



Natural revegetation of abandoned horse corrals over time in Grand Teton National Park, Wyoming
by Susan Bromley Kelly

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in
Earth Sciences

Montana State University

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Abstract:

Eight horse corrals that were formerly used by dude ranches and have been resting unused for differing periods of time were studied to determine the degree to which plant species composition and cover had returned to predisturbance conditions. Measurements of species stem density and percent cover of bare ground, rock, litter, grass, sedge, forb, and shrub were collected and tabulated along eight transects within each of the eight corral boundaries, and within eight non-disturbed, control boundaries. Five 0.5 meter by 0.5 meter quadrats were measured at equidistant points along each transect. Tests for percent sand, silt, and clay, and soil color were completed, by horizon, at each corral and control. Accurate soil density measurements were attempted unsuccessfully using a variety of methods. Chemical analysis for soil potassium, electrical conductivity, nitrogen, organic material, phosphorus, and pH were completed at the corral with the shortest resting time, the corral with the longest resting time, and their corresponding controls. A history of each dude ranch was compiled for each corral, by using historical literature, oral interviews, photographs and maps. Data collected included years of corral use and period of rest, physical parameters of each site, and number of horses in use at each ranch.

Species data show great variation in both corral and control sites. Of the 128 species sampled, only eleven species were found in every control location. Only two species were found in all corral sites, one of which occurs in all corral and control sites. Native, non-weedy, perennial forbs were most abundant across all sites, with slightly higher amounts of weedy species and annuals found in corrals. Percent cover of shrubs was greater in all controls when compared to corrals. Forb, litter, and rock coverage were higher, and grass percent cover was lower, in most controls when compared to corrals. Bare ground coverage was variable across all sites. Physical and chemical soil properties were uniform, and were not found to relate to plant recovery in abandoned horse corrals and paired controls.

Similarity indices show, varying similarity between each corral and its control over time. While there were differences in plant composition between corral and control sites, they were most often site specific and could not be associated to time of rest. The results of this study show great heterogeneity in the natural sagebrush environment, and suggest that revegetation of abandoned horse corrals is a highly site specific process that is not obviously time dependent. The findings of this study suggest that classic models of succession that assume increasing site similarity with time, often applied to plant revegetation projects by land managers and restoration scientists, are not wholly accurate in describing plant dynamics of revegetating horse corrals in the sagebrush community of Jackson Hole, Wyoming, in Grand Teton National Park.

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APPROVAL

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April 26th 1999

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ABSTRACT

Eight horse corrals that were formerly used by dude ranches and have been resting unused for differing periods of time were studied to determine the degree to which plant species composition and cover had returned to predisturbance conditions. Measurements of species stem density and percent cover of bare ground, rock, litter, grass, sedge, forb, and shrub were collected and tabulated along eight transects within each of the eight corral boundaries, and within eight non-disturbed, control boundaries. Five 0.5 meter by 0.5 meter quadrats were measured at equidistant points along each transect. Tests for percent sand, silt, and clay, and soil color were completed, by horizon, at each corral and control. Accurate soil density measurements were attempted unsuccessfully using a variety of methods. Chemical analysis for soil potassium, electrical conductivity, nitrogen, organic material, phosphorus, and pH were completed at the corral with the shortest resting time, the corral with the longest resting time, and their corresponding controls. A history of each dude ranch was compiled for each corral, by using historical literature, oral interviews, photographs and maps. Data collected included years of corral use and period of rest, physical parameters of each site, and number of horses in use at each ranch.

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Similarity indices show varying similarity between each corral and its control over time. While there were differences in plant composition between corral and control sites, they were most often site specific and could not be associated to time of rest. The results of this study show great heterogeneity in the natural sagebrush environment, and suggest that revegetation of abandoned horse corrals is a highly site specific process that is not obviously time dependent. The findings of this study suggest that classic models of succession that assume increasing site similarity with time, often applied to plant revegetation projects by land managers and restoration scientists, are not wholly accurate in describing plant dynamics of revegetating horse corrals in the sagebrush community of Jackson Hole, Wyoming, in Grand Teton National Park.

INTRODUCTION

The National Park Service protects wildlands throughout the United States. These protected areas act as natural baselines from which change can be detected. Use of our national parks is increasing, and the rate and areas disturbed are increasing as well.

Vegetation acts as an environmental monitor of disturbance, and studies of vegetation are one way of monitoring environmental change. It is important for managers to understand the rate and direction of environmental change in order to assess if management intervention is necessary to maintain protected areas in as pristine of a state as possible.

Within the valley of Jackson Hole, Wyoming, farming, homesteading, and dude ranching were common pursuits during the early 1900's. Since then, dude ranches have ceased operation, abandoning the corrals and other structures that held horses. These corrals which had been trampled, have since been left to rest and recover. Once trampling has ceased, one would expect some degree of soil recovery and vegetation regrowth. Classic vegetation succession models hypothesize that if given enough time a plant and soil system reach predisturbance state. The degree of recovery of sites subjected to trampling by horses was the subject of this study.

Objectives of Study

The objective of this study was to determine if areas once trampled by horses, but which have experienced some period of rest or recovery without horses, had undergone succession towards predisturbance plant and soil conditions. Four questions were formulated in order to address this objective. First, could history of use and physical boundaries of horse corrals be established? Second, does vegetation composition differ between corral and control? Third, does the physical and chemical composition of soil differ between corral and control? Fourth, is the degree of difference between corral and control less with longer periods of recovery or rest, so that degree of recovery exhibited will be time-of-rest-related?

Previous Studies

Vegetation

Succession is a broad term used to describe the phenomenon of changes in vegetation types in both time and space (Glenn-Lewin, et al. 1992). The concept of plant succession originated in North America during the early decades of the twentieth century. The precursor to succession theory was the development of the "Geographical Cycle," a theory that addressed the ordered development of a landform and its geomorphic cycle, by William Morris Davis (Davis, 1899). Henry C. Cowles, a physiographer at the

University of Chicago, first applied this idea of an orderly progression through identifiable stages to vegetation (Cowles, 1899). Clements (1904, 1916) dominated the study of vegetation dynamics through his documentation of the highly ordered and predictable stages vegetation moves through towards a sustainable state during the succession process. Plant communities were believed to converge through succession towards climax vegetation as controlled by climate. During the 1960's Ramon Margalef and Eugene Odum furthered the idea of progressive plant change toward a stable state. Margalef (1963, 1968) argued that simple ecosystems moved toward complex ecosystems, with greater diversity of both species and lifeform that obtain higher trophic levels. Odum (1969) documented the tendency of ecosystems to move towards homeostasis, with succession proceeding towards an ecosystem of maximum biomass and diversity. During the 1970's to the present, competing, more complex theories about succession have been introduced. Contemporary ecologists view vegetation change as a result of plant populations interacting with pervading environmental conditions. Current succession hypotheses represent succession progression as gradients of time or resource availability (Drury and Nisbet, 1973; Pickett, 1976; Tilman, 1985, 1987), the results of differing life characteristics, (Drury and Nisbet, 1973; Pickett, 1976; Noble and Slater, 1980; Glenn-Lewin, 1980; Bornkamm, 1981; Parish, 1982; Huston and Smith, 1987, Pickett et al, 1987), or as a stochastic process (Horn, 1976). Recognition of the complex nature of biotic systems has caused ecologists to observe that succession patterns may not return to equilibrium (previously undisturbed state) after disturbance, but rather maintain

non-equilibrium status, as disturbance continues or climatic change prevents return to original state (McLendon and Redente, 1990; Myster and Pickett, 1992).

Studies concerning patterns of secondary succession have concentrated on areas recovering after mining (Hatton and West, 1987), and old fields/farmland (Bard, 1952; Dormaar and Smoliak, 1985; Leps 1987; Myster and Pickett, 1990). Studies have also looked at patterns of natural revegetation on abandoned gravel pads (Bishop and Chapin, 1989) and on horse corral/ pasture recovery, both historically (Putnam et al., 1991) and in more recent times (Belsky, 1986(a); Uhl et al., 1988; Tsuyuzaki and Kanda, 1996). A study conducted in Grand Teton National Park looked at a variety of anthropogenic disturbances and the degree of vegetative recovery of these sites (Zakley, 1994). Studies showing vegetation divergence (sites become more different over time) have been conducted (Glenn-Lewin, 1980; Facelli and D'Angela 1990). Studies showing convergence (sites become more similar with time), have also been completed (Despuit and Redente, 1980; Hatton and West, 1987; Inouye and Tilman 1988). Appearance of convergence may depend on the scale of the study (Glenn-Lewin, 1980; Austin, 1981; Inouye and Tilman, 1988) as well as differences in site histories (Myster and Pickett, 1990).

Miles (1987) emphasized in his study of fire and grazing dynamics that patterns of secondary succession can take on multiple pathways. Other studies that have been conducted show that succession patterns can be "not unidirectional" (Webb et al., 1972). Divergent patterns of succession were observed in repeated colonization of Pinus strobus (Sharik et al., 1990), in disturbed stands of Pinus banksiana (Abrams et al., 1985), and in

Australian rainforests (Webb et al., 1972). Herben and Krahulec (1990) found multiple patterns of revegetation in the secondary succession of patches of montane grassland, while McLendon and Redente (1990) found different patterns of revegetation in sagebrush habitat.

Vegetation dynamics (the study of plant succession and regeneration dynamics) has interested scientists for both theoretical and practical reasons. An understanding of vegetation processes is necessary to explain observations in the field (Cole and Trull, 1992). On a practical level, there are many reasons to understand and predict vegetation change, whether to improve forage production on our rangelands, preserve specific plant and animal species, or entire biotic communities. The increasing concern of anthropogenic climate change within our life span reinforces the necessity of a better understanding of vegetation dynamics.

Methods of Vegetation Study

Different methods have been used in the study of vegetation dynamics. Direct observations made from permanent plots over time have been employed (Buell et al. 1971; Pickett, 1982; McLendon and Redente, 1990; Myster and Pickett, 1990, 1992). Permanent plot studies provide useful data on initial site conditions, environmental change during study period, and information about mechanisms of change during the succession process. Because it typically takes a long time to see the entire vegetation pattern change, studies using permanent plots are limited by practicality. A more common method of describing succession is to collect data from sites in similar environments but of different ages or stages of succession. The resulting vegetation

sequence is assumed to be a succession sequence, an approach called "chronosequence" by Picket (1989). However, Picket (1989) and Austin (1981) caution that the assumption of "similar environments" is often in question, particularly because site history is so often important, and not well known. The careful use of historical records has been used by ecologists to further the knowledge of site histories. Historical records include sources like journals (Wyckoff and Hansen, 1991), repeat photography (Hastings and Turner, 1965; Veblen and Lorenz, 1991), repeated aerial photography and mapping (Van Dorp et al., 1985), and land survey records (Vale, 1982; Zakley, 1994).

Soil

It has been theorized and shown that soil is susceptible to trampling (Hammitt and Cole, 1987). Through compaction, soil particles are pushed together which eliminates pore space. Soil structure is disrupted and total porosity is lessened. Since less water can move through soil, less water enters the soil and water infiltration rates are reduced. This leads to water stress for plants and increases in runoff and erosion (Hammitt and Cole, 1987).

In all soils the top layers of the mineral soil are most compacted. This has been illustrated in soils impacted by both recreational use and grazing. Compaction on recreational sites is seldom evident more than 12 cm to 16 cm below the surface (Summer, 1986). Two grazing studies, (Alderfer and Robinson, 1947; Weltz, et al., 1989) confirm that compaction from grazing cattle was limited to the surface 13 cm of the soil. Lull (1964), found that trampling by livestock compacts the upper 15 cm of soil, and exerts pressure equivalent to heavy tractors. It is compaction of surface soils that is most

critical to the alteration of water and air movement in the soil, vegetative rooting zones, and the habitat of soil organisms (Hammitt and Cole, 1987).

Compaction of soils by recreational use is also reflected in increased values for bulk density, penetration resistance, conductivity, and decreased permeability values (Lull 1959, Weaver and Dale 1978; Hammitt and Cole, 1987; Weltz et al., 1989; Summer, 1986; Cole, 1994). Weaver and Dale (1978) measured bulk density after experimentally trampling a grassland 1000 times with motorcycles, hikers, and horses. Horses increased soil density 0.3gm/cm^3 , the same amount of increase caused by motorcycle use. In another study, bulk density increased from 1.09 gm/cm on ungrazed to 1.51gm/cm on lightly grazed sites, and ranged from 1.54 gm/cm to 1.91 gm/cm for heavily grazed sites in sandy loam soil (Lull 1959).

Little is known about areas disturbed by trampling in relation to number of stock (Lull 1964; Hammitt and Cole, 1987; McClaran, 1989). However, cattle and horse use in ancient grassland sites was consistent despite differences in grazing area, total size, topography, and stocking densities (Putnam et al., 1991). Weltz et al., (1989) found that infiltration rates were significantly reduced after cattle had grazed within an enclosure for 14 hours. After a 110-day resting period, the enclosures were measured again and infiltration rates were one-half the infiltration rates of the pretrampled treatment. This suggests that impacts to the soil occur quickly and could have a sustained impact to plant revegetation over time.

While nutritional requirements of plants in natural settings are relatively unknown and cannot be assumed to respond like species in agricultural settings, soil nutrient levels

have been shown to impact species behavior. Soil chemicals have been shown to impact species composition and revegetation of native and non-native species (Tilman, 1985; 1987; Cotts, 1990; Tilman and Gleeson, 1990). In semiarid environments the macronutrients of nitrogen (N) and phosphorus (P), are found to be the most deficient of all soil nutrients. Nitrogen is found in naturally low levels in arid environments, while disturbed areas that have not supported plant communities for several years typically lose mycorrhizal fungi essential for increasing phosphorus intake. (Munshower, 1994). The addition of nitrogen has been shown to have a major effect on the rate and direction of post disturbance succession (Tilman, 1984, 1987; Tilman and Gleeson, 1990; Cotts, 1990). Deliberate and repeated addition of nitrogen to experimental plots increased the number and cover of species that revegetated disturbed ground in Jackson Hole sagebrush habitat (Cotts, 1990) while increased levels of phosphorus had no apparent effect on plant growth patterns, suggesting that phosphorus is not a limiting factor to plant development in this setting.

Zakley (1994) completed soil texture, chemical analysis, and soil infiltration tests in sagebrush habitat in the southern portion of Jackson Hole. Chemical soil analyses of sagebrush habitat in the same area of Jackson Hole were also completed in areas disturbed by settlement (Cotts, 1990; Zakley, 1994) and in areas used for horse and cattle grazing (Schiller and Kelly, 1996). In all cases similar soil chemical levels were reported, which suggest that soil chemistry may not be effected by disturbance or impact plant revegetation patterns. However, soil factors can be important and should be

considered because soil conditions can directly influence the rate and direction of plant community development (Dormaar and Smoliak, 1985; McLendon and Redente, 1990).

Study Area

Eight abandoned corrals and paired controls in the southern section of Grand Teton National Park were studied (Figure 1 and 2). This area was chosen as a study area because a variety of sites were impacted by horses over periods of time ranging from 4 to 56 years, in physically similar settings, allowing a chronosequence of vegetation change to be observed in the field. Grand Teton National Park is located in the northwest corner of Wyoming, at approximately 43° N and 111° W. Although the physiography of the park as a whole is extremely variable, the physiography of the valley of Jackson Hole is not. The valley is 77 km in length north to south, and slopes gently 8 to 24 km wide east to west, and varies in elevation between 1952 m and 2105 m. The 64 km long Teton Range dominates the valley's western boundary, and varies in width from 15 km to 24 km, extending south to southwest from the Yellowstone Plateau. Elevation of the range decreases both north and south of the centrally located highest peak, Grand Teton, at 4,198 m.

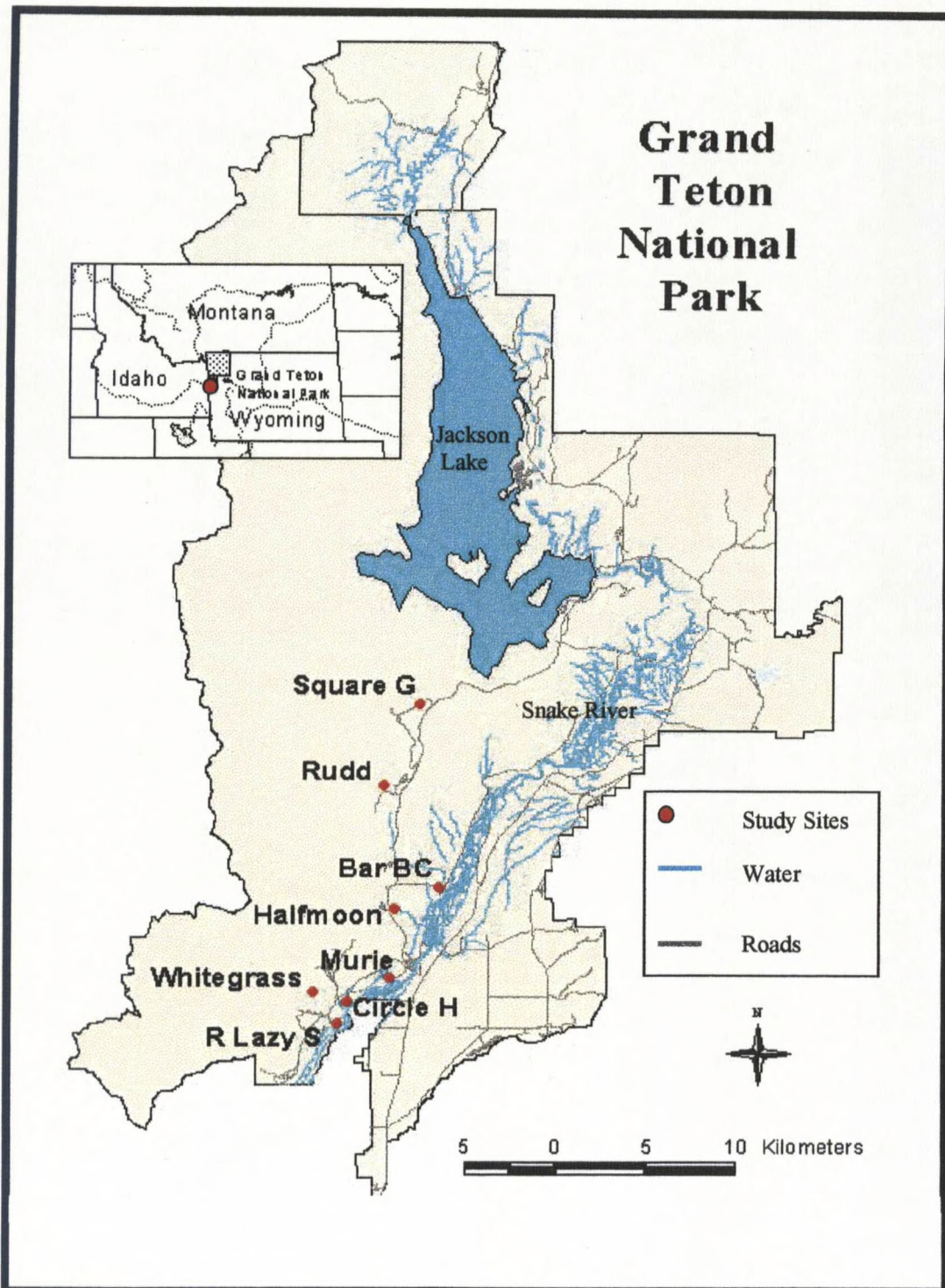


Figure 1. The study area within Grand Teton National Park, Wyoming, showing the eight corral sites.

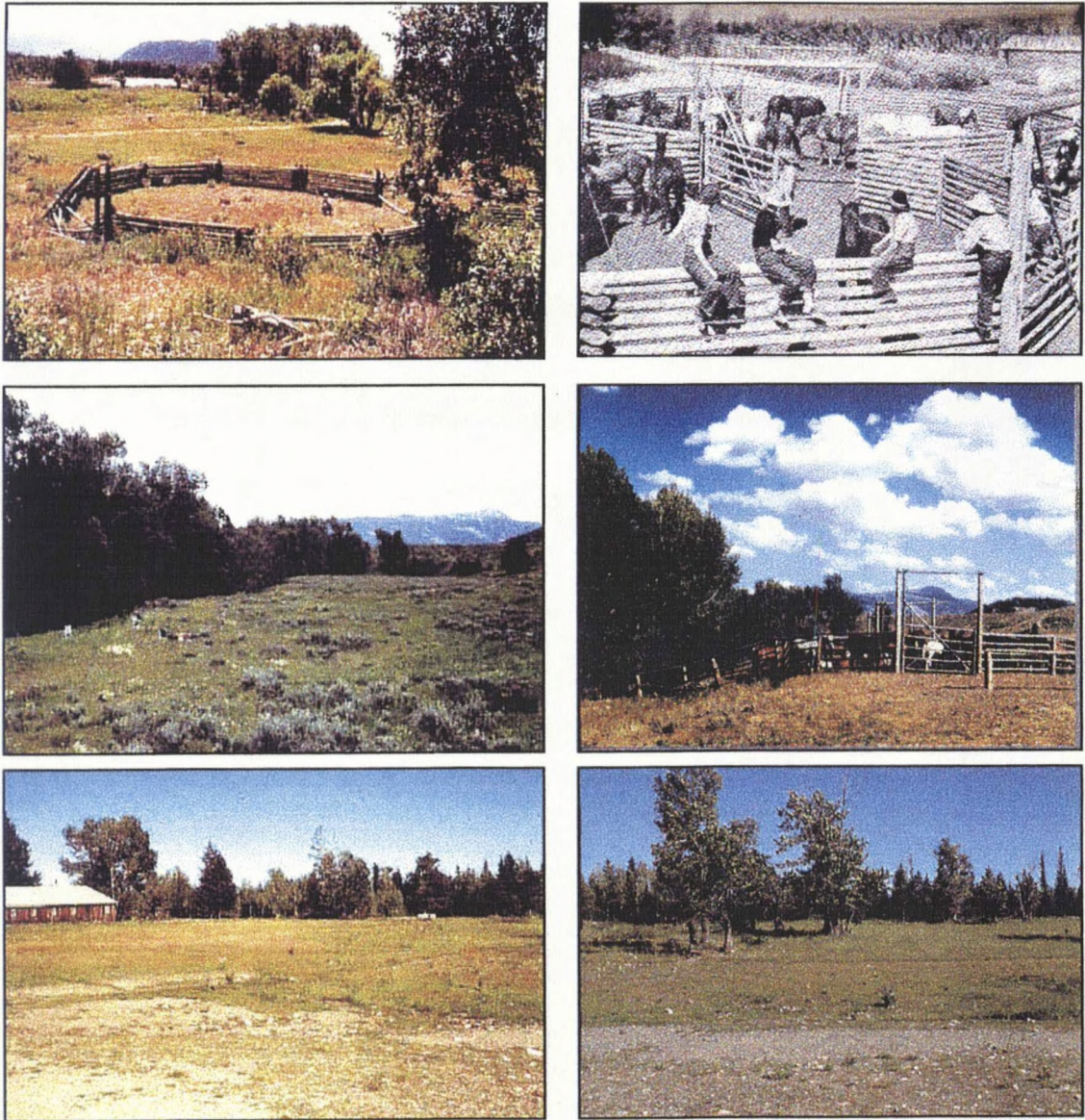


Figure 2. Photographs of corral sites. From top left, view of the Bar BC corral abandoned in 1980, photograph taken during the summer of 1996, black and white photograph shows Bar BC, circa 1930. Halfmoon corral site, abandoned in 1967 photograph taken during the summer of 1997, and Halfmoon corral circa 1949. Two views of Rudd corral, abandoned in 1993, photograph taken during the summer of 1997.

The Teton Range is one of the youngest ranges in the Rocky Mountains (Good and Pierce, 1996). Their ruggedness is due to two factors: youth and process of formation. The Teton Range is estimated to have begun rising 12-15 million years ago (Love and Reed, 1989; Love, et al., 1992), with the majority of uplift occurring less than 3 million years ago (Smith, et al., 1993). The Teton Range is an extensional fault-block mountain range. The western footwall block was uplifted along a series of normal faults at the eastern base of the range, while the eastern hanging wall block dropped, forming the flat valley of Jackson Hole.

The area drains into the Snake River, which bisects the valley floor. The Snake originates in the southern part of Yellowstone National Park, flows south through Jackson Hole, turns west, after reaching the Snake River Plain, and eventually flows into the Columbia River, and ultimately the Pacific Ocean.

Geology

The geology of the park provides the foundation upon which physical and biological processes take place. A very complete sedimentary rock sequence, which chronicles the Paleozoic through Cenozoic eras, is present on the western side of the Teton Range, as well as the northern and southern ends of the range. Volcanic activity in the Yellowstone area during the Quaternary contributed rhyolitic debris predominantly to the northern portion of the range and valley. All surface materials within Jackson Hole, with the exception of outcrops on Signal Mountain and Blacktail Butte, are Pleistocene or Holocene in age. (Love et al., 1992). The sedimentary rocks that once covered the Teton

Range have been eroded so that the Precambrian gneisses, granites, and diabases are evident. Strontium-rubidium dating reveal the gneisses to be approximately 2.5 Ba. (Harris et al., 1997).

Tremendous tensional forces extended crustal blocks creating the Teton fault block system, bringing Precambrian crystalline rocks into view through erosion of the footwall block. The two large crustal blocks are separated by a 64.4 km normal fault system that has been most dynamic during the last 3 million years, and is still considered seismically active (Good and Pierce 1996; Smith, et al. 1993).

Superimposed on the block-faulted features of the Tetons are the effects of multiple Pleistocene glaciations (Good and Pierce 1996). The Bull Lake glaciation (locally referred to as the Munger glaciation) which began 140,000 yr. B. P., was the most extensive of the late Pleistocene. Thick tongues of ice flowed south out of present-day Yellowstone, as well as down the Pacific Creek and Buffalo Fork drainages, with moraines more than 100 m thick deposited in the southern part of Jackson Hole.

During Pinedale times (80,000 to 10,000 yr. B. P.) ice flowed into the Jackson Hole region during three distinct phases, with glaciers forming in both the mountains and the valleys. The Pinedale glaciations ended approximately 15,000 yr. B. P., with the last of the ice receding from the valley. Much of Jackson Hole is covered in outwash debris from the Pinedale glaciers, which forms a youthful cobble matrix for continued soil development. Wind deposited sediments from the windward side of the range add to the soil composition, especially in the southwestern areas of the park (Soil Conservation Service, 1982).

Vegetation

The vegetation patterns on the floor of Jackson Hole correspond with the general locations of glacial and alluvial deposits. Forests composed of Douglas fir (Pseudotsuga menziesii), subalpine fir (Abies lasiocarpa), and lodgepole pine (Pinus contorta) are present in the valley in those areas where glacial moraines are present. Forests exist on the unsorted glacial till because of its water-holding capacity and higher clay content. Sagebrush-grassland vegetation dominates the outwash plains and river terraces that characterize most of the valley. The substrate of the sagebrush community is predominantly an outwash plain that formed during the waning stages of the Pinedale glaciation. Aspen (Populus tremuloides), black cottonwood (Populus trichocarpa), willows (Salix spp.), and spruce inhabit river and stream banks, and loess deposits in southern portions of the valley support a wider array of vegetation.

The sagebrush grassland is one of the most extensive plant communities in the park. With over 100 species of plants present (Shaw, 1992), it is one of the most complex and important parts of the ecosystem. The sagebrush community covers an area of about 168 km², at an elevation of 1947 to 2114 m, and provides year-round cover and forage to a great number of wildlife species (Clark, 1981).

Botanical studies suggest that Artemisia spp. (sagebrush) have been a stable community type throughout the West. Section Tridentatae of Artemisa is endemic to western North America, and distinct from a similar Eurasian section, Seriphidium (McArthur and Plummer, 1978). The Tridentatae are thought to have evolved in North

America during the late Tertiary or early Quaternary because of increasing aridity (Whitlock, 1993). Four different sagebrush communities characterize the vegetation of the valley floor in Grand Teton National Park. These communities are characterized respectively as Artemisa tridentata Nutt. (big sagebrush.); A. arbuscula Nutt. (low sagebrush); A. tridentata and A. arbuscula ; A. tridentata and Purshia tridentata (Pursh) D.C. (bitterbrush) (Sabinske and Knight, 1978). The community made up of A. arbuscula and A. tridentata is the most widespread.

Temperature

Summer days are usually mild, with daytime maximum temperatures between 21.1 and 26.7° C and nighttime minimums below 4.4° C. Nighttime frosts can be expected year-round at higher elevations. July is consistently the warmest month with a record high of 38.3°C in Jackson during July 1934. Winters are cold, with daily maximum temperatures frequently below freezing. January is the coldest month. The record low of -52.8°C was reached at Moran, a small community in the northern part on the park, during January 1977. The park lies within range of the expected southward movement of cold arctic air masses connected with the polar front. Winter storm activity is frequent. Cold arctic air can invade intermountain valleys and remain for days at a time due to temperature inversions and topographic blocking. Temperature inversions are common in the larger valleys, occurring on 40 percent or more of the days during seven months of the year (Dirks and Martner, 1982).

Precipitation

Despain (1990) summarizes the precipitation of the area. Snow is the most common form of precipitation in the park. The date that snow begins to accumulate is influenced by elevation. On the average, snow begins to accumulate at 2,743 m by October 5 within Grand Teton National Park and the surrounding ecosystem. Snow accumulation occurs progressively later at lower elevations (approximately 9 days for every 305 m decrease in elevation). Using SNOTEL data, Despain (1990) found that sites that are located between 1921 m to 2043 m receive the first snow accumulation between October 18th and the 23rd. Mean duration of snow cover has been calculated at 213 days at 2134 m and increases at the rate of 29 days per 305m of elevation gain (Despain, 1990). Maximum snowpack in Jackson Hole is typically reached during the last week of March, and snow pack usually melts completely around May 20th (Despain, 1990). Average total snowfall for the valley floor is 533 cm, approximately equivalent to 46 cm of water.

The dominance of the subtropical high in the summer brings higher daily temperatures. Development of daily thermally induced lows during the warmer months results in convection, expansional cooling of local air masses, and thunderstorms.

Wind

Wind data for the Grand Teton area are sparse and wind conditions are highly variable due to surrounding topography, seasonality, and time of day. Predominant wind direction in the summer is from the southwest, and in the winter from the southeast due to low sun angle and the blocking effect of the Teton Range on the valley's western border. Wind

chill factors have been recorded as low as -61.1°C on Rendezvous Mountain, located in the southern Teton Range (Dirks and Martner, 1982).

Study Site Descriptions

Eight abandoned dude ranch corrals and corresponding undisturbed controls, within Grand Teton National Park, were studied (Appendix A). All study sites were located in the southwestern section of the park between the Jenny Lake area and the Death Canyon trailhead north to south, and from the western bank of the Snake River to the base of the Teton Range, east to west. Corrals used as part of dude ranching operations were chosen for study because use was similar between corrals. In order to keep variability between sites to a minimum, all study sites were located on glacial outwash deposits or alluvial stream terraces, in flat, open sagebrush-dominated vegetation. Site elevations were relatively constant, varying from 1951 m to 2043 m. All sites were located in big sagebrush habitat. Climatic maps show that the sites receive approximately 51-61 cm of precipitation each year (Farnes, 1996).

METHODS

Historical Use and Location

Originally, 27 different corrals were located in the valley through the use of archival documents from both Grand Teton National Park records and Teton County Historical Society files. These included photographs, slides, 35mm films, homesteading claim records, dude ranch brochures, newspaper clippings, secondary sources, and personal interviews conducted during the summer of 1996. Information collected was used to determine location of the ranches and their corrals, the periods of corral use, the number of horses within the corrals, as well as the timing of the closure of the ranches and removal of horses from corrals. Additionally, a general history of dude ranching within the valley of Jackson Hole was acquired through this archival research.

Site Selection

Of the original 27 corrals, eight were chosen for this study. This choice was based on accurate location in the field, and similar geographic setting (aspect, slope, soil type, pre-disturbance plant community, and intensity of use). The location of the corrals was determined by using historical information (maps, photographs, etc), field evidence (fence posts, nails, horseshoes), and personal interviews with former dude ranchers in the field. Each corral site was documented in two or more ways historically.

Historical methodology began with an assessment of the different source materials available. First, 1937 topographic maps were used to determine general site locations. From these maps the number of corrals was limited to those in similar geographic settings. Historical archival information such as newspaper articles and historical photographs from both the Teton County Historical Society and Grand Teton National Park were useful in locating corral sites not present on the 1937 map, as well as providing specific information pertaining to site histories and number of years of corral use. While historical documentation helped to refine site information, personal interviews conducted with past and present ranch owners, as well as former dude ranch employees and retired park service personnel, were most useful in specific site location. These interviews provided invaluable information about site use histories, such as the number of horses present in corrals during specific time periods. Personal interviews and on-site tours with local Jackson Hole residents made the identification of corrals in the field more precise and added historical verification to the sites that were sampled, which reinforced accurate chronosequence development. Aerial photographs of the area were useful in the identification of specific corral boundaries, but were not available for all sites.

Historical information was also crucial to the establishment of control sites for two reasons. First, it was necessary to locate controls in areas of no known human disturbance, which was not always apparent by visual inspection alone. Secondly, use of historical records to locate corrals was necessary to help prevent sampling-bias, so that selected control sites were not based on sampler perceptions of an undisturbed sagebrush community. Homesteading claims and land survey records held by Grand Teton National

Park were most useful in control site location. Once undisturbed locations were located through analysis of these materials, control sites were established randomly within these areas.

Study Design

Corral locations were determined during the summer of 1996, and corral boundaries were clarified and marked during the following spring. Visual identification of boundaries using remainders of fences and fence postholes aided in the most accurate placement of corral boundaries. Often a noticeable vegetation change accompanied the approximate boundary. Each corral site was mapped, and compass bearings were taken along corral boundaries to note precise location and orientation. At least two sides of each corral were clearly identifiable, and in four cases all boundaries were identified. The average size of the corrals was approximately 20m by 30m, although some variation occurred. Similar-sized plots were chosen as control sites in an undisturbed location, as determined from available records, in a similar setting as close as possible to each corral.

Eight transects were placed equidistantly along and perpendicular to the longest axis through each corral. Transect 1 began at the eastern boundary of each corral, while transect 8 was placed at the western boundary. Five (0.5 by 0.5) meter quadrats were placed equidistantly along each of the eight transects, so that forty quadrats were tabulated for each corral and corresponding control. Two sites (Bar BC and Square G) had smaller corral areas so 30 quadrat measurements were tabulated at these sites. This was done so that the scale of measurement remained similar across site locations. Each quadrat and transect was numbered and mapped in the field.

Vegetation Sampling

Vegetation sampling was conducted in each corral and corresponding control during the last week of June and first two weeks of July 1997, during peak flowering time. This ensured accurate species identification and consistent estimates of vegetative cover between the corrals and controls. A pilot study using a point quadrat count (Cotts, 1990, Zakley, 1994) was used at the Murie corral during the summer of 1996. This method was found to be unsatisfactory because forb densities were under represented, and during the summer of 1997 a quadrat count using a (0.5 by 0.5) meter frame (Chapman, 1976; Belsky, 1986a,b) was used instead because it provided a more accurate measure of vegetation. Forb and shub species type, density, and frequency were recorded by quadrat. Density was defined as the number of individuals of a particular species per unit area. Unit area was computed from the 30 or 40 quadrats. No density measurements for grass and grasslike species were calculated, because species that spread vegetatively are impossible to accurately define in this manner (Chapman, 1976; Greig-Smith, 1983). Plant species and frequency were recorded using a stem count within each quadrat. Frequency was defined as the chance of finding a species in a particular area within the sampled site. The frequency measurement was calculated by using quadrats, and was expressed as the number of quadrats occupied by a given species per number of quadrats counted, stated as a percentage. The frequency of a species is dependent upon quadrat size, (0.5 x 0.5) m, and should not be considered an absolute measure. Percent cover for

all ground vegetation within each quadrat was recorded according to lifeform: grass, sedge, forb, and shrub. Percent cover of bare ground, rock and litter were also measured. Cover is defined as the proportion of the ground occupied by a perpendicular projection of the aerial parts of species or lifeforms under consideration (Grieg-Smith, 1983), and is expressed as a percentage. Because of the overlaying of different species, total cover for an area may exceed 100 percent. Grasses and sedges was quantified using percent cover, and identified by species when possible. Differing grass phenology made species identification difficult, because seed heads useful in identification were not always present.

To accurately identify each plant species, a representative of each plant sampled was given a species number for the sampling period. Each numbered specimen was pressed and mounted as a herbarium specimen. Species' identification were verified in a laboratory setting with assistance from Stuart Markow (1997) and Cathy Seibert (1997).

Plant species were grouped into a variety of categories for analysis purposes. Family, genus and species names were identified using Flora of the Pacific Northwest (Hitchcock and Cronquest, 1994). Plant habit (perennial/annual), and native or introduced category was determined using Vascular plants of Wyoming (Dorn, 1992) and cross-referenced with Vascular Plants of Grand Teton National Park (Shaw, 1992). The weedy/ non-weedy categories were determined from the Plant Information Network database (Dittberger and Olson, 1983). This database categorizes plant species in relation to agricultural and stock needs and also allowed further categorization of weedy species into

native, colonizing, economic, and noxious plant species. Plant species information was summarized in tabular form (Appendix B).

Two similarity indices were applied to all species to make comparisons between each corral and paired control. In order to assess recovery over time, a score was calculated for each site. The first index used was the Sorenson's similarity index (Chapman, 1976; see Glenn-Lewin, 1980; Bornkamm 1981; Hatton and West, 1987). The score is derived from the number of species shared between each corral and control in relation to the total number of species found in each site, a measure of similar floristic composition. Sorenson's similarity index takes the form of the number of species in common expressed as a percentage of the mean number of species in the two areas being compared:

$$SI = w / [(a + b) / 2]$$

w = number of shared species
a = total species in controls b = total species in corrals

A second index was devised in which a score was derived for each site from categorical species data through comparison of the number of species in each category between paired corral and the control. Categorical species data includes species origin (native or introduced), habit (annual, biennial, or perennial) and weediness (weedy or non-weedy) information by site. The absolute value of the difference between corral and control was calculated for each category, and then category values were summed as a measure of similarity between corral and control:

$$SI = \sum_{i=1}^{25} |a_i - b_i|$$

a = category value in corral b = category value in control
i = specific category

Soil Sampling

Chemical composition, soil compaction, and soil texture were assessed. Initial chemical tests were completed during the summer of 1996. Six surface samples, 13 to 19 cm in depth were collected from areas currently used by horses, and six samples were removed from an undisturbed control area. Although conditions were not completely similar to dude ranch corrals in question, initial sampling helped to determine the extent of additional sampling needed during the summer of 1997. The most recently disturbed corral/control site (Rudd) and the corral/control resting for the longest period of time (Murie) were sampled during the summer of 1997. Ten samples, approximately 12.7 cm deep, were extracted from each corral and control, and composited. Standard chemical analysis for organic matter (OM) (Sims and Haby, 1970; Page, et al., 1982a), pH, potassium (K) (Page, et al., 1982a), phosphorus (P) (Page, et al., 1982b), nitrogen (N) (Sims and Jackson, 1971), and electrical conductivity (EC) were completed.

A soil pit was dug in each corral and control to a depth that was non-mechanically possible, and soil was excavated from each soil horizon. Soil color was determined in the field using the Munsell color charts (Munsell, undated). Each soil horizon layer was later air-dried, ground using a mortar and pestle, and sieved through a 2mm (no.10) sieve.

Mechanical analysis of soil was then completed using the Bouycous hydrometer method (Bouyoucos, 1962).

Measurement of compaction was attempted a number of ways. An indirect measurement of compaction was attempted using first single ring (Bouwer, 1986) and then double ring infiltrometers (Johnson, 1963). The single ring infiltrometers could not be driven into the ground uniformly to the necessary depth by manual methods, which were required because of site locations and National Park regulation. Because of rocky substrate, double-ring infiltrometers could not be placed in ground consistently so that a proper seal could be established. Bulk density measurements were also attempted. Core sampling with an AMS core sampler (Blake and Hartge, 1965), and sand replacement methods were used (Blake and Hartge, 1965). Finally, Natural Resource Conservation Service personnel were consulted (Rectner, 1997), and compaction was assessed to be unmeasureable due to soil makeup and restrictions placed on sampling by location of sites and park regulation, which prohibited the use of destructive sampling techniques.

RESULTS AND DISCUSSION

Dude Ranch History and Use

The dude ranch played an important role in the settlement of the West, including the area of Jackson Hole, Wyoming. Settlement in the area surrounding the Teton Range began during the late 1890's. Presumably, the harsh climatic conditions and the rough terrain contributed to the rather late date of permanent occupation in the valley of Jackson Hole, located in northwestern Wyoming. While some permanent farming was established on loess deposits in the southeastern portion of the valley, locally known as Mormon Row, the young, rocky soils and harsh climatic conditions also made farming and ranching an unprofitable venture. Some of the people that made up the small population in the valley turned to dude ranching, an early form of tourism, as the "dudes" typically 'paid better than cows" (Daugherty, 1987). Twenty-seven dude ranches were documented north of the town of Jackson between 1908 and 1993 (Teton County Historical Society files). Eight of these ranches were chosen as representative sites for this study. The ranches are listed by increasing time of rest. The physical characteristics and use histories of each site are summarized, and the historical sources are provided (Table 1).

Table 1. Dude Ranch Site Physical and Historical Characteristics

Site Name	Elevation	Aspect	Dominant Vegetation	Soil Classification (SCB)	Time of Use	Years of use	Years of Recovery	Number of Horses	Sources Consulted to Locate Sites
Rudd Corral	2073 m	flat	Sagebrush	Taglake-Sebud association glacial moraine	1950-1993	63	4	40-80	USGS map 1967 Aerial Photographs Interview of owners building foundations, fencepost holes
White Grass Ranch	2049 m	flat	Sagebrush	Tineman gravelly loam	1919-1985	66	12	40-80	USGS map 1937, 1967 Historic photographs newspaper articles Dude Ranch and railroad publications fenceposts, remaining buildings Park Service management plan
Bar BC Ranch	1988 m	flat	Sagebrush	Tineman gravelly loam	1912-1980	68	17	25-45	USGS map 1937, 1967 Corral intact in the field Book Park historical survey/ National registry Newspaper and Magazine articles
Circle H Ranch	2012 m	flat	Sagebrush	Teton-Wilsonville fine sandy loam	1945-1978	33	19	15-35	USGS map 1967 Questionnaire from former owners Park lease agreement Intact corral in the field
R Lazy S Ranch	1951 m	flat	Sagebrush		1946-1971	25	26	30-45	USGS map 1937, 1967 Interview with dude rancher On site tour with owner Grand Teton National Park Historical Files Teton County Historical Files
Halfmoon Ranch	2012 m	flat	Sagebrush	Tineman gravelly loam	1927-1967	40	30	40	USGS map 1967 1950 picture of the site On site tour with past dude rancher Interview with former cook Bridle pieces, horseshoes, fence posts
Square G Ranch	2122 m	flat	Sagebrush	Taglake-Sebud association glacial moraine	1933-1950	17	47	30-45	USGS map 1937, 1967 Park historical files On site tour with past dude rancher
Murie Ranch	1927 m	flat	Sagebrush	Teton-Wilsonville fine sandy loam	1921-1941	20	56	20	USGS map 1937, 1967 Park historical files Interview with ranch owner and son Newspaper articles Book

Rudd Corral

The Rudd corral was established in its present location in 1950, as Teton Trail Rides, a Park Service concession. The Rudd family provided horseback riding and packing services to tourists through 1993, when their concession permit expired. The corrals were located just south of Jenny Lake in Grand Teton National Park. While there were not overnight facilities for guests, horse use was similar to horse activity on a traditional dude ranch. According to Nancy Rudd-Dalley (1997) horse numbers varied from 40 horses during the 1950's, to approximately 80 by 1993. Aerial photos show, and personal interviews confirm, five horse corral structures, including areas for horseshoeing, injured or sick horse isolation, overnight containment, and daily horse rides. The main corral, 13 m by 32 m, was sampled. It was chosen for sampling because it was most similar in dimension and horse number to the other corrals. The National Park Service is investigating restoration possibilities at this site. The other ranches in this study were chosen to establish a chronosequence to which Rudd's corral could be compared, and in which natural revegetation progress could be assessed.

Whitegrass Ranch

Whitegrass Ranch is located in the southwest corner of Grand Teton National Park at an elevation of 1951 m. The ranch is located at the entrance to Death Canyon, 10.47 km southwest of park headquarters at Moose, Wyoming.

Harold Hammond and Tucker Bispham homesteaded two homestead claims in 1913, approximately 129 hectares. They began dude operations in 1919, and the ranch operated

almost continually through the fall of 1985 (Jackson Hole News, 1985a,b; Jackson Hole Guide, 1973). The Whitegrass Ranch is the third oldest dude ranch operation in the valley of Jackson Hole.

Prior to 1919, the main house, some guest cabins, a 9 m by 15 m barn and 3 adjacent corrals (largest estimated to be 18 m in diameter) were constructed (Teton County Historical Society files, 1996). Due to financial constraints, the ranch was sold to the Bar BC ranch in 1924 and was operated as a boy's summer camp (16-guest capacity) during the summers of 1925, 1926, and 1927 (McCraney, 1992). In 1927, Hammond and Bispham bought the ranch back from the Bar BC. Bispham sold his 160 acre interest to Hammond in December of that year, and moved to the Three Rivers Ranch in northern Jackson Hole (Daugherty, 1987). Historical documentation shows that the ranch operated through the 1930's with 35 dudes at the ranch at a time (Jackson Hole Guide, 1964). In 1930 the ranch had eighteen cabins in addition to the main house, outbuildings and swimming pool (Daugherty, 1987). Harold Hammond died in 1938, and his wife Marion took over ranch operations. Because tourist dollars were few, the ranch was closed during WWII. After the war, the ranch capacity was expanded to 55 to 70 dudes at a time and 80 horses (Jackson Hole News, 1985c). Marion Hammond's son Frank Galey and his wife, Nona, began managing ranch operations in 1945, and the ranch remained fully occupied until operations ceased. Seasonally, the ranch operated May through October, and was a year-round home for owners and staff.

The park's annexation of 129.6 hectares of Whitegrass land began in 1957, with the purchase of 122 hectares from Frank Galey. The park purchased the final 2.44 hectares

of the ranch in 1983. With Mr. Galey's death July 6th 1985, the lifetime lease on the land expired, and some fencing and buildings were removed beginning in 1986. Nona Galey was given a ten-year lease to live in her house, and use of two other cabins on the property. A fire damaged her house, November 6th 1985, and she relinquished her lease soon after (Jackson Hole News, 1985(b)).

The corrals were located immediately adjacent to the main house structure, and slanted downhill gently from west to east. The barn was removed from the area in 1991, in accordance with initial restoration plans (Burgette, 1985). Sectioned corrals are still evident, with downed fence posts and postholes visible. Water was running overland (no channel) in the northeastern section of the corral during sampling in 1997. Overland flow was not observed during the summers of 1995 or 1996 during the same time period, and may have been a result of the greater than average snowfall during the 1996-97 winter season.

Bar BC Ranch

Struthers Burt began building the Bar B-C Dude Ranch in 1912. His first endeavor in the valley of Jackson Hole was a partnership with Lewis Joy at the valley's first dude ranch, the JY ranch, from 1908-1911. The Bar BC was the second dude ranch to be established in the valley of Jackson Hole, and today remains the most physically intact example of a dude ranch in the state of Wyoming.

Maxwell Struthers Burt, his wife Katharine Newlin Burt and Dr. Horace Cancross were the primary owners of the ranch. Irving Corse joined the partnership between 1926 and 1929 (Bar BC Structure Report, 1991). Both of the Burts were nationally known

writers. Diary of a Dude Rancher, originally written by Struthers Burt in 1924, is an autobiographical account of the formative years at the Bar BC (Burt, 1938). Many of the rich and famous from the East Coast, particularly Philadelphia, Struthers Burt's hometown, enjoyed the Bar BC. When Horace Cancross died in 1927, the Burts bought a new ranch, the Three Rivers Ranch, near Moran in the northern part of the Jackson Hole, and took up residence there in 1930 Burt, 1938. That same year, the Bar BC property was sold to the Snake River Land Company for future inclusion into Grand Teton National Park, in which Struthers Burt played an active role. This left Irving Corse the sole partner to manage the ranch until his death in 1953. His wife Maggie Corse resumed management and continued to reside at the Bar BC under a revised agreement, which gave her life tenancy on the property. The dude ranching component disappeared during Maggie Corse's tenure, although she continued to rent cabins in the summer. Mrs. Corse surrendered her tenancy of the Bar BC in 1986, two years before her death. The Bar BC Ranch complex was listed on the National Register of Historic Places in 1988. Historical sources (Corse, 1954; Gizycka, 1978) indicate that horses were utilized throughout the 1960's, and were phased out during the late 1970's or early 1980's. References from Diary of a Dude Rancher and interviews on file at the Teton County Historical Society show that horse numbers varied at from at least 25 to 45. The main corral is still intact today, and is shaped in a figure eight, with a gate connecting the upper and lower circles. Due to the small size of this corral, fewer quadrats (30) were sampled. Corral boundaries were 11.5 m by 9 m in the northernmost circle, and 10m by 7m in the southern loop, making the Bar BC the smallest corral in the study.

Circle H Ranch

During the 1920's H.H. and Ethyl Harrison started a dude ranch located 8.1 km south of Moose, Wyoming, on the eastern side of the Moose-Wilson road. By 1927, seven guest cabins and a main lodge were built. The property was operated as a working hay ranch and farm, and housed 14 dudes at \$12 per day. The land was sold to John C. Dilworth in 1928 for \$20,000 and was not operated as a dude ranch again until Harry Barker Sr., purchased it in 1945. The ranch was then operated through 1966, when the land was sold to government for a 30-year lease. The original 1940 corrals are still standing. Personal interviews with the Barkers revealed that 2 horses were kept in the original corral until 1978, and between 15 to 30 horses were kept in the corral when the ranch was in operation (Barker, 1997). An open figure-eight shape forms the corral boundaries, which were roughly 25 m by 14 m. A creek lies immediately adjacent to the northeastern boundary of the corral.

R Lazy S Ranch

The R Lazy S was originally homesteaded by Elsie James, and was purchased by Owen Wister, author of The Virginian, in 1912 (Huyler, 1996). The property was only occupied during the summer of 1912, because Wister's wife died. The property was sold to the Chauncey Spears in 1920 (Property Inholdings File, Grand Teton National Park), and run as a dude ranch according to Daugherty (1987). No additional references to dude ranching at the Circle H were found in historical records until the 1940's, with an advertisement in a Northern Pacific Railroad guide (Northern Pacific, undated). Spears

sold the land to Robert McConaughy in 1929. Although Daugherty (1987) indicated that dude ranching continued under McConaughy in 1930, McConaughy (1997) revealed that horse use began in 1941. McConaughy sold to the Jackson Hole preserve in 1947, and continued to lease the land until 1972, when the entire ranching operation was relocated to its present location just northeast of the Jackson Hole ski area in Teton Village. The buildings from the original site were removed after 1972, although some building outlines and roads and trails are still obvious. A personal interview and tour of the site with members of the McConaughy family indicate that 30 to 45 horses occupied the corrals during the McConaughy tenure. Since the abandonment of the ranch in 1972, dikes were constructed along the Snake River that flows parallel to the R Lazy S site. The construction of dikes downstream from the ranch has changed the course of the Snake River and much of the land upon which the ranch sat has been consumed by the river. The river was not visible in a 1960's picture taken from the corrals, however the land upon which the cabin area was built that lay between the corral area and the river has been completely eroded away. Accordingly, the abandoned corral is closer to the river's edge today than when occupied by horses. The corral was constructed in a "L" shape with cottonwood trees located at the bend of the L, with approximate boundaries of 36 m by 17 m. Sections of corral fence and nails were still attached to the cottonwood trees, and postholes marking the fence line were evident.

Halfmoon Ranch

Mr. and Mrs. Peter Karppi homesteaded this ranch in 1923. The ranch is located 6.4 km directly north of Moose, Wyoming on a terrace of the Snake River Plain. The original Park Headquarters at Beaver Creek are approximately .81 km directly west of the ranch. Cottonwood creek flows through the ranch area. Between 1923 and 1927 a four room house, 12 cabins, icehouse, well, log barn, corrals, and buck and pole fence were built (Daugherty, 1987). The ranch was operated as a dude ranch from 1927 until 1967. According to the Midwest Review (1927), the ranch housed 28 girls and 16 boys for two, seven-week sessions during the summer of 1927.

Anita Tarbell became a partner in 1928, and was effectively the ranch manager until her death in 1960. Tarbell left the ranch to Charles Guss. He sold the Halfmoon property to the park in 1967, and was given a lease to continue operation. Guss gave up the lease in 1972, and buildings were removed. Archival records, from personal interviews held in the Teton County Historical Society files, show 40 horses at the ranch in 1942.

The corral was located with the help of an old photograph, a verbal description, and a 35mm film taken by a former cook, Doris Platts (1996). A horseshoe and leather bridle-bits found on site help to affirm that area was used as a horse corral. The corral area was rectangular in shape, approximately 22m by 20m. The corral began on a flat surface, dropped down 1 meter to the east, and then flattened again. Exposed river cobble was evident through out the corral and surrounding area. The corral is bounded by Cottonwood Creek to the east, which is approximately 15 meters below the corral. The

creek is lined with vegetation. Paths from the corral to the river suggest that the horses utilized the stream regularly.

Square G Ranch

The Square G Ranch is located on the north side of the North Jenny Lake road, 0.4 km east of the Cathedral Group turnout at an elevation of 1108 m. Mr. Gabby homesteaded the area in 1922, and the first cabins were built in 1925. The property was used as a small dude ranch beginning in 1933, with the opening of the dining room, which was sponsored by the Duncan Hines company. At its height, the ranch included 40 cabins, 32 cabins for guests. In addition to the large dining hall, there was a main lodge, outhouses, and other outbuildings, as well as corrals. Square G Ranch brochures indicate that guest capacity was 40 people in 1936. Robert Krandenburg, a longtime resident of the valley and foreman at the Square G, indicated that 25-35 horses were kept in the corrals (Krandenburg, 1996). Mr. Gabby died in 1949, and the land was purchased by the Jackson Hole Reserve, and donated to Grand Teton National Park. The ranch was used as seasonal park housing until 1956 when the buildings were moved to Colter Bay and other locations outside the park.

The old road, some building foundation outlines, an on-site tour with Bob Krandenburg, a former employee of both the Square G ranch and the National Park Service, and a Ranch map (Wright, 1977) helped to locate corral. The corral boundaries were approximately 13 m by 15 m, in sagebrush dominated vegetation.

Murie (STS) Ranch

The STS (named for ESTES) was the smallest dude ranch operation included in the study. The ranch is located approximately 2.42 km southwest of Moose, Wyoming in the southwest corner of Grand Teton National Park, at an elevation of 1951.2 m, in flat sagebrush dominated vegetation. Buster and Frances Mears Estes homesteaded the STS. He was a ranch hand on the 4-Lazy F, and she was a dudeen at the Bar BC ranch. They married and applied for a 31 hectare tract in January 1921. From 1923 to 1927 there was a small house that was their residence, a few cabins and tents. By 1927, a 5-room main house, 3 cabins, a log garage, and barn were constructed on site (Jackson Hole Guide, 1964a). Facilities at this time could accommodate 10 guests. By 1930, ten cabins, two bunkhouses, laundry facilities, a bathhouse, and a chicken coop completed the ranch and the guest capacity was 24 to 30 guests. This small facility was hit hard financially by the depression and prices were lowered to \$20 a week. Horses were not included as part of the price, but were charged as a daily or weekly expense, \$3 a day or \$15 a week (STS Ranch brochure, undated). The ranch was not operated during WWII, and was sold to Adolph and Marty Murie in 1946. The Muries used the ranch as a private residence and as a headquarters for the National Wilderness Society. Horse operations were discontinued. No horse disturbance has occurred since 1941, although outbuildings and the barn were removed from the area during the late 1950's and early 1960's. Marty Murie resides at the ranch today. The corral site is located west of the Murie residence. Debris from the removal of the barn, and a standing tack shed are still evident.

Approximate corral boundaries are 20m by 23m. Populus trichocarpa (black cottonwood), Populus tremuloides (aspen), Pseudotsuga menziesii (Douglas fir) and Pinus contorta (lodgepole pine) bound the corral to the north and east, and a small creek provides a southern boundary.

All Sites

Sites were accurately located through a combination of written historical documentation, physical evidence and personal interviews. While the history of each site is as complete as records allowed, the number of horses at each site over the time the corral was in use had to be inferred from available information. The number of horses occupying the corrals could be inferred from ranch advertising brochures which often listed guest capacity, newspaper articles, old photographs, and even ranch inventory lists, which listed the number of saddles owned. Because tourist numbers grew as ranch activity expanded, it is probable that the number of horses utilized fluctuated. Therefore, a range in the number of horses used is reported when known.

The location of undisturbed sites in close proximity to corral sites proved challenging. Dude ranch history, maps and on site tours helped to discern areas which were not disturbed by human activities. Land survey records from the Snake River Land Company, which included original homesteading claims, were also used to assure that controls were placed in non-disturbed areas, and not based on similar physical characteristics alone.

Vegetation

All Species

A total of 128 species were found; 103 forbs and 25 grasses. The total number of species at each site and between corral and paired control were compared graphically (Figure 3). Species numbers varied by site, and variation in total species number (species richness) was greater in controls than corrals. The variation within the control sites reaffirms the heterogeneity of the natural environment in which the sites existed. The lowest number of species (19) was found in the Bar BC corral, and the highest (47) in the Whitegrass control. The low number of species in the Bar BC corral may be due in part to the smaller number of quadrats sampled at that site, so that fewer species were included in the sample population. An increase or decrease in species number was not found to correspond to increasing time of rest in corral sites. Total species numbers appear to be more strongly related to site than time of rest.

Plants Found in All Controls or Corrals

Eleven species occurred in every control; Polygonium douglasii, Collomia linearis, Galium bifolium, Nemophilla breviflora, Erigonium umbellatum, Taraxacum laevigatum, Viola vallicola, Lupinus sericeus, Delphinium spp., Poa pratensis, and Artemisa tridentata. The first nine species listed are forbs, P. pratensis is a grass, and A. tridentata is a shrub. All are native species, with the exception of T. laevigatum and P. pratensis, which are introduced species. The average density and frequency of all the

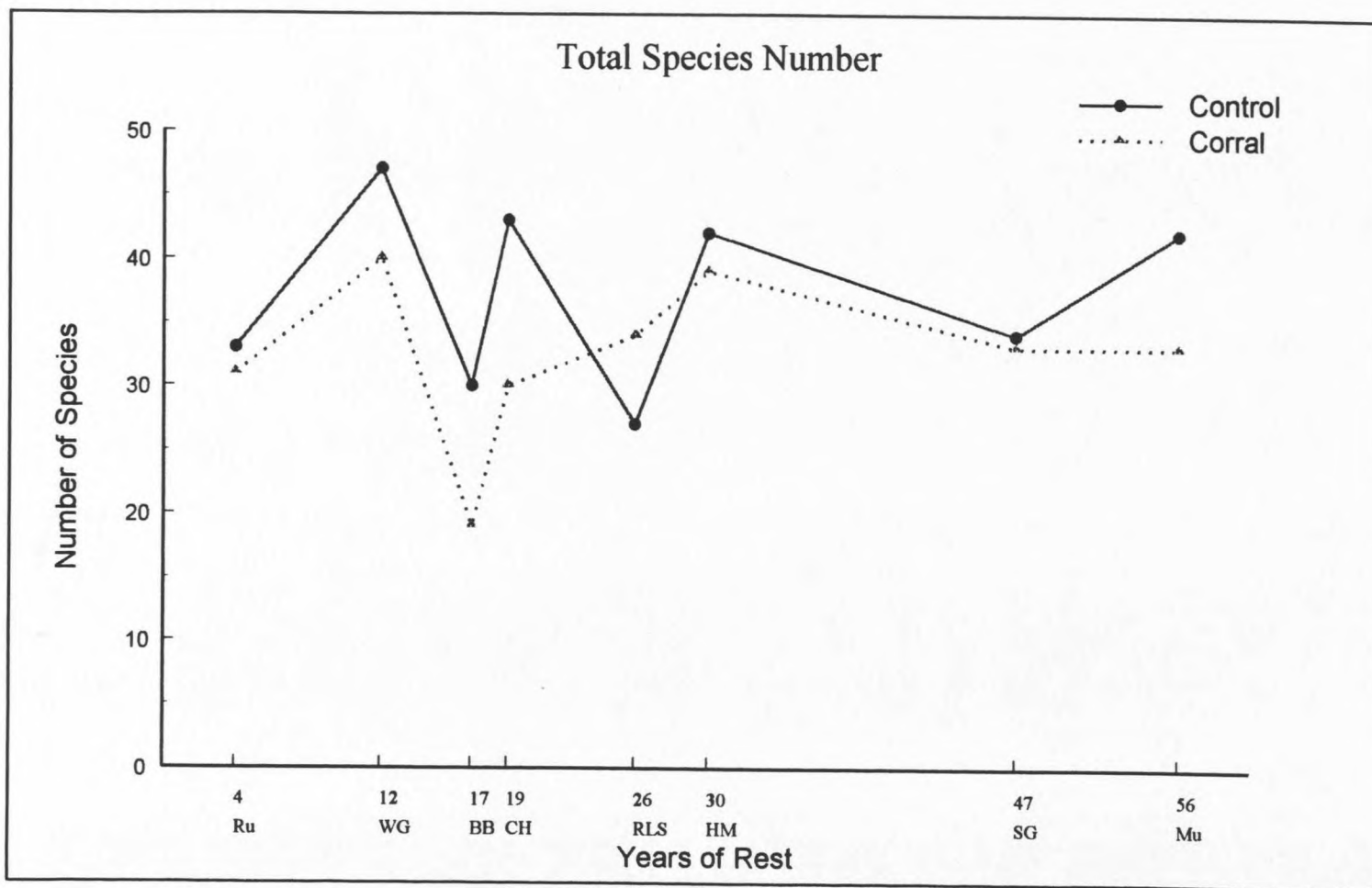


Figure 3. Total number of species in corral and control at each site.

species that occurred in all the controls were computed, and graphically displayed using bar graphs in order to assess the similarity of controls (Figure 4).

With the exception of P. douglasii (Podo), C. linearis (Coli), and G. bifolium (Gabi), the average densities of the shared species are low, indicating that while they are present, they are not dominant species within the control sites. In addition species densities are not consistent across all sites. For example, G. bifolium (Gabi) showed a great range in average stem density, with the highest average value at the Rudd's control (15.18 stems per quadrat), and the lowest average at the R Lazy S control (.06 stems per quadrat). Overall variation in species densities across sites is not obviously time-of-rest related, and for some species appears site specific.

Frequency data for shared control species show that P. douglasii (Podo), E. umbellatum (Erum), and A. tridentata (Arti), were fairly equally distributed across all controls. C. linearis (Coli), G. bifolium (Gabi), and P. pratensis (Popr) species were equally represented in all sites except Circle H and R Lazy S controls. Average stem density and frequency measurements in the Bar BC, R Lazy S, and Circle H controls are lower than those found in the other control sites, indicating that the shared species are less numerous, occur less frequently, and that all controls are not the same. The Snake River has eroded the riverbank of the R Lazy S property since the ranch stopped operating in 1972, so that river-induced changes in the microclimate of the control might explain differences in vegetation. However, microclimate changes were not tested in this study, and no obvious changes have occurred at the Bar BC and Circle H controls to provide an explanation for lower species densities and frequencies found at these sites.

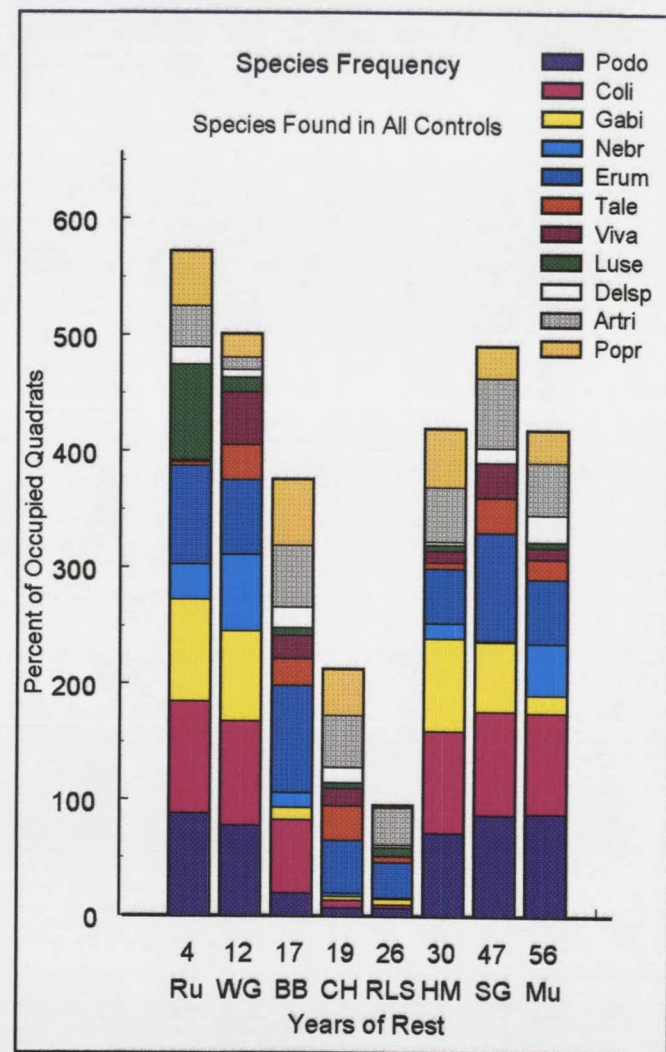
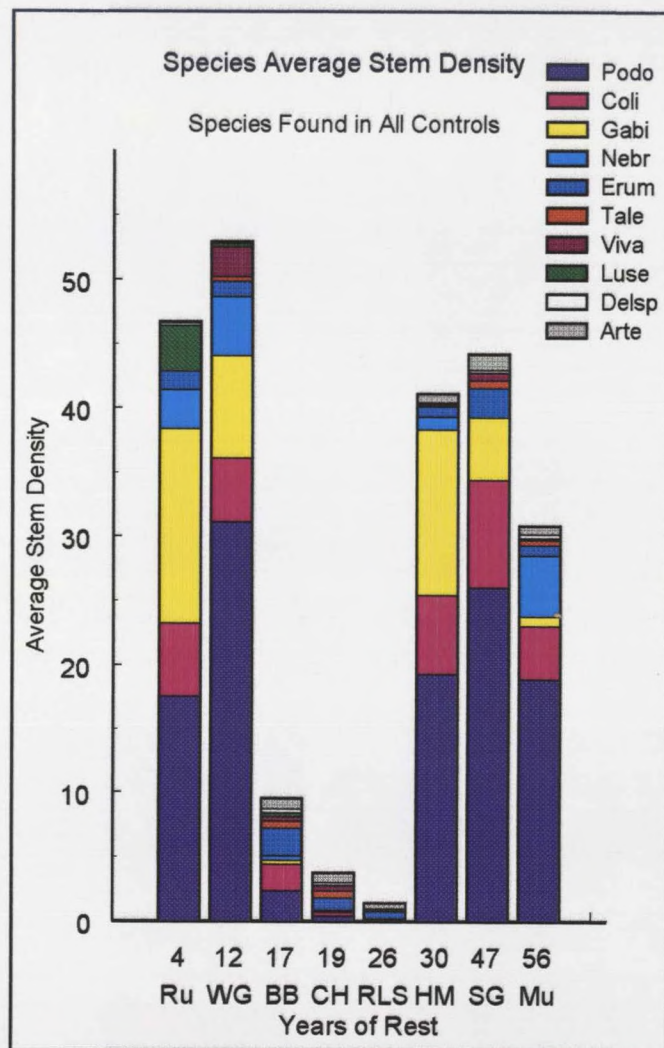


Figure 4. Stem density and frequency of species found in all control sites. Ranch abbreviations: Ru, Rudd; WG, Whitegrass; BB, Bar BC; CH, Circle H; RLS, R Lazy S; HM, Halfmoon; SG, Square G; Mu, Murie. Species are abbreviated using the first two letters of the genus and species, complete species names are listed in the text. Popr, *Poa pratensis* is a grass species, for which no stem density measurement was taken.

The average stem densities of the species shared by all the controls were individually compared to average stem densities of the same species in the corresponding corals (Figure 5). Individual comparison of the average stem density of each species found in all control sites with its density in paired corral sites show with exception of P. douglasii (Podo) that the overall densities of these species are low, and that the standard error of each sample is variable across sites

Only two plants were found in all corals, P. douglasii and Gayophytum diffusum (Figure 6). P. douglasii has the distinction of being the only species found in all corals and controls. The average stem density of both species in corral sites was variable, with highest concentrations shown in specific corral sites. The average stem density of P. douglasii is similar in corral sites, with the exception of Whitegrass corral (86.6 stems) and Rudds corral (34.3 stems), where it is locally abundant, and the Circle H corral, where density was sparse (.15 stems). G. diffusum was consistently found in low density, and was most abundant at Murie corral with an average density of 5.2 stems.

Analysis of data show that few species are found in all controls. These shared species, with the exception of P. douglasii, are found in low densities, and while present in all controls, do not represent dominant species. The assemblage of shared species shows that the undisturbed plant community is naturally diverse and that a particular grouping of species is not strongly associated with control sites. It is not possible to predict the makeup of corals as only two species were found at all corral sites.

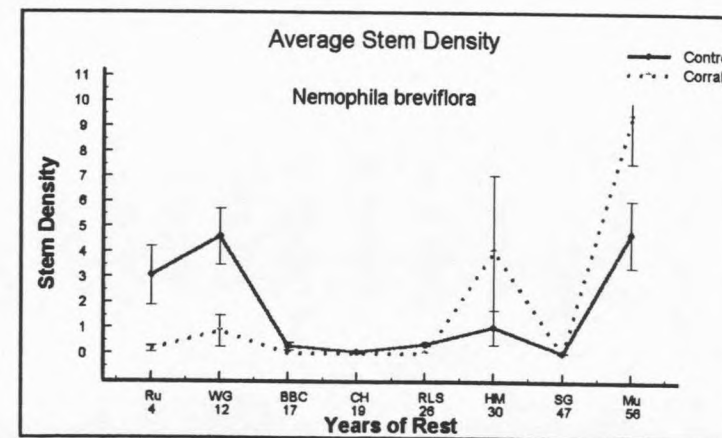
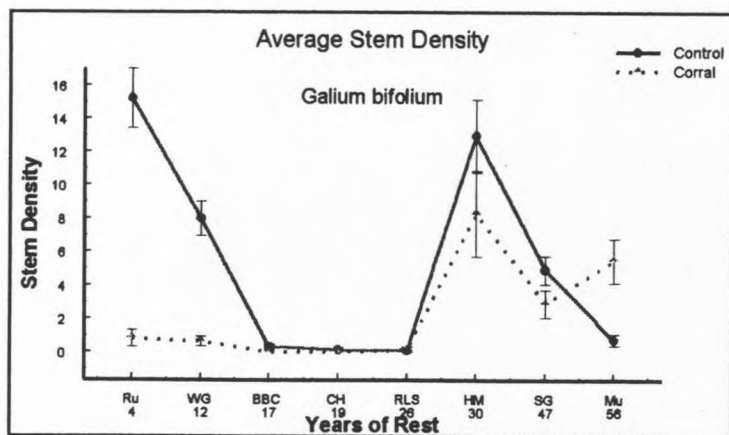
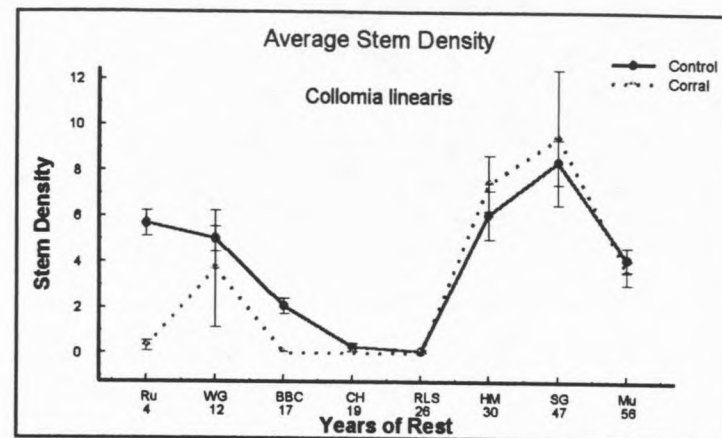
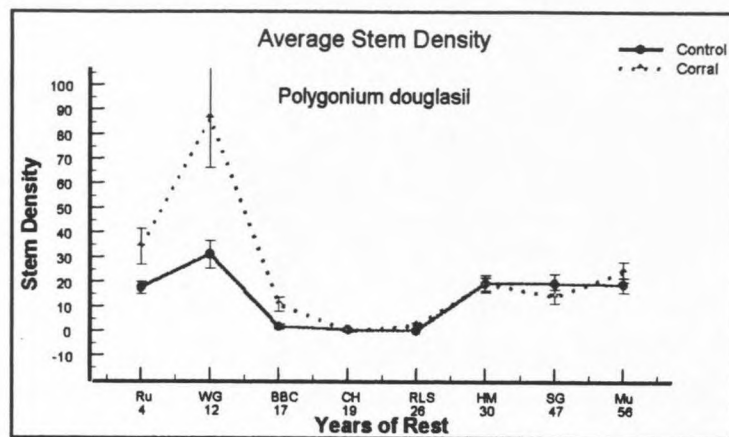


Figure 5. Average stem density of the ten forb species found in all controls shown with the standard error of the sample, by site. Species average density in control sites are shown in comparison to species average density in paired corrals.

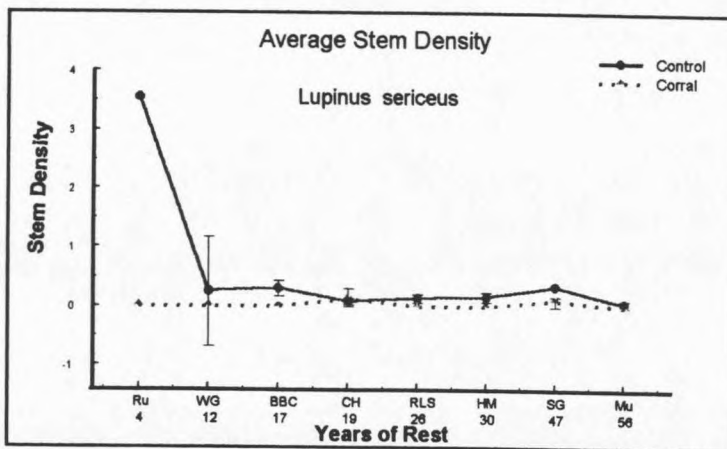
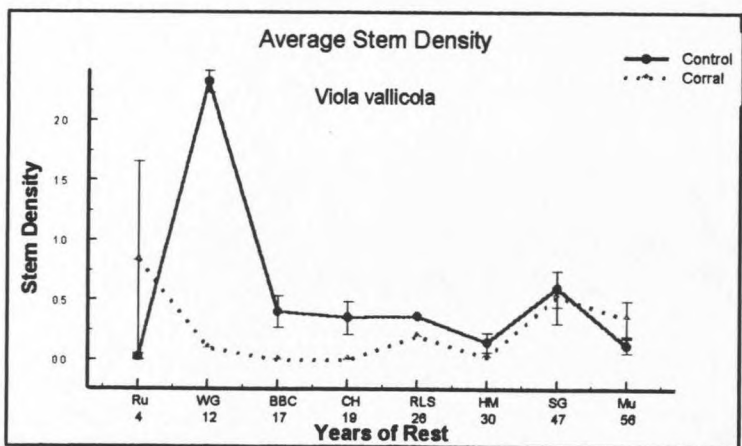
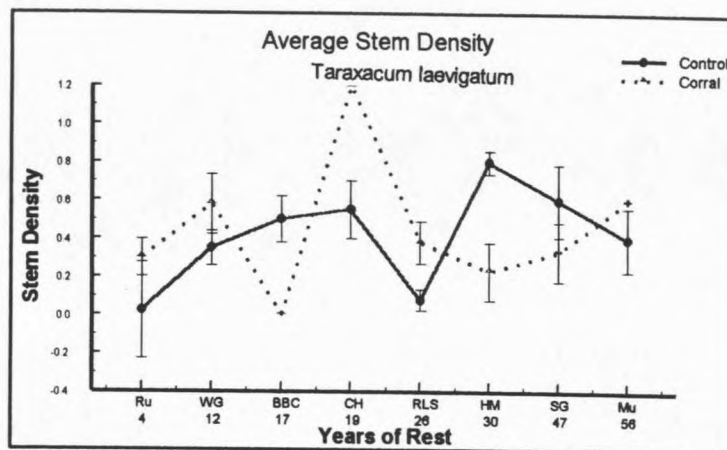
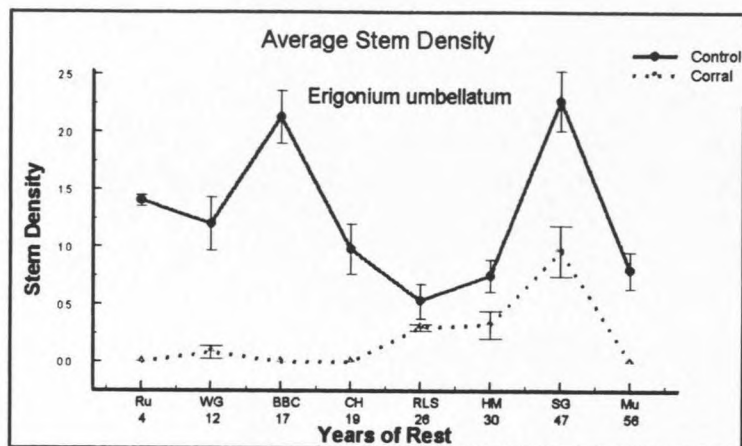


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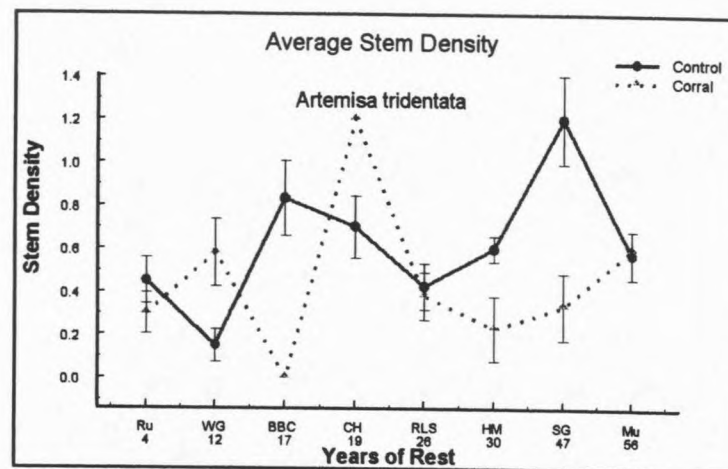
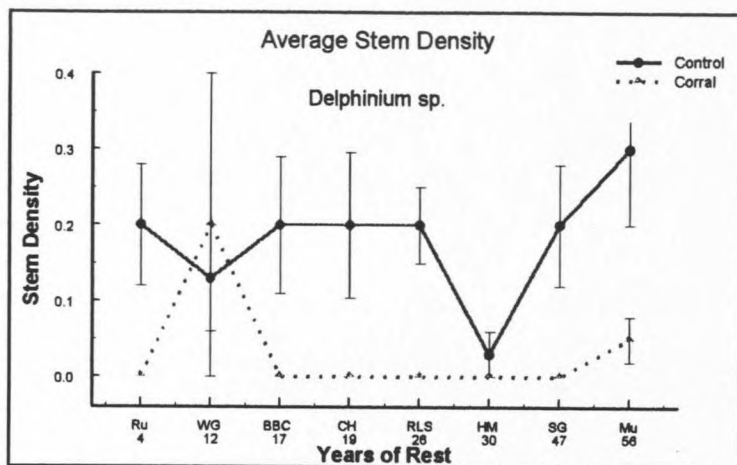


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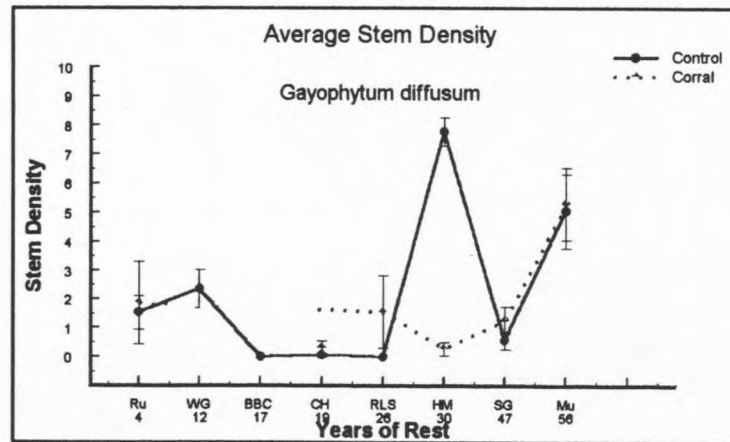
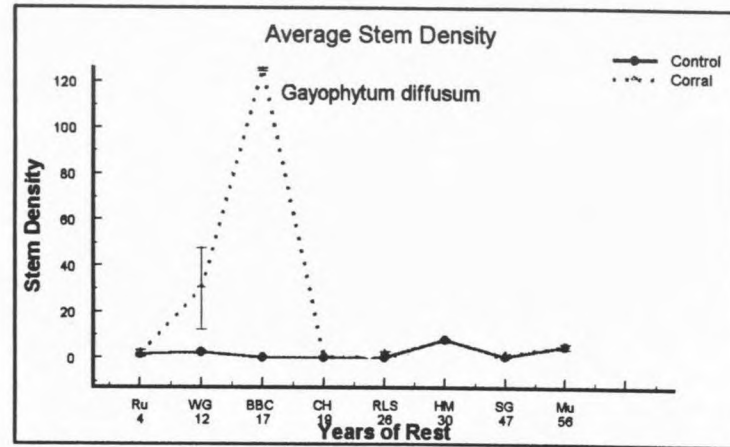
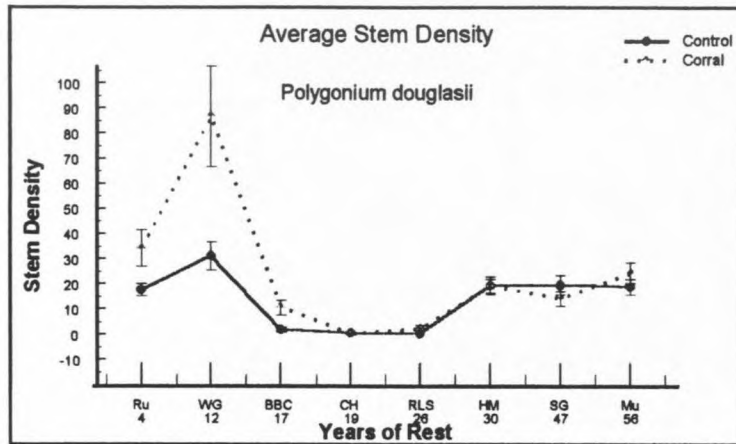


Figure 6. Average stem density of species found in all corral sites shown with the standard error of the sample, by site. Species average density in corral sites are shown in comparison to species' average density in paired controls. *P. Douglasii* is found in all corral and control sites. *G. diffusum* is graphed using two different scales to show variability in average density across corral sites.

Commonly held notions of plant regeneration after disturbance suggest that disturbed sites progress to a climatically induced stable state. Results of this analysis suggest that the establishment of a specific composite profile of undisturbed sagebrush vegetation induced by stable climatic conditions was difficult, and that the natural species variation within the sagebrush dominated sites overwhelmed any moderating factors caused by similar environmental conditions across all sites. These results challenge the notion that specific species composition within a climatically induced climax community can be identified and predicted.

Species Categorical Data

Plant habit, origin, and weediness designation for all species sampled is presented in tabular form (Appendix B), and in summary by site (Appendix C, Table 2). Analysis of data in this categorical format aided in the description of similarities and differences of vegetation composition between corral and controls sites, and helped to reveal any changes in vegetation pattern over time.

The species identified included 29 annuals, 8 biennials, and 91 perennials. Ninety-five species are documented as non-weedy and 33 as weedy species. Of the thirty-three species categorized as weedy, 12 are considered colonizing weeds, 15 are economic weeds, and 6 are noxious weeds. Thirty-seven of the 128 species have been found in disturbed sites by previous surveys (Dorn, 1992, Shaw, 1992). Sixty-nine of the 128 species sampled were perennial, native, non-weedy species.

Table 2. Species Categorical Data By Site

	Rudds		Whitegrass		Circle H		Halfmoon		RLS		Bar BC		Square G		Murie	
	Control	Corral	Control	Corral	Control	Corral	Control	Corral	Control	Control	Corral	Control	Corral	Control	Corral	Control
Forbs	28	24	41	32	38	25	36	32	23	26	26	17	25	26	26	33
Grasses	5	7	6	8	5	5	6	7	4	8	4	2	9	7	7	9
Perennial forbs	17	13	26	12	0	14	20	15	16	11	13	8	13	1	1	29
Perennial grass	4	7	6	7	5	5	6	6	4	8	4	2	9	7	6	0
Annual forbs	10	14	12	15	9	7	11	14	5	11	11	7	10	9	11	10
Annual grass	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
Biennial forbs	1	2	2	3	0	4	3	1	0	2	2	0	2	1	2	2
Biennial grass	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Unknown P/A forb	0	2	0	3	1	0	2	2	2	2	0	2	0	0	2	1
Unknown P/A grass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Native forb	24	17	36	20	31	17	31	25	18	17	20	15	22	24	18	27
Native grass	3	3	3	3	3	1	2	3	2	3	2	0	7	5	5	6
Introduced forb	4	7	6	11	6	8	6	7	5	9	6	2	3	2	8	6
Introduced grass	2	4	1	5	2	4	4	1	2	5	2	2	2	2	2	3
Colonizing forbs	1	2	3	4	4	2	2	2	0	3	0	3	0	1	1	0
Colonizing grass	2	2	2	2	2	3	2	1	0	3	1	1	1	2	2	2
Economic forbs	3	3	4	7	4	3	5	4	3	3	4	1	3	2	6	4
Economic grass	0	0	0	1	0	0	0	1	0	0	0	0	1	1	0	0
Unknown weedy forbs	1	0	1	2	3	1	1	2	1	3	0	0	3	3	1	2
Unknown weedy grass	0	0	1	0	0	0	1	1	0	0	0	2	1	1	0	0
Nonweedy forbs	23	18	31	17	25	13	26	23	19	16	21	11	18	21	15	24
Nonweedy grass	3	5	4	5	3	2	3	4	4	5	3	1	6	3	5	0
Noxious forbs	0	1	2	2	2	4	1	0	0	3	1	0	1	0	2	2
Noxious grass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tot # Species	33	31	47	40	43	30	42	39	27	34	30	19	34	33	33	42

Forb Habit

Forbs were the dominant lifeform in all sites (Figure 7). Forbs occur in higher percentages in the control sites, with the exception of the Bar BC and Square G controls, which exhibit slightly higher forb percentages in the corral sites. The amount of each type of forb present (annual, biennial, and perennial) varies when comparing corrals and controls (Fig 7). Annuals make up a larger percentage of the total forb composition in the corrals when compared to the controls, except in the Square G where annual forbs are slightly more dominant. Annual forbs are present in highest concentration in the two most recently disturbed corrals, Rudds and Whitegrass, and they are present in near-equal concentrations at the Bar BC control and corral.

Perennial forbs makeup the highest percentage of forbs across all control sites (Figure 7). The percent of vegetation composed of perennial forbs within controls varies from 65% at the Circle H to 38% at the Square G. Perennials compose a greater percentage of forb vegetation in all controls when compared to corrals except in the Square G, where a greater percentage of perennial forbs is found in the corral, and in Bar BC where the corral and control exhibit fairly equal percentages of perennial forbs

Biennials (Figure 7) consistently makeup a small percentage of the total forb composition, less than 7% in all sites except the Circle H Corral which exhibits a 13% biennial forb composition. Biennial forb percentages change between control and corral, establishing no trend with time.

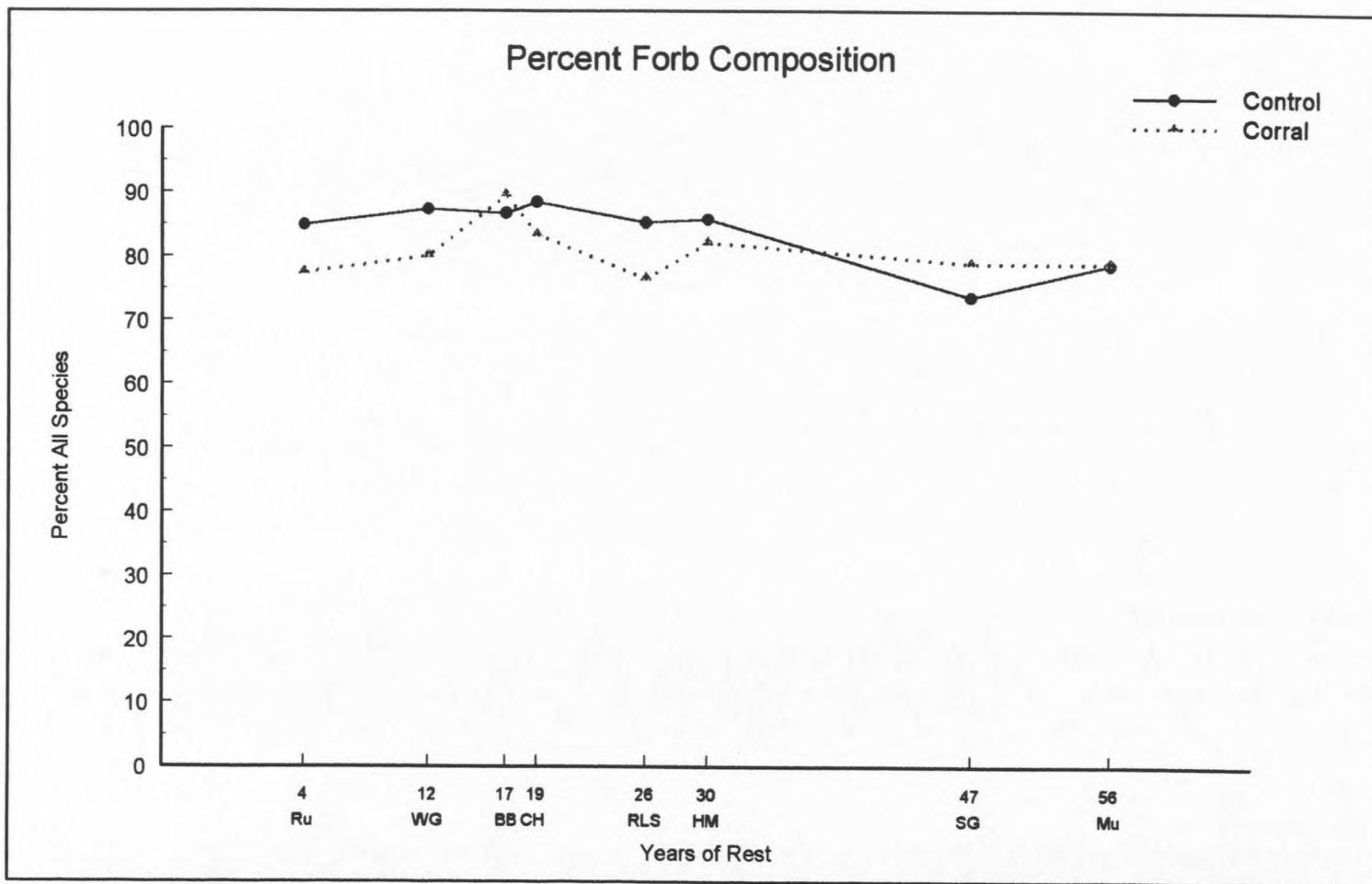


Figure 7. Species categorical data. Percent of total species that are forbs, percent annual forb composition, percent perennial forb composition, percent biennial forb composition from total forb composition.

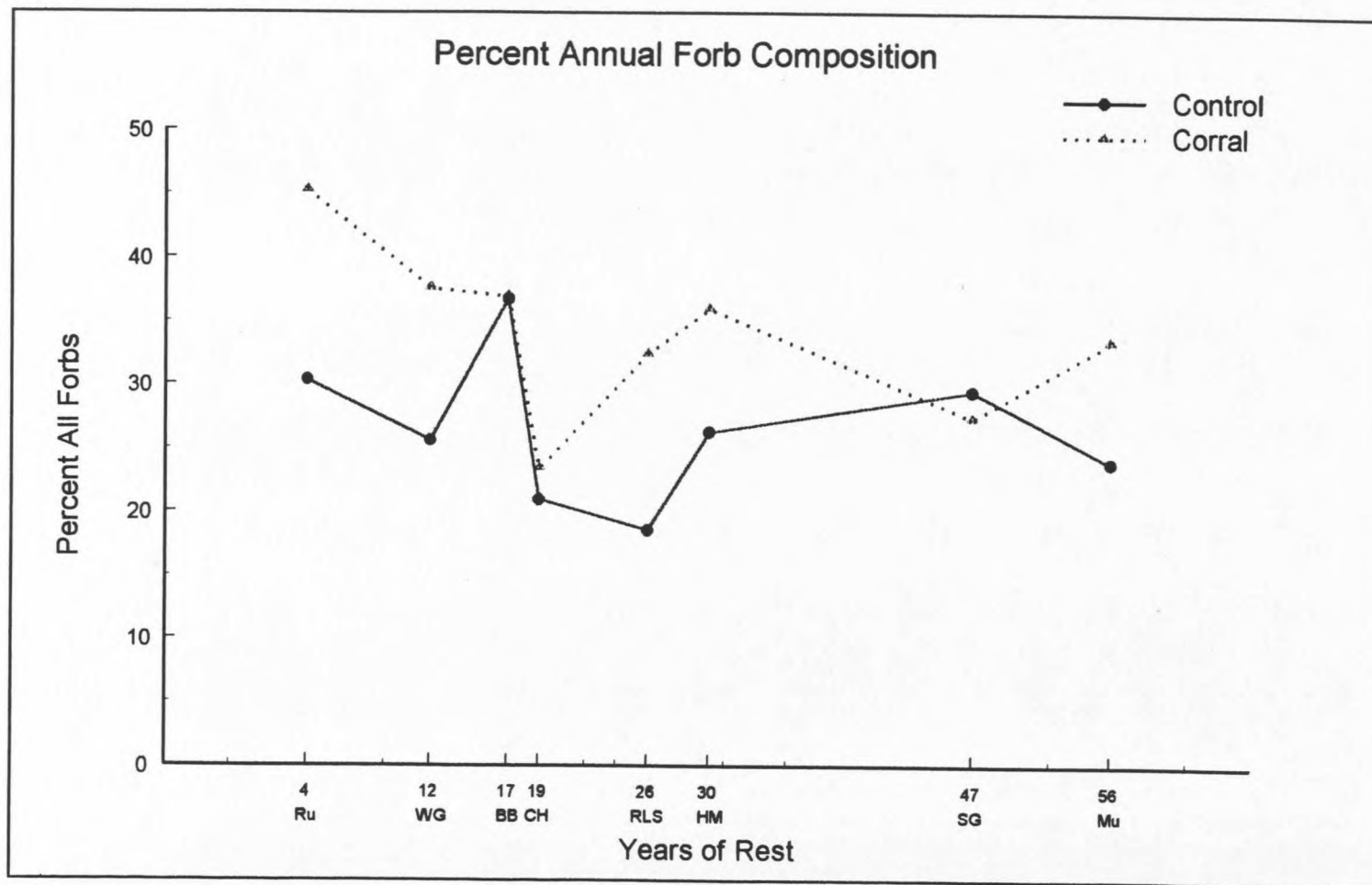


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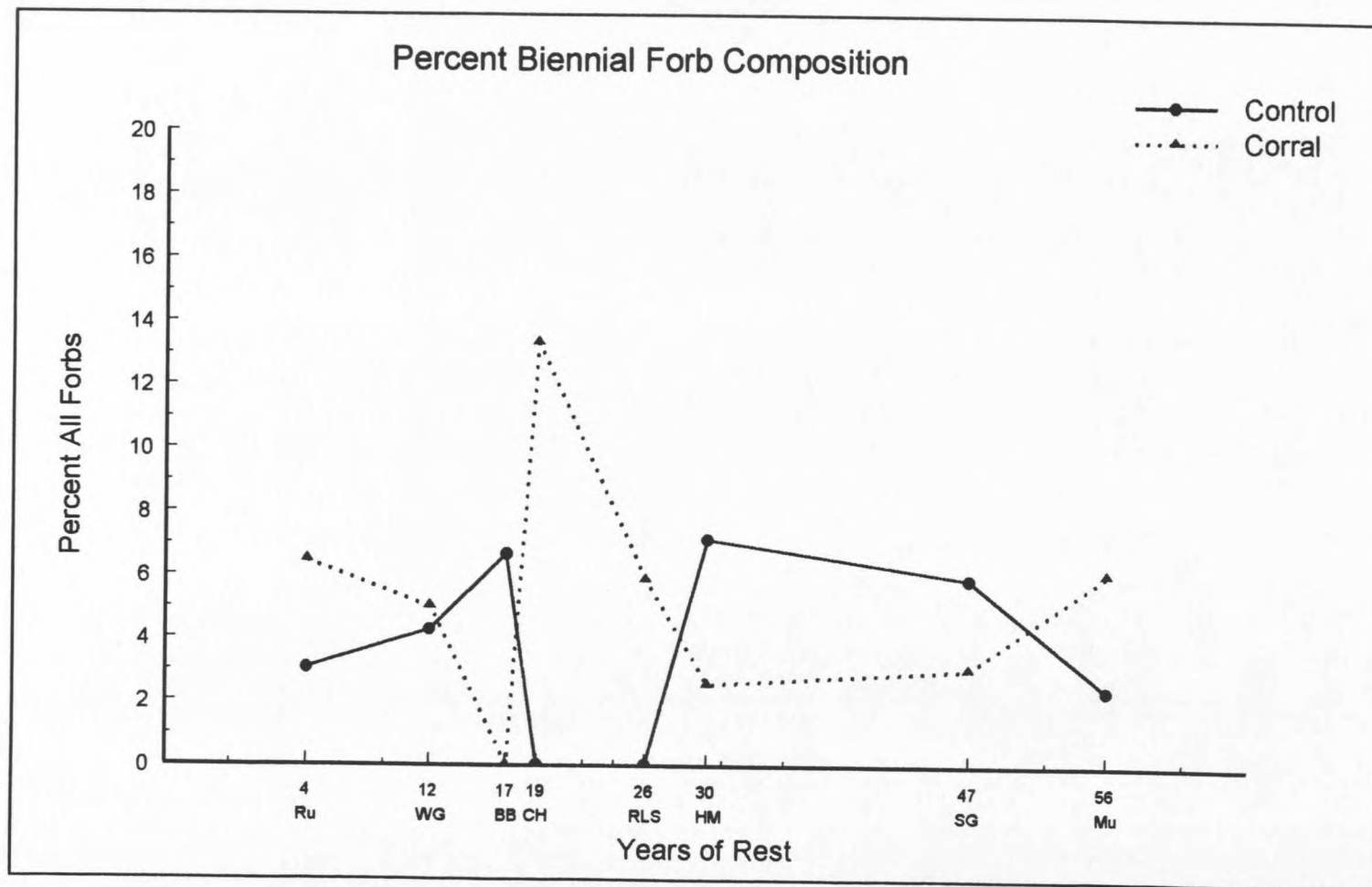


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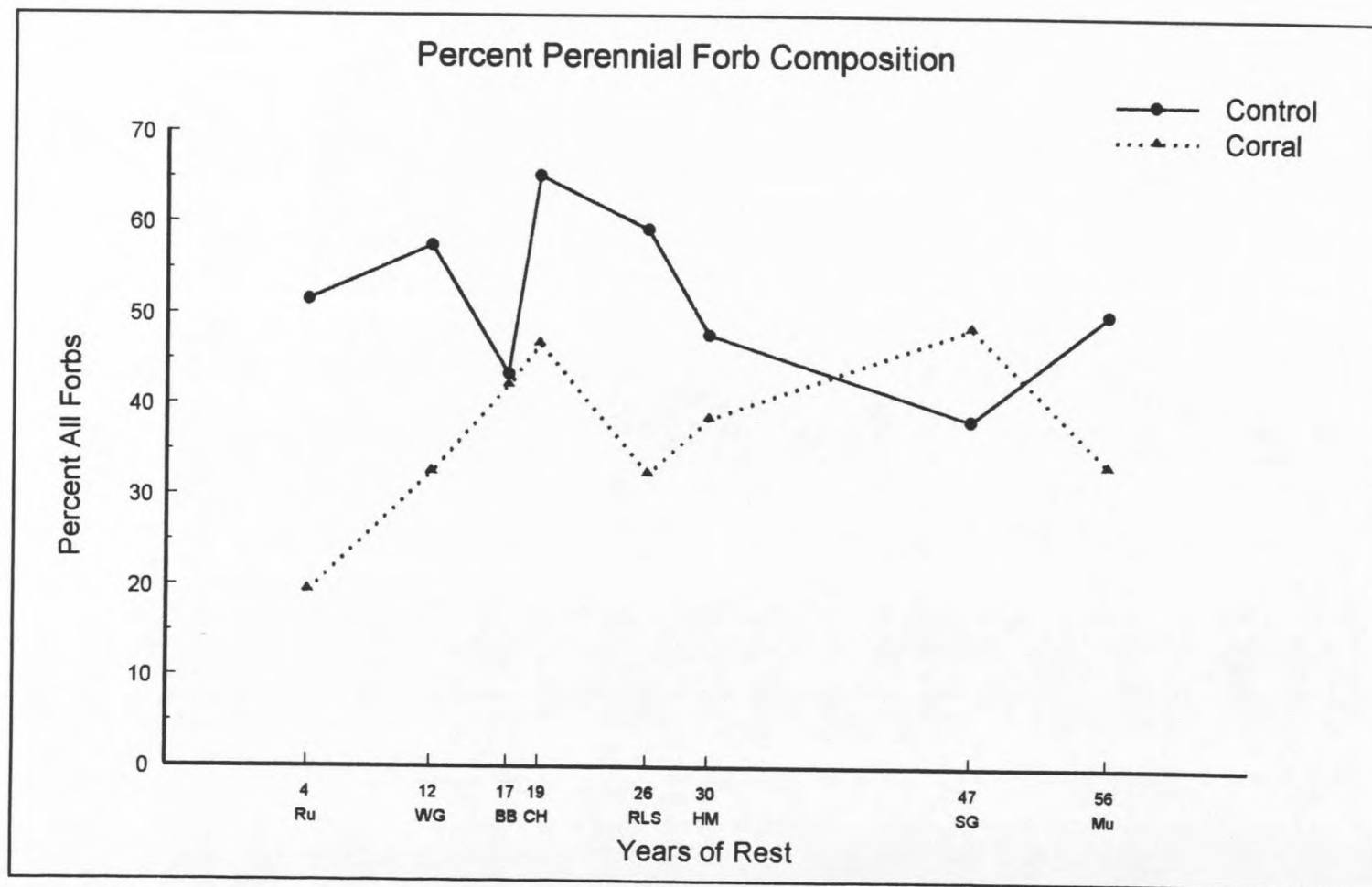


Figure 7. Continued

Previous studies have shown that life form changes occur during succession, moving from a community dominated by annuals to one dominated by perennials. Belsky (1996a) noted that perennials were dominant in sites one to five years after initial disturbance in the African grasslands of the Serengeti. Bornkamm (1981), Myster and Pickett (1992), and Leps (1988) also noted perennial dominance within the first four years of vegetative recovery after disturbance in old field and grassland studies. Tsuyuzakai and Kanda (1996) found that perennial herbs accounted for 72.5% of the plant taxa surveyed in abandoned pastures in Northern Japan, and Uhl (et al., 1988) found that perennial forbs, shrubs, vines and trees dominated recovering pastures in East Amazonia. McLendon and Redente (1990) show that communities that initially colonized areas following soil disturbance were dominated by annual species. This dominance was short-lived as all disturbed sites were dominated by perennial species within four years. Interestingly, of the four sites that were sampled in that study, three exhibited very different vegetation structure after 12 years of rest, suggesting that the influence of initial floristic composition on further vegetation development was not evident. Leps (1987) also found that the influence of species composition in early succession on future community development was difficult to establish.

The results of this study generally support initial floristic patterns found in previous studies, which find annual species replaced by perennials over time. Annual forbs are more abundant in the corral sites with the least time of rest, Rudd and Whitegrass, and perennial forbs represent the largest share of plant species represented across all other

sites. However higher percentages of annual forbs were found in the Murie corral when compared to its control, making the trend of decreasing percent annuals with time less clear.

Native/Introduced Species

Native species are defined as species that are indigenous to an area, while introduced species are species which have more recently colonized an area outside of their ecosystem of origin. Some land managers make a distinction between naturalized and introduced species, the former consisting of plants of foreign origin whose influence in a new ecosystem is known, the latter consists of species whose role in new ecosystem is either unstudied or unknown because of recent appearance. For the purposes of this study, native species imply species that were originally found in the undisturbed environment, while introduced species imply species that originated elsewhere (typically Eurasia), and are currently found in Greater Yellowstone Ecosystem.

Native species make up a larger percentage of total species than introduced species across all sites (corrals and controls) (Figure 8). Native species make up between 74% and 84% of the total species present in all controls. The Bar BC and the Square G sites have slightly higher percentages of native species in corrals in comparison to controls. Native species makes up 50% or more of total species composition in all corrals.

Conversely, introduced species comprise between 14% and 41% of species composition across all sites (corrals and controls). Higher percentages of introduced species are found in six of the eight corrals sampled, with the greatest difference in paired corral and control sites at Rudd, Whitegrass, and Circle H sites. No clear trend with time

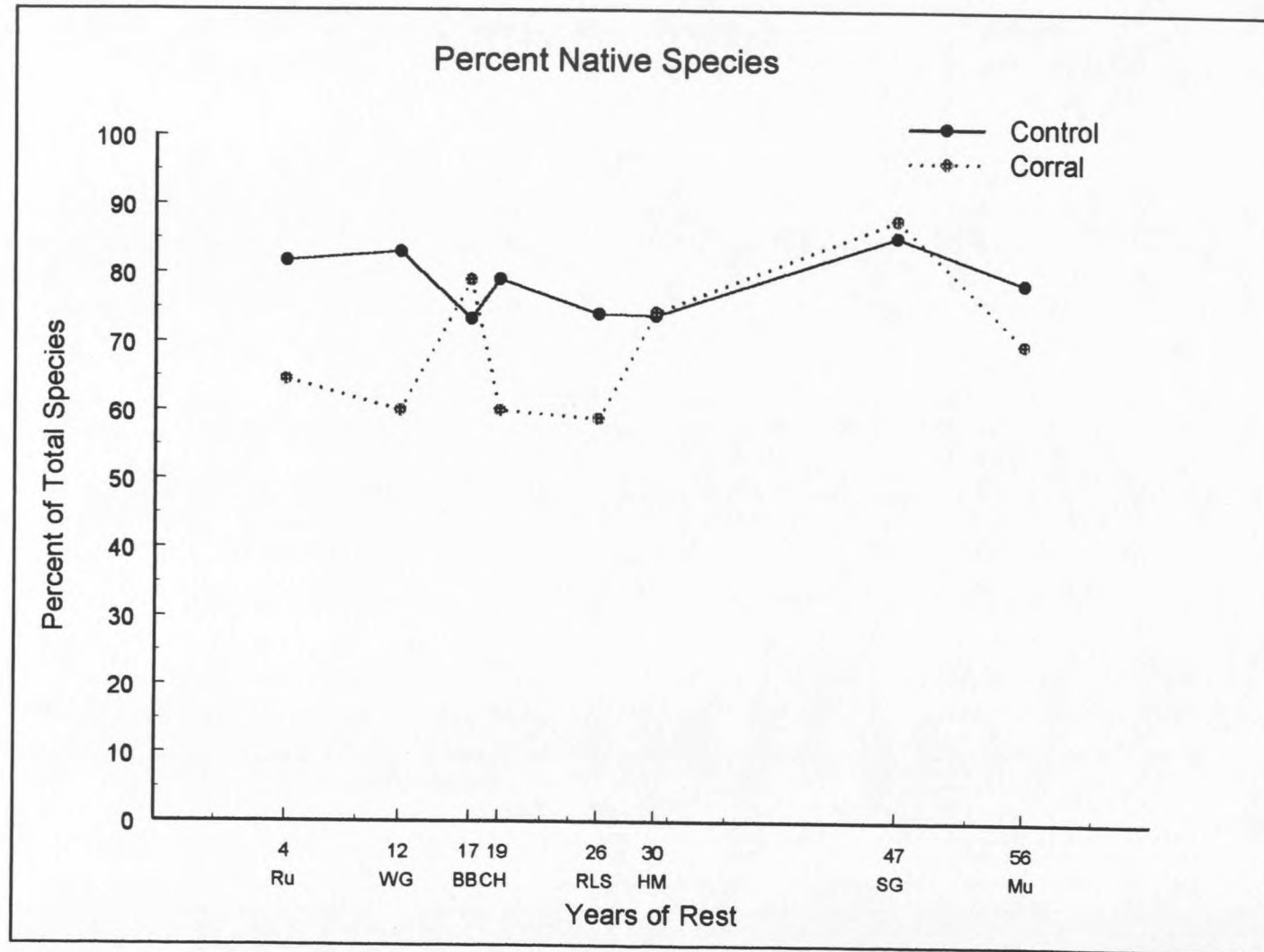


Figure 8. Percent of native and introduced species

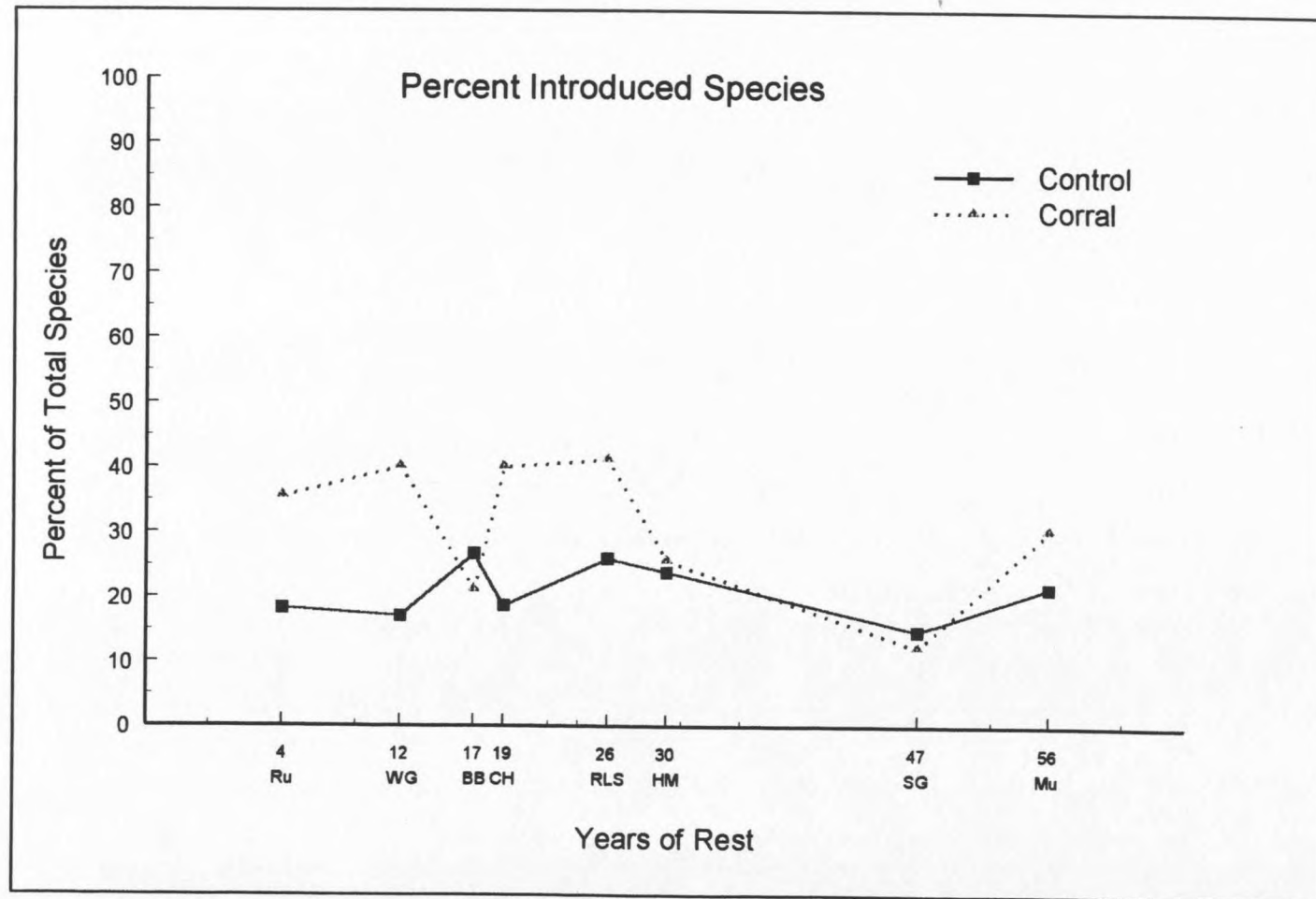


Figure 8. Continued

is evident, illustrated by comparison of the Bar BC, with 17 years of rest, to Circle H, with 19 years of rest. The Bar BC site exhibits similar percentages of introduced species between corral and control, while the Circle H site has the largest difference between corral and control introduced species percentages, which suggests that time of rest does not influence change in species origin and establishment in corral sites. Instead, initial colonizing species, seed bank composition around corral sites, or stochastic events may influence post disturbance vegetation development (Tsuyuzakai and Kanda, 1996).

Non-Weedy/Weedy Species

Non-weedy species make up a larger percentage of the total species than weedy species, in all corrals and controls (Figure 9). Weedy species are found at higher average percentages in most corrals versus controls, and the five most recently disturbed corrals have the highest percentages of weedy species when compared to all other sites. A five-year field study completed by Allen and Knight (1984) assessed the effects of introduced, weedy annuals on secondary succession in sagebrush grassland, and found that the weedy species were more aggressive colonizers in sites that were disturbed. The higher percentage of weeds in the most recently disturbed corral sites supports the idea that weedy species are more aggressive colonizers. However, percent cover of weedy species would be a more useful measurement, as a few weedy species can dominate a plant community, and this is not shown directly through number of weedy species present. That is, it may be more useful to know how much cover a species occupies in addition to how many stems are present.

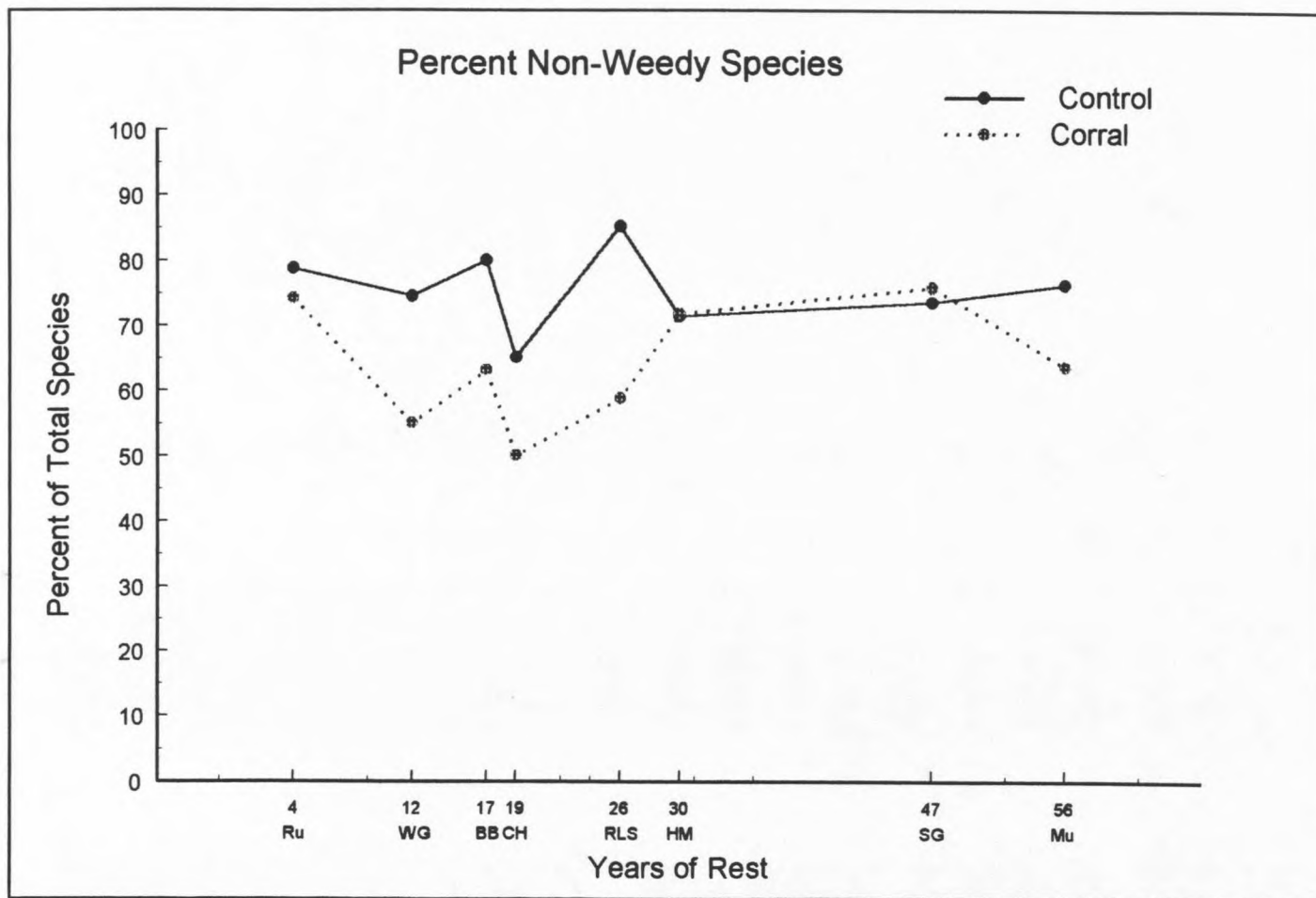


Figure 9. Percent of non-weedy and weedy species.

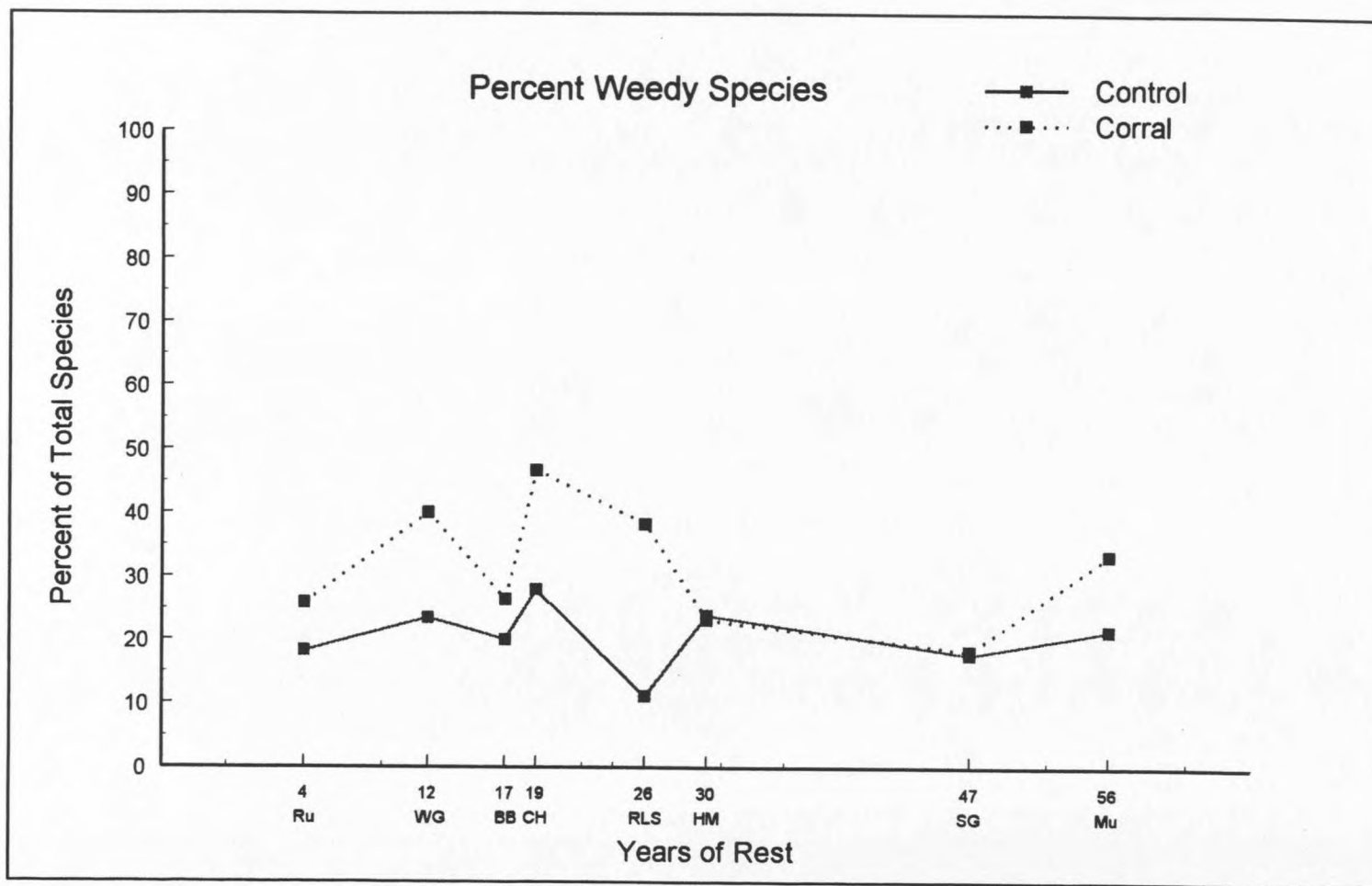


Figure 9. Continued.

Because the definition of a "weedy" species can differ based on the users objective, comparison of weedy data must be used with caution. A general definition of a weed is, a plant that interferes with management objectives for a given area of land at a given point of time (Dittenburger and Olson, 1983). This definition emphasizes land use objectives, which can vary over space and time. For example, the farming community may call a plant that displaces an agricultural crop a weed, while a cultivar that displaces native vegetation might be considered a weedy species from the conservation perspective. Likewise, some Forest Service personnel classify larkspur (*Delphinium* spp.) which is considered a native wildflower by the Park Service, as a weed because it can poison domestic cattle that utilize grazing allotments that contain larkspur species.

The results of this study show that weedy species are found in equal or greater percentages in corrals when compared to controls, and that weedy species are found in lower percentage across all sites when compared to non-weedy plant species. The Circle H corral exhibits the greatest number of weedy species (49% of total species are weedy). The Murie corral has a higher percentage of weeds than both the Rudd and the Bar BC corrals, indicating that weedy species distribution is not affected by time of rest alone. The lower percentage of weeds compared to non-weedy species, even in sites more recently disturbed, is surprising given that weedy species occupy a broader niche, and are often better adapted to survive and establish in disturbed settings than native species (Forcella and Harvey, 1988; Westman, 1990). A comparison of Figure 8 and Figure 9 show that non-weedy plant distribution mirrors the distribution of native species while

introduced species follow weedy patterns, suggesting that many native species are often non-weedy, while some introduced species are often weedy. This trend is confirmed when species characteristics are compared (Appendix B).

Similarity Scores

Similarity index scores between each corral and its paired control were calculated. The set of scores, based on Sorenson's index, are shown as a percentage and listed chronologically in order of increasing time of rest. Higher values indicate a higher degree of similarity (Table 3).

Table 3. Sorensen's similarity index scores between corrals and paired controls.

Site	Similarity Index Score (%)	Corral Years of Rest
Rudd	40.63	4
Whitegrass	43.68	12
Bar BC	24.5	17
Circle H	35.62	19
R Lazy S	39.34	26
Halfmoon	60.24	30
Square G	56.72	47
Murie	64.52	56

The Sorenson similarity index scores indicate that the site with the longest period of rest (Murie corral) has more species in common with its paired control than the sites resting for fewer years. The scores show a general increase in similarity of paired sites over time when shared number of species is used as the indice, however site similarity over time is not strictly linear. Rudd corral, which has rested for the shortest period of time, is more similar to its control than the Bar BC corral, which has the lowest similarity index score but has rested three times as long. The Halfmoon corral is more similar to its

control after thirty years than the Square G corral to its control after 47 years. Likewise, the Bar BC and Circle H corrals, which have rested similar amounts of time, show an 11-unit difference in similarity scores.

Using a second approach to assess site similarity, the absolute value of the difference in each category (habit, origin, weediness) between each corral and paired control was calculated and recorded (Table 4). The absolute values were then summed and the resulting number is an index reflects the overall difference in plant species composition between corral and control by site. This method acts as a more comprehensive measure of similarity for each corral and paired control than the Sorenson's similarity index because it takes into account more than one variable. Those sites with values closest to zero are more similar to each other, conversely a higher number indicates greater differences between a corral and paired control. A summation across all categories, and grouping of perennial forbs, native forbs, and non-weedy species showed no clear trend in similarity over time. The results of this analysis are shown graphically in comparison to Sorenson's index previously discussed (Figure 10).

In summary, analysis of plant categorical data shows that forbs are the dominant lifeform at all sites. Annuals makeup a slightly higher percentage of total forb composition in corrals, and are most dominant in the two most recently disturbed corrals. Native species and non-weedy species are dominant in all sites. There is less variability in controls compared to corrals for native and introduced species, as well as non-weedy and weedy species. Corrals did not become more similar to paired controls with increasing time of rest when absolute values are used as a similarity index, which is in

Table 4. Absolute difference in species categorical data by site. Values were obtained by subtracting corral value from control value and converting the difference into an absolute value. Resulting value is a measure of the difference by category between each paired corral and control.

	Rudd	Whitegrass	Bar BC	Circle H	R Lazy S	Halfmoon	Square G	Murie
Forbs	4	9	9	13	3	4	1	7
Grasses	2	2	2	0	4	1	2	2
Perennial forbs	4	14	5	14	5	5	12	28
Perennial grass	3	1	2	0	4	0	2	6
Annual forbs	4	3	4	2	6	3	1	1
Annual grass	0	1	0	0	0	1	0	0
Biennial forbs	1	1	2	4	2	2	1	0
Biennial grass	1	0	0	0	0	0	0	1
Unknown P/A forb	2	3	2	1	0	0	0	1
Unknown P/A grass	0	0	0	0	0	0	0	0
Native forb	7	16	5	14	1	6	2	9
Native grass	0	0	2	2	1	1	2	1
Introduced forb	3	5	4	2	4	1	1	2
Introduced grass	2	4	0	2	3	3	0	1
Colonizing forbs	1	1	3	2	3	0	1	1
Colonizing grass	0	0	0	1	3	1	1	0
Economic forbs	0	3	3	1	0	1	1	2
Economic grass	0	1	0	0	0	1	0	0
Unknown weedy forbs	1	1	0	2	2	1	0	1
Unknown weedy grass	0	1	2	0	0	0	0	0
Nonweedy forbs	5	14	10	12	3	3	3	9
Nonweedygrass	2	1	2	1	1	1	3	5
Noxious forbs	1	0	1	2	3	1	1	0
Noxious grass	0	0	0	0	0	0	0	0
Tot # Plants	2	7	11	13	7	3	1	9
Sum	45	88	69	88	55	39	35	86
Perennial forbs	4	14	5	14	5	5	12	28
Native forbs	7	16	5	14	1	6	2	9
Nonweedy forbs	5	14	10	12	3	3	3	9
Sum	16	44	20	40	9	14	17	46
Forbs	4	9	9	13	3	4	1	7
Grasses	2	2	2	0	4	1	2	2
Sum	6	11	11	13	7	5	3	9

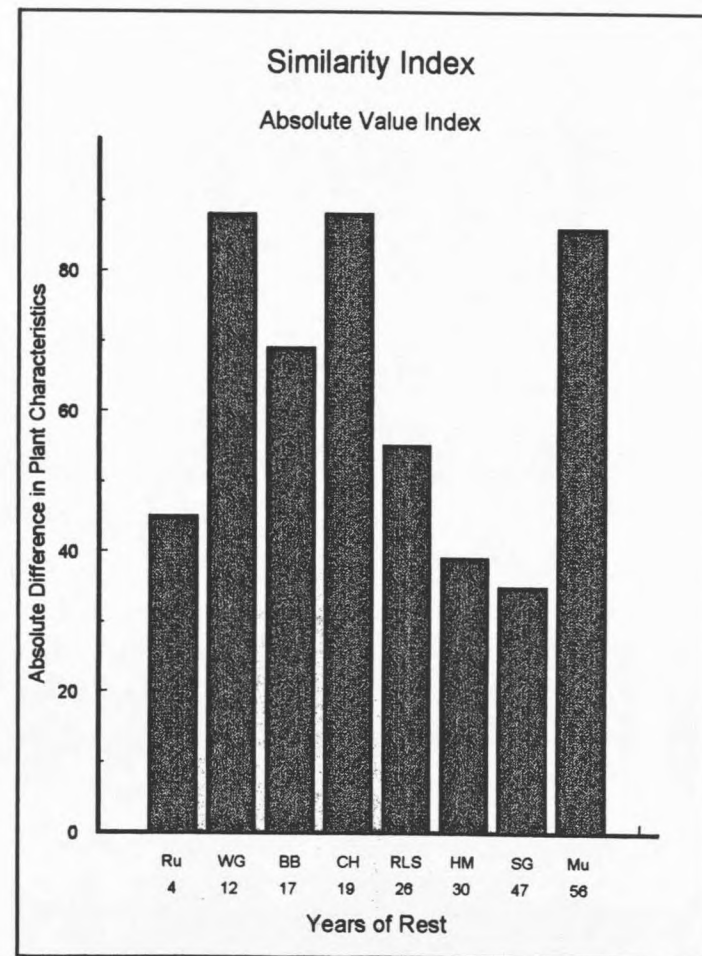
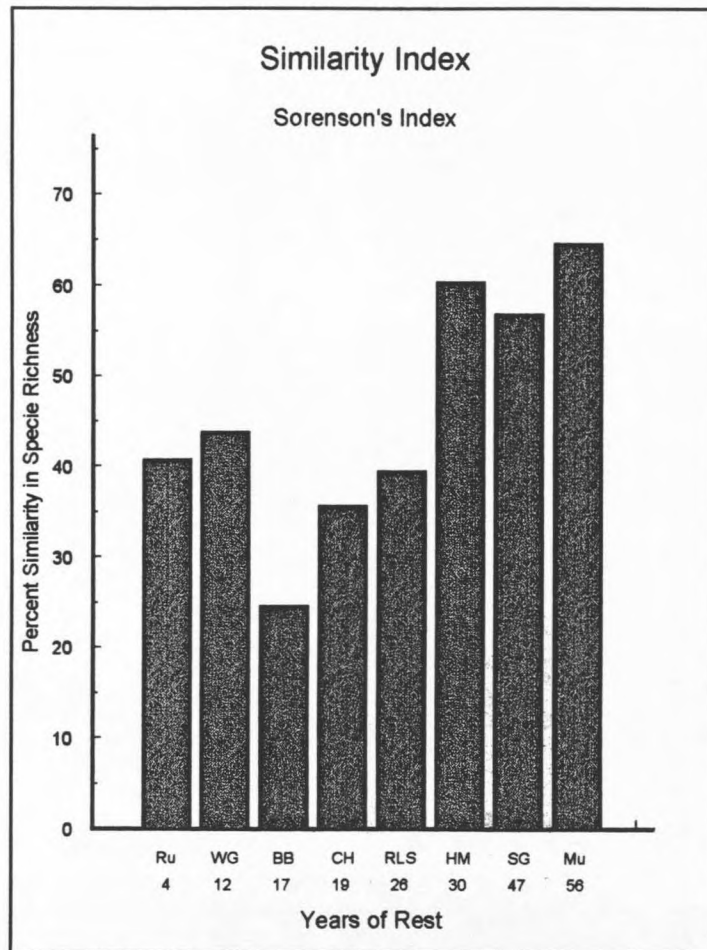


Figure 10. Similarity indices: Sorenson's similarity index and the absolute value index.

general agreement with the results of the Sorenson's index that showed some increase in site similarity over time, although increase was not strictly linear. Because the data has shown the natural heterogeneity of the undisturbed sagebrush environment and the absolute value method incorporates more variables than the Sorenson's index, which compares species number only, it is not surprising that more variation is found in absolute value scores.

Grouped Forb Species Data

Forb species data were grouped based on presence within corral, control, or both to identify trends of more commonly occurring species. Species that occurred in two or fewer controls, or two or fewer controls and one corral, were removed from the data set. Of the initial 103 forbs, the remaining 55 forbs were further categorized in one of four groups labeled adventurers, colonizers, ubiquitous, and undisturbed (Table 5). These groupings were created to assess whether forb species change in a predictable pattern over time, and whether a pattern of forb distribution could be attributed to a particular period of rest along the established chronosequence.

Table 5. Grouped forb category designations

Group name	Designation
Adventurers	One or two corrals, and one control
Colonizers	Three or more corrals, and two controls
Ubiquitous	Four or more corrals and controls
Undisturbed	Three or more controls and two or less corrals

For purposes of grouping, the plant adventurers were plants that occurred in one to two corrals and no more than one control. Colonizing plants appeared more frequently, being present in three or more corrals, and two controls, suggesting continued succession over time. Plants that were found in four or more corrals and controls were categorized as ubiquitous species, species that are found in both disturbed and undisturbed sites. Plants that were found in three or more controls and two or less corrals were categorized as undisturbed plants, suggestive of species that comprise an undisturbed plant community. Grouped forb data in tabular form is included in Appendix D.

Scatter plots showing species density by site were created to identify trends in species presence and species number over time (Figure 11). Within these groups, the species were further classified according to habit, origin, and weedy status (Table 6).

Table 6. Categorical classification of grouped forb data.

Group	Total Forb	Annual	Bennial	Perennial	Native	Introduced	Weedy	Non-Weedy	Unkn Weed
Adventurer	13	7	1	5	10	3	3	8	2
Colonizer	9	5	1	3	4	5	7	2	0
Ubiquitous	14	8	0	6	11	3	3	11	0
Undisturbed	19	2	2	15	17	2	3	16	0

Of the 13 total species found in the adventurer category, 7 annuals, indicative of early succession, and 10 native species were found. More than one-half of the plants are considered non-weedy, and 5 of the adventure species have been identified in disturbed sites in the valley of Jackson Hole by previous workers (Shaw, 1992). Ten of the 13 species are found in one or more of the most recently disturbed corrals, Rudd, Whitegrass, and the Bar BC, reinforcing the suggestion that these species are indicative of early succession. Cynoglossum officinale, (Hound's tongue) a noxious weed, was

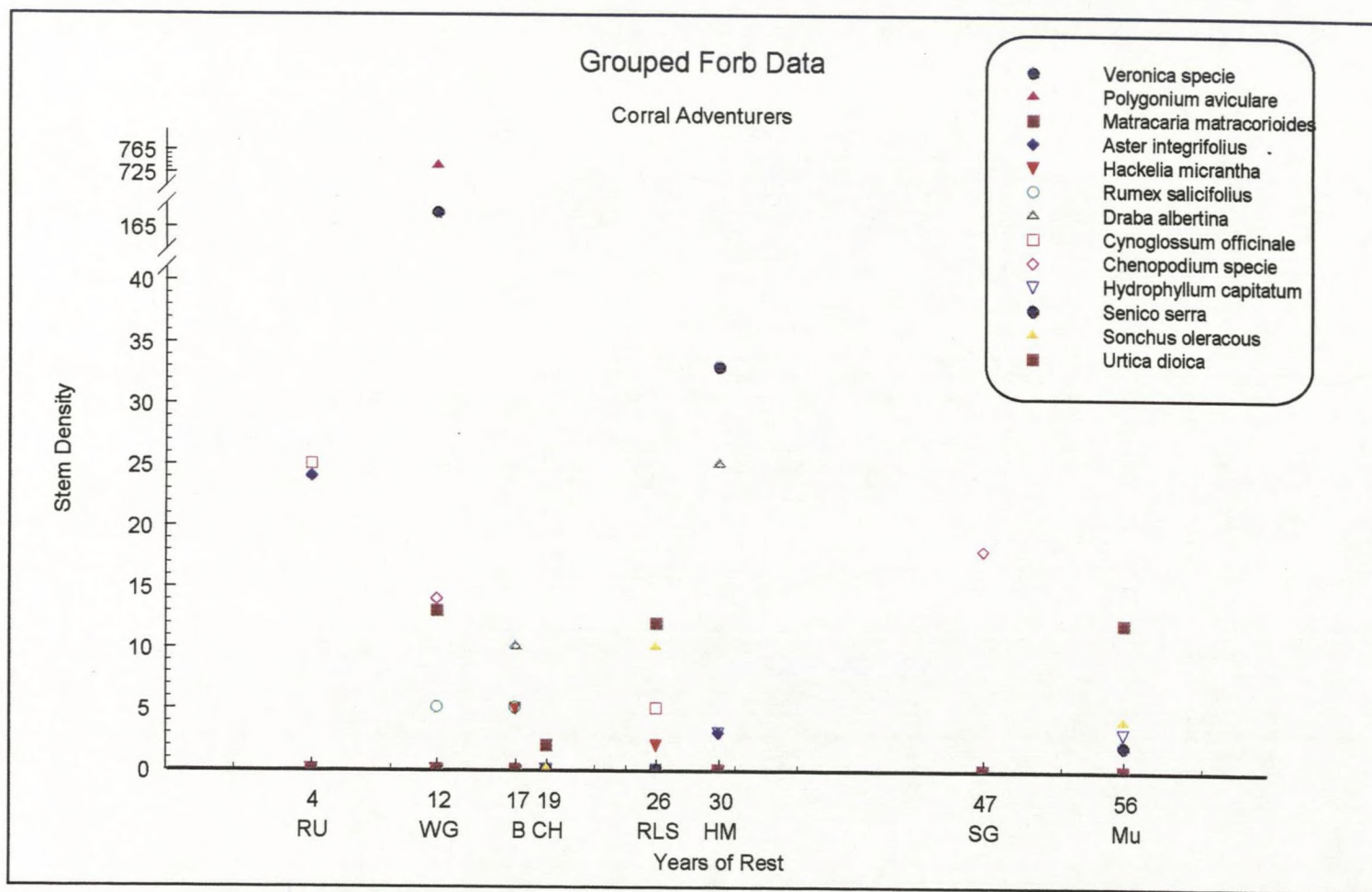


Figure 11. Scatterplots showing stem density of grouped forb data by site: corral adventurers, corral colonizers, ubiquitous species in corral and control and undisturbed control species.

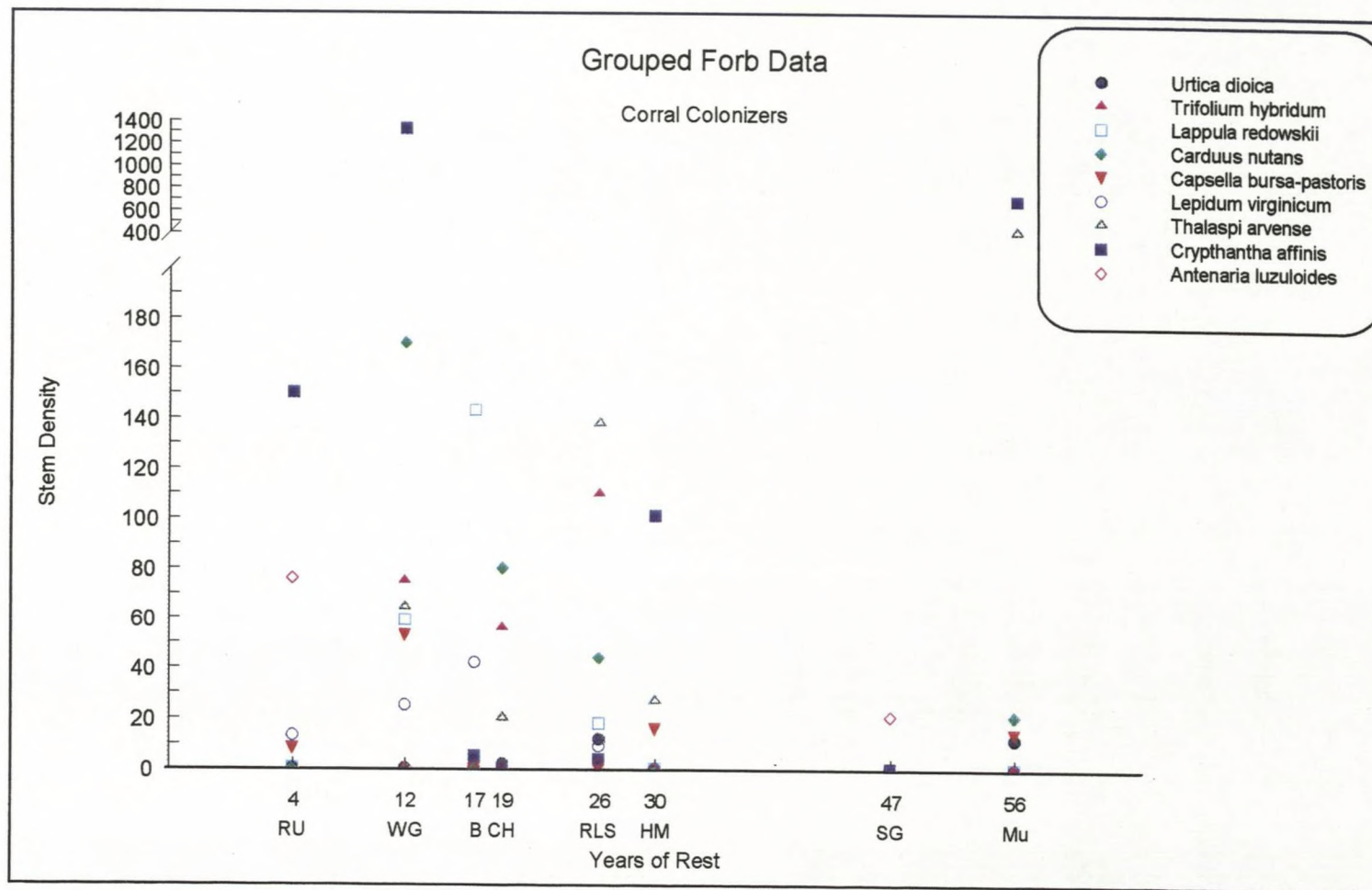


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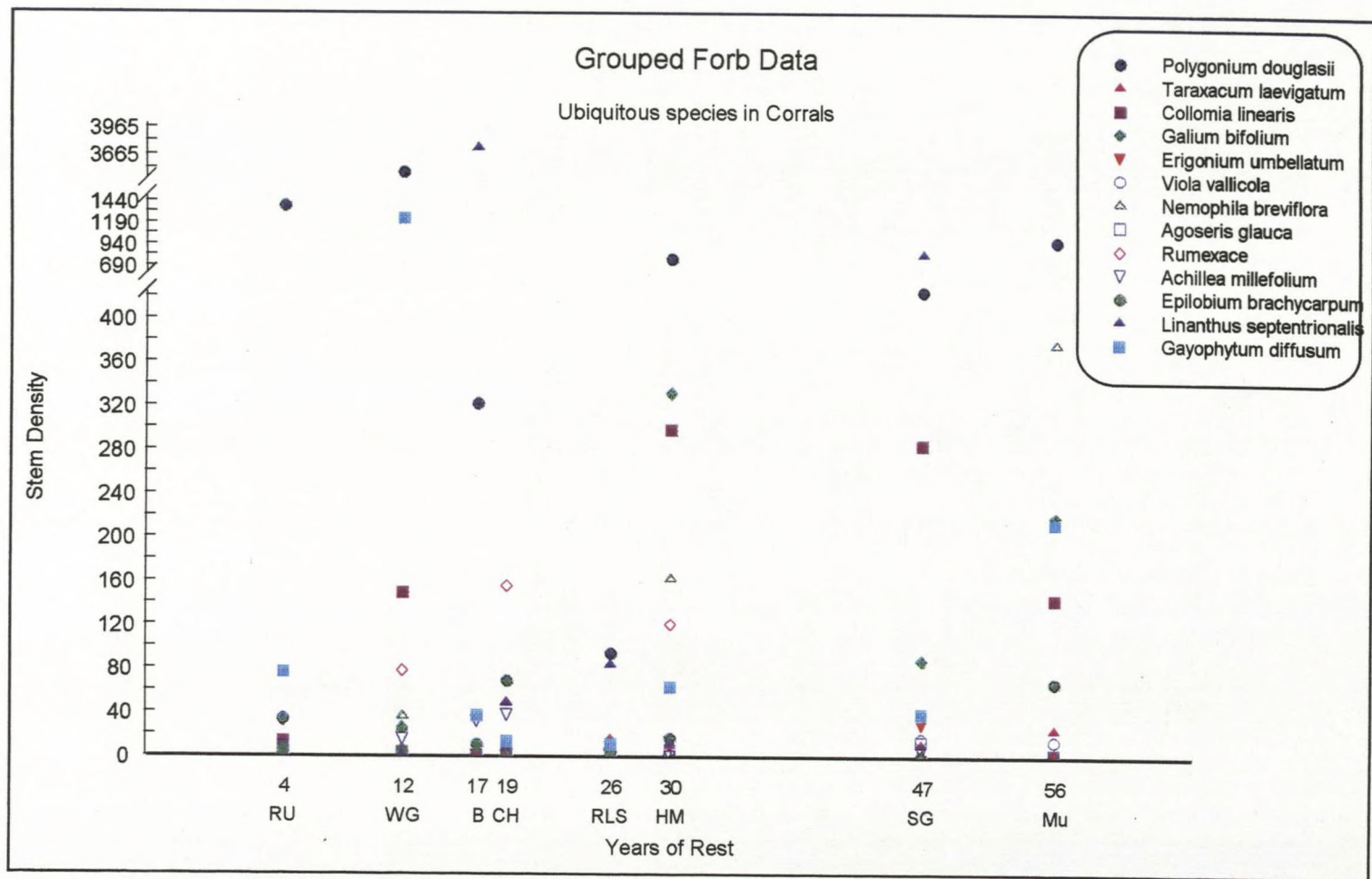


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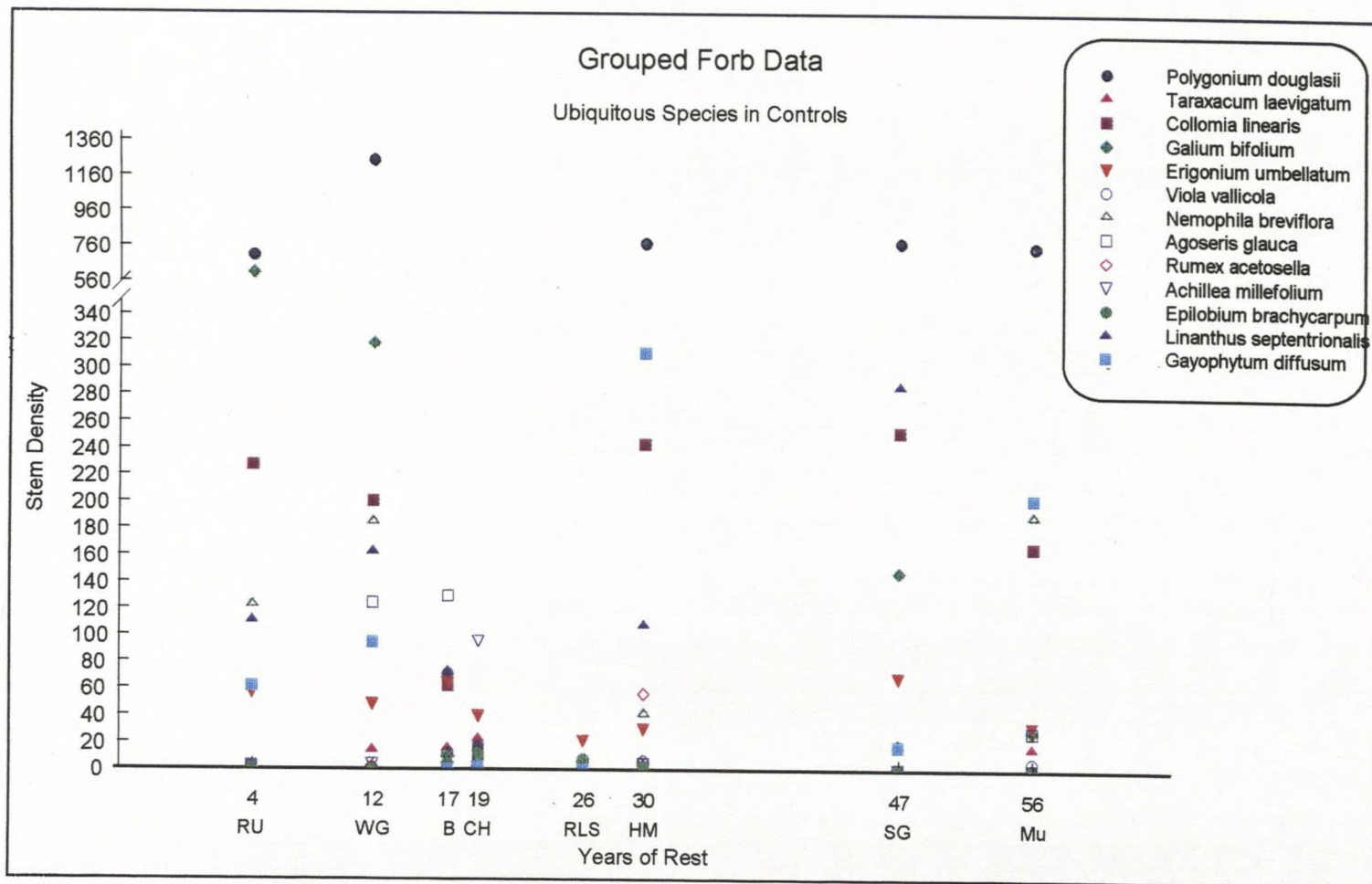


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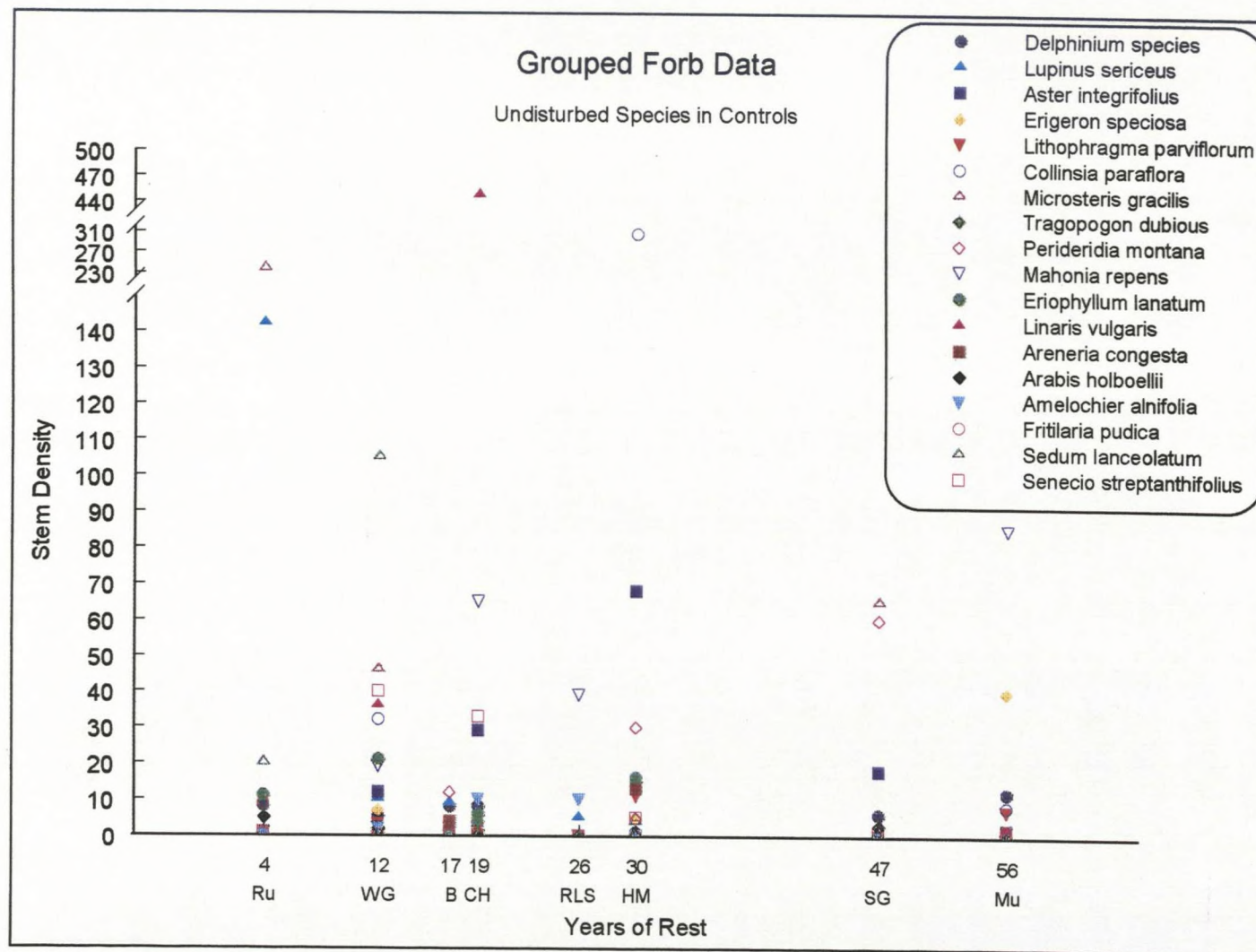


Figure 11. Continued.

found only at the Rudd's corral, the most recently disturbed site. Polygonum aviculare (760 stems) and Veronica sp. (165 stems) were found in high densities in the Whitegrass control.

Of the 9 total species in the colonizer group, annuals and introduced weedy species predominate. However, species distribution by site is less uniform. The colonizing species are found in the three most recently disturbed sites, as well as in the R Lazy S corral and the Murie corral, sites with longer periods of rest, so that no successional pattern with time was clear. Seven of the 9 species have been found in disturbed sites in Grand Teton National Park (Shaw, 1992), and 7 of 9 are considered weedy species. Three species, Thlaspi arvense, Lepidium virginicum, and Capsella bursa-pastoris are members of the Brassicaceae (Mustard) family, and are introduced weedy species. T. arvense is found in 5 sites, in highest density in the Murie corral (423 stems). Trifolium hybridum is an introduced clover, found in disturbances and a known colonizer. Carduus nutans (Musk Thistle) is a noxious species, and is found in 6 of 8 sites, with the highest density at the Whitegrass corral (170 stems). Cryptantha affinis, a native non-weedy forb, is found in 6 of the disturbed sites, in high density in both Whitegrass (1326 stems) and Murie corral (700 stems).

Ubiquitous species are found in 4 or more corral and controls, with most species appearing more frequently. Annual species are slightly more prevalent and native species and non-weedy species are clearly dominant. Only 5 of the 14 species classified as ubiquitous have previously been noted in disturbed sites in Grand Teton National Park (Shaw, 1992), suggesting that they can exist in a wide range of environments. P.

douglasii was found in all sites, in high densities in 5, with a high of 1360 stems in the Whitegrass control. G. bifolium was present in high density in Rudds (607 stems) and Halfmoon (517 stems) controls. G. diffusum occurred in all eight corrals, with highest density in the Whitegrass corral (1227 stems). Ubiquitous species are present in more sites, but their density across sites is still highly variable. For example, Linathus septentrionalis, an annual non-weedy species, is found in extremely high densities in some sites, 6362 stems in Rudd corral and 3727 in the Bar BC, and low densities in others, 0 in Whitegrass corral and 11 in the Halfmoon corral.

The undisturbed group is comprised of the largest number of species, and is clearly dominated by perennial, native, non-weedy species, the majority of which are present in more than one-half of the controls. These plants would be found more commonly in a wildflower guide than a weed manual, and have been identified throughout the valley of Jackson Hole in undisturbed environments. Three shrubby species are found in the undisturbed group, A. Tridentata, Mahonia repens and Amelanchier alnifolia. Most species are represented by 70 stems or less, with high, site-specific densities of Microsteris gracillis, and Collinsia paraflorea both native annual nonweedy species, in Rudd and Halfmoon controls. Interestingly, Linaria vulgaris (butter-and-eggs), an aggressive introduced perennial noxious weed, is found in four of the eight controls (488 stems, Circle H control), and in only one corral.

Because grouped forb adventurer, colonizer, and ubiquitous categories are delineated by increasing species presence in corrals, and the undisturbed category is based on species found in more than half corrals and controls, I hypothesized that corrals with

longer periods of rest would contain a higher number of species in the ubiquitous, and undisturbed categories while corrals with shorter periods of rest would have higher numbers of species found in adventurer and colonizer groups (Table 7).

Table 7. Number of individual species in each group by corral site.

Number of Individual Species in Each Group by Corral Site					
Total Species in Each Group		Adventurer	Colonizer	Ubiquitous	Undisturbed
		13	9	14	19
Rudd	Corral	2	4	12	3
Whitegrass	Corral	7	7	13	4
Bar BC	Corral	4	4	6	1
Circle H	Corral	4	4	7	3
R Lazy S	Corral	3	8	10	2
Halfmoon	Corral	3	3	12	7
Square G	Corral	1	1	10	7
Murie	Corral	3	5	11	3

The data show no evidence of such a trend in number of species present within groups over time. The only species group that shows a large number of representative species over time is the ubiquitous category, which encompasses those species that are commonly found in the study area regardless of corral or control setting. In summary, grouped forb species data show that no pattern of invasion or extinction in relation to time was evident at the species level. Even the more commonly occurring species were not very common, with the exception of those species grouped in the ubiquitous category, which were consistently present in higher number across all sites.

Annuals and introduced weedy species were more prevalent in the colonizer grouping while annuals and native species were more common in the adventurer category. This suggests that annual introduced species may be more successful at early establishment

because they are found more frequently in corrals than the native annuals in the adventurer group. An association with prevalence of introduced annuals in most recently disturbed sites does not exist as some succession theory suggests because adventurer species do not exist exclusively in sites with less recovery time. The colonizer group has the highest number of forbs (7 of 9 in the weedy category), and weedy species commonly found here occurred in low densities. The forbs within the ubiquitous category were most evenly distributed by site and stem density. The undisturbed grouping is comprised of the largest number of forbs and is dominated by perennial, native, non-weedy species, traits one would expect in undisturbed plant communities. However, Lineria vulgaris, a noxious weed, falls into this category. The presence of L. vulgaris in half of the control sites suggests that the invasive ability of this plant is not tied to disturbance alone.

Percent Cover Analysis

Percent cover measurements were tabulated for bare ground, rock, litter, grass, sedge, forb, and shrub at the quadrat level. The quadrat level data was summed by transect and averaged for each site, and is included in Appendix E.

A two-way Analysis of Variance (ANOVA) procedure was used to determine if any significant differences exist in cover variables between site types (all corral sites versus all control sites)(Table 8) or within individual sites (one corral versus its control)(Table 9). Percent cover results for both corrals and controls are presented in graphic form to determine if percent cover values were similar among controls, and if percent cover values are related to time of rest in corrals (Figure 12).

The ANOVA procedure used to compare percent cover across quadrats at all corral and all control sites (all corrals versus all controls), and between paired site types, (e.g., Murie corral versus Murie control) yielded the following significant results.

Table 8. Percent Cover All Controls vs. All Corrals.

a= values higher in corrals b= values higher in controls

Percent Cover Differences All Corrals vs. All Controls							
	Bareground	Rock	Litter	Grass	Sedge	Forb	Shrub
F value	0.001	23.01b	4.42a	147.07a	2.42	87.91a	202.46b
P value	0.966	0.0001	0.0001	0.0001	0.1206	0.0001	0.0001

Table 9. Two-way ANOVA results for percent cover variables between paired sites. Negative values indicate coverage is greater in corral sites, positive values indicate coverage is greater in control sites.

Paired Site Percent Cover Differences Control Mean - Corral Mean								
		Bareground	Rock	Litter	Grass	Sedge	Forb	Shrub
Rudd	T value	-2.4640	0.7755	-1.1790	-1.6050	0.0000	1.9650	8.0240
	Probability	0.0140	0.4384	0.2386	0.1089	1.0000	0.0499**	0.0001***
Whitegrass	T value	1.4910	6.9603	3.5991	-6.7970	0.0000	0.2880	3.5830
	Probability	0.1365	0.0001***	0.0003***	0.0001***	1.0000	0.7733	0.0004**
Bar BC	T value	2.5390	5.2090	0.5174	3.8790	-38.4850	-9.5069	1.3350
	Probability	0.0117**	0.0001***	0.6050	0.0001***	0.0001***	0.0001***	0.1250
Circle H	T value	-3.1834	11.7525	-1.0254	-12.1212	33.8410	-2.1944	0.0611
	Probability	0.0015***	0.0001***	0.03056**	0.0001***	0.0001***	0.0286**	0.9513
R Lazy S	T value	-1.3217	0.9267	-2.9860	-10.5340	1.0160	7.9800	14.1519
	Probability	0.1868	0.3540	0.0032**	0.0001***	0.3100	0.017**	0.0001***
Halfmoon	T value	3.6642	-8.8640	0.2663	-2.3459	-0.5802	2.3770	6.1379
	Probability	0.0003***	0.0001***	0.7900	0.0193**	0.5620	0.017**	0.0001***
Square G	T value	1.7960	0.8746	-2.7450	-6.0667	2.0306	3.2840	3.5860
	Probability	0.073*	0.3820	0.0062***	0.0001***	0.0420**	0.0011***	0.0004***
Murie	T value	-0.0729	-4.4543	-1.6130	0.2280	3.1820	2.4130	4.0169
	Probability	0.9419	0.0001***	0.1072	0.8195	0.0015***	0.0161**	0.0001***

* = Significant at 0.10 level

** = Significant at 0.05 level

*** = Significant at 0.01 level

Differences between corral and control were seen in percent cover measurements for bareground, rock, litter, grass, sedge, forb and shrub. When all corrals were compared to all controls, corrals showed significantly lower amounts of rock, forbs, and shrubs, and

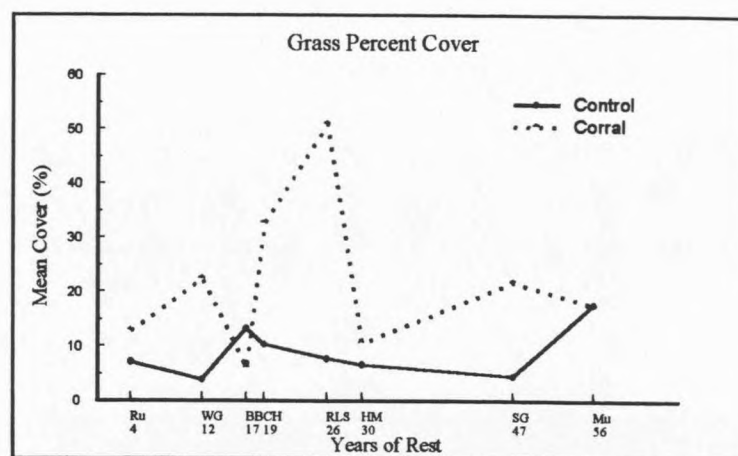
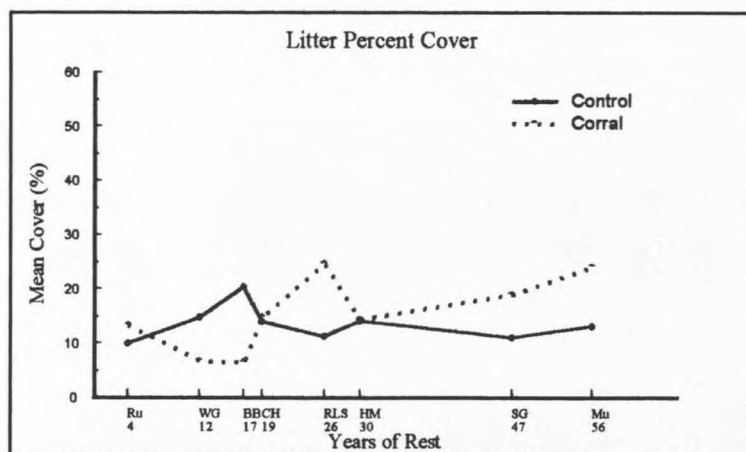
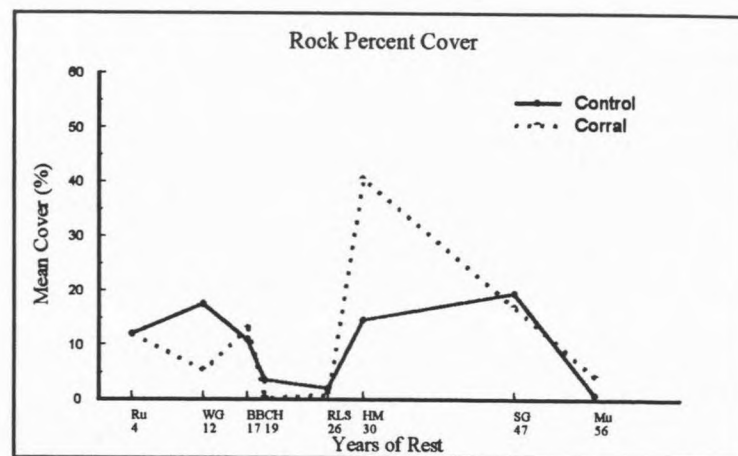
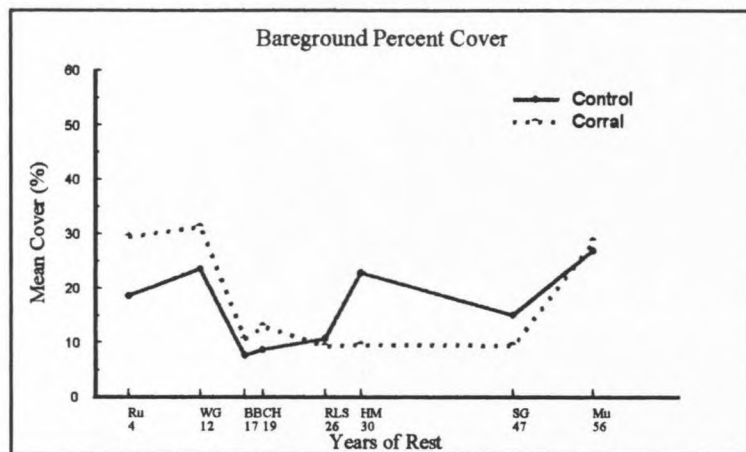


Figure 12. Average percent cover of bareground, rock, litter, grass, sedge, forb and shrub at each corral and paired control.

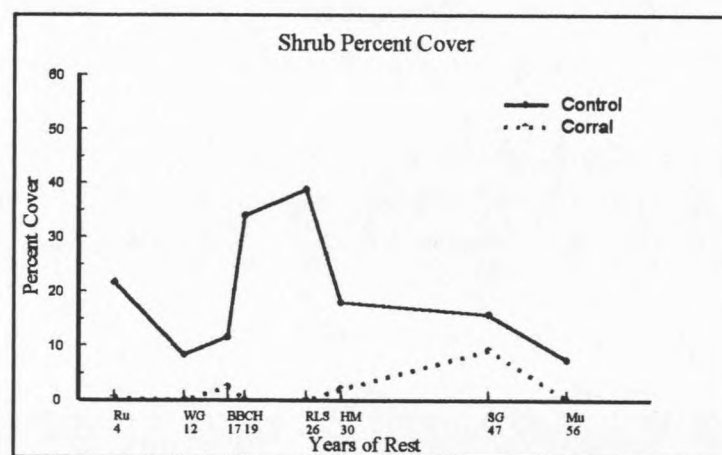
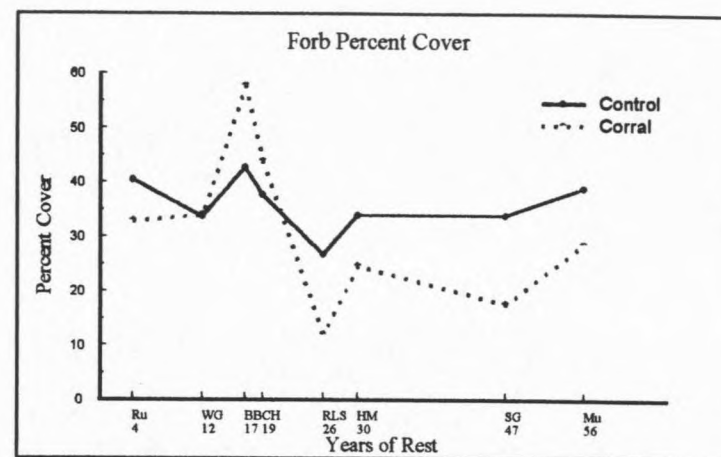
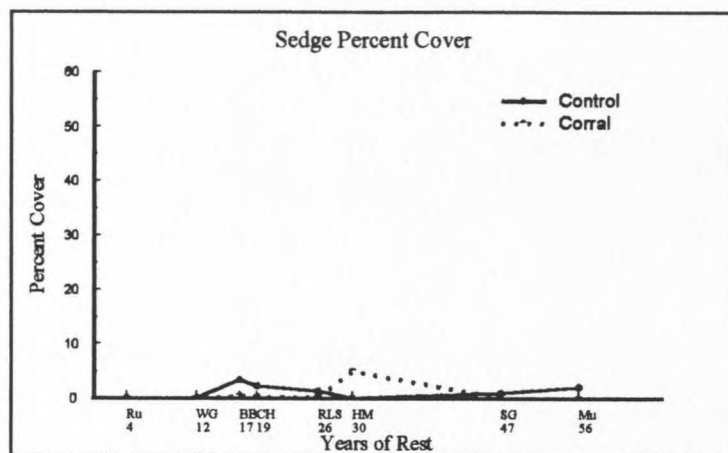


Figure 12. Continued.

higher amounts of litter and grass. A significant difference was not found between all corrals and all controls in bareground or sedge percent cover. Analyses of percent cover values between paired sites show that all corrals had significantly lower cover values for shrubs across all sites. Forb percent cover was significantly lower in all corrals, except Circle H. Significantly higher percentages of grass were found in all corrals except Bar BC and Murie. Litter values varied between sites, with a significantly higher percent of litter in Circle H, R Lazy S, and Square G corrals, and Whitegrass control. Percent rock was significantly higher in all controls, except Halfmoon and Murie. It is possible that rock coverage was higher in controls because rocks were manually removed from corrals over time. There were significant differences in bareground between paired corral and control at Rudd, Circle H, and Halfmoon sites. Significantly higher percentages of bareground were found in the Rudd and Circle H corrals, and a significantly lower percentage of bareground was found in the Halfmoon corral when compared to its paired control.

Soil Texture Analysis

Specific percentages of sand, silt, and clay, and soil color, for each site at varying depths were determined (Appendix F), and are shown graphically for the top soil horizon (Figure 13). There were no meaningful differences in soil texture between individual paired sites or between all corrals and controls. Soil texture test results indicate that all soils are classified as a loam or sandy loam.

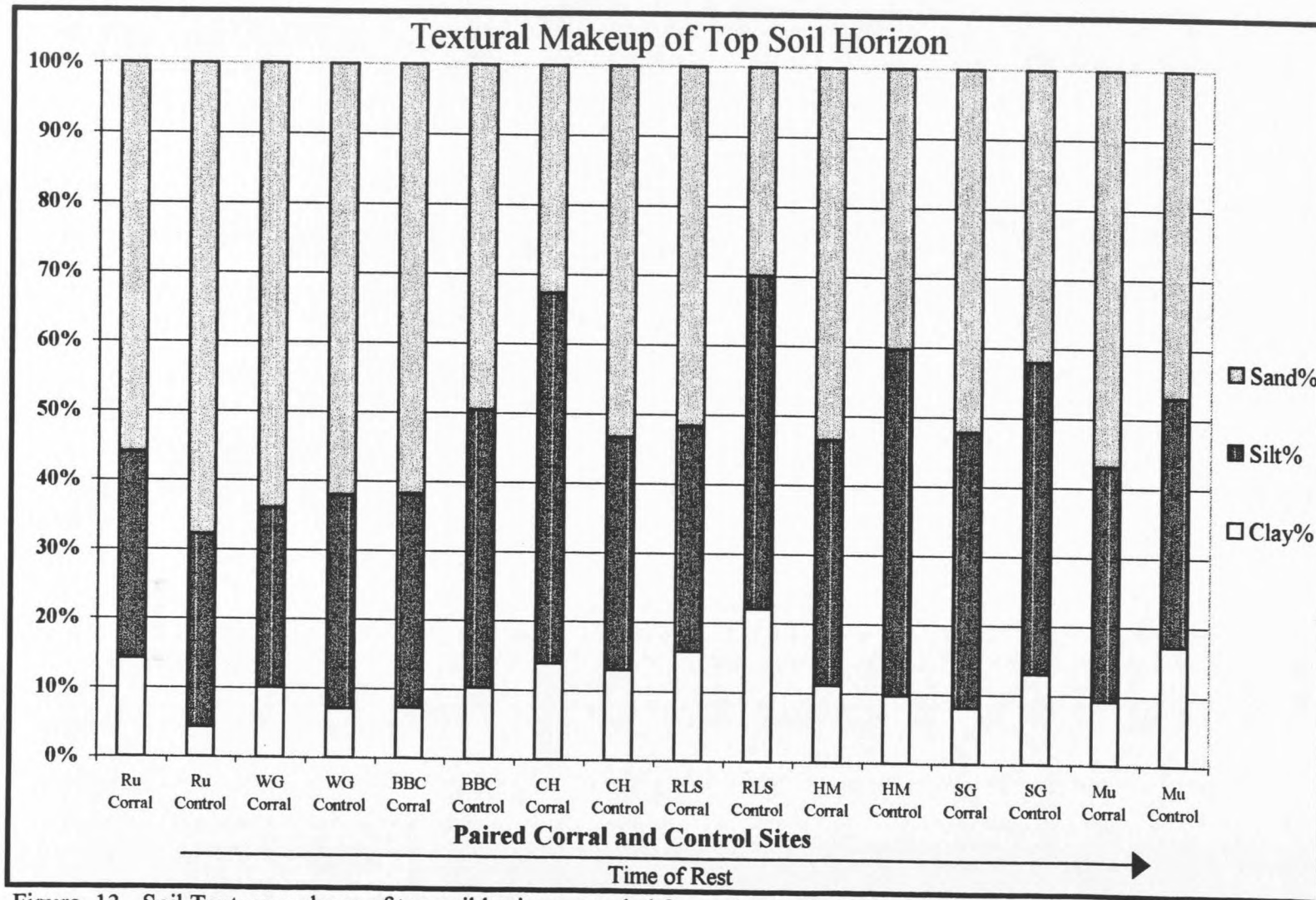


Figure 13. Soil Texture makeup of top soil horizon sampled for each paired corral and control.

The impact of soil compaction on plant regeneration could not be accurately assessed due to the unconsolidated makeup of a young alluvial soil, despite numerous attempts using different methodologies and equipment. I observed that the topmost layer of soil did not allow water to penetrate as quickly in the corral vs. the control, but this phenomenon was not accurately quantifiable in the field.

The high percentage of sand present in all samples, coupled with the intermixed stoney substrate, may make the issue of compaction moot, because sand is limited in its compactibility. In addition, frost-freeze phenomenon, and pocket gopher activity may reverse compaction of soil from horse activity.

Constant freezing and thawing of the soil can occur in the valley of Jackson Hole especially during the fall and spring months when temperatures often drop below freezing at night and insulating snow cover has either not accumulated or has already melted. Frost action over time may help to loosen soil surfaces, and reverse soil compaction caused by horses.

Pocket gopher activity was evident in all corral sites. Pocket gopher (Geomyidae) disturbance has been documented at the soil surface and above ground. Pocket gophers are active year round, and do much of their feeding from below ground using a system of tunnels they excavate and maintain. In constructing tunnels, pocket gophers move soil to the surface and deposit piles called mounds. Tunneling can be widespread, covering as much as 25-30% of the ground surface, existing estimates of soil moved above ground range from 1 to 8.5 kg m⁻² yr⁻¹ by individual gopher (Anderson, 1987). Not all soil excavated by burrowing gophers is moved to the ground surface. Some is used to fill old

tunnels. Anderson, (1987) found that 41% to 87% of excavated soil was deposited as backfill; this backfill ranged to 30 L./da per gopher. Effects of backfilling on plants remain unknown, but backfilled soil has been found to have a lower bulk density.

Studies have shown that pocket gopher mounds differ in physical and chemical properties from undisturbed soil and affect plant development (Huntly and Inouye, 1988). Gophers increase spatial variation in the availability of soil nitrogen and light. Overall, plant diversity (species richness) is greater on or near gopher mounds, and abundance of annual forbs has been shown to increase (Huntly and Inouye, 1988). All sites showed evidence of pocket gopher activity, and it is plausible that their activity has also helped to reverse soil compaction in horse corrals.

Soil Chemical Analysis

Table 10. Soil Chemical Analysis of Rudd and Murie Sites

Soil Chemicals	K	CEC	NO ₃ -N	Organic Matter	Olson Phosphorus	pH
	mg/kg	mmhos/cm	mg/kg	%	mg/kg	
Rudd Corral	350	0.08	1.6	6.89	72.3	7.2
Rudd Control	218	0.06	2.9	7.33	38.4	5.9
Murie Corral	242	0.08	7.1	8.66	35	6.3
Murie Control	152	0.03	0.7	3.07	12.4	6.4

Soil chemical analysis was completed for the Murie corral and control and the Rudd corral and control (Table 10). There are no meaningful differences in chemical tests between corrals and controls and between the corral with the shortest and the corral with the longest rest periods, as determined by expected soil chemical agricultural values

(Munshower, 1994). Zakley (1994) completed similar soil tests in similar habitat in the southern portion of the valley of Jackson Hole in 1992. Nitrogen levels are lower in this study than those found by Zakley (1994), but all levels fall within the range considered normal. A higher phosphorus reading in Rudd corral may be caused by the recent removal of horses from the site as residual amounts from horse fecal material remain in the corral. However, phosphorus toxicity is unknown in a natural environment and was not shown to effect plant revegetation in the sagebrush community of Grand Teton National Park (Cotts, 1990).

In summary, there was little difference in soil texture and soil chemistry. The soil textural and chemical properties are not ecologically significant in terms of plant regeneration over time. There does not appear to be a relationship between soil texture, soil chemistry and plant regeneration rate. Soil chemistry values and texture measurements were similar to values found in a recent study conducted in the same areas of Grand Teton National Park (Zakley, 1994) and to soil samples analyzed in adjacent grazing pastures currently being used (Schiller and Kelly, 1996).

CONCLUSIONS

The objectives of this study were to examine natural revegetation of dude ranch corral sites that rested for varying periods of time in order to establish whether recovery was related to time of rest. It was theorized that corral sites more recently disturbed would display less similarity to paired controls than corrals that had rested for longer periods of time. Other workers have looked at vegetative recovery and succession pathways over time, few in habitat similar to this study. This study focused on vegetation composition in three different ways: 1) patterns in vegetation habit, origin, and weediness, 2) patterns at the species level for forb species, and 3) patterns in percent cover variables. Soil texture and chemistry were also examined. Four research questions were addressed: 1) Could boundaries and history of use of corrals be accurately found in the field? 2) Does vegetation differ between corral and control sites? 3) Does physical and chemical makeup of the soil differ between corral and control? 4) Is vegetative recovery time-of-rest related?

Use of Historical Information

Dude ranches within Grand Teton National Park provide a unique opportunity to evaluate the revegetation processes following horse use in corrals, in a relatively undisturbed, physically homogenous area, where historical locations and horse use can be

documented. The documentation of both physical and cultural evidence provides an accurate basis for revegetation analysis.

Historical reconstruction of dude ranch locations and patterns of use were necessary in the creation of a legitimate chronosequence of abandoned horse corrals. Site history has been crucial to studies using time as an independent variable. Chronosequence use is particularly important in studies evaluating plant regeneration after human disturbance because the impact of human caused disturbance on natural systems has begun to be studied relatively recently, with few long term studies focused on plant dynamics.

Careful and systematic use of historical and cultural data from a variety of sources helped to accurately identify physical boundaries of horse corrals, and identify years of use and numbers of horses present. Use of historical information was also extremely important in the designation of areas that were not disturbed. Historical documents, maps, and land records were used to insure control sites accurately reflected an undisturbed sagebrush community. Minimization of physical differences between sites was an achieved goal. Because minimization of physical differences was a necessary requirement, sample size was restricted and the time of rest in the chronosequence was not uniform between sites. However, homogenous conditions necessary for completion of the study were attained.

The number of horses in use at each site was the most difficult information to obtain, and an estimate was inferred from all historical information available. There were differences in horse number across time at each site and between corral sites. Grazing studies suggest that change in site condition as measured by decreasing infiltration rates

occurs quickly, and a sustained disturbed state is maintained over time until stock are removed (Weltz, et al., 1989). These findings suggest that once a disturbance threshold is crossed, the degraded area is maintained, regardless of time of rest between disturbance or number of stock in a confined area. While the time it took for the corrals to reach a bare unvegetated state is unknown, all corrals were small, and it is probable that all sites reached similar conditions rapidly, and that those conditions were maintained throughout the corral's use. Because disturbance threshold levels were probably exceeded rapidly and maintained over time, the precise number of horses in use, and the length of corral use was considered not as important as the number of years of rest each corral underwent.

Differences in Vegetation Patterns Between Corrals and Controls

Overall vegetation composition does differ between corral and control sites. Differences between all control and all corral sites and between paired corrals and controls were however often subtle and unpredictable. Of the total 128 species collected, 73 species occurred in 3 or less of 16 possible sites. Only eleven species were common to all control sites, while two species were common to all corrals. Only one species was common to all corral or control sites. With the exception of P. douglasii, the species common to all corrals or controls exhibited low stem densities and varying frequency across sites. In addition, frequency and density patterns of the shared species were lower in the R Lazy S, Circle H and Bar BC controls when compared to the other control sites indicating variation in the expression of shared species between sites. With the exception of the eleven shared species, it was difficult to predict the vegetation makeup of either

corral or control site, and the predictive ability did not improve with increasing time of rest. Variation in species makeup was the dominant commonality across all sites.

Analysis of species number and type (forb vs. grass), habit (annual, biennial, perennial), origin (native, introduced), and weediness (weedy or non-weedy) was completed for each species. Differences in species number, habit, origin, and weediness between corral and controls were subtle but did exist. All corrals had fewer species than paired controls except the R Lazy S corral. Forbs were the dominant vegetation type across all sites. Perennial and native forbs were more common in controls than corrals, while annuals and introduced species were slightly more common in corrals, with annuals the dominant forb type in the most recently disturbed corrals, Rudd and Whitegrass. There was a higher percentage of weedy species in corrals than in controls.

Grouped forb data was used to elucidate relationships at the species level. Four categories: (adventurer, colonizer, ubiquitous, and undisturbed) were created which organized species based on increasing presence in all sites. Only 55 of the total 103 forbs sampled occurred enough to be members of one of these groups. Analyses of data show that even the more commonly occurring species were not very common. At the species level, patterns of forb invasion or extinction were not evident, and stem density of individual species was often variable and appeared site specific. Differences at the species level were harder to delineate because of the highly individualistic behavior of species across all sites.

Differences between corrals and controls were seen in percent cover measurements for bareground, rock, litter, grass, sedge, forb and shrub. When all corrals were compared to

all controls, corrals showed significantly lower amounts of rock, forbs, and shrubs, and higher amounts of litter and grass. A significant difference was not found between all corrals and all controls in bareground percent cover, but significant differences were shown in paired site comparisons. There were no significant differences in sedge coverage between site types or between paired sites. Analysis of differences between paired sites for rock, forb, shrub, litter and grass followed the general trends outlined above, and no cover patterns over time were shown.

Similarity between paired corral and control sites was described using two indices of similarity: Sorenson's similarity index (1948) and a newly devised absolute difference method that compared the absolute differences of species categorical data between each paired site. Comparison of shared number of species between each corral and control using the Sorenson coefficient expressed varying degrees of similarity between each corral and control, the extent of which varied by site. The absolute difference method used as a similarity index also expressed variation in similarity between paired corral and control sites. Because the Sorenson index is a simpler measurement, a higher degree of similarity between paired sites was shown. However, there was no consistent increase in site similarity with increased time of corral rest.

Differences In Soil Characteristics Between Corral and Control

No ecologically significant differences between corrals and controls were found to exist when standard chemical analysis for K, CEC, N, OM, P, and Ph were completed. A study completed in Grand Teton National Park by Zakley (1994) reported similar results

for soil samples in sagebrush dominated vegetation. Results suggest that horse activity in corrals has not impacted soil chemistry measurably, and that soil chemistry does not show any obvious relationship to the natural revegetation process of abandoned corrals.

Soil texture was found to be fairly uniform across all sites, and is classified as a loam or sandy loam. Accurate measurement of soil compaction was not successfully obtained by hydrometer, soil corer or sand replacement methods. Previous studies suggest that soil disturbance can have a lasting effect on revegetation process (McLendon and Redente, 1990) or slow recovery down (Hatton and West, 1987, Cotts, 1990).

Recreational impacts to soil, including horse use, have been shown to effect the top 15cm to 19 cm of soil. Although no published information specific to horses in corrals is known to exist, Weltz, et.al, (1989) showed an immediate increase in soil infiltration rates when cattle were removed from pasture areas. While an accurate bulk density measurement could not be made in the field, observations in the field question whether compaction would remain and impede vegetation recovery.

All sites exhibited some degree of disturbance by pocket gophers. Pocket gophers have been shown to impact soil density at the surface and below ground, and have been shown to impact vegetation composition (Huntly and Inouye, 1988). The frost- freeze phenomena that impacts soil surfaces before and after insulating snow covers the valley floor also may help to undo soil compaction by horses hooves, so that soil compaction will not continually impact revegetation patterns in horse corrals over time. In addition, all sites were found to contain between 30% (RLS control) and 67% (Rudd control) sand.

The predominantly sand and cobble soil structure suggests that extent of compaction would be limited by soil composition.

Change In Revegetation Pattern Over Time

Classic succession theory suggests that plant recovery after disturbance is unidirectional and predictable (Clements, 1916; Margalef, 1963; Odum 1969), with maximum species diversity and biomass represented in a climatically induced stable climax community. Deterministic successional theories hypothesize that plant regeneration exhibits signs of convergence toward the vegetative makeup of a stable climax community over time. Undisturbed sagebrush communities have been reported as largely homogeneous and predictable in pattern (Hatton and West, 1987; Cotts, 1990; Zakley, 1994; McLendon and Redente, 1990). Convergence of vegetation after disturbance has been shown to occur in sagebrush communities (Hatton and West, 1987; McLendon and Redente, 1990) well as grasslands (Bornkamm, 1981) and in old fields (Tilman, 1984, 1985; Inouye and Tilman, 1988; Myster and Pickett, 1992). Results of this study do not show vegetative convergence of disturbed sites to controls over time.

If classical succession models are upheld in sagebrush communities then control plots sampled should represent the species composition of the undisturbed sagebrush community. Few similar species were found between all control sites despite the homogenous physical environment in which they existed. Of the ten herbaceous herbs, that were common to all controls, only P. douglasii occurred in high density consistently across all sites. Species that otherwise occurred in high density tended to be site specific,

occurring in a specific site, corral, or control. Data at the species level is more variable than previous studies have shown (Sabinske and Knight, 1978; Zakley, 1994; Hatton and West, 1987), and suggests that there is great variability in the makeup of this sagebrush community at the species level. Because of the great variability that these data show; attempts to measure vegetation recovery after disturbance against a composite undisturbed sagebrush community is misguided. This research shows the large variability that exists within undisturbed sagebrush community in similar physical conditions, and thus argues against the use of one predictable climax community model at the species level.

Classic succession theories suggest that plant recovery after disturbance is unidirectional and predictable. The results of this study do not support models that suggest that plants interact strongly during succession processes and that these actions structure communities. Instead, this study suggests that the successional process is highly individualistic and species specific. The results of this data concur with the findings of long-term repeated-measure studies in old fields (Pickett, 1982, Myster and Pickett, 1992) and grassland settings (Glenn-Lewin, 1980; Belsky, 1986b).

Similarity and differences in vegetation makeup were shown by the comparison of vegetation data between corrals and controls and for each corral and paired control site. Variation within rather than similarity between sites was found in all analyses of the data. Similarity and differences in measurements of forb distribution, percent cover, and individual species habits, origin, and weediness were identified between corrals and controls and individually between paired sites. There was a great amount of variability in

the data, and data analysis results show no clear trend in vegetation change over time with increasing time of rest. More than half of the species sampled occurred so infrequently it was impossible to suggest their role in succession. Those species that appeared more frequently often appeared erratically with highly variable or low stem densities, and no invasion or extinction of species over time was apparent, which would be expected if time of rest played a role in post disturbance plant composition.

The Sorenson similarity index showed that some sites exhibited greater similarity in species makeup, but the scores did not increase linearly over time. Absolute values of plant categorical data used as a similarity index did not show an increase in similarity between sites either. In addition, sites that are most closely related in years of rest do not have similar index scores, which would be expected if vegetation succession patterns were linear, as proposed. These variations are not explained by differences in soil texture, soil chemistry, site aspect, slope, or elevation. Results of data collected from a chronosequence of disturbed horse corrals indicate that natural revegetation patterns are not linear over time and regeneration is individualistic and highly unpredictable. Time of rest does not correlate well with degree of recovery.

Data grouped by habit, weediness, and origin did exhibit some differences between corral sites and controls in that corral sites contained more weedy species. However, there were not differences in habit type or origin of species in that perennials and native plants were dominant in both corrals and controls. Change in habit within corral sites did exhibit a pattern with time in that the two most recently disturbed sites had a slightly higher percentage of annuals than perennials, however percent annuals remains fairly

constant, between 25 to 35 percent in all corrals. The range between percent annuals and perennials in control sites was greater, and more variable.

Differences in percent cover measurements were identified between corrals and controls and individually between paired sites. Time of rest was not identifiable as a potential cause of these differences. Furthermore, although we can show that forb and shrub percent cover is higher in controls vs. corrals, the findings of this study suggest that the makeup of the forbs within that cover measurement are diverse and unpredictable.

In terms of number of species, sites did become more similar over time but the trend was not linear, suggesting that time of rest was not solely responsible for species similarity.

Two broad conclusions are shown from the data, the natural heterogeneity found in sagebrush vegetation, and the individualistic and site specific nature of plant community development in the sagebrush community of Jackson Hole, Wyoming.

Future Management Implications

The implications of this study are important for land managers in Grand Teton National Park and the surrounding area. Traditional succession models as first applied by Clements (1916) and later improved upon by Margalef (1963) and Odum (1969), uphold the idea that vegetation change is unidirectional and predictable as vegetation moves towards a stable climax community. Although deterministic theories of vegetation succession have been replaced by more complex explanations of plant revegetation,

deterministic theories of plant succession are still commonly applied in revegetation sciences (Call and Roundy, 1991). Although the study of plant community change over time is recognized as more dynamic, simplistic and perhaps outdated models which are deterministic pervade the scientific community charged with monitoring vegetative change.

This study adds to a growing body of literature that shows that vegetative communities are complex, and diverse in their revegetation patterns, in plant communities that some workers have previously considered homologous.

The results suggest that revegetation of abandoned horse corrals is highly site specific and is independent of time of rest, which is in agreement with the findings of some other studies (Pickett 1992; Glenn-Lewin 1980). This is of particular importance to those land managers that want to return disturbed areas to the undisturbed vegetation condition. The results of this study show that active revegetation methods will have to be initiated by the manager; period of rest alone will not be sufficient to return disturbed areas back to non-disturbed conditions, as defined by vegetation conditions in paired controls. A large variety of species were found within the undisturbed sagebrush environment, often in low densities. To accurately reconstruct predisturbance vegetation conditions a diverse seed mix should be used.

This study identified a number of species that existed in both disturbed and undisturbed settings that could be used in revegetation projects. Those plants grouped as ubiquitous forbs, species that are found in both undisturbed and disturbed settings, as well as those species found in the undisturbed grouped forb category, species that prefer

undisturbed environments, could be used in revegetation projects. In addition, this study has shown that shrub coverage in disturbed corral sites did not approximate shrub coverage of the paired controls throughout the 56-year chronosequence. Therefore reestablishment of shrubs, especially Artemisa tridentata, which was most common, should also be included in a site restoration plan.

Future Studies

Three avenues for future studies are suggested. Permanent plots could be established in the corral sites, and sampling could be done on a regular basis to see if revegetation patterns remain variable over time. Many dude ranches were closed permanently between 1948 and 1950, when much of the Jackson Hole valley was included in an expansion of Grand Teton National Park boundaries. If corrals that were abandoned during this time period were sampled, a period of rest with site replication could be studied, and variability in revegetation composition reviewed. Lastly, previous disturbance studies in Grand Teton National Park have been completed which looked at vegetation recovery on old roads, homestead sites and barrow pits. More complete information about vegetation recovery response could be ascertained by establishing permanent markers in the field and resampling all disturbances using the same methodology. In addition to species density, estimates of cover for individual species and biomass measurements would provide the most comprehensive information about vegetative response after disturbance, in a variety of settings.

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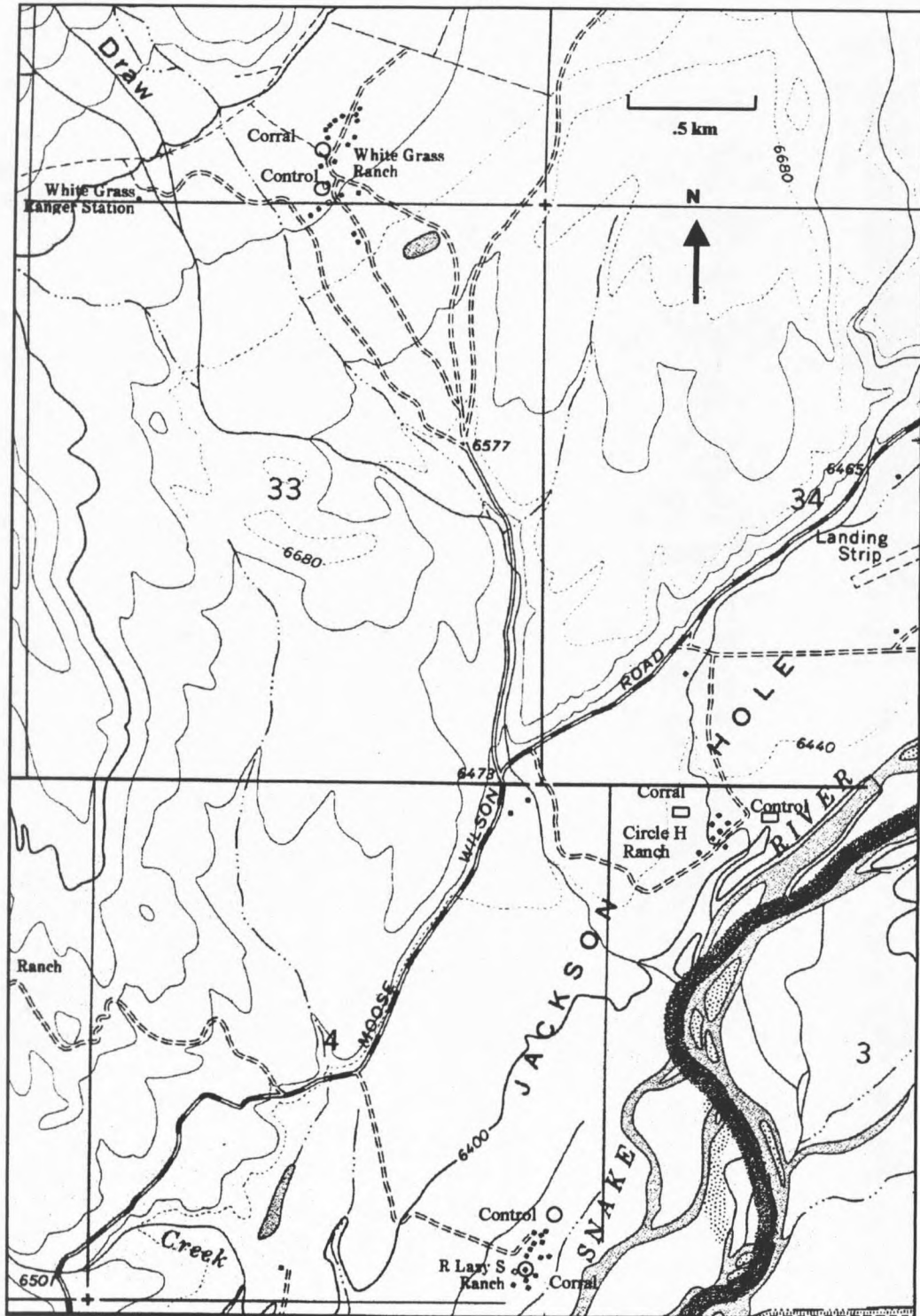
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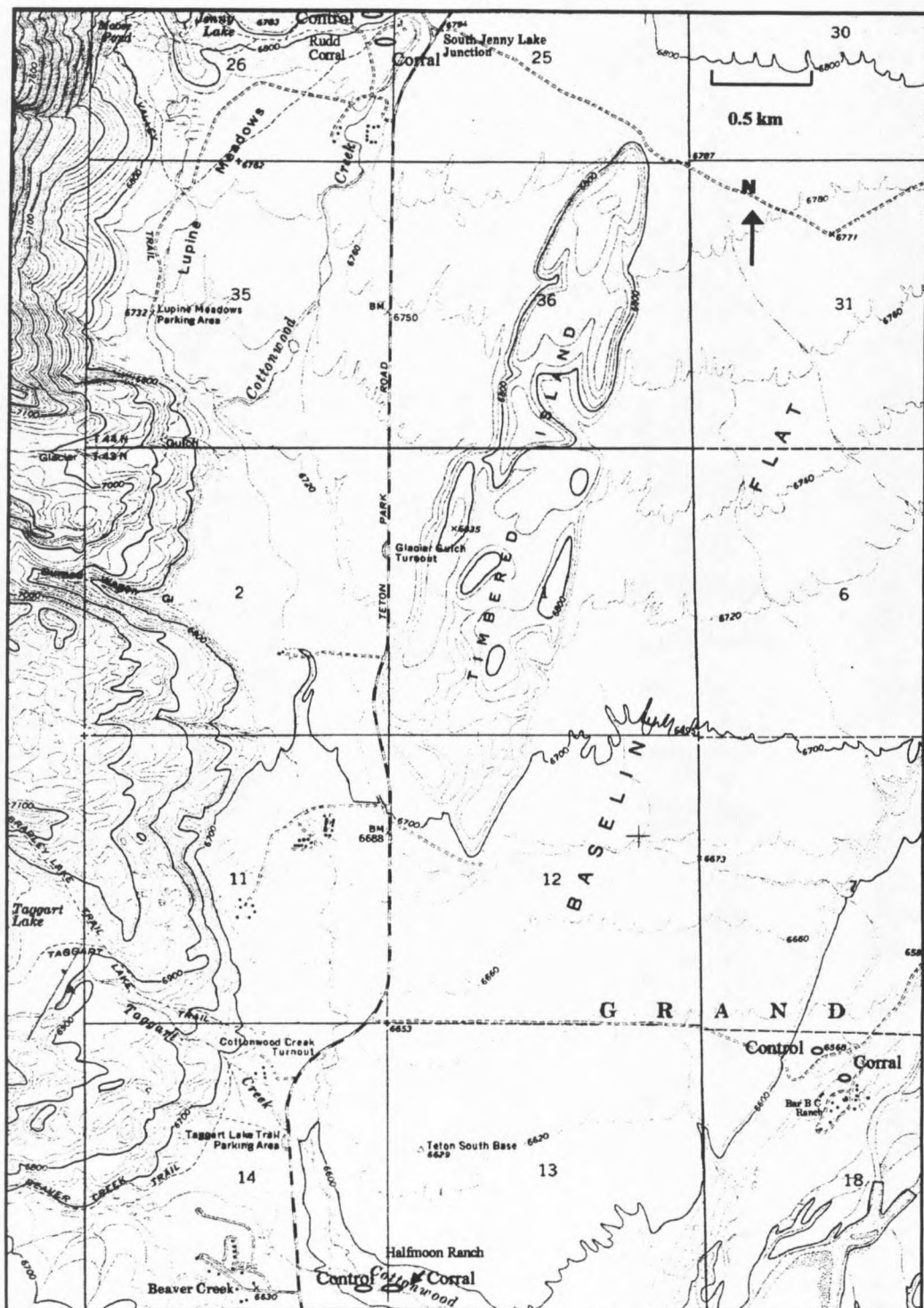
APPENDICES

APPENDIX A

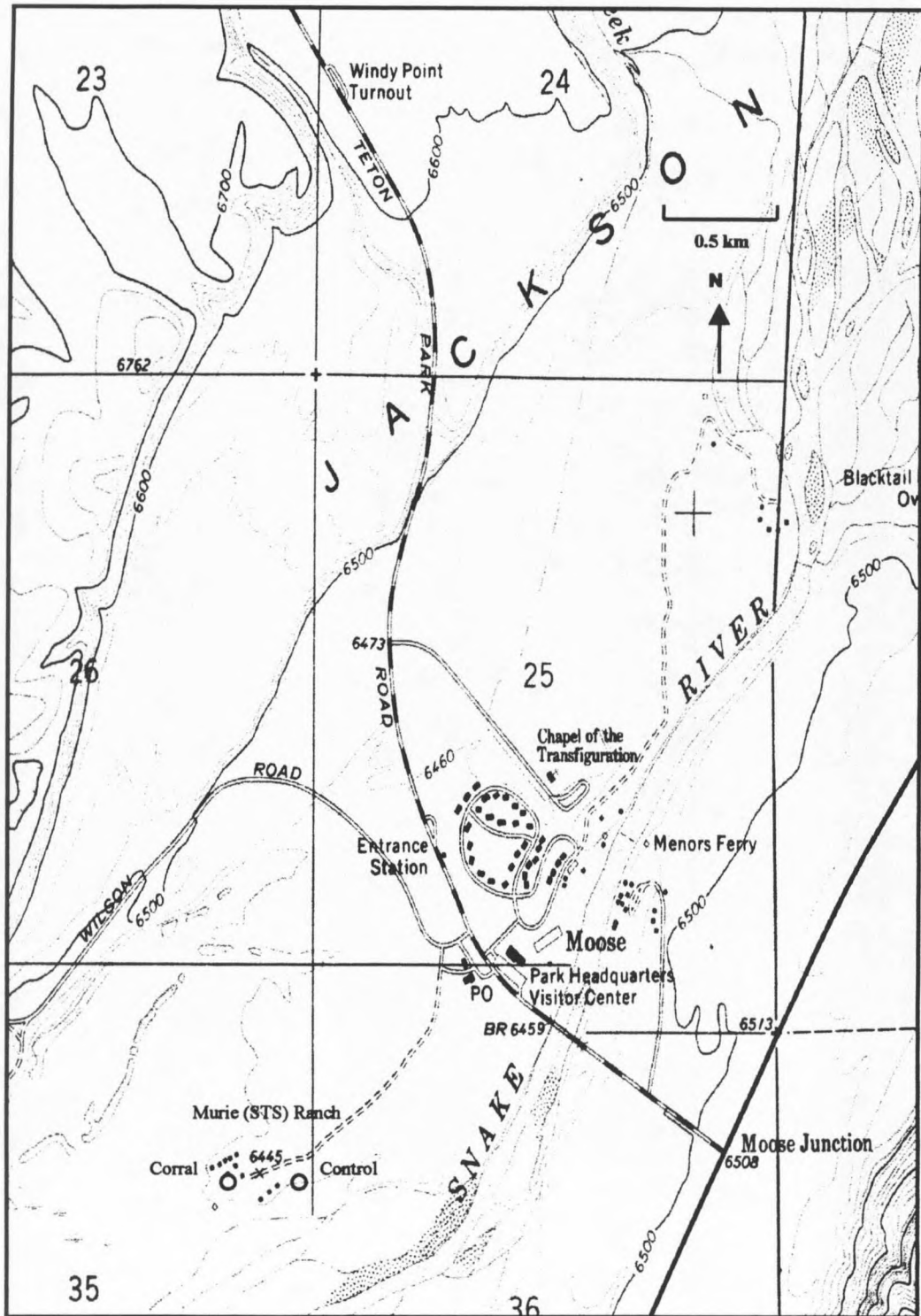
Study Site Maps



Site location of Whitegrass Ranch, R Lazy S Ranch, and Circle H Ranch. ○ Indicate corral and control locations. Grand Teton Quadrangle, Teton County, Wyoming. 1967 United States Geologic Survey.



Site Locations of Square G Ranch, Rudd Corral, Bar BC Ranch, Halfmoon Ranch. ○ Indicate corrals and controls. Moose Quadrangle, Teton County, Wyoming, 1967 United States Geologic Survey.



Site location of the Murie (STS) Ranch. ○ Indicate corral and control locations.
Moose Quadrangle, Teton County, Wyoming, 1967 United States Geologic Survey.

APPENDIX B

Comprehensive Species List of All Species Sampled
In Pocket

APPENDIX C

Species Lists by Site

Murie Control				
Species Name	Family	Annual/ Perennial	Introduced/Native	Weedy/Non-weedy
Polygonum douglasii	Polygonaceae	Annual	Introduced	Non-weedy
Collomia linearis	Polemoniaceae	Annual	Native	Non-weedy
Cryptantha sp.	Boraginaceae		Native	Non-weedy
Thlaspi arvense	Brassicaceae	Annual	Introduced	Noxious
Galium bifolium	Onagraceae	Annual	Native	Non-weedy
Linanthus septentrionalis	Polemoniaceae	Annual	Native	Non-weedy
Gayophytum diffusum	Onagraceae	Annual	Native	Non-weedy
Nemophila parviflora	Hydrophyllaceae	Annual	Native	Non-weedy
Erigonum umbellatum	Polygonaceae	Perennial	Native	Non-weedy
Colinsia pariflora	Scrophulariaceae	Annual	Native	Non
Aster integrifolius	Asteraceae	Perennial	Native	Non-weedy
Mahonia repens	Berberidaceae	Perennial	Native	Non-weedy
Artemisa tridentata	Asteraceae	Perennial	Native	Non-weedy
Erigeron speciosa/glabrous	Asteraceae	Perennial	Native	
Taraxacum leavigatum	Asteraceae	Annual	Introduced	Economic
Hydrophyllum capitatum	Hydrophyllaceae	Perennial	Native	Non-weedy
Tragopogon dubius	Asteraceae	Biennial	Introduced	Economic
Lithophragma parviflorum	Saxifragaceae	Perennial	Native	Non-weedy
Viola vallicola	Violaceae	Perennial	Native	Non-weedy
Lupinus sericeus	Fabaceae	Perennial	Native	Non-weedy
Machaeranthera canescens	Asteraceae	Perennial	Native	
Agoseris glauca	Asteraceae	Perennial	Native	Non-weedy
Delphinium sp.	Ranunculaceae	Perennial	Native	Economic
Ranunculus macounii	Ranunculaceae	Perennial	Native	Non-weedy
Linaria vulgaris	Scrophulariaceae	Perennial	Introduced	Noxious
Antennaria luzuloides	Asteraceae	Perennial	Native	Non-weedy
Balsamorhiza sagittata	Asteraceae	Perennial	Native	Non-weedy
Crepis acuminata	Asteraceae	Perennial	Native	Non-weedy
Wyethia amplexicaulis	Asteraceae	Perennial	Native	Economic
Fritillaria Pudica	Liliaceae	Perennial	Native	Non-weedy
Juniperus communis	Cupressaceae	Perennial	Native	Non-weedy
Lithospermum rudevale	Boraginaceae	Perennial	Native	Non-weedy
Medicago lupulina	Fabaceae	Annual	Introduced	Economic
Bromus inermis	Poaceae	Perennial	Introduced	Non-weedy
Elymus trachycaulus	Poaceae	Perennial	Native	Non-weedy
Poa pretensis/compressa	Poaceae	Perennial	Introduced	Colonizing
Stipa nelsonii	Poaceae	Perennial	Native	Non-weedy
Melica spectabilis	Poaceae	Perennial	Introduced	Non-weedy
Carex hoodii	Cyperaceae	Perennial	Native	Non-weedy
Koleria macrantha	Poaceae	Perennial	Native	Non-weedy
Elymus lanceolatus	Poaceae	Perennial	Native	Non-weedy
Bromus carinatus	Poaceae	Biennial	Native	Colonizing

Murie Corral				
Species Name	Family	Annual/ Perennial	Introduced/Native	Weedy/Non-weedy
<i>Polygonum douglasii</i>	Polygonaceae	Annual	Introduced	Non-weedy
<i>Collomia linearis</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Cryptantha</i> sp.	Boraginaceae		Native	Non-weedy
<i>Thlaspi arvense</i>	Brassicaceae	Annual	Introduced	Noxious
<i>Galium bifolium</i>	Onagraceae	Annual	Native	Non-weedy
<i>Linanthus septentrionalis</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Gayophytum diffusum</i>	Onagraceae	Annual	Native	Non-weedy
<i>Epilobium</i> sp.	Onagraceae		Native	Non-weedy
<i>Nemophila parviflora</i>	Hydrophyllaceae	Annual	Native	Non-weedy
<i>Capsella bursa-pastoris</i>	Brassicaceae	Annual	Introduced	Economic
<i>Lomatium ambiguum</i>	Apiaceae	Perennial	Native	Colonizing
<i>Colinsia paraflorea</i>	Scrophulariaceae	Annual	Native	Non-weedy
<i>Rumex acetosella</i>	Polygonaceae	Perennial	Introduced	Economic
<i>Senecio serrata</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Taraxacum leavigatum</i>	Asteraceae	Annual	Introduced	Economic
<i>Dracocephalum parviflorum</i>	Lamiaceae	Perennial	Native	
<i>Amelanchier alnifolia</i>	Rosaceae	Perennial	Native	Non-weedy
<i>Hydrophyllum capitatum</i>	Hydrophyllaceae	Perennial	Native	Non-weedy
<i>Tragopogon dubius</i>	Asteraceae	Biennial	Introduced	Economic
<i>Viola vallicola</i>	Violaceae	Perennial	Native	Non-weedy
<i>Agoseris glauca</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Delphinium</i> sp.	Ranunculaceae	Perennial	Native	Economic
<i>Carduus nutans</i>	Asteraceae	Biennial	Introduced	Noxious
<i>Urtica dioica</i>	Urticaceae	Perennial	Native	Economic
<i>Symphoricarpos oreophilus</i>	Caprifoliaceae	Perennial	Native	Non-weedy
<i>Sonchus</i> sp.	Asteraceae	Annual	Introduced	Exotic
<i>Bromus inermis</i>	Poaceae	Perennial	Introduced	Non-weedy
<i>Poa pretensis/compressa</i>	Poaceae	Perennial	Introduced	Colonizing
<i>Stipa nelsonii</i>	Poaceae	Perennial	Native	Non-weedy
<i>Poa secunda</i> var. <i>elongata</i>	Poaceae	Perennial	Native	Non-weedy
<i>Koeleria macrantha</i>	Poaceae	Perennial	Native	Non-weedy
<i>Juncus balticus</i>	Juncaceae	Perennial	Native	Non-weedy
<i>Bromus carinatus</i>	Poaceae	Biennial	Native	Colonizing

Square G Control				
Species Name	Family	Annual/ Perennial	Introduced/Native	Weedy/Non-weedy
<i>Polygonum douglasii</i>	Polygonaceae	Annual	Introduced	Non-weedy
<i>Collomia linearis</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Galium bifolium</i>	Onagraceae	Annual	Native	Non-weedy
<i>Linanthus septentrionalis</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Gayophytum diffusum</i>	Onagraceae	Annual	Native	Non-weedy
<i>Erigeron umbellatum</i>	Polygonaceae	Perennial	Native	Non-weedy
<i>Aster integrifolius</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Microseris nutans</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Artemisa tridentata</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Erigeron speciosa/glabrous</i>	Asteraceae	Perennial	Native	
<i>Taraxacum officinales</i>	Asteraceae	Annual	Introduced	Economic
<i>Dracocephalum parviflorum</i>	Lamiaceae	Annual	Native	
<i>Tragopogon dubius</i>	Asteraceae	Biennial	Introduced	Economic
<i>Perdideridia montana</i>	Apiaceae	Perennial	Native	Non-weedy
<i>Potentilla gracilis</i>	Rosaceae	Perennial	Native	Non-weedy
<i>Viola vallicola</i>	Violaceae	Perennial	Native	Non-weedy
<i>Delphinium sp.</i>	Ranunculaceae	Perennial	Native	Economic
<i>Antennaria luzuloides</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Microsteris gracilis</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Stellaria longapias</i>	Carophyllaceae	Perennial	Native	Noxious
<i>Chenopodium</i>	Chenopodiaceae	Annual	Native	
<i>Sedum lanceolatum</i>	Crassulaceae	Perennial	Native	Non-weedy
<i>Arabis holboellii</i>	Brassicaceae	Biennial	Native	Non-weedy
<i>Microseris nutans</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Fritillaria Pudica</i>	Liliaceae	Perennial	Native	Non-weedy
<i>Elymus trachycaulus</i>	Poaceae	Perennial	Native	Non-weedy
<i>Poa pretensis/compressa</i>	Poaceae	Perennial	Introduced	Colonizing
<i>Melica spectabilis</i>	Poaceae	Perennial	Introduced	Non-weedy
<i>Carex hoodii</i>	Cyperaceae	Perennial	Native	Non-weedy
<i>Koleria macrantha</i>	Poaceae	Perennial	Native	Non-weedy
<i>Hordeum jubatum</i>	Poaceae	Perennial	Native	Economic
<i>Danthonia spicata</i>	Poaceae	Perennial	Native	Non-weedy
<i>Elymus elymoides</i>	Poaceae	Perennial	Native	
<i>Carex geveeri</i>	Cyperaceae	Perennial	Native	Non-weedy

Square G Corral				
Species Name	Family	Annual/ Perennial	Introduced/Native	Weedy/Non-weedy
<i>Polygonum douglasii</i>	Polygonaceae	Annual	Introduced	Non-weedy
<i>Collomia linearis</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Galium bifolium</i>	Onagraceae	Annual	Native	Non-weedy
<i>Linanthus septentrionalis</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Gayophytum diffusum</i>	Onagraceae	Annual	Native	Non-weedy
<i>Erigeron umbellatus</i>	Polygonaceae	Perennial	Native	Non-weedy
<i>Microseris nutans</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Artemisa tridentata</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Erigeron speciosa/glabrous</i>	Asteraceae	Perennial	Native	
<i>Taraxacum officinales</i>	Asteraceae	Annual	Introduced	Economic
<i>Violeta praemorsa</i>	Violaceae	Perennial	Native	Non-weedy
<i>Artemisa tripartita</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Lithophragma parviflorum</i>	Saxifragaceae	Perennial	Native	Non-weedy
<i>Perdideridia montana</i>	Apiaceae	Perennial	Native	Non-weedy
<i>Viola vallicola</i>	Violaceae	Perennial	Native	Non-weedy
<i>Lupinus sericeus</i>	Fabaceae	Perennial	Native	Non-weedy
<i>Agoseris glauca</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Phlox longifolia</i>	Polemoniaceae	Perennial	Native	Non-weedy
<i>Achillea millefolium</i>	Asteraceae	Perennial	Native	Colonizing
<i>Antennaria luzuloides</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Microsteris gracilis</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Chenopodium sp.</i>	Chenopodiaceae	Annual	Native	
<i>Arabis holboellii</i>	Brassicaceae	Biennial	Native	Non-weedy
<i>Crepis acuminata</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Wyethia amplexicaulis</i>	Asteraceae	Perennial	Native	Economic
<i>Fritillaria Pudica</i>	Liliaceae	Perennial	Native	Non-weedy
<i>Poa pretensis/compressa</i>	Kentucky/Canada Bluegrass	Perennial	Introduced	Colonizing
<i>Elymus elymoides</i>	Squirreltail	Perennial	Native	
<i>Melica spectabilis</i>	Showy Onion Grass	Perennial	Introduced	Non-weedy
<i>Koleria macrantha</i>	Junegrass	Perennial	Native	Non-weedy
<i>Elymus lanceolatus</i>	Thickspike wheatgrass	Perennial	Native	Colonizing
<i>Hordeum jubatum</i>	3-awn/Foxtail Barley	Perennial	Native	Economic
<i>Danthonia spicata</i>	One-spike danthonia	Perennial	Native	Non-weedy

Halfmoon Control				
Species Name	Family	Annual/ Perennial	Introduced/Native	Weedy/Non-weedy
Polygonum douglasii	Polygonaceae	Annual	Introduced	Non-weedy
Collomia linearis	Polemoniaceae	Annual	Native	Non-weedy
Cryptantha sp.	Boraginaceae		Native	Non-weedy
Thlaspi arvense	Brassicaceae	Annual	Introduced	Noxious
Galium bifolium	Onagraceae	Annual	Native	Non-weedy
Linanthus septentrionalis	Polemoniaceae	Annual	Native	Non-weedy
Gayophytum diffusum	Onagraceae	Annual	Native	Non-weedy
Epilobium sp.	Onagraceae			Non-weedy
Nemophila parviflora	Hydrophyllaceae	Annual	Native	Non-weedy
Erigonum umbellatum	Polygonaceae	Perennial	Native	Non-weedy
Colinsia parviflora	Scrophulariaceae	Annual	Native	Non-weedy
Lomatium ambiguum	Apiaceae	Perennial	Native	Colonizing
Rumex acetosella	Polygonaceae	Perennial	Introduced	Economic
Aster integrifolius	Asteraceae	Perennial	Native	Non-weedy
Artemisa tridentata	Asteraceae	Perennial	Native	Non-weedy
Erigeron speciosa/glabrous	Asteraceae	Perennial	Native	
Taraxacum leavigatum	Asteraceae	Annual	Introduced	Economic
Taraxacum officinales	Asteraceae	Annual	Introduced	Economic
Eriophyllum lanatum	Asteraceae	Perennial	Native	Non-weedy
Tragopogon dubious	Asteraceae	Biennial	Introduced	Economic
Artemisa tripartita	Asteraceae	Perennial	Native	Non-weedy
Ipomopsis aggregata	Polemoniaceae	Biennial	Native	Non-weedy
Lithophragma parviflorum	Saxifragaceae	Perennial	Native	Non-weedy
Perdideridia montana	Apiaceae	Perennial	Native	Non-weedy
Viola vallicola	Violaceae	Perennial	Native	Non-weedy
Senecio streptanthifolius	Asteraceae	Perennial	Native	Non-weedy
Lupinus sericeus	Fabaceae	Perennial	Native	Non-weedy
Arabis glabra	Brassicaceae	Biennial	Native	Non-weedy
Aster sp.	Asteraceae	Perennial	Native	
Arenaria congesta	Caryophyllaceae	Perennial	Native	Non-weedy
Potentilla gracilis	Rosaceae	Perennial	Native	Non-weedy
Agoseris glauca	Asteraceae	Perennial	Native	Non-weedy
Phlox longifolia	Polemoniaceae	Perennial	Native	Non-weedy
Achillea millefolium	Asteraceae	Perennial	Native	Colonizing
Delphinium sp.	Ranunculaceae	Perennial	Native	Economic
Microsteris gracilis	Polemoniaceae	Annual	Native	Non-weedy
Bromus inermis	Poaceae	Perennial	Introduced	Non-weedy
Elymus trachycaulus	Poaceae	Perennial	Native	Non-weedy
Poa pretensis/compressa	Poaceae	Perennial	Introduced	Colonizing
Elymus elymoides	Poaceae	Perennial	Native	
Melica spectabilis	Poaceae	Perennial	Introduced	Non-weedy
Dactylis glomerata	Poaceae	Perennial	Introduced	Colonizing

Halfmoon Corral				
Species Name	Family	Annual/ Perennial	Introduced/Native	Weedy/Non-weedy
<i>Polygonum douglasii</i>	Polygonaceae	Annual	Introduced	Non-weedy
<i>Collomia linearis</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Cryptantha</i> sp.	Boraginaceae		Native	Non-weedy
<i>Thlaspi arvense</i>	Brassicaceae	Annual	Introduced	Noxious
<i>Galium bifolium</i>	Onagraceae	Annual	Native	Non-weedy
<i>Linanthus septentrionalis</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Gayophytum diffusum</i>	Onagraceae	Annual	Native	Non-weedy
<i>Epilobium</i> sp.	Onagraceae		Native	Non-weedy
<i>Nemophila parviflora</i>	Hydrophyllaceae	Annual	Native	Non-weedy
<i>Erigeron umbellatus</i>	Polygonaceae	Perennial	Native	Non-weedy
<i>Capsella bursa-pastoris</i>	Brassicaceae	Annual	Introduced	Economic
<i>Colinsia parviflora</i>	Scrophulariaceae	Annual	Native	Non-weedy
<i>Lomatium ambiguum</i>	Apiaceae	Perennial	Native	Colonizing
<i>Rumex acetosella</i>	Polygonaceae	Perennial	Introduced	Economic
<i>Senecio serra</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Aster integrifolius</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Microseris nutans</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Mahonia repens</i>	Berberidaceae	Perennial	Native	Non-weedy
<i>Veronica biloba</i>	Scrophulariaceae	Annual	Introduced	Colonizing
<i>Draba albertina</i>	Brassicaceae	Annual	Native	Non-weedy
<i>Artemisa tridentata</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Erigeron speciosa/glabrous</i>	Asteraceae	Perennial	Native	
<i>Taraxacum leavigatum</i>	Asteraceae	Annual	Introduced	Economic
<i>Taraxacum officinales</i>	Asteraceae	Annual	Introduced	Economic
<i>Violeta praemorsa</i>	Violaceae	Perennial	Native	Non-weedy
<i>Dracopis parviflorum</i>	Lamiaceae	Perennial	Native	
<i>Amelanchier alnifolia</i>	Rosaceae	Perennial	Native	Non-weedy
<i>Hydrophyllum capitatum</i>	Hydrophyllaceae	Perennial	Native	Non-weedy
<i>Artemisa Arbuscula</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Ipomopsis aggregata</i>	Polemoniaceae	Biennial	Native	Non-weedy
<i>Lithophragma parviflorum</i>	Saxifragaceae	Perennial	Native	Non-weedy
<i>Helianthella uniflora</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Bromus inermis</i>	Poaceae	Perennial	Introduced	Non-weedy
<i>Elymus trachycaulus</i>	Poaceae	Perennial	Native	Non-weedy
<i>Poa pretensis/compressa</i>	Poaceae	Perennial	Introduced	Colonizing
<i>Elymus elymoides</i>	Poaceae	Perennial	Native	
<i>Stipa nelsonii</i>	Poaceae	Perennial	Native	Non-weedy
<i>Poa secunda</i> var. <i>elogata</i>	Poaceae	Perennial	Native	Non-weedy
<i>Bromus tectorum</i>	Poaceae	Annual	Introduced	Economic

R Lazy S Control				
Species Name	Family	Annual/ Perennial	Introduced/Native	Weedy/Non-weedy
<i>Polygonium douglasii</i>	Polygonaceae	Annual	Introduced	Non-Weedy
<i>Collomia linearis</i>	Polemoniaceae	Annual	Native	Non-Weedy
<i>Cryptantha</i> sp.	Boraginaceae		Native	Non-weedy
<i>Galium bifolium</i>	Onagraceae	Annual	Native	Non-Weedy
<i>Epilobium</i> sp.	Onagraceae		Native	Non-Weedy
<i>Erigonium umbellatum</i>	Polygonaceae	Perennial	Native	Non-Weedy
<i>Rumex acetosella</i>	Polygonaceae	Perennial	Introduced	Economic
<i>Senecio serra</i>	Asteraceae	Perennial	Native	Non-Weedy
<i>Mahonia repens</i>	Berberidaceae	Perennial	Native	Non-Weedy
<i>Artemisa tridentata</i>	Asteraceae	Perennial	Native	Non-Weedy
<i>Taraxacum officinales</i>	Asteraceae	Annual	Introduced	Economic
<i>Amelanchier alnifolia</i>	Rosaceae	Perennial	Native	Non-Weedy
<i>Prunus virginiana</i>	Rosaceae	Perennial	Native	Non-Weedy
<i>Lupinus sericeus</i>	Fabaceae	Perennial	Native	Non-Weedy
<i>Aster ascendens</i>	Asteraceae	Perennial	Native	
<i>Medicago lupulina</i>	Fabaceae	Annual	Introduced	Economic
<i>Vicia americana</i>	Fabaceae	Perennial	Native	Non-Weedy
<i>Atrémisa dracuculus</i>	Asteraceae	Perennial	Native	Non-Weedy
<i>Shepherdia canadensis</i>	Elaeagnaceae	Perennial	Native	Non-Weedy
<i>Potentilla fruticosa</i>	Rosaceae	Perennial	Native	Non-Weedy
<i>Ribes inerme</i>	Grossulariaceae	Perennial	Native	Non-Weedy
<i>Myosotis scorpioides</i>	Boraginaceae	Perennial	Introduced	Non-Weedy
<i>Salix lasiondra</i>	Salix	Perennial	Native	Non-Weedy
<i>Bromus inermis</i>	Poaceae	Perennial	Introduced	Non-Weedy
<i>Agrostis stolonifera</i>	Poaceae	Perennial	Introduced	Non-Weedy
<i>Juncus balticus</i>	Juncaceae	Perennial	Native	Non-Weedy
<i>Elymus glaucus</i>	Poaceae	Perennial	Native	Non-Weedy

R Lazy S Corral				
Species Name	Family	Annual/ Perennial	Introduced/Native	Weedy/Non-weedy
<i>Polygonum douglasii</i>	Polygonaceae	Annual	Introduced	Non-weedy
<i>Collomia linearis</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Cryptantha</i> sp.	Boraginaceae		Native	Non-weedy
<i>Thlaspi arvense</i>	Brassicaceae	Annual	Introduced	Noxious
<i>Galium bifolium</i>	Onagraceae	Annual	Native	Non-weedy
<i>Linanthus septentrionalis</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Gayophytum diffusum</i>	Onagraceae	Annual	Native	Non-weedy
<i>Epilobium</i> sp.	Onagraceae		Native	Non-weedy
<i>Erigeron umbellatum</i>	Polygonaceae	Perennial	Native	Non-weedy
<i>Erigeron speciosus/glabrous</i>	Asteraceae	Perennial	Native	
<i>Taraxacum officinale</i>	Asteraceae	Annual	Introduced	Economic
<i>Violeta praemorsa</i>	Violaceae	Perennial	Native	Non-weedy
<i>Achillea millefolium</i>	Asteraceae	Perennial	Native	Colonizing
<i>Carduus nutans</i>	Asteraceae	Biennial	Introduced	Noxious
<i>Solidago</i> sp.	Asteraceae	Perennial	Native	Non-weedy
<i>Trifolium hybridum</i>	Fabaceae	Perennial	Introduced	Colonizing
<i>Urtica dioica</i>	Urticaceae	Perennial	Native	Economic
<i>Hackelia micronatha</i>	Boraginaceae	Perennial	Native	Non-weedy
<i>Antennaria luzuloides</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Cynoglossum officinale</i>	Boraginaceae	Biennial	Introduced	
<i>Microsteris gracilis</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Lepidium virginicum</i>	Brassicaceae	Annual	Introduced	Economic
<i>Cirsium arvense</i>	Asteraceae	Perennial	Introduced	Noxious
<i>Lappula redowskii</i>	Boraginaceae	Annual	Native	Colonizing
<i>Sonchus</i> sp.	Asteraceae	Annual	Introduced	Exotic
<i>Aster ascendens</i>	Asteraceae	Perennial	Native	
<i>Bromus inermis</i>	Poaceae	Perennial	Introduced	Non-weedy
<i>Poa pretensis/compressa</i>	Poaceae	Perennial	Introduced	Colonizing
<i>Dactylis glomerta</i>	Poaceae	Perennial	Introduced	Colonizing
<i>Phleum prantense</i>	Poaceae	Perennial	Introduced	Colonizing
<i>Elymus lanceolatus</i>	Poaceae	Perennial	Native	Non-weedy
<i>Agrostis stolonifera</i>	Poaceae	Perennial	Introduced	Non-weedy
<i>Juncus balticus</i>	Juncaceae	Perennial	Native	Non-weedy
<i>Elymus glaucus</i>	Poaceae	Perennial	Native	Non-weedy

Circle H Control				
Species Name	Family	Annual/ Perennial	Introduced/Native	Weedy/Non-weedy
Polygonum douglasii	Polygonaceae	Annual	Introduced	Non-weedy
Collomia linearis	Polemoniaceae	Annual	Native	Non-weedy
Galium bifolium	Onagraceae	Annual	Native	Non-weedy
Gayophytum diffusum	Onagraceae	Annual	Native	Non-weedy
Epilobium sp.	Onagraceae		Native	Non-weedy
Nemophila parviflora	Hydrophyllaceae	Annual	Native	Non-weedy
Erigonum umbellatum	Polygonaceae	Perennial	Native	Non-weedy
Rumex acetosella	Polygonaceae	Perennial	Introduced	Economic
Aster integrifolius	Asteraceae	Perennial	Native	Non-weedy
Mahonia repens	Berberidaceae	Perennial	Native	Non-weedy
Artemisa tridentata	Asteraceae	Perennial	Native	Non-weedy
Erigeron speciosa/glabrous	Asteraceae	Perennial	Native	
Taraxacum officinales	Asteraceae	Annual	Introduced	Economic
Amelanchier alnifolia	Rosaceae	Perennial	Native	Non-weedy
Eriophyllum lanatum	Asteraceae	Perennial	Native	Non-weedy
Artemisa tripartita	Asteraceae	Perennial	Native	Non-weedy
Lithophragma parviflorum	Saxifragaceae	Perennial	Native	Non-weedy
Viola vallicola	Violaceae	Perennial	Native	Non-weedy
Senecio streptanthifolius	Asteraceae	Perennial	Native	Non-weedy
Lupinus sericeus	Fabaceae	Perennial	Native	Non-weedy
Potentilla gracilis	Rosaceae	Perennial	Native	Non-weedy
Phlox longifolia	Polemoniaceae	Perennial	Native	Non-weedy
Achillea millefolium	Asteraceae	Perennial	Native	Colonizing
Delphinium sp.	Ranunculaceae	Perennial	Native	Economic
Aster ascendens	Asteraceae	Perennial	Native	
Geranium viscosissimum	Geraniaceae	Perennial	Native	Colonizing
Androsace septentrionalis	Primulaceae	Annual	Native	Non-weedy
Trifolium hybridum	Fabaceae	Perennial	Introduced	Colonizing
Linaria vulgaris	Scrophulariaceae	Perennial	Introduced	Noxious
Potentilla glandulosa	Rosaceae	Perennial	Native	Non-weedy
Symphoricarpos oreophilus	Caprifoliaceae	Perennial	Native	Non-weedy
Descurainia californica	Brassicaceae	Annual	Native	Non-weedy
Cirsium arvense	Asteraceae	Perennial	Introduced	Noxious
Agastache urticifolia	Laminaceae	Perennial	Native	Non-weedy
Aster sp.	Asteraceae	Perennial		
Lappula redowskii	Boraginaceae	Annual	Native	Colonizing
Wyethia amplexicaulis	Asteraceae	Perennial	Native	Economic
Castilleja sp	Scrophulariaceae	Perennial	Native	Non-weedy
Elymus trachycaulus	Poaceae	Perennial	Native	Non-weedy
Poa pretensis/compressa	Poaceae	Perennial	Introduced	Colonizing
Phleum pratense	Poaceae	Perennial	Introduced	Colonizing
Carex hoodii	Cyperaceae	Perennial	Native	Non-weedy
Elymus lanceolatus	Poaceae	Perennial	Native	Non-weedy

Circle H Corral				
Species Name	Family	Annual/ Perennial	Introduced/Native	Weedy/Non-weedy
Polygonum douglasii	Polygonaceae	Annual	Introduced	Non-weedy
Thlaspi arvense	Brassicaceae	Annual	Introduced	Noxious
Linanthus septentrionalis	Polemoniaceae	Annual	Native	Non-weedy
Gayophytum diffusum	Onagraceae	Annual	Native	Non-weedy
Epiolbium brachycarpum	Onagraceae	Annual	Native	Non-weedy
Lomatium ambigum	Apiaceae	Perennial	Native	Colonizing
Taraxacum leavigatum	Asteraceae	Annual	Introduced	Economic
Tragopogon dubius	Asteraceae	Biennial	Introduced	Economic
Lupinus sericeus	Fabaceae	Perennial	Native	Non-weedy
Arabis glabra	Brassicaceae	Biennial	Native	Non-weedy
Potentilla gracilis	Rosaceae	Perennial	Native	Non-weedy
Achillea millefolium	Asteraceae	Perennial	Native	Colonizing
Carduus nutans	Asteraceae	Biennial	Introduced	Noxious
Aster ascendens	Asteraceae	Perennial	Native	
Geranium viscosissimum	Geraniaceae	Perennial	Native	Colonizing
Androsace septentrionalis	Primulaceae	Annual	Native	Non-weedy
Trifolium hybridum	Fabaceae	Perennial	Introduced	Colonizing
Maiathemum stellatum	Liliaceae	Perennial	Native	Non-weedy
Ranunculus macounii	Ranunculaceae	Perennial	Native	Non-weedy
Fragaria vesca	Rosaceae	Perennial	Native	Non-weedy
Linaria vulgaris	Scrophulariaceae	Perennial	Introduced	Noxious
Carduus nutans	Asteraceae	Biennial	Introduced	Noxious
Urtica dioica	Urticaceae	Perennial	Native	Economic
Solidago canadensis	Asteraceae	Perennial	Native	Non-weedy
Cirsium scariosum	Asteraceae	Perennial	Native	Non-weedy
Bromus inermis	Poaceae	Perennial	Introduced	Non-weedy
Poa pretensis/compressa	Poaceae	Perennial	Introduced	Colonizing
Dactylis glomerata	Poaceae	Perennial	Introduced	Colonizing
Phleum pratense	Poaceae	Perennial	Introduced	Colonizing
Carex hoodii	Cyperaceae	Perennial	Native	Non-weedy

Bar BC Control				
Species Name	Family	Annual/ Perennial	Introduced/Native	Weedy/Non-weedy
<i>Polygonum douglasii</i>	Polygonaceae	Annual	Introduced	Non-weedy
<i>Colomia linearis</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Galium bifolium</i>	Onagraceae	Annual	Native	Non-weedy
<i>Linanthus septentrionalis</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Epilobium brachycarpum</i>	Onagraceae	Annual	Native	Non-weedy
<i>Nemophila parviflora</i>	Hydrophyllaceae	Annual	Native	Non-weedy
<i>Erigonum umbellatum</i>	Polygonaceae	Perennial	Native	Non-weedy
<i>Colinsia parafflora</i>	Scrophulariaceae	Annual	Native	Non-weedy
<i>Aster integrifolius</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Microseris nutans</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Artemisa tridentata</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Taraxacum officinales</i>	Asteraceae	Annual	Introduced	Economic
<i>Tragopogon dubious</i>	Asteraceae	Biennial	Introduced	Economic
<i>Lithophragma parviflorum</i>	Saxifragaceae	Perennial	Native	Non-weedy
<i>Perdideridia montana</i>	Apiaceae	Perennial	Native	Non-weedy
<i>Viola vallicola</i>	Violaceae	Perennial	Native	Non-weedy
<i>Lupinus sericeus</i>	Fabaceae	Perennial	Native	Non-weedy
<i>Arenaria congesta</i>	Caryophyllaceae	Perennial	Native	Non-weedy
<i>Agoseris glauca</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Delphinium sp.</i>	Ranunculaceae	Perennial	Native	Economic
<i>Linaria vulgaris</i>	Scrophulariaceae	Perennial	Introduced	Noxious
<i>Lepidium virginicum</i>	Brassicaceae	Annual	Introduced	Economic
<i>Linum lewisii</i>	Linaceae	Perennial	Native	Non-weedy
<i>Arabis drummondii</i>	Brassicaceae	Biennial	Native	Non-weedy
<i>Salix drummondiana</i>	Salicaceae	Perennial	Native	Non-weedy
<i>Sonchus sp.</i>	Asteraceae	Annual	Introduced	Exotic
<i>Poa pretensis/compressa</i>	Poaceae	Perennial	Introduced	Colonizing
<i>Melica spectabilis</i>	Poaceae	Perennial	Introduced	Non-weedy
<i>Carex hoodii</i>	Cyperaceae	Perennial	Native	Non-weedy
<i>Koleria macrantha</i>	Poaceae	Perennial	Native	Non-weedy

Bar BC Corral				
Species Name	Family	Annual/ Perennial	Introduced/Native	Weedy/Non-weedy
Polygonum douglasii	Polygonaceae	Annual	Introduced	Non-weedy
Cryptantha sp.	Boraginaceae		Native	Non-weedy
Linanthus septentrionalis	Polemoniaceae	Annual	Native	Non-weedy
Gayophytum diffusum	Onagraceae	Annual	Native	Non-weedy
Epilobium sp.	Onagraceae		Native	Non-weedy
Draba albertina	Brassicaceae	Annual	Native	Non-weedy
Artemisa tridentata	Asteraceae	Perennial	Native	Non-weedy
Artemisa tripartita	Asteraceae	Perennial	Native	Non-weedy
Machaeranthera canescens	Asteraceae	Perennial	Native	
Achillea millefolium	Asteraceae	Perennial	Native	Colonizing
Hackelia micronatha	Boraginaceae	Perennial	Native	Non-weedy
Antennaria luzuloides	Asteraceae	Perennial	Native	Non-weedy
Lepidum virginicum	Brassicaceae	Annual	Introduced	Economic
Lappula redowskii	Boraginaceae	Annual	Native	Colonizing
Erigeron sp.	Asteraceae	Annual	Native	
Rumex salicifolius	Polygonaceae	Perennial	Native	Non-weedy
Potentilla argentea	Rosaceae	Perennial	Native	Colonizing
Bromus inermis	Poaceae	Perennial	Introduced	Non-weedy
Poa pretensis/compressa	Poaceae	Perennial	Introduced	Colonizing

White Grass Control				
Species Name	Family	Annual/ Perennial	Introduced/Native	Weedy/Non-weedy
Polygonum douglasii	Polygonaceae	Annual	Introduced	Non-weedy
Collomia linearis	Polemoniaceae	Annual	Native	Non-weedy
Galium bifolium	Onagraceae	Annual	Native	Non-weedy
Linanthus septentrionalis	Polemoniaceae	Annual	Native	Non-weedy
Gayophytum diffusum	Onagraceae	Annual	Native	Non-weedy
Nemophila parviflora	Hydrophyllaceae	Annual	Native	Non-weedy
Erigonum umbellatum	Polygonaceae	Perennial	Native	Non-weedy
Colinsia paraflorea	Scrophulariaceae	Annual	Native	Non-weedy
Lomatium ambiguum	Apiaceae	Perennial	Native	Colonizing
Rumex acetosella	Polygonaceae	Perennial	Introduced	Economic
Aster integrifolius	Asteraceae	Perennial	Native	Non-weedy
Mahonia repens	Berberidaceae	Perennial	Native	
Artemisa tridentata	Asteraceae	Perennial	Native	Non-weedy
Erigeron speciosa/glaberous	Asteraceae	Perennial	Native	
Taraxacum officinales	Asteraceae	Annual	Introduced	Economic
Violeta praemorsa	Violaceae	Perennial	Native	Non-weedy
Dracocephalum parviflorum	Lamiaceae	Annual	Native	
Eriophyllum lanatum	Asteraceae	Perennial	Native	Non-weedy
Artemisa tripartita	Asteraceae	Perennial	Native	Non-weedy
Ipomopsis aggregata	Polemoniaceae	Biennial	Native	Non-weedy
Lithophragma parviflorum	Saxifragaceae	Perennial	Native	Non-weedy
Viola vallicola	Violaceae	Perennial	Native	Non-weedy
Senecio streptanthifolius	Asteraceae	Perennial	Native	Non-weedy
Lupinus sericeus	Fabaceae	Perennial	Native	Non-weedy
Agoseris glauca	Asteraceae	Perennial	Native	Non-weedy
Achillea millefolium	Asteraceae	Perennial	Native	Colonizing
Delphinium sp.	Ranunculaceae	Perennial	Native	Economic
Geranium viscosissimum	Geraniaceae	Perennial	Native	Colonizing
Fragaria vesca	Rosaceae	Perennial	Native	
Linaria vulgaris	Scrophulariaceae	Perennial	Introduced	Noxious
Antennaria luzuloides	Asteraceae	Perennial	Native	Non-weedy
Symphoricarpos oreophilus	Caprifoliaceae	Perennial	Native	Non-weedy
Spergularia rubra	Caryophyllaceae	Annual	Introduced	Non-weedy
Microsteris gracilis	Polemoniaceae	Annual	Native	Non-weedy
Lepidium virginicum	Brassicaceae	Annual	Introduced	Economic
Stellaria longipes	Carophyllaceae	Perennial	Native	Noxious??
Helianthella uniflora/quinquenervis	Asteraceae	Perennial	Native	
Sedum lanceolatum	Crassulaceae	Perennial	Native	Non-weedy
Arabis holboellii	Brassicaceae	Biennial	Native	Non-Weedy
Balsamorhiza sagittata	Asteraceae	Perennial	Native	Non-weedy
Microseris nutans	Asteraceae	Perennial	Native	Non-weedy
Bromus inermis	Poaceae	Perennial	Introduced	Non-weedy
Poa pretensis/compressa	Poaceae	Perennial	Introduced	Colonizing
Elymus trachycaulus	Poaceae	Perennial	Native	Non-weedy
Koeleria macrantha	Poaceae	Perennial	Native	Non-weedy
Carex geyeri	Cyperaceae	Perennial	Native	Non-weedy
Bromus carinatus	Poaceae	Perennial		Colonizing

White Grass Corral				
Species Name	Family	Annual/ Perennial	Introduced/Native	Weedy/Non-weedy
<i>Polygonium douglasii</i>	Polygonaceae	Annual	Introduced	Non-weedy
<i>Collomia linearis</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Cryptantha</i> sp.	Boraginaceae		Native	Non-weedy
<i>Thlaspi arvense</i>	Brassicaceae	Annual	Introduced	Noxious
<i>Galium bifolium</i>	Onagraceae	Annual	Native	Non-weedy
<i>Gayophytum diffusum</i>	Onagraceae	Annual	Native	Non-weedy
<i>Epilobium</i> sp.	Onagraceae		Native	Non-weedy
<i>Nemophila parviflora</i>	Hydrophyllaceae	Annual	Native	Non-weedy
<i>Erigonum umbellatum</i>	Polygonaceae	Perennial	Native	Non-weedy
<i>Capsella bursa-pastoris</i>	Brassicaceae	Annual	Introduced	Economic
<i>Lomatium ambiguum</i>	Apiaceae	Perennial	Native	Colonizing
<i>Rumex acetosella</i>	Polygonaceae	Perennial	Introduced	Economic
<i>Taraxacum officinale</i>	Asteraceae	Annual	Introduced	Economic
<i>Violeta praemorsa</i>	Violaceae	Perennial	Native	Non-weedy
<i>Tragopogon dubius</i>	Asteraceae	Biennial	Introduced	Economic
<i>Perideridia montana</i>	Apiaceae	Perennial	Native	Non-weedy
<i>Arenaria congesta</i>	Caryophyllaceae	Perennial	Native	Non-weedy
<i>Agoseris glauca</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Achillea millefolium</i>	Asteraceae	Perennial	Native	Colonizing
<i>Delphinium</i> sp.	Ranunculaceae	Perennial	Native	Economic
<i>Carduus nutans</i>	Asteraceae	Biennial	Introduced	Noxious
<i>Trifolium hybridum</i>	Fabaceae	Perennial	Introduced	Colonizing
<i>Spergularia rubra</i>	Caryophyllaceae	Annual	Introduced	Non-weedy
<i>Lepidium virginicum</i>	Brassicaceae	Annual	Introduced	Economic
<i>Lappula redowskii</i>	Boraginaceae	Annual	Native	Colonizing
<i>Veronica species</i>	Scrophulariaceae	Perennial	Native	Non-weedy
<i>Madia glomerata</i>	Asteraceae	Annual		
<i>Polygonium aviculare</i>	Polygonaceae	Annual	Introduced	Economic
<i>Matricaria matricarioides</i>	Asteraceae	Annual	Native	Non-weedy
<i>Chenopodium</i> sp.	Chenopodiaceae	Annual	Native	
<i>Rumex salicifolius</i>	Polygonaceae		Native	Non-weedy
<i>Lithospermum rudevale</i>	Boraginaceae	Perennial	Native	Non-weedy
<i>Bromus inermis</i>	Poaceae	Perennial	Introduced	Non-weedy
<i>Elymus trachycaulus</i>	Poaceae	Perennial	Native	Non-weedy
<i>Poa pretensis/compressa</i>	Poaceae	Perennial	Introduced	Colonizing
<i>Bromus tectorum</i>	Poaceae	Annual	Introduced	Economic
<i>Phleum pratense</i>	Poaceae	Perennial	Introduced	Colonizing
<i>Poa bulbosa</i>	Poaceae	Perennial	Introduced	Non-weedy
<i>Koeleria macrantha</i>	Poaceae	Perennial	Native	Non-weedy
<i>Elymus lanceolatus</i>	Poaceae	Perennial	Native	Non-weedy

Rudd Control				
Species Name	Family	Annual/ Perennial	Introduced/Native	Weedy/Non-weedy
<i>Polygonum douglasii</i>	Polygonaceae	Annual	Introduced	Non-weedy
<i>Collomia linearis</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Galium bifolium</i>	Onagraceae	Annual	Native	Non-weedy
<i>Linanthus septentrionalis</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Gayophytum diffusum</i>	Onagraceae	Annual	Native	Non-weedy
<i>Nemophila parviflora</i>	Hydrophyllaceae	Annual	Native	Non-weedy
<i>Erigonum umbellatum</i>	Polygonaceae	Perennial	Native	Non-weedy
<i>Capsella bursa-pastoris</i>	Brassicaceae	Annual	Introduced	Economic
<i>Aster integrifolius</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Artemisa tridentata</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Taraxacum leavigatum</i>	Asteraceae	Annual	Introduced	Economic
<i>Violeta praemorsa</i>	Violaceae	Perennial	Native	Non-weedy
<i>Eriophyllum lanatum</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Artemisa tripartita</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Perdideridia montana</i>	Apiaceae	Perennial	Native	Non-weedy
<i>Lupinus sericeus</i>	Fabaceae	Perennial	Native	Non-weedy
<i>Arenaria congesta</i>	Caryophyllaceae	Perennial	Native	Non-weedy
<i>Agoseris glauca</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Achillea millefolium</i>	Asteraceae	Perennial	Native	Colonizing
<i>Delphinium</i> sp.	Ranunculaceae	Perennial	Native	Economic
<i>Spergularia rubra</i>	Caryophyllaceae	Annual	Introduced	Non-weedy
<i>Microsteris gracilis</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Sedum lanceolatum</i>	Crassulaceae	Perennial	Native	Non-weedy
<i>Arabis holboellii</i>	Brassicaceae	Biennial	Native	Non-weedy
<i>Salix</i>	Salicaceae	Perennial	Native	
<i>Fritillaria Pudica</i>	Liliaceae	Perennial	Native	Non-weedy
<i>Castilleja</i> sp	Scrophulariaceae	Perennial	Native	Non-weedy
<i>Myosotis scorpioides</i>	Boraginaceae	Perennial	Native	Non-weedy
<i>Poa pretensis/compressa</i>	Poaceae	Perennial	Introduced	Colonizing
<i>Stipa nelsonii</i>	Poaceae	Perennial	Native	Non-weedy
<i>Melica spectabilis</i>	Poaceae	Perennial	Introduced	Non-weedy
<i>Festuca idahodensis</i>	Poaceae	Perennial	Native	Non-weedy
<i>Bromus carinatus</i>	Poaceae	Biennial	Native	Colonizing

Rudd Corral				
Species Name	Family	Annual/ Perennial	Introduced/Native	Weedy/Non-weedy
<i>Polygonum douglasii</i>	Polygonaceae	Annual	Introduced	Non-weedy
<i>Collomia linearis</i>	Polemoniaceae	Annual	Native	Non-Weedy
<i>Cryptantha</i> sp.	Boraginaceae		Native	Non-weedy
<i>Galium bifolium</i>	Onagraceae	Annual	Native	Non-Weedy
<i>Linanthus septentrionalis</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Gayophytum diffusum</i>	Onagraceae	Annual	Native	Non-weedy
<i>Epilobium</i> sp.	Onagraceae		Native	Non-weedy
<i>Nemophila parviflora</i>	Hydrophyllaceae	Annual	Native	Non-weedy
<i>Aster integrifolius</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Capsella bursa-pastoris</i>	Brassicaceae	Annual	Introduced	Economic
<i>Colinsia paraflorea</i>	Scrophulariaceae	Annual	Native	Non-weedy
<i>Veronica biloba</i>	Scrophulariaceae	Annual	Introduced	Colonizing
<i>Taraxacum officinale</i>	Asteraceae	Annual	Introduced	Economic
<i>Artemisa tripartita</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Ipomopsis aggregata</i>	Polemoniaceae	Biennial	Native	Non-weedy
<i>Viola vallicola</i>	Violaceae	Perennial	Native	Non-weedy
<i>Agoseris glauca</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Achillea millefolium</i>	Asteraceae	Perennial	Native	Colonizing
<i>Antennaria luzloides</i>	Asteraceae	Perennial	Native	Non-weedy
<i>Spergularia rubra</i>	Caryophyllaceae	Annual	Introduced	Non-weedy
<i>Cynoglossum officinale</i>	Boraginaceae	Biennial	Introduced	Noxious
<i>Microsteris gracilis</i>	Polemoniaceae	Annual	Native	Non-weedy
<i>Lepidum virginicum</i>	Brassicaceae	Annual	Introduced	Economic
<i>Descurainia californica</i>	Brassicaceae	Annual	Native	Non-weedy
<i>Bromus inermis</i>	Smooth Brome	Perennial	Introduced	Non-weedy
<i>Elymus trachycaulus</i>	Slender Wheatgrass	Perennial	Native	Non-weedy
<i>Poa pretensis/compressa</i>	Kentucky/Canada Bluegrass	Perennial	Introduced	Colonizing
<i>Phleum prantense</i>	Timothy	Perennial	Introduced	Colonizing
<i>Poa bulbosa</i>	Bulbous bluegrass	Perennial	Introduced	Non-weedy
<i>Koleria macrantha</i>	Junegrass	Perennial	Native	Non-weedy
<i>Elymus lanceolatus</i>	Thickspike wheatgrass	Perennial	Native	Non-weedy

APPENDIX D

Grouped Forb Raw Data

Name	Site Type		Yrs of rest	Veronica species	Polygonum aviculare	Matricaria matracorioides	Aster integrifolius	Hackelia micrantha	Madia glomerata
Annual/Perennial				Perennial	Annual	Annual	Annual	Perennial	Annual
Native/introduced				Native	Introduced	Native	Native	Native	Native
Weedy/Non-weedy				Non-weedy	Economic	Non-weedy	Non-weedy	Non-weedy	
Found in Disturbance						Disturbed			Disturbed
Rudd	control	subtot		0	0	0	0	0	0
Whitegrass	control	subtot		0	0	0	0	0	0
Bar BC	control	subtot		0	0	0	0	0	0
Circle H	control	subtot		0	0	0	0	0	0
R Lazy S	control	subtot		0	0	0	0	0	0
Halfmoon	control	subtot		0	0	0	0	0	0
Square G	control	subtot		0	0	0	0	0	0
Murie	control	subtot		0	0	0	0	0	0
	CONTROL	TOTAL		0	0	0	0	0	0
Rudds	corral	subtot	4	0	0	0	24	0	0
Whitegrass	corral	subtot	12	174	735	13	0	0	13
Bar BC	corral	subtot	17	0	0	0	0	5	16
Halfmoon	corral	subtot	19	0	0	0	3	0	0
R Lazy S	corral	subtot	26	0	0	0	0	2	0
Circle H	corral	subtot	30	0	0	0	0	0	0
Square G	corral	subtot	47	0	0	0	0	0	0
Murie	Corral	subtot	56	0	0	0	0	0	0
	CORRAL	TOTAL		174	735	13	27	7	29
				0 in 1			0 in 2		
				Adventurers					

<i>Rumex salicifolius</i>	<i>Draba albertina</i>	<i>Cynoglossum officinale</i>	<i>Chenopodium species</i>	<i>Hydrophyllum capitatum</i>	<i>Senecio serra</i>	<i>Sonchus oleraceus</i>	<i>Urtica dioica</i>	<i>Trifolium hybridum</i>
Perennial	Annual	Biennial	Annual	Perennial	Perennial	Annual	Perennial	Perennial
Native	Native	Introduced	Native	Native	Native	Introduced	Native	Introduced
Non-weedy	Non-weedy	Noxious		Non-weedy	Non-weedy	Economic	Economic	Colonizing
Disturbed		Disturbed	Disturbed			Disturbed		Disturbed
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0	6
0	0	0	0	0	2	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0
0	0	0	0	1	0	0	0	0
0	0	0	1	1	2	1	0	6
0	0	25	0	0	0	0	0	0
5	0	0	14	0	0	0	0	75
5	10	0	0	0	0	0	0	0
0	25	0	0	3	33	0	0	0
0	0	5	0	0	0	10	12	110
0	0	0	0	0	0	0	2	56
0	0	0	18	0	0	0	0	0
0	0	0	0	3	2	4	12	0
10	35	30	32	8	35	14	26	241
				1 in 2			0 in 3	1 in 3
							Colonizers	

<i>Lappula redowskii</i>	<i>Carduus nutans</i>	<i>Capsella bursa-pastoris</i>	<i>Lepidium virginicum</i>	<i>Thlaspi arvense</i>	<i>Cryptantha affinis</i>	<i>Antennaria luzuloides</i>	<i>Artemisia arbuscula</i>	<i>Rumex acetosella</i>
Annual	Biennial	Annual	Annual	Annual	Annual	Perennial	Perennial	Perennial
Native	Introduced	Introduced	Introduced	Introduced	Native	Native	Native	Introduced
Colonizing	Noxious	Economic	Economic	Noxious	Non-weedy	Non-weedy	Non-weedy	Economic
Disturbed	Disturbed	Disturbed	Disturbed	Disturbed	Disturbed			Disturbed
0	0	1	0	0	0	0	16	0
0	0	0	4	0	0	597	16	2
0	0	0	1	0	0	0	0	0
1	0	0	0	0	0	0	19	2
0	0	0	0	0	0	0	0	5
0	0	0	0	10	93	0	8	56
0	0	0	0	0	0	36	0	0
0	0	0	0	0	25	66	0	0
1	0	1	5	10	118	699	59	65
0	0	8	13	0	150	76	6	0
59	170	53	25	64	1326	0	1	77
143	0	0	42	0	5	1	1	0
0	0	16	0	27	101	0	2	120
18	44	0	9	138	4	2	0	0
0	80	0	0	20	0	0	0	155
0	0	0	0	0	0	21	0	0
0	21	14	0	423	700	0	0	3
220	315	91	89	672	2286	100	10	356
	0 in 4		2 in 4	2 in 5	2 in 6	3 in 4	4 in 4	4 in 3
							Ubiquitous	

<i>Achillea millefolium</i>	<i>Epilobium brachycarpum</i>	<i>Linanthus septentrionalis</i>	<i>Gayophytum diffusum</i>	<i>Polygonum douglasii</i>	<i>Taraxacum levigatum</i>	<i>Collomia linearis</i>	<i>Gallium bifolium</i>
Perennial	Annual	Annual	Annual	Annual	Annual	Annual	Annual
Native	Native	Native	Native	Introduced	Introduced	Native	Native
Colonizing	Non-weedy	Non-weedy	Non-weedy	Non-weedy	Economic	Non-weedy	Non-weedy
Disturbed				Disturbed	Disturbed		
1	0	110	61	703	1	227	607
3	0	162	94	1245	14	200	318
0	4	72	0	71	15	62	9
95	11	0	2	17	22	11	5
0	7	0	0	4	3	3	3
4	2	107	311	774	3	243	517
0	0	286	17	781	18	252	147
0	0	438	202	757	16	166	29
103	24	1175	687	4352	92	1184	1635
7	5	6362	75	1372	12	13	32
15	2	0	1227	3462	24	148	25
31	10	3727	36	321	0	0	0
0	16	11	62	769	9	298	331
2	4	82	11	93	15	1	6
37	67	47	13	6	48	0	0
5	0	816	38	424	10	284	87
0	66	459	212	974	24	143	218
97	170	11504	1674	7421	142	887	699
4 in 6	4 in 7	6 in 7	6 in 8	8 in 8	8 in 7	8 in 6	

<i>Erigonum umbellatum</i>	<i>Viola vallicola</i>	<i>Nemophila breviflora</i>	<i>Agoseris glauca</i>	<i>Artemisia tridentata</i>	<i>Delphinium species</i>	<i>Lupinus sericeus</i>	<i>Aster integrifolius</i>	<i>Erigeron speciosa</i>
Perennial	Perennial	Annual	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial
Native	Native	Native	Native	Native	Native	Native	Native	Native
Non-weedy	Non-weedy	Non-weedy	Non-weedy	Non-weedy	Economic	Non-weedy	Non-weedy	Non-weedy
58	1	122	2	18	8	142	0	0
48	94	184	124	6	5	10	12	7
64	12	11	129	25	8	9	3	0
39	14	2	0	28	8	3	29	5
21	0	0	0	17	0	5	0	0
30	6	41	4	24	1	4	68	5
68	18	0	0	36	6	0	18	3
32	5	189	28	23	12	2	2	40
358	150	549	287	177	48	175	132	60
0	33	7	2	0	0	0	3	0
3	4	35	2	0	8	0	0	0
0	0	0	0	40	0	0	0	0
13	1	161	0	4	0	0	3	3
1	8	0	0	0	0	0	0	18
0	0	0	0	0	0	5	0	0
29	16	0	13	9	0	3	0	27
0	14	376	2	0	2	0	0	0
48	76	579	19	53	10	8	6	48
8 in 4	7 in 6		5 in 4	8 in 3	7/2		Presence 5 or 6 controls. 3 or less controls	
			Undisturbed					

<i>Lithophragma parviflorum</i>	<i>Collinsia parviflora</i>	<i>Microsteris gracilis</i>	<i>Tragopogon dubious</i>	<i>Perideridia montana</i>	<i>Mahonia repens</i>	<i>Eriophyllum lanatum</i>	<i>Linaria vulgaris</i>
Perennial	Annual	Annual	Biennial	Perennial	Perennial	Perennial	Perennial
Native	Native	Native	Introduced	Native	Native	Native	Introduced
Non-weedy	Non-weedy	Non-weedy	Economic Disturbed	Non-weedy	Non-weedy	Non-weedy Disturbed	Noxious Disturbed
0	0	238	0	5	0	11	0
3	32	46	0	0	19	21	36
2	3	0	0	12	0	0	2
2	0	0	4	0	65	6	448
0	0	0	0	0	39	0	0
11	305	5	15	30	0	16	0
0	0	65	1	60	0	0	0
7	8	0	1	0	85	0	2
25	348	354	21	107	208	54	488
0	23	25	0	0	0	0	0
0	0	0	1	3	0	0	0
0	0	0	0	0	0	0	0
2	177	0	0	0	27	0	0
0	0	3	0	0	0	0	0
0	0	0	3	0	0	0	20
26	0	109	0	71	0	0	0
0	3	0	7	0	0	0	0
28	203	137	11	74	27	0	20
					4 control, 2 or less coral		

<i>Areneria congesta</i>	<i>Arabis holboellii</i>	<i>Amelanchier alnifolia</i>	<i>Fritilaria pudica</i>	<i>Sedum lanceolatum</i>	<i>Senecio streptanthifolius</i>
Perennial	Biennial	Perennial	Perennial	Perennial	Perennial
Native	Native	Native	Native	Native	Native
Non-weedy	Non-weedy	Non-weedy	Non-weedy	Non-weedy	Non-weedy
1	5	0	9	20	0
0	2	2	0	105	40
4	0	0	0	0	0
0	0	10	0	0	33
0	0	10	0	0	0
13	0	0	0	0	5
0	3	0	2	1	0
0	0	0	2	0	0
18	10	22	13	126	78
0	0	0	0	0	0
1	0	0	0	0	0
0	0	0	0	0	0
0	0	1	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	2	0	0	0	0
0	0	0	0	0	0
1	2	1	0	0	0
3 and 1			3 and 0		

APPENDIX E

Percent Cover Values Summary, and by Quadrat for Each Corral and Control

Average Percent Cover								
	Bareground	Rock	Litter	Grass	Sedge	Forb	Shrub	Sellaginella
Corrals								
Rudd Corral	29.50	11.88	13.95	12.78	0.00	32.20	0.38	0.00
Whitegrass Corral	31.33	5.30	6.73	22.35	0.00	34.00	0.00	0.00
Bar BC Corral	10.70	13.00	6.40	5.97	0.33	57.73	2.43	3.10
Circle H Corral	13.05	0.13	14.75	32.53	0.20	43.88	0.00	0.10
R Lazy S Corral	9.38	0.73	24.58	50.98	0.25	12.03	0.00	0.00
Halfmoon corral	9.68	40.50	14.38	10.55	0.38	24.60	2.05	5.75
Square G Corral	9.53	17.00	19.00	21.70	0.00	17.60	9.23	12.50
Murie Corral	28.70	4.13	24.05	17.48	0.00	28.63	0.13	0.00
Controls								
Rudd Control	18.55	11.93	9.93	7.05	0.00	40.38	21.58	0.18
Whitegrass Control	23.50	17.43	14.65	3.78	0.00	33.68	8.25	0.00
Bar BC Control	7.67	10.93	20.23	13.20	3.37	42.60	11.55	0.00
Circle H Control	8.63	3.46	13.90	10.28	2.23	37.63	33.90	0.00
R Lazy S Control	10.75	1.88	11.25	7.63	1.23	26.68	38.75	0.78
Halfmoon Control	22.70	14.55	14.05	6.58	0.00	33.80	17.95	0.23
Square G Control	15.00	19.53	10.97	4.43	0.87	33.83	15.73	0.43
Murie Control	26.88	0.75	13.05	17.63	1.98	38.93	7.45	0.00
Corral vs. Control by Site								
Rudd Corral	29.50	11.88	13.95	12.78	0.00	32.20	0.38	0.00
Rudd Control	18.55	11.93	9.93	7.05	0.00	40.38	21.58	0.18
Whitegrass Corral	31.33	5.30	6.73	22.35	0.00	34.00	0.00	0.00
Whitegrass Control	23.50	17.43	14.65	3.78	0.00	33.68	8.25	0.00
Bar BC Corral	10.70	13.00	6.40	5.97	0.33	57.73	2.43	3.10
Bar BC Control	7.67	10.93	20.23	13.20	3.37	42.60	11.55	0.00
Circle H Corral	13.05	0.13	14.75	32.53	0.20	43.88	0.00	0.10
Circle H Control	8.63	3.46	13.90	10.28	2.23	37.63	33.90	0.00
R Lazy S Corral	9.38	0.73	24.58	50.98	0.25	12.03	0.00	0.00
R Lazy S Control	10.75	1.88	11.25	7.63	1.23	26.68	38.75	0.78
Halfmoon Corral	9.68	40.50	14.38	10.55	0.38	24.60	2.05	5.75
Halfmoon Control	22.70	14.55	14.05	6.58	0.00	33.80	17.95	0.23
Square G Corral	9.53	17.00	19.00	21.70	0.00	17.60	9.23	12.50
Square G Control	15.00	19.53	10.97	4.43	0.87	33.83	15.73	0.43
Murie Corral	28.70	4.13	24.05	17.48	0.00	28.63	0.13	0.00
Murie Control	26.88	0.75	13.05	17.63	1.98	38.93	7.45	0.00

Murie Control	(%) Bareground	(%) Rock	(%) Litter	(%) Grass	(%) Sedge	(%) Forb	(%) Shrub
Transect							
1	0	0	10	20	5	70	0
2	40	0	0	5	0	40	25
3	0	0	15	40	0	40	5
4	60	0	1	5	2	35	2
5	80	0	3	5	0	15	0
6	20	0	5	5	0	70	0
7	15	0	30	5	0	25	25
8	10	0	40	30	0	25	15
9	75	0	3	30	0	15	0
10	40	0	10	35	1	35	5
11	25	0	10	5	0	70	0
12	20	0	5	5	0	35	65
13	55	0	5	30	0	15	5
14	10	0	5	25	0	70	7
15	70	20	0	25	0	12	1
16	30	0	10	5	0	60	0
17	15	0	5	7	0	35	5
18	25	0	20	45	0	15	15
19	65	0	5	5	0	40	0
20	25	0	20	35	0	20	0
21	40	0	10	7	0	35	0
22	35	0	15	3	0	60	0
23	10	10	20	25	0	25	15
24	50	0	10	5	0	45	5
25	10	0	10	60	0	30	0
26	50	0	5	1	0	45	0
27	10	0	30	10	0	35	0
28	50	0	10	40	5	5	5
29	5	0	10	15	0	70	0
30	0	0	45	20	0	40	0
31	25	0	5	2	0	65	0
32	20	0	10	50	10	25	7
33	0	0	0	0	0	0	0
34	5	0	15	30	40	15	1
35	0	0	10	10	0	85	0
36	30	0	20	15	1	35	0
37	0	0	35	10	0	65	15
38	0	0	15	25	0	60	40
39	0	0	40	0	0	50	35
40	55	0	5	10	15	25	0
AVERAGE	26.88	0.75	13.05	17.63	1.98	38.93	7.45

Murie Corral	(%) Bareground	(%) Rock	(%) Litter	(%) Grass	(%) Sedge	(%) Forb	(%) Shrub
Transect							
1	5	1	65	5	0	25	0
2	25	5	30	15	0	40	0
3	50	10	5	40	0	5	0
4	70	5	1	3	0	20	0
5	60	5	1	3	0	25	5
6	50	1	15	10	0	30	0
7	5	2	2	5	0	85	0
8	15	2	2	5	0	80	0
9	55	2	0	20	0	20	0
10	85	10	0	2	0	5	0
11	0	0	50	3	0	45	0
12	45	1	5	40	0	10	0
13	25	1	5	30	0	40	0
14	30	1	1	10	0	60	0
15	20	60	1	5	0	15	0
16	1	1	60	20	0	20	0
17	60	1	5	5	0	35	0
18	0	0	90	0	0	10	0
19	15	1	10	20	0	50	0
20	60	7	1	1	0	30	0
21	45	1	5	35	0	15	0
22	20	0	15	40	0	30	0
23	5	2	5	65	0	25	0
24	30	2	10	35	0	30	0
25	60	15	2	5	0	20	0
26	0	0	90	5	0	5	0
27	5	1	35	50	0	15	0
28	55	3	2	5	0	40	0
29	30	5	30	2	0	40	0
30	70	2	2	10	0	25	0
31	0	0	95	5	0	2	0
32	0	2	15	5	0	80	0
33	25	1	2	70	0	10	0
34	5	0	50	40	0	10	0
35	50	2	10	25	0	10	0
36	0	0	90	10	0	3	0
37	0	0	95	2	0	5	0
38	2	1	15	20	0	70	0
39	0	2	40	20	0	35	0
40	70	10	5	8	0	25	0
AVERAGE	28.70	4.13	24.05	17.48	0.00	28.63	0.13

Square G Control	(%) Bareground	(%) Rock	(%) Litter	(%) Grass	(%) Sedge	(%) Forb	(%) Shrub
Transect							
1	20	40	10	10	0	20	0
2	30	25	10	5	0	5	25
3	10	30	25	3	2	35	0
4	35	15	0	5	0	35	10
5	20	20	5	1	0	30	35
6	10	20	5	1	0	50	20
7	40	30	5	0	1	35	25
8	30	30	5	10	0	10	30
9	20	30	10	1	1	20	20
10	1	20	5	3	0	5	20
11	15	20	10	20	0	35	5
12	25	25	20	1	0	20	10
13	10	20	20	20	0	15	15
14	5	30	40	1	0	20	5
15	5	15	35	1	0	35	30
16	20	30	10	10	0	20	10
17	10	20	30	5	10	10	30
18	3	5	30	1	0	60	7
19	10	20	20	1	0	40	30
20	10	25	5	5	0	45	5
21	10	25	1	1	0	50	0
22	20	20	1	1	0	35	20
23	10	5	5	5	0	70	0
24	1	1	5	5	0	75	5
25	20	15	5	5	0	15	30
26	5	5	0	0	1	30	40
27	5	10	1	1	0	80	20
28	15	20	1	1	1	15	25
29	20	5	5	5	0	60	0
30	15	10	5	5	10	40	0
AVERAGE	15.00	19.53	10.97	4.43	0.87	33.83	15.73

Square G Corral	(%) Bareground	(%) Rock	(%) Litter	(%) Grass	(%) Sedge	(%) Forb	(%) Shrub
Transect							
1	30	20	10	10	0	25	25
2	10	40	5	25	0	10	0
3	0	30	10	15	0	15	0
4	5	10	10	45	0	20	0
5	10	20	15	45	0	1	0
6	5	10	20	15	0	25	75
7	2	55	10	20	0	5	0
8	1	10	40	30	0	5	0
9	3	10	25	35	0	7	10
10	5	10	15	60	0	5	0
11	5	15	30	10	0	20	25
12	0	25	20	15	0	25	0
13	5	20	40	15	0	10	7
14	5	20	30	15	0	15	10
15	10	10	20	35	0	5	0
16	5	15	10	30	0	20	0
17	15	25	10	20	0	15	0
18	10	20	25	15	0	25	0
19	10	10	45	25	0	10	0
20	10	15	25	35	0	10	0
21	0	10	40	10	0	40	30
22	5	25	10	10	0	15	10
23	5	10	5	15	0	25	0
24	10	10	20	30	0	30	0
25	20	25	10	20	0	15	0
26	5	10	35	10	0	25	5
27	5	15	10	5	0	15	40
28	5	5	10	1	0	25	40
29	35	5	10	10	0	40	0
30	50	5	5	25	0	25	0
AVERAGE	9.53	17.00	19.00	21.70	0.00	17.60	9.23

Halfmoon Control	(%) Bareground	(%) Rock	(%) Litter	(%) Grass	(%) Sedge	(%) Forb	(%) Shrub
Transect							
1	15	15	10	10	0	30	0
2	5	20	15	15	0	2	25
3	50	35	10	0	0	20	0
4	35	30	15	1	0	35	10
5	0	0	10	0	0	90	0
6	65	10	5	1	0	25	0
7	10	0	10	5	0	25	45
8	5	10	0	5	0	55	35
9	5	10	25	0	0	35	15
10	10	30	15	0	0	10	60
11	15	7	10	5	0	15	30
12	15	20	10	5	0	45	0
13	20	10	0	1	0	75	0
14	10	5	35	1	0	40	55
15	3	65	0	10	0	35	2
16	20	15	15	5	0	30	5
17	20	10	15	1	0	45	40
18	0	5	10	1	0	15	75
19	25	15	10	1	0	45	10
20	20	25	0	5	0	20	35
21	40	5	20	1	0	40	5
22	60	20	0	1	0	20	15
23	55	15	5	10	0	25	0
24	30	5	30	1	0	25	30
25	70	15	2	0	0	25	1
26	0	5	40	1	0	35	6
27	0	5	10	5	0	35	90
28	5	20	30	1	0	30	0
29	0	0	20	10	0	70	3
30	5	40	10	15	0	30	1
31	60	10	15	0	0	35	0
32	55	5	10	1	0	30	0
33	0	5	40	5	0	60	0
34	30	0	15	5	0	60	0
35	5	20	35	20	0	20	20
36	35	20	5	15	0	10	40
37	10	5	25	5	0	40	65
38	10	20	20	50	0	40	0
39	40	10	10	25	0	15	0
40	50	20	0	20	0	15	0
AVERAGE	22.70	14.55	14.05	6.58	0.00	33.80	17.95

Halfmoon Corral	(%) Bareground	(%) Rock	(%) Litter	(%) Grass	(%) Sedge	(%) Forb	(%) Shrub
Transect							
1	20	40	2	25	0	30	0
2	25	25	5	5	0	40	0
3	5	65	5	10	15	0	0
4	20	40	2	7	0	55	2
5	20	20	10	65	0	10	1
6	40	30	5	10	0	30	0
7	30	30	10	5	0	35	0
8	15	20	5	10	0	50	0
9	60	20	5	7	0	35	0
10	20	20	5	20	0	20	0
11	20	50	5	0	0	30	0
12	15	55	3	10	0	25	5
13	5	20	45	5	0	35	0
14	5	20	25	2	0	45	0
15	3	5	45	10	0	15	5
16	5	50	5	20	0	10	0
17	5	80	1	0	0	15	0
18	20	45	5	10	0	10	0
19	0	20	20	5	0	10	0
20	0	5	5	10	0	20	0
21	2	65	20	20	0	10	0
22	0	90	5	7	0	5	0
23	0	65	40	5	0	5	0
24	5	65	5	5	0	15	0
25	0	15	70	5	0	25	0
26	2	65	20	35	0	40	
27	0	20	60	10	0	15	0
28	0	40	20	1	0	25	55
29	0	85	5	5	0	15	0
30	5	45	5	5	0	15	0
31	0	30	5	5	0	50	0
32	5	90	0	1	0	7	0
33	0	85	0	2	0	2	
34	0	55	0	5	0	40	0
35	10	30	2	15	0	10	5
36	5	15	20	15	0	40	0
37	0	5	40	5	0	45	0
38	0	0	25	10	0	70	0
39	5	35	10	15	0	15	0
40	15	60	10	15	0	15	5
AVERAGE	9.68	40.50	14.38	10.55	0.38	24.60	2.05

R Lazy S Control	(%) Bareground	(%) Rock	(%) Litter	(%) Grass	(%) Sedge	(%) Forb	(%) Shrub
Transect							
1	5	0	10	5	0	25	45
2	10	0	5	20	0	20	35
3	5	0	15	15	0	35	40
4	0	0	5	5	0	35	35
5	5	5	15	15	0	45	5
6	15	5	0	5	0	20	60
7	10	0	10	5	0	30	40
8	15	0	5	5	0	40	35
9	15	5	10	5	5	20	40
10	20	0	15	5	0	20	35
11	5	5	15	15	10	25	20
12	15	0	20	10	0	35	25
13	0	0	5	5	0	45	45
14	5	5	5	5	0	30	40
15	10	0	10	5	1	25	50
16	5	0	15	20	0	40	30
17	5	0	10	20	0	20	40
18	10	5	5	5	0	50	15
19	5	0	10	5	10	2	65
20	5	10	5	10	0	25	45
21	10	5	30	10	0	20	30
22	15	5	10	5	0	35	25
23	0	10	10	10	0	20	45
24	5	5	20	5	0	25	35
25	10	0	5	10	1	25	55
26	5	0	20	5	5	20	40
27	10	0	15	5	15	10	35
28	5	0	10	10	0	35	40
29	30	0	20	0	0	20	35
30	20	0	35	5	0	15	30
31	10	0	15	5	0	45	25
32	15	5	0	0	0	30	65
33	20	0	5	0	0	15	50
34	25	0	10	5	2	10	50
35	20	0	15	10	0	25	30
36	30	0	0	5	0	20	40
37	5	0	0	10	0	25	55
38	10	0	5	10	0	40	40
39	5	5	15	5	0	20	50
40	15	0	20	5	0	25	30
AVERAGE	10.75	1.88	11.25	7.63	1.23	26.68	38.75

R Lazy S Corral	(%) Bareground	(%) Rock	(%) Litter	(%) Grass	(%) Sedge	(%) Forb	(%) Shrub
Transect							
1	70	0	0	20	0	10	0
2	25	0	5	75	0	0	0
3	35	1	4	20	0	15	0
4	40	0	15	25	0	20	0
5	5	0	30	60	0	10	0
6	20	0	10	60	0	5	0
7	20	0	20	55	0	1	0
8	20	0	30	50	0	1	0
9	5	0	40	50	0	5	0
10	5	0	35	45	0	5	0
11	10	0	50	35	0	50	0
12	10	0	20	60	0	1	0
13	10	0	40	50	0	1	0
14	0	0	20	70	10	1	0
15	0	0	0	95	0	0	0
16	0	0	55	40	0	5	0
17	0	0	40	50	0	10	0
18	0	0	25	45	0	25	0
19	0	0	95	5	0	1	0
20	0	0	80	15	0	5	0
21	0	0	20	80	0	0	0
22	0	0	20	80	0	0	0
23	0	0	20	80	0	0	0
24	5	5	15	85	0	0	0
25	0	0	35	65	0	0	0
26	0	0	10	80	0	5	0
27	0	0	5	20	0	30	0
28	0	0	15	80	0	5	0
29	0	10	15	65	0	5	0
30	0	0	5	70	0	25	0
31	10	2	5	33	0	50	0
32	40	2	0	10	0	40	0
33	0	0	10	85	0	5	0
34	0	0	5	90	0	5	0
35	10	0	2	75	0	10	0
36	0	0	2	1	0	80	0
37	5	5	50	25	0	10	0
38	5	2	50	35	0	10	0
39	10	1	55	20	0	10	0
40	15	1	30	35	0	20	0
AVERAGE	9.38	0.73	24.58	50.98	0.25	12.03	0.00

Circle H Control	(%) Bareground	(%) Rock	(%) Litter	(%) Grass	(%) Sedge	(%) Forb	(%) Shrub
Transect							
1	0	0	20	5	0	55	45
2	0	0	20	5	0	70	60
3	45	5	0	5	50	35	30
4	0	0	25	1	0	60	20
5	10	10	25	5	0	40	15
6	0	10	35	5	5	20	30
7	0	0	5	1	0	45	20
8	0	0	10	15	0	25	40
9	0	5	10	1	0	45	45
10	5	5	20	1	0	60	10
11	5	0	20	5	0	65	10
12	15	5	1	1	0	85	0
13	15	15	5	1	0	5	55
14	10	5	10	5	1	40	55
15	15	15	15	5	0	45	20
16	0	5	5	5	0	40	85
17	0	0	20	30	0	5	45
18	10	5	10	5	0	30	55
19	5	0	20	20	0	10	55
20	0	0	40	10	0	20	40
21	0	0	20	40	0	20	25
22	10	0	20	10	1	20	40
23	5	0	10	25	0	30	15
24	0	0	10	40	0	30	50
25	0	0	20	25	30	40	35
26	5	2	25	30	0	25	25
27	0	0	20	20	0	10	85
28	20	5	20	10	0	5	25
29	35	10	10	15	0	30	20
30	5	2	15	5	0	60	40
31	0	0	10	30	0	45	25
32	10	5	10	5	0	60	30
33	30	5	1	1	0	50	25
34	0	0	10	2	0	55	40
35	5	5	10	5	0	40	20
36	0	5	15	3	0	30	40
37	70	5	3	1	0	5	15
38	5	5	0	5	0	15	45
39	5	1	10	5	0	65	1
40	5	3	1	3	2	70	20
AVERAGE	8.63	3.45	13.90	10.28	2.23	37.63	33.90

Circle H Corral	(%) Bareground	(%) Rock	(%) Litter	(%) Grass	(%) Sedge	(%) Forb	(%) Shrub
Transect							
1	0	0	5	40	0	60	0
2	20	0	20	10	0	35	0
3	5	0	10	30	0	55	0
4	0	0	0	75	0	25	0
5	0	0	0	50	0	50	0
6	0	0	0	55	5	45	0
7	40	0	0	35	3	25	0
8	20	0	5	50	0	35	0
9	5	0	25	2	0	70	0
10	2	0	5	20	0	80	0
11	5	0	25	20	0	45	0
12	20	0	35	0	0	70	0
13	15	0	5	10	0	65	0
14	5	0	10	70	0	15	0
15	25	0	0	5	0	70	0
16	5	0	15	50	0	40	0
17	35	5	5	1	0	55	0
18	25	0	10	10	0	65	0
19	5	0	25	20	0	65	0
20	5	0	30	10	0	55	0
21	0	0	20	35	0	50	0
22	5	0	25	45	0	25	0
23	5	0	35	50	0	15	0
24	0	0	0	95	0	5	0
25	5	0	35	35	0	30	0
26	0	0	35	70	0	5	0
27	15	0	5	15	0	65	0
28	35	0	5	30	0	55	0
29	30	0	0	25	0	50	0
30	55	0	10	1	0	40	0
31	5	0	40	40	0	20	0
32	20	0	5	10	0	70	0
33	0	0	20	25	0	65	0
34	5	0	15	40	0	45	0
35	35	0	0	2	0	70	0
36	0	0	20	80	0	0	0
37	60	0	0	20	0	20	0
38	5	0	30	25	0	45	0
39	5	0	35	55	0	5	0
40	0	0	25	40	0	50	0
AVERAGE	13.05	0.13	14.75	32.53	0.20	43.88	0.00

Bar BC Control	(%) Bareground	(%) Rock	(%) Litter	(%) Grass	(%) Sedge	(%) Forb	(%) Shrub
Transect							
1	20	5	20	10	0	45	0
2	20	25	10	5	0	40	0
3	10	20	20	20	0	30	0
4	5	10	20	15	0	40	20
5	0	10	40	20	0	20	15
6	0	0	45	1	0	60	35
7	0	25	25	25	0	25	1
8	15	30	10	10	0	20	20
9	5	1	30	5	0	60	0
10	0	0	15	10	0	35	40
11	10	15	5	10	1	50	10
12	5	2	2	1	0	85	7
13	10	20	10	15	0	45	1
14	10	10	5	50	0	25	0
15	0	5	30	30	0	40	0
16	20	10	20	30	0	20	0
17	5	5	10	5	0	40	35
18	5	0	10	10	0	75	0
19	5	0	20	10	100	55	0
20	10	10	10	10	0	60	0
21	0	0	35	0	0	30	35
22	10	10	45	25	0	10	0
23	10	20	10	1	0	75	45
24	20	5	5	7	0	58	1
25	20	25	20	10	0	45	0
26	10	20	10	5	0	40	0
27	5	10	20	20	0	30	0
28	0	10	20	15	0	40	20
29	0	0	40	20	0	20	15
30	0	25	45	1	0	60	35
AVERAGE	7.67	10.93	20.23	13.20	3.37	42.60	11.17

Bar BC Corral	(%) Bareground	(%) Rock	(%) Litter	(%) Grass	(%) Sedge	(%) Forb	(%) Shrub
Transect							
1	20	20	5	15	0	30	0
2	10	35	5	5	0	40	0
3	10	10	5	1	0	75	0
4	10	5	20	1	0	65	0
5	15	20	1	5	0	60	0
6	10	40	5	1	0	35	0
7	10	5	5	0	0	80	0
8	5	5	10	1	0	90	0
9	5	10	5	0	0	80	0
10	10	30	5	0	0	55	0
11	10	15	10	5	0	60	1
12	15	10	5	10	0	65	5
13	35	5	1	0	0	60	0
14	10	20	5	0	0	65	0
15	15	10	5	1	0	70	0
16	5	15	5	35	0	40	0
17	10	10	2	1	0	67	10
18	5	20	5	0	10	60	0
19	5	5	5	0	0	85	0
20	5	10	3	2	0	80	5
21	10	20	0	10	0	35	5
22	10	10	0	10	0	45	5
23	5	10	20	5	0	45	1
24	1	5	20	20	0	15	25
25	0	10	10	30	0	50	0
26	0	0	5	5	0	80	15
27	40	10	0	1	0	50	0
28	30	10	10	5	0	45	1
29	5	10	10	5	0	45	0
30	0	5	5	5	0	60	0

Whitegrass Control	(%) Bareground	(%) Rock	(%) Litter	(%) Grass	(%) Sedge	(%) Forb	(%) Shrub
Transect							
1	35	15	5	10	0	25	0
2	30	10	3	5	0	60	0
3	0	5	60	5	0	30	0
4	15	35	5	10	0	35	0
5	30	15	10	2	0	45	0
6	10	35	10	5	0	4	0
7	50	15	8	2	0	45	0
8	5	10	10	1	0	60	15
9	25	20	10	1	0	15	30
10	10	25	10	5	0	40	10
11	25	10	10	1	0	55	0
12	30	20	5	1	0	25	25
13	25	10	10	5	0	45	0
14	35	20	20	1	0	30	0
15	70	20	5	0	0	15	0
16	20	30	20	1	0	40	0
17	35	10	10	1	0	45	0
18	45	20	15	5	0	20	0
19	60	10	5	5	0	20	0
20	30	5	5	0	0	35	25
21	25	5	10	1	0	1	70
22	50	20	10	1	0	15	25
23	0	5	25	5	0	35	25
24	20	30	15	5	0	0	0
25	50	20	10	1	0	20	0
26	5	10	20	1	0	35	30
27	25	25	10	15	0	30	0
28	10	20	10	15	0	45	0
29	10	25	15	12	0	30	0
30	15	30	15	5	0	35	0
31	5	2	20	1	0	75	0
32	20	20	10	4	0	25	35
33	5	15	15	1	0	65	0
34	10	40	10	5	0	35	0
35	20	40	10	5	0	25	0
36	20	15	20	3	0	42	0
37	30	10	10	1	0	20	40
38	30	15	10	1	0	45	0
39	5	5	45	2	0	45	0
40	0	5	60	1	0	35	0
AVERAGE	23.50	17.43	14.65	3.78	0.00	33.68	8.25

Whitegrass Corral	(%) Bareground	(%) Rock	(%) Litter	(%) Grass	(%) Sedge	(%) Forb	(%) Shrub
Transect							
1	20	1	5	1	0	75	0
2	60	0	10	5	0	25	0
3	53	5	2	25	0	10	0
4	30	5	10	30	0	25	0
5	60	10	10	10	0	10	0
6	5	1	0	0	0	95	0
7	60	10	5	5	0	20	0
8	40	2	5	5	0	40	0
9	0	0	45	15	0	40	0
10	45	0	5	20	0	30	0
11	10	5	1	1	0	85	0
12	35	2	2	40	0	35	0
13	20	1	3	2	0	75	0
14	10	5	5	60	0	15	0
15	10	10	15	5	0	55	0
16	40	1	0	2	0	60	0
17	30	10	5	20	0	35	0
18	40	2	8	1	0	50	0
19	35	10	5	30	0	15	0
20	5	5	10	35	0	40	0
21	5	0	0	10	0	85	0
22	40	5	0	5	0	50	0
23	10	0	45	20	0	25	0
24	5	0	5	40	0	45	0
25	5	0	5	50	0	40	0
26	0	2	10	45	0	40	0
27	75	5	0	15	0	10	0
28	35	5	2	7	0	50	0
29	70	5	5	15	0	5	0
30	60	10	0	25	0	5	0
31	60	5	5	25	0	10	0
32	25	10	3	25	0	35	0
33	20	15	5	55	0	5	0
34	50	10	5	30	0	5	0
35	35	10	3	40	0	15	0
36	50	10	5	30	0	5	0
37	5	10	0	40	0	45	0
38	15	15	10	25	0	30	0
39	30	5	5	50	0	10	0
40	50	5	5	30	0	10	0
AVERAGE	31.33	5.30	6.73	22.35	0.00	34.00	0.00

Rudd Control	(%) Bareground	(%) Rock	(%) Litter	(%) Grass	(%) Sedge	(%) Forb	(%) Shrub
Transect							
1	25	10	2	20	0	20	35
2	25	20	10	5	0	40	0
3	10	5	1	1	0	40	80
4	20	5	10	5	0	40	35
5	10	15	20	10	0	35	30
6	1	1	3	2	0	20	90
7	25	10	5	2	0	60	5
8	5	10	5	1	0	35	60
9	5	10	10	1	0	80	0
10	5	15	10	15	0	20	50
11	0	5	30	20	0	20	0
12	10	5	10	1	0	45	80
13	20	10	20	0	0	30	30
14	10	10	20	5	0	35	60
15	15	15	10	1	0	60	0
16	25	15	5	3	0	50	1
17	25	10	5	15	0	35	15
18	30	5	10	3	0	55	1
19	1	20	10	5	0	75	40
20	5	20	5	5	0	50	15
21	10	1	25	1	0	65	0
22	10	5	5	7	0	70	0
23	45	20	5	10	0	20	0
24	35	10	5	10	0	45	10
25	10	10	20	5	0	30	20
26	30	20	5	5	0	40	0
27	30	20	5	30	0	25	0
28	35	25	5	15	0	20	0
29	55	15	1	4	0	25	0
30	40	20	0	5	0	30	5
31	30	15	20	5	0	35	10
32	5	5	15	5	0	60	50
33	30	15	5	30	0	35	0
34	40	15	0	5	0	30	10
35	10	15	10	2	0	20	40
36	15	5	5	10	0	65	0
37	10	10	20	1	0	55	5
38	15	20	10	1	0	40	25
39	10	10	15	1	0	20	60
40	5	5	20	10	0	40	1
AVERAGE	18.55	11.93	9.93	7.05	0.00	40.38	21.58

Rudd Corral	(%) Bareground	(%) Rock	(%) Litter	(%) Grass	(%) Sedge	(%) Forb	(%) Shrub
Transect							
1	20	10	5	10	0	50	0
2	25	30	5	1	0	45	0
3	80	10	1	10	0	5	0
4	30	15	5	20	0	55	0
5	20	5	20	25	0	30	0
6	50	35	1	1	0	15	0
7	5	35	40	1	0	25	0
8	30	7	2	5	0	45	0
9	15	5	5	20	0	50	0
10	50	5	5	10	0	30	0
11	60	25	1	0	0	15	0
12	5	35	5	25	0	30	0
13	30	5	1	10	0	55	0
14	20	20	10	25	0	25	0
15	45	10	10	15	0	25	0
16	60	10	5	0	0	25	0
17	35	15	5	1	0	35	0
18	30	5	10	5	0	50	0
19	15	10	15	55	0	7	0
20	40	5	40	3	0	7	0
21	60	5	5	15	0	15	0
22	15	5	25	5	0	60	0
23	50	5	15	10	0	15	0
24	10	10	25	20	0	35	0
25	50	3	40	0	0	7	0
26	50	3	40	0	0	7	0
27	40	20	5	5	0	30	0
28	5	2	40	10	0	45	0
29	5	0	5	5	0	85	0
30	30	0	20	1	0	50	0
31	30	15	5	3	0	45	0
32	5	20	10	15	0	50	0
33	15	5	15	25	0	35	0
34	15	1	10	55	0	20	0
35	30	10	30	0	0	30	0
36	15	7	7	15	0	55	0
37	5	35	25	35	0	10	0
38	50	10	5	10	0	25	0
39	20	2	20	25	0	20	10
40	15	20	20	15	0	25	5
AVERAGE	29.50	11.88	13.95	12.78	0.00	32.20	0.38

APPENDIX F

Soil Texture and Color Raw Data

Murie Corral	0-10	57.03	33.82	9.15	Sandy loam	10yr 2/2
	10-19	34.44	32.58	32.98	Clay loam	10yr 2/2
	19-29	27.73	56.18	16.09	Silt loam	10yr 5/2
Murie Control	0-10	47.02	35.85	17.13	Loam	10yr 3/2
	10-20	55.07	30.81	14.12	Sandy loam	10yr 3/3
	20-	62.82	27.99	9.19	Sandy loam	10yr 5/5
Halfmoon Corral	0-22	53.54	35.44	11.02	Sandy loam	10yr 3/3
	22-33	42.95	37.9	19.15	Loam	10yr 3/3
Halfmoon Control	0-11	54.94	68.1	13.16	Sandy loam	10yr 3/4
	11-20	61.93	30.9	7.17	Sandy loam	10yr 4/4
Bar BC Corral	0-7	61.93	30.96	7.19	Sandy loam	10yr 3/2
	7-13	63.92	27.91	8.17	Sandy loam	10yr 3/4
	13-	55.97	26.89	17.14	Sandy loam	10yr 2/2
Bar BC Control	0-7	49.62	40.2	10.18	Loam	10yr 4/4
	7-13	49.65	40.18	10.17	Loam	10yr 3/4
Rudd Corral	0-5	56.03	29.84	14.13	Sandy loam	10yr 3/2
	5-10	51.94	36.89	11.17	Loam	10yr 3/3
	10-15	47.92	31.92	20.16	Loam	10yr 4/4
Rudd Control	0-10	67.85	27.96	4.19	Sandy loam	10yr 3/2
	10-20	56.06	31.96	11.98	Sandy loam	10yr 4/4
Whitegrass Corral	0-6	64.03	25.98	9.99	Sandy loam	10yr 3/2
	6-15(r)	32.45	55.27	12.28	Silt loam	10yr 3/2
Whitegrass Control	0-7	62.06	30.95	6.99	Sandy loam	10yr 2/2
	7-19(r)	60.06	31.95	7.99	Sandy loam	10yr 3/3
RLS Corral	0-5	51.72	32.56	15.72	Sandy loam	5yr 2.5/2
	5-9(r)	54.06	35.95	9.99	Sandy loam	7.5yr 4/2
RLS Control	0-5	30.03	47.98	21.99	Loam	10yr 2/2
	5-9	42.02	35.99	21.99	Loam	10yr 3/3
	9-11	58.6	32	10.4	Sandy loam	10yr 3/3
Square G Corral	0-7	52.23	39.81	7.96	Sandy loam	10yr 3/4
Square G Control	0-7	42.08	44.92	13	Loam	10yr 3/4
Circle H Corral	0-6	32.77	53.39	13.84	Silt loam	10yr 2/2
	6-13	19.24	58.86	21.9	Silt loam	10yr 2/2
Circle H Control	0-8	53.38	33.63	12.99	Sandy loam	7.5yr 2.5/1
	8-16	52.24	29.85	17.91	Sandy loam	7.5yr 2.5/1

Depth of sample determined by depth of each soil horizon. Maximum depth sampled is related to depth of soil pit achieved by manual methods, and not necessarily horizon division. Soil color determined in the field, not on a dried samples.

Species Data								Control								Corral							
Species Name	Common Name	Family	Annual/Perennial	Introduced/Native	Weedy/Non-weedy	Known Habitat	Disturbance	RUD	WG	BBC	CH	RLS	HM	SG	MUR	RUD	WG	BBC	CH	RLS	HM	SG	MUR
FORBS																							
<i>Achillea millefolium</i> L. var. <i>lanulosa</i> (Nutt.)	Yarrow	Asteraceae	Perennial	Native	Colonizing	Disturbed/outwash	Disturbance	X	X		X		X			X	X	X	X	X		X	
<i>Agastache urticifolia</i> (Benth.) Kuntze	Horsemint	Lamiaceae	Perennial	Native	Non-weedy	Open slopes/moraines				X													
<i>Agoseris glauca</i> (Pursh) Raf.	False dandelion	Asteraceae	Perennial	Native	Non-weedy	Meadows		X	X	X			X		X	X	X					X	X
<i>Agropyron cristatum</i> (L.) Gaertn.	Crested Wheatgrass	Poaceae	Perennial	Introduced	Colonizing	Disturbed/exotic	Disturbance						X										
<i>Agrostis stolonifera</i> L.	Redtop	Poaceae	Perennial	Introduced	Non-weedy	Disturbed/exotic	Disturbance					X											
<i>Amelanchier alnifolia</i> (Nutt.) Nutt. Ex Roem.	Serviceberry	Rosaceae	Perennial	Native	Non-weedy	River/lake					X	X									X		X
<i>Androsace septentrionalis</i> L.	Rock Jasmine	Primulaceae	Annual	Native	Non-weedy	Moist to dry sites												X					
<i>Antennaria luzuloides</i> T. and G.	Pussy Toes	Asteraceae	Perennial	Native	Non-weedy	Rocky flats			X				X	X	X		X		X		X		X
<i>Arabis drummondii</i> Gray	Drummond Rockcress	Brassicaceae	Biennial	Native	Non-weedy	Moraine /outwash				X													
<i>Arabis glabra</i> (L.) Benth.	Tower mustard	Brassicaceae	Biennial	Native	Non-weedy	Sage							X						X				
<i>Arabis holboellii</i> Hornem.	Holboell's Rockcress	Brassicaceae	Biennial	Native	Non-weedy	Sage/moraine		X	X					X									X
<i>Arenaria congesta</i> Nutt.	Congested sandwort	Caryophyllaceae	Perennial	Native	Non-weedy	Open woods/ sagebrush		X		X			X				X						
<i>Artemisa arbuscula</i> Nutt.	Low Sagebrush	Asteraceae	Perennial	Native	Non-weedy	Well drained areas		X	X		X		X			X	X	X				X	
<i>Artemisa dracunculula</i> L.	Tarragon	Asteraceae	Perennial	Native	Non-weedy	Dry hillsides						X											
<i>Artemisa tridentata</i> Nutt.	Big Sagebrush	Asteraceae	Perennial	Native	Non-weedy	Valley sites		X	X	X	X	X	X	X	X		X				X	X	
<i>Aster ascendens</i> Lindl.	Long-leafed Aster	Asteraceae	Perennial	Native	Non-weedy	Hills and valley slopes	Disturbance			X									X	X			
<i>Aster integrifolius</i> Nutt.	Thicketstemmed Aster	Asteraceae	Perennial	Native	Non-weedy	Spruce fir			X	X	X		X	X	X	X					X		
<i>Balsamorhiza sagittata</i> (Pursh) Nutt.	Arrowleaf Balsamroot	Asteraceae	Perennial	Native	Non-weedy	Sage/moraine								X	X								
<i>Capsella bursa-pastoris</i> (L.) Medic.	Shepard's Purse	Brassicaceae	Annual	Introduced	Economic	Disturbed sites	Disturbance	X								X	X				X		X
<i>Carduus nutans</i> L.	Musk thistle	Asteraceae	Biennial	Introduced	Noxious	Disturbed sites	Disturbance							X		X		X	X				X
<i>Castilleja</i> sp.	Paintbrush Species	Scrophulariaceae	Perennial	Native	Non-weedy	Dry sage		X			X												
<i>Chenopodium</i> sp.	Goosefoot species	Chenopodiaceae	Annual	Native	Non-weedy		Disturbance						X			X						X	
<i>Cirsium arvense</i> (L.) Scop.	Canada Thistle	Asteraceae	Perennial	Introduced	Noxious	Disturbed sites	Disturbance				X									X			
<i>Cirsium scariosum</i> Nutt.	Elk/ Everet's thistle	Asteraceae	Perennial	Native	Non-weedy														X				
<i>Collinsia parviflora</i> Lindl.	Blue-Eyed Mary	Scrophulariaceae	Annual	Native	Ncn-weedy	Sage			X	X			X		X	X					X		X
<i>Colomia linearis</i> Nutt.	Narrowleaf Collomia	Polemoniaceae	Annual	Native	Non-weedy	Sage/moraine		X	X	X	X	X	X	X	X	X	X			X	X	X	X
<i>Crepis acuminata</i> Nutt.	Tapertip Hawksbeard	Asteraceae	Perennial	Native	Non-weedy	Open forests								X								X	
<i>Cryptantha affinis</i> (Gray) Greene	Slender Cryptantha	Boraginaceae	Annual	Native	Non-weedy	Disturbed sites/open	Disturbance					X		X		X	X	X		X	X		X
<i>Cynoglossum officinale</i> L.	Hounds Tongue	Boraginaceae	Biennial	introduced	Noxious	Disturbed sites	Disturbance						X		X	X	X	X		X	X		X
<i>Delphinium</i> sp.	Larkspur species	Ranunculaceae	Perennial	Native	Economic	Gravelly soils		X	X	X	X	X	X	X	X	X	X						X
<i>Descurainia californica</i> (Gray) O.E. Schultz	Tansy Mustard	Brassicaceae	Annual	Native	Non-weedy	Slopes/ open woods					X					X							
<i>Draba albertina</i> Greene	Slender Draba	Brassicaceae	Annual	Native	Non-weedy													X			X		
<i>Dracocephalum parviflorum</i> Nutt.	Dragonhead	Lamiaceae	Perennial	Native	Non-weedy	Open moist	Disturbance	X						X							X		X
<i>Epilobium brachycarpum</i> Presl.	Willowherb	Onagraceae	Annual	Native	Non-weedy					X	X	X	X	X		X	X	X	X	X	X	X	X
<i>Eriogon speciosa</i> (Lindl.) D.C./glabellus (Nutt.)	Fleabane	Asteraceae	Perennial	Native	Non-weedy	Sage/open meadows			X	X	X	X	X	X	X					X	X	X	
<i>Eriogonum umbellatum</i> Torrey	Buckwheat	Polygonaceae	Perennial	Native	Non-weedy	Sage		X	X	X	X	X	X	X	X		X			X	X	X	
<i>Eriophyllum lanatum</i> (Pursh) Forbes	Wooly Sunflower	Asteraceae	Perennial	Native	Non-weedy	Sage/moraine	Disturbance	X			X	X	X								X	X	X
<i>Fragaria vesca</i> L.	Woodland Strawberry	Rosaceae	Perennial	Native	Non-weedy					X									X				
<i>Fritillaria Pudica</i> (Pursh) Spreng.	Yellowbell	Liliaceae	Perennial	Native	Non-weedy	Sage		X						X	X								
<i>Galium biflorum</i> Wats.	Thinleaf Bedstraw	Rubiaceae	Annual	Native	Non-weedy	River/canyon		X	X	X	X	X	X	X	X	X	X			X	X	X	X
<i>Gayophytum diffusum</i> T. and G.	Groundsmoke	Onagraceae	Annual	Native	Non-weedy	Dry gravelly		X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
<i>Geranium viscosissimum</i> F. and M.	Sticky Geranium	Geraniaceae	Perennial	Native	Colonizing	Dry/sage			X		X									X			
<i>Hackelia micrantha</i> (Eastw.) J. Gentry	False Forget-Me-Not	Boraginaceae	Perennial	Native	Non-weedy													X		X			
<i>Helianthella uniflora</i> (Nutt) T. and G. / <i>quinque-nervis</i> (Hook.) Gray	Helianthella	Asteraceae	Perennial	Native	Non-weedy				X												X		
<i>Hydrophyllum capitatum</i> Dougl. ex Benth.	Dwart Waterleaf	Hydrophyllaceae	Perennial	Native	Non-weedy	Open valley slopes								X							X		X
<i>Ipomopsis aggregata</i> (Pursh) V. Grant	Scarlet Gilla	Polemoniaceae	Biennial	Native	Non-weedy	Rocky slopes			X				X		X						X		
<i>Juniperus communis</i> L. var. depressa Pursh	Common Juniper	Cupressaceae	Perennial	Native	Non-weedy										X								
<i>Lappula redowskii</i> (Hornem.) Greene	Stickseed	Boraginaceae	Annual	Native	Colonizing	Disturbed sites	Disturbance				X						X	X		X			
<i>Lepidium virginicum</i> L.	Pepperweed	Brassicaceae	Annual	Introduced	Economic				X	X						X	X	X	X	X			
<i>Linanthus septentrionalis</i> Mason	Northern Linanthus	Polemoniaceae	Annual	Native	Non-weedy	Open dry meadow		X	X	X			X	X	X	X	X	X	X	X	X	X	X
<i>Linaria vulgaris</i> Mill.	Butter and Eggs	Scrophulariaceae	Perennial	Introduced	Noxious	Disturbed sites	Disturbance	X	X	X				X					X				
<i>Linum lewisii</i> Pursh	Blue Flax	Linaceae	Perennial	Native	Non-weedy	Outwash				X													
<i>Lithophragma parviflorum</i> (Hook.) Nutt. Ex T. and G.	Woodland Star	Saxifragaceae	Perennial	Native	Non-weedy	Moraine/ dry meadows		X	X	X			X		X						X	X	
<i>Lithospermum rudevale</i> Dougl.vex Lehm	Western Stoneseed	Boraginaceae	Perennial	Native	Non-weedy	River/sage flats								X		X							
<i>Lomatium ambigum</i> (Nutt.) Coult. And Rose	Biscuitroot	Apiaceae	Perennial	Native	Colonizing	Disturbed sites	Disturbance		X				X		X		X		X		X		X
<i>Lupinus sericeus</i> Pursh	Silly Lupine	Fabaceae	Perennial	Native	Non-weedy	Dry sites		X	X	X	X	X	X	X				X		X		X	
<i>Machaeranthera canescens</i> (Pursh) Gray	Hoary Aster	Asteraceae	Perennial	Native	Non-weedy									X	X			X					
<i>Madia glomerata</i> Hook.	Cluster Tarweed	Asteraceae	Annual		Economic	Disturbed sites	Disturbance							X		X	X						
<i>Mañonia repens</i> (Lindl.) G. Don	Oregon Grape	Berberidaceae	Perennial	Native	Non-weedy	Woods			X		X	X		X							X		
<i>Maithemum stellatum</i> (L.) Link	Starry False Solomon Seal	Liliaceae	Perennial	Native	Non-weedy	Moist sites													X				
<i>Matricaria matracunculoides</i> (Less.) Porter	Pineapple Weed	Asteraceae	Annual	Native	Non-weedy	Disturbed sites	Disturbance									X							
<i>Medicago lupulina</i> L.	Black Medic	Fabaceae	Annual	Introduced	Economic	Nitrogen fixer					X			X									
<i>Microseris nutans</i> (Hook.) Schultz-Bip.	Nodding Microseris	Asteraceae	Perennial	Native	Non-weedy	Valley slopes			X					X									
<i>Microseris nutans</i> or <i>Microseris gracilis</i> (Hook.) Greene	Nodding Microseris	Polemoniaceae	Annual	Native	Non-weedy	Lupine meadows				X				X						X	X		
<i>Microsteris gracilis</i> (Hook.) Greene	Microsteris	Polemoniaceae	Annual	Native	Non-weedy	Slopes/valley		X	X				X	X	X					X	X	X	
<i>Myosotis scorpioides</i> L.	True Forget-Me-Not	Boraginaceae	Perennial	Introduced	Non-weedy	Exotic	Disturbance	X				X											
<i>Nemophila breviflora</i> Gray	Small-Flowered Nemophila	Hydrophyllaceae	Annual	Native	Non-weedy		Disturbance	X	X	X	X		X	X	X	X	X				X		X
<i>Penderidea montana</i> (Blank.) Dorn	Yampa	Apiaceae	Perennial	Native	Non-weedy	Open woods		X		X			X	X		X						X	
<i>Phlox longifolia</i> Nutt	Long leaved Phlox	Polemoniaceae	Perennial	Native	Non-weedy	Sage					X		X			X						X	
<i>Polygonium aviculare</i> L.	Knotweed	Polygonaceae	Annual	Introduced	Economic	Disturbed sites	Disturbance				X		X				X						
<i>Polygonium douglasii</i> Greene	Douglas Knotweed	Polygonaceae	Annual	introduced	Non-weedy	Disturbed sites	Disturbance	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
<i>Potentilla argentea</i>	Tall Cinquefoil	Rosaceae	Perennial	Native	Colonizing	Meadows												X					
<i>Potentilla fruticosa</i> / <i>Pentaphylloides floribunda</i>	Shrubby Cinquefoil	Rosaceae	Perennial	Native	Non-weedy						X												
<i>Potentilla glandulosa</i>	Gland Cinquefoil	Rosaceae	Perennial	Native	Non-weedy	Various communities					X												
<i>Potentilla gracilis</i>	Showy Cinquefoil	Rosaceae	Perennial	Native	Non-weedy	Meadows							X	X						X			
<i>Prunus virginiana</i> L.	Chokecherry	Rosaceae	Perennial	Native	Non-weedy	River/moraines					X												
<i>Ranunculus macounii</i> Britt.	Macoun's Buttercup	Ranunculaceae	Perennial	Native	Non-weedy	Sage/meadows								X						X			
<i>Ribes inermis</i> Rydb.	Whitestem Gooseberry	Grossulariaceae	Perennial	Native	Non-weedy	Moist sites					X												
<i>Rumex acetosella</i> L.	Sourweed/Sheep Sorrel	Polygonaceae	Perennial	Introduced	Economic	Disturbed sites	Disturbance	X		X	X	X									X		X
<i>Rumex salicifolius</i> Weinm. Var. <i>triangulivalvis</i> Danser	Willowleaf Dock	Polygonaceae	Perennial	Native	Non-weedy	Disturbed sites	Disturbance									X	X						
<i>Salix drummondiana</i> Barratt ex Hook.	Drummond Willow	Salicaceae	Perennial	Native	Non-weedy	Wet meadows				X													
<i>Salix lasiandra</i> Benth. var. <i>caudata</i> (Nutt.) Sudw.	Whiplash Willow	Salix	Perennial	Native	Non-weedy	Stream banks						X											
<i>Salix</i> sp.	Willow	Salicaceae																					

APPENDIX B

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