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

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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of

Master of Science

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Earth Sciences

MONTANA STATE UNIVERSITY
Bozeman, Montana

April 1999

APPROVAL

Of a thesis submitted by

Susan Bromley Kelly

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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Date April 26th 1999

ACKNOWLEDGEMENTS

I would like to thank my graduate advisor, Dr. Kathy Hansen for her patience, support and excellent editing skills during the thesis creation process. I also deeply appreciate the help received from others, which improved the content and presentation of this project. I express heartfelt thanks to Dr. Bill Locke, who offered invaluable advice and guidance and challenged me to expand my scientific understanding. I appreciate the attention to statistical detail provided by Dr. John Borkowski, as well as input from Dr. Bill Wyckoff and Dr. Joe Ashley who both provided guidance throughout my graduate studies, and improved and clarified my writing. I also express thanks to Grand Teton National Park personnel for their assistance, especially Dr. Robert Schiller, Chief of Resource Management, for help and encouragement during the data collection phase.

I am forever grateful for the helpful plant identification assistance cheerfully given by Stuart Markow and Cathy Seibert after long hours in the field, and peering through the microscope. I deeply appreciate the invaluable field assistance from both Sue Dougherty, who patiently recorded unending amounts of plant data in an organized fashion, and my mom, Barbara Kelly, who went above and beyond her motherly duties in typical fashion.

I acknowledge the financial support provided by 2 ½ years of teaching assistantships from the Department of Earth Sciences, and financial assistance from Grand Teton National Park.

I recognize that I could not have achieved this goal without the unending support of both family and friends, especially Mark Henderson, and our dogs, Bridger and Moki, who know more about plant identification and word processing than most humans.

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ABSTRACT

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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; Picket, 1976; Noble and Slater, 1980; Glenn-Lewin, 1980; Bornkamm, 1981; Parish, 1982; Huston and Smith, 1987, Picket 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 macronurtrients 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.

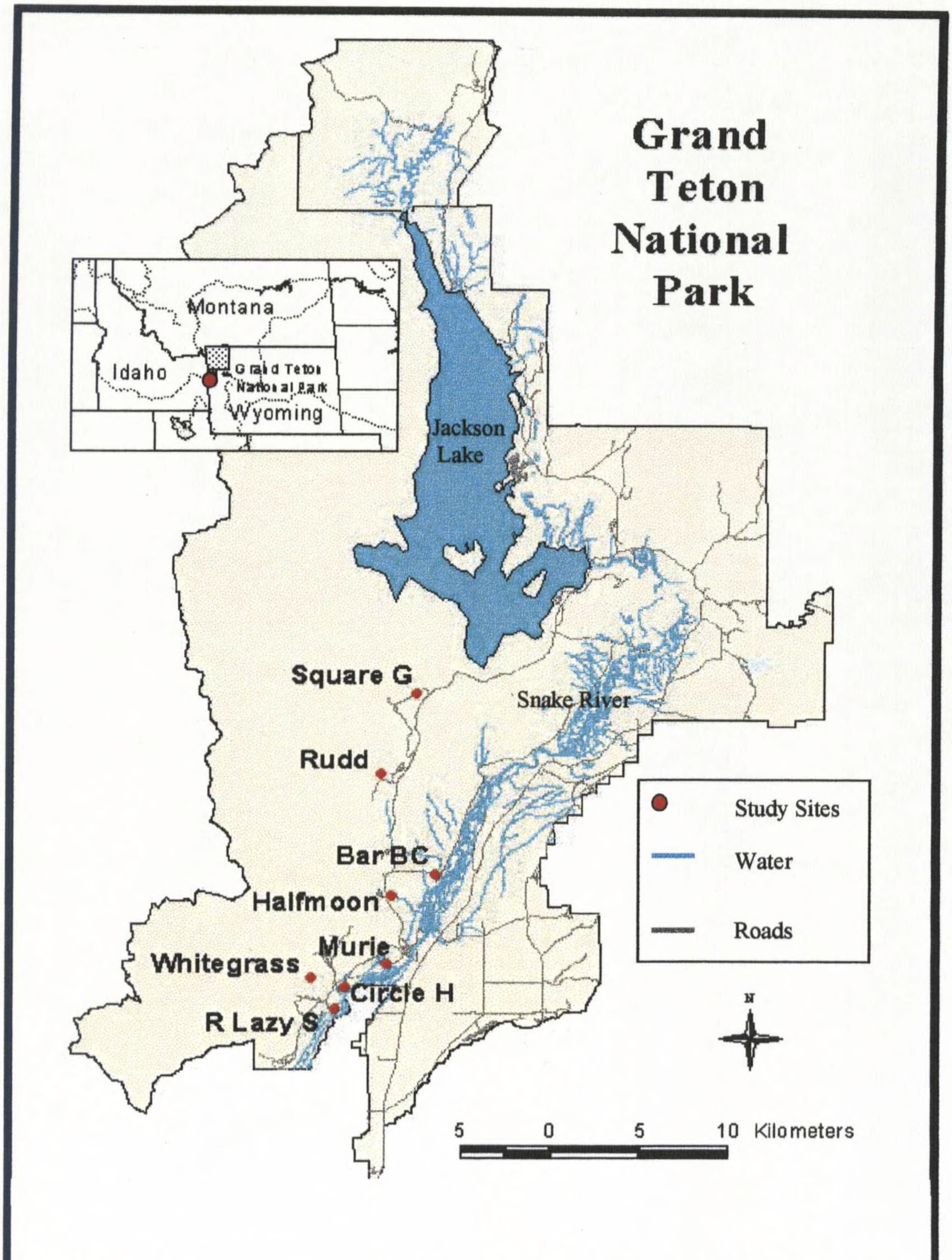

Figure 1. The study area within Grand Teton National Park, Wyoming, showing the eight corral sites.