. Succession from a black cottonwood cover to a cover of willows and alder was apparently retarded by late season grazing by livestock.

Multivariate analysis (MANOVA) found no significant differences in species diversity (H'), species richness (S), or equitability (J') for all communities when testing grazing treatments within the same year. This indicated that even though there were increases and/or decreases of particular species in plant communities, these differences were not great enough to indicate a significant community change using the tested parameters. Using MANOVA, significant differences were detected in the standing phytomass component of some plant communities and this will be discussed in the next section.

Significant differences from MANOVA were found testing among years (independent of treatment) for species diversity in Douglas hawthorne communities; species richness in gravel bar communities; and standing phytomass in black cottonwood - mixed conifer communities. This indicated that annual environmental effects played a significant role in the species composition of these communities. Percent frequency, species diversity, species richness, equitability and McArthur's difference values of treatments within years is summarized in Appendix D.

Impacts of Livestock on Standing Phytomass and Productivity

Examination of three years' data indicated that differences in standing phytomass occurred due to both annual climatic fluctuations and grazing treatments. In the years of above average precipitation (1978, 1980), high standing phytomass estimates were recorded while the opposite was true for the year of low precipitation (1979). This general trend occurred regardless of treatment. However, the amount of change in productivity due to weather was not necessarily constant between grazed and ungrazed areas.

In general, the communities with the greatest amount of standing phytomass in the field layer were the communities exhibiting the greatest response to cessation of grazing. These communities (primarily meadow and Douglas hawthorne communities) were also the areas most heavily utilized by cattle as a forage source. Vegetation stands with a low standing phytomass in the field layer generally displayed little response to cessation of grazing after three years rest. These included forested communities and cheatgrass dominated communities which normally were not utilized as a forage source and therefore experience little if any impacts due to forage removal by livestock.

Significant differences in the total standing phytomass estimate for moist meadow communities as well as for standing phytomass estimates for many individual species within moist meadows were noted. Pretreatment standing phytomass estimates were approximately 7000 kg/ha for both grazed and exclosed areas (Table 6). During 1979, vegetation stands that were grazed changed very little with a mean standing phytomass estimate of 6550 kg/ha. In exclosures, the standing phytomass estimate decreased to 3500 kg/ha in 1979. This estimate was significantly less than that of the 1978 estimate within exclosures and significantly less than 1979 standing phytomass estimates in grazed stands.

The favorable environmental conditions in 1980 served to increase standing phytomass in exclosures to an estimated 9180 kg/ha. The phytomass estimates for 1980 in exclosures was a significant increase over 1979 phytomass estimates. There was no significant difference in 1980 standing phytomass estimates between grazed and ungrazed areas. Standing phytomass of moist meadows in grazed areas was estimated at 8750 kg/ha.

Individual species within moist meadows had different reactions to cessation of grazing. Phytomass estimates for Kentucky bluegrass in grazed areas was

TABLE 6. Standing phytomass, percent utilization, species richness, species diversity, equitability and McArthur's difference value for grazed and ungrazed plant communities along the Catherine Creek Study Area.

Alnus incana/Poa pratensis

	1978		1979		1980	
	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed
Standing phytomass (kg/ha)	1080	1206	962	1193	1369^{+}	1609
Percent utilization	25	T	16	5	14	3
Species richness (S)	51	34	49	41	45	51
Species diversity (H')	3.0126	2.7199	3.2930	3.1915	3.1585	3.2870
Equitability (J')	.7662	.7713	.8461	.8594	.8297	.8360
McArthur's Difference Value	1.150		1.194		1.142	

Crataegus douglasii/Poa pratensis

	1978		1979		1980	
	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed
Standing phytomass (hg/ha)	1784	1691	1462	1632	1813	2498$^{*+§}$
Percent utilization	25	2	47	1	37	3
Species richness (S)	53	44	56	51	61	51
Species diversity (H')	3.0194	2.9464	3.3976	3.0300	3.4259	3.2527
Equitability (J')	.7605	.7786	.8517	.7785	.8334	.8273
McArthur's Difference Value	1.0898		1.1154		1.1375	

Populus trichocarpa-Mixed Conifer

	1978		1979		1980	
	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed
Standing phytomass (kg/ha)	2668	2597	1291^{+}	938^{+}	2139^{+}	1602$^{+§}$
Percent utilization	23	1	11	1	9	T
Species richness (S)	38	33	37	36	43	41
Species diversity (H')	3.0973	2.8069	2.7379	2.7799	2.8267	2.8270
Equitability (J')	.8515	.8028	.7582	.7757	.7515	.7613
McArthur's Difference Value	1.1243		1.2222		1.1354	

Pinus Ponderosa/Poa pratensis

	1978		1979		1980	
	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed
Standing phytomass (kg/ha)	1655	1632	1390	1553	1457	1962
Percent utilization	27	T	17	T	10	T
Species richness (S)	39	32	45	35	46	38
Species diversity (H')	2.9554	2.3502	3.0466	2.5069	2.9921	2.7206
Equitability (J')	.8067	.6781	.8003	.7051	.7815	.7479
McArthur's Difference Value	1.256		1.376		1.220	

Gravel Bar Communities

	1978		1979		1980	
	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed
Standing phytomass (kg/ha)	1973	2345	1389	1816	2156	2779
Percent utilization	18	8	19	2	40	T
Species richness (S)	46	52	51	57	63	59
Species diversity (H')	3.2035	3.2971	3.3276	3.4608	3.5181	3.4470
Equitability (J')	.8367	.8344	.8463	.8560	.8491	.8453
McArthur's Difference Value	1.184		1.142		1.111	

Poa pratensis-Mixed Forbs

	1978		1979		1980	
	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed
Standing phytomass (kg/ha)	2620	3950*	2829	2463^{+}	3371	4173^{*+}
Percent utilization	44	2	70	1	67	T
Species richness (S)	50	34	44	26	59	35
Species diversity (H')	2.9971	2.3959	3.0579	1.8847	3.3162	2.8701
Equitability (J')	.7661	.6794	.8080	.5785	.8133	.8072
McArthur's Difference Value	1.1692		1.1215		1.1534	

Poa pratensis-Phleum pratense-Mixed Grasslikes and Forbs

	1978		1979		1980	
	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed
Standing phytomass (kg/ha)	7150	6990	6553	3497^{*+}	8750^{+}	9176^{+}
Percent utilization	66	T	73	2	59	T
Species richness (S)	26	24	51	32	53	49
Species diversity (H')	2.7544	2.6887	3.1306	2.7930	3.2737	3.2030
Equitability (J')	.8356	.8460	.7962	.8059	.8245	.8230
McArthur's Difference Value	1.0180		1.0947		1.0617	

Bromus tectorum-Mixed Forbs

	1978		1979		1980	
	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed
Standing phytomass (kg/ha)	1920	2001	974	1093^{+}	2020^{+}	1702
Percent utilization	11	T	2	T	1	T
Species richness (S)	20	17	28	18	32	16
Species diversity (H')	2.1559	2.1984	2.2453	2.0128	2.4988	2.3947
Equitability (J')	.7322	.8570	.6680	.7104	.7489	.7535
McArthur's Difference Value	1.315		1.176		1.113	

[1]Poa pratensis-Bromus tectorum

	1978		1979		1980	
	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed
Standing phytomass (kg/ha)	2173	3275	2162	1990	--	--
Percent utilization	37	T	57	T	--	--
Species richness (S)	24	16	35	35	--	--
Species diversity (H')	1.8210	2.0415	2.3674	2.5651	--	--
Equitability (J')	.5730	.7363	.6741	.7215	--	--
McArthur's Difference Value	1.0465		1.069			

[1]Symphoricarpos albus-Rosa woodsii

	1978		1979		1980	
	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed
Standing phytomass (kg/ha)	3964	3643	3987	3213	--	--
Percent utilization	15	4	15	2	--	--
Species richness (S)	40	34	45	30	--	--
Species diversity (H')	2.8666	2.7136	3.0984	2.7319	--	--
Equitability (J')	.7771	.7695	.8139	.8032	--	--
McArthur's Difference Value	1.136		1.165			

* Significant difference among treatments within the same year (P ≥ .05)
\+ Significant change of same treatment compared to previous year (P ≥ .05)
§ Significant difference between 1978-1980 within the same treatment (P ≥ .05)

1 Communities not sampled in 1980

relatively stable with estimates of 3300, 3030, and 3680 kg/ha in 1978, 1979, and 1980, respectively. Phytomass estimates of Kentucky bluegrass within exclosures fluctuated greatly with estimates of 3460, 1450, and 3960 kg/ha for 1978, 1979, and 1980, respectively (Appendix E.).

Phytomass estimates of timothy in grazed areas were not as stable as estimates of Kentucky bluegrass. Standing phytomass for timothy in grazed areas was estimated at 2310 kg/ha in 1978, 1420 kg/ha in 1979, and 2040 kg/ha in 1980. In exclosures standing phytomass estimates for timothy were 1860 kg/ha in 1978, 170 kg/ha in 1979, and 720 kg/ha in 1980. When comparing grazed and ungrazed treatments, significant differences in standing phytomass estimates for timothy occurred in 1979 and 1980. It was apparent that cessation of grazing in moist meadows has decreased the abundance of timothy.

Large Carex spp. (*Carex aquatilis*, *Carex stipata* and *Carex rostata*) responded in exclosed moist meadows with a significant increase in standing phytomass estimates from 810 kg/ha in 1979 to 2960 kg/ha in 1980. There was no significant difference between years in standing phytomass of the sedges in grazed areas.

Total forb phytomass in moist meadows, though not significantly different between grazing treatments, appeared to have declined somewhat in the exclosures. Estimated phytomass for the forb component in 1980 was 910 kg/ha in grazed moist meadows and 750 kg/ha in exclosed moist meadows. The greatest differences in the forb component were changes in the species composition of moist meadows rather than significant changes in phytomass between grazed and ungrazed areas.

In a very productive moist meadow stand in which half was grazed and half was exclosed from grazing, 1980 phytomass estimates for large sedges were 5580 kg/ha in the grazed section and 8420 kg/ha in the exclosed section of the meadow. In this same vegetation stand, standing phytomass of timothy was estimated at 2990 kg/ha in the grazed area and 820 kg/ha in the exclosed area. Standing phytomass for mesic/hydric forbs has increased. Smooth willoweed (<u>Epilobium glabberrimum</u>) phytomass estimates were 16 kg/ha in the grazed portion and 220 kg/ha in the exclosed portion. Line leaf indianlettuce phytomass was estimated at 210 kg/ha in the exclosure, but was absent in the grazed area. The significant differences in this stand appeared to be reflective of trends occurring in all stands of the moist meadow communities.

In this particular stand of moist meadow vegetation, it was apparent that without grazing, succession towards a more mesic/hydric plant community was occurring. In the exclosure, exotic grasses such as timothy and forbs more attuned to drier environments were decreasing in the composition and were being replaced by native sedges and mesic forbs. Though compositions between the two grazing treatments have changed, 1980 standing phytomass estimates for this particular stand were 14,390 and 14,970 kg/ha for the grazed and exclosed areas, respectively.

Annual fluctuations in total standing phytomass in dry meadows were much the same as in moist meadows. In areas excluded from grazing 1979 phytomass was significantly less than for 1978 or 1980. Estimated phytomass in exclosures was 3950, 2460 and 4170 kg/ha for 1978, 1979 and 1980, respectively. In contrast, grazed dry meadows had relatively stable phytomass estimates of 2620, 2830, and 3370 kg/ha for 1978, 1979 and 1980, respectively.

A significant difference in standing phytomass between grazing treatments was measured in 1978 and 1980. Unfortunately, the differences in standing phytomass before treatments were applied (1978) makes within year comparisons between treatments difficult.

Phytomass for the forb component of dry meadows excluded from grazing were significantly less than dry meadows that were grazed. In exclosures, the forb component of those Kentucky bluegrass dry meadows steadily declined each year of the study. Phytomass estimates for the forb composition in exclosures was 300, 140 and 110 kg/ha for 1978, 1979 and 1980, respectively. Phytomass estimates for the forb composition in exclosures was 590, 430 and 470 kg/ha successively for the three years of the study.

After three years of no livestock grazing, the Douglas hawthorne - Kentucky bluegrass communities in exclosed areas had significantly higher phytomass than grazed areas. Phytomass for 1980 was 2500 kg/ha in exclosures and 1810 kg/ha in grazed areas. Standing phytomass was not different in the previous years between grazing treatments. Phytomass estimates were 1690 kg/ha and 178 kg/ha for exclosed and grazed areas in 1978 and 1630 kg/ha and 1460 kg/ha in 1979 for exclosed and grazed areas, respectively.

This increase in the standing phytomass estimate for Douglas hawthorne communities was attributed exclusively to an increase in phytomass of Kentucky bluegrass. Estimates for Kentucky bluegrass in exclosures increased from 1380 kg/ha and 1300 kg/ha for the first two years of the study, respectively, to 2176 kg/ha in 1980.

In the forested communities (black cottonwood - mixed conifer, Ponderosa pine and thin leaf alder communities), few changes in standing phytomass occurred after three years of cessation from grazing. No significant differences in standing phytomasss among grazing treatments were encountered in these communities.

In black cottonwood - mixed conifer communities, the decline in phytomass for 1979 and 1980 as compared to 1978 was attributed to low estimates of shrub phytomass during these two years. In 1978 cottonwood communities were sampled in sections of stands with a larger shrub component than locations sampled in 1979 or 1980. It is believed that the differences in standing phytomass apparently reflect a sampling error or location error rather than actual changes in standing phytomass.

In ponderosa pine - Kentucky bluegrass communities, the only major change in standing phytomass estimates was in the graminoid component of the composition. Blue wildrye (*Elymus glaucus*) has significantly increased in exclosures with phytomass estimates of 24, 160 and 380 kg/ha for 1978, 1979 and 1980, respectively. In grazed areas, blue wildrye has increased slightly from an estimated 8 hg/ha in 1978 to 21 kg/ha in 1980.

On gravel bars dominated by willows and black cottonwood saplings, there were no significant differences in the total standing phytomass between grazed and exclosed areas. However, black cottonwood sapling phytomass was significantly greater in grazed areas than exclosed areas. This difference was relative to a particular exclosed stand sampled in 1978 and 1979 that was destroyed in 1980 by a natural channel change. Black cottonwood phytomass for this destroyed stand was 540 and 660 kg/ha in 1978 and 1979, respectively. The new stand sampled to replace the destroyed stand had a phytomass estimate of only 26 kg/ha for black cottonwood saplings. Conversely, this stand had phytomass estimates for willow species much higher than the destroyed stand that was sampled in 1978 and 1979. Therefore it was difficult to compare shrub composition changes between treatments using these phytomass estimates. Using the phytomass estimates with these constraints in mind, there appeared to be no differences in shrub production between grazed and exclosed areas. Difficulties in obtaining an accurate phytomass estimate for shrub species in gravel bars, particularly the inadequate plot size will be discussed in the discussion section of this chapter.

Cheatgrass communities showed little response to the different grazing treatments after three years. No significant differences have been noted due to treatment effects in phytomass estimates of either the graminoid or forb component in the stands sampled.

There were no significant differences in snowberry - Wood's rose communities or Kentucky bluegrass - cheatgrass communities in 1979 after one year of treatment effects. These communities were not sampled in 1980. Environmental impacts on standing phytomass masked any treatment effects in these communities, if they were present, after only one year of treatment differences.

Standing phytomass estimates for all ten communities sampled is summarized in Table 6 and Appendix E.

Discussion

Problems with Shrub Composition Estimates

The one quarter meter^2 plot size was determined to be the optimal sized plot for standing phytomass estimates and frequency measurements of the herbaceous component in most of the riparian plant communities that were examined. However, for measurements of standing phytomass and plant frequency of the shrub component of vegetation communities, a larger plot size would have been more desireable.

Estimates for woody vegetation were probably inaccurate in those vegetation stands in which plots fell primarily in intershrub spaces or in those vegetation stands where the sampling of one large shrub could greatly exaggerate phytomass of the shrub component. Vegetation stands where this could be a potential problem include black cottonwood - mixed conifer communities, ponderosa pine communities, thin leaf alder communities and in Douglas hawthorne communities where only shrubs less than two meters in height were estimated. In hawthorne communities standing phytomass of shrubs over two meters in height were not measured. A larger plot for sampling shrub phytomass and frequency of the shrub component would probably have improved accuracy of estimations and lowered variability of those estimations. The one meter^2 plot size used for shrub density and height estimations was thought to give a much more accurate estimation of the shrub component.

The one quarter meter^2 plot was a reasonably accurate size for estimation of shrub phytomass and plant frequency in snowberry - Wood's rose communities and for most gravel bar communities. However, this relationship varied with shrub density, shrub composition and age of the shrub stand on the gravel bars.

Observed Impacts of Livestock on Riparian Plant Communities

Impacts on plant community composition and structure were apparent in many vegetation stands where a decrease in total species numbers in the exclosed areas occurred. Similar observations were noted in riparian ecosystems in Idaho (Hayes 1978) and in New Zealand (Dobson 1973). Dobson (1973) concluded the effect of grazing had been to open up the vegetation, creating more niches in which plants could establish themselves.

Livestock impacts on woody vegetation, a major component of the structural diversity of riparian ecosystems has been termed of critical importance due to its dominant role in wildlife habitat and in altering the riparian/stream microclimate (Thomas et al. 1979). Utilization on woody vegetation was light in all communities with the exception of gravel bars. A late season grazing scheme appeared to have no short term effects on the woody vegetation.

It has been observed that grazing pressures on woody vegetation have prevented the establishment of seedlings, thus producing an even-aged, non-reproducing vegetation community (Carothers 1977, Crouch 1979, Glinski 1977). In thin leaf alder communities and in black cottonwood - mixed conifer communities, there was little, if any, regeneration of either alders or cottonwoods. These communities appeared to succeed in an approximate seral order of black cottonwood sapling communities formed on gravel bars to willow dominated communities, to thin leaf alder dominated communities. Often black cottonwood - mixed conifer communities succeed thin leaf alder communities or, in rare cases, can succeed the black cottonwood sapling dominated communities on gravel bars. Annual high flows associated with Spring runoff generally inundate gravel bars, usually preventing growth of black cottonwood saplings into trees. Establishment of cottonwood saplings into trees on gravel bars was observed only where a particular gravel bar was formed on an old channel sufficiently elevated to minimize spring runoff impacts. This gravel bar was also protected from grazing to a large extent by a boundary fence on one side of the community and the creek with relatively steep bank on the other side. In most stands examined, the natural succession to black cottonwood - mixed conifer communities appeared to evolve through the seral stages associated with willow and then alder dominance with each seral stage being associated with minute changes in the environmental conditions creating new habitats optimal for succession. These environmental conditions include gradual soil build up due to alluvial deposition and slight channel changes, which served to lower high spring flows over the communities and thus reduced the associated scouring.

Examination of the woody species composition on willow - black cottonwood sapling dominated gravel bars indicated that grazing was retarding succession, thereby disallowing succession to thin leaf alder communities. This phenomenon was observed by examination at several locations of willow - cottonwood dominated communities bisected by exclosure fences at the onset of the study. After three years, shrub density and height was significantly greater in the enclosed portion of the stands and some species of willows and thin leaf alder that were not found in grazed areas were present. Conversely, the grazed portions of these stands of vegetation were dominated by shorter, less vigorous stands of black cottonwood saplings and willow species. Although it is too early yet to determine if a late season grazing scheme has a definite negative impact on succession to woody dominated communities and hence the long term structural diversity of this riparian ecosystem, early evidence and observations indicated that this might be happening.

Though it could be argued that late season grazing would increase intensity of utilization of the shrub component in a riparian zone, this would probably not be as severe as the shrub utilization in upland communities in this season. Late in the growing season, the herbaceous component was still succulent and palatable in the riparian zone whereas the herbaceous vegetation in uplands generally was not. In the riparian zone fenced from the uplands, observations indicated that shrub use by cattle was related to availability of herbaceous vegetation and the palatability of the particular shrub species. It appeared that as long as herbaceous vegetation was available in the riparian zone, shrub utilization did not occur to a greater extent due to the late season scheme.

Herbage removal by livestock appeared to be an important factor in altering seasonal phenology of the mesic/hydric meadow communities. In the ungrazed wet and moist meadow communities, onset of the growing season occurred approximately two weeks after the grazed meadow communities in 1979 and 1980. Examination of phenology of individual plants in meadows, indicated that at the time of anthesis for most grasses, sedges and perennial forbs in grazed areas; most of the vegetation in exclosed areas was still in a vegetative form. The dense litter layer formed in exclcsed meadows probably kept soil temperatures below levels for initiation of growth for longer periods of time than grazed areas in which there was only a weak litter layer due to herbage removal by cattle. Sharrow and Wright (1977) found similar soil temperature relationships between areas in which the litter layer had been removed by fire and unburned control plots containing a litter layer. They attributed increased soil temperatures to increased solar exposure of the soil surface due to litter removal.

Greater soil moisture levels and saturated surface soils were observed to be present longer into the growing season in exclosed moist meadows as compared to grazed moist meadows. Litter and herbage removal in grazed areas may have decreased soil moisture either by increased soil temperatures and increased evaporation from the soil surface or by increased transpirational losses due to the earlier growing season in these grazed areas. Though the combination of both factors could account for the earlier, somewhat drier soil conditions in grazed moist and wet meadows; probably decreased evaporation due to the presence of the litter layer in exclosed areas accounted for the greatest differences. This can be explained by the appearance that soil moisture in exclosures was markedly greater than soil moisture in ungrazed areas later into the growing season after substantial forage growth occurred in exclosures. The increased soil moisture due to litter layer accumulation could also be an important factor for the increased abundance of the more mesic/hydric species and the decreased abundance of species more attuned to drier environments in the exclosed moist and wet meadows.

Impacts of livesotck trailing and trampling was localized primarily in those communities with moist or saturated soils susceptible to compaction by livestock and in those communities with very fragile, loosely consolidated gravelly soils susceptible to physical damage by the uprooting of established vegetation. Other areas that received apparent localized soil disturbance included salting areas, favored dusting and rubbing areas, perennially used trails and along the streambank where livestock frequently used a particular area to traverse the creek.

Livestock trampling damage appeared to be most severe in those few areas that contained very moist soils susceptible to compaction late into the Summer. After only a few days grazing in these areas, trailing and trampling damage was apparent. The impacts on infiltration rates, soil structures and the subsequent effects on species composition and community productivity cannot be determined without more intensive studies on the impacts that livestock trampling has on soil properties in these moist meadow communities. Rauzi and Hanson (1967) examining livestock impacts on soils similar to those found in moist meadows (silty clay and silty clay-loam soils) found significant impacts by livestock trampling on soil structure, infiltration and subsequently species composition. If water intake rates are reduced by livestock trampling in grazed moist meadows, then this impact, in addition to the well developed litter layer in exclosed moist meadows could be an important factor in creating a more mesic/hydric species composition in the exclosed moist meadows.

Moist and wet meadows, and communities with saturated soils present for the entire Summer were the only vegetation stands with a potential for severe compaction damage during the late season grazing period. In the majority of the vegetation stands, soil moisture was low enough to minimize potential physical damage to the soils.

Other areas potentially impacted by trailing and trampling damage were those areas with unstructured gravelly soils highly susceptible to mechanical damage to established vegetation. Some evidence of recovery due to cessation of livestock use was noted (Table 5). Changes in species composition, plant density and litter cover was measured in exclosed stands especially in comparison to those stands which experienced a disproportionate amount of trampling due to the proximity of a fence or the streambank.

Management Implications of a Late Season Grazing Scheme

Evaluation of the impacts of livestock grazing in riparian ecosystems is of paramount importance because of the many values associated with these areas. These values include maintenance of water quality and quantity, wildlife and fisheries habitat, a forage resource for livestock and the many recreational values of riparian/stream ecosystems. Ideally the results of proper management would be to perpetuate, rehabilitate or improve the above mentioned values associated with riparian ecosystems.

It must be recognized that no two streams or stream segments are the same and methods of management to restore disturbed streamsides to their former productive state will vary considerably (Claire and Storch in press). Even within a single segment of a riparian ecosystem the great diversity of plant community types should be considered. Because of the great community diversity, and differing ecological tolerances of community types, a management practice that may be beneficial for one community in a riparian zone may not be beneficial to another community in the same area. Herein lies what may be a fundamental problem in the future of riparian zone management. That is managing the riparian ecosystem in such a way as to be of the greatest benefit to the communities which are deemed most important for multiple use management, or whatever use is most preferred for that particular riparian ecosystem (e.g., terrestrial wildlife production, livestock production, fish production, etc.).

Many authors have discussed specialized grazing systems and livestock management practices to maintain or rehabilitate riparian ecosystems (Claire and Storch in press, Evans and Krebs 1977, Hayes 1978, Meehan and Platts 1978, Platts 1978, Severson and Bolt 1978, Storch 1979, Volland 1978). Almost all of these authors have stressed the need to manage riparian ecosystems separately from upland ecosystems. A recent trend in public land management agencies has been to fence riparian zones and manage them separately as special use pastures. Rather than exclude all livestock from these riparian zones, it would appear to be desireable to utilize the valuable forage resource for livestock production in such a way as to minimize damage to the integrity of these ecosystems. Late season grazing has been discussed as one management alternative to achieve this goal (Claire and Storch in press, Pond 1961). Late season grazing here pertains to grazing after the growing season is over for the majority of the forage species and carbohydrate root reserves are at a maximum, usually beginning August 15 - September 1 in the Pacific northwest.

Positive characteristics of a late season grazing scheme include utilization of the forage resource by livestock, maintenance and/or improvement in vigor, species composition and structure of riparian plant communities, maintenance of water quality, minimization of disturbance to the population ecology of the wildlife inhabitants, and minimization of soil disturbance and erosion.

Some positive characteristics of a late season grazing scheme in riparian ecosystems for livestock interests include increased calf gains, improved condition of mother cows and improved utilization of upland plant communities.

Late in the grazing season, vegetation growing in riparian zones generally is more palatable and of higher nutritive quality than vegetation in upland plant communities. Several sedges common to riparian zones of the Pacific northwest outrank key upland forage species in sustained protein and energy content (McLean et al. 1963, Paulsen 1964, Skovlin 1967).

Vavra and Philips (1979) found improved dry matter digestibility, improved protein levels, lowered acid detergent fiber and lowered lignin contents in diets of fistulated heifers grazing the riparian study area during late August - early September, than what upland pastures provided up to one month preceeding this period. Daily intake rates were also greater in the riparian zone than in upland pastures either before or after this period.

Cows were maintaining or losing weight until moved into the riparian zone where they once again gained weight. While grazing uplands, calf average daily gains were in excess of one kilogram per day during June and July and dropped in August as forage quality declined. Late season grazing in the riparian study area increased calf gains to about one kilogram per day and improved cow condition. This increase in condition is an important management consideration as cows going into the winter in better condition need less feed (Vavra and Phillips 1979).

Fish and terrestrial wildlife habitats are apparently less impacted by a late season grazing system compared to grazing systems which utilize the riparian vegetation earlier in the season. After four years' rest from continuous grazing a late season grazing system was initiated on a Blue Mountain riparian zone and was found to exert no measureable effect on fish populations (Claire and Storch in press). No short term effects of late season grazing were noted on the nesting/brooding populations of avian species in the present study. The removal of vegetation and physical damage by livestock grazing during late May to July might have detrimental effects on those avian species which utilize shrub and herbaceous vegetation as nesting/brooding cover. Late season grazing also appeared to have minimal influences on the population ecology of small mammals. Impacts of late season grazing on wildlife populations will be discussed in further detail in the next chapter.

Though trampling and trailing damage by livestock was apparent in the communities with wet soils, a late season grazing scheme will minimize disturbance to soils in the vast majority of the plant communities. Soils in most of the plant communities were dry at this time and trailing and trampling damage was minimal.

There are many economic, aesthetic and management factors that must be considered before fence construction and implementation of a special use pasture grazing system. Riparian zones in many mountain grazing allotments provide up to 21 percent of the total forage produced (Reid and Pickford 1947, Roath 1980). Quite often due to livestock distribution problems this fraction of total forage produced supplies up to 81 percent of the total forage consumed by livestock (Roath 1980). Rather than fence pastures of equal size, fencing areas of equal forage producing capacities and similar ecological responses should be implemented. Fencing uplands in separate pastures from riparian types is a start in this direction.

The higher profits resulting from increased calf gains and lower winter feeding costs of the cow herd due to increased fitness would ameliorate some of the fencing costs. Increased livestock weights would be gained not only by saving the high quality riparian forage until late season, but also by earlier utilization of the upland forage when it is of higher quality. When livestock are grazed in the same pastures containing both riparian areas and uplands, Roath (1980) found the entire herd spent the first seven to ten days in the riparian zone with some animals progressively dispersing onto other areas. After 21 days, 35 to 45 percent of the herd was still utilizing the riparian zone exclusively with other cattle moving back and forth between upland and riparian types. It appears that with minimal livestock management, livestock tend to utilize riparian vegetation first, then move to upland vegetation later in the season when forage quality is lower. This is the opposite utilization pattern recommended by Vavra and Phillips (1979) to increase livestock gains on mountain grazing allotments.

If distribution on uplands is improved it may be possible to increase stocking rates and maintain utilization of forage species well under proper use recommendations. The potential for increased stocking rates in uplands can be extrapolated from Roath's data where 79 percent of the forage produced in an allotment came from uplands but only accounted for 19 percent of the total forage consumed.

Another economic benefit of exclosed riparian zones grazed under late season schemes, would possibly include an increased return from the fisheries resource due to an improvement of the riparian/instream habitat (Claire and Storch in press). In the Pacific northwest this would include both resident and anadromous fish populations.

Water quality impacts as related to temperatures would be minimized since overhanging vegetation which provides shade cover would not be removed until after the warmest periods of the year.

Increased recreational and economic benefits for both consumptive and nonconsumptive uses of wildlife populations would occur. With no disturbance from livestock during the nesting/brooding periods, avian densities could be increased. This would be particularly true for ground nesting species including upland game birds and waterfowl.

Land and/or livestock management flexibility is easily attained when the riparian zone is fenced separately and used as a special use pasture for late season grazing. Utilization of upland forages could be achieved without having to "sacrifice" riparian vegetation. And, depending on environmental conditions for a given year, length of riparian grazing could be optimized to achieve a proper use factor for the key riparian species whether they be woody or herbaceous species.

Conclusion

Late season grazing impacts on riparian ecosystems varied greatly among riparian plant communities. Few impacts were noted on the herbaceous component of forested communities while significant impacts were noted for meadow and Douglas hawthorne dominated communities.

Forested riparian plant communities received only light use, if any, by livestock. Impacts here were minimal and little change in community composition was noted. Meadow types received heavy utilization pressures by livestock and changes in standing phytomass and species composition were noted.

Livestock impacts on moist and wet meadows included herbage removal and the subsequent loss of a well developed litter layer and some trampling effects. The removal of these impacts appeared to be creating more mesic/hydric conditions in exclosed moist and wet meadows.

The significant increases in standing phytomass estimates for exclosed meadows, and Douglas hawthorne communities were probably an interaction between favorable environmental conditions and cessation from grazing which may have created a more favorable microclimate. This favorable microclimate was created by the presence of a well developed litter layer which appeared to minimize soil moisture losses at the soil surface. It is unknown whether increases in standing phytomass will reappear annually particularly during drier years of if favorable environmental conditions (as experienced in 1980) must also be present for significant increases in phytomass to occur.

Utilization on the shrub component of riparian vegetation was light in all vegetation stands except in willow - black cottonwood sapling dominated gravel bars where significant increases in shrub density and height occurred in ungrazed areas. Long term impacts of shrub removal as related to the structural diversity of the riparian ecosystem may be significant. However, it is too early to determine the extent of this impact.

A late season grazing system has many positive characteristics when considering management schemes for riparian zones. Late season grazing minimizes soil compaction because soils are firm at this time of year. Plant species have built up carbohydrate reserves, therefore plant vigor may be maximized. Nutritive quality of riparian forage species is higher at this time of year compared to upland forage species. Impacts on other values associated with riparian ecosystems appeared to be minimized, particularly the fish and wildlife habitat values.

Though negative impacts on some vegetation communities were noted, particularly moist meadows, dry meadows and Douglas hawthorne communities, a late season grazing system may have the least impact on these communities, particularly in relation to soil compaction and community productivity.

CHAPTER III

Synecological Effects of Livestock on Riparian Wildlife Communities

SYNECOLOGICAL EFFECTS OF LIVESTOCK ON RIPARIAN WILDLIFE COMMUNITIES

Abstract

An exceptionally diverse mosaic of riparian plant communities adjacent to Catherine Creek in the Wallowa Mountains of northeastern Oregon provided habitat for many species of nongame wildlife. Comparisons of habitat conditions between riparian plant communities grazed under a late season grazing scheme (late August - mid September) and communities totally excluded from grazing illustrated no significant differences in avian communities. Late season grazing had few short term impacts on avian populations particularly during the nesting/brooding season. There was a significant decrease in small mammal populations after grazing in all communities sampled. However, by the following August small mammals had recolonized the grazed plant communities in essentially the same species composition and densities. Late season grazing may impact the long term structural diversity of the riparian habitats in that succession of willow dominated gravel bars, an early stage in the sere leading towards black cottonwood dominated communities, was retarded. However, assuming no other natural or man-caused perturbations on these communities occur, reproduction and succession of vegetation leading towards the

important forested communities should take place where grazing is managed similarly to this study.

Introduction

Riparian ecosystems have been identified as critical zones of management because of their many values including wildlife habitat (Ames 1977, Thomas et al. 1979) and as a valuable forage and water source for domestic livestock production (Cook 1966, Reid and Pickford 1946). It is believed that among terrestrial ecosystems the riparian/stream ecosystem is the single most productive wildlife habitat type benefiting the greatest number of species (Ames 1977, Hubbard 1977, Miller 1951, Patton 1977).

Riparian ecosystems are valuable to wildlife as a source of water, food and cover (Stevens et al. 1977, Thomas et al. 1979). They provide nesting and brooding habitat (Carothers et al. 1974, Johnson et al. 1977, Tubbs 1980). By furnishing abundant thermal cover and favorable microclimates, especially when surrounded by non-forested ecosystems, they facilitate the maintenance of homeostasis, particularly for big game (Thomas et al. 1979). Riparian ecosystems also serve as big game migration routes between summer and winter range (Thomas et al. 1979) and provide routes and nesting cover for migrating avian species (Stevens et al. 1977, Wauer 1977).

Excessive livestock grazing in riparian areas can severely impact terrestrial wildlife habitat causing a subsequent decrease in wildlife species and numbers (Ames 1977, Townsend and Smith 1977, Tubbs 1980, Wiens and Dyer 1975). While various other management activities have caused serious losses or reductions in habitat productivity, livestock grazing has been suggested as the major factor identified in numerous studies throughout the 11 western states (Oregon - Washington Interagency Wildlife Council 1978). Conversely, Busby (1979) suggested that it was not reasonable to conclude that livestock grazing is the only, nor necessarily the major cause of impacts to riparian ecosystems.

One management plan that takes into account both the livestock and wildlife values is fencing the riparian area separate from upland areas and managing them as special use pastures. Rather than indefinite exclusion of grazing, several grazing schemes have been suggested to utilize the riparian forage with livestock, while preserving the integrity of the riparian stream/ecosystem (Claire and Storch in press, Platts 1978). One such system is a late season grazing scheme.

The objectives of this study were to describe the bird and mammal communities of the riparian zone, and to examine the influence of livestock grazing on these wildlife communities.

Study Area

Location

The study area is located on the Hall Ranch, a unit of the Eastern Oregon Agriculture Research Center. The Hall Ranch is located in the southwestern foothills of the Wallowa Mountains, 19 km southeast of Union, Oregon. The specific location of this study area is Township 5, South, Range 41, East of the Willamette Meridian.

The study area is approximately a 50 meter by three kilometer strip of riparian vegetation adjacent to Catherine Creek. Uplands are dominated by mixed conifer and ponderosa pine (*Pinus ponderosa*) habitat types. Elevation along the creek is approximately 1030 meters.

Climate

The majority of precipitation occurs in the form of snow during the months of November to May. Summers are typically warm and dry with temperatures rarely exceeding 38° C. Freezing or near freezing temperatures are possible every month. Catherine Creek serves as a cold air drainage for high elevations, resulting in frequent morning frosts during the summer months.

The 17 year precipitation mean for the study area was 60 cm. Mean monthly precipitation and temperature data can be found in greater detail in chapter one.

Plant Communities

Plant communities were separated and described with ocular reconaissance, frequency, standing phytomass, and shrub density data. The techniques utilized and detailed descriptions of the riparian ecosystem can be found in chapters one and two. There were three dominant vegetation types along this particular section of Catherine Creek. These types include forested communities dominated by black cottonwood (Populus trichocarpa), ponderosa pine and/or other coniferous species; tall shrub dominated by Douglas hawthorne (Crataegus douglassi) and/or thin leaf alder (Alnus incana); and meadow type communities dominated by Kentucky bluegrass (Poa pratensis), sedges (Carex spp.), rushes (Juncus spp.) and/or many other grass and forb species.

Kentucky bluegrass - mixed forb communities were predominantly dominated by Kentucky bluegrass and may be in co-dominance either singly or jointly with redtop (Agrostis alba), timothy (Phleum pratense), Baltic rush (Juncus balticus) and cheatgrass (Bromus tectorum). Common forbs comprising an important component of the composition include stork's bill (Erodium cicutarium), western yarrow (Achillea millefollium), white clover

(Trifolium repens), chickweed (Cerastium viscosum), common dandelion (Taraxacum officinale), velvet lupine (Lupinus leucophyllus), tall butter cup (Ranunculus acris) and many others.

Species diversity (H') ranged from less than 1.0 in near monospecific stands of Kentucky bluegrass to almost 3.3 in communities with a high species richness in the graminoid and forb component. Standing phytomass was high in Kentucky bluegrass communities. Mean standing phytomass ranged from 2400-4200 kg/ha. Usually Kentucky bluegrass accounted for greater than 75 percent of the phytomass estimate and in some stands accounted for over 96 percent of the estimate.

These communities are preferred foraging sites by both domestic livestock and big game. Utilization was estimated to be 78 percent in 1979 and 68 percent in 1978 and 1980. Average stubble height of Kentucky bluegrass after the grazing season was 3-4 cm.

Douglas hawthorne communities generally contain two vegetation layers, a shrub layer and a field or herbaceous layer. The shrub layer was dominated solely by Douglas hawthorne, or in some stands in co-dominance with western chokecherry (Prunus virginiana) and thin leaf alder (Alnus incana). The field layer was dominated by Kentucky bluegrass sometimes with redtop, mountain brome (Bromus carinatus), Baltic rush and cheatgrass being important in the graminoid component. Common forbs include western yarrow, common dandelion, hook violet (Viola adunca), white clover, leafy bract aster (Aster foliaceus), American vetch (Vicia americana), black medic (Medicago lupulina) and tall buttercup.

Species richness of plant species was high in Douglas hawthorne communities as was plant species diversity (H' = 2.4 - 3.4). Standing phytomass of the field layer was estimated at 1500-2500 kg/ha. The vegetation stands with a high canopy cover of hawthornes were not as productive as those with a relatively open canopy. Kentucky bluegrass accounted for 61-87 percent of the phytomass estimate in the field layer.

Cattle utilized approximately 30-50 percent of the available forage in hawthorne communities. Stubble heights after the grazing season were less than 8.4 cm.

In communities sampled, mean shrub density of Douglas hawthornes was approximately 3.4 rooting stems per meter^2.

Black cottonwood - mixed conifer communities were the most structurally diverse of all commnities sampled in the riparian zone. Black cottonwood - mixed conifer stands sometimes had up to 5 vegetation layers in addition to a cryptogam layer. These layers include a conifer layer usually dominated by ponderosa pine; a black cottonwood dominated layer; a tall shrub - low tree layer dominated by either/and/or thin leaf alder, Douglas hawthorne and water birch (*Betula occidentalis*); a low shrub layer dominated by snowberry (*Symphoricarpos albus*) and Wood's rose (*Rosa woodsii*) and a field layer. The most common species found in the field layer included Kentucky bluegrass, blue wildrye (*Elymus glaucus*), sedges (*Carex* spp.), common dandelion, tall buttercup, golden ragwort (*Senecio pseudareus*), wild sweet anise (*Osmorhiza chilensis*) and miner's lettuce (*Montia perfoliata*). Species diversity of the field layer ranged from 2.7-3.1. Standing phytomass estimates of the field layer ranged from 940 kg/ha to 2670 kg/ha. Utilization by livestock was light with less than 23 percent of the forage removed by livestock in grazed areas.

Methods

Approximately one-half of the streambank and associated riparian vegetation within 50 meters of the streambank was excluded from livestock prior to the grazing period in 1978. This was accomplished by the construction of five livestock exclosures of various sizes alternating with grazed portions of the study area. Exclosures were built in such a manner as to minimize alterations in normal livestock movements.

Eighty-five to 104 spring calving cow-calf pairs grazed the study area beginning in late August (usually August 25) and were grazed three-four weeks depending on the amount of forage produced and the number of livestock grazing. Utilization under this system varied from 70 percent of the standing phytomass in meadow communities to less than ten percent in forested riparian communities.

Avian populations were sampled by a fixed circular plot technique (Anderson 1970). This method involved recording the species and numbers of individuals occurring within a predetermined sized plot for the community being sampled. Plot sizes were determined by the maximum horizontal distance possible for detection of avian species. For Douglas hawthorne and cottonwood - mixed conifer communities a radius of 20 meters was determined to be the maximum detectable distance for birds. In the meadow communities, a plot size with a 40 meter radius was selected. A few stations were not of this size and density estimates had to be adjusted for their particular size.

Four permanent censusing stations were established in four separate vegetation stands in each community type sampled in each treatment (grazed or excluded from grazing). Each station was sampled five times during the census period for a total of 20 observations per community type in each treatment. Each station was sampled for ten minutes. The areas were sampled each morning usually beginning one hour after sunrise.

Avian populations were censused late Spring (May, 1980), early Summer (June, 1979), late Summer (August, 1978, 1979) and early Autumn (September-October 1978, 1979). Length of census periods usually lasted 10-12 days with an average of 12 stations censused each morning.

From the census data, density (number of birds per hectare), bird species diversity (H'), species richness (S) and equitability (J') were calculated for each vegetation type in each treatment. Shannon's Information Measure (Shannon 1948) was used to calculate H'. Species richness is the total number of species sampled within a community, and equitability is a measure of apportionment of individuals among species. Species richness and equitability are components of the diversity measure (Lloyd and Ghelardi 1964).

Each species that was censused was assigned to one of 15 ecological foraging guilds. Guild assignments were based on observations of feeding habits. When the diet of a species was not known, data from Martin et al. (1951), Anderson(1970) and Noyes (1982) were used (Table 7).

A multivariate analysis of variance (MANOVA) (Morrison 1976) was used to test for seasonal, habitat and grazing treatment differences. Treatment effects

Table 7. Forage guild classification for birds utilizing the Catherine Creek.

Foraging Guild	Major Food Item	Foraging Mode	Foraging Substrate	Guild No.	Typical Species
Air-insect	Invertebrate (insect)	glean/sally	air	1	Trail's flycatcher
Foliage-insect	Invertebrate	glean	foliage	2	Black-capped chickadee
Ground-insect	Invertebrate	glean and/or probe	ground	6	House wren Spotted sandpiper
Aquatic-insect	Invertebrate	glean	water	9	Water ousel
Ground-seed	Plant	glean	ground/plant	7	American goldfinch
Ground-plant	Plant-insect	glean/graze	ground/plant	12	Ruffed grouse
Foliage-seed	Plant	glean	plant	3	Cassin's finch
Nectar-foraging	Nectar	glean	floral	13	Calliope hummingbird
Timber-searching	Invertebrate/ plant	glean	bark	4	Red-breasted nuthatch
Timber-drilling	Invertebrate	probe	bark	5	White-headed woodpecker
Aquatic-forage	Plant	dabble	water	11	Mallard
Aquatic-predator	Vertebrate	dive and/or wade	water	10	Belted kingfisher Great blue heron

Table 7. (Continued)

Foraging Guild	Major Food Item	Foraging Mode	Foraging Substrate	Guild No.	Typical Species
Ground-predator	Vertebrate-invertebrate	raptorial	ground	8	Red-tailed hawk
Air-predator	Vertebrate-invertebrate	raptorial	air	14	Sharp-shinned hawk
Scavenger-predator	Invertebrate vertebrate plant	ubiquitous	ground-foliage	15	Common raven

were tested by the ratio of change rather than absolute numbers. Avian population parameters used were density, S, J' and H'. Wilk's lambda (Λ) was the test statistic used to detect significant differences with the MANOVA (Neter and Wasserman 1974). If a significant lambda was obtained, a univariate F-test was used to determine which community parameter(s) were significant. The student-Newman-Keuls test (Steele and Torrie 1960) was used to test where differences occurred (e.g., which habitat, season or treatment differences were present).

A stepwise discriminate analysis was used to indicate which avian population parameters were most sensitive in indicating treatment effects and differences. Fiducial limits for all statistical analysis procedures were set at the $P \leq 0.05$ level unless specified otherwise.

Population estimates of small mammals were determined with a removal technique in which a specified number of traps are set over several trapping periods (Zippin 1958). Fifty unbaited Museum Special traps were set in a 50 x 25 meter plot in cottonwood communities, hawthorne communities and meadow communities in both grazed and ungrazed stands. Traps were reset daily for three days for a total of 150 trap nights in each vegetation stand for each grazing treatment.

Density (numbers per hectare), and relative abundance of species were population parameters synthesized from the trapping data. Relative abundance is expressed as the percent composition of a particular species captured, to the total captured population.

Small mammal populations were censused during late Summer (August 1979) and early Autumn (September 1978, 1979). In addition, meadow communities were sampled during early Summer (June 1979).

Differences in population densities between grazed and exclosed communities were tested using a modified t-test (Davis 1963). Fiducial limits were set at $P \leq .05$.

Results

Avian Communities

Significant differences were encountered for avian populations between habitats, years and seasons in the MANOVA. With respect to habitats, avian populations in black cottonwood - mixed conifer communities had significantly higher density, species diversity and species richness when compared to the other community types sampled (Table 8). The early summer census corresponding to the nesting brooding season (June 1979) was the season in which highest densities, species diversities and species richnesses were found. Testing of year effects indicated that 1979 avian populations were significantly different from 1978 populations for all parameters tested.

TABLE 8. Density, Diversity, Evenness, Species Richness and Total Individuals of avian species in selected Riparian Plant Communities (1978 - 1980).

Season and Community	Density Avg.	Diversity (H')	Equitability (J')	Species #	Total Individuals
1978 Late Summer					
meadow-grazed	0.6	0.0	1.0	1	2
exclosed	0.6	0.6931	1.0	2	2
hawthorne-grazed	9.4	2.042	.8868	10	19
exclosed	5.6	1.5493	.9626	5	17
cottonwood-grazed	11.9	1.796	.8174	9	21
exclosed	4.3	1.475	.9164	5	7
1978 Early Fall					
meadow-grazed	0.9	0.9235	.6400	2	3
exclosed	2.5	0.9650	.8783	3	9
hawthorne-grazed	7.4	1.5145	.7783	7	13
exclosed	6.8	1.2945	.8043	5	11
cottonwood-grazed	38.1	1.6904	.7341	10	95
exclosed	22.3	0.9872	.5073	7	42
1979 Early Summer					
meadow-grazed	28.6	2.0707	.6912	20	153
exclosed	14.0	2.1193	.7826	15	50
hawthorne-grazed	31.5	2.3924	.8277	18	79
exclosed	27.5	2.3283	.8398	16	68
cottonwood-grazed	47.6	2.267	.7334	21	84
exclosed	22.0	2.927	.9614	20	54
1979 Late Summer					
meadow-grazed	7.1	1.4493	.8089	6	29
exclosed	2.9	1.778	.9139	7	14
hawthorne-grazed	17.1	1.9181	.8330	10	43
exclosed	11.2	1.8843	.8576	9	29
cottonwood-grazed	23.1	1.8874	.7152	14	58
exclosed	21.0	1.6139	.7009	16	53
1979 Early Fall					
meadow-grazed	8.1	1.8744	.8140	10	37
exclosed	9.1	1.8805	.7842	11	41
hawthorne-grazed	13.6	2.0790	.8367	12	32
exclosed	4.0	2.0253	.9740	8	10
cottonwood-grazed	15.5	2.0755	.8352	12	40
exclosed	3.6	1.1506	.8300	4	9
1980 Spring					
meadow-grazed	15.7	1.5306	.6647	10	86
exclosed	11.2	1.7642	.6878	13	52
hawthorne-grazed	20.0	2.1462	.8367	13	48
exclosed	11.6	2.0411	.8864	10	27
cottonwood-grazed	25.5	2.4771	.9147	15	65
exclosed	10.8	1.3420	.7490	6	27

Mean densities and species richness of avian populations were highest in black cottonwood communities for all seasons and years sampled. The great structural diversity, high woody species diversity and high edge to area ratios of these communities provided more habitats for more avian species than in the other communities sampled. In addition, more species utilized black cottonwood communities as nesting habitat than in the other communities. Twenty-three species were observed as utilizing cottonwood - mixed conifer communities as nesting habitat. Nine of the 15 ecological foraging guilds identified on the study area were sited utilizing cottonwood communities during the census periods (Table 7). However, almost all avian species in the riparian zone were observed utilizing cottonwood communities at one time or another.

Low densities and richness of avian species were usually encountered in meadow communities relative to other communities sampled. The lack of structural diversity in these communities due to the absence of woody species provided habitat only for those species which utilized herbaceous vegetation. Of the nine ground nesting species observed, only three utilized meadow communities as nesting habitat. The birds in the study area utilized meadow communities primarily for predation (insect and small mammal), as a forage resource for seeds and other vegetative materials, and as a source of nesting materials.

Avian communities in Douglas hawthorne stands were generally intermediate to black cottonwood and meadow communities with respect to density, species diversity and species richness. The thorny multi-stemmed physiognomy of hawthornes provided good nesting and foraging cover for the many species which utilized these communities. Fourteen species utilized these communities as nesting habitat.

Though seasonal changes in avian populations were not the same for the three vegetation types sampled, there were similarities in the patterns of use for all communities in the riparian zone. In general, the highest avian utilization was encountered during Spring and early Summer corresponding to the nesting/brooding season. The lowest periods of avian use were late summer and early autumn. Seasonal changes in avian populations fluctuated the greatest in meadow communities and the least in black cottonwood communities.

In meadows, the only utilization of any consequence by avian species (with the exception of raptors) was during the nesting/brooding season when these areas were used extensively as an insect, seed and nesting material resource. At this season densities were as high as 29 birds/ha and species richness as high as 20. Conversely, after the nesting/brooding season, avian use in the meadows declined to utilization by only a few species, primarily raptors. Avian densities at these seasons (late summer and early autumn) was as low as 0.6 birds/ha, and species richness as low as 1-2.

Seasonal and annual differences in avian populations may be related to high annual variations in plant phenology and production of riparian vegetation as well as conditions of upland community types. For example in 1978 early leaf abscission of woody species and hence lower cover for avian species occurred, compared to a much later leaf fall in 1979. This may have accounted for the lower avian use during late Summer and early Autumn for Douglas hawthorne communities and associated meadow communities in 1978 compared to 1979. Other environmental factors relative to these seasons which may have accounted for the different species composition between years included a good hawthorne berry crop in 1979 and drier upland conditions during the same year. These drier upland conditions in 1979 may have concentrated avian use in the more mesic riparian zone. Data on avian populations by season and habitat are summarized in Appendix C.

No significant differences in the MANOVA were found when testing for differences in the ratio of change between grazed and exclosed communities for density, species richness, diversity and eveness.

A change in habitat physiognomy through the removal of forage did appear to cause some differential use both in species and foraging guilds between treatments. Generally, these differences were greatest immediately after the grazing season and negligible during late Summer when plant growth and cover were not measurably different between grazed and exclosed habitats.

In 1978, prior to the grazing season, insect foraging guilds comprised 43 and 52 percent of the avian populations in grazed and exclosed habitats, respectively. After grazing, insect foraging guilds comprised 79 percent of the avian population in grazed habitats and 33 percent of the avian population in exclosed habitats (significant at $P \leq .05$). Herbivorous/granivorous guilds comprised 11 percent of the avian population in grazed habitats and 61 percent of the avian populations in exclosed habitats (significant at $P \leq .05$). Similar trends were noted before and after the grazing season in 1979.

During the nesting/brooding seasons, more species utilized the riparian area in greater densities than at any other season. Trends in population increases and habitat use did not differ significantly between grazed and exclosed areas. Neither treatment appeared to have any impact on the avian communities at this season.

During the nesting/brooding season, few differences were noted in avian species composition or in population structures due to grazing treatment effects. During this season insect foraging guilds comprised 60-80 percent of the avian populations censused for both grazed and exclosed habitats. Herbivorous/granivorous foraging guilds made up only 10-20 percent of the populations for both treatments. In addition, foraging guilds were difficult to determine, particularly since many species usually considered to be herbivorous or granivorous were preying upon insects for their nestlings. Treatment differences between the composition of avian communities as they relate to foraging guilds were negligible during the nesting/brooding season.

Late season grazing did not appear to impact the nesting habit of avian species which utilize Douglas hawthorne shrubs. Heights of 100 nests in grazed and exclosed hawthorne communities were not significantly different. Average heights were 103 and 90 cm for grazed and exclosed areas, respectively. The majority of these nests were of the American robin (Turdus migratorus), the cedar waxwing (Bombycilla cedrorum) and the yellow warbler (Dendroica petechia).

With the exception of the early Autumn census which correspond to the season immediately after grazing, there appeared to be few short term impacts on avian use of the riparian zone by a late season grazing scheme. The removal of forage decreased forage availability for those species dependent on herbaceous vegetation and increased availability of insects for those species of insect preying guilds. Short term impacts on nesting cover and habitat use by nesting species were negligible in shrub and meadow communities which were utilized most extensively by livestock as a forage resource. Livestock grazing appeared to have no effects on tree nesting species in black cottonwood - mixed conifer habitats.

Small Mammal Communities

Significant differences in small mammal populations were noted among different habitats, and vegetation stands within the same communities. Differences among habitats included species composition, relative abundance of species trapped and density of mammals.

The highest densities of small mammals were found in Douglas hawthorne/Kentucky bluegrass communities and in meadow communities. Density estimates of small mammals were as high as 800/ha with a mean density of 459/ha in undisturbed productive stands of open Douglas hawthorne communities.

The highest density estimate for meadow communities was 568 mammals/ha with a mean density estimate of 440 mammals/ha in undisturbed communities (either exclosures or grazed areas before forage removal). Species compositions of mammals in hawthorne and meadow communities were similar, with the mountain vole being the most common species trapped and the deer mouse (*Peromyscus maniculatus*) and vagrant shrew (*Sorex vagrans*) appearing in lower numbers. Meadow communities also provided preferred habitat for Columbian ground squirrels (*Citellus columbianus*) and the Northern pocket gopher (*Thomomys talpoides*). These communities were the only habitats in which pocket gophers were trapped.

Lower estimated densities and different species compositions were found in black cottonwood communities compared to either hawthorne or meadow communities. Estimated densities in cottonwood communities were as high as 254 mammals/ha with a mean density estimate of 180 mammals/ha for undisturbed communities. Mammal communities differed from either hawthorne or meadow communities in that the mountain vole was not always the dominant species found in undisturbed stands. Rather, relative abundance of both the mountain vole and the deer mouse was about equal when all cottonwood censuses were combined.

Seasonal changes in small mammal populations appeared to be great but not enough seasons were censused and other trapping methods would have been necessary to estimate these seasonal changes. For example, densities of Columbian ground squirrels and northern pocket gophers appeared to be high early in the growing season but were inactive by the onset of the grazing period in late August. Their early season impacts on plant communities due to forage removal and soil disturbance appeared to play a role in plant community composition and information on the structure of small mammal populations at these seasons would be valuable.

Detailed population estimates for all small mammal censuses are summarized in Table 9 and Appendix F.

The areas grazed by livestock had significantly lower small mammal densities after the grazing season. This decrease appeared to be a short term decrease as population levels the following year were estimated to be as high as they were prior to grazing (Table 9).

After the 1978 grazing period, trap success for small mammals was 0 percent in grazed meadow communities and 24 percent in exclosed meadow communities. Unfortunately, vandalism destroyed the census in the exclosures after the second trap night, so no population estimates could be made. Small mammal populations in exclosed black cottonwood and Douglas hawthorne communities were significantly greater than the grazed communities after the 1978 grazing season. Post grazing season population estimates for black cottonwood communities were 48 and 217 mammals/ha for grazed and exclosed areas, respectively.

Table 9. Population estimates for small mammal communities, 1978 - 1979.

Community and Season	Estimated Density (nos./ha) Grazed	Estimated Density (nos./ha) Exclosure	Species Richness Grazed	Species Richness Exclosure
Early Summer 1979				
Kentucky bluegrass-mixed forbs	480	568	3	2
Late Summer 1979 (Before grazing)				
Kentucky bluegrass-mixed forbs	450	235	4	3
Douglas hawthorne/Kentucky bluegrass	800	690	3	3
black cottonwood-mixed conifer	129	118	4	3
Early Autumn 1978 (After grazing)				
Kentucky bluegrass-mixed forbs	*	0	0	2
Douglas hawthorne/Kentucky bluegrass	30	208	1	3
black cottonwood-mixed conifer	48	217	1	3
Early Autumn 1979 (After grazing)				
Kentucky bluegrass-mixed forbs	60+	463*	2	2
Douglas hawthorne/Kentucky bluegrass	83+	136*	1	3
black cottonwood-mixed conifer	42+	254*	3	4

% Density estimates not possible due to vandalism of traps during the third trap night.

* Denotes significant differences in population estimates between treatments ($P \geq .05$).

\+ Denotes significant differences in the same vegetation types when comparing before and after the 1979 grazing season in grazed areas only. NSD between populations in exclosed communities.

In Douglas hawthorne communities, population estimates were 30 and 208 mammals/ha for grazed and exclosed areas, respectively.

By early summer the following year, population densities in grazed and exclosed meadows were not significantly different from one another. However, species compositions were not similar between treatments with a relative abundance index of 52 and 70 percent for the mountain vole in grazed and exclosed areas, and a relative abundance of 29 and 8 percent for the deer mouse in grazed and exclosed areas, respectively. These data were not statistically tested.

During the late summer census (1979 prior to the grazing period) there were no significant differences in density estimates between grazing treatments for all communities sampled.

After the grazing season (early Autumn 1979) populations in grazed areas were significantly different from the pregrazing season population levels in grazed areas and significantly different from exclosed areas after grazing. When comparing grazed areas before and after the grazing season, population densities decreased from 800 to 83 mammals/ha in hawthorne communities; from 450 to 60 mammals/ha in meadow communities and from 129 to 42 mammals/ha in cottonwood communities. Population densities in exclosed areas changed from 690 to 136 mammals/ha in hawthorne communities; from 235 to 463 mammals/ha in meadow communities; and from 118 to 254 mammals/ha in cottonwood communities.

The significant decrease in total small mammal populations in grazed areas may be due to a loss of cover resulting in increased predation on small mammals and/or immigration out of the grazed habitats into neighboring exclosed habitats. Though total small mammal populations declined in grazed communities, density estimates and relative abundances of the deer mouse increased after the grazing season in all grazed communities. After the grazing season the deer mouse was the dominant or co-dominant species in grazed areas where it was found in only minor proportions in both pre-grazing season censuses and in the exclosed post-grazing season census. The mountain vole which comprised more than 80 percent of the total mammal population, and the vagrant shrew were either drastically reduced in numbers or disappeared from the habitats altogether due to grazing.

Utilizing density estimates and relative abundance indices it is apparent that livestock grazing caused a significant short term decrease in mammal densities and alterations of community compositions.

Discussion

Factors observed causing variations in avian populations included vegetation structure and species composition of the particular plant community censused, species composition and vegetation structure of adjacent habitats and the proximity of censused communities to Catherine Creek and upland sites. These factors as well as seasonal and annual differences in environmental conditions altered bird compositions much more than treatment effects.

In black cottonwood - mixed conifer communities, avian species were found in greater numbers and higher densities in those vegetation stands with a good mix of conifers, mature cottonwoods, snags and a high structural diversity of the understory woody and herbaceous layers. Unfortunately, habitats sampled in grazed areas generally appeared to be inherently richer in all criteria listed above. In addition, high spring runoff in 1979 destroyed about half of one sampling station in an exclosure and a lightning strike destroyed a very large snag in another sampling station in an exclosure. Avian use noticeably declined after these two natural phenomena occurred. Inherent differences in plant communities between grazed and exclosed areas were the reasons ratios of change were tested among treatments rather than absolute numbers.

Avian populations in Douglas hawthorne communities varied according to community structure. Stands of dense, mature hawthornes supported a greater density of warblers, Vireos (Vireo spp.) and other avian species that were largely restricted to shrub habitats. Open stands of Douglas hawthorne were favored by the American robin, Brewer's blackbird (Euphagus cyanocephalus) and species more attuned to open or meadow habitats.

Avian use of meadow communities appeared to be enhanced by the presence of a few solitary shrubs in the communities which were utilized as hiding cover, or as a perch in which to hunt for or consume insects. In addition bare areas for dusting and low depressions containing both standing water and emergent vegetation also appeared to enhance avian utilization. In general, it appeared the greater the structural diversity of a particular vegetation stand, the greater the avian utilization of that stand regardless of season, year, treatment or habitat.

Habitats adjacent to areas censused also appeared to affect avian utilization. Vegetation stands with ecotones of a wide variety of community types and vegetation structure generally had higher avian use than stands which bordered only one or two community types. Douglas hawthorne and meadow communities bordering forested type communities usually received much higher avian use than stands which bordered only one or two community types. Douglas hawthorne and meadow communities bordering forested type communities usually received much higher avian use than those not bordering forested communities. This was particularly true during the nesting season when birds utilizing cottonwood habitats for nesting and brooding would use the adjacent open habitats as an insect source. In addition, cottonwood communities bordering meadow communities received increased use from meadow species of birds which utilized cottonwoods as resting, roosting or feeding cover. Similar observations were made in cottonwood communities bordering the creek where increased utilization by aquatic feeding guilds were noted.

Exclosures on the study area were all less than two hectares in area and usually not greater than 50 meters in width. Because of the mobility of avian species, it was improbable that censuses measured avain population utilizing only grazed or exclosed habitats. Rather it was observed that birds freely utilized both sides of the exclosure fences. Unfortunately the exclosures were too small to census only grazed or exclosed habitats.

As community composition and structural changes occur in some communities, within exclosures, diversity of the riparian area may be enhanced and increased avian populations may follow.

Similar difficulties were noted with censusing small mammal populations. Before grazing, variation among stands within treatments appeared to be as great or even greater than between treatments. It must be noted that this will probably change as plant species compositions change in the exclosed communities. However, in 1978 and 1979 plant species compositions had not changed any great amount to cause any significant changes in mammal populations. Within treatment variations appeared to be attributed to amount of herbaceous vegetation produced and the presence of habitat features such as downed logs, stumps, rocks, etc. There appeared to be a direct correlation among amount of herbaceous vegetation produced and number of small mammals present. This was particularly true for the mountain vole.

Another factor which may have altered small mammal population estimates, was the possible egress out of grazed areas during grazing and the subsequent ingress back into these areas after sufficient cover from vegetation regrowth occurred. This may be masking effects of livestock grazing that could result in long term density reductions, in that the exclosures will always provide refuge areas for reinvasion by small mammals which would not be possible without these exclosures.

Potential Impacts of Livestock Grazing on Riparian Wildlife Communities

Small mammals may have a significant influence on plant communities and succession and represent important prey species for avian and mammalian predators (Ahlgren 1966, Krefling and Ahlgren 1974). A sudden drop in their populations could stress predatory species forcing them to seek alternative food sources (Goodwin and Hungerford 1979). Therefore, any treatment which alters small mammal populations may also affect other plant and animal populations. Influences on ecosystems by avian populations has generally been characterized as minor, though largely unknown (Wiens 1973). These influences included herbivorous insect control or regulation, seed consumption and dispersal (Peterson 1980), nutrient cycling or transfer (Wiens and Dyer 1975) and as a prey species for predators. Grazing effects on wildlife communities are not uniform or easily defined (Wiens and Dyer 1975). Grazing alters the composition and density of forage and subsequently alters bird and rodent populations (Howard 1960, Townsend and Smith 1977).

Grazing significantly reduced small mammal densities and altered population structures in all habitats sampled. This is similar to results in upland communities by Frank (1957) and Reynolds and Trost (1980) and Reid (in press).

Significantly lower mountain vole numbers and increased deer mouse numbers were noted after grazing. In addition, vagrant shrews were absent while the relative abundance of the yellow pine chipmunk were increased in grazed areas. Well into June the following year (nine months after grazing), relative abundances of the mountain vole and vagrant shrew were lower and the deer mouse, higher, than in the ungrazed exclosures. This coincided with the findings of Baker and Frischknect (1973), Frischknect and Baker (1972), Phillips (1936), and Quast (1948). These studies showed that a good herbaceous cover is conducive to a buildup of high populations of voles (Microtus spp.) inasmuch as they form their runways through the litter on top of the ground. Removal of this vegetation by grazing decreases vole numbers. Conversely, deer mouse populations have been found to increase due to forage removal and the subsequent loss of cover (Goodwin and Hungerford 1979, Baker and Frischknect 1973, Phillips 1936, Quast 1946).

In 1979, prior to grazing, mammal populations in grazed and exclosed areas were similar in species composition. As the plant species composition in exclosed communities change as was particularly observed in moist meadows, it would appear that small mammal populations will also change.

The dense litter layer forming in exclosed areas appeared to be better habitat for the mountain vole and the vagrant shrew, but not for the deer mouse or yellow pine chipmunk.

Removal of forage apparently was not the only livestock induced factor causing a decrease in small mammal numbers. In cottonwood - mixed conifer habitats, herbaceous utilization was estimated at 22 percent in 1978 and 9.5 percent in 1979. Even with barely discernible utilization by livestock, particularly in 1979, small mammal populations were significantly lowered. It is unknown if this decrease is a behavioral response of small mammals to livestock, or if livestock use of this community as bedding and resting grounds lowered the habitat values for small mammals. Probably the latter is a more feasible explanation. Reid (in press) found that the degree of grazing did not make any measurable differences in small mammal populations in ponderosa pine - bunchgrass ranges. Rather the height of herbaceous ground cover was the controlling factor. Therefore, it is possible that trampling and lodging the vegetation by the resting activities of livestock could have also caused decreased small mammal populations.

There were few apparent short term effects of late season livestock grazing on the avian populations of the riparian zones. Avian species apparently had no preference for grazing treatments as nesting/brooding habitat. However, if succession and/or regeneration of woody species was retarded by livestock grazing, then habitats for avian species which utilize woody vegetation could eventually be lost. Succession on willow dominated communities, an early seral stage in the sere leading to cottonwood dominated communities, was apparently retarded by livestock grazing. Research directed on the specific long term effects of livestock on woody plant succession could perhaps assist managers in protecting these habitats. There was little evidence of natural cottonwood regeneration in the understory of cottonwood - mixed conifer communities nor was there evidence of thin leaf alder regeneration in the understory of alder dominated communities. Carothers (1977) suggested grazing pressures prevented the establishment of seedlings which created even aged, nonreproducing vegetation communities. As the trees died of natural causes, there were no young trees to take their place.

If late season grazing inhibits succession to cottonwood communities in all areas of the riparian zone that were accessible to cattle, then the long term effects on avian populations would be detrimental. Young cottonwoods and alders were observed growing on islands in the creek and in a few other areas which, because of localized physiography were inaccessible to livestock grazing. However, these areas were accessible to a recent beaver (*Castor canadensis*) invasion. Beavers were removing young to medium aged cottonwoods at a rapid rate. In order to manage for mature cottonwood communities and hence a quality, long term habitat for birds that depend on this type, limits on livestock and beaver numbers and distribution may have to be implemented on this particular riparian ecosystem.

Positive Characteristics of a Late Season Grazing Scheme

There are several advantages of this grazing scheme to avian populations which utilize riparian habitats. There is no disruption by livestock during the critical periods of nesting, and the fledgling and dispersal of offspring. Rather, livestock utilization of riparian forage occurs at the period of the growing season in which avian use is lowest. Forage regrowth apparently was sufficient for adequate nesting cover the following season in meadow and shrub habitats.

Impacts of livestock grazing on vegetation composition and subsequently the forage composition available for wildlife species should be considered. Continuous grazing systems which utilize virtually all forage available is likely to provide insufficient food and cover for seed eating birds (Buttery and Shields 1975). In addition, an early season grazing system which inhibits flowering, while increasing tillering production (Volland

1978), could decrease availability of seeds for granivorous species. Late season grazing allowed for seed ripening, making seed available for those many avian and mammalian species which depended on seeds as a forage resource.

Though it appeared that late season grazing inhibited succession leading to cottonwood communities and hence the long term structural diversity of avian habitats; under moderate stocking rates, these communities may develop in those areas inaccessible or not preferred by livestock. However, beaver control may be necessary to limit perturbations to the existing young and middle aged cottonwoods. Finally, when the riparian zone is fence from uplands, livestock utilization could be intensively regulated in the riparian zone to attain utilization to that point where the optimum amount of herbaceous forage is utilized without damage to the shrub constituent of the ecosystem.

It is unknown what the reactions of many small mammal species are to a late season grazing scheme in comparison to other grazing schemes. One apparent advantage is that forage cover is left intact until the end of the growing season. Removal of forage late in the growing season allowed for adequate cover for small mammal populations to increase after the winter stress period. This is an important consideration when evaluating the value of small mammals as a prey source for the numerous avian and mammalian predators present in the riparian system.

Conclusion

The riparian zone along Catherine Creek was an extremely diverse and complex ecosystem. This riparian area provided habitat for 81 avian species, at least 34 of which utilized the area as nesting/brooding habitat. Five species of small mammals with densities of up to 800/ha were present during the seasonal peak of population densities (late August).

Avian densities, species richness and species diversities were generally highest in black cottonwood - mixed conifer communities. Densities of up to 47 individuals/ha were not uncommon during this season. Species richness of 22 and species diversity indices of 2.93 corresponded to these high densities during the nesting/brooding season (May-June). The lowest avian use in cottonwood - mixed conifer communities as in all communities was measured during late summer. The only utilization of meadow habitats by avian populations, except raptors, of any consequence was during the nesting/brooding season when these areas were used extensively as a resource for nesting materials and insects for the broods.

A late season grazing scheme appeared to have few short term impacts on avian communities which utilized the area. No significant differences were encountered in avian populations in grazed and ungrazed plant communities over all seasons. During the first three years of the study there appeared to be no preference between grazing treatments as nesting habitat. Trends in foraging guild utilization indicated that grazed riparian communities favor insect foraging guilds while the ungrazed habitats favored avian populations of herbivorous/granivorous foraging guilds.

Peak densities of small mammal populations were noted during late summer and early Autumn. Late season grazing and the removal of forage caused significant decreases in small mammal populations for all communities censused. This decrease in small mammal densities was probably related to a loss of cover due to forage removal resulting in increased predation and immigration out of grazed habitats.

Late season grazing schemes under moderate intensities appeared to be of no detriment to avian populations in that there was no disturbance and there was adequate cover available during the nesting/brooding season. This grazing scheme also facilitated seed production for granivorous species. Small mammal populations though impacted immediately after the grazing season appeared to recolonize the grazed areas in composition and densities no different than exclosed habitats by late summer the following year.

When riparian ecosystems are separated from upland pastures, management can be flexible enough to optimize forage utilization for red meat production while at the same time preserving the integrity of the critical wildlife habitat features of the riparian zone.

CHAPTER IV

Livestock Impacts on Streambank Physiognomy and Erosion

LIVESTOCK IMPACTS ON STREAMBANK PHYSIOGNOMY AND EROSION

Abstract

Impacts of a late season livestock grazing scheme on streambank erosion, physiognomy and undercutting were studied along Catherine Creek. Amount of bank loss, bank disturbance and undercut depths were compared between grazing treatments, vegetation cover, and streambank location. Significant differences were found only when comparing grazed and ungrazed portions of the streambank. Significantly greater streambank erosion and disturbance occurred in grazed areas than in exclosed areas during the 1978 and 1979 grazing periods. While overwinter losses accounted for much of the streambank erosion, the erosion and disturbance caused by livestock grazing and trampling was enough to create significantly greater annual streambank losses in grazed areas over ungrazed areas.

Introduction

Vegetation along streams is an important component of the riparian/stream ecosystem (Campbell and Franklin 1979, Jahn 1978). It provides the detritial substrate on which much of the instream system is based (Campbell and Franklin 1979); it acts as a roughness element that reduces the velocity and erosive energy of overbank flow (Li and Shen 1973); and it stabilizes streambanks providing cover in the form of overhanging banks (Marcuson 1977, Meeham et al. 1977).

Livestock grazing can affect all four components of the aquatic system - streamside vegetation, stream channel morphology, shape and quality of the water column and the structure of the soil portion of the streambank (Behnke and Raleigh 1978, Claire and Storch in press, Marcusson 1977, Platts 1979). Improper livestock use of riparian ecosystems can affect the streamside environment by changing, reducing or eliminating vegetation bordering the stream (Ames 1977, Behnke and Raleigh 1978, Claire and Storch in press, Platts 1979).

The effects of livestock grazing have been shown to vary greatly depending upon several factors, in particular the nature of the stream studied. Behnke and Zarn (1976), Dahlem (1978), Duff (1979), Gunderson (1969) and

Heede (1977) found livestock grazing and excessive trampling caused a decrease in bank undercuts, increases in channel widths, and a general degradation of fish habitat. Buckhouse et al. (1981), Hayes (1978) and Knight (1978) found that stream channel movement did not occur more frequently in grazed riparian ecosystems compared to ungrazed riparian ecosystems.

Because of the values riparian ecosystems and associated stream environments have for resident and anadromous fish populations, terrestrial wildlife, water quality and quantity, recreation, aesthetics and livestock production it is important that they be managed in such a way as to provide suitable habitat values and/or requirements for all these important uses.

One method of riparian management is to separate the riparian ecosystem from upland communities and manage them as special use pastures. In 1978 a study was initiated to examine some of the synecological effects of a late season grazing scheme in riparian ecosystems that are separated from upland communities. One of the objectives of this study was to compare streambank physiognomy, erosion and undercutting between areas of streambank that were grazed under a late season grazing scheme and areas of streambank that were totally excluded from livestock grazing.

Study Area

Location

The study area is located on the Hall Ranch, a unit of the Eastern Oregon Agriculture Research Center. The Hall Ranch is located in the southwestern foothills of the Wallowa Mountains, 19 km southeast of Union, Oregon. The specific location of the study area is Township 5, South, Range 41, East of the Willamette Meridian.

The study area is roughly a three kilometer section of Catherine Creek. Approximately one half of the area has been excluded from grazing by the construction of five exclosures alternating with grazed portions of the creek. Plant communities along the creek are described in detail in Chapters one and two. Uplands are dominated by mixed conifer and ponderosa pine (*Pinus ponderosa*) habitat type.

Catherine Creek

Catherine Creek is a third order tributary of the Grande Rhonde River which ultimately flows in the Snake River. The major tributaries of Catherine Creek above the study area are the North, Middle and South fork of Catherine Creek.

Streamflow data was acquired from a gaging station

(station number 13320000) located ten kilometers downstream from the study area. At this station, Catherine Creek has an average discharge of 119 ft^3/s (3.370 m^3/s) (USGS 1981). Peak annual flows usually occur in late April, May and early June. During the spring runoff period, discharges of over 500 ft^3/s are not uncommon. Comparisons between annual discharges for water years (1978-80) and a 17 year mean (1964-80) are summarized in Figure 3 in Chapter 1.

Soils

Soils of the study area are mapped as a veazie soil (Anderson pers. comm.). The veazie series consists of deep, well-drained soils, that formed in alluvium from mixed sources (Strickler 1966). This is not an accurate description of any of the soils on the study area except those found in dry meadows (*Poa pratensis* - mixed forbs). Soils on the area vary from well developed, well drained loamy soils greater than 100 cm in thickness to unconsolidated sands, gravels and cobbles.

General descriptions of soils of the most prevalent communities in the study area can be found in Chapter one. In addition, further information concerning the geology, climate, plant communities and wildlife can be found in Chapters one, two, and three of this thesis.

Methods

Prior to the grazing period in 1978, a total of 125 one-quarter inch steel stakes were established along the bank with 67 stakes established in exclosures and 58 stakes established in grazed areas. Stakes were established in a systematically random manner along the entire three kilometers of the strebank within the study area.

After the bank measurement stakes were established, general site characteristics were described. These characteristics included general descriptions of the soils, plant community and location relative to creek flow for each sampling stake. Stakes were placed in three broad vegetational types. These vegetation types were separated into banks that were either covered with a herbaceous cover, a shrub cover, or a tree cover. Stream locations are relative to "cut" and "fill" areas of the creek. Stakes were established on the top-outside, middle-outside, bottom-outside and straight portions of the streambank as well as in fill areas (Figure 4).

The distance from the sampling stake to streambank edge, bank height and undercut depths were then measured at each sampling stake. An azimuth reading of the exact direction of the line from the stake to the bank was recorded to insure the same points were measured each

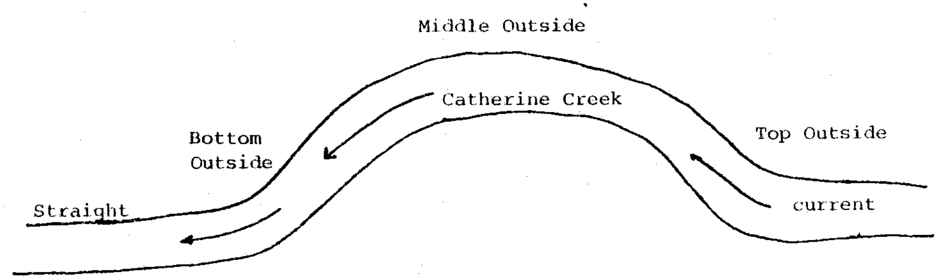

Figure 4. Streambank designations relative to the channel locations on Catherine Creek.

sampling period.

Measurements were taken prior to grazing at the onset of the study in 1978, after the 1978 grazing period, prior to the 1979 grazing period and immediately after the 1979 grazing period.

Streambank erosion or loss was tested using a 2 x 3 x 4 factorial design (Steal and Torrie 1960). Factors included grazing treatment (grazed or exclosed from grazing), vegetation cover (herbaceous, shrub, or tree) and channel location (straight, top-outside, middle-outside, and bottom-outside).

Changes in undercut depths were tested between treatments using a student's t-test (Steel and Torrie 1960). A disturbance index which measured any change in the distance from a sampling stake to streambank edge was also tested using a student's t-test. This disturbance index was formulated to monitor any disturbance or alteration to the streambank whether it was a loss or increase in distance from bank edge to sampling stake. This index not only accounted for disturbance due to bank sloughoff, but also accounted for an actual increase in the stake to bank distance caused by animal trampling or natural factors which by breaking down the bank, could change the bank physiognomy and cause an increase in the stake to bank distance.

Comparisons of the percent of sampling points that were disturbed between grazed and ungrazed portions of the streambank were accomplised using a chi-square test of binomial distribution (Steel and Torrie 1960). A chi-square test was also used to compare differences among grazing treatments of the percent of sampling points with undercuts greater than 7.6 cm (three inches).

Only 76 sampling stations were used in the analysis. Fifteen stations sampled on gravel bars (fill areas) were omitted from the analysis as these areas had no sharp measurable streambank edge. Approximately 10 stakes disappeared. They may have been washed out by channel changes. However, this was difficult to determine or distinguish from the major cause of lost data, vandalism.

Prior to the establishment of exclosures in 1978, there were 3303 meters of accessible streambank available to livestock. Accessible streambank is defined as those areas where livestock movements are not impaired by steep cliffs, fences or dense woody vegetation. Animal use before the construction of exclosures was approximately 0.54-0.64 animal unit days (AUD) per meter of streambank. After exclosures were built, an estimated 1730 meters of streambank were available to cattle which equated to an intensity of 1.03-1.21 AUD/M of streambank. The stocking rate during the study was approximately 0.4-0.5 AUM/ha (1.1-1.2 AUM/ac).

Results

Significant differences were found when comparing average streambank loss between grazed and ungrazed portions of the creek (Table 10). Grazed areas had significantly greater streambank losses compared to exclosed areas. No significant differences were found in the amount of annual streambank loss between vegetation cover and streambank locations of the "cut" areas along the outside bends and straight sections of the creek. Grazed portions of the streambank had significantly greater disturbance indices and significantly fewer undercuts less than 7.6 cm (3 inches) after two grazing seasons and one overwintering period.

During the 1978 grazing period 32 sampling points in grazed areas had a mean bank loss of 14 cm, and 44 sampling points in exclosures had a mean bank loss of 2 cm. During this same season 39 percent of the sampling points were disturbed in grazed areas and 13 percent of the sampling points were disturbed or altered in exclosed areas.

There was no significant difference in bank erosion or streambank loss during the nongrazing periods (late September - early August). This would also include losses due to high Winter and Spring runoff events. At this period a mean of 15 cm of streambank sloughouff

TABLE 10. Streambank alterations along Catherine Creek 1978 - 1979.

	Grazing Season 1978	Winter 1978-1979	Grazing Season 1979	Combined Grazing Seasons 1978+1979	Total Annual Change Aug. 1978-Aug. 1979
			Streambank Loss (cm.)		
Exclosure	2	9	4	6	9
Grazed	14	15	13	27	30
t-stat	2.511**	0.86	2.91***	4.02***	2.60**
		Disturbance Index (Mean cm. change from pre-treatment readings)			
Exclosure	3	14	5	7	14.0
Grazed	15	25	15	30.0	40.4
t-stat	2.58**	1.73*	3.42***	3.74***	3.68***

* significant at P ≥ .10
** significant at P ≥ .05
*** significant at P ≥ .001

TABLE 11. Percentage of sampling points that were disturbed[+], 1978 - 1979.

	Grazing Season 1978	Winter 1978-1979	Grazing Season 1979	Total change during study
Grazed	39.1	70.0	64.5	80.6
Exclosed	13.2	60.5	44.4	50.0
x^2	8.767***	0.070	2.966*	24.060***

+ disturbed meaning the stake to bank distance changed greater than 2.5 cm.
* significant at P ≥ .10
** significant at P ≥ .05
*** significant at P ≥ .001

occurred in grazed areas and a mean of 9 cm of streambank sloughoff occurred in exclosed areas. Seventy percent of the sampling stations were disturbed along the grazed streambank and 60 percent of the sampling stations were disturbed in exclosures during the overwintering period.

Similar trends were observed during the 1979 grazing period as occurred during the 1978 grazing period. Significantly greater streambank erosion occurred in grazed areas compared to ungrazed areas. A mean of 3.6 cm of streambank was lost in exclosures and a mean of 13.00 cm was lost in grazed areas. Sixty-five percent of the sampling stations in grazed areas were disturbed (e.g., had a change in the bank to stake measurement) during the 1979 grazing period and 44 percent of the sampling stations in exclosed areas were disturbed during the 1979 grazing period. Significantly greater numbers of sampling sations were disturbed in grazed areas during both grazing seasons and during the first two years of the study (two grazing periods and one overwintering period) compared to ungrazed areas.

Prior to the 1978 grazing period (August 1978), average undercut depths in grazed and exclosed portions of the streambank were 23 cm and 16 cm, respectively ($.1<p<.05$). At this time approximately 72 percent of the undercuts were greater than 7.6 cm (3 inches) in both grazed and exclosed areas. Immediately after the grazing season (1978) there was no significant difference in undercut depths with a mean depth of 19 cm and 15 cm in grazed and exclosed areas, respectively. This was probably due to livestock impacts on bank undercuts in grazed areas as undercut depths and amount of streambank loss were not correlated ($r^2 = .03$) in ungrazed areas.

Similar trends were noted during the 1979 grazing season. After the grazing season there was no significant difference in mean undercut depths with depths of 13 cm and 14 cm in grazed and exclosed areas, respectively. However, at this period, after two years of no grazing in exclosures, 81 percent of the sampling points in exclosed areas had undercut depths greater than 7.6 cm and 48 percent of the sampling points in grazed areas had undercut depths of greater than 7.6 cm (significant at $p < .001$). In addition, mean undercut depths significantly decreased ($p < .05$) in grazed areas after 2 grazing seasons from 23 cm (August 1978) to 13.0 cm (September 1979). Undercut depth in the exclosed portions of the streambank was not significantly different.

After the construction of exclosures the stocking rate increased from 0.6-0.8 AUM/ha to 0.4-0.5 AUM/ha. Animal presence on the streambank increased from 0.5-0.6 AUD/m of streambank to 1.0-1.2 AUD/m of streambank. This increased intensity of livestock use on riparian

TABLE 12. Percentage of sampling points with undercuts greater than 7.6 cm. and mean depth of undercuts in grazed and exclosed areas.

	Percent undercuts ≥ 7.6 cm.	Mean depth undercuts (cm.)
August 1978 (Pretreatment)		
Grazed	71.0	23
Exclosed	73.3	16
x^2 / t-stat	0.01267	1.93*
September 1978 (After grazing)		
Grazed	62.2	19
Exclosed	71.7	15
x^2 / t-stat	0.9937	1.04
August 1979 (After 1 year of non use)		
Grazed	62.5	19
Exclosed	63.0	14
x^2 / t-stat	0.0940	1.02
September 1979 (After 2 years of non use)		
Grazed	48.4	13
Exclosed	81.0	14
x^2 / t-stat	9.0390***	0.179

* significant at P ≥ .10
** significant at P ≥ .05
*** significant at P ≥ .001

streambanks may be the cause of the significant decrease in both the number and depth of undercuts in grazed areas.

No significant differences were found comparing bank loss between herbaceous, shrub or tree covered banks. Herbaceous covered banks dominated by Kentucky bluegrass (Poa pratensis), sedges (Carex spp.), rushes (Juncus spp.), and forbs had mean annual losses of 14 cm that ranged from 0-107 cm. Shrub covered banks dominated by hawthorne (Crataegus douglasii), snowberry (Symphoricarpos albus) and/or Wood's rose (Rosa woodsii) had mean annual bank losses of 28 cm that ranged from 0-188 cm. And, tree covered banks dominated by black cottonwood (Populus trichocarpa) and/or thin leaf alder (Alnus incana) had mean annual bank losses of 26 cm that ranged from 0-69 cm.

There were also no significant differences in bank loss when comparing sampling points according to their location in "cut" areas. Sampling points on the top-outside of a bend in the creek had mean annual losses of 18 cm. Middle-outside locations had mean annual losses of 23 cm, bottom-outside locations had mean annual losses of 5 cm, and straight sections of the creek had mean annual losses of 14 cm.

Discussion

Late season grazing (late August to mid-September) under moderate intensities significantly accelerated streambank erosion compared to no grazing. In grazed areas along the creek, intensity of livestock utilization varied greatly among sampling points primarily due to factors such as community type, location of trails or fences, and the presence of established creek crossings, or, conversely, steep banks which limited livestock movements across the creek at a particular location.

The accelerated erosion and increased bank disturbance created by livestock grazing is similar to findings of Behnke and Zarn (1976), Dahlem (1978), Duff (in press), Gunderson (1969) and Marcuson (1977). Marcuson (1977) found mean channel widths to be 53 meters, with 224 meters/ha of undercut banks/ha in a heavily grazed portion of Rock Creek in Montana, compared to a channel width of 18.6 meters with 685 meters/ha of undercut banks in ungrazed areas.

The accelerated streambank loss along Catherine Creek is unlike the findings of Buckhouse et al. (1981) and Hayes (1978). Buckhouse et al. (1981) found that while moderately grazed portions of Meadow creek in Oregon showed higher mean annual erosion losses than ungrazed areas, the differences were not significant. Most bank cutting losses were attributed to overwintering periods when high water, ice floes and channel physiognomy were critical.

Overwinter events such as high water and ice floes also caused the greatest amount of streambank disturbances and erosional losses along Catherine Creek. However, livestock grazing was the factor that apparently caused the significantly greater bank sloughoff in grazed areas over ungrazed areas. Though there was no significant difference in streambank loss between grazed and ungrazed areas during the overwintering period, significantly greater streambank disturbance occurred in grazed areas compared to ungrazed areas at this time. Possibly, livestock grazing weakened the streambank structure through trampling and forage removal to the point where ice floes and high water had a more damaging effect on grazed portions of the streambank.

In general, the degree of forage utilization along streambanks varied greatly among the vegetation types sampled. Herbaceous dominated streambanks were usually the most heavily utilized by livestock followed by shrub/herbaceous covered banks and tree/shrub/herbaceous covered streambanks. Streambanks dominated by grasses and/or grasslikes had utilization estimates varying from 35 to 85 percent in grazed areas. The shrub and tree dominated banks had lower utilization estimates ranging from 10 to 60 percent. Utilization estimates for all communities in exclosed portions was always less than 20 percent. Though degree of livestock utilization was greatest on herbaceous covered banks, streambank losses were less compared to shrub and tree covered banks than in herbaceous covered banks, though not significant.

This can partially be attributed to inherent soil differences among the plant communities. Streambanks dominated by grasses and grasslikes were composed of deep, moderately to well developed finer textured soils. Soils in shrub and tree dominated streambanks characteristically were unstructured, medium-coarse textured and rocky and appeared to be much more susceptible to disturbance or erosion than the herbaceous (meadow) covered soils. However, there are not enough data to determine if soil characteristics were the only factor or even most important factor in streambank susceptibility to erosion.

Some results were apparently biased due to upstream management practices off the study area. Immediately above the study area, a road parallels the streambank. This factor in particular, as well as upstream logging and other land use practices probably impacted the streambanks on the study area to some degree. At the upper end of the study area just below the point where the road no longer parallels the creek is an exclosure. Winter erosion disturbed 85 percent of the sampling stations in this exclosure compared to 54 percent in exclosures further downstream. It is unknown how far and to what degree upstream influences impacted streambank characteristics on the study area, but it appeared that these influences were alleviated somewhat after only a few hundred meters into the study area.

Conclusion

After two grazing periods and one overwintering period, a late season grazing scheme under moderate intensities significantly increased streambank sloughoff or erosion compared to nonuse. During the 1978 and 1979 grazing seasons significantly greater erosion and streambank disturbance occurred in grazed portions of the study area. Though overwintering losses were not significantly different, disturbance indices were significantly greater in grazed areas over exclosed areas. There were no significant differences in undercut depths between grazed and exclosed areas, but grazed portions of the streambank had a significant decrease in undercut depth after two grazing seasons and one overwintering period. In addition, after two years of nonuse in the exclosed areas, a significantly greater number of undercuts were deeper than 7.6 cm (three inches) than in grazed areas.

These findings illustrated a greater erosional hazard for Catherine Creek than Buckhouse et al. (1981) or Hayes (1978) found with similar light to moderate intensities of livestock utilization. It may be that some streams are more susceptible to disturbance by livestock than others. This natural variation as well as the other values and uses of the riparian/stream ecosystem, and the impacts of grazing on these values should be considered in a riparian management scheme. Management plans should be geared for each particular riparian/stream ecosystem studied, as responses to land use activities may tend to vary greatly from stream to stream.

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APPENDICES

APPENDIX A

Scientific and Common Names of Plant Species Identified in the Catherine Creek Riparian Area, According to the Nomenclature of Hitchcock and Cronquist (1973), Garrison *et al*. (1976) and Peck (1941).

APPENDIX A.

Scientific name	Common name
Grasses	
Agropyron cristatum (L.) Gagrth.)	fairway crested wheatgrass
Agropyron repens (L.) Beauv.	quackgrass
Agropyron spicatum (Pursh) Scribn. and Smith	bluebunch wheatgrass
Agrostis alba L.	redtop
Agrostis diegoensis Vasey	thin bentgrass
Agrostis exarata Trin.	spike bentgrass
Agrostis scabra Willd.	winter bentgrass
Alopecurus aequalis sobol.	shortawn foxtail
Alopecurus pratensis L.	meadow foxtail
Arrhenatherum elatus (L.) Presl.	tall oatgrass
Bromus brizaeformis Fisch. and Mey.	rattle brome
Bromus marginatus Ness	mountain brome
Bromus mollis L.	soft brome
Bromus racemosus L.	bald brome
Bromus tectorum L.	cheatgrass
Calamagrostis rubescens Buckl.	Pinegrass
Dactylis glomerata L.	orchardgrass
Deschampsia caespitosa (L.) Beauv.	tufted hairgrass
Deschampsia danthonoides (Trin.) Munro Ex Benth.	Annual hairgrass
Deschampsia elongata (Hook.) Munro Ex Benth.	Slender hairgrass
Elymus glaucus Buckl.	blue wildrye
Festuca elatior L.	meadow fescue
Festuca idahoensis Elmer	idaho fescue
Festuca occidentalis Walt.	western fescue
Festuca ovina L.	sheep fescue
Glyceria elata (Nash) M. E. Jones	tall mannagrass
Glyceria striata (Lam.) A. S. Hitcho.	fowl mannagrass
Holcus lanatus L.	common velvetgrass
Hordeum jubatum L.	foxtail barley
Koeleria cristata	prairie junegrass
Melica bulbosa Geyer Ex Porter and Coult.	oniongrass
Muhlenbergia filiformis (Thurb.) Rydb.	pullup muhly
Phleum alpinum L.	alpine timothy
Phleum pratense L.	timothy
Poa ampla Merrill	big bluegrass
Poa bulbosa L.	bulbous bluegrass
Poa compressa L.	Canada bluegrass
Poa nevadensis Vasey Ex Scribn.	Nevada bluegrass
Poa pratensis L.	Kentucky bluegrass
Poa sandbergii Vasey	Sandberg bluegrass
Sitanion hystrix (Nutt.) J. G. SM.	bottlebrush squirreltail
Stipa occidentalis Thurb. Ex. Wats.	western needlegrass
Trisetum canescens Buckl.	tall trisetum
Grasslikes	
Carex aquatilis Wahl.	water sedge
Carex atrostachya Olney.	slenderbeak sedge
Carex comosa Boott.	bristly sedge

APPENDIX A. (Continued)

Scientific name	Common name
Grasslikes	
Carex geyeri Holm.	elk sedge
Carex microptera Mark.	smallwing sedge
Carex nebrascensis Dewey	Nebraska sedge
Carex rostrata Allioni	beaked sedge
Carex stiptata Muhl.	sawbeak sedge
Carex straminiformis L. H. Bailey	Mount Shasta sedge
Juncus balticus var. *balticus* Willd.	baltic rush
Juncus balticus var. *montanus* Englem.	baltic rush
Juncus ensifolius Wilsk.	swordleaf rush
Luzula campestris var. multiflora (Ehrh.) Celak.	common woodrush
Scirpus microcarpus Presl.	panicled bulrush
Forbs and Allies	
Achillea millefolium L.	western yarrow
Acontium columbianum Nutt.	Columbia monkshood
Agoseris glauca (Pursh) Raf.	pale agoseris
Allium acuminatum Hook.	tapertip onion
Alyssum alyssoides L.	pale allysum
Anaphalis margaritacea (L.) B. & H.	common pearleverlasting
Anemone piperi Britt.	piper anemone
Antennaria rosea Greene	rose pussytoes
Aquilegia formosa Fisch.	Sitka columbine
Arabis drummondii Gray	Drummond rockcress
Arenaria macrophylla Hook.	sandwort
Arenaria serpyllifolia L.	sandwort
Arnica chamissonis Less.	chamisso arnica
Artemisia ludoviciana Nutt.	Louisiana wormwood
Aster campestris Nutt.	aster
Astragalus canadensis L.	Canada milkvetch
Barbarea orthoceras Ledeb.	wintercress
Besseya rubra (Dougl.) Ryab.	besseya
Brodiaea douglasii Wats.	Douglas brodiea
Camassia quamash (Pursh) Greene	common camas
Capsella bursa-pastoris (L.) Medik.	shepards purse
Cardaria draba (L.) Desv.	whitetop
Castilleja cusickii Greenm.	cusick paintbrush
Cerastium viscosum L.	sticky cerastium
Cicuta douglasii (DC.) Coult. & Rose	western waterhemlock
Cirsium vulgare (Savi) Airy-shew	bull thistle
Collinsia parviflora Lindl.	littleflower collinsia
Collomia grandiflora Hook.	collomia
Collomia linearis Nutt.	narrowleaf collomia
Conyza canadensis (L.) Cronq.	horseweed
Daucus carota L.	wild carrot
Delphinium bicolor Nutt.	little larkspur
Descurania pinnata (Walt.) Britt.	pinnate tansymustard
Dicentra cucullaria (L.) Bernh.	Dutchman's breeches
Dipsacus sylvestris Huds.	teasel

APPENDIX A. (Continued)

Scientific name	Common name
Forbs and Allies	
Draba verna L	spring draba
Epilobium glabberimum Barbcy	smooth willoweed
Epilobium paniculatum Nutt. Ex T. & G.	autumn willoweed
Equisetum arvense L.	field horsetail
Equisetum variegatum schleich.	variegated horsetail
Erigeron philadelphicus L.	Philadelphia fleabane
Erigeron pumilus Nutt.	low fleabane
Eriogonum heracleoides Nutt.	wyeth Eriogonum
Erodium cicutarium (L.) Loher.	stork's bill
Fragaria vesca L.	Wood's strawberry
Fragaria virginiana Duchsne	blueleaf strawberry
Galium asperrimum Gray	rough bedstraw
Galium boreale L.	northern bedstraw
Geranium bicknellii	bicknell geranium
Geranium viscosissimum F. & M.	stick geranium
Geum macrophyllum Willd.	largeleaf averis
Geum triflorum Pursh.	prairiesmoke avens
Gnaphalium palustre Nutt.	cudweed
Habenaria dilatata (Pursh) Hook.	white bogorchid
Heracleum lanatum Michx.	common Eowparsnip
Holosteum umbellatum L.	jagged chickweed
Hydrophyllum capitatum Dougl. Ex Benth	ballhead waterleaf
Hypericum anagalloides C. & S.	trailing St. Johnswort
Hypericum perforatum L.	common St. Johnswort
Iris missouriensis Nutt.	rockymountain iris
Lactuca serriola L.	prickly lettuce
Lamium purpureum L.	deadnettle
Lepidium perfoliatum L.	clasping pepperweed
Lepidium virginicum L.	tall pepperweed
Lithophragma parviflora (Hook). Nutt. Ex T. & G.	smallflower woodlandstar
Lomatium triternatum (Pursh) Coult. & Rose	nineleaf lomatium
Lupinus leucophyllus Dougl. Ex Lindl.	velvet lupine
Medicago lupulina L.	black medic
Mentha arvensis L.	field mint
Mertensia campanulata A. Nels.	bluebells
Microsteris gracilis (Hook.) Greene	microsteris
Mimulus guttatus var. *depauperatus* (Gray) Grant	common monkeyflower
Mimulus guttatus var. *guttatus* DC.	common monkeyflower
Mimulus lewisii Pursh.	lewis monkeyflower
Mimulus lewisii var. *alba* Henry	white lewis monkeyflower
Mimulus moschatus Dougl.	muskplant monkeyflower
Montia linearis (Dougl.) Greene	lineleaf indianlettuce
Montia perfoliata (Donn) How.	minerslettuce
Nemophila breviflora Gray	great basin nemophila
Nemophila pedunculata Dougl. Ex Benth.	nemophila
Onopordium acanthium L.	scotch thistle
Osmorhiza chilensis H. & A.	wild sweetanise
Penstemon rydbergii A. Nels.	rydberg penstemon
Plantago lanceolata L.	buckhorn plantain

APPENDIX A. (Continued)

Scientific name	Common name
Forbs and Allies	
Plantago major L.	rippleseed plantain
Polemenium occidentale Greene	western polemonium
Polygonum aviculare L.	prostate knotweed
Polygonum douglasii Greene	douglas knotweed
Potentilla arguta Rydb.	baker cinquefoil
Potentilla glandulosa Lindl.	gland cinquefoil
Potentilla gracilis Dougl. Ex Hook.	northwest cinquefoil
Prunella vulgaris L.	common selfheal
Ranunculus acris L.	tall buttercup
Ranunculus testiculatus Crantz	buttercup
Ranunculus uncinatus D. Don	buttercup
Rudbeckia occidentalis Nutt.	blackhead
Rumex acetosella L.	sheep sorrel
Rumex crispus L.	curly dock
Rumex occidentalis Watts.	western dock
Sedum stenopetalum Pursh	warmleaf stonecrop
Senecio integerrimus Nutt.	lambstongue groundsel
Senecio pseudareus Rydb.	golden ragwort
Senecio serra Hook.	butterweed groundsel
Sidalecea oregana (Nutt.) Gray	Oregon checkermallow
Sisymbrium altissimum L.	tumblemustard
Smilacina stellata (L.) Desf.	starry solomon plume
Solidago missouriensis Nutt.	Missouri goldenrod
Stellaria nitins Nutt.	chickweed
Taraxacum officinale Weber	common dandelion
Thalictrum occidentale Gray	western meadowrue
Thlaspi arvense L.	field pennycress
Tragopogon dubius Scop.	salsify
Trifolium agrarium L.	yellow clover
Trifolium pratense L.	red clover
Trifolium repens L.	white clover
Trillium petiolatum Pursh	Idaho trillium
Urtica gracilis Ait.	slim nettle
Veratrum californicum Durand	California falsehellbore
Verbascum thapsus L.	flannel mullien
Veronica americana Schewin. Ex Benth.	American speedwell
Veronica arvensis L.	common speedwell
Veronica serpyllifolia L.	thymeleaf speedwell
Vicia americana Muhl. Ex Willd.	American vetch
Viola adunca Sm.	hook violet
Viola nuttallii var. major Hook.	nuttal violet
Shrubs	
Amelanchier alnifolia Nutt.	Saskatoon serviceberry
Berberis repens Lindl.	creeping hollygrape
Chrysothamnus nauseosus (Pall.) Brit.	gray rabbitbrush
Cornus stolonifera Michv.	red oshier dogwood
Crataegus douglasii Lindl.	black hawthorne

APPENDIX A. (Continued)

Scientific Name	Common name
Shrubs	
Holodiscus discolor (Pursh) Maxim	creambush rock spirea
Lonicera involucrata (Rich.) Banks Ex Spreng.	bearberry honeysuckle
Philadelphicus lewisii Pursh	Lewis mockorange
Ribes aureum Pursh	golden currant
Ribes cereum Dougl.	wax currant
Ribes hudsonianum Richards.	Hudsonbay currant
Ribes lacustre (Pursh) Poir.	prickly currant
Rosa woodsii Lindl.	Woods rose
Rubus idaeus L.	red raspberry
Salix amygoeloides Anderss.	peachleaf willow
Salix bebbiana var. perrustrata (Rydb.) Schneid.	bebb willow
Salix exigua var. exigua	coyote willow
Salix rigida var. mackenzieana (Hook.) Cronq.	Mackenzie willow
Salix rigida var. watsonii (Bebb.) Cronq.	Mackenzie willow
Sambucus cerula Raf.	blue elderberry
Symphoricarpos albus (L.) Blake	common snowberry
Symphoricarpos oreophilus Gray	mountain snowberry
Trees	
Abies grandis (Dougl.) Lindl.	grand fir
Alnus incana (L.) Moench.	thin leaf alder
Betula occidentalis Hook.	water birch
Larix occidentalis Nutt.	westernlarch
Picea englemannii Parry Ex Englem.	Englemann spruce
Pinus contorta Dougl. Ex Loud.	lodgepole pine
Pinus ponderosa Dougl. Ex Loud.	ponderosa pine
Populus trichocarpa T. & E. Ex Hook.	black cottonwood
Prunus virginiana L.	common chokecherry
Pseudotsuga menziesii (Mirbel) Franco	Douglas fir

APPENDIX B

Avian Species Identified in the Catherine Creek Riparian Study Area (May-September, 1978-1980).

Appendix B. Partial listing of avian species utilizing the Catherine Creek riparian zone (May - September 1978-1980).

Common Name	Scientific Name	Foraging Guild Number†
American goldfinch	Spinus tristis	7
American kestrel	Falco sparverius*	8
American robin	Turdus migratorius	6
Audobon's warbler	Dendroica audoboni*	2
bald eagle	Holiaeetus leucocephalus	8
barn swallow	Hirundo rustica	1
belted kingfisher	Megaceryle alpyon*	10
black-billed magpie	Pica pica	15
black-capped chickadee	Parus atricappallus*	2
black-headed grosbeak	Pheuctieus melanocephalus*	3
Brewer's blackbird	Euphague cyanocephalus*	6
brown-headed cowbird	Molothrus ater*	7
California quail	Lophortyx californicus*	7
calliope hummingbird	Stellula calliope*	13
Canada goose	Branta canadensis	12
Cassins's finch	Carpodacus cassinii	3
cedar waxwing	Bombycilla cedrorum*	3
chipping sparrow	Spizella passerina*	6,7
Clark's nutcracker	Nucifraga columbiana	2
common crow	Corvus brachyrhynchos	15
common flicker	Colaptes cafer*	6
common merganser	Mergus merganses	10
common nighthawk	Chordeilies minor	1
common raven	Corvus corvax	15
common snipe	Capella gallinago*	6
Cooper's hawk	Accipiter cooperii	14
dark-eyed junco	Junco hymenalis*	7
downy woodpecker	Dendrocopos pubescens*	5
evening grosbeak	Hesperiphona vespertina	3
fox sparrow	Passerella iliaca	7
golden eagle	Aquila chrysaetos	8
golden-crowned kinglet	Regulus satrapa	2
goshawk	Accipiter gentilis	14
great blue heron	Ardea herodias	10
great horned owl	Bubo virginianus	8
green-winged teal	Anus carlinensis	11
hairy woodpecker	Dendrocopos vilosus*	5
house wren	Troglodytes aedon	6
kildeer	Charadrius vociferus*	6
MacGillivray's warbler	Oporornis tolmiei*	2
marsh hawk	Circus cyaneus	8
merlin	Falco columbarius	14
mountain bluebird	Sialia currucoides	6
mountain chickadee	Parus gambeli	2
mourning dove	Zenaidura macroura*	7
pine siskin	Spinus pinus	7

Appendix B. (Continued)

Common Name	Scientific Name	Foraging Guild Number†
pintail	Ana acuta	11
purple finch	Carpodacus purpureus	3
pygmy nuthatch	Sitta pygmaea	4
red-breasted nuthatch	Sitta canadensis*	4
red-crossbill	Loxia curvirostra	3
red-tailed hawk	Buteo jamaicensis	8
red-winged blackbird	Agelaius phoeniceus*	7,6
rock dove	Columba livia	7
rough-winged swallow	Stelgidopteryx ruficollis*	1
ruby-crowned kinglet	Regulus caledula	2
ruffed grouse	Bonasa umbellus*	12
rufous-sided towhee	Pipilo erythrophtalmus	6
savannah sparrow	Passerculus sandwichensis	7
sharp-shinned hawk	Accipiter striatus	14
solitary vireo	Vireo solitarius	2
song sparrow	Melospiza melodia*	6,7
spotted sandpiper	Actitis macularia*	6
starling	Sturnus vulgaris*	6
Stellar's jay	Cyanocitta stelleri*	3
Swainson's hawk	Buteo swainsoni	8
Townsend's solitaire	Myadestes townsendi	1
Townsend's warbler	Dendroica townsendi	2
trail's flycatcher	Empidonax virescens	1
tree swallow	Iridoprocne bicolor*	1
violet-green swallow	Tachycineta thalassina*	1
warbling vireo	Vireo gilvus*	2
water ousel	Cinclus mexicanus*	9
western bluebird	Sialia mexicana*	6
western meadowlark	Sturnella neglecta	7
white-breasted nuthatch	Sitta carolinensis	4
white-crowned sparrow	Zonotrichia leucophrys*	6,7
white-headed woodpecker	Dendrocopos albolarvatus*	5
winter wren	Troglodytes troglodytes	6
yellow-bellied sapsucker	Sphyrapicus varius	5
yellow warbler	Dendroica petechia*	2

† see Table 7 Chapter 3
* species known to have utilized riparian study area as nest sites.

APPENDIX C

Mean density (no. /ha) of Avian Species censused in the Catherine Creek Study Area, 1978-1980.

Appendix C

Species	Late Summer 1978 (prior to grazing) Meadows Grazed	Meadows Exclosed	Hawthorne Grazed	Hawthorne Exclosed	Cottonwood Grazed	Cottonwood Exclosed	Early Fall 1978 (after the grazing season) Meadows Grazed	Meadows Exclosed	Hawthorne Grazed	Hawthorne Exclosed	Cottonwood Grazed	Cottonwood Exclosed
American robin	0.66		1.87	1.39		0.61	0.57		2.27	1.71	9.21	0.33
Chipping sparrow			1.40		5.67	1.83			0.57	0.57	2.09	10.61
Black capped chickadee			0.48		1.14				2.27		17.17	2.65
Kestrel		0.28	0.48					0.28			0.42	
Cedar waxwing			.94	0.80	0.57							0.53
Stellar's jay			1.87		0.57							
McGilvarav's warbler			0.48		0.57							0.53
Ruffed grouse				0.80		0.61				0.57		
Yellow warbler				0.80								
Calliope hummingbird						0.61						
Cassin finch							0.28	1.13			1.07	6.37
Western bluebird									0.57		0.42	
Red breasted nuthatch											3.93	
Brewer's blackbird												
Rough-winged swallow												
Song sparrow												
Tree swallow												
Water ousel												0.53
Common flicker											0.42	
Rufous sided towhee										0.57		
Mountain chickadee										3.42	2.93	
Western meadowlark									0.57			
Purple finch					0.57							
Trail's flycatcher		0.28	0.94									
House wren			0.48		1.70							
Solitary vireo			0.48		0.57			1.13	0.57			
Barn swallow				1.59	0.57							
Unknowns						0.61			0.57		0.84	0.53
Warbling vireo												
Mourning dove												
Whiteheaded woodpecker												
Violet-green swallow												
Red tailed hawk												
Sharp shinned hawk												
Audobon's warbler												
Merlin												
Starling												
Black headed grosbeak												
Hairy woodpecker												
Evening grosbeak												
Downy woodpecker												
Red crossbill												
Great horned owl												
Brown headed cowbird												
Savannah sparrow												
White crowned sparrow												
Fox sparrow												
Ruby crowned kinglet												
Golden crowned kinglet												
Belted kingfisher												
Bald eagle												
Redwinged blackbird												
Towsend's solitaire												
Yellow-bellied sapsucker												
Common snipe												
White-breasted nuthatch												
Total avian density	0.66	0.56	9.42	5.58	11.93	4.27	0.85	2.54	7.39	6.84	38.10	22.28

Appendix C

	Early Summer 1979 (Nest brooding season)						Late Summer 1979 Before Grazing Season					
	Meadows		Hawthorne		Cottonwood		Meadows		Hawthorne		Cottonwood	
Species	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed
American robin	8.05	4.72	4.77	5.17	14.37	1.30	1.20	0.25	5.3		0.80	2.39
Chipping sparrow	0.75	0.40	0.80	3.58	1.20	1.20		0.20	2.78		1.20	
Black capped chickadee			0.40		2.40	1.50						
Kestrel	0.87	1.02	1.59	1.59		0.80	1.22		0.80	1.20	11.13	10.73
Cedar waxwing		0.20			4.00	0.40		0.21				
Steller's jay										4.40	0.80	0.40
McGilvaray's warbler	0.10	0.20	2.39	1.20	0.40	0.40				0.40	0.40	1.60
Ruffed grouse						0.40		0.80	2.75	1.20	1.20	0.80
Yellow warbler	0.87	1.21	8.75	4.37	3.20	3.20					0.40	0.40
Calliope hummingbird				0.80	0.40	0.40						
Cassin finch								0.60			0.40	
Western bluebird	0.70	1.00	1.20		2.00	1.20					3.16	
Red breasted nuthatch					0.80	1.20						
Brewer's blackbird	5.30	2.56	5.17	1.59	4.00	0.40	3.33				1.60	2.78
Rough-winged swallow	7.28			0.80	4.40			0.40	1.20		0.80	
Song sparrow	0.20	0.45	0.40	1.20	2.00	0.40	0.21					
Tree swallow	0.87											
Water ousel	0.25											
Common flicker	1.53	0.10	1.20	0.40	0.30	0.80						
Rufous sided towhee	0.25				0.40	0.60						
Mountain chickadee												
Western meadowlark												
Purple finch									0.80	0.40		
Trail's flycatcher			0.40	1.59	0.80	1.20			1.50	1.20		0.40
House wren												
Solitary vireo												
Barn swallow	0.25	0.65	0.40	0.40	1.30	1.20			0.40		0.40	0.40
Unknowns	0.10	1.00	0.80	2.39	0.80	2.40			0.40			
Warbling vireo	0.56					0.40						
Mourning dove	0.21											
Whiteheaded woodpecker	0.10	0.21	1.20	1.59	0.80							
Violet-green swallow	0.10		0.40				0.80	0.80		0.80		
Red tailed hawk	0.25		0.40									
Sharp shinned hawk		0.05	0.80			1.20					0.40	
Audobon's warbler		0.25				0.80						
Merlin				0.40								
Starling			0.40	0.40	1.20	0.80						
Black headed grosbeak					0.80						0.40	1.20
Hairy woodpecker					0.80							
Evening grosbeak					0.40							
Downy woodpecker							0.32					
Red crossbill									0.40			
Great horned owl										0.80		
Brown headed cowbird										0.60		
Savannah sparrow												
White crowned sparrow												
Fox sparrow												
Ruby crowned kinglet												
Golden crowned kinglet												
Belted kingfisher												
Bald eagle												
Redwinged blackbird												
Townsend's solitaire												
Yellow-bellied sapsucker												
Common snipe												
White-breasted nuthatch												
Total avian density	28.59	14.02	31.47	27.47	47.57	22.00	7.08	2.91	17.10	11.20	23.10	21.10

Appendix C

Species	Early Fall 1979 (after the grazing season) Meadows Grazed	Meadows Exclosed	Hawthorne Grazed	Hawthorne Exclosed	Cottonwood Grazed	Cottonwood Exclosed	Spring 1980 (Early nesting season) Meadows Grazed	Meadows Exclosed	Hawthorne Grazed	Hawthorne Exclosed	Cottonwood Grazed	Cottonwood Exclosed
American robin	3.00	3.11	0.80	0.80	3.98	1.39	3.49	1.36	4.00	1.20	5.90	5.20
Chipping sparrow	0.75	2.46	1.20				0.11		0.40		0.40	
Black capped chickadee	0.21		1.39	0.809	3.18				0.40	0.80	0.80	
Kestrel	0.10							0.21				
Cedar waxwing												
Steller's jay	0.57	0.20			1.39						2.00	
McGilvray's warbler												
Ruffed grouse						0.40			0.40			
Yellow warbler			0.40				0.57		4.80	4.00	1.20	0.40
Calliope hummingbird												
Cassin finch												
Western bluebird			0.40					0.62	0.80			
Red breasted nuthatch			0.40		0.30				0.40		1.60	
Brewer's blackbird							6.97	5.76	2.00		2.40	
Rough-winged swallow							2.00	0.40	2.00			
Song sparrow		0.42		0.40		0.80		0.25	1.20	1.20	1.20	3.20
Tree swallow							1.33	0.62	1.20	0.80	1.20	
Water ouzel												
Common flicker	0.21			0.40	1.20			0.46	0.80	1.20	2.60	
Rufous sided towhee	1.19	0.83	1.50									
Mountain chickadee								0.60				0.80
Western meadowlark							0.42					
Purple finch												
Trail's flycatcher												
House wren												
Solitary vireo		0.21										
Barn swallow							0.25	0.21				
Unknowns	0.21	0.40	0.40									
Warbling vireo												
Mourning dove												
Whiteheaded woodpecker												
Violet-green swallow												
Red tailed hawk		0.21		0.40						0.40		0.40
Sharp shinned hawk												
Audubon's warbler	0.42	0.63			0.80						2.80	0.80
Merlin												
Starling												
Black headed grosbeak												
Hairy woodpecker											0.40	
Evening grosbeak												
Downy woodpecker					0.80							
Red crossbill												
Great horned owl												
Brown headed cowbird												
Savannah sparrow												
White crowned sparrow	1.25	0.63	3.98	0.40	0.40							
Fox sparrow	0.25	0.21	0.80		0.80					0.40		
Ruby crowned kinglet			0.80	0.40	0.40	0.40		0.25	1.60	0.80	0.40	
Golden crowned kinglet			0.80		1.20			0.50				
Belted kingfisher					0.40							
Bald eagle							0.10					
Redwinged blackbird							0.45					
Townsend's solitaire										0.60		
Yellow-bellied sapsucker								2.00			1.60	
Common snipe								0.50				
White-breasted nuthatch												0.80
Total avian density	9.10	9.12	13.57	4.00	15.45	3.58	15.69	11.24	20.00	11.60	25.50	10.80

APPENDIX D

Average percent frequency, total species encountered, diversity (H') evenness (J'), McArthur's difference values and total numbers of plots sampled in selected plant communities, using 0.25 m^2 and 0.0625 m^2 plots, 1978-1980.

Appendix D.

Table D-1. Gravel Bars

Species	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$
Graminoids												
Poa pratensis	12	26	5	10	19	31	7	15	22	29	11	21
Oval carex spp.	3	13	-	8	3	16	10	27	2	12	7	33
Agrostis exarata	1	5	17	39	8	14	8	15	-	3	2	6
Agrostis alba	-	11	3	8	-	-	4	5	11	16	1	2
Bromus racemosus	2	9	-	7	1	7	1	2	6	14	1	6
Alopecurus aequalis	-	-	2	8	-	2	3	5	1	1	-	-
Elymus glaucus	-	1	1	6	-	-	1	2	1	1	1	1
Deschampsia elongata	1	4	3	4	-	-	3	6	3	3	1	2
Poa ampla	4	5	-	2	1	1	-	-	-	-	-	-
Glyceria striata	2	5	-	1	4	8	-	1	-	3	1	2
Trisetum canescens	-	-	-	1	-	-	-	-	-	-	-	-
Bromus tectorum	-	-	-	1	3	12	-	-	3	7	-	-
Deschampsia caespitosa	-	-	-	1	-	-	-	-	-	-	-	-
Poa compressa	-	-	-	1	2	2	4	8	-	3	2	4
Agropyron repens	3	6	-	-	2	3	-	-	-	-	1	1
Phleum pratense	1	4	-	-	6	9	2	7	1	3	2	4
Juncus balticus	3	3	-	1	1	1	-	-	1	1	-	-
Scirpus microcarpus	-	-	-	1	-	-	-	-	-	-	-	-
Carex stiptata	-	-	-	-	-	-	4	7	-	-	-	-
Festuca elatior	-	-	-	-	1	2	-	-	-	-	-	-
Carex nebraskensis	-	-	-	-	-	1	1	4	2	2	1	6
Agrostis diegensis	-	-	-	-	-	-	2	5	9	20	27	49
Festuca occidentalis	-	-	-	-	-	-	-	-	1	1	-	-
Melica bulbosa	-	-	-	-	-	-	-	-	-	-	1	4
Poa bulbosa	-	-	-	-	-	-	-	-	-	-	1	1
Phleum alpinum	-	-	-	-	-	-	-	-	-	-	1	1
Luzula multiflora	-	-	-	-	-	-	-	-	-	-	-	1
Luzula spp.	-	-	-	-	-	-	-	-	2	2	2	3
Agrostis scabra	-	-	-	-	-	-	-	-	6	17	1	3
Bromus carinat	-	-	-	-	-	-	-	-	-	1	-	-
Arrhenatherum elatius	-	-	-	-	-	-	-	-	-	1	-	-
Unknown grass(es)	-	-	-	-	-	-	-	3	1	5	3	7
Lg Carex spp.*	-	-	-	-	-	-	2	7	3	7	-	-
Vulpia spp.	-	-	-	-	3	7	-	-	-	-	-	1
Agrostis spp.	-	-	-	-	-	-	-	-	1	1	-	-

Appendix D.
Table D-1. (Continued)

Species	1976				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$
Forbs												
Trifolium repens	39	48	36	41	36	51	41	48	45	64	50	63
Taraxacum officinale	7	14	6	27	14	35	18	33	8	19	16	30
Epilobium glaberrimum	2	3	7	23	3	11	16	34	15	26	22	29
Equisetum arvense	8	28	3	17	13	17	13	21	22	28	14	19
Verbascum thapsus	3	10	6	14	14	25	2	4	4	13	1	5
Medicago lupulina	6	13	3	12	2	9	1	4	12	21	1	7
Plantago major	3	4	4	11	1	4	2	12	1	1	2	8
Cerastium viscosum	1	11	1	11	3	9	1	3	1	4	4	8
Epilobium paniculatum	2	9	2	9	19	44	11	18	19	33	11	16
Aster foliacens	1	1	3	8	3	4	4	7	4	8	8	10
Erigeron philadelphicus	-	1	1	3	11	22	1	3	3	5	-	1
Rumex acetosella	4	8	3	8	3	5	3	4	3	4	6	11
Achillea millefolium	9	22	1	6	15	32	14	20	26	43	5	21
Prunella vulgaris	2	4	4	6	2	4	5	8	9	22	16	19
Caryophyylaceae spp.	-	-	-	-	1	1	-	1	1	2	1	1
Lactuca serriola	2	3	3	5	-	4	-	1	1	3	1	1
Geum macrophyllum	-	-	-	3	2	3	1	3	1	3	3	7
Rumex crispus	-	1	-	3	-	1	3	3	-	-	1	1
Aster campestris	3	9	2	3	5	10	3	8	-	5	10	15
Trifolium pratense	2	2	-	2	2	2	-	-	-	2	-	1
Antennaria rosea	-	1	-	1	-	-	-	-	-	-	-	-
Mimulus guttatus	-	-	-	1	-	-	3	4	1	4	1	3
Mentha arvensis	-	1	1	1	2	3	-	2	7	12	2	7
Arabis drummondii	-	-	-	1	-	-	-	-	-	-	-	-
Ranunculus acris	1	2	-	1	-	3	-	1	2	5	2	7
Galium vaillantii	-	-	-	1	-	-	-	-	-	-	-	1
Lepidium perfoliatum	-	1	1	1	-	-	-	-	-	-	-	-
Solidago missouriensis	-	-	-	1	-	1	-	1	1	1	-	-
Fragaria virginiana	-	0.5	-	0.5	-	-	-	-	-	-	1	2
Potentilla glandulosa	-	0.5	-	0.5	-	-	-	-	-	-	-	-
Agoseris glauca	-	0.5	-	0.5	-	-	-	-	-	-	-	-
Cirsium vulgare	2	5	-	-	1	2	3	7	-	3	-	1
Besseya rubra	-	-	-	2	-	-	-	-	-	-	-	-
Collomia linearis	-	3	-	-	-	-	-	1	1	3	-	-
Anaphalus margaritaceae	3	13	-	-	1	2	1	1	-	-	2	2
Microsteris gracilis	-	-	-	-	5	8	-	-	6	12	-	7
Vicia americana	-	-	-	-	-	-	1	1	2	2	1	6
Erigeron pumilus	-	-	-	-	-	1	-	-	-	-	-	-
Erodium cicutarium	-	-	-	-	1	1	-	-	-	-	-	-
Veronica arvensis	-	-	-	-	-	-	-	1	1	2	-	-
Rudbeckia occidentalis	-	-	-	-	-	-	-	1	-	-	-	-
Equisetum variegatum	-	-	-	-	-	-	-	1	-	-	-	-
Hypericum analgoloides	-	-	-	-	-	-	-	1	-	-	-	-
Senecio pseudarcus	-	-	-	-	-	-	1	1	-	-	-	-
Rumex arvense	-	-	-	-	-	-	-	1	-	-	-	-

Appendix D.
Table D-1. (Continued)

	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
Species	.0615m^2	0.25m^2	.0625m^2	0.25m^2	.0625m^2	0.25m^2	.0625m^2	0.25m^2	.0625m^2	0.25m^2	.0625m^2	0.25m^2
Viola nuttallii	-	-	-	-	-	1	1	2	-	-	-	-
Holosteum umbellatum	-	-	-	-	-	-	-	-	2	5	-	-
Draba verna	-	-	-	-	-	-	-	-	5	10	-	-
Collinsia parviflora	-	-	-	-	-	-	-	-	-	3	-	-
Veronica americana	-	-	-	-	-	-	-	-	2	3	1	6
Potentilla gracilis	-	-	-	-	-	-	-	-	-	2	-	-
Veronica serpyllifolia	-	-	-	-	-	-	-	-	-	1	-	-
Viola adunca	-	-	-	-	-	-	-	-	-	-	-	1
Unknown (Forbs)	4	38	-	6	3	10	5	7	7	18	3	8
Shrubs - Trees												
Populus trichocarpa	5	19	17	36	4	8	3	12	6	18	11	28
Salix rigida	8	10	2	4	2	3	4	10	2	4	8	25
Salix exigua	-	0.5	-	0.5	-	1	2	3	1	1	-	-
Artemisia ludoviciana	-	-	1	2	-	1	-	1	2	3	1	6
Alnus incana	1	1	-	-	2	2	-	3	1	2	1	3
Crataegus douglasii	-	-	-	-	-	-	-	-	-	2	-	-
Salix bebbiana	-	-	-	-	-	-	-	-	-	2	-	-
Salix spp.	-	-	-	-	1	2	-	1	-	-	1	3
Ribes lacustre	1	1	-	-	-	-	-	-	-	-	-	-
Total Species		46		52		51		57		63		59
Diversity (H')		3.2035		2.2971		3.3276		3.4608		3.5181		3.4470
McArthur's Difference Value		.8367		.8344		.8463		.8560		.8491		.8453
No. Plots Sampled			1.184				1.142				1.111	
		120		90		120		120		120		90

Appendix D

Table D-2. Alnus incana/Poa pratensis

Species	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	.0625m²	0.25m²	.0625m²	0.25m²	.0625m²	0.25m²	.0625m²	0.25m²	.0625m²	0.25m²	.0625m²	0.25m²
Graminoids												
Poa pratensis	85	94	87	90	70	82	66	67	82	95	84	87
Large Carex spp.	4	11	13	23	13	18	7	12	-	1	5	7
Agrostis alba	4	12	8	13	-	-	-	-	-	-	-	-
Phleum pratense	3	5	2	12	3	8	3	4	1	1	-	-
Holcus lanatus	-	-	10	10	-	-	-	-	-	-	3	6
Agrostis exarata	-	-	3	3	-	-	-	-	-	1	-	3
Bromus tectorum	-	-	-	1	4	7	-	-	-	-	-	-
Poa ampla	-	-	-	1	-	-	-	-	-	-	-	-
Poa compressa	3	7	-	-	14	19	1	2	-	-	2	2
Elymus glaucus	2	4	-	-	2	4	3	6	12	20	4	6
Festuca elatior	1	3	-	-	-	-	-	-	-	-	-	-
Poa bulbosa	2	2	-	-	-	-	-	-	-	-	-	-
Agropyron repens	1	2	-	-	4	12	1	2	-	-	-	-
Trisetum canescens	-	1	-	-	-	-	-	-	-	2	-	-
Bromus marginatus	-	0.5	-	-	-	-	-	-	-	-	-	-
Arrhenatherum elatius	-	2	-	-	-	-	-	-	-	-	-	-
Juncus balticus	1	1	15	14	-	-	-	-	-	-	-	-
Melica bulboa	-	-	-	-	-	1	-	-	1	2	7	12
Oval Carex spp.	-	-	-	-	2	6	-	-	11	14	4	9
Carex stiptata	-	-	-	-	-	-	4	9	-	-	-	-
Glyceria striata	-	-	-	-	2	6	12	20	5	7	27	30
Scirpus microcarpus	-	-	-	-	-	-	7	11	-	-	3	7
Bromus racemosus	-	-	-	-	-	1	-	-	-	-	-	-
Juncus balticus	-	-	-	-	1	2	18	22	-	-	8	10
Luzula multiflora	-	-	-	-	-	-	-	-	1	3	-	1
Alopecurus aequalis	-	-	-	-	-	-	-	-	-	-	-	-
Agrostis diegoensis	2	5	-	-	-	6	-	-	-	-	1	1
Festuca sp.	-	-	-	-	1	1	-	-	-	-	-	-
Poa sp.	3	3	-	-	-	-	-	-	4	7	1	1
Unknown grass	4	7	2	4	-	-	-	-	-	2	-	-

Appendix D
Table D-2 (Continued)

Species	1978 Grazed .0625m²	1978 Grazed 0.25m²	1978 Exclosed .0625m²	1978 Exclosed 0.25m²	1979 Grazed .0625m²	1979 Grazed 0.25m²	1979 Exclosed .0625m²	1979 Exclosed 0.25m²	1980 Grazed .0625m²	1980 Grazed 0.25m²	1980 Exclosed .0625m²	1980 Exclosed 0.25m²
Forbs												
Taraxacum officinale	14	31	8	27	22	34	16	41	25	50	21	40
Aster foliaceus	2	9	4	24	9	25	9	26	13	25	4	7
Geum macrophyllum	10	34	8	22	8	14	4	8	8	21	7	17
Galium vaillanti	2	7	7	21	3	6	3	8	7	12	2	7
Ranunculus acris	-	47	-	20	23	33	10	21	28	46	13	23
Trifolium repens	2	4	2	12	3	5	1	2	2	2	-	1
Achillea millefolium	3	8	2	10	3	7	11	22	3	8	3	13
Arenaria macrophylla	13	31	8	8	9	15	2	6	9	12	-	3
Prunella vulgaris	5	12	4	5	2	4	2	6	3	9	7	10
Viola adunca	1	7	-	2	-	-	1	2	-	-	-	-
Fragaria vesca	-	4	2	3	-	-	1	7	-	-	1	2
Plantago major	1	2	2	2	-	1	-	-	-	-	-	-
Urtica gracilis	-	1	-	2	-	6	-	-	2	3	-	-
Epilobium glaberrimum	1	1	-	2	-	-	1	2	-	-	-	-
Cirsium vulgare	-	-	-	1	-	-	-	-	1	3	1	1
Rumex crispus	-	-	1	1	-	-	-	-	-	-	-	-
Montia perfoliata	-	-	-	1	15	28	9	18	30	39	3	17
Rumex acetosella	-	0.5	-	0.5	1	3	-	-	-	-	-	-
Fragaria virgianiana	-	-	-	0.5	-	1	3	4	-	-	3	7
Equisetum arvense	3	9	-	-	7	12	-	1	7	15	1	3
Osmorhiza chilensis	2	7	-	-	3	6	1	1	8	14	-	-
Senecio pseudareus	9	10	-	-	-	-	-	-	3	11	2	9
Mentha arvensis	1	1	-	-	-	-	3	8	3	7	-	-
Geranium viscosissimum	-	2	-	-	-	-	-	-	-	-	-	-
Medicago lupulina	-	1	-	-	-	-	1	1	-	-	-	1
Trifolium pratense	-	0.5	-	-	-	-	-	-	-	-	-	-
Solidago missouriensis	-	0.5	-	-	-	-	-	-	4	5	3	7
Besseya rubra	-	0.5	-	-	-	-	-	-	-	-	-	-
Erodium cicutarium	-	0.5	-	-	-	-	-	-	-	-	-	-
Castilleja cucksickii	-	0.5	-	-	-	-	-	-	-	-	-	-
Aquilega formosa	-	-	-	0.5	-	1	-	-	-	-	1	1
Viola nutallii	-	-	-	-	-	1	-	-	-	-	-	-
Urtica gracilis	-	-	-	-	-	6	-	-	2	3	-	-
Iris missouriensis	-	-	-	-	-	-	-	1	-	-	-	-
Caryophyllaceae spp.	-	-	-	-	4	7	-	-	-	-	1	2
Solidago missouriensis	-	-	-	-	3	6	-	-	-	-	-	-
Dipsacus sylvestris	-	-	-	-	-	-	4	7	-	-	4	9
Aster campestris	-	-	-	-	-	-	3	4	1	2	-	-
Vicia americana	-	-	-	-	-	-	-	2	-	-	2	2
Smilacena stellata	-	-	-	-	-	-	-	1	-	-	2	3
Galium boreale	-	-	-	-	2	2	-	-	-	-	-	-

Appendix D
Table D-2 (Continued)

Species	1978 Grazed .0625m²	1978 Grazed 0.25m²	1978 Exclosed .0625m²	1978 Exclosed 0.25m²	1979 Grazed .0625m²	1979 Grazed 0.25m²	1979 Exclosed .0625m²	1979 Exclosed 0.25m²	1980 Grazed .0625m²	1980 Grazed 0.25m²	1980 Exclosed .0625m²	1980 Exclosed 0.25m²
Veronica arvensis	–	–	–	–	1	1	–	–	–	–	–	–
Collinsia parviflora	–	–	–	–	3	3	–	–	3	8	1	10
Lithophragma parviflora	–	–	–	–	–	1	–	–	2	2	–	1
Trillium petiolatum	–	–	–	–	–	1	–	–		–	–	–
Collomia linearis	–	–	–	–	3	6	–	–	–	–	–	–
Mimulus guttatus	–	–	–	–	–	–	1	3	2	2	10	19
Microsteris gracilis	–	–	–	–	–	–	–	1	1	2	1	1
Agoseris glauca	–	–	–	–	–	2	–	–	–	–	–	–
Tragopogon dubius	–	–	–	–	–	1	–	–	–	–	–	–
Cerastium viscosum	–	–	–	–	6	9	14	20	3	6	1	3
Heracleum lanatum	–	–	–	–	–	–	–	–	2	3	–	–
Stellaria graminea	–	–	–	–	–	–	–	–	3	6	7	10
Draba verna	–	–	–	–	–	–	–	–	1	2	–	–
Nemophila pedunculata	–	–	–	–	–	–	–	–	–	–	1	1
Lactuca serriola	–	–	–	–	–	–	–	–	–	–	1	2
Holosteum umbellatum	–	–	–	–	–	–	–	–	–	–	–	–
Verbascum thapsus	–	–	–	–	–	–	–	–	–	–	–	2
Unknown Forb	9	23	11	25	6	12	1	9	3	9	2	4
Epilobium paniculatum	–	–	–	–	–	–	–	–	1	1	–	–
Shrubs												
Alnus incana	–	3	–	1	–	2	–	–	–	–	–	–
Rosa woodsii	–	–	–	2	–	1	1	4	1	3	2	3
Crataegus douglasii	–	–	–	0.5	2	3	1	2	1	6	–	–
Symphoricarpos albus	–	1	–	–	–	–	1	1	–	3	–	1
Amelanchier alnifolia	–	0.5	–	–	–	–	1	2	–	1	–	1
Artemisia ludoviciana	–	0.5	–	–	–	–	–	–	–	–	–	–
Salix spp.	–	0.5	–	–	–	–	–	–	–	–	–	–
Cornus stolonifer	–	–	–	–	–	1	–	–	–	–	–	–
Pinus ponderosa (seedings)	–	–	–	–	–	2	–	–	–	–	–	–
Rubus idaeus	–	–	–	–	–	–	–	–	–	–	2	2
Total species		51		34		49		41		45		51
Diversity (H')		3.0126		2.7199		3.2930		3.1915		3.1585		3.2870
Evenness (J')		.7662		.7713		.8461		.8594		.8297		.8360
McArthur's Dfiference Value			1.150				1.194				1.142	
No. Plots Sampled		90		60		90		90		90		0

Appendix D

Table D-3. *Populus trichocarpa* – mixed conifer

Species	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$
Graminoids												
Poa pratensis	79	89	88	93	89	95	96	97	97	100	95	99
Trisetum canescens	19	25	23	33	–	–	–	3	–	–	2	6
Bromus tectorum	–	–	–	–	1	1	1	6	1	2	4	6
Agrostis alba	15	16	–	4	–	–	–	–	–	–	–	–
Elymus glaucus	3	9	–	–	2	6	1	2	2	9	–	1
Carex sp.	6	10	7	10	7	8	3	6	–	1	5	8
Festuca elatior	7	7	–	–	–	–	–	–	–	–	1	2
Agrostis exarata	–	–	–	3	–	–	–	–	–	–	–	–
Glyceria striata	–	–	–	1	–	–	–	–	–	–	–	–
Bromus racemosus	–	–	–	1	–	–	–	–	1	1	–	–
Phleum pratense	0.5	1	–	–	–	–	–	–	–	–	–	–
Scirpus microcarpus	–	–	1	5	–	–	–	–	–	–	–	–
Juncus balticus	–	1	–	–	–	–	–	1	–	–	–	–
Bromus carinatus	–	–	–	–	–	2	2	3	–	–	–	–
Melica bulbosa	–	–	–	–	3	5	–	–	–	–	1	2
Poa compressa	–	–	–	–	–	–	6	6	–	–	3	3
Bromus brizaeformis	–	–	–	–	–	–	–	–	–	–	–	1
Luzula multiflora	–	–	–	–	–	–	–	–	–	–	2	2
Forbs												
Taraxacum officinale	23	42	18	44	19	38	25	49	10	39	15	36
Ranunculus acris	9	22	15	39	17	42	1	24	24	32	20	24
Senecio pseudareus	10	20	19	28	5	8	6	6	9	12	11	14
Trifolium repens	8	10	7	14	1	3	7	12	3	6	7	9
Prunella vulgaris	–	33	–	13	3	3	2	3	–	–	3	7
Osmorhiza chilensis	7	21	–	12	21	35	4	8	35	39	11	17
Viola adunca	10	21	3	12	1	2	1	4	8	15	2	7
Arenaria macrophylla	1	7	5	11	3	4	2	2	1	2	4	18
Galium vaillantii	2	10	1	7	6	13	1	3	6	11	7	11
Aster foliaceus	–	–	–	7	10	16	9	9	1	3	1	2
Geum macrophyllum	1	5	3	5	3	7	9	18	–	–	–	–
Achillea millefolium	2	6	1	4	2	4	–	3	3	9	1	3

Appendix D.
Table D-3. (Continued)

	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
Species	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$
Fragaria virginiana	-	2	-	3	-	-	-	-	-	-	-	-
Fragaria vesca	1	2	1	3	-	-	-	-	-	-	-	1
Rumex acetosella	8	8	1	2	1	1	1	1	2	8	2	2
Epilobium glaberrimum	-	-	-	2	-	-	-	-	-	-	-	-
Plantago major	-	3	-	-	-	-	-	-	-	-	-	-
Montia perfoliata	2	6	2	6	8	15	8	11	4	8	8	20
Smilacena stellata	2	6	2	6	1	3	3	10	-	3	10	21
Trifolium pratense	-	1	-	-	-	1	-	-	2	3	-	-
Cirsium vulgare	-	1	-	-	-	-	-	-	-	-	-	-
Trillium petiolatum	-	1	-	-	2	9	-	3	-	2	2	2
Vicia americana	-	1	-	-	-	3	1	9	1	3	2	7
Aquilega formosa	7	1	-	-	-	-	-	-	-	-	-	-
Mentha arvensis	-	0.5	-	-	-	-	-	-	-	-	-	-
Cerastium viscosium	-	-	-	-	1	3	4	8	6	6	3	8
Urtica gracilis	-	-	-	-	1	1	-	-	-	-	-	-
Sisymbrium altissimum	-	-	-	-	1	3	-	-	1	1	-	-
Nemophila pedunculata	-	-	-	-	-	1	-	-	2	5	-	-
Aster campestris	-	-	-	-	-	2	-	-	-	-	-	-
Lithophragma parviflora	-	-	-	-	-	-	7	9	2	7	8	11
Epilobium paniculatum	-	-	-	-	-	-	1	1	-	2	-	-
Medicago lupulina	-	-	-	-	2	4	3	6	3	8	-	-
Collinsia parviflora	-	-	-	-	-	-	-	-	3	3	-	-
Viola nuttallii	-	-	-	-	-	-	-	-	-	1	-	1
Galium boreale	-	-	-	-	-	-	-	-	2	3	-	-
Tragopogon dubius	-	-	-	-	-	-	-	-	1	1	-	-
Astragalus canadensis	-	-	-	-	-	-	-	-	-	1	1	3
Veronica arvensis	-	-	-	-	-	-	-	-	1	2	1	2
Solidago missouriensis	-	-	-	-	-	-	-	-	-	1	-	-
Lactuca serriola	-	-	-	-	-	-	-	-	1	2	1	1
Hydrophyllum capitatum	-	-	-	-	-	-	-	-	-	2	-	1
Potentilla glandulosa	-	-	-	-	-	-	-	-	-	-	-	1
Agoseris glauca	-	-	-	-	-	-	-	-	-	-	1	1
Verbascum thapsus	-	-	-	-	-	-	-	-	-	-	1	1
Unknown caryophyllaceae	-	-	-	-	1	1	10	18	-	-	-	-
Unknown forb	-	8	-	8	1	4	-	1	-	1	-	6

Appendix D
Table D-3. (Continued)

Species	1978				1979				1980			
	.0625m²	9,25n²	.0625m²	0.25m²	.0625m²	0.25m²	.0625m²	0.25m²	.0625m²	0.25m²	.0625m²	0.25m²
Shrubs												
Salix sp.	3	5	5	12								
Crataegus douglasii	3	7	5	8	3	9	1	4	3	13	1	3
Symphoricarpos albus	3	16	-	2	4	8	-	2	8	18	4	11
Rosa woodsii	5	9	-	2	4	5	1	8	-	2	6	8
Pinus ponderosa	-	1	-	1	-	-	1	1	-	1	-	-
Alnus incana	0.5	0.5	1	1	-	-	-	-	-	-	-	-
Populus tirchocarpa	-	-	-	-	-	1	-	1	1	3	-	-
Amelanchier alnifolia	-	-	-	-	2	4	-	--	1	1	-	-
Total Species		38		33		37		36		43		41
Diversity (H')		3.0973		2.8069		2.7799		2.7799		2.8267		2.8270
Equitability (J')		.8515		.8028		.7582		.7757		.7515		.7613
McArthur's Difference Value			1.1243				1.1222				1.1354	
No. Plots Sampled		90		90		120		90		90		90

Appendix D

Table D-4. Poa pratensis - mixed forbs

Species	1978 Grazed .0625m²	1978 Grazed 0.25m²	1978 Exclosed .0625m²	1978 Exclosed 0.25m²	1979 Grazed .0625m²	1979 Grazed 0.25m²	1979 Exclosed .0625m²	1979 Exclosed 0.25m²	1980 Grazed .0625m²	1980 Grazed 0.25m²	1980 Exclosed .0625m²	1980 Exclosed 0.25m²
Graminoids												
Poa pratensis	98	99	98	100	99	100	99	100	100	100	100	100
Festuca elatior	5	5	13	17	6	9	-	-	4	4	-	-
Phleum pratense	5	10	4	7	7	9	1	6	2	5	-	1
Agrostis alba	-	0.5	2	3	3	40	-	-	17	18	1	2
Agropyron repens	3	4	1	3	3	5	-	-	5	6	10	11
Bromus marginatus	2	2	9	13	4	11	-	-	6	7	-	-
Bromus tectorum	3	7	6	10	4	7	3	5	7	11	1	6
Elymus glaucus	1	2	1	1	-	-	-	-	-	1	-	-
Bromus recemosus	4	3	-	-	3	4	5	5	9	12	-	-
Melica bulbosa	-	-	-	-	2	3	-	-	7	9	-	-
Poa compressa	-	-	-	-	-	-	-	-	1	2	-	-
Poa ampla	-	-	-	-	-	-	-	-	1	1	-	-
Juncus balticus	1	3	-	-	2	2	2	3	4	7	-	-
Carex aquatiis	1	1	-	-	-	-	-	-	-	-	-	-
Carex sp.	1	3	-	-	2	5	-	-	0.5	0.5	-	-
Oval sedges		-	-	-	-	5	-	-	5	7	1	3
Carex stiptata	-	-	-	-	-	-	2	2	-	-	-	-
Forbs												
Erodium cicutarium	17	25	11	57	2	4	-	2	22	26	6	11
Achillea millefolium	28	51	33	56	41	66	22	35	40	54	14	28
Trifolium repens	13	21	22	35	16	25	6	9	9	17	6	8
Cerastium viscosum	14	21	13	17	25	26	9	17	15	20	3	8
Taraxacum officinale	13	34	11	16	30	51	28	45	27	40	20	30
Lupinus leucophyllus	5	6	3	13	7	11	-	-	9	15	5	12
Aster foliaceus	6	14	1	8	20	33	8	12	18	24	13	18
Ranunculus acris	11	19	3	4	35	41	19	25	26	36	8	14
Vicia americana	-	3	4	10	-	-	2	7	3	7	.9	16
Fragaria virginiana	6	11	5	8	9	17	-	-	10	13	-	-
Fragaria vesca	-	1	-	-	1	1	-	-	-	-	-	-
Veronica arvensis	-	-	-	-	10	15	-	-	35	43	25	41
Cirsium vulgare	-	4	3	11	3	9	2	11	2	3	3	8
Tragopogon dubius	1	5	-	4	-	-	0.5	0.5	1	2	-	-
Rumex acetosella	-	1	1	4	2	6	1	3	8	13	-	-
Trifolium pratense	-	-	-	2	1	3	-	-	5	8	-	-

Appendix D
Table D-4. (Continued)

Species	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	.0625m²	0.25m²	.0625m²	0.25m²	.0625m²	0.25m²	.0625m²	0.25m²	.0625m²	0.25m²	.0625m²	0.25m²
Medicago lupulina	5	14	1	1	12	16	7	8	14	23	2	8
Plantago major	-	1	1	1	-	-	-	-	-	-	-	-
Viola adunca	8	9	-	0.5	3	8	-	-	3	8	-	2
Potentilla gracilis	2	5	-	0.5	-	0.5	-	-	0.5	2	-	-
Collomia graniflora	2	5	-	0.5	-	-	-	-	-	2	-	-
Epilobium paniculatum	-	1	-	0.5	0.5	-	0.5	4	4	8	12	27
Lactuca serriola	-	1	-	0.5	-	-	-	-	-	1	-	-
Geum macrophyllum	-	0.5	-	0.5	0.5	2	4	6	-	-	1	3
Equisetum arvense	-	0.5	-	0.5	-	-	-	-	-	-	-	-
Senecio pseudareus	3	8	-	-	6	8	-	-	2	4	-	-
Prunella vulgaris	1	3	-	-	-	0.5	-	-	2	2	-	-
Antennaria rosea	-	2	-	-	-	0.5	-	-	2	3	-	-
Potentilla glandolosa	1	2	-	-	-	-	-	-	-	-	-	-
Dipsacus sylvestris	0.5	1	-	-	2	5	-	-	-	-	-	-
Verbascum thapsus	-	1	-	-	-	-	-	-	0.5	0.5	1	2
Lepidium perfoliatum	-	0.5	-	-	-	-	-	-	0.5	2	-	-
Geranium viscosissimum	-	1	-	-	-	-	-	-	-	-	-	-
Smilacina stellata	0.5	0.5	-	-	-	-	-	-	-	-	-	-
Erigeron pumulis	0.5	1	-	-	-	-	-	0.5	-	-	-	-
Montia perfoliata	-	-	-	-	-	1	-	-	-	2	1	5
Equisetum arvense	-	-	-	-	-	1	-	-	-	-	-	1
Polygonum douglasii	-	-	-	-	-	1	-	-	-	-	-	-
Agoseris glauca	-	-	-	-	4	5	-	-	2	5	-	-
Draba verna	-	-	-	-	-	0.5	-	-	11	18	5	8
Plantago major	-	-	-	-	-	1	1	2	0.5	2	-	-
Galium vaillantii	-	-	-	-	-	-	-	-	1	1	-	-
Gilia capillaris	-	-	-	-	-	-	0.5	1	4	7	8	17
Nemophila breviflora	-	-	-	-	-	-	1	2	-	-	-	-
Collinsia parviflora	-	-	-	-	-	-	-	-	4	8	25	51
Geranium bicknellii	-	-	-	-	-	-	-	-	3	4	-	-
Aquilegia formosa	-	-	-	-	-	-	-	-	-	0.5	-	-
Epilobium glaberrimum	-	-	-	-	-	-	-	-	-	0.5	-	-
Galium boreale	-	-	-	-	-	-	-	-	-	0.5	-	-
Holosteum umbellatum	-	-	-	-	-	-	-	-	2	4	1	5
Stellaria nitens	-	-	-	-	-	-	-	-	2	4	-	2
Astragalus canadensis	-	-	-	-	-	-	-	-	-	0.5	3	5
Penstemon rydbergii	-	-	-	-	-	-	-	-	-	-	1	2
Allium acuminatum	-	-	-	-	-	-	-	-	-	-	-	1
Unknown Caryophyllaceae	-	-	-	-	2	6		-	13	23	-	2
Unknown rosettes	13	20	7	20	2	4	-	2	3	6	1	2
Erigeron sp.	0.5	1	-	-	-	-	-	-	-	-	-	-

Appendix D
Table D-4. (Continued)

Species	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$
Shrubs												
Symphoricarpos albus	0.5	2	-	0.5	0.5	0.5	0.5	1	-	-	1	3
Rosa woodsii	-	0.5	-	0.5	-	-	-	-	0.5	2	-	-
Crataegus douglasii	1	2	-	-	0.5	2	-	-	-	0.5	-	-
Conifer seedling	-	-	-	-	0.5	2	-	-	-	-	-	-
Total species		50		34		44		26		59		35
Diversity (H')		2.997		2.3949		3.0578		1.8847		3.3162		2.8701
Evenness (J')		.7651		.6794		.8080		.57847		.8133		.8072
McArthur's Difference			1.1692				1.1215				1.1534	
Number of Plots Sampled		210		150		180		150		180		150

Appendix D

Table D-5. Poa pratensis - Phleum pratense - mixed grasslikes

Species	1978 Grazed $.0625m^2$	1978 Grazed $0.25m^2$	1978 Exclosed $.0625m^2$	1978 Exclosed $0.25m^2$	1979 Grazed $.0625m^2$	1979 Grazed $0.25m^2$	1979 Exclosed $.0625m^2$	1979 Exclosed $0.25m^2$	1980 Grazed $.0625m^2$	1980 Grazed $0.25m^2$	1980 Exclosed $.0625m^2$	1980 Exclosed $0.25m^2$
Graminoids												
Poa pratensis	91	92	90	91	99	100	94	100	100	100	100	100
Phleum pratense	78	89	81	91	49	74	21	33	47	73	15	40
Carex aquatilis	23	26	30	33	-	-	-	-	24	26	32	36
Juncus balticus	29	29	24	24	18	33	28	36	28	35	23	24
Agrostis alba	18	22	-	29	12	4	8	9	11	18	12	18
Oval sedges	-	-	-	-	6	14	12	23	14	26	13	21
Glyceria striata	7	8	7	8	1	1	-	-	-	-	-	-
Agropyron repens	-	1	-	-	-	-	-	-	-	-	-	-
Bromus carinatus	-	-	-	-	5	7	-	-	-	1	1	3
Bromus teccorum	-	-	-	-	-	-	-	-	-	-	-	-
Elymus glaucus	-	-	-	-	-	-	-	-	-	-	-	-
Melica bulbosa	-	-	-	-	-	1	-	-	1	1	-	-
Bromus racemosus	-	-	-	-	-	1	-	-	-	-	-	-
Luzula multiflora	-	-	-	-	-	2	-	-	-	-	-	-
Festuca elatior	3	8	4	10	-	3	-	-	8	10	8	10
Carex stiptata	-	-	-	-	14	17	20	31	9	9	12	25
Poa compressa	-	-	-	-	2	2	-	-	-	-	-	-
Agrostis diegoensis	-	-	-	-	-	-	-	-	-	-	1	4
FORBS												
Ranunculus acris	34	49	57	74	36	44	38	55	42	55	64	80
Aster foliaceus	33	47	27	47	45	57	32	49	46	57	47	55
Trifolium repens	29	44	29	37	27	33	8	12	25	32	9	19
Taraxacum officinale	34	42	21	34	21	38	32	52	26	44	34	38
Achillea millefolium	28	57	28	38	40	62	23	33	48	60	14	36
Potentilla gracilis	-	24	-	24	21	31	8	20	29	38	10	27
Cerastium viscosum	12	20	13	19	27	45	19	24	-	-	-	-
Trifolium pratense	10	1	4	5	4	6	3	8	12	18	7	10
Medicago lupulina	1	5	1	3	14	17	5	7	9	16	8	13
Viola adunca	-	5	2	5	6	9	3	6	14	22	20	24
Vicia americana	1	6	1	6	11	20	1	4	10	24	11	18
Senecio pseudareus	2	3	-	-	2	3	2	3	15	16	-	1
Caryophyllaceae spp.	-	-	-	-	1	3	-	1	13	18	16	21
Fragaria virginiana	8	16	9	17	3	9	-	1	5	10	7	12
Fragaria vesca	-	8	-	8	-	2	1	1	1	1	-	1

Appendix D
Table D-5. (Continued)

Species	1979				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	.0625m²	0.15m²	.0625m²	0.25m²	.0625m²	0.25m²	.0625m²	0.25m²	.0625m²	0.25m²	.0625m²	0.25m²
Veratrum californicum	4	6	4	7	2	4	4	12	3	8	3	3
Geum macrophyllum	-	5	-	5	1	2	3	5	1	4	-	3
Cirsium vulgare	2	3	3	5	-	2	1	1	1	4	3	6
Rumex acetosella	2	3	1	2	2	5	-	-	3	6	3	6
Plantago major	-	-	-	1	-	-	-	1	1	3	-	-
Tragopogon dubius	-	-	-	-	-	12	-	-	-	-	-	-
Prunella vulgaris	1	1	-	-	-	-	-	-	1	1	1	1
Veronica arvensis	-	-	-	-	2	5	1	1	10	18	-	7
Montia linearis	-	-	-	-	9	15	6	14	1	3	10	16
Collinsia parviflora	-	-	-	-	1	1	-	-	7	9	-	1
Draba verna	-	-	-	-	1	2	-	-	3	4	1	2
Lupinus leucophyllus	-	-	-	-	1	2	1	1	3	3	2	7
Sidalcea oregana	-	-	-	-	2	3	-	-	2	3	-	-
Erodium cicutarium	-	-	-	-	4	8	-	-	-	-	-	-
Epilobium paniculatum	-	-	-	-	-	-	1	2	2	3	-	1
Gilia capillaris	-	-	-	-	3	8	-	-	2	5	-	-
Verbascum thapsus	-	-	-	-	1	2	-	-	-	-	-	-
Geranium bicknellii	-	-	-	-	-	1	-	-	1	1	-	-
Collomia graniflora	-	-	-	-	-	1	-	-	-	-	-	-
Polygonum douglasii	-	-	-	-	1	1	-	-	-	-	-	-
Penstemon rydbergii	-	-	-	-	1	1	-	-	3	3	-	-
Liliaceae sp.	-	-	-	-	-	2	-	-	-	-	-	-
Trillium petiolatum	-	-	-	-	-	-	-	2	-	-	-	2
Solidago missouriensis	-	-	-	-	-	-	1	1	-	-	-	-
Brassicaceae sp.	-	-	-	-	-	-	-	-	-	-	1	1
Galium boreale	-	-	-	-	-	-	-	-	2	3	-	-
Astragalus canadensis	-	-	-	-	-	-	-	-	2	3	-	-
Galium vaillantii	-	-	-	-	-	-	-	-	-	1	-	-
Stellaria sp.	-	-	-	-	-	-	-	-	7	15	1	2
Aster sp.	-	-	-	-	-	-	-	-	2	2		2
Agoseris glauca	-	-	-	-	-	-	-	-	5	6	-	-
Antennaria rosea	-	-	-	-	-	-	-	-	5	6	-	-

Appendix D
Table D-5. (Continued)

Species	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$
Viola nuttallii	-	-	-	-	-	-	-	-	-	1	-	-
Castilleja sp	-	-	-	-	-	-	-	-	-	1	-	-
Epilobium glaberrimum	-	-	-	-	-	-	-	-	-	1	1	1
Rumex occidentalis	-	-	-	-	-	-	-	-	1	1	1	1
Mimulus guttatus	-	-	-	-	-	-	-	-	1	1	1	1
Besseya rubra	-	-	-	-	-	-	-	-	6	7	6	8
Equisetum variegatum	-	-	-	-	-	-	-	-	-	-	1	4
Potentilla glandulosa	-	-	-	-	-	-	-	-	-	-	-	2
Shrubs												
Rosa woodsii	-	-	-	-	-	-	-	-	-	-	2	3
Total Species		26		24		51		32		53		49
Diversity (H')		2.7544		2.6887		3.1306		2.7930		3.2737		3.2030
Evenness (J')		.8356		.8460		.7962		.8059		.8245		.8230
McArthur's Difference Value		1.080	1.080				1.0947				1.0617	
Number of Plots Sampled		90		90		120		90		120		90

Appendix D

Table D-6. *Crataegus douglasii*/*Poa pratensa* - mixed forbs

Species	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$
Graminoids												
Poa pratensis	98	100	91	94	97	98	97	100	99	100	99	100
Festuca elatior	1	1	19	27	-	-	1	1	1	2	5	9
Bromus tectorum	1	1	20	20	2	3	5	7	-	1	5	5
Phleum pratense	5	8	11	19	2	3	3	7	1	2	2	5
Bromus racemosus	-	0.5	1	10	9	13	11	13	-	1	5	7
Bromus carinatus	2	5	3	7	5	8	5	5	7	12	4	7
Agrostis alba	12	13	5	9	9	12	-	-	12	17	1	3
Elymus glaucus	3	10	3	3	-	-	-	-	-	1	-	0.5
Agropyron repens	1	6	-	0.5	3	3	1	2	2	3	-	-
Melica bulbosa	-	0.5	-	-	2	3	-	-	1	5		
Trisetum canescens	-	0.5	-	-	2	3	-	-	2	2	-	-
Festuca idahoensis	-	-	-	-	-	-	0.5	0.5	-	-	-	-
Poa compressa	-	-	-	-	-	1	0.5	0.5	-	-	-	-
Unknown grass sp.	-	0.5	-	-	-	-	0.5	0.5	-	-	-	-
Juncus balticus	-	0.5	-	-	5	7	1	3	1	4	-	-
Carex geyeri	-	-	-	-	-	-	-	-	1	1	-	-
Luzula multiflora	-	-	-	-	-	-	-	-	-	-	-	0.5
Carex sp.	1	3	5	9	6	10	3	4	1	3	-	-
Carex stiptata	-	-	-	-	-	-	0.5	1	-	-	-	
Oval head sedges	-	-	-	-	9	11	-	1	5	11	1	3
Forbs												
Achillea millifolium	13	30	38	58	23	39	31	51	28	50	35	54
Taraxacum officinale	30	42	21	38	50	71	32	53	30	52	21	39
Cerastium viscosum	17	29	26	35	28	43	20	32	22	38	12	23
Viola adunca	2	16	13	26	8	18	7	13	22	39	11	20
Trifolium repens	7	13	13	26	11	18	11	20	18	27	8	15
Aster foliaceus	19	33	14	25	19	25	19	24	26	39	11	24
Vicia americana	4	7	6	17	5	12	3	9	5	10	7	17
Medicago lupulina	6	14	7	16	18	30	15	22	5	12	3	3
Ranunculus acris	9	19	9	13	33	40	11	20	43	62	7	11
Fragaria virginiana	5	14	10	18	4	9	12	20	8	12	7	11
Erodium cicutarium	3	5	2	5	1	1	-	-	-	-	1	2
Senecio pseudarcus	1	2	3	5	3	4	5	9	7	13	-	3
Trifolium pratense	4	5	0.5	4	2	4	4	7	2	4	-	0.5
Prunella vulgaris	1	4	2	4	3	7	1	4	7	13	1	3
Tragopogon dubius	-	0.5	0.5	4	-	1	-	3	1	1	-	0.5

Appendix D
Table D-6. (Continued)

Species	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$
Agoseris glauca	-	-	2	4	-	-	-	1	-	-	2	7
Equisetum arvense	-	0.5	-	2	4	4	1	2	9	14	-	-
Cirsium vulgare	3	5	-	2	1	3	3	5	-	-	4	11
Collomia grandiflora	-	0.5	-	2	1	3	2	4	1	3	7	8
Antennaria rosea	-	0.5	0.5	2	-	-	0.5	1	-	-	3	5
Fragaria vesea	-	7	1	2	6	10	0.5	2	3	3	0.5	0.5
Veratrum californicum	-	-	-	1	-	-	2	4	-	-	0.5	2
Verbascum thapsis	-	0.5	-	0.5	2	3	4	6	-	-	-	-
Potentilla gracilis	-	-	-	0.5	-	-	-	-	-	-	-	1
Epilobium glaberrimum	-	-	-	0.5	-	-	-	-	-	-	-	-
Galium vaillantii	0.5	1	0.5	0.5	-	2	-	-	3	7	-	-
Allium acuminatum	-	-	0.5	0.5	-	-	-	-	-	-	-	-
Aquilegia formosa	-	1	-	0.5	-	-	0.5	1	2	3	-	-
Trillium petiolatum	-	1	-	0.5	1	2	-	-	-	1	-	-
Smilacena stellata	0.5	3	-	-	-	-	-	-	-	-	-	-
Lactuca serriola	1	1	-	-	15	22	-	0.5	-	-	-	-
Geum macrophyllum	0.5	4	-	-	6	9	0.5	3	8	12	-	-
Osmorhiza chilensis	0.5	1	-	-	1	3	-	-	-	-	3	5
Rumex acetosella	0.5	0.5	-	-	1	7	0.5	1	2	7	4	5
Epilobium paniculatum	-	0.5	-	-	-	2	-	0.5	6	9	7	13
Plantago major	-	4	-	-	3	11	-	-	6	13	-	0.5
Besseya rubra	-	0.5	-	-	-	-	-	-	-	-	-	-
Geranium viscossimum	-	0.5	-	-	-	-	-	-	-	-	-	-
Dipsacus sylvestris	-	0.5	-	-	3	8	-	0.5	3	8	-	-
Cardaria draba	-	-	-	-	-	-	-	1	-	-	-	-
Veronica arvensis	-	-	-	-	3	6	0.5	3	15	24	21	30
Equisetum variegatum	-	-	-	-	-	1	-	-	3	4	-	-
Microsteris gracilis	-	-	-	-	1	3	1	3	3	7	21	34
Montia perfoliata	-	-	-	-	2	3	-	-	6	10	7	15
Habenaria dilatata	-	-	-	-	1	-	-	-	-	-	-	-
Mimulus guttatus	-	-	-	-	-	1	-	-	-	-	-	-
Geranium bicknellii	-	-	-	-	2	3	-	-	3	5	-	-
Stellaria graminea	-	-	-	-	-	-	-	-	-	2	-	0.5
Astragalus canadensis	-	-	-	-	-	-	-	-	1	4	0.5	2
Collinsia parviflora	-	-	-	-	-	-	-	-	16	26	22	24
Galium boreale	-	-	-	-	-	-	-	-	2	2	-	1
Draba verna	-	-	-	-	-	-	-	-	2	3	2	5
Nemophila pedunculata	-	-	-	-	-	-	-	-	3	4	-	-
Holosteum umbellatum	-	-	-	-	-	-	-	-	1	5	-	-
Lithophragma parvifolia	-	-	-	-	-	-	-	-	1	1	4	7
Ranunculus uncinatus	-	-	-	-	-	-	-	-	-	1	-	-

Appendix D
Table D-6. (Continued)

Species	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$
Unknown caryophyllaceae	1	6	-	3	2	4	1	2	3	7	3	7
Unknown Forbs	-	-	-	-	3	3	2	5	2	3	1	3
<u>Lathyrus</u> sp	-	-	-	-	-	-	-	-	3	3	-	-
<u>Shrubs</u>												
<u>Crataegus douglasii</u>	5	11	1	3	3	9	2	5	6	9	0.6	1
<u>Symphoricarpos albus</u>	5	16	1	1	2	3	0.5	0.5	1	5	0.5	0.5
<u>Rosa woodsii</u>	1	4	0.5	2	3	3	-	-	1	1	0.5	0.5
Conifer seedlings	-	-	0.5	0.5	-	4	-	2	-	2	-	0.5
<u>Amelanchier alnifolia</u>	-	0.5	-	-	3	4	-	-	-	-	-	-
<u>Alnus incana</u>	-	-	-	-	-	-	-	0.5	-	-	-	-
Total Species		53		44		56		51		61		51
Diversity (H')		3.0194		2.9464		3.3976		3.0300		3.4259		3.2527
Evenness (J')		.7605		.7786		.8517		.7785		.8334		.8273
McArthur's Difference Value			1.0898				1.1154				1.1375	
Number Plots Sampled		120		150		120		150		120		150

Appendix D

Table D-7. Pinus ponderosa/Poa pratens

Species	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$
Graminoids												
Poa pratensis	94	98	97	97	94	100	97	99	100	100	94	97
Carex sp.	1	2	-	1	2	5	3	4	1	6	-	1
Carex geyeri	-	-	-	-	10	16	-	-	2	3	-	-
Phleum pratense	2	4	-	-	2	4	-	-	-	2	-	-
Trisetum canescens	7	8	-	-	1	2	-	-	-	3	-	-
Bromus tectorum	6	31	36	41	-	-	10	14	1	3	6	11
Agrostis alba	-	-	-	-	-	-	1	1	-	-	-	-
Bromus racemosus	-	8	21	23	-	1	11	16	-	1	-	2
Melica bulbosa	-	-	-	-	-	1	-	-	1	2	-	-
Festuca elatior	3	13	-	2	-	4	-	-	-	-	2	3
Poa compressa	-	-	-	1	1	3	4	7	1	2	-	-
Agropyron repens	-	-	-	-	-	-	7	10	-	-	-	-
Elymus glaucus	2	19	-	3	-	1	7	19	4	4	9	30
Bromus carinatus	3	8	3	3	-	-	-	-	1	7	-	-
Agropyron repens	1	1	-	-	-	-	-	-	-	-	5	12
Juncus balticus	2	3	-	-	-	-	-	-	-	-	-	-
Luzula multiflora	-	-	-	-	-	-	-	-	3	7	-	-
Forbs												
Arenaria macrophylla	24	34	3	12	11	22	2	3	16	23	4	7
Achillea millefolium	22	30	7	12	31	46	-	1	29	44	4	8
Taraxacum officinale	21	34	3	5	18	38	4	7	15	28	1	2
Ranunculus acris	12	29	-	-	12	19	-	1	17	21	4	8
Trifolium repens	11	18	-	1	19	25	-	-	7	13	2	4
Aster foliaceus	13	22	3	3	30	43	-	1	18	23	4	10
Cerastium viscosum	-	-	-	-	16	21	1	3	1	4	1	1
Vicia americana	2	6	-	-	11	27	-	-	5	18	-	1
Fragaria vesca	1	4	-	2	-	3	-	-	-	-	-	-
Galium vailantii	-	2	-	2	2	4	6	7	1	1	11	17
Ozmorhiza chilensis	-	1	-	2	3	5	3	13	-	2	7	11
Viola adunca	3	8	-	1	5	12	-	-	2	6	1	2
Geum macrophyllum	-	2	-	1	-	-	-	-	-	-	-	-
Dipsacus sylvestris	-	1	-	1	-	-	-	-	-	-	-	-
Tragopogon dubius	-	-	-	1	-	-	-	1	-	1	-	-

Appendix D
Table D-7. (Continued)

Species	1978 Grazed .0625m²	1978 Grazed 0.25m²	1978 Exclosed .0625m²	1978 Exclosed 0.25m²	1979 Grazed .0625m²	1979 Grazed 0.25m²	1979 Exclosed .0625m²	1979 Exclosed 0.25m²	1980 Grazed .0625m²	1980 Grazed 0.25m²	1980 Exclosed .0625m²	1980 Exclosed 0.25m²
Urtica gracilis	-	-	-	1	-	-	-	1	-	-	-	1
Rumex acetosella	-	-	-	1	2	3	-	3	1	3	-	1
Solidago missouriensis	-	-	-	1	-	-	-	-	-	-	-	-
Agoseris glauca	-	-	-	1	-	2	1	2	-	-	-	-
Senecio pseudareus	12	18	-	-	7	17	-	-	-	-	-	-
Fragaria virginiana	8	16	-	-	9	10	-	-	4	12	-	2
Prunella vulgaris	2	4	-	-	-	-	-	-	3	3	-	-
Cirsium vulgare	2	3	-	-	-	2	-	-	3	8	-	-
Antennaria rosea	2	3	-	-	1	1	-	-	-	-	-	-
Potentilla glandulosa	-	3	1	3	-	-	-	-	-	-	-	-
Aquilega formosa	-	1	-	-	6	6	-	-	-	-	-	-
Plantago major	-	1	-	-	-	-	-	-	-	-	-	-
Smilacina stellata	-	0.5	-	-	-	1	1	2	-	-	1	1
Lupinus leucophyllus	-	0.5	-	-	4	9	-	-	4	8	-	-
Equisetum arvense	-	1	-	-	-	-	-	-	-	2	-	-
Lepidium perfoliatum	-	0.5	-	-	-	-	-	-	-	-	-	-
Trillium petiolatum	-	-	-	-	1	4	3	3	1	2	-	1
Trifolium pratense	-	-	-	-	-	-	-	1	-	1	-	-
Lactuca serriola	-	-	-	-	-	-	-	1				
Galium boreale	-	-	-	-	1	3	-	-	1	3	1	2
Lithophragma parviflora	-	-	-	-	-	-	1	2	1	5	2	4
Besseya rubra	-	-	-	-	1	1	-	-	-	-	-	-
Medicago lupulina	-	-	-	-	1	2	1	1	-	1	-	-
Montia perfoliata	-	-	-	-	1	1	6	14	-	-	-	-
Sidalcea oregana	-	-	-	-	1	1	-	-	-	-	-	-
Senecio serra	-	-	-	-	-	-	-	1	-	-	-	-
Veronica arvensis	-	-	-	-	-	-	1	2	1	2	3	4
Microsteris gracilis	-	-	-	-	-	1	-	-	-	2	2	11
Astragalus canadensis	-	-	-	-	-	-	-	-	1	7	-	2
Collinsia parvifloria	-	-	-	-	-	-	-	-	-	4	-	3
Allium acuminatum	-	-	-	-	-	-	-	-	-	1	-	-
Stellaria graminea	-	-	-	-	-	-	-	-	1	1	1	3
Hydrophyllum capitatum	-	-	-	-	-	-	-	-	-	-	1	2
Geranium bicknelli	-	-	-	-	-	-	-	-	-	-	2	7
Holosteum umbellatum	-	-	-	-	-	-	-	-	-	-	1	1
Potentilla gracilis	-	-	-	-	-	-	-	-	-	-	1	1
Veronica americana	-	-	-	-	-	-	-	-	-	-	1	1
Lathyrus sp	-	-	-	-	-	-	-	-	-	2	-	-
Unknown caryophyllaceae	-	-	-	-	1	2	2	11	3	6	1	2
Unknown lilliaceae	-	-	-	-	-	-	-	1	-	-	-	-
Unknown Forbs	9	13	10	12	-	1	1	3	-	1	-	-

Appendix D
Table D-7. (Continued)

Species	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$
Shrubs												
Symphoricarpos albus	6	10	-	10	9	17	1	1	-	-	-	-
Rosa woodsii	-	3	3	5	-	-	-	1	-	-	-	-
Crataegus douglasii	4	8	-	1	2	7	-	-	-	2	-	-
Salix spp.	-	-	-	1	-	-	-	-	-	-	-	1
Amelanchier alnifolia	-	-	-	-	-	1	-	-	1	2	2	4
Pinus ponderosa (Seedlings)	-	-	-	4	-	4	-	1	-	-	-	-
Berberis repens	-	-	-	5	-	1	-	-	-	-	-	-
Total Species		39		32		45		35		46		38
Diversity (H')		2.9554		2.3502		3.0466		2.5069		2.9921		2.7206
Evenness (J')		.8067		.6781		.8003		.7051		.7815		.7179
McArthur's Difference Value			1.256				1.376				1.220	
Number Plots Sampled		90		90		90		90		90		90

Appendix D

Table D-8. Symphoricarpus albus-Rosa woodsii/Poa pratensis

	1978				1979			
	Grazed		Exclosed		Grazed		Exclosed	
Species	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$
Graminoids								
Poa pratensis	97	97	97	100	99	100	94	97
Agrostis alba	5	10	12	13	4	7	-	1
Bromus racemosus	4	7	10	12	3	5	16	18
Elymus glaucus	2	5	5	10	1	3	4	6
Agropyron repens	-	6	-	5	2	3	2	9
Bromus tectorum	-	0.5	-	0.5	1	2	17	17
Bromus carinatus	-	-	-	0.5	-	2	7	7
Festuca elatior	-	-	-	0.5	1	2	-	-
Trisetum canescens	3	3	-	-	-	-	-	-
Phleum pratense	-	3	-	-	-	-	-	-
Oval head Carex spp.	-	9	16	16	10	16	-	3
Scirpus microcarpus	-	-	-	2	-	-	-	-
Juncus balticus	-	-	-	-	-	1	-	-
Phleum pratense	-	-	-	-	4	4	-	-
Melica bulbosa	-	-	-	-	2	2	-	-
Forbs								
Trifolium repens	32	40	39	45	13	18	4	5
Taraxacum officinale	12	27	24	41	16	34	19	47
Cerastium viscosum	-	7	13	31	12	20	1	2
Achillea millefolium	7	15	12	8	14	25	13	18
Aster foliaceus	5	8	2	5	11	24	1	4
Geum macrophyllum	7	7	4	16	10	11	4	8
Dipsacus sylvestris	-	-	15	16	1	2	-	-
Ranunculus acris	19	25	5	14	27	42	-	7
Rumex acetosella	-	-	3	10	-	2	1	1
Medicago lupulina	7	10	4	7	-	-	1	1
Fragaria virginiana	10	16	3	7	1	4	-	-
Cirsium vulgare	-	-	2	6	2	8	-	-
Erodium cicutarium	-	4	1	5	-	-	-	-
Prunella vulgaris	-	4	2	5	-	-	-	-
Trifolium pratense	2	5	-	4	7	9	-	-
Tragopogon dubius	3	5	-	4	2	4	-	-
Smilacina stellata	2	3	-	3	2	3	-	-
Osmorhiza chilensis	-	-	-	2	-	-	-	-
Lepidium perfoliatum	-	-	1	1	-	-	-	-
Epilobium glaberrimum	-	-	-	1	-	-	-	-
Senecio pseudareus	10	25	-	-	7	9	-	-

Appendix D
Table D-8. (Continued)

Species	1978 Grazed .0625m²	1978 Grazed 0.25m²	1978 Exclosed .0625m²	1978 Exclosed 0.25m²	1979 Grazed .0625m²	1979 Grazed 0.15m²	1979 Exclosed .0625m²	1979 Exclosed 0.25m³
Collomia linearis	5	6	-	-	1	1	-	3
Vicia americana	3	3	-	-	3	9	-	-
Epilobium paniculatum	1	1	-	-	-	1	-	2
Galium vailantii	-	1	-	-	1	3	-	-
Trillium petiolatum	1	2	-	-	3	4	1	1
Equisetum arvense	2	5	-	-	-	-	-	-
Fragaria vesca	-	0.5	-	-	1	8	1	1
Viola adunca	-	0.5	-	-	7	8	-	-
Geranium viscosissimum	-	0.5	-	-	-	-	-	-
Erigeron philadelphicus	-	0.5	-	-	-	-	-	-
Plantago major	-	0.5	-	-	-	-	-	-
Arenaria macorphylla	-	-	-	-	4	5	-	-
Capsella bursa-pastoris	-	-	-	-	-	-	-	1
Aquilegia formosa	-	-	-	-	2	4	-	2
Solidago missouriensis	-	-	-	-	1	1	-	-
Lactuca serriola	-	-	-	-	-	2	-	-
Microsteris gracilis	-	-	-	-	-	1	-	-
Montia perfoliata	-	-	-	-	2	3	-	-
Senecio serra	-	-	-	-	-	1	1	1
Prunella vulgaris	-	-	-	-	-	1	-	-
Verbascum thapsus	-	-	-	-	-	1	1	2
Ozmorhiza chilensis	-	-	-	-	-	1	-	-
Unknown forb	-	5	3	8	3	7	-	1
Shrubs								
Symphoricarpos albus	9	25	27	54	20	42	38	62
Rosa woodsii	20	35	-	10	21	36	12	19
Crataegus douglasii	1	2	2	5	-	2	-	1
Salix sp.	1	1	-	-	-	-	-	1
Total Species		40		34		45		30
Diveristy (H')		2.8656		2.7136		3.0984		2.7318
Evenness (J')		.7771		.7695		.8139		.8032
McArthur's Difference value			1.136				1.165	
Number Plots Sampled		60		60		90		120

Appendix D
Table D-9. Bromus tectorum

Species	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$
Graminoids												
Bromus tectorum	100	100	94	100	91	98	91	98	95	97	100	100
Poa pratensis	40	49	46	51	4	7	3	8	3	4	-	-
Bromus racemosus	-	3	2	7	13	18	-	-	5	8	-	-
Poa sandbergii	-	9	-	-	-	-	4	9	-	-	14	17
Festuca elatior	-	1	-	-	-	-	-	-	-	-	-	-
Elymus glaucus	-	2	-	-	-	-	-	3	-	-	-	-
Agropyron repens	-	-	-	-	-	-			-	0.5	-	-
Stipa occidentalis	-	-	-	-	1	3	-	-	0.5	1	-	-
Bromus brizaeformis	-	-	-	-	-		-	1		-	-	-
Poa bulbosa	-	-	-	-	-	-	-	-	-	0.5	-	-
Annual Poa sp.	-	-	-	-	-	-	-	-	-	0.5		
Unknown annual	-	-	-	-	-	-	-	-	-	1.0	-	4
Carex sp.	-	-	-	-	-	-	-	-	-	-	-	2
Juncus balticus	-	-	1	1	-	-	-	-	-	-	-	-
Forbs												
Erodium cicutarium	19	36	20	47	15	29	12	19	39	54	50	62
Achillea millifolium	14	21	17	26	14	24	-	9	5	9	2	7
Epilobium paniculatum	-	3	-	2	9	28	10	21	28	47	35	59
Lepidium perfoliatum	1	3	11	21	6	7	2	5	-	0.5	2	2
Polygonum douglasi	-	-	-	-	1	4	9	19	13	19	19	22
Taraxacum officinale	15	22	4	5	1	1	1	4	-	3	2	9
Tragopogon dubius	-	-	2	2	1	2	-	1	-	-	-	-
Agoseris glauca	-	-	-	2	1	1	-	-	-	-	-	-
Medicago lupulina	-	-	1	2	-	-	-	-	-	-	-	-
Allium accuminatum	-	-	2	2	-	-	-	-	-	-	-	4
Trifolium repens	-	-	-	1	-	-	-	-	0.5	0.5	-	-
Cerastium viscosum	-	33	17	24	1	1	-	-	-	2	-	2
Rumex acetosella	-	6	-	-	3	8	3	12	1	21	12	32
Erigeron pumilus	-	1	-	-	-	-	-	-	-	-	-	-
Viola adunca	-	1	-	-	-	-	-	-	-	-	-	-
Collomia grandiflora	8	9	-	-	11	22	20	22	6	11	-	-
Lactuca serriola	-	2	-	-	-	-	-	1	0.5	0.5	-	-
Aster campestris	-	1	-	-	-	-	-	-	-	-	-	-
Verbascum thapsus	-	4	2	3	-	2	-	1		0.5	-	-
Draba verna	-	-	-	-	3	9	-	-	3	8	4	10
Sisymbrium altissimum	-	-	-	-	-	1	-	-	-	0.5	-	2
Aster foliaceus	-	-	-	-	1	2	-	-	0.5	0.5	-	-
Cirsium vulgare	-	-	-	-	-	1	-	-	-	-	-	-
Vicia americana	-	-	-	-	2	6	-	-	-	-	-	-
Rumex occidentalis	-	-	-	-	-	2	-	-	-	-	-	-

Appendix D
Table D-9. (Continued)

Species	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$	$.0625m^2$	$0.25m^2$
Collinsia parviflora	-	-	-	-	-	1	-	-	7	11	5	13
Fragaria virginiana	-	-	-	-	1	1	-	-	-	1	-	-
Artemisia ludoviciana	-	-	-	-	-	-	-	3	-	-	-	-
Microsteris gracilis	-	-	-	-	4	10	4	9	18	26	-	-
Veronica arvensis	-	-	-	-	-	-	-	-	11	15	-	4
Capsella bursa-pastoris	-	-	-	-	-	-	-	-	0.5	0.5	-	-
Holosetum umbellatum	-	-	-	-	-	-	-	-	-	1	-	-
Mentha arvensis	-	-	-	-	-	-	-	-	-	0.5	-	-
Caryophyllaceae sp.	-	-	-	-	3	6	-	-	5	11	-	4
Unknown rosettes	19	20	-	7	-	1	-	-	7	12	-	-
Erigeron sp	-	-	-	-	3	8	-	-	-	-	-	-
Total Species		20		17		28		18		32		18
Annuals		10		7		12		6		9		6
Perennials		10		7		16		12		23		12
Diversity (H')		2.1559		2.1984		2.2453		2.0128		2.4988		2.3947
Evenness (j')		.7322		.8570		.6680		.7104		.7489		.7535
McArthur's Difference Value			1.315				1.176				1.113	
Number Plots Sampled		90		90		90		90		120		90

Appendix D

Table D-10. Poa pratensis - Bromus tectorum

Species	1978 Grazed .0625 m^2	1978 Grazed 0.25 m^2	1978 Exclosed .0625 m^2	1978 Exclosed 0.25 m^2	1979 Grazed .0625 m^2	1979 Grazed 0.25 m^2	1979 Exclosed .0625 m^2	1979 Exclosed 0.25 m^2
Graminoids								
Poa pratensis	91	94	59	78	80	90	86	92
Bromus tectorum	85	95	70	89	68	86	53	68
Bromus racemosus	13	17	33	33	18	23	32	39
Agropyron repens	-	1	-	1	1	2	-	-
Poa sandbergii	-	-	-	0.5	-	-	0.5	2
Poa compressa	-	-	-	0.5	-	-	-	-
Poa bulbosa	-	-	-	0.5	-	-	-	-
Bromus carinatus	-	0.5	-	-	-	-	-	-
Agropyron cristatum	-	0.5	-	-	0.5	1	-	-
Juncus balticus	-	-	-	-	0.5	1	-	0.5
Carex stiptata	-	-	-	-	-	-	0.5	1
Unknown grass	-	-	-	-	-	-	-	0.5
Forbs								
Erodium cicutarium	35	67	31	63	7	17	9	17
Achillea millifolium	22	37	11	29	31	53	15	36
Cerastium viscosum	6	29	6	10	0.5	2	7	13
Caryophyllaea spp.	3	5	1	2	14	26	5	10
Lactuca serriola	-	0.5	2	7	0.5	0.5	0.5	0.5
Lupinus leucophyllus	-	-	1	2	-	-	-	0.5
Verbascum thapsus	-	1	1	2	-	-	-	-
Tragopogon dubius	1	1	-	-	1	3	0.5	2
Epilobium paniculatum	-	0.5	-	-	1	1	2	5
Medicago lupulina	0.5	0.5	-	-	-	-	-	-
Allium acuminatum	0.5	0.5	-	-	-	-	-	-
Sisymbrium altissimum	-	0.5	-	-	1	3	-	-
Capsella bursa-pastoris	-	0.5	-	-	-	0.5	-	-
Lepidium perfoliatum	-	0	-	-	-	2	0.5	2
Taraxacum officinale	-	1	-	-	6	15	11	20
Vicia americana	1	3	-	-	4	9	1	2
Rumex acetosella	-	3	-	1	1	4	2	5
Antennaria rosea	-	0.5	-	-	-	-	-	-
Veronica arvensis	-	-	-	-	17	29	4	8
Microsteris gracilis	-	-	-	-	1	5	5	11
Collomia linearis	-	-	-	-	0.5	1	8	16
Polygonum douglasii	-	-	-	-	1	3	4	10
Agoseris glauca	-	-	-	-	-	1	0.5	3
Fragaria virginiana	-	-	-	-	0.5	0.5	-	-
Aster foliaceus	-	-	-	-	1	1	3	5

Appendix D
Table D-10. (Continued)

Species	1978				1979			
	Grazed		Exclosed		Grazed		Exclosed	
	.0625m²	0.15m²	.0625m²	0.25m²	.0625m²	0.25m²	.0625m²	0.25m²
Viola adunca	–	–	–	–	1	1	–	0.5
Potentilla gracilis	–	–	–	–	0.5	1	0.5	2
Trifolium pratense	–	–	–	–	1	1	–	0.5
Draba verna	–	–	–	–	1	3	–	0.5
Fragaria vesca	–	–	–	–	–	0.5	–	–
Geum macrophyllum	–	–	–	–	–	0.5	–	–
Trifolium repens	–	–	–	–	–	–	0.5	2
Cirsium vulgare	–	–	–	–	–	–	–	1
Trillium petiolatum	–	–	–	–	–	–	1	2
Ranunculus acris	–	–	–	–	–	–	1	2
Shrubs								
Symphoricarpos albus	–	2	–	2	0.5	1	–	–
Pinus ponderosa (Seedling)	–	–	–	–	–	0.5	0.5	2
Total Species		24		16		35		35
Diversity (H')		1.8210		2.0415		2.3674		2.5651
Evenness (J')		.5730		.7363		.6741		.7215
McArthur's Difference Value			1.0465				1.069	
Number Plots Sampled		210		90		210		180

APPENDIX E

Standing phytomass and utilization by livestock and big game in selected plant communities, 1978-1980 (Kg/ha).

Appendix E

Table E-1. Gravel Bars

Species	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.
Graminoids												
Agrostis alba	39	-	25	2	26	-	13	-	97	24	-	-
Poa pratensis	31	3	78	-	29	4	21	2	51	5	46	-
Oval head Carex sp.	31	3	41	7	55	6	108	0.5	50	13	73	-
Agrostis exarata	23	18	11	T	28	-	41	-	-	-	13	-
Deschampsia danthonoides	-	-	-	-	T	T	T	-	-	-	5	-
Bromus racemosus	T	-	8	-	T	-	T	-	33	-	T	-
Elymus glaucus	-	-	-	-	7	-	-	-	-	-	-	-
Juncus ensifolius	-	-	-	-	-	-	-	-	40	-	T	-
Poa ampla	-	-	8	-	-	-	-	-	-	-	-	-
Glyceria striata	-	-	-	-	-	-	35	-	-	-	1	-
Trisetum canescens	-	-	-	-	T	-	T	-	-	-	-	-
Bromus tectorum	T	-	-	-	T	-	-	-	-	-	-	-
Deschampsia caespitosa	-	-	-	-	-	-	-	-	-	-	-	-
Poa compressa	-	-	-	-	13	T	3	-	7	-	T	-
Agropyron repens	31	-	15	-	-	-	-	-	T	T	8	-
Phleum pratense	5	4	24	-	-	-	1	0.5	22	-	3	-
Juncus balticus	-	T	-	-	-	-	T	-	-	-	-	-
Scirpus microcarpus	-	-	-	-	-	-	-	-	-	-	-	-
Bromus carinatus	-	-	-	-	-	-	1	-	-	-	-	-
Carex stiptata	-	-	-	-	T	T	13	-	-	-	5	-
Aloepcurus aequalis	-	-	-	-	-	-	5	-	-	-	1	-
Muhlenbergia filiformis	-	-	-	-	-	-	-	-	7	-	4	-
Agrostis scabra	-	-	-	-	-	-	-	-	23	-	-	-
Vulpia sp.	-	-	-	-	T	-	T	-	T	-	-	-
Unknown grass	-	-	-	-	11	-	T	-	T	T	10	-
Juncus sp.	-	-	-	-	-	-	-	-	T	-	5	-
Poa sp.	-	-	-	-	T	-	-	-	-	-	57	-
Forbs and allies												
Trifolium repens	341	82	689	163	418	117	898	23	507	299	562	5
Taraxacum officinale	9	-	89	2	12	T	30	0.5	5	T	26	-
Epilobium glabberimum	T	T	18	-	9	-	60	-	17	T	33	-
Equisetum arvense	T	-	25	1	-	-	82	-	8	2	4	-
Verbascum thapsus	501	-	205	-	47	1	30	-	98	-	24	-
Medicago lupulina	53	16	3	-	37	1	22	-	1	0.5	-	-
Plantago major	T	-	17	-	2	T	13	-	2	-	12	-
Cerastium viscosum	T	-	T	-	6	-	-	-	T	-	T	-
Epilobium paniculatum	19	-	-	-	29	-	3	-	11	T	9	-
Aster foliaceus	127	-	-	-	44	4	T	-	56	24	116	-

Appendix E
Table E-1. (Continued)

Species	1978 Grazed Phyto.	1978 Grazed Util.	1978 Exclosed Phyto.	1978 Exclosed Util.	1979 Grazed Phyto.	1979 Grazed Util.	1979 Exclosed Phyto.	1979 Exclosed Util.	1980 Grazed Phyto.	1980 Grazed Util.	1980 Exclosed Phyto.	1980 Exclosed Util.
Rumex acetosella	3	-	19	10	1	-	T	-	5	T	-	-
Achillea millefolium	20	-	16	-	39	1	1	-	14	T	22	-
Prunella vulgaris	T	T	57	-	2	-	15	0.5	37	2	140	-
Lactuca serriola	T	-	21	-	2	-	-	-	-	-	9	-
Rumex crispus	256	T	-	-	6	-	-	-	-	-	-	-
Trifolium pratense	10	-	-	-	T	T	16	-	22	6	-	-
Ranunculus acris	-	T	-	-	5	-	5	-	T	T	T	-
Cirsium vulgare	69	-	6	-	3	-	6	-	T	-	T	-
Hypericum perfoliatum	-	-	-	-	-	-	T	-	-	-	-	-
Anophilis margaritaceae	-	-	-	-	23	-	-	-	-	-	6	-
Draba verna	-	-	-	-	T	-	T	-	T	-	T	-
Fragaria virginiana	-	-	1	-	T	-	T	-	-	-	-	-
Mimulus guttatus	-	-	-	-	-	-	2	-	T	-	2	-
Geum macrophyllum	-	-	192	-	T	-	T	-	T	T	-	-
Veronica americana	-	-	-	-	-	-	33	-	-	-	-	-
Cerastium viscosum	-	-	-	-	6	-	-	-	-	-	-	-
Dipsacus sylvestris	-	-	-	-	-	-	5	-	T	-	4	-
Tragopogon dubius	12	-	-	-	-	-	3	-	-	-	-	-
Solidago missouriensis	-	-	-	-	-	-	3	-	-	-	4	-
microsteris gracilis	-	-	-	-	1	-	-	-	T	-	-	-
Viola adunca	-	-	-	-	-	-	T	-	-	-	-	-
Stellaria graminea	-	-	-	-	1	-	-	-	-	-	-	-
Aster campestris	-	-	87	-	95	-	12	-	1	-	11	-
Polygonum aviculare	-	-	-	-	-	-	17	-	-	-	-	-
Polygonum douglasii	-	-	-	-	T	-	-	-	-	-	-	-
Collinsia parviflora	-	-	-	-	-	-	1	-	-	-	-	-
Mentha arvensis	-	-	-	-	-	-	34	-	-	-	T	-
Holosteum umbellatum	-	-	-	-	-	-	-	-	T	-	-	-
Veronica americana	-	-	-	-	-	-	-	-	T	-	-	-
Antennaria rosea	-	-	-	-	-	-	-	-	T	-	T	-
Veronica serpyllifolia	-	-	-	-	-	-	-	-	-	-	5	-
Erigeron philadelphicus	T	-	T	-	4	-	-	-	-	-	29	-
Erodium cicutarium	-	-	-	-	-	-	-	-	-	-	4	-
Hypericum analgaloides	-	-	-	-	-	-	-	-	-	-	T	-
Aster sp.	-	-	-	-	-	-	-	-	21	T	-	-
Caryophyllaceae spp.	-	-	-	-	-	-	-	-	3	-	-	-
Galium asperrimum	-	-	-	-	-	-	-	-	-	-	9	-
Potentilla gracilis	-	-	-	-	-	-	-	-	-	-	1	-
Unknown forbs	9	-	3	-	-	-	-	-	T	-	9	-
Rudbeckia occidentalis	-	-	-	-	-	-	-	-	-	-	34	-

Appendix E
Table E-1. (Continued)

Species	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.
Shrubs - Trees												
Populus trichocarpa	187	158	444	2	156	48	223	1	760	378	244	1
Salix rigida	T	T	58	5	212	64	45	1	250	120	393	T
Salix exigua	194	78	159	-	64	17	-	-	T	T	-	T
Alnus incana	T	-	T	-	-	-	16	-	T	-	101	-
Ribes sp.	T	-	-	-	-	-	-	-	-	-	-	-
Pinus ponderosa	T	-	-	-	-	-	-	-	5	-	-	-
Rosa woodsii	8	-	-	-	-	-	-	-	-	-	-	-
Artemisia ludoviciana	1	-	-	-	-	-	T	-	3	-	-	-
Crataegus douglasii	-	-	-	-	-	-	T	-	-	-	-	-
Unknown *Salix* sp.*	-	-	-	-	-	-	-	-	-	-	-	-
Total Phytomass (Kg/ha)	1973		2345		1389		1816		2156		2779	
Total Utilization (Kg/ha)		362		191		267		28		874		6
Percent Utilization		18.3		8.1		19.2		1.5		40.1		0.2

* Possibly *Salix exigua*

Appendix E

Table E-2. Alnus incana/Poa pratensis

	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
Species	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto	Util.	Phyto.	Util.	Phyto.	Util.
Graminoids												
Poa pratensis	807	250	860	1	493	140	788	12	924	160	1263	46
Oval carex spp.	37	7	145	-	81	-	-	-	82	19	42	-
Holcus lanatus	-	-	35	-	-	-	T	T	-	-	11	2
Phleum pratense	25	14	-	-	11	T	2	-	67	13	8	2
Trisetum canescens	3	-	20	-	T	-	-	-	-	-	-	-
Elymus glaucus	T	T	17	-	T	-	T	T	-	-	3	-
Agrostis alba	11	-	5	-	-	-	-	-	19	-	51	-
Bromus tectorum	-	-	7	-	T	-	-	-	-	-	-	-
Poa ampla	8	-	-	-	-	-	-	-	-	-	-	-
Agropyron repens	12	-	-	-	-	-	-	-	8	-	-	-
Bromus carinatus	T	T	-	-	-	-	-	-	-	-	-	-
Juncus balticus	5	-	-	-	-	-	45	1	-	-	T	-
Lg. Carex sp.	-	-	-	-	52	10	11	T	-	-	-	-
Poa compressa	-	-	-	-	73	4	6	-	T	T	-	-
Glyceria striata	-	-	-	-	14	T	245	49	-	-	3	1
Bromus racemosus	-	-	-	-	8	-	-	-	-	-	-	-
Melica bulbosa	-	-	-	-	T	T	-	-	8	-	119	
Agrostis scabra	-	-	-	-	-	-	T	T	-	-	-	-
Calamagrostis rubescens	-	-	-	-	8	-	-	-	-	-	-	-
Scirpus microcarpus	-	-	-	-	-	-	-	-	-	-	27	1
Unknown grass	-	-	-	-	T	T	T	T	T	-	-	-
Forbs												
Prunella vulgaris	57	-	17	-	T	T	15	T	19	T	5	-
Ranunculus acris	36	-	T	-	23	T	11	-	4	-	2	-
Geum macrophyllum	5	-	23	-	6	T	8	-	40	T	22	-
Rumex cripsus	-	-	17	-	-	-	-	-	-	-	-	-
Taraxacum officinale	11	-	16	-	23	-	19	-	29	T	9	T
Aster foliaceus	5	T	13	-	3	0.5	4	-	11	2	14	0.5
Arenaria macrophylla	8	T	11	-	T	-	T	T	6	T	T	-
Plantago major	-	-	11	-	-	-	-	-	-	-	-	-
Rumex acetosella	14	-	3	-	T	T	-	-	10	3	-	-
Achillea millefolium	4	-	3	-	19	-	17	-	17	-	7	-
Viola adunca	1	-	-	-	T	-	T	-	T	-	-	-
Epilobium glabberimum	-	-	4	-	T	T	T	-	-	-	-	-
Cirsium vulgare	3	-	-	-	T	T	-	-	T	-	T	-
Fragaria virginiana	1	-	T	-	T	-	-	-	1	-	T	-
Equisetum arvense	2	-	1	-	11	-	1	-	1	-	-	-
Osmorhiza chilensis	1	-	-	-	1	-	T	-	9	-	T	-
Senecio pseudareus	-	-	4	-	11	-	T	T	-	-	T	-
Mentha arvensis	T	-	-	-	-	-	5	-	T	-	-	-

Appendix E
Table E-2. (Continued)

Species	1978 Grazed Phyto.	1978 Grazed Util.	1978 Exclosed Phyto.	1978 Exclosed Util.	1979 Grazed Phyto.	1979 Grazed Util.	1979 Exclosed Phyto.	1979 Exclosed Util.	1980 Grazed Phyto.	1980 Grazed Util.	1980 Exclosed Phyto.	1980 Exclosed Util.
Medicago lupulina	-	-	T	-	T	-	-	-	T	-	-	-
Trifolium pratense	T	-	-	-	-	-	-	-				
Solidago missouriensis	3	-	-	-	-	-	-	-	11	-	-	-
Erodium cicutarium	1	-	-	-	-	-	-	-	-	-	-	-
Castillega cucksickii	T	-	-	-	-	-	-	-	-	-	-	-
Aquilegia formosa	-	-	4	-	-	-	-	-	-	-	-	-
Galium asperrimum	1	-	-	-	T	-	3	-	17	-	3	-
Trifolium repens	1	-	-	-	-	-	-	-	-	-	T	-
Cerastium viscosum	-	-	-	-	15	-	4	-	2	-	T	-
Dipsacus sylvestris	-	-	-	-	23	0.5	4	-	-	-	2	-
Stellaria graminea	-	-	-	-	-	-	T	-	8	-	2	-
Veronica arvensis	-	-	-	-	-	-	-	-	T	-	-	-
Thalictcum occidentale	-	-	-	-	-	-	-	-	9	-	-	-
Draba verna	-	-	-	-	-	-	-	-	T	-	-	-
Tragopagon dubius	-	-	-	-	-	-	-	-	4	-	13	-
Collinsia parviflora	-	-	-	-	-	-	-	-	-	-	T	-
Agoseris glauca	-	-	-	-	-	-	-	-	-	-	T	-
Lactuca serriola	-	-	-	-	-	-	5	-	-	-	-	-
Mimulus guttatus	-	-	-	-	T	T	-	-	-	-	-	-
Aster campestris	-	-	-	-	56	-	1	T	-	-	-	-
Montia perfoliata	-	-	-	-	21	-	-	-	-	-	-	-
Epilobium paniculatum	-	-	-	-	T	-	-	-	-	-	-	-
Viola nuttallii	-	-	-	-	T	-	-	-	-	-	-	-
Coilomia linearis	-	-	-	-	T	-	-	-	-	-	-	-
Fragaria vesca	-	-	-	-	1	-	T	-	-	-	-	-
Caryophyllaceae spp.	-	-	-	-	8	-	-	-	4	-	-	-
Aster sp.	-	-	-	-	-	-	-	-	27	-	-	-
Unknown forb	-	-	T	-	T	-	T	-	4	T	T	-
Shrubs												
Alnus incana (Seedlings)	T	-	T	-	T	T	T	-				
Rosa woodsii	11	-	8	-	-	-	T	-	16	-	-	-
Crataegus douglasii	1	-	T	-	-	-	T	T	4	-	T	-
Pinus ponderosa (Seedling)	-	-	-	-	T	T.	-	-	-	-	-	-
Amelanchier alnifolia	1	-	-	-	-	-	-	-	-	-	3	-
Artemisia ludoviciana	1	T	-	-	-	-	-	-	-	-	-	-
Salix spp.	T	T	-	-	-	-	-	-	-	-	-	-
Total Phytomass (Kg/ha)	1080		1206		962		1193		1369		1609	
Total Utilization (Kg/ha)		272		1		157		62		197		53
Percent Utilization		25.2		T		16.3		5.2		14.4		3.3

Appendix E.
Table E-3. Populus trichocarpa - mixed conifer

Species	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.
Graminoids												
Poa pratensis	1753	380	1523	14	853	92	738	7	1475	178	1446	T
Agrostis alba	-	-	-	-	8	-	T	-	208	-	-	-
Oval head Carex sp.	-	-	60	-	20	-	60	-	132	-	T	-
Bromus tectorum	-	-	21	-	-	-	T	-	-	-	T	-
Elymus glaucus	12	12	20	-	114	16	-	-	8	-	3	-
Phleum pratense	21	-	T	T	T	T	-	-	-	T	-	-
Agrostis exarata	-	-	20	-	-	-	-	-	-	-	-	-
Bromus racemosus	-	-	-	-	-	-	T	-	-	-	-	-
Trisetum canescens	-	-	-	-	-	-	9	0.5	-	-	42	-
Large Carex sp.	-	-	-	-	T	T	14	-	-	-	-	-
Juncus balticus	-	-	-	-	T	T	-	-	-	-	-	-
Poa compressa	-	-	-	-	-	-	T	T	-	-	T	-
Bromus carinatus	-	-	-	-	-	-	-	-	54	-	9	-
Festuca elatior	-	-	-	-	-	-	-	-	27	-	-	-
Festuca sp.	-	-	-	-	-	-	-	-	-	-	9	-
Forbs												
Taraxacum officinale	11	T	34	-	21	-	7	-	36	1	13	-
Geum macrophyllum	20	-	-	-	22	1	T	-	T	T	T	-
Ranunculus acris	1	T	T	T	14	-	25	-	28	T	2	-
Senecio pseudareus	8	-	-	-	6	-	9	-	11	-	22	-
Trifolium repens	1	1	4	-	T	-	T	-	4	1	9	-
Prunella vulgaris	-	-	3	-	2	T	2	0.5	-		T	-
Osmorhiza chilensis	17	-	T	T	9	-	13	-	-	-	19	-
Viola adunca	T	-	-	-	T	T	T	-	13	T	T	-
Arenaria macrophylla	T	-	T	T	3	-	10	-	-	-	T	-
Galium asperrimum	T	-	9	-	2	-	12	-	T	-	T	-
Aster foliaceus	3	-	-	-	7	-	3	-	73	3	2	-
Fragaria virginiana	T	-	-	-	1	-	T	-	T	-	-	-
Rumex acetosella	T	-	T	T	-	-	2	-	-	-	T	-
Plantago major	-	-	3	-	T	T	-	-	-	-	-	-
Smilacina stellata	5	-	-	-	8	-	7	-	3	-	-	-
Mentha arvensis	T	-	-	-	-	-	-	-	-	-	-	-
Rumex crispus	54	-	-	-	-	-	-	-	-	-	-	-
Trifolium pratense	-	-	-	-	T	-	T	-	-	-	T	-
Cerastium viscosum	-	-	-	-	2	-	T	-	T	-	6	-
Fragaria vesca	-	-	-	-	-	-	T	-	-	-	-	-
Montia perfoliata	-	-	-	-	3	-	4	-	-	-	T	-
Medicago lupulina	-	-	-	-	T	-	T	-	T	-	-	-
Vicia americana	-	-	-	-	T	-	-	-	19	-	-	-

Appendix E
Table E-3. (Continued)

Species	1978 Grazed Phyto.	1978 Grazed Util.	1978 Exclosed Phyto.	1978 Exclosed Util.	1979 Grazed Phyto.	1979 Grazed Util.	1979 Exclosed Phyto.	1979 Exclosed Util.	1980 Grazed Phyto.	1980 Grazed Util.	1980 Exclosed Phyto.	1980 Exclosed Util.
Stellaria graminea	-	-	-	-	5	-	T	-	-	-	-	-
Achillea millefolium	-	-	-	-	-	-	1	-	T	-	T	-
Aquilegia formosa	-	-	-	-	-	-	2	-	-	-	-	-
Collomia linearis	-	-	-	-	-	-	T	-	-	-	-	-
Urtica gracilis	-	-	-	-	-	-	T	-	-	-	-	-
Potentilla gracilis	-	-	-	-	-	-	T	-	-	-	-	-
Tragopogon dubius	-	-	-	-	-	-	T	-	-	-	-	-
Agoseris glauca	-	-	-	-	-	-	T	-	T	-	-	-
Potentilla glandulosa	-	-	-	-	-	T	-	-	-	-	-	-
Cirsium vulgare	-	-	-	-	-	-	-	-	T	T	-	-
Equisetum arvense	-	-	-	-	-	-	-	-	13	-	-	-
Mimulus guttatus	-	-	-	-	-	-	-	-	T	-	-	-
Veronica arvensis	-	-	-	-	-	-	-	-	-	-	T	-
Viola nuttallii	-	-	-	-	-	-	-	-	-	-	T	-
Geranium bicknellii	-	-	-	-	-	-	-	-	-	-	T	-
Dipsacus sylvestris	-	-	-	-	-	-	-	-	-	-	13	-
Collinsia parviflora	-	-	-	-	-	-	-	-	-	-	T	-
Stellaria nitins	-	-	-	-	-	-	-	-	-	-	T	-
Caryophyllaceae sp.	-	-	-	-	-	-	4	-	T	-	T	-
Unknown forb	-	-	-	-	T	-	3	-	-	-	2	-
Shrubs												
Populus trichocarpa (Sapling)	16	-	-	-	5	-	-	-	-	-	T	T
Crataegus douglasii	T	-	T	T	24	3	T	-	5	T	T	-
Symphoricarpos albus	581	208	894	16	82	-	T	-	25	-	5	-
Rosa woodsii	165	3	6	-	92	4	11	-	4	0.5	T	-
Amelanchier alnifolia	-	-	-	-	T	T	T	-	T	-	-	-
Pinus ponderosa	-	-	-	-	-	-	-	-	-	-	T	-
Total Phytomass (Kg/ha)	2668		2597		1291		938		2139		1602	
Total utilization (Kg/ha)		611		30		137		8.3		182		T
Percent Utilization		22.9		1.2		10.6		0.9		8.5		T

Appendix E

Table E-4. *Poa pratensis* – mixed forbs

Species	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.
Graminoids												
Poa pratensis	1912	1055	3534	58	2239	1779	2300	24	2771	2146	4028	–
Juncus balticus	65	17	–	–	55	28	–	–	55	22		
Agropyron repens	–	–	92	–	T	–	–	–	1	–	–	–
Bromus tectorum	25	–	–	–	T	–	2	–	38	T	–	–
Festuca elatior	11	–	–	–	1	–	–	–	11	–	–	–
Phleum pratense	8	T	26	–	21	–	9	1	–	–	24	–
Bromus carinatus	3	T	–	–	5	T	21	3	–	–	10	–
Oval *Carex* spp.	5	2	–	–	5	5	–	–	12	–	2	–
Bromus racemosus	–	–	–	–	26	–	T	–	13	–	–	–
Agrostis alba	–	–	–	–	12	–	T	–	–	–	–	–
Carex aquatilis	–	–	–	–	31	28	–	–	–	–	–	–
Poa compressa	–	–	–	–	–	–	T	–	–	–	–	–
Melica bulbosa	–	–	–	–	–	–	–	–	3	–	–	–
Unknown grass	–	–	–	–	6	–	–	–	–	–	–	–
Forbs and Allies												
Achillea millefolium	99	–	45	–	221	125	49	0.5	134	11	12	–
Aster foliaceus	101	41	41	–	46	10	15	T	106	43	25	–
Erodium cicutarium	44	22	18	1	–	–	–	–	36	T	–	–
Cerastium viscosum	3	–	21	–	T	–	T	–	–	–	–	–
Lupinus leucophyllus	259	26	T	T	52.	8	–	–	55	22	–	–
Ranunculus acris	–	–	37	–	–	–	T	–	–	–	T	–
Trifolium repens	T	T	13	–	T	–	T	–	–	–	T	–
Taraxacum officinale	T	T	11	–	3	T	–	–	3	–	4	–
Cirsium vulgare	–	–	59	–	68	–	8	–	–	–	2	–
Vicia americana	–	–	–	–	2	–	11	–	–	–	–	–
Tragopogon dubius	9	–	9	–	11	–	–	–	15	–	T	–
Rumex acetosella	50	–	–	–	–	–	T	T	–	–	T	–
Medicago lupilina	–	–	1	–	T	–	T	–	T	–	3	–
Viola adunca	5	–	–	–	T	T	–	–	T	T	–	–
Geum macrophyllum	–	–	7	–	–	–	42	–	T	–	T	–
Equisetum arvense	–	–	4	–	–	–	–	–	–	–	–	–
Prunella vulgaris	T	T	–	–	–	–	–	–	–	–	–	–
Potentilla glandulosa	16	–	–	–	–	–	–	–	–	–	–	–
Verbascum thapsus	T	T	–	–	T	–	5	–	–	–	T	–
Lepidium perfoliatum	–	–	T	–	–	–	–	–	–	–	–	–
Epilobium glaberrimum	–	–	–	–	–	–	–	–	T	–	–	–
Fragaria virginiana	–	–	–	–	–	–	–	–	T	T	–	–
Stellaria graminea	–	–	–	–	–	–	T	–	–	–	–	–

Appendix E
Table E-4. (Continued)

Species	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed-	
	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.
Epilobium paniculatum	-	-	-	-	5	-	T	-	57	-	34	-
Trillium petiolatum	-	-	-	-	T	-	-	-	-	-	-	-
Plantago major	-	-	-	-	-	-	-	-	-	-	T	-
Collomia linearis	-	-	-	-	-	-	-	-	3	-	-	-
Draba verna	-	-	-	-	T	-	-	-	T	-	T	-
Holosteum umbellatum	-	-	-	-	-	-	-	-	T	-	T	-
Microsteris gracilis	-	-	-	-	-	-	T	-	17	-	26	-
Veronica arvensis	-	-	-	-	T	-	-	-	25	-	3	-
Agoseris glauca	-	-	-	-	-	-	-	-	T	-	-	-
Lactuca serriola	-	-	-	-	3	-	-	-	T	-	-	-
Aquilegia formosa	-	-	-	-	-	-	-	-	T	-	-	-
Stellaria nitins	-	-	-	-	-	-	-	-	-	-	T	-
Collinsia parviflora	-	-	-	-	-	-	-	-	-	-	T	-
Nemophila pedunulata	-	-	-	-	-	-	-	-	-	-	T	-
Potentilla gracilis	-	-	-	-	18	-	-	-	T	T	-	-
Antennaria rosa	-	-	-	-	-	-	-	-	T	T	-	-
Penstemon rydbergii	-	-	-	-	-	-	-	-	-	-	T	-
Caryophyllaceae spp.	-	-	-	-	T	-	T	-	7	-	T	-
Aster sp.	-	-	-	-	-	-	-	-	2	-	-	-
Unknown forb	3	T	-	-	T	-	-	-	T	-	-	-
Erigeron philadelphicus	T	T	-	-	-	-	-	-	-	-	-	-
Allium acuminatum					T	-	-	-	-	-	-	-
Shrubs												
Symphoricarpos albus	-	-	21	-	-	-	T	T	-	-	-	-
Rosa woodsii	-	-	11	-	-	-	-	-	-	-	-	-
Pinus ponderosa	-	-	-	-	T	-	-	-	-	-	-	-
Total Phytomass (Kg/ha)	2620		3950		2829		2463		3371		4173	
Total Utilization (kg/ha)		1163		59		1983		29		2243		T
Percent Utilization		44.4		1.5		70.1		1.2	66.5			T

Appendix E

Table E-5. Poa pratensis - Phleum pratense - mixed grasslikes

Species	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.
Graminoids												
Poa pratensis	3299	2214	3464	8	3027	2429	1455	30	3679	2498	3963	T
Phleum pratense	2312	1753	1863	278	1418	1079	174	6	2037	1216	716	16
Carex spp.[1]	392	254	394	-	1496	1210	812	28	1889	1220	2961	T
Juncus balticus	402	220	388	-	164	71	566	T	49	14	322	-
Agrostis alba	32	30	83	-	16	-	6	T	43	-	70	-
Bromus carinatus	11	-	38	-	-	-	3	-	-	-	358	-
Bromus tectorum	-	-	5	-	-	-	-	-	-	-	-	-
Agropyron repens	-	-	31	-	-	-	T	-	-	-	13	-
Melica bulbosa	-	-	-	-	16	-	-	-	-	-	21	-
Oval head sedges[2]	-	-	-	-	10	-	8	-	86	-	-	-
Elymus glaucus	-	-	-	-	-	-	56	-	-	-	T	-
Koeleria cristata	-	-	-	-	-	-	25	-	-	-	-	-
Stipa occidentalis	-	-	-	-	-	-	11	-	-	-	-	-
Festuca elatior	-	-	-	-	-	-	-	-	29	-	5	-
Forbs												
Aster foliaceus	113	51	56	-	40	6	157	-	292	29	179	-
Potentilla gracillis	83	58	276	-	65	13	T	T	228	127	77	1
Ranunculus acris	52	15	50	2	14	T	71	-	75	T	56	-
Trifolium repens	196	116	177	-	T	-	T	-	12	-	T	T
Taraxacum officinale	35	3	21	-	T	-	T	T	8	T	T	-
Achillea millefolium	73	11	40	-	24	-	22	-	77	-	49	-
Cerastium viscosum	30	4	9	4	2	-	T	-	10	-	T	-
Fragaria virginiana	14	-	1	-	T	-	-	-	7	-	11	-
Vicia americana	T	-	T	-	30	-	116	-	2	-	T	-
Viola adunca	T	1	3	-	3	-	T	-	5	-	T	T
Cirsium vulgare	56	-	56	-	-	-	-	-	24	-	-	-
Medicago lupulina	25	-	T	-	-	-	-	-	T	-	T	-
Rumex acetosella	25	-	26	-	-	-	T	-	2	-	T	-
Plantago major	-	-	1	-	-	-	4	-	T	-	4	-
Tragopogon dubius	-	-	8	-	58	-	-	-	-	-	-	-
Antennaria rosea	-	-	T	-	-	-	T	-	-	-	-	-
Geum macrophyllum	-	-	-	-	16	-	T	-	6	-	13	-
Stellaria graminea	-	-	-	-	11	-	3	-	T	-	5	-
Veratrum californicum	-	-	-	-	117	-	-	-	48	-	134	-
Senecio pseudareus	-	-	-	-	T	-	T	-	-	-	4	-

Appendix E
Table E-5. (Continued)

Species	1978 Grazed Phyto.	1978 Grazed Util.	1978 Exclosed Phyto.	1978 Exclosed Util.	1979 Grazed Phyto.	1979 Grazed Util.	1979 Exclosed Phyto.	1979 Exclosed Util.	1980 Grazed Phyto.	1980 Grazed Util.	1980 Exclosed Phyto.	1980 Exclosed Util.
Veronica arvensis	-	-	-	-	T	-	-	-	T	T	T	-
Draba verna	-	-	-	-	T	-	-	-	-	-	-	-
Lupinus leucophyllus	-	-	-	-	4	-	-	-	T	-	-	-
Arenaria macrophylla	-	-	-	-	T	-	-	-	-	-	-	-
Galium boreale	-	-	-	-	11	-	5	-	-	-	-	-
Prunella vulgarus	-	-	-	-	-	-	T	-	-	-	-	-
Penstemon rydbergii	-	-	-	-	-	-	3	-	24	-	-	-
Unknown forb	-	-	-	-	T	-	T	-	T	-	T	-
Veronica serpyllifolia	-	-	-	-	-	-	-	-	-	-	T	-
Mimulus guttatus	-	-	-	-	-	-	-	-	-	-	T	-
Epilobium glaberrimum	-	-	-	-	-	-	-	-	5	-	75	-
Agoseris glauca	-	-	-	-	-	-	-	-	T	-	-	-
Equisetum variegatum	-	-	-	-	-	-	-	-	9	-	T	-
Potentilla glandulosa	-	-	-	-	-	-	-	-	4	-	T	-
Sidalcea oregana	-	-	-	-	-	-	-	-	7	-	24	-
Daucus carota	-	-	-	-	-	-	-	-	T	-	-	-
Trifolium pratense	-	-	-	-	-	-	-	-	90	36	T	-
Epilobium paniculatum	-	-	-	-	-	-	-	-	3	-	-	-
Erigeron philadelphicus	-	-	-	-	-	-	-	-	-	-	27	-
Montia linearis	-	-	-	-	-	-	-	-	-	-	71	-
Fragaria vesca	-	-	-	-	-	-	-	-	-	-	3	-
Liliaceae sp.	-	-	-	-	-	-	-	-	-	-	T	-
Shrubs												
Symphoricarpos albus	-	-	-	-	T	-	-	-	3	-	-	-
Rosa woodsii	-	-	-	-	11	-	-	-	-	-	-	-
Pinus ponderosa (Seedling)	-	-	-	-	T	-	-	-	-	-	-	-
Total Phytomass (Kg/ha)	7150		6990		6553		3497*		8750		9176.	
Total Utilization (Kg/ha)		4730		288		4808		64		5133		17
% Utilization		66.2		0.4		734		1.8		58.7		0.2

1 - Lg. Carexsp. include 1 or more of the following and possibly other unidentified Carex spp.: Carex aquatilus, C. stiptata, C. rostrata and C. nebrascensis
2 - Oval head sedges include 1 or more of the following and possibly other unidentified Carex sp.: Carex arthrostachya, C. microptera and C. Straminfcrmis
T - Trace amount of production and/or utilization
* indicates a significant difference in Phytomass

Appendix E

Table E-6. Crataegus douglasii/Poa pratensis

	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
Species	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.
Graminoids												
Poa pratensis	1061	425	1381	28	1150	677	1301	13	1236	590	2176	64
Agrostis alba	39	3	29	-	T	-	10	-	37	2	-	-
Elymus glaucus	82	-	-	-	T	T	-	-	27	-	-	-
Juncus balticus	51	-	10	-	18	3	-	-	59	50	-	-
Agropyron repens	23	-	-	-	26	-	-	-	7	-	-	-
Bromus carinatus	28	-	1	-	9	T	9	-	7	-	28	-
Phleum pratense	11	-	9	-	T	-	45	-	4	-	-	-
Bromus tectorum	-	-	T	-	T	T	T	-	-	-	-	-
Bromus racemosus	-	-	3	-	T	-	T	-	T	T	-	-
Trisetum canescens	T	-	-	-	-	-	-	-	-	-	-	-
Oval Carex sp.	T	-	T	-	7	-	14	-	5	-	-	-
Festuca elatior	-	-	3	-	-	-	-	-	-	-	5	-
Poa sandbergii	-	-	-	-	-	-	10	-	-	-	-	-
Carex stiptata	-	-	-	-	5	-	-	-	-	-	-	-
Poa compressa	-	-	-	-	T	T	-	-	-	-	-	-
Large Carex spp.	-	-	-	-	5	1	-	-	-	-	-	-
Unknown grass	19	-	-	-	-	-	-	-	-	-	-	-
Forbs and Allies												
Achillea millefolium	21	1	91	T	17	3	86	-	52	0.5	141	-
Taraxacum officinale	36	1	5	T	14	-	4	T	60	2	10	-
Cerastium viscosum	6	T	19	-	6	0.5	7	-	3	T	4	-
Viola adunca	30	1	9	T	12	T	12	T	22	3	T	-
Trifolium repens	24	T	36	T	T	-	-	-	8	1	2	-
Aster foliaceus	80	12	51	2	45	-	86	-	90	T	62	T
Medicago lupulina	26	T	18	-	4	-	T	-	2	0.5	5	-
Epilobium paniculatum	32	-	-	-	-	-	14	-	-	-	62	-
Plantago major	17	4	-	-	9	T	-	-	30	14	-	-
Galium asperrimum	16	-	-	-	-	-	-	-	-	-	-	-
Verbascum thapsus	40	-	1	-	-	-	1	-	-	-	-	-
Equisetum arvense	16	-	-	-	4	-	-	-	43	-	-	-
Prunella vulgaris	17	-	-	-	-	-	-	-	11	T	-	-
Senecio pseudareus	13	-	9	-	1	-	-	-	T	T	-	-
Ranunculus acris	6	T	-	-	12	-	T	T	5	T	2	-
Fragaria virginiana	11	1	T	T	8	-	6	-	8	T	2	-
Tragopogon dubius	T	T	7	3	8	-	11	2	56	-	-	-
Cirsium vulgare	-	-	8	1	-	-	T	T	1	-	-	-
Antennaria rosea	-	-	T	-	-	-	T	-	-	-	-	-

Appendix E
Table E-6. (Continued)

Species	1978				1978				1978			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.
Fragaria vesca	T	–	1	–	2	–	–	–	–	–	–	–
Allium acuminatum	T	–	–	–	–	–	2	–	T	–	–	–
Aquilegia formosa	3	–	–	–	–	–	–	–	T	–	–	–
Lactuca serriola	–	–	T	T	–	–	–	–	T	2	–	–
Rumex acetosella	3	T	–	–	T	–	1	–	T	T	–	–
Geranium bicknellii	T	–	–	T	–	1	–	T	T	T	–	–
Dipsacus sylvestris	8	T	–	–	5	T	–	–	–	–	–	–
Vicia americana	T	–	–	–	T	–	9	–	5	–	T	–
Erodium cicutarium	–	–	T	–	–	–	–	–	–	–	–	–
Trifolium pratense	–	–	–	–	T	–	T	T	–	–	–	–
Galium boreale	–	–	–	–	–	–	T	T	–	–	–	–
Veronica arvensis	–	–	–	–	T	–	T	–	T	–	T	–
Geum macrophyllum	–	–	–	–	12	T	T	–	7	T	–	–
Erigeron philadelphicus	–	–	–	–	23	–	–	–	–	–	–	–
Viola nuttallii	–	–	–	–	T	–	–	–	4	–	–	–
Draba verna	–	–	–	–	–	–	T	–	–	–	–	–
Lithophragma parviflora	–	–	–	–	–	–	T	T	–	–	–	–
Collomia linearis	–	–	–	–	–	–	T	–	–	–	–	–
Microsteris gracilis	–	–	–	–	–	–	1	–	T	–	T	–
Stellaria graminea	–	–	–	–	–	–	T	–	–	–	–	–
Agoseris glauca	–	–	–	–	–	–	3	–	–	–	–	–
Equisetum variegatum	–	–	–	–	–	–	–	–	9	–	–	–
Stellaria nitins	–	–	–	–	–	–	–	–	T	–	T	–
Caryophyllaceae sp.	–	–	–	–	–	–	–	–	T	–	–	–
Unknown forb	–	–	–	–	T	T	–	–	T	T	T	–
Shrubs												
Crataegus douglasii (Seedling)	T	–	–	–	3	–	1	–	3	–	–	–
Rosa woodsii	–	–	–	–	43	T	–	–	6	–	–	–
Symphoricarpos albus	65	T	T	T	14	T	–	–	5	–	–	–
Pinus ponderosa (Seedling)	–	–	–	–	T	–	–	–	–	–	–	–
Total Phytomass (Kg/ha)	1784		1691		1462		1632		1813		2498	
Total Utilization (Kg/ha)		448		34		684		15		665		64
Percent Utilization		25.1		2.0		46.8		0.9		36.7		2.5

Appendix E

Table E-7. Pinus ponderosa/Poa pratensis

Species	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.
Graminoids												
Poa pratensis	1434	445	1278	-	1109	195	1034	11	1264	136	1426	2
Bromus tectorum	1	-	70	-	T	-	8	-	-	-	T	-
Elymus glaucus	8	4	24	-	T	-	164	6	21	-	376	-
Oval head Carex sp.	6	2	-	-	-	-	-	-	-	-	-	-
Agropyron repens	-	-	45	-	-	-	70	8	-	-	-	-
Bromus carinatus	3	-	-	-	1	1	-	-	20	-	-	-
Festuca elatior	10	-	-	-	-	-	-	-	-	-	-	-
Trisetum canescens	15	-	-	-	4	-	-	-	9	-	-	-
Agrostis scabra	-	-	-	-	T	-	-	-	-	-	-	-
Carex geyeri	-	-	-	-	3	T	-	-	-	-	-	-
Arrhenatherum elatius	-	-	-	-	-	-	3	-	-	-	-	-
Luzula multiflora	-	-	-	-	-	4	-	-	-	-	-	-
Bromus racemosus	-	-	7	-	T	T	-	-	-	-	-	-
Large Carex spp.	-	-	-	-	-	-	13	-	-	-	-	-
Oval Carex spp.	-	-	-	-	T	-	-	-	21	-	T	-
Poa compressa	-	-	-	-	T	T	-	-	-	-	-	-
Phleum pratense	-	-	-	-	15	1	-	-	7	-	-	-
Juncus balticus	-	-	-	-	9	1	-	-	-	-	-	-
Forbs												
Achillea millefolium	5	2	12	-	11	T	20	-	55	T	9	-
Arenaria macrophylla	25	-	4	-	22	T	T	-	7	T	-	-
Taraxacum officinale	9	1	T	-	T	T	-	-	6	-	T	-
Vicia americana	-	-	-	-	-	-	5	-	T	-	5	-
Aster foliaceus	1	1	T	-	20	T	15	-	10	4	8	-
Fragaria vesca	8	-	-	-	-	-	-	-	2	-	-	-
Galium asperrimum	-	-	T	-	1	-	-	-	-	-	T	-
Osmorhiza chilensis	4	-	-	-	T	-	-	-	-	-	15	-
Trifolium repens	1	T	-	-	T	T	-	-	T	-	-	-
Viola adunca	13	-	T	-	9	-	-	-	T	T	-	-
Dipsacus sylvestris	20	-	-	-	-	-	-	-	-	-	-	-
Tragopogon dubius	-	-	16	1	-	-	11	-	-	-	5	-
Urtica gracilis	-	-	3	-	-	-	-	-	-	-	-	-
Rumex acetosella	20	-	-	-	T	T	-	-	-	-	-	-
Solidago missouriensis	1	-	-	-	-	-	-	-	-	-	-	-
Ranunculus acris	3	-	-	-	6	T	-	-	T	-	-	-
Senecio pseudareus	1	-	-	-	1	T	-	-	-	-	-	-
Fragaria virginiana	1	T	-	-	T	T	-	-	20	-	-	-

Appendix E
Table E-7. (Continued)

Species	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.
Prunella vulgaris	3	-	-	-	T	-	-	-	T	-	-	-
Cirsium vulgare	4	-	-	-	19	T	-	-	-	-	-	-
Potentilla glandulosa	1	-	-	-	-	-	-	-	-	-	-	-
Smilacina stellata	1	-	-	-	3	-	-	-	-	-	-	-
Lupinus leucophyllus	T	-	-	-	-	-	-	-	6	3	-	-
Cerastium viscosum	-	-	-	-	T	T	T	-	T	-	-	-
Geum macrophyllum	-	-	-	-	T	T	-	-	-	-	-	-
Stellaria graminea	-	-	-	-	2	-	T	T	-	-	-	-
Galium boreale	-	-	-	-	T	-	T	-	-	-	7	-
Trifolium pratense	-	-	-	-	T	T	-	-	-	-	-	-
Lactuca serriola	-	-	-	-	T	T	-	-	-	-	-	-
Varonica arvensis	-	-	-	-	-	-	T	-	-	-	-	-
Medicago lupulina	-	-	-	-	T	-	-	-	-	-	-	-
Stellaria nitins	-	-	-	-	-	-	-	-	-	-	T	-
Trillium petiolatum		-	-	-	-	-	-	-	-	-	24	-
Collinsia parviflora	-	-	-	-	-	-	-	-	-	-	T	-
Equisetum arvense	-	-	-	-	-	-	-	-	11	-	-	-
Viola nuttallii	-	-	-	-	-	-	-	-	T	-	-	-
Montia perfoliata	-	-	-	-	-	-	-	-	-	-	T	-
Caryophyllaceae sp.	-	-	-	-	T	-	-	-	T	-	-	-
Unknown forb	1	-	T	-	T	-	-	-	-	-	5	-
Shrubs												
Symphoricarpos albus	49	-	132	2	152	32	39	-	-	-	50	-
Rosa woodsii	-	-	26	-	-	-	171	T	-	-	30	-
Crataegus douglasii	7	-	-	-	T	T	-	-	T	-	T	-
Pinus ponderosa (Seedling)	-	-	-	-	T	-	-	-	-			
Amelanchier alnifolia	-	-	-	-	T	-	-	-	-	T	-	
Berberis repens	-	-	15	-								
Total Phytomass (Kg/ha)	1655		1632		1390		1558		1457		1962	2
Total Utilization (Kg/ha)		452		3		234		27		143		
Percent Utilization		27.3		0.2		16.8		0.2		9.8		T

Appendix E

Table E-8. *Symphoricarpos albus*/*Rosa woodsii*

Species	1978 Grazed Phyto.	1978 Grazed Util.	1978 Exclosed Phyto.	1978 Exclosed Util.	1979 Grazed Phyto.	1979 Grazed Util.	1979 Exclosed Phyto.	1979 Exclosed Util.
Graminoids								
Poa pratensis	1696	277	2073	24	940	327	1079	34
Agrostis alba	306	-	-	-	157	-	-	-
Elymus glaucus	T	-	42	13	T	T	5	T
Bromus tectorum	5	3	47	-	T	-	92	T
Bromus carinatus	-	-	13	-	-	-	-	-
Phleum pratense	49	-	-	-	T	T	-	-
Bromus racemosus	-	-	4	-	-	-	T	-
Agropyron repens	-	-	T	-	-	-	-	-
Festuca elatior	-	-	T	-	-	-	-	-
Carex sp.	4	-	-	-	29	-	-	-
Oval *Carex* spp.	-	-	-	-	42	-	-	-
Bromus brizaeformis	-	-	-	-	T	-	-	-
Forbs								
Aster foliaceus	79	4	-	-	37	-	-	-
Geum macrophyllum	14		70	-	112	-	8	T
Senecio pseudareus	66	-	-	-	35	T	-	-
Ranunculus acris	40	-	T	-	10	T	-	-
Tragopogon dubius	44	7	-	-	10	-	6	1
Taraxacum officinale	17	-	13	-	1	-	T	-
Cerastium viscosum	8	-	-	-	-	-	-	-
Achillea millefolium	16	T	T	-	24	-	22	-
Trifolium repens	4	-	-	-	5	T	-	-
Trifolium pratense	11	-	-	-	T	T	-	-
Osmorhiza chilensis	14	-	-	-	-	-	-	-
Plantago major	5	T	-	-	T	T	-	-
Vicia americana	5	-	-	-	25	-	-	-
Smilacina stellata	5	-	-	-	9	-	1	-
Prunella vulgaris	5	-	-	-	4	-	-	-
Cirsium vulgare	3	-	1	-	T	-	11	-
Fragaria virginiana	7	-	-	-	T	T	T	-
Rumex acetosella	-	-	T	-	3	-	-	-
Erodium cicutarium	-	-	T	-	T	T	-	-
Epilobium paniculatum	4	-	-	-	T	-	T	-
Fragaria vesca	T	-	-	-	-	-	-	-
Viola adunca	T	-	-	-	T	-	-	-
Geranium bicknellii	T	T	-	-	-	-	-	-
Erigeron philadelphicus	T	T	-	-	-	-	15	-

Appendix E
Table E-8. (Continued)

Species	1978				1979			
	Grazed		Exclosed		Grazed		Exclosed	
	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.
Lithophragma parviflora	–	–	–	–	T	T	T	–
Epilobium glaberrimum	–	–	–	–	–	–	5	–
Arenaria macrophylla	–	–	–	–	T	–	–	–
Fragaria vesca	–	–	–	–	T	–	–	–
Polygonum douglasii	–	–	–	–	–	–	T	–
Stellaria graminea	–	–	–	–	T	–	–	T
Medicago lupulina	–	–	–	–	T	–	–	–
Trillium petiolatum	–	–	–	–	4	–	–	–
Mentha arvensis	–	–	–	–	–	–	T	T
Collomia linearis	–	–	–	–	–	–	T	–
Draba verna	–	–	–	–	–	–	T	–
Unknown Forb	–	–	–	–	T	–	T	–
Shrubs								
Symphoricarpos albus	1366	319	1139	100	1801	168	1540	29
Rosa woodsii	191	28	240	13	738	89	426	4
Crataegus douglasii	–	–	1	–	T	–	–	–
Amelanchier alnifolia	–	–	–	–	T	–	–	–
Total Phytomass (Kg/ha)	3964		3643		3987		3213	
Total Utilization (Kg/ha)		588		150		584		67
Percent Utilization		1418		4.1		14.5		2.1

Appendix E

Table E-9. Bromus tectorum

Species	1978				1979				1980			
	Grazed		Exclosed		Grazed		Exclosed		Grazed		Exclosed	
	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.	Phyto.	Util.
Graminoids												
Bromus tectorum	1037	174	1896	T	824	23	946	8	1828	23	1398	T
Poa pratensis	656	29	32	2	-	-	43	-	55	6	T	T
Bromus racemosus	T	-	5	-	T	-	-	-	-	-	-	-
Poa sandbergii	-	-	40	-	T	-	52	-	-	-	T	T
Festuca elatior	-	-	10	-	-	-	-	-	-	-	-	-
Poa compressa	-	-		-	26	-	-	-	-	-	-	-
Agropyron repens	21	-	-	-	-	-	-	-	-	-	-	-
Poa bulbosa	-	-	-	-	T	-	-	-	T	-	-	-
Forbs												
Erodium cicutarium	56	T	13	T	62	T	1	-	86	-	118	-
Achillea millefolium	T	T	9	-	11	T	20	-	T	T	13	-
Cerastium viscosum	118	-	T	-	3	-	-	-	-	-	-	-
Lepidium perfoliatum	-	T	-	-	-	-	-	-	5	-	T	-
Taraxacum officinale	T	T	6	-	2	-	5	-	-	-	T	-
Tragopogon dubius	T	-	T	-	-	-	-	-	-	-	-	-
Epilobium paniculatum	T	-	-	-	T	T	T	-	13	-	119	2
Rumex acetosella	-	T	-	-	T	T	1	T	T	-	T	T
Astor foliaceus	-	T	-	-	-	-	-	-	-	-	-	-
Erigeron pumulis	32	-	-	-	-	-	-	-	-	-	-	-
Lactuca serriola	T	-	T	-	-	-	11	-	-	-	3	-
Polygonum douglasii	-	-	-	-	T	T	2	-	1	-	7	-
Polygonum aviculare	-	-	-	-	5	-	T	T	-	-	-	-
Veronica arvensis	-	-	-	-	11	-	-	-	17	-	9	-
Draba verna	-	-	-	-	3	-	T	-	T	-	-	-
Capsella bursa-pastoris	-	-	-	-	5	-	T	-	-	-	-	-
Microsteris gracilis	-	-	-	-	2	T	T	-	-	-	-	-
Sisymbrium altissimum	-	-	-	-	2	-	-	-	-	-	-	-
Collomia linearis	-	-	-	-	T	T	-	-	-	-	-	-
Stellaria nitins	-	-	-	-	-	-	-	-	5	-	5	-
Holosteum umbellatum	-	-	-	-	-	-	-	-	6	-	-	-
Collinsia parviflora	-	-	-	-	-	-	-	-	-	-	3	-
Descurainia pinnata	-	-	-	-	-	-	-	-	-	-	T	-
Verbascum thapsus	-	-	-	-	-	-	5	-	-	-	-	T
Caryophyllaceae sp.	-	-	-	-	2	-	T	-	5	-	-	-
Brassicaceae sp.	-	-	-	-	-	-	-	-	-	-	T	-
Lepidium sp.	-	-	-	-	-	-	T	-	-	-	-	-
Unknown forb	T	-	T	-	T	-	T	-	T	-	?T	-
Shrubs												
Symphoricarpos albus	-	-	-	-	16	-	-	-	-	-	T	-
Rosa woodsii	-	-	-	-	-	-	8	-	-	-	-	-
Total Phytomass (Kg/ha)	1920		2001		974		1093		2020		1702	
Total Utilization (Kg/ha)		203		2		23.0		8		29		2.0
Percent Utilization		10.5		T		2.4		0.7		1.4		T

Appendix E

Table E-10. Poa pratensis - Bromus tectorum

Species	1978 Grazed Phyto.	1978 Grazed Util.	1978 Exclosed Phyto.	1978 Exclosed Util.	1979 Grazed Phyto.	1979 Grazed Util.	1979 Exclosed Phyto.	1979 Exclosed Util.
Graminoids								
Bromus tectorum	836	120	1265	1	683	71	713	T
Poa pratensis	1182	656	1558	10	1348	1164	1106	10
Bromus racemosus	3	-	323	-	21	2	96	T
Poa compressa	-	7	-	-	-	-	-	-
Poa bulbosa	-	T	-	-	-	-	-	-
Poa sanbergii	-	T	-	-	-	-	-	-
Agropyron repens	35	11	-	-	7	-	-	-
Bromus carinatus	T	-	-	-	-	-	-	-
Agropyron cristatum	T	-	-	-	46	-	-	-
Poa bulbosa					-	-	T	-
Oval head Carex sp.					T	T	-	-
Forbs								
Erodium cicutarium	63	12	81	T	T	T	T	-
Achillea millefolium	37	7	29	-	19	3	14	-
Cerastium viscosum	5	-	5	-	T	-	-	-
Lepedium perfoliatum	-	-	-	-	T	-	T	-
Tragopogon dubius	-	-	5	-	30	T	T	-
Trifolium repens	T	-	T	-	-	-	-	-
Epilobium paniculatum	-	T	-	T	-	-	6	-
Medicago lupulina	T	-	-	-	-	-	-	-
Lepidium perfoliatum	3	-	9	-	-	-	-	-
Taraxacum officinale	T	T	T	-	-	-	T	-
Vicia americana	-	-	-	-	5	-	-	-
Rumex acetosella	11	T	-	-	T	T	-	-
Antennaria rosea	T	-	-	-	-	-	-	-
Veronica arvensis	-	-	-	-	3	-	-	-
Draba verna	-	-	-	-	T	-	T	-
Stellaria graminea	-	-	-	-	T	-	-	-
Collomia linearis	-	-	-	-	-	-	4	-
Polygonum douglasii	-	-	-	-	-	-	9	-
Lupinus leucophyllus	-	-	-	-	-	-	42	-
Aster foliaceus	-	-	-	-	T	T	T	-
Cardaria draba	-	-	-	-	-	-	T	-
Caryophylaceae sp.	-	-	-	-	T	-	T	-
Unknown Forb	3	-	T	-	-	-	-	-
Shrubs								
Symphoricarpos albus	-	-	-	-	-	-	T	-
Crataegus douglasii	-	-	-	-	-	-	T	-
Ribes lacustre	-	-	-	-	-	-	T	-
Pinus ponderosa	-	-	-	-	T	-	-	-
Total Phytomass (Kg/ha)	2173		3275		2162		1990	
Total Utilization (Kg/ha)		806		11		1240		10
Percent Utilization		37.1		0.3		56.5		0.5

APPENDIX F

Estimated Density, Relative Abundance, Diversity (H') and Equitability of Mammal Populations in the Catherine Creek Study area, 1978-1980.

Appendix F.

Season and Community	Species	Estimated Density (numbers/ha) Grazed	Exclosed	Relative Abundance Grazed	Exclosed	Community Diversity (H') Grazed	Exclosed	Community Equitability (J') Grazed	Exclosed
Early Summer 1979 (June)									
Poa pratensis - Phleum pratense - mixed forbs									
	Totals	480	568			1.105	.9228	.9234	.6656
	Microtus montanus	251	410	.52	.70				
	Peromyscus maniculatus	102	*	.29	.075				
	Thomomys talpoides	47	46	.19	.15				
	Sorex vagrans	-	*	-	.075				
Late Summer 1979 (Before Grazing - August)									
Poa pratensis - Phleum pratense - mixed forbs									
	Totals	450	235			.4290	.3020	.3090	.2750
	Microtus montanus	423	222	.90	.93				
	Peromyscus maniculatus	*	*	.05	.035				
	Thomomys talpoides	*	-	.025	-				
	Sorex vagrans	*	*	.025	.035				
Crataegus douglasii/Poa pratensis									
	Totals	800	690			.0980	.4600	.1410	.6580
	Microtus montanus	786	513	.98	.83				
	Peromyscus maniculatus	14	118	.02	.17				
Populus trichocarpa - mixed conifer									
	Totals	129	118			.6480	1.001	.5890	.9112
	Microtus montanus	126	26	.79	.43				
	Peromyscus maniculatus	*	31	.14	.43				
	Eutamias amoenus	*	*	.07	.14				
Early Autumn 1979 (After grazing - September)									
Poa pratensis - Phleum pratense - mixed forbs									
	Totals	60	463			.6803	.3025	.9814	.4364
	Microtus montanus	35	457	.58	.91				
	Peromyscus maniculatus	25	-	.42	-				
	Sorex vagrans	-	*	-	.09				
Crataegus douglasii/Poa pratensis									
	Totals	83	136						
	Microtus montanus	49	136	.60	1.0	.8979	0	.8173	0
	Peromyscus maniculatus	30	-	.30	-				
	Eutamias amoenus	*	-	.10	-				
Populus trichocarpa - mixed conifer									
	Totals	42	254			.6803	.3025	.9814	.4364
	Microtus montanus	*	158	.20	.70				
	Peromyscus maniculatus	*	31	.40	.11				
	Eutamias amoenus	*	*	.40	.07				
	Sorex vagrans	-	*	-	.11				

Appendix F. (Continued)

Season and Community	Species	Estimated Density (numbers/ha)		Relative Abundance		Community Diversity (H')		Community Equitability (J')	
		Grazed	Exclosed	Grazed	Exclosed	Grazed	Exlosed	Grazed	Exclosed
Early Autumn 1978 (After grazing - September)									
Poa pratensis - Phleum pratense - mixed forbs									
	Totals	-[1]	-[2]			0	.3864	0	.5574
	Microtus montanus	-	-	-	.87				
	Sorex vagrans	-	-	-	.13				
Crataegus douglasii/Poa pratensis									
	Totals	30	208			0	.4991	0	.4543
	Microtus montanus	30	171	1.0	.80				
	Sorex vagrans	-	*	-	.095				
	Peromyscus maniculatus	-	*	-	.048				
Populus trichocarpa - mixed conifer									
	Totals	48	217						
	Microtus montanus	-	25	-	.19	0	1.044	0	.9507
	Peromyscus maniculatus	48	78	1.0	.44				
	Sorex vagrans	-	77	-	.38				

[1] No animals trapped

[2] Second trap night was vandalized and no density estimate possible.

* Numbers of animals trapped too small to estimate densities.

- No animals trapped.