AN ABSTRACT OF THE THESIS OF

Kenric Walburger for the degree of Master of Science in Animal Science presented on January 18, 2002.
Title: Twenty-Five Years of Grazing Research at Meadow Creek in the Starkey Experimental Forest and Range

Redacted for Privacy

Abstract approved: ______________________________
Timothy DelCurto

Redacted for Privacy

____
Martin Vavra

Three studies were conducted to evaluate different grazing systems on mixed conifer rangelands in eastern Oregon, and photo points and aerial photography was used to determine effects of 25 years of cattle grazing on stream channel changes and vegetation responses. The first study was designed to determine if grazing treatment and pasture aspect had an affect on forage quality, ADG and cattle distribution. Yearling heifers were assigned randomly to two treatments: 1) free choice season-long access to both a grassland (south-slope aspect) pasture and a forest (north-slope aspect) pasture, riparian zone excluded; and 2) a predefined grazing system between grassland and forest pastures, with the riparian zone excluded. The second study was designed to determine if season long grazing produced higher gains with yearling heifers than a rest-rotation grazing system within riparian pastures. The third study was designed to evaluate the difference in animal performance between a traditional 2-

pasture 1-herd deferred rotation grazing system and a predefined plant community grazing system. For study 1, in three of five years, total weight gain of managed heifers was greater ($P<.10$) than the weight gain of free choice heifers. As the grazing season progressed, forage CP and IVDMD decreased ($P<.05$). Forage quality was influenced by aspect ($P<.10$). Specifically, Idaho fescue (*Festuca idahoensis*) CP and IVDMD were greater ($P<.10$) for north- vs. south-facing aspects. Bluebunch wheatgrass (*Pseudoroegneria spicata*) CP was higher ($P<.10$) for north aspects, but IVDMD only tended to be greater ($P\leq.17$) for north aspects. Distribution patterns in the first year favored ($P<.10$) south aspects later in the grazing season. In the second year, distribution patterns favored ($P<.10$) south aspects for the entire grazing season. In the second study, only one year showed differences ($P<.10$) in total gain, with rest rotation grazing system having the greater gains. In the third study, there was no statistical difference ($P>.10$) between mature cow performance in any of the weigh periods or for total gain. Total gain by the calves on the plant community grazing system was higher across all years but only different ($P\leq.10$) in the final year. Aerial photos were taken in 1976, 1984 and 2001, and photos were geocorrected using 33 permanent blocks. In 1976 stream channel length was 1109 m, and by 2001 was 1148 m long. Channel widths are difficult to analyze due to changes in flow between 1976 and the following years. In 1984 the width was 4.79 m and by 2001 increased by 0.11 m. Islands present in 1976 and 2001 are different from each other. Photo points began in 1976 and continued every year. The photo points revealed an increase in shrub cover and abundance regardless of presence or absence of cattle. All photos indicate that since 1976 the riparian is recovering and that grazing is having no negative effects on the riparian area.

Twenty-Five Years of Grazing Research at Meadow Creek in the Starkey Experimental Forest and Range

by
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APPROVED:

Redacted for Privacy

Co-major Professor, representing Animal Sciences

Redacted for Privacy

Co-major Professor, representing Animal Sciences

Redacted for Privacy

Head of Department of Animal Sciences

Redacted for Privacy

Dean of the Graduate School

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Kenric Walburger, Author

CONTRIBUTION OF AUTHORS

Dr. Larry Bryant assisted with the establishment and collection of photo points and the original sets of aerial photographs. Dr. John Kie aided in obtaining funding to summarize Meadow Creek data.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF FIGURES CONT.

LIST OF FIGURES CONT.

LIST OF TABLES

LIST OF APPENDIX TABLES

TWENTY-FIVE YEARS OF GRAZING RESEARCH AT MEADOW CREEK IN THE STARKEY EXPERIMENTAL FOREST AND RANGE

CHAPTER 1

INTRODUCTION

INTRODUCTION

Cattle grazing is under increased scrutiny with the public becoming more interested in the management of public rangelands. Since the end of the Civil War, rangelands in the western US have been grazed by livestock. Overstocking and poorly managed grazing caused severe degradation of landscapes particularly during the late stages of the 19th century and early 20th century up to the Taylor Grazing Act of 1934. Many areas, particularly arid rangelands still show impacts of poor management today. The impacts related to livestock grazing often are associated with the decline and elimination of native species, down-cutting of streams, invasion of non-native species, and changes in composition of plant and animal species across the landscape.

In the past decade, the public has become increasingly involved in public land management, requiring protection of natural resources with management requirements and laws such as, Multiple Use Act, Endangered Species Act, Clean Water Act, and National Environmental Policy Act. All of these try to provide the structure for proper management of public rangelands.

Even though regulations and penalties are in place, the majority of rangelands remain in less than an optimal state. Proper management of livestock can produce desirable results that are in line with the above mentioned management and legislation programs. It is well known that cattle have behavioral traits that inhibit uniform distribution across a diverse landscape. Cattle distribution on mountain ranges is less than optimal. They distribute themselves in a predictable manner; in general they do not travel far from water (Bryant, 1982, Roath and Krueger, 1982, Pinchak *et al.*, 1991, Hart *et al.*, 1993), and as the grazing season advances the distance traveled is reduced (Bryant, 1982, Roath and Krueger, 1982, Pinchak *et al.*, 1991, Hart *et al.*, 1993, DelCurto *et al.*, 2000, Parsons *et al.*, 2000). Meuggler (1965) and Cruz *et al.* (1998) observed that cattle prefer areas with less slope. If cattle are left to distribute in this manner, they can cause significant damage to areas by overgrazing.

On public rangelands, many aspects of the grazing management system are defined by the government agency responsible for the land. Therefore, grazing management systems sometimes lack the flexibility and dynamic nature needed to provide for sustainable natural resource management. Usually grazing management on federal lands provides stability in timing and animal numbers from year to year which simplifies agency and permitee management. Cattle come on the range at a similar date every year and are removed at a similar time, and this is done independent of the conditions that have presented themselves prior to and during the grazing season. This type of management is inflexible and can be detrimental to the environment. However, livestock managers use these dates in planning. From an ecological viewpoint, cattle turn-on and -off dates should have greater flexibility which would allow for better management of the rangeland, but this would be nearly impossible for planning by ranchers and land managers putting an increasing stress on their limited resources.

Grazing systems have been implemented to allow for better distribution of cattle and better ecological management of the land resources. The primary objective of any grazing plan should be the sustained yield of vegetation and soil protection (Rittenhouse 1984), and once implemented one would expect to see an increase in range condition (Malechek, 1984). However, there is insufficient evidence to indicate that pasture deterioration is usual on continuous grazed pastures, and that stability can be achieved by introduction of grazing systems (Gammon 1978). Range deterioration may be more a factor of overstocking or timing of use rather than the implementation of grazing systems. However, on forested landscapes, congregation of cattle, due to poor distribution, can lead to problems that are associated with overgrazing. Roath and Krueger (1982) reported that cattle obtained approximately 80% of their forage from 2% of the landscape, in this case a riparian area. The use of grazing systems may aid in reduction of congregating cattle in sensitive areas, such as riparian zones.

Attempts to balance ecological management within the framework of grazing management have been reported. Two such places are Catherine Creek and Meadow Creek, both of these sites are located in eastern Oregon. Each site has had unique grazing experiments conducted over the past 30 years. Grazing in riparian zones, upland grazing and grazing systems have been studied and analyzed for both the impacts on cattle performance, distribution, forage selection and ecological consequences of grazing.

Even though much research has been conducted, some of the research over the past 25 years on Meadow Creek has not been summarized nor published, whereas Catherine Creek data is well documented. The purpose of the following chapters is to provide a summary of the last 25 years of unpublished data from Meadow Creek and provide for its use in future management and research. Cattle performance among differing grazing systems and cattle distribution on forested rangelands will be presented in Chapter 2. In addition, in Chapter 3, the effects that grazing has on the riparian environment will be discussed and evaluated by interpretation of aerial photographs and repeat photography using various photo points.

HISTORY OF STARKEY EXPERIMENTAL FOREST AND RANGE

There is a diverse history of grazing from the original settlers to the present day. (For a more complete history of Starkey Experimental Forest and Range see Skovlin, 1991) Grazing began in the Starkey basin as early as 1843. The initial movement of cattle was from east to west along with the settlers; however, beginning in the 1860's cattle began to move from west to east because the production of beef on the west side of Oregon occurred first. Each spring between 1876 and 1886 it was common to find cattle herds crossing the Starkey basin in numbers approaching 25,000 head.

Beginning in the mid-1880's, tens of thousands of sheep were also grazed in this area. Local stockman began noticing the lack of vegetation on the rangeland by October and blamed the sheep as being the sole cause.

By the year 1910, the stocking rate was half of what it had been leading up to 1900. Recorded stocking rates in the now Experimental Forest and Range began in 1907 at 0.81 ha/AUM. Stocking rates continually declined until 1940 when stocking rates were set as 3.0 ha/AUM.

Logging was also an integral force in shaping the landscape. From 1890 until 1906, logs were floated out on Meadow Creek by the aid of splash dams. A splash dam was constructed of large logs and rocks to form a large pool of water. When logs were placed in the stream corridor, the splash dam would be dynamited to create a flood which would then carry the logs down stream. Remnants of a splash dam in Meadow Creek can still be seen today. In 1927, railway spur lines were placed along Meadow Creek to aid in the removal of logs. The spur lines were removed from the Experimental Forest as logging was completed in the 1940's but the main line running up through Meadow Creek was not removed until 1955.

On July 11, 1940 the Forest Service created the Starkey Experimental Forest. The original goals of the allotment were to: 1) act as a location for range research and 2) to serve as a demonstration range under practical management. In 1940 and 41, cattle were grazed season long and beginning in 1942, after cross fences were in place, a two unit deferred rotation was established (Harris 1954). Beginning in 1954, an 11-year study began to evaluate the differences between deferred rotation and season long grazing, as well as intensity of grazing on the performance of cattle, soil compaction, forage production and the influence of grazing on forest regeneration (Skovlin *et al.* 1976). In all years of grazing, even though the stocking rate was lowered, riparian areas still received heavy cattle use (Bohn and Buckhouse, 1985).

The next major grazing research project was implemented in Meadow Creek in 1975. At this time, Meadow Creek was cross fenced to evaluate grazing systems, cattle performance, vegetation production, animal intake and diet composition and quality. Riparian, upland, and upland with riparian area pastures were created to assist in this evaluation. Another important feature was the addition of a New Zealand game fence constructed around the perimeter of 8800 ha of the Experimental Forest and Range in 1987 (Rowland *et al.*, 1997), to facilitate intensive wild ungulate research.

MEADOW CREEK GRAZING HISTORY 1975 TO 2000

Meadow Creek is located in the Starkey Experimental Forest and Range in northeastern Oregon. In 1975 fences were placed to create different pastures for grazing research. No grazing occurred during this year. Phase I and Phase IV were built to separate south facing slopes (grassland), north facing slopes (forest), and riparian areas. The riparian areas of Phase I and Phase IV were further divided into smaller pastures. Phase II was designed to study grazing systems and to allow access of cattle to grassland, forest and riparian areas. Finally, Phase III was designed to evaluate intensive grazing systems on riparian pastures. Another unique feature of Phase III is a game fence around the perimeter which excludes use by mule deer and elk. Thus, the effects seen in Phase III are attributable to the influence of cattle grazing, whereas all of the other pastures also had grazing pressure by mule deer and elk at various times during the year. In any year that pastures were not used in experimentation, grazing continued under the previous grazing system unless stated.

Grazing commenced in Phase I upland pastures in summer of 1976 and lasted for three grazing years. Cattle grazing began in mid-June of all years and continued until mid-October, which is typical for public land management of forested rangelands in this area. Both pastures were grazed season long at a stocking rate of approx. 4.5 ha/AUM. Two age groups of cattle grazed these pastures, 15 yearling heifers and 10 cows with calves, but each age group was grazed separately. At the beginning of the grazing season, age groups were placed into separate pastures for four weeks, and then rotated between each pasture every two weeks. This experiment was designed to look at the differences in movement between age groups (Bryant, 1982). Following the experiment by Bryant (1982) in 1979 the upland pastures of Phase I have remained ungrazed.

Phase I riparian pastures were divided into 5 smaller pastures, four pastures for grazing studies and one pasture as a control with no grazing. Pasture 1 served as the ungrazed control. Initially these pastures were used to look at willow regeneration under different intensities of grazing. In the first year of this study, only one pasture was grazed with five cows and calves. In each following year, an additional pasture was added until the final year when the five head had access to all four of the riparian pastures. These pastures were again used in a grazing experiment from 1987 to 1990. At this time, 10 cow/calf pairs were grazed in these riparian pastures from mid-August to mid-September. Grazing began in pasture 2 and lasted for 1 week and then cattle were moved to the next down stream pasture. Each pasture was grazed for one week and in the same order every year of the study. Beginning in 1991 the riparian pastures of Phase I were excluded from grazing.

Phase II was divided into five smaller pastures. Four of the five pastures were grazed with different grazing schemes, while pasture 5 served as the ungrazed control. Grazing commenced in 1976 and ended after the grazing season of 1990. From 1976 to 1986, the pastures were grazed under the same grazing system and with the same number of animals (Holechek, 1980, Berry, 1982, Holechek *et al.* 1987). Pastures 1 and 4 were used in a rest rotation grazing system and were grazed with 20 yearling heifers at a combined stocking of approx. 2.58 ha/AUM. Pasture 2 was used in a single unit in a deferred rotation grazing system and stocked with 20 yearling heifers at a stocking rate of approximately 3.09 ha/AUM. Pasture 3 was grazed season long with 10 yearling heifers at a stocking rate of approx. 2.09 ha/AUM. From 1976 through 1980 movement dates were mid-way through the grazing season, occurring in mid-August. During these years, grazing systems were evaluated on cattle performance, vegetation production, animal intake and diet composition and quality. There was a change during the years of 1981 to 1986; the rest rotation moving date was change to mid-July. In the years of 1982 to 1985 only animal performance was analyzed. Beginning in 1987 a new grazing plan was implemented and lasted thru 1990. Phase II served as a treatment to compare a traditional deferred rotation grazing system to a plant community grazing system. This study used pastures 1 and 2 together in the deferred system and then used pastures 3 and 4 as the replicate. Sixteen cow/calf pairs were used in each replicate at a stocking rate of 2.20 ha/AUM for pastures 1 and 2 and 1.68 ha/AUM for pastures 3 and 4. From 1991 until present no cattle grazing has taken place in Phase II.

Phase III served to duplicates the grazing systems of Phase II. The differences are that these pastures were mainly riparian pastures; the entire area is game fenced to exclude big game wildlife, mainly mule deer and elk. Grazing exclosures were placed in each individual pasture to serve as ungrazed controls. Phase III was divided up in a similar method as Phase II, five pastures with the fifth pasture being the ungrazed control. All pastures had the same grazing systems implemented as the pastures in Phase II from 1976 to 1986, pastures 1 and 4 as rest rotation, pasture 2 as deferred rotation, and pasture 3 as season long. In the rest rotation pastures, four yearling heifers were used at a stocking rate of 1.02 ha/AUM. As in Phase II, move dates from

1976 to 1981 were in mid-August and then move date was changed to mid-July for 1982 thru 1986. Pasture 2 was also stocked with four yearling heifers at a stocking rate of 0.98 ha/AUM. Pasture 3 was grazed with two yearling heifers season long at a stocking of 0.98 ha/AUM. Beginning in 1987 there was a change in grazing systems.

From 1987 to 1991, Phase I and Phase III were used as riparian pastures in a plant community grazing system with Phase IV serving as the upland pastures. Phase I served as the replicate to Phase III, but since it is smaller only 10 cow/calf pairs were placed in Phase I and the remainder, 22 cow/calf pairs, were placed in Phase III at a stocking rate of 0.87 ha/AUM. Grazing was similar to Phase I. These pastures were grazed from mid-August to mid-September, each pasture was grazed for one week and then cattle were moved to the next pasture. Grazing began in the farthest upstream pasture and then moved down stream, this pattern was done for the entire study.

From 1992 thru 1998 Phase III was grazed with Phase IV riparian pastures, it was grazed annually mid-July to mid-August. These pastures served as riparian pastures in a rotational grazing system with Phase IV upland pastures. They were grazed with 40 cow/calf pairs at a stocking rate of 0.78 ha/AUM. Prior to the grazing season of 1999, all partition fences and the game fence were removed from Phase III. The only fences that remain are the ungrazed exclosures in each pasture and the perimeter fence of pasture 5; these are to remain as ungrazed controls. Since 1999 Phase III has been incorporated with Phase IV west pastures.

The Phase IV riparian area, sometimes called Phase V, was managed in the same manner from the onset of grazing in 1976 to 1990. The total size of the fenced off riparian area is 8.63 ha, which is divided into two separate pastures of approximately equal sizes. These pastures were grazed for 28 days each and grazing lasted from mid-August until mid-October. Every other year each pasture was grazed early and the other pasture grazed late. Three mature cows and 11 yearling heifers grazed these pastures from 1976 to 1978, and in the remaining years these had the same stocking rate, 0.90 ha/AUM, with either yearling heifers or cow/calf pairs. In 1991, these riparian pastures were used as a substitute for the Phase I riparian pastures in the complementary grazing system. Beginning in 1992 and continuing to the end of the 1998 grazing season, the pastures were used with Phase III pastures to graze 40 cow/calf pairs from mid-July to mid-August. Prior to grazing in 1999 riparian fences were removed and these pastures were incorporated with Phase IV east upland pastures.

Phase IV was grazed differently than Phase I, II and III. Beginning in 1976 the northern (grassland) two pastures and the southern (forest) two pastures were used to determine composition of grazing livestock diets (Holechek *et al.* 1981, Holechek *et al.* 1982a and 1982b, Holechek and Vavra, 1982). Each set of pastures was managed with a rest rotation grazing system that utilized 18 head of yearling heifers, four steers, and four cows. This system of management continued through 1982. Animal performance, intake, and diet quality and composition were determined across years and within year.

From 1982 to 1986 Phase IV pastures were used in a new research plan (Walburger *et al.* 2000). In this study, the east forest pasture and the east grassland pasture were grazed season long by 26 yearling heifers. These pastures were joined together by a water gap allowing for free access by cattle to both pastures. Whereas the west grassland and west forest pastures were managed so the 26 yearling heifers grazed the grassland pasture for the initial four weeks, then moved to the forested pasture for eight weeks, then returned to the original grassland pasture for the final four weeks of grazing. Forage quality was measured over the first two years of the study and heifer movement was monitored in the season long pasture. Animal performance was measured for the duration of the study.

Again in 1987 there was a switch in management strategy applied to the pastures in Phase IV. The western pastures served as a replicate for the pastures in a complimentary grazing system. Animal performance was measured over the entire duration of the study. This complimentary grazing system was compared to the deferred rotation grazing system in Phase II. Within each replicate, 16 cow/calf pairs were grazed beginning in the grassland pasture from mid-June to mid-July. They were then moved to the forest pasture until mid-August when they were place in Phase I riparian pastures and Phase III. Beginning in mid-September the number of animals was cut in half with eight head going to grassland pasture and eight head going to forested pasture.

After the cessation of the complementary grazing system, there were no active research projects until the summer of 2000. However, the pastures were grazed the same every year beginning in the grassland pasture in mid-June and then moved the riparian pastures of Phase IV and Phase III in mid July. After grazing the riparian pastures cattle were moved to the forested pastures and finally removed in mid-September. During this time 40 cow/calf pairs were used to graze this area.

Prior to the grazing season of 1999, fences were removed in riparian areas separating upland pastures. This allowed cattle to have access to forest, grassland and riparian areas in both the west and east sides of Phase IV. Grazing for 1999 began in mid-June and lasted for nine weeks. For the first five weeks, 40 cow/calf pairs were in the eastern pastures and then moved to the western pastures for the final four weeks.

Vegetation production cages were placed in all Phases of Meadow Creek when cattle were present. All of the vegetation production records are located in the Forestry and Range Sciences Laboratory in La Grande, Oregon. Also, from 1976 through 1992, measurements were made on shrub populations within Phase III. During the grazing season of 1993 to 1999, utilization estimates were made on willow *spp.* and alder *spp.*, these records are also located in the Forestry and Range Sciences Laboratory in La Grande, Oregon.

Woody debris was placed in the creek in 1990, by the LaGrande Range District as part of a PNW Research Station project, to provide structure and allow pooling of water. Around 25% of the debris placed in Meadow Creek was anchored and the remaining 75% was unanchored to allow for free movement of debris. In the spring of 1991 a 25 year flood event occurred and redistributed the woody debris.

Other destructive events at Meadow Creek including ice flows that are less well documented because they usually happen in winter and/or early spring. Ice flows have caused major destruction to the banks and vegetation along Meadow Creek. Two major ice flow events have taken place during the past 25 years. The first happened in the 1985 and the next happened in 1997. These major events can cause damage to the shrub population and the stream channel. Ice damage to alder can cause varieties of fungi to enter into the damaged areas and cause significant mortality. Large chunks of ice can also scour the stream banks and move large amounts of debris to new locations.

In the following chapters grazing systems in Phase II, III and IV will be evaluated for the years 1982 through 1989. Also, aerial photos and photo points will be used to determine stream channel changes and vegetation responses in Phase III.

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CHAPTER 2

INFLUENCE OF GRAZING SYSTEMS AND ASPECT ON THE NUTRITIONAL QUALITY OF FORAGES, AND PERFORMANCE AND DISTRIBUTION OF CATTLE GRAZING FORESTED RANGELANDS.

Kenric Walburger, Timothy DelCurto, Martin Vavra, Larry Bryant, and John Kie

authors are graduate student, Oregon State University, Corvallis, OR; animal scientist, Eastern Oregon Agriculture Center – Union, Union, OR; superintendent and research leader, Eastern Oregon Agriculture Center – Burns, Burns, OR and USDA Forest Service, La Grande, OR; wildlife biologist, USDA Forest Service, La Grande, OR; National Range Ecologist, USDA Forest Service, Washington DC

INTRODUCTION

Livestock grazing is but one use that is currently being assessed on our public rangelands. Reduction of cattle numbers is not uncommon. Reduction in animal numbers can be attributed to perceived or actual degradation of rangelands and failure to meet multiple use concepts. Politicians, environmental groups and the public at large are putting increasing pressure on ranchers to apply sustainable grazing management practices. Grazing systems are being implemented to better use plant communities, allow preferred species time to recover from grazing and to encourage improved distribution of cattle across diverse landscapes. However, the primary goal of any grazing system should be the sustained yield of vegetation and soil protection (Rittenhouse, 1984). In the past, grazing systems were implemented on public rangelands without receiving input from the rancher. During these times, ranchers viewed grazing systems in negative terms. In their view grazing systems put increasing pressure on limited resources and also were thought to reduce animal performance (Malechek, 1984).

It has been documented that as the grazing season advances the energy content of grasses decreases, but levels tend to remain above requirements (Cook and Harris, 1968). Crude protein levels usually dip below the requirements of the animal (Cook and Harris, 1968). Also, Cook and Harris (1968) documented that differing plant communities provide differing nutrient levels depending on the season. Holechek *et al.* (1982 a & b) observed that cattle on southern exposure slopes tended to consume grasses throughout the year, whereas cattle grazing north-facing slopes had a greater diversity of grasses, forbs and shrubs available that, in turn, was reflected in diets throughout the year. Because of the influence of aspect on range vegetation diversity, decreases in diet quality may occur at different times of the year depending on site characteristics. Therefore, animal performance should be maintained and possibly increased if a grazing system could take advantage of these potential differences.

In general, south-facing slopes tend to be drier, have shallower soils and contain more open areas. North-facing slopes are more mesic, have deeper soils, and greater canopy cover. With these differences, forage quality and utilization by cattle would differ between north- and south-facing slopes (Harris, 1954, and Vavra and Phillips, 1979). Given these differences cattle may prefer one habitat type to another at differing times during the grazing period.

Sustainable grazing systems need to incorporate the differences that exist upon a diverse forested landscape. Effective grazing systems need to provide the following acceptable levels of beef cow/calf production and allow for better distribution and use of resources.

Therefore, our study objectives were: 1) To test the hypothesis that a grassland-forest grazing system would improve animal production versus cattle grazed season long in a mixed grassland-forest pasture, 2) determine seasonal forage quality in the season long pasture and observe if this affects cattle preference for pasture aspect within the season long pasture.

The objective of study 2 was to evaluate the effect of two grazing systems, rest rotation and continuous, on the performance of yearling heifers.

The final study objective was to evaluate the possible differences of a complementary grazing system vs. a deferred grazing system on cow/calf performance.

MATERIALS AND METHODS

The experimental area, for all studies, was located in the Starkey Experimental Forest and Range, located 48 km southwest of La Grande, Oregon (Figure 2.1). The pastures included upland and riparian pastures on Meadow Creek (Figure 2.2). Meadow Creek ranges in elevation of approximately 1080 to 1525m with an average yearly precipitation of around 53 cm that mainly occurs in the winter and spring. On average, one year out of two will have enough fall precipitation to cause significant regrowth of grasses (Skovlin, 1967). Due to gaps in precipitation records located at the Experimental Forest and Range, precipitation data was collected from Ukiah, which is located approximately 45 km west of the Starkey Experimental Forest. Total monthly precipitation was corrected by a regression equation (R^2=0.85) calculated by Berry (1982).

Within all studies, animal weights were taken approximately every 28 days. Non-shrunk weights were taken due to lack of holding facilities on the study area. All cattle were weighed after they had been allowed to graze in the morning and then allowed to drink prior to weighing. This was done to minimize the potential effects of rumen fill and the lack of knowledge of watering the day of weighing on heifer weights.

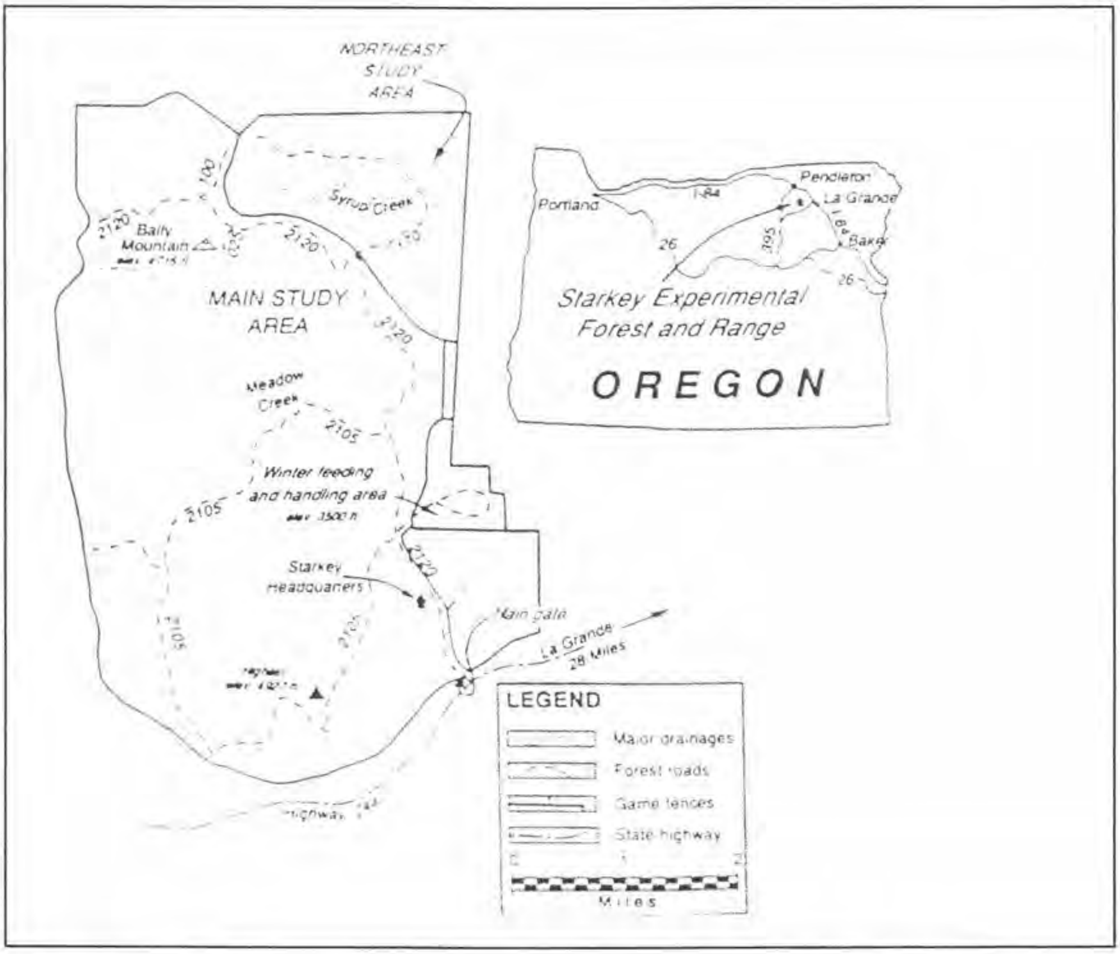

Figure 2.1. Starkey Experimental Forest and Range in northeast Oregon (Rowland *et al*., 1997)

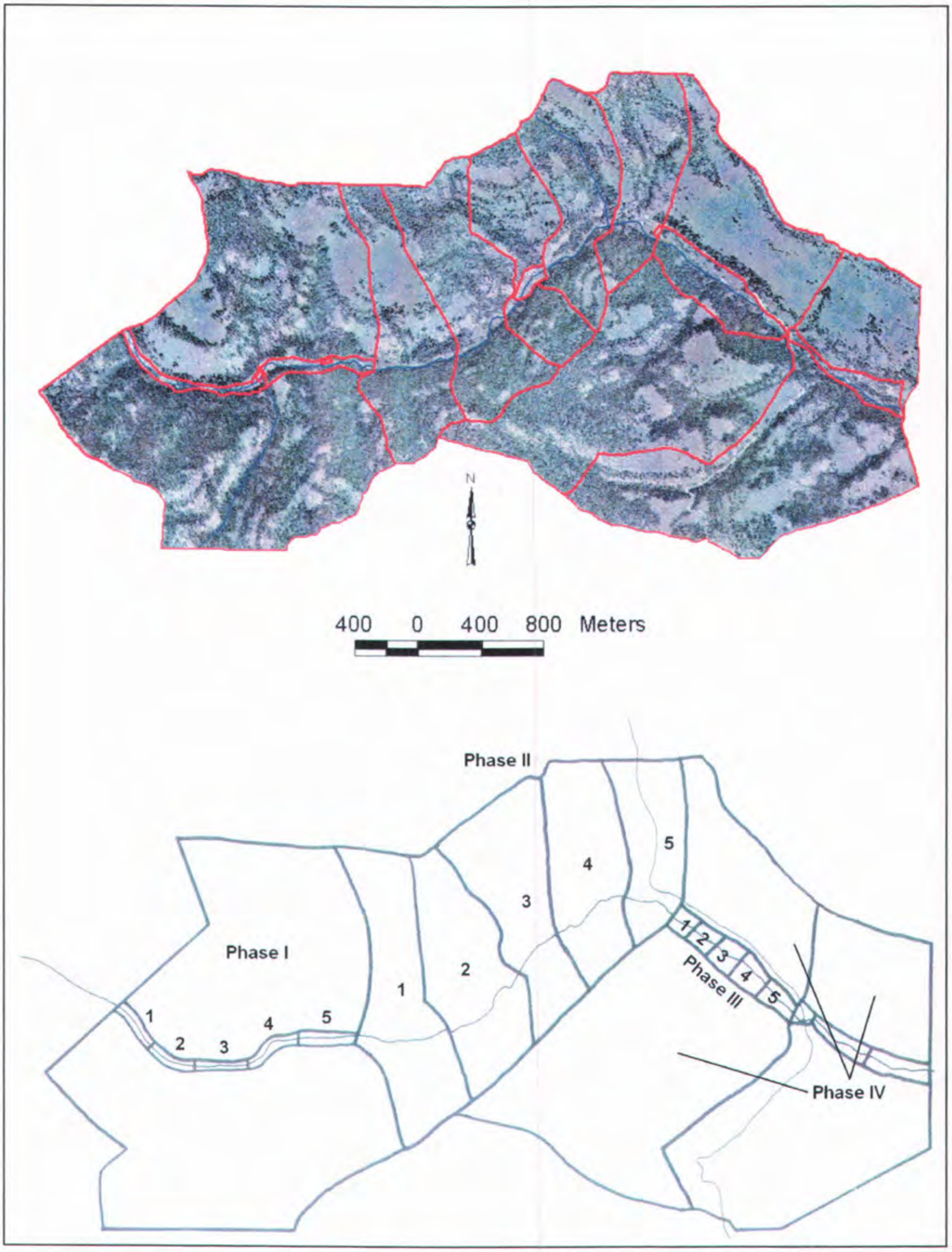

Figure 2.2. Meadow Creek study area located within the Starkey Experimental Forest and Range

Study 1:

Fifty-two yearling heifers (avg. initial wt. = 383kg) were assigned randomly to treatments evaluating a managed grazing system on forested rangelands (Phase IV of Meadow Creek, Figure 2.2). In treatment 1, a grassland pasture and a forested pasture were used as the free-choice season-long grazing system. The heifers were allowed free-choice on deciding which pasture they would graze at any given day or time. Pastures were connected by a water gap to allow for easy access to either pasture. Other than the water gap, heifers were excluded from the riparian area. In treatment 2, the remaining grassland and forested pastures were used as the managed system of grazing. The managed heifers began in the grassland pasture in mid-June and then moved into the forested pasture in mid-July. They remained in the forested pasture until mid-September when they were moved back to the original grassland pasture for the remainder of the grazing season. The rationale for returning to the grassland pasture was to take advantage of the improved forage quality from fall precipitation. Other than access to the creek, via a similar sized water gap as in the free-choice treatment, the heifers were excluded from the riparian zone. The grazing period began in mid-June and continued until mid-October and was pseudo-replicated yearly for a five year period (1982-1986). All grassland and forested pastures are of similar grazing capacity and each treatment had a stocking rate of approximately 3.2 ha/AUM. In addition, to accommodate concurrent range vegetation research, the same pastures were used every year for the same treatment.

Holechek et al. (1982 a & b) discovered that cattle on these pastures had a preference for Idaho Fescue (*Festuca idahoensis*) and bluebunch wheatgrass (*Pseudoroegneria spicata*). These plants are located in the grassland and forest pastures and they are in relatively similar abundance within aspect or plant community. Ten plots, of ungrazed plant material, were clipped weekly during the grazing season of 1982 and 1983. These clipped plots were then combined into a single sample and chemically analyzed to determine crude protein (CP) and *in vitro* dry matter digestibility (IVDMD).

Throughout the 1982 and 1983 grazing seasons, visual observations were conducted to determine the location of the heifers in the free choice pastures. Within an observation period heifers were recorded as to what pasture they were in, grassland or forest. At the end of each day, total heifer hours were calculated for each heifer in the grassland and forest pastures. Observations were conducted four days out of every week and times observed were broken down into the following periods, 0500 to 1000 hrs, 1000 to 1500 hrs and 1500 to 2000hrs.

Heifer performance was analyzed as a repeated measures design within year (SAS, 1997), and initial and final weight was analyzed within year. Linear regression was used to determine the effects of season on forage quality and General Linear Model procedures (SAS, 1997) were used to determine the effects of pasture on forage quality. Heifer observations were analyzed using a completely randomized design of a 2x2x3 factorial arrangement of treatments contrasting year, aspect, and season within year, and a second 2x2x3 factorial design was used in contrasting year, aspect and time of day.

Study 2:

Fifty yearling heifers (avg. initial wt. = 338 kg) were assigned randomly to treatments evaluating rest-rotation, deferred-rotation and season-long grazing systems on forested rangelands (Phase II of Meadow Creek, Figure 2.2). In treatment 1, 20 yearling heifers were used in a 2-pasture 1-herd deferred-rotation grazing system. This grazing system used a single pasture, therefore grazing commenced in mid-June and continued until mid-August and then the following year grazing began in mid-August and continued until mid-October. This system was continued throughout the entire study period. In treatment 2, 20 yearling heifers were used in a rest-rotation grazing system. The pastures simulated units of a 4-pasture rest-rotation system. One year in four a pasture was not grazed. Heifer movement date, when necessary, was in mid-July. In treatment 3, the remaining 10 heifers were used in the season-long grazing system. Pasture assignments and movement dates for all grazing systems are displayed in Table 2.1. Heifers in all pastures have access to riparian, forest and grassland plant communities, and all pastures are of similar grazing capacity. The grazing period began in mid-June and continued until mid-October and was pseudo-replicated yearly for a four year period (1982-1985). In addition, to accommodate concurrent range vegetation research, the same pastures were used every year for the same treatment. Heifer performance, between similar weigh periods of treatments, was analyzed as a repeated measures design within year (SAS, 1997).

Table 2.1. Grazing schedule and numbers of yearling heifers from 1982 to 1985 in Phase II

	Year	mid-June to mid-July	mid-July to mid-Aug.	mid-Aug. to mid-Sept.	mid-Sept. to mid-Oct.
Rest rotation grazing system					
Pasture 1	82	0			
Pasture 4		20			
Pasture 1	83	20	0		
Pasture 4		0	20		
Pasture 1	84	20			
Pasture 4		0			
Pasture 1	85	0	20		
Pasture 4		20	0		
Season long grazing system					
Pasture 3	82-85	10			

Study 3:

Sixty-four mature cow/calf pairs (cow avg. initial wt. = 477 kg and calf avg. initial wt. = 125 kg) were randomly assigned into two replications of two treatments evaluating grazing management systems on forested rangelands (Phase I, Phase II, Phase III and Phase IV of Meadow Creek, Figure 2.2). In treatment 1, a forested pasture, riparian pasture and grassland pasture were used as a plant-community based grazing system using Phase I riparian pastures, Phase III, and Phase IV upland pastures. The groups began on the grassland pastures in mid-June and then moved to the forest pastures in mid-July. Following the forest pasture the pairs were moved to the riparian pastures in mid-August where they remained until mid-September. Due to the smaller pasture sizes of Phase I, a greater number of pairs were placed in Phase III.

Grazing always began in the farthest up-stream pasture and moved down-stream, each riparian pasture was grazed for one week. Beginning in mid-September each replicate was divided in half and returned to either the grassland pasture or the forested pasture for the remainder of the grazing season.

In treatment 2, a traditional 2-pasture 1-herd deferred-rotational grazing system was implemented using the pastures of Phase II. For all pasture assignments, movement dates and numbers of pairs see Table 2.2. The grazing period began in mid-June and continued until mid-October and was pseudo-replicated yearly for a three year period (1987-1989). All treatments were of similar stocking rate. In

Table 2.2. Grazing schedule and cow/calf pair numbers from 1987 to 1989 in Meadow Creek

	Mid-June to mid-July	Mid-July to mid-Aug.	mid-Aug. to mid-Sept.	Mid-Sept. to mid-Oct.
Complementary grazing system				
Grassland #1	16			8
Grassland #2	16			8
Forest #1		16		8
Forest #2		16		8
Phase I[a]			10	
Phase III[b]			22	
Deferred rotation grazing system[c]				
Pasture #1	16*		16**	
Pasture #2	16**		16*	
Pasture #3	16*		16**	
Pasture #4	16**		16*	

[a] Pastures 2, 3, 4, 5 were used and grazing lasted for 1 week in each pasture

[b] Pastures 1, 2, 3, 4 were used and grazing lasted for 1 week in each pasture

[c] Pastures with like superscripts were grazed in the same year (* 1987 and 1989, ** 1988)

addition, to accommodate concurrent range vegetation research, the same pastures were used every year for the same treatments.

Cow and calf performance was analyzed as a repeated measures design within year (SAS, 1997), and initial and total gain was analyzed within year.

RESULTS AND DISCUSSION

Study 1:

Precipitation data are (Figure 2.3) arranged to represent the crop year accumulation (October 1 through September 31). Above average amounts of precipitation occurred from 1982 through 1984, however, in 1985 and 1986 below average and average precipitation occurred. In 1982 through 1984, rainfall occurred within the grazing season, whereas in 1985 and 1986, there was lower amounts of rainfall. As a result, late season grazing could be negatively affected, in 1985 and possibly 1986, because of lower amounts of precipitation reducing late-season forage regrowth.

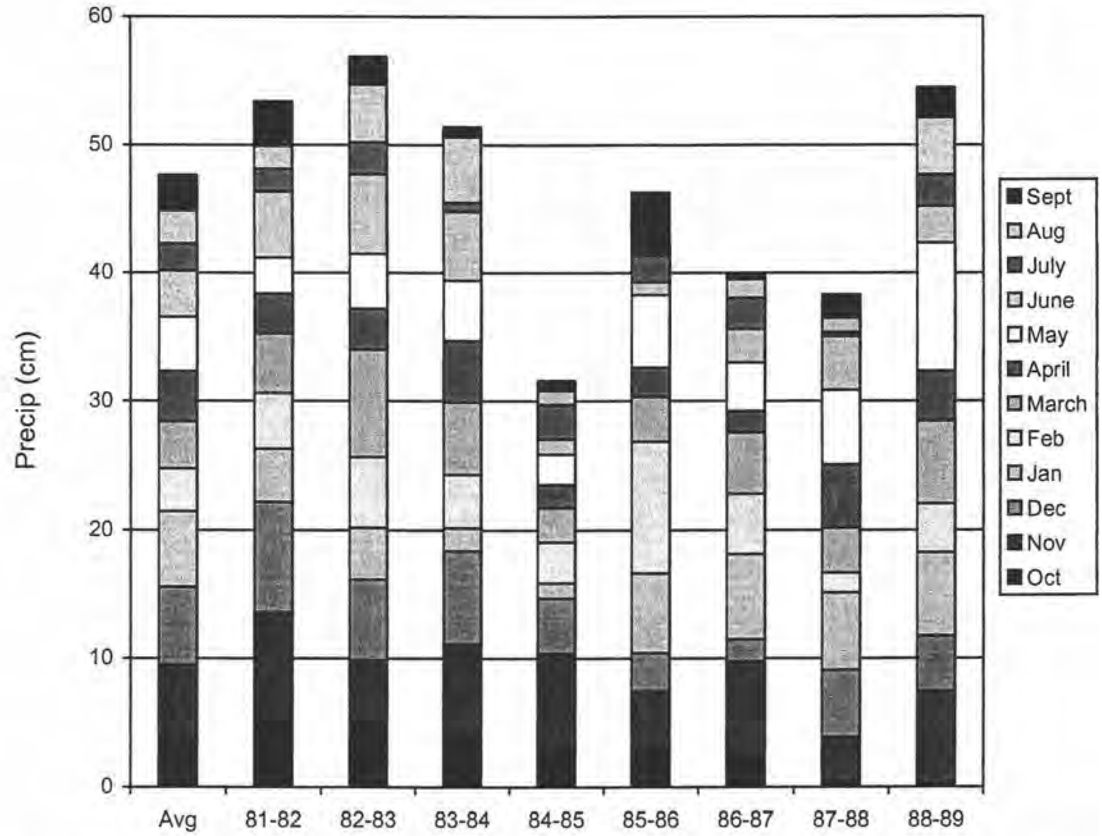

Figure 2.3. Extrapolated crop year precipitation for Starkey Experimental Forest from Ukiah precipitation.
Starkey precip = .260 + 1.054 x Ukiah precip (cm) (Berry, 1982)

Animal performance:

Heifer body weight changes varied throughout the season and among years (Table 2.3). Initial weights of the heifers did not differ between treatments for any years. Within the first period, gains were highest in 1982 and 1985. In 1984 and 1985, heifers in the managed grazing system had better performance (P<.10) than the free-

Table 2.3. Influence of season of use and grazing treatment on performance of yearling heifers.

Year		Init. Wt. (kg)	Period Gains (kg/d) 1	2	3	4	Total Gain (kg)
1982	Managed	327	1.51	0.77	0.77[a]	0.38	96.4[a]
	Free Choice	328	1.44	0.78	0.45[a]	0.40	88.2[a]
	SE[b]	7.97	0.05	0.05	0.08	0.04	2.34
1983	Managed	376	0.68	0.86	0.71	0.54[a]	77.7
	Free Choice	376	0.71	0.79	0.71	0.29[a]	71.0
	SE	6.04	0.07	0.07	0.05	0.05	2.76
1984	Managed	334	0.69[a]	1.34[a]	0.60[a]	0.97[a]	103[a]
	Free Choice	333	0.53[a]	1.56[a]	0.47[a]	0.73[a]	93.5[a]
	SE	4.70	0.04	0.07	0.04	0.05	2.57
1985	Managed	378	1.48[a]	0.33[a]	0.63	-0.26[a]	72.0
	Free Choice	382	1.06[a]	0.54[a]	0.54	0.06[a]	68.1
	SE	5.45	0.06	0.07	0.04	0.08	2.23
1986	Managed	398	0.69	0.87[a]	0.44	-0.40[a]	49.4
	Free Choice	398	0.76	0.70[a]	0.33	-0.08[a]	52.7
	SE	6.32	0.06	0.05	0.07	0.07	2.26

[a] values differ significantly ($P<.10$)
[b] SE = Standard error of the mean

choice heifers. In 1984 at the time of weighing, managed heifers were gathered from outside their original pasture because of fence failure.

In the second grazing period, the first four-week period on the forest pasture, heifers in three of the five years had higher gains for the free choice grazing system. Gains were significantly ($P<.10$) higher in two of the three years. However, in 1986 the managed heifers performed ($P<.10$) better. Depression in performance, for the heifers moved to the forested pasture may be attributed to unfamiliarity with the pasture (Gammon, 1978).

In the third period, the second four-week period in the forest pasture, heifers in the managed grazing system performed equal to or better than heifers on the free choice grazing system, with two of the years showing increased ($P<.10$) heifer weight gains.

In 1985 and 1986, weight loss by many heifers, in managed and free-choice systems, occurred in the final grazing period, when nutritional stress was the highest. In 1983 and 1984, managed heifers, after being put back on the grassland, had greater ($P<.10$) gains. Cattle on the managed grazing system performed poorer in 1985 and 1986, possibly because of movement to the grassland pasture with little or no regrowth of vegetation. In both years free choice heifers had greater ($P<.10$) gains from mid-September to mid-October.

The total gain by heifers favors the managed grazing system four of five years, with three years having significantly ($P\leq.10$) greater gains. If heifers had been removed prior to the final grazing period in 1985 and 1986, the managed grazing system heifers would have shown significantly higher ($P>.10$) total gains.

In general as the grazing season advances variation in cattle performance increases and animal performance decreases. During the four month grazing period all heifers had made 68% of weight gain by mid-August and 93% by mid-September. However, Ratliff *et al.* (1972) reported that yearling heifers made 73% of their gain by August 1 and 81% by August 15.

Observing heifer performance within 28-day intervals, the potential variation in fill because of nonshrunk weights may make it difficult to assess the true effects of grazing treatments. However, with the number of animals in the treatment and weighing strategy used, differences in animal performance could be reflective of differences between the grazing systems.

Other studies of grazing systems have not clearly shown any preference toward improving or reducing animal performance (Skovlin and Harris, 1974, Skovlin *et al.* 1976, Gammon, 1978, Peiper 1980, Berry, 1982, Knight *et al.* 1990, Hart *et al.* 1993). However, in reviews by Driscoll (1967), Gammon (1976), and Peiper (1980), cattle that continuously grazed pastures, on average, had better performance than cattle in rotational grazing systems. Greater gains were attributed to increased animal selectively, which, in turn, allowed for selecting a higher quality diet. In most reported grazing studies, pastures are arbitrarily divided to provide pastures of similar size and composition. In contrast, in our study, pastures were divided to provide animals with higher quality forage at time of movement. Therefore, on these pastures, heifers should be able to select high quality diets because of the diversity and phenology of plants available due to aspect and size of the pastures. Composition of diets obtained from these pastures revealed cattle diets varied between the pastures. In the summer months, diet quality was greater in the forested pasture (Holechek *et al.* 1981, Holechek *et al.* 1982a and 1982b).

Forage quality:

The results of forage quality analysis were not as expected. Crude protein content of Idaho fescue (Figure 2.4) decreased ($P<.01$) in 1982 as the season advanced, but in

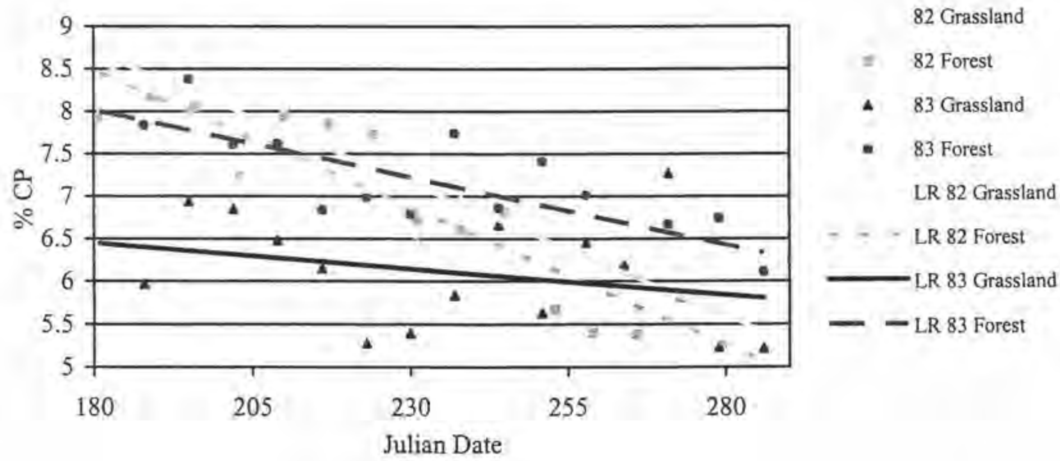

Figure 2.4. Influence of grassland (south) and forested (north) aspect on crude protein content of Idaho fescue.
LR = Linear regression trend line
1982 Grassland $y = -0.031x + 14.3$; $P < 0.01$; $R^2 = 0.77$
1982 Forest $y = -0.032x + 14.3$; $P < 0.01$; $R^2 = 0.83$
1983 Grassland $y = -0.005x + 7.34$; $P = 0.41$; $R^2 = 0.05$
1983 Forest $y = -0.016x + 10.9$; $P < 0.01$; $R^2 = 0.60$
Aspect differs (P=.21) in 1982
Aspect differs (P<.01) in 1983

1983 there was no difference (P>.10) in crude protein content as the season advanced. In 1983 grassland, the regression equation for Idaho fescue crude protein content accounts for less than 10% of the variation. As the grazing season advanced there was an increase in crude protein on the grassland in 1983 and this probably accounted for the lack of fit of the regression equation. In 1982, the grassland pasture had numerically higher crude protein content than the forest pasture, but in 1983 forest pasture had higher (P<.01) quality than the grassland pasture. *In vitro* DMD of Idaho fescue (Figure 2.5) showed significant (P>.10) reduction in quality as the season advanced, except for 1983 grassland when quality remained similar (P>.10)

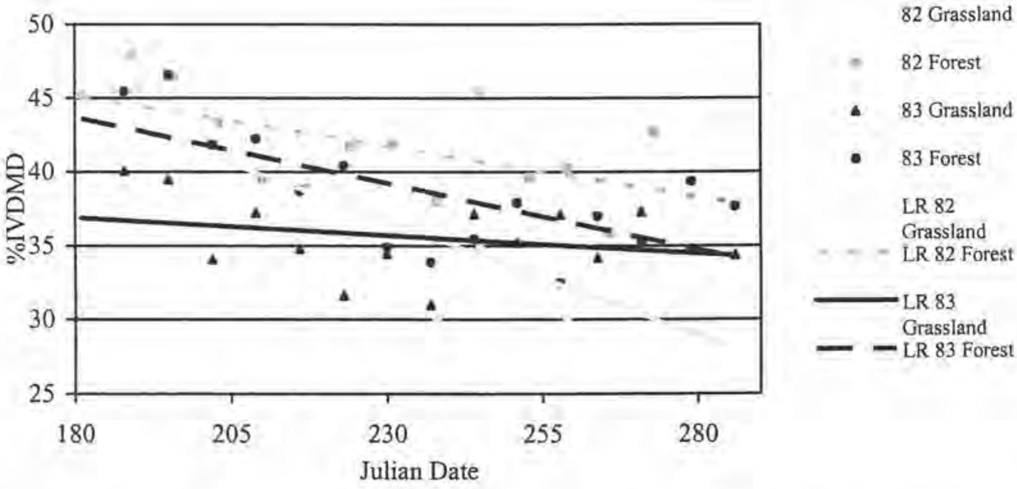

Figure 2.5. Influence of grassland (south) and forested (north) aspect on IVDMD content of Idaho fescue.

LR = Linear regression trend line
1982 Grassland $y = -0.156x + 72.3$; $P < 0.01$; $R^2 = 0.74$
1982 Forest $y = -0.068x + 57.4$; $P = 0.03$; $R^2 = 0.34$
1983 Grassland $y = -0.024x + 41.3$; $P = 0.28$; $R^2 = 0.08$
1983 Forest $y = -0.091x + 60.2$; $P < 0.01$; $R^2 = 0.46$
Aspect differs ($P<.01$) in 1982
Aspect differs ($P<.01$) in 1983

throughout the season. As with crude protein content, there was an increase in digestibility as the season progressed. However, the digestibility of Idaho fescue remained higher ($P\leq.01$) on the forested pastures than on the grassland pastures, even for grassland in 1982.

Bluebunch wheatgrass quality was higher than Idaho fescue at the beginning of the season. Pasture quality in both years, CP (Figure 2.6) and IVDMD (Figure 2.7), declined as the grazing season advanced ($P<.01$). In both years, bluebunch wheatgrass

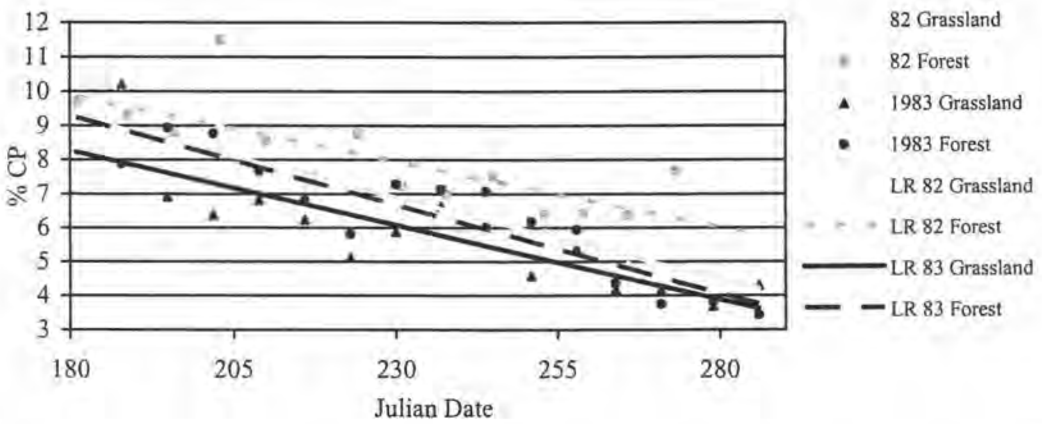

Figure 2.6. Influence of grassland (south) and forested (north) on the crude protein content of Bluebunch wheatgrass.

LR = Linear regression trend line

1982 Grassland $y = -0.048x + 18.0; P < 0.01; R^2 = 0.81$

1982 Forest $y = -0.046x + 18.1; P < 0.01; R^2 = 0.45$

1983 Grassland $y = -0.045x + 16.3; P < 0.01; R^2 = 0.71$

1983 Forest $y = -0.053x + 18.8; P < 0.01; R^2 = 0.82$

Aspect differs (P<.01) in 1982

Aspect differs (P=.09) in 1983

crude protein levels of the forested pastures were higher (P<.10) than the grassland pasture. *In vitro* DMD of the forested pastures in 1982 was greater (P<.10) than the grassland pastures, but in 1983 the forested pasture was numerically greater than the grassland pasture. The decrease in quality of range plants was consistent with what other researchers have documented (Cook and Harris, 1968; and Svejcar and Vavra, 1985). As the season advanced, plants matured and crude protein and digestibility declined. Quality differences between aspects were not unexpected, increased quality of north-facing slopes may, in part, be due to cooler microclimates, ash derived soils, greater soil depth, and higher moisture retention potential of the soil (Strickler, 1965, Geist and Strickler, 1978). Likewise, south-facing slopes have shallower basalt type

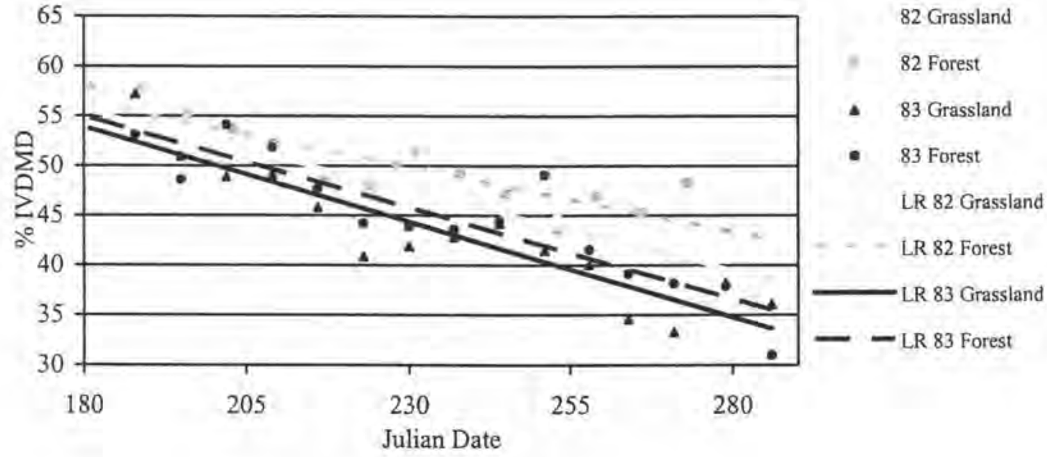

Figure 2.7. Influence of grassland (south) and forested (north) aspect on IVDMD content of Bluebunch wheatgrass.

LR = Linear regression trend line

1982 Grassland	$y = -0.168x + 85.9$; $P < 0.01$; $R^2 = 0.84$
1982 Forest	$y = -0.130x + 79.9$; $P < 0.01$; $R^2 = 0.74$
1983 Grassland	$y = -0.194x + 88.9$; $P < 0.01$; $R^2 = 0.84$
1983 Forest	$y = -0.185x + 88.3$; $P < 0.01$; $R^2 = 0.79$

Aspect differs (P=.02) in 1982
Aspect differs (P=.16) in 1983

soils and have low water storage potentials (Strickler, 1965, Geist and Strickler 1978). Dominant forage species on differing aspects have quality differences with northern aspects having higher quality in the summer (Svejcar and Vavra, 1985). However, in this study quality differed within the same grass species. Presumably, if bluebunch wheatgrass and Idaho fescue had differing quality between aspects, north vs. south, then it could be assumed that other plant species that occur within both pastures may also have quality differences as well.

Distribution of heifers:

Heifer distribution patterns (Table 2.4) were different between years for both time of day and season. In no year was there a pasture x time x season interaction. In 1982, heifer distribution, throughout the season, was similar to the managed grazing system.

Heifers favored the grassland at the beginning of the grazing season in 1982, moved to the forest pasture during the mid-grazing period and then moved to the grassland in the remainder of the grazing season. However, during the final observation period heifers exhibited a strong preference ($P<.01$) for the grassland pasture. Throughout 1983 heifers demonstrated a strong preference ($P<.10$) for the grassland pasture, and the strongest preference was shown during the mid grazing season.

By looking at preference within a day, heifers in 1982 preferred ($P<.10$) the grassland pasture in the early morning, but for the remainder of the day heifers showed no difference ($P>.10$) between pastures. In the second year, 1983, there was a different daily routine than in the previous year. In the early morning, heifers were equally distributed ($P>.10$) between pastures, but heifers numerically favored the forested pasture. However, for the remainder of the day, heifers preferred ($P\leq.10$) the grassland pasture.

For heifers in the free choice pasture there was no defined pattern to their distribution between years. Harris (1954), and Vavra and Phillips (1979) noted that utilization by cattle differs correspondingly with forage quality differences between north and south facing slopes. Hours spent in a given pasture do not necessarily

Table 2.4: Influence of season of use and time of day on the proportion of hours heifers spent on a grassland and forested pasture in northeastern Oregon

		Season			Time of Day[a]		
		Early	Mid	Late	Early	Mid	Late
1982							
	Grassland	0.57	0.48	0.67[c]	0.63[c]	0.54	0.54
	Forest	0.43	0.52	0.33[c]	0.39[c]	0.46	0.46
	SE[b]	0.10	0.08	0.08	0.10	0.07	0.09
1983							
	Grassland	0.58[c]	0.67[c]	0.57[c]	0.45	0.64[c]	0.72[c]
	Forest	0.42[c]	0.33[c]	0.43[c]	0.55	0.36[c]	0.28[c]
	SE	0.07	0.07	0.07	0.07	0.06	0.07

[a] corresponds to the hours on the day early=0500-1000, mid=1000-1500, and late=1500-2000

[b] Standard error of the mean

[c] values differ significantly ($P \leq .10$)

correspond to utilization. However, if the heifers were maximizing nutrient intake, distribution patterns would tend to favor the northern aspects (forested pasture) over southern aspects (grassland pasture). Harris (1954) noted that cattle given a free choice on timbered rangelands tended to use grasslands, when forage was available, and only used forested areas to escape heat or insects.

From previous research conducted on these pastures, Idaho fescue and bluebunch wheatgrass account for 57% of cattle diets in the grassland pasture, whereas they account for only 28% of the cattle diets in the forested pasture (Holechek *et al.*, 1982a and 1982b). With only 57% and 28% of the diets being accounted for in forage quality, it would be impossible to determine if difference in forage quality of Idaho fescue and bluebunch wheatgrass, due to aspect, were responsible for pasture selection by the heifers. Other influences could be driving habitat selection for the heifers, such as temperature (Parsons et al. 2000), availability of forage, precipitation (Harris 1954), alternative forages, such as shrubs, forbs and regrowth on grasslands.

Other research conducted by Mitchell and Rodgers (1985) revealed a shift in cattle use from one month to the next, with 70% of time in forest/shrub environments during July but only 55% of their time in the same environment during August. We did not see these changes in heifer preference of habitat. Instead, in our study, heifers tended to favor more open grassland sites as the season progressed. Heifer movement favored the grassland sites for all but one of the seasons. Senft (1986) also reported that cattle preferred open grassland portions of the pasture.

Study 2:

When evaluating performance data it was helpful to distinguish when the rest rotation system was in a single pasture the entire year (Table 2.1), 1982 and 1984, and when both pastures were utilized. The first period of grazing (Table 2.5), heifers performance was similar (P>.10) between both treatments, but a substantial amount of variability existed among years. In the second period there are some differences between treatments and also between similar years. In the years of 1982 and 1984 rest-rotation heifers had greater (P<.10) weight gains than continuous grazed heifers. In 1985, heifers on the season-long grazing system performed better (P<.10) than the rest-rotation heifers. Movement to the new pasture may have negatively influenced

Table 2.5. Influence of season of use and grazing treatment on performance of yearling heifers from 1982 to 1985.

Year		Init. Wt. (kg)	Period Gains (kg/d) 1	2	3	4	Total Gain (kg)
	Rest Rot.	308	1.12	1.04[a]	0.67	-0.17	71.6[a]
1982	Continuous	307	1.00	0.76[a]	0.77	-0.28	58.0[a]
	SE[b]	12.67	0.08	0.06	0.08	0.06	4.76
	Rest Rot.	369	0.29	0.73	0.60[a]	0.04	42.6
1983	Continuous	367	0.23	0.66	0.97[a]	-0.06	53.3
	SE	6.05	0.08	0.09	0.05	0.07	4.80
	Rest Rot.	345	0.50	0.85[a]	0.49[a]	0.45	61.7
1984	Continuous	343	0.62	0.71[a]	0.68[a]	0.50	71.2
	SE	7.64	0.06	0.05	0.06	0.06	4.19
	Rest Rot.	341	1.84	0.26[a]	0.59	0.10[a]	85.2
1985	Continuous	341	1.74	0.58[a]	0.62	-0.17[a]	84.5
	SE	7.56	0.09	0.09	0.04	0.08	3.51

[a] values differ significantly (P<.10)
[b] SE = Standard error of the mean

these heifers. Ratliff (1972) also observed that when heifers were moved to new pastures, under a rest-rotation grazing system, weight gains were less when compared to a season-long grazing system. Season-long heifers in the third period had greater gains than rest-rotation heifers in all years of the study, but only in two years were the gains significantly greater (P<.10). However, in the final period, 1985 was the only year to show differences in heifer performance with rest-rotation heifers gaining 0.2 kg/day more. During this final period, heifers in the season-long grazing treatment lost weight in three of the four years.

In only one of the four years was there a statistical differenced in total gain. Rest-rotation heifers had greater (P<.10) total gain than the continuous heifers for 1982. In that year there was higher than average amounts of precipitation (Figure 2.3) which may have created conditions for greater forage regrowth within the rest-rotation pasture.

By attempting to design study areas that minimize pasture effects, cattle in rotational grazing systems do not always perform better than continuous grazing systems, and sometimes have poorer performance (Driscoll, 1967, Skovlin and Harris, 1974, Peiper, 1980, Knight *et al.* 1990, Hart *et al.* 1993). Years when rest-rotation heifers are in a pasture for the entire year are of special interest. In those years, 1982 and 1984, neither grazing system provided consistently higher gains; this is consistent with what Holechek *et al.* (1987) found.

Study 3:

This study was conducted from 1987 to 1989. Precipitation (Figure 2.3) during this study was variable among years. The grazing seasons of 1987 and 1988 had below average amounts of precipitation occurred, whereas 1989 precipitation was above average. Also in 1989, greater amount of precipitation occurred in the months of May through September.

Mature cow gains (Table 2.6) varied throughout the year and also among years. Initial weights were not different ($P>.10$) between treatments. In all periods, cattle gains were not different ($P>.10$) from each other. Neither the deferred rotation nor the plant community grazing system showed any trend in increasing performance over the other. During the second period in 1988, it is important to note that mature cows on the plant community grazing system began to lose weight while deferred rotation cows did not.

During the third grazing period, when the plant community grazing system pairs were in the meadow pastures, these cattle had lower gains in two of the three years than the cattle on the deferred rotation system. A possible reason for these results is that forage species in the meadows had often already matured and, as a result, may not have been as high of quality as upland vegetation.

In the final grazing period cattle on the plant community grazing system were split between the grassland and forest pastures, gains between these two groups were not statistically different ($P>.10$) from each other, therefore, weights were combined into a single average. This was also the period where cattle performance, in 1987 and 1988, was the poorest. On average all cows were losing 0.90 kg/day. However in 1989, all cattle were gaining weight, but the plant community grazing system tended to have greater gains ($P=.14$) than the deferred rotation system.

Between similar precipitation years, total gain of cattle was similar. In 1988, cattle in the deferred rotation grazing system actually lost weight. If the final weigh period was not included, cattle performance would be similar between all years, but with 1989 still having higher total gain for both treatments. In all three years of the study the plant community grazing system had numerically greater gains than the deferred rotation grazing system. In general, as the season advanced cattle gains increased in variability.

Table 2.6. Influence of season of use and grazing treatment on performance of mature cows with calves.

Year		Init. Wt. (kg)	Period Gains (kg/d) 1	2	3	4	Total Gain (kg)
1987	Plant Com[a]	455	1.08	0.54	0.05	-0.99	10.51
	Deferred[b]	464	0.88	0.21	0.24	-0.82	7.74
	SE[c]	9.45	0.07	0.10	0.28	0.14	5.54
1988	Plant Com	484	1.31	-0.14	-0.04	-0.80	6.07
	Deferred	484	0.77	0.58	-0.28	-1.01	-2.83
	SE	28.45	0.16	0.33	0.22	0.09	10.04
1989	Plant Com	494	1.62	0.82	-0.09	0.48	87.28
	Deferred	480	1.98	0.03	-0.02	0.05	59.84
	SE	10.17	0.16	0.39	0.15	0.26	8.30

[a] Plant community grazing treatment
[b] Deferred Rotation Grazing Treatment
[c] SE = Standard error of the mean

Calf performance (Table 2.7) was less variable among years and periods than that of cows. However, calf performance did decline as the grazing season advanced. The only statistical difference in period gains occurred in the first period in 1988. At this time plant community system calves had greater ($P<.10$) gains. On average, when looking at differences among years, calf growth was fairly consistent for all periods but within 1989 gains were slightly higher. In the final period we saw lower gains in 1987 and 1988.

Overall gain by calves was similar among like years, and by removing the final weigh period calves across all years had similar gains. In all years, the plant community grazing system had higher total gain, and, in 1989, the gains were statistically greater ($P\leq.10$) than calves in the deferred rotation grazing system. Again, in general, as the season progressed calf performance became more variable.

Table 2.7. Influence of season of use and grazing treatment on performance of calves.

Year		Init. Wt. (kg)	Period Gains (kg/d) 1	2	3	4	Total Gain (kg)
1987	Plant Com[a]	126[d]	1.21	1.18	0.80	0.39	99.96
	Deferred[b]	121[d]	1.19	1.14	0.78	0.34	96.46
	SE[c]	0.60	0.04	0.07	0.19	0.05	2.71
1988	Plant Com	134[d]	1.37	1.06	0.88	0.24	101.10
	Deferred	131[d]	1.25	1.14	0.74	0.06	90.41
	SE	0.66	0.03	0.07	0.06	0.08	5.55
1989	Plant Com	120	1.55	1.27	0.82	1.05	141.46[d]
	Deferred	119	1.52	0.98	1.04	0.74	129.26[d]
	SE	3.61	0.04	0.14	0.13	0.18	3.03

[a] Plant community grazing treatment
[b] Deferred Rotation Grazing Treatment
[c] SE = Standard error of the mean
[d] values differ significantly ($P \leq .10$)

Probable reasons why calf weights did not greatly fluctuate between years was because the cows were Simmental cross which produced greater amounts of milk and the calves were able to supplement their diets with milk. As milk becomes less important in the calves diet, forage quality alone will become the dominant factor in determining the level of growth, and this could be why in the last year of the study calves had higher gains than the previous two years.

Since this was a grazing plan that tried to move cattle to optimize use of forage resources, most grazing research published will not compare with it. However, for research dealing with rotational grazing vs. continuous grazing, the performance data concludes that neither grazing system is able to continually produce greater results in animal weight gains (Driscoll, 1967, Skovlin and Harris, 1974, Peiper, 1980, Knight *et al.* 1990, Hart *et al.* 1993).

There are several potential reasons why the plant community grazing system was unable to produce greater weight gains than the simpler deferred-rotation grazing treatment. First, as mentioned earlier, when cattle entered riparian meadows, the vegetation has often already matured and, as a result, was lower in nutritional quality compared to upland vegetation. To counter this problem, if cattle began the grazing season in the riparian meadows, performance might have been enhanced. Likewise, if riparian and grassland sites could be grazed together in the early season, increased animal weight gains may be possible. Caution must be taken when entering into riparian areas early, soil moisture is greater and, as a result, soil compaction and increased damage to stream banks may result.

Secondly, research has shown that cattle tend to remain close to water (Bryant, 1982, Roath and Krueger, 1982, Pinchak et al., 1991, Hart et al., 1993). In the deferred-rotation pastures, cattle had access to riparian meadows continuously throughout the grazing season. Once the old plant material was removed, cattle could have continual access to high quality regrowth. However, this may be detrimental for overall riparian health.

IMPLICATIONS

Influence of forage quality and precipitation can be a major factor in determining animal condition coming off the range. Toward the end of the grazing season as forage quality begins to decline animal performance declines and variability increases. Designing grazing systems that use forage quality calendars could increase kilograms of beef produced while keeping stocking rate and land area the same. Grassland, south aspect, slopes had their highest nutritive forage quality in the early season and as the season progressed forage quality dropped below animal requirements. Forested, north aspect, slopes tended to have better quality later in the season and should be used at this time.

Corresponding to the decline in forage quality, a decrease in individual animal performance is usually observed. This drop can greatly affect the condition of the animal coming off of the range, but not all animals are equally affected. Young suckling calves show the most resilience while lactating females show the least. Supplementation, early weaning, or early removal may be viable options when trying to minimize poor performance nearing the end of the grazing season.

These studies demonstrated that introduction of a grazing system can work without any reduction in animal performance. Performance in most years indicates that cattle should be removed during the last grazing period. It may be possible to maintain animal units by grazing more cattle for less time and avoid the last grazing period.

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CHAPTER 3

EFFECTS OF 25 YEARS OF CATTLE GRAZING ON VEGETATION AND STREAM BANKS AS MEASURED BY AERIAL PHOTOS AND PHOTO POINTS.

Kenric Walburger, Larry Bryant, Tim DelCurto, Martin Vavra, John Kie

authors are graduate student, Oregon State University, Corvallis, OR; National Range Ecologist, USDA Forest Service, Washington DC animal scientist, Eastern Oregon Agriculture Center – Union, Union, OR; superintendent and research leader, Eastern Oregon Agriculture Center – Burns, Burns, OR and USDA Forest Service, La Grande, OR; wildlife biologist, USDA Forest Service, La Grande, OR

INTRODUCTION

Effects of cattle grazing on riparian habitats have been studied and documented for over 25 years. In reviews by Kauffman and Krueger (1984) and Belsky *et al.* (1999) they reported that livestock grazing, if not managed properly, can have negative effects on riparian areas, such as channel widening, reduced herbaceous cover of riparian vegetation, litter decline and possible increased bare ground. However, research indicates management strategies can reduce the impacts that cattle have on riparian areas. In a study conducted in a Sierra Nevada Mountain meadow (Huber *et al.*, 1995) standing crop at initiation of grazing was numerically greater in grazed pastures than in areas where grazing was excluded. Sedgwick and Knopf (1991) reported late season grazing produced more standing crop the following grazing pastures season than did exclosures. However, Schultz and Leininger (1990) found that peak standing crop within an exclosure was almost twice that of the grazed pasture. Possible differences between the varying results are that Huber *et al.* (1995) and Sedgwick and Knopf (1991) made their measurements at the beginning of the grazing season, grazing was in defined time periods, not season-long, and grazing was confined to the riparian areas, whereas Schultz and Leininger (1990) measured standing crop 29 years after exclosures were constructed on a public range allotment and grazing was season long.

Stocking rates and grazing systems can also play an important role in determining the structural characteristics of a riparian zone. In the Sierra Nevada Mountains low and moderate stocking rates, 1500 kg/ha and 1000 kg/ha forage remaining respectively, produced similar to greater standing crop biomass than control pastures at the beginning of the following grazing season, and in one of the two years at the end of the grazing season the lower stocking rate had similar standing crop biomass compared to the control pasture (Huber *et al.* 1995). Comparing two different grazing systems, deferred and continuous, Gillen *et al.* (1985) found that, in central Oregon, remaining herbage standing crop in a riparian zone was similar between systems by the end of the grazing season.

Herbage standing crop is not the only measure of the effect of cattle grazing on riparian vegetation; species composition between grazed and ungrazed areas can provide important information about plant community structure and response to grazing. Schultz and Leininger (1990) reported differences in vegetation structure between grazed and ungrazed plots. They found that the ungrazed pasture had greater litter build up, less bare ground, greater total shrub cover, and greater total graminoid cover, however, total forb and total tree cover was similar between treatment plots.

Herbage removal was different between continuous and deferred rotation grazing system. The early deferred rotation and the season long grazing system were similar in that herbage was grazed early in the life cycle with little to no allowance for accumulation of regrowth, but in the late deferred rotation, growth was almost completed by the onset of grazing (Gillen *et al.*1985). Gillen *et al.* (1985) also found that within a deferred rotation grazing system, the early season pasture had fewer cows in the riparian zone than the late season pasture. However, season long grazing showed occupation throughout the season similar to the late use deferred rotation pasture. In general, early grazing results in less occupancy in riparian areas than later grazing and early use offered by the deferred rotation system showed less occupation than a continuous grazing system for the same time period.

When riparian areas are used early in the grazing season, cattle do not congregate in the riparian areas (Clary and Booth, 1993). However, greater attention must be given to minimize or reduce soil compaction, not to physiologically damage the plants and allow grazed plants an opportunity for recovery. Researchers (Marlow and Pogacnik, 1986) in Montana also demonstrated that cattle in June and early July spent less time in riparian zones than later in the grazing season. Movement away from riparian areas in June and July is important because of an increase in the potential for streambank erosion due to higher flows and increased soil moisture (Marlow *et al.* 1987).

Other researchers (Bryant, 1982, Marlow and Pogacnik, 1986, DelCurto *et al.* 2000, Parsons *et al.* 2000) have also demonstrated that as the grazing season advances cattle move towards the riparian area. Bryant (1982) also documented that age of cattle can affect occupancy in the riparian zone, with younger cattle spending more time in the riparian area. However, in years when less than average amounts of precipitation occur, cattle move earlier to riparian areas (Marlow and Pogacnik, 1986).

Grazing systems may affect infiltration rates and sediment production. According to Bohn and Buckhouse (1985), infiltration rates and sediment production on a riparian pasture can be altered by cattle grazing. In ungrazed control pastures, they observed an increase in infiltration rate suggesting the area was recovering from a historically deteriorated riparian condition. The rest-rotation grazing system also had increased infiltration rates whereas the deferred rotation and continuous grazing systems did not. Rest-rotation grazing also had similar trends in sediment production as the ungrazed pastures, but season-long grazing had increased sediment production. From this work, one must be careful not to make broad generalizations, but it may appear that rest rotation grazing along this stream showed increased infiltration rates and reduced sediment production that in turn, may imply that the stream is recovering while grazing is taking place.

Other activities can and do have negative impacts on riparian function. Urban development, mining, road construction, dam development, logging, agricultural activities, water diversions for various uses, and recreational uses can have negative impacts on riparian ecosystems and cause lasting damage. It must be kept in mind that none of the above-mentioned impacts happens in isolation, and usually several happen in combination.

Management can play an important role in the recovery of riparian pastures. However, cattle grazing in the past has not been well managed and in turn has caused significant destruction of riparian areas. This is still a problem, and past research has not been adequate in trying to resolve this controversy. In part, Belsky *et al.* (1999) identified eight problems with drawing generalizations from past riparian studies:

1. Inadequate design – most watershed/riparian plans were not designed as experiments for long term studies.
2. Variability between and within watersheds – The most important aspect is that all streams are unique and a management technique that works in one stream may not work in another.
3. Insufficient study replication.

4. Differences in study design – without exact measurements of grazing intensity it is difficult to compare studies based on light and heavy stocking.
5. Grazing of exclosures by wild mammals – small rodents, birds and big game can have a significant influence on the ungrazed control pasture.
6. There is little or no record of prior grazing history or general history of the area. Since many factors can make up the current condition of a particular stream, grazing alone may or may not have contributed to current stream condition.
7. Time needed for recovery of riparian areas can be variable. Vegetation may recover quickly but stream channel may take considerably longer to recover from a deteriorated state.
8. Outside influences could be causing the negative activity within the study area.

In order to work toward a useful solution to the problem of improper cattle grazing in riparian areas, comments such as "livestock do not benefit stream and riparian communities, water quality or hydrologic function in any way" (Belsky *et al.*, 1999, p. 428) need to be avoided. Especially, when research shows that with "improved livestock management, previously denuded stream banks may revegetate and erosion may decline, but recovery will take longer than if grazing were terminated completely" (Belsky *et al.* 1999, p. 429). In the American Fisheries Society position statement, the authors commented that when grazing is properly implemented and supervised it could become an important management tool benefiting fish and wildlife habitats (Amour *et al.* 1991). These authors also commented that grazing systems could be used without permanent damage to riparian ecosystems as long as proper monitoring is conducted.

This study was designed to look at the changes in stream channel and vegetation characteristics on a riparian area that was subjected to various grazing systems. Aerial photography was employed to measure channel changes and photo points were used to visually document vegetation changes over the past 25 years of grazing.

MATERIALS AND METHODS

The experimental area was located in the Starkey Experimental Forest and Range, located 48 km southwest of La Grande, Oregon (Figure 3.1). Topography of the Experimental Forest and Range is typified by broad rolling uplands separated by moderately deep canyon drainages (Skovlin, 1976). The segment of channel observed was within Phase III in the Meadow Creek study area (Figure 3.2). Meadow Creek is at the elevation of approximately 1080 m above mean sea level. The average yearly precipitation is around 53 cm and mainly occurs in the winter and spring. A brief history of use up to 1975 and a complete grazing history since 1975 are given on the previous pages. Phase III was a cattle only grazing area, a game proof perimeter fence was constructed in 1975 and removed in 1999.

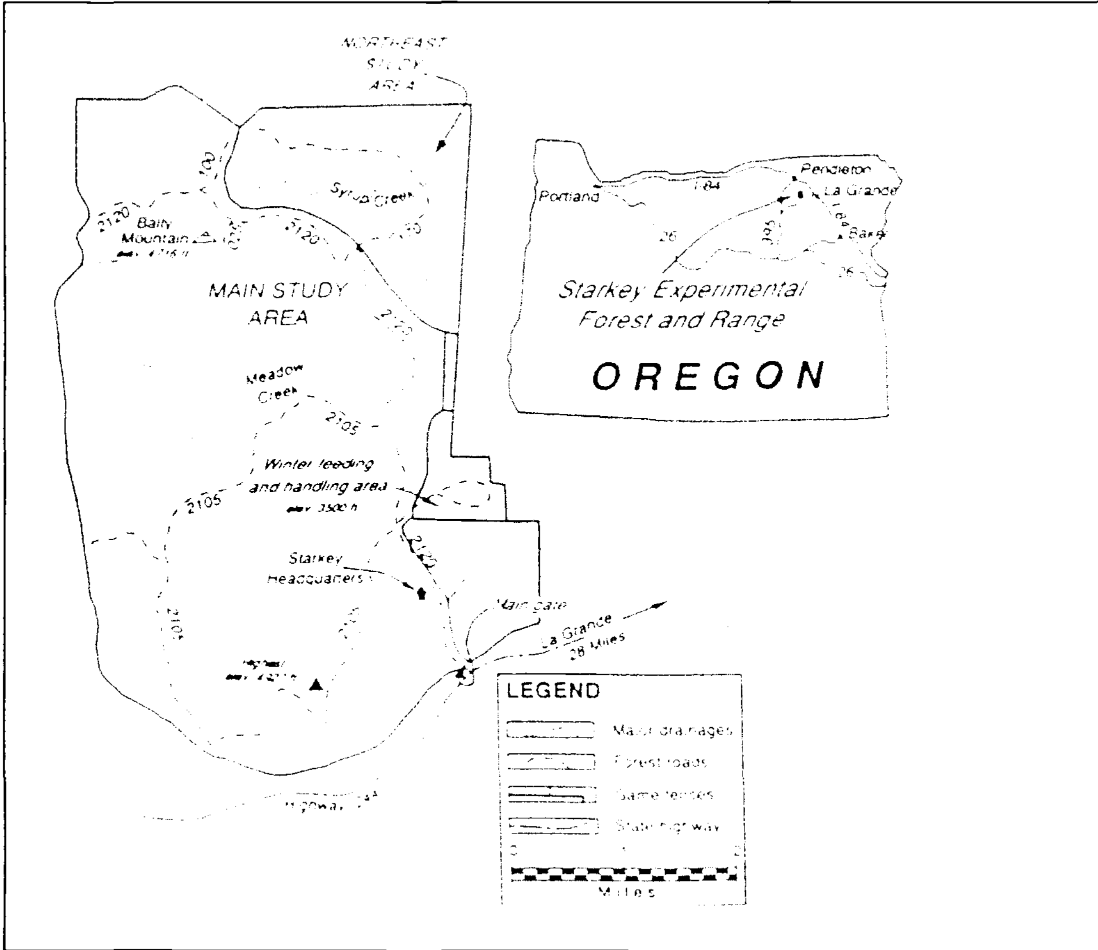

Figure 3.1. Starkey Experimental Forest and Range in northeast Oregon (Rowland *et al.*, 1997).

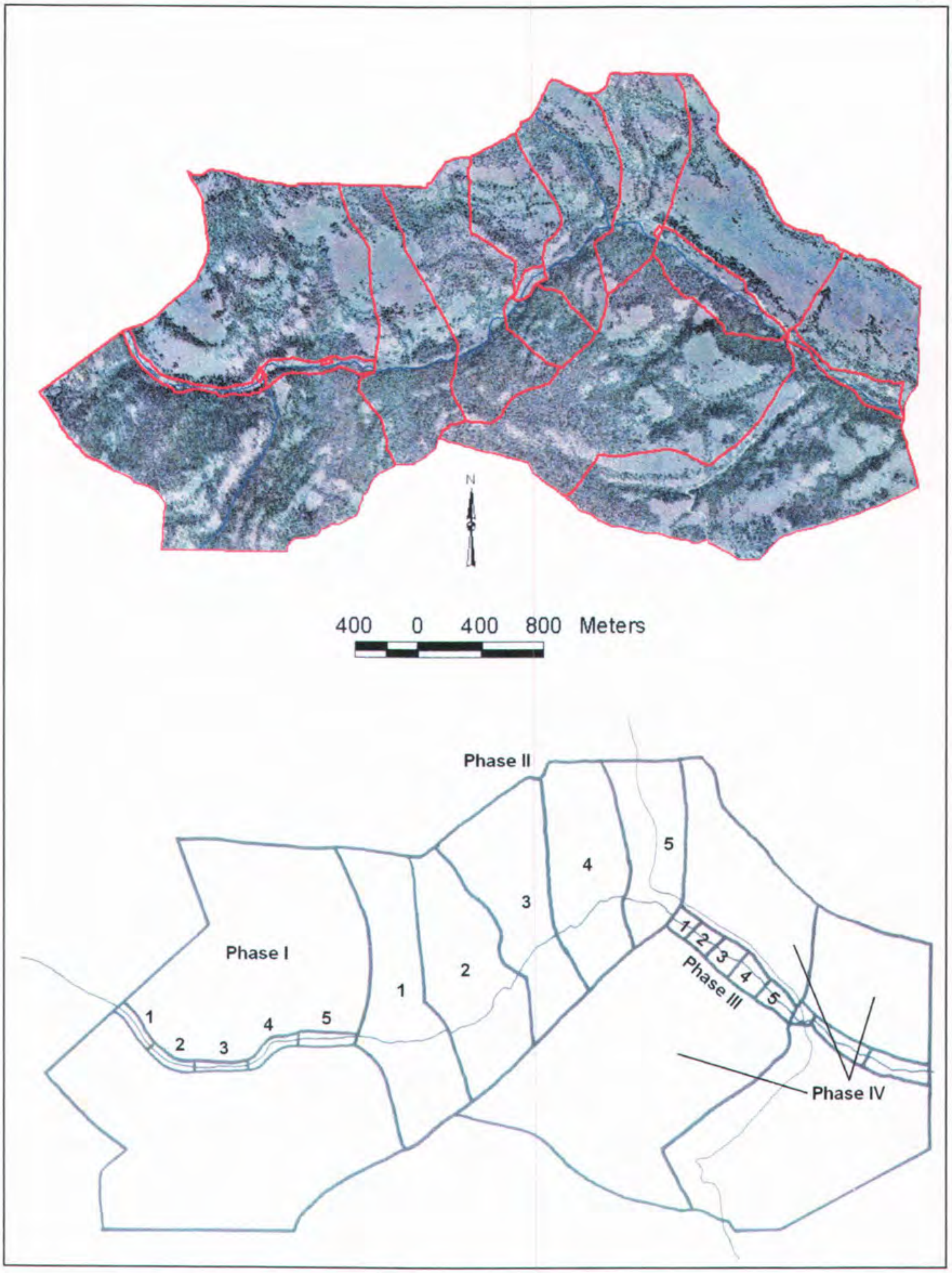

Figure 3.2. Meadow Creek study area located within the Starkey Experimental Forest and Range

Aerial Photos

The US Forest Service took aerial photographs of Meadow Creek on June 11, 1976 and August 23, 1984 (photographs are on file with the Forestry and Range Sciences Laboratory in La Grande, Oregon). A private contractor photographed Meadow Creek again on August 7, 2001 (photos are on file with the Eastern Oregon Agricultural Research Center – Union Station located in Union, Oregon). Only a single pass was required for photographing the stream within Phase III.

Photographs were scanned into the computer using a flat bed scanner at a resolution of 600 dpi providing an electronic image. Images in 2001 were geo-corrected, using the computer program IDIRISI 32®, with 50 ground control points so distances and areas could be accurately measured. Ground control points were geo-positioned using two Trimble® Pathfinder Pro XR differential global positioning receivers with data loggers. One unit served as a base station while the other as a rover (Laliberte 2000), and all points were post-differentially corrected (Laliberte 2000). The 1976 and 1984 images were corrected using similar features, such as rocks, stumps and fence corners, which were present in the 2001 images. The average Root Mean Square (RMS) errors and GPS errors are presented in Table 3.1. Stream channels were on-screen digitized from the corrected photos using IDRISI 32®. Wetted edge of stream instead of bankfull was used for designation of the stream channel. This was done because of ability to distinguish between water and land on the aerial photos. The vector files that were obtained from each photo were added

Table 3.1. Documentation and correction errors for aerial photographs of Meadow Creek.

Date	# of photos	Photo Errors (m)	
		RMS[a]	GPS[b]
11 June 1976	6	0.35	
23 Aug 1984	5	0.18	
7 Aug 2001	2	0.65	0.59

[a] Root Mean Square error averaged for all photographs as determined by IDRISI following geocorrection

[b] Average GPS errors for ground control points (2001 only)

together by using the vector editing program CartaLinx® to form the entire stream outline. Due to photo distortion, lines were joined in what was considered a best fit. Islands that were present in any year were also added to the file to get a complete vector image of the stream. From this, a geo-corrected vector map was created for the stream and islands. Stream vectors were rasterized to maps with a pixel size of 0.5 x 0.5 m for surface analysis. All estimates of stream length, width, sinuosity, water surface area and island surface area were taken from either the vector or rasterized images. Overlays were made to determine differences between years. Calculation of stream width was done according to the procedure described by Laliberte (2000).

Photo Points

Photo points were established, within Phase III of the Meadow Creek study area, in the initial year of the study, 1976, and were photographed every year at approximately the same time; however a few photo points were initiated in 1975. The photo points were established to visually appraise the vegetation changes that occurred. Some photo points have changed over the years because non-permanent markers were established and different photographers, cameras, and lenses were used. One major shift in photo points occurred in the early 1990's, therefore only two of the seven photo points presented will be continuous from 1976. Over the years, some of the photo point photographs, mainly the earlier years, have been misplaced; therefore there is a non-continuous record of all photo points.

Beginning in 1986, a photo point was established in Phase II pasture 5. This pasture has been excluded from cattle grazing since 1976 and provides comparisons to be made from total exclusion of grazing (Phase III pasture 5) to cattle grazing only (Phase III pastures 1 thru 4) to big game only grazing (Phase II pasture 5).

RESULTS AND DISCUSSION

Aerial Photos

From the 1976 aerial photos (Figure 3.3) shrubs along the creek are absent or present only in a few places. By 1984 (Figure 3.4) shrubs are larger and in greater number along the creek and grasses are filling in old stream channels. Finally, in the year 2001 (Figure 3.5) shrubs are an important component of riparian vegetation. At the beginning of the 1976 grazing season, Phase III was rested for one year following what was characterized as heavy use by congregating cattle (Bohn and Buckhouse, 1985).

Grazing or the removal of grazing may show varying effects upon the length of streams. In 1976 the total length of the stream, the distance of where the stream enters to where it exits from Phase III, was 1109 m; by 1984 there was an increase of approximately 40 m (Table 3.2). But, channel lengths of 2001 and 1984 were similar, 1150 and 1148 m respectively. As length of stream changes so must the sinuosity. Sinuosity is calculated as stream length divided by the valley length. In 1976 the sinuosity was 1.07, and in 1984 and 2001 the sinuosity was 1.11 and 1.10, respectively.

The channel can further be split into its grazed and ungrazed components. By just looking at the ungrazed section of the stream, it is evident that the stream is getting longer and therefore sinuosity is increasing. In 1976 the length of the ungrazed stream channel was 237 m, increased by 10 m in 1984 and by 2001 the length was 251 m. The length of the ungrazed control increased by 6%, with the majority of the in the initial eight years. The grazed section was considered as a single unit due to the fact that grazing systems were changed and did not remain constant throughout the entire period. At the initiation of the grazing experiments in 1976 the grazed channel length was approx. 870 m, and length had increased 31 m by 1984. The length of the channel in 2001 was approx. 900 m, slightly less than the length in 1984. The channel increased in length by 4% in the initial eight years of the study, and in total increased by 3%. Similarly, in a study observing stream channel characteristics

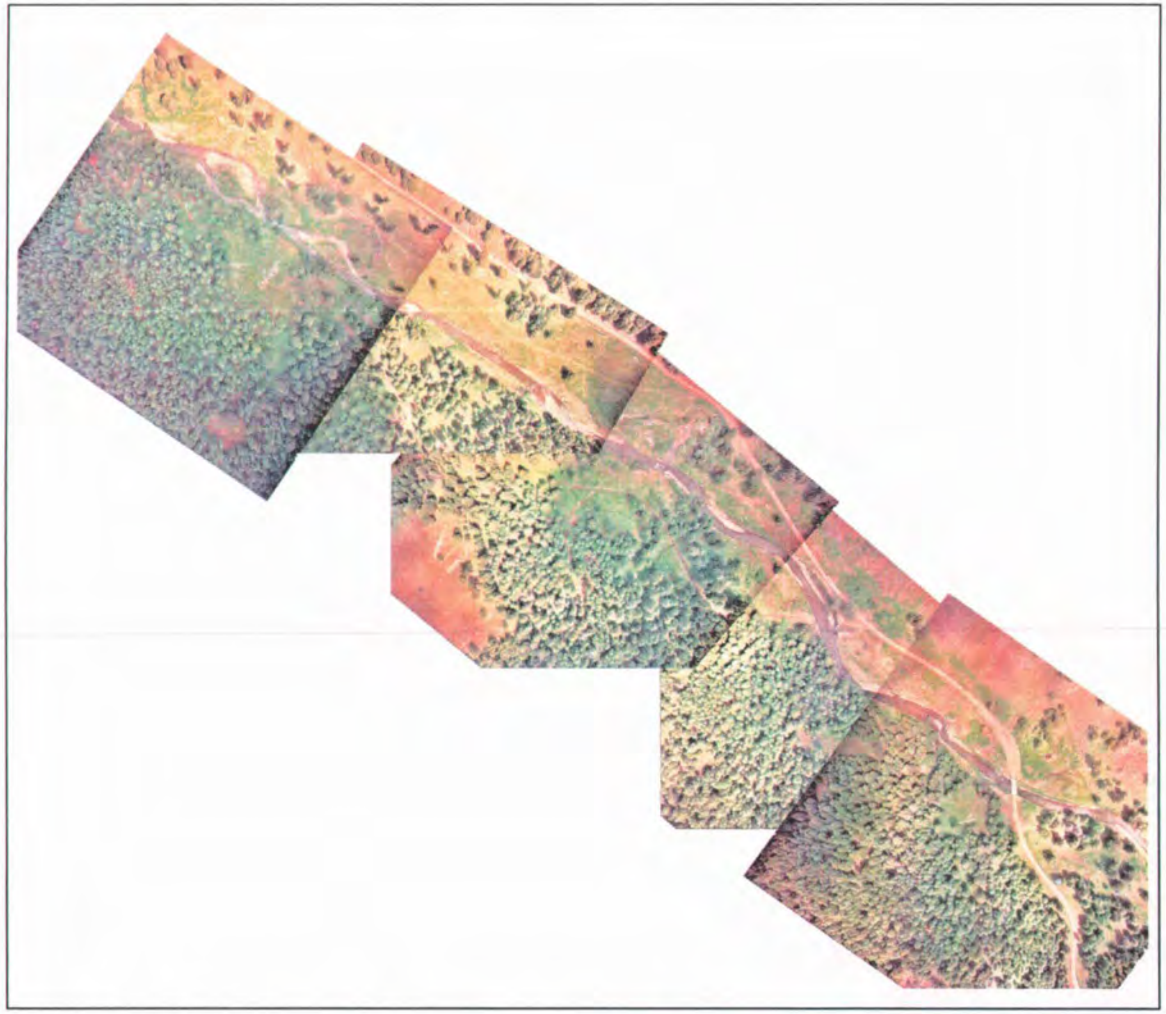

Figure 3.3. Combination of geocorrected aerial photographs taken on June 11, 1976 for Phase III in Meadow Creek

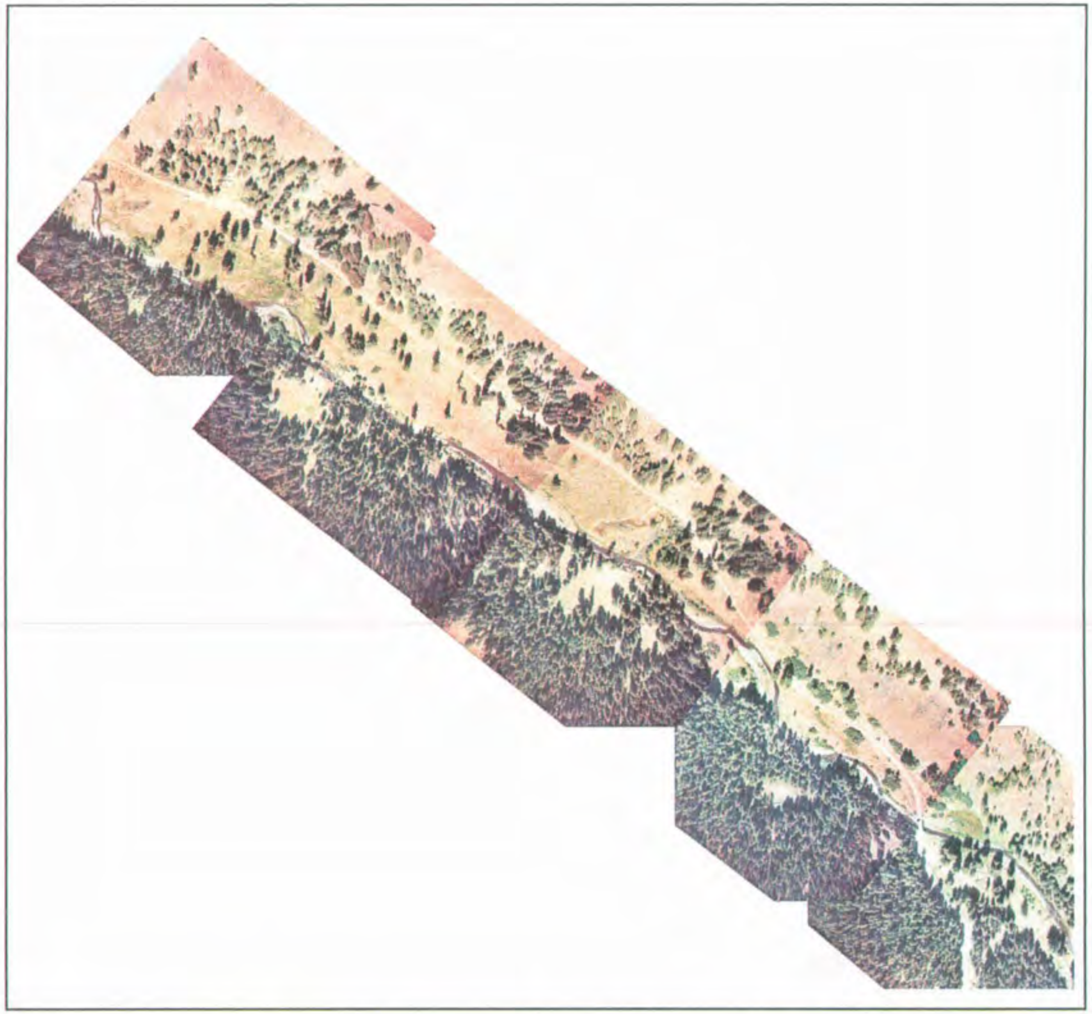

Figure 3.4. Combination of geocorrected aerial photographs taken on August 23, 1984 for Phase III in Meadow Creek

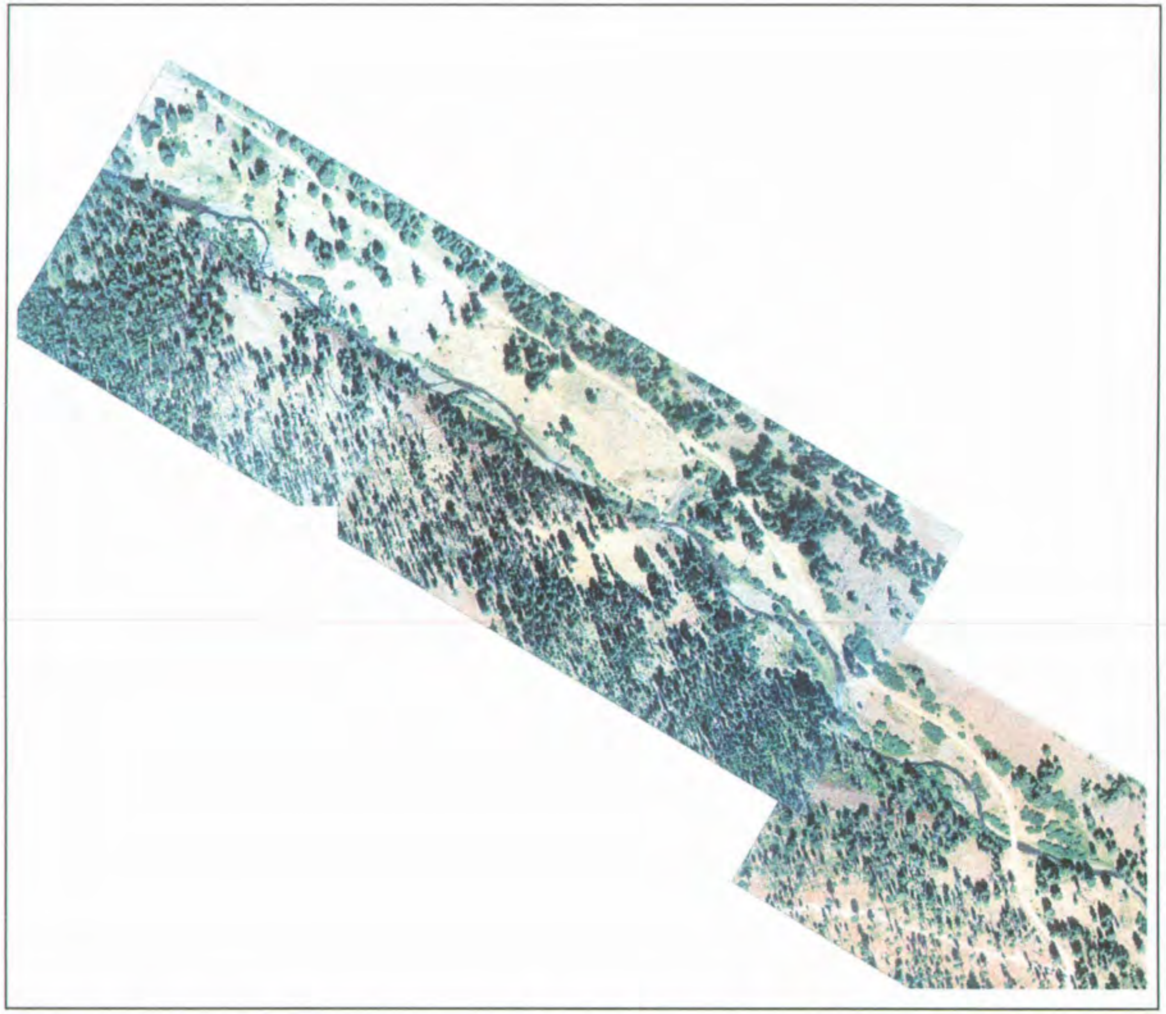

Figure 3.5. Combination of geocorrected aerial photographs taken on August 7, 2001 for Phase III in Meadow Creek

Table 3.2. Effects of 25 years of grazing on stream length changes for Meadow Creek in the Starkey Experimental Forest and Range.

Year	Treatment		Distance (m)	Stream length (m)	Sinuosity[a]
1976	Grazed	South Bank	863	872	1.05
		North Bank	880		
	Ungrazed	South Bank	242	237	1.11
		North Bank	232		
	Total	South Bank	1105	1109	1.07
		North Bank	1113		
1984	Grazed	South Bank	898	903	1.09
		North Bank	908		
	Ungrazed	South Bank	251	247	1.15
		North Bank	243		
	Total	South Bank	1149	1150	1.11
		North Bank	1151		
2001	Grazed	South Bank	904	898	1.08
		North Bank	892		
	Ungrazed	South Bank	253	251	1.17
		North Bank	249		
	Total	South Bank	1157	1148	1.10
		North Bank	1141		

[a] sinuosity is calculated as channel length / valley length

conducted in central Oregon, Magilligan and McDowell (1997) reported that on 3 of 4 streams the grazed channel had greater sinuosity than the ungrazed exclosures.

Stream widths that are presented (Table 3.3) here are the population therefore limited statistical calculations were conducted. In 1976, the average width of the channel was 8.39 m, and 4.79 and 4.90 m in 1984 and 2001, respectively. The difference for widths could be attributed to the changes in flow for 1976. Flow for Meadow Creek on June 11, 1976 was 0.35 m^3s^{-1}, August 23, 1984 was 0.044 m^3s^{-1} and 0.045 m^3s^{-1} on August 7, 2001. Average flows were given because gauging stations were not present or non-functional for 1976 or 1984, but for 2001 the actual flow measurement was available.

In 1976, the width of the grazed section, 8.38 m, was similar to the ungrazed section, 8.51 m, but in 1984 and 2001 the ungrazed section was narrower. In 1984 the difference of width between grazed and ungrazed was less than a meter, 4.92 and 4.28 m respectively. However, by 2001 the difference between grazed and ungrazed had become greater than a meter, 5.21 and 3.90 m respectively. The results given here are similar to those reported by Magilligan and McDowell (1997). In their study bankfull width of the grazed section of the stream was on average a meter wider than the width of the ungrazed section. However, other researchers (Kondolf, 1993 and Laliberte, 2000) showed that widths were not different between grazed and ungrazed segments

Table 3.3. Surface area and width measurements of Meadow Creek as determined by aerial photography

Year	Treatment	Surface Area (m^2)	Width (m)	SD[a]	N[b]	Flow (m^3s^{-1})[c]
1976	Grazed	7076	8.38	2.63	1541	
	Ungrazed	2047	8.51	2.57	415	
	Average		8.39	2.62	1968	0.35
1984	Grazed	4506	4.92	1.92	1590	
	Ungrazed	1069	4.28	1.14	435	
	Average		4.79	1.81	2024	0.044
2001	Grazed	4622	5.21	2.49	1560	
	Ungrazed	998	3.90	1.13	455	
	Average		4.90	2.31	2037	0.045

[a] Standard Deviation
[b] Number of stream width measurements taken
[c] 1976 and 1984 was calculated as an average flow, and 2001 was actual flow

of stream. In the above research, ungrazed sections have had grazing removed for at least 10 years.

When looking at how similar the channels were between years, it is clear that little overall change has taken place. The 1984 stream was 72% as similar as the 1976 stream (Figure 3.6), in other words approximately ¾ of stream in 1984 was in the same location as 1976. This was most likely due to the greater width of the stream in 1976. Fifty one percent of the stream in 2001 was the same as it was in 1984 (Figure 3.7). However, 53% of the 2001 stream was the same as in 1976 (Figure 3.8), this increase of similarity was due to the greater stream channel width in 1976. The greatest difference in stream segments occurred when comparing the ungrazed sections of 1984 and 2001, where 37% of the 2001 channel was the same as 1984. In general, the grazed treatments were more similar than the ungrazed treatments. Laliberte (2000) showed that treatment effect, grazing vs. ungrazed, had little effect on the similarity of channels between years.

The difference in islands within the creek between 1976 and 2001 (Figure 3.9) may give some insight into stability of this system. In 1976 there were islands present in both the grazed and ungrazed sections of the stream, but in 1984 no islands were present, but islands were again present in 2001. Comparing 1976 and 2001, no islands were in the same location for either year. This may imply that Meadow Creek is a fairly dynamic system and that grazing has little effect on channel characteristics.

This segment of stream has unique features that influence the characteristics of the channel. The channel has down cut to bedrock so only lateral movement is possible.

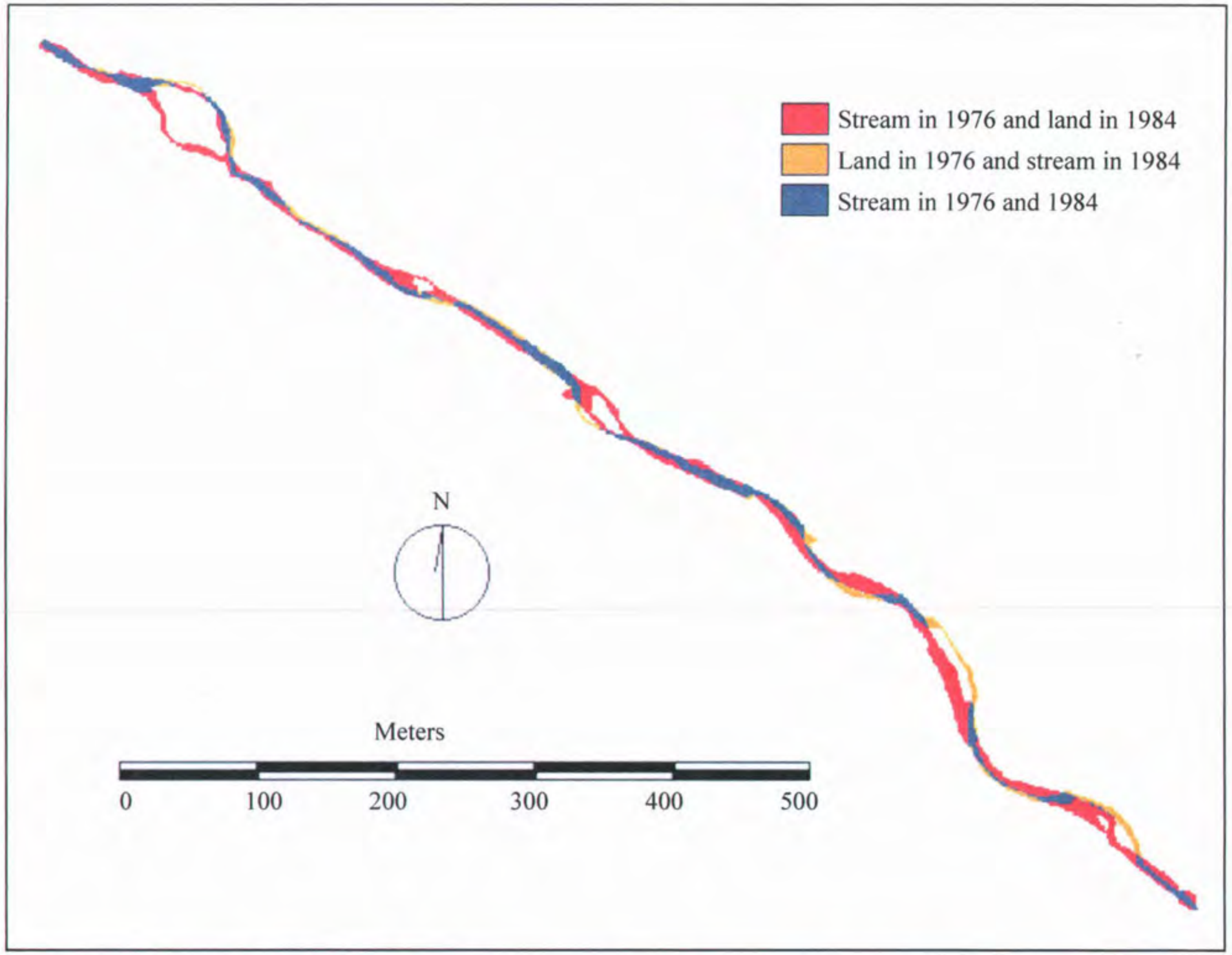

Figure 3.6. Overlay of Meadow Creek stream channels representing aerial photos taken in 1976 and 1984

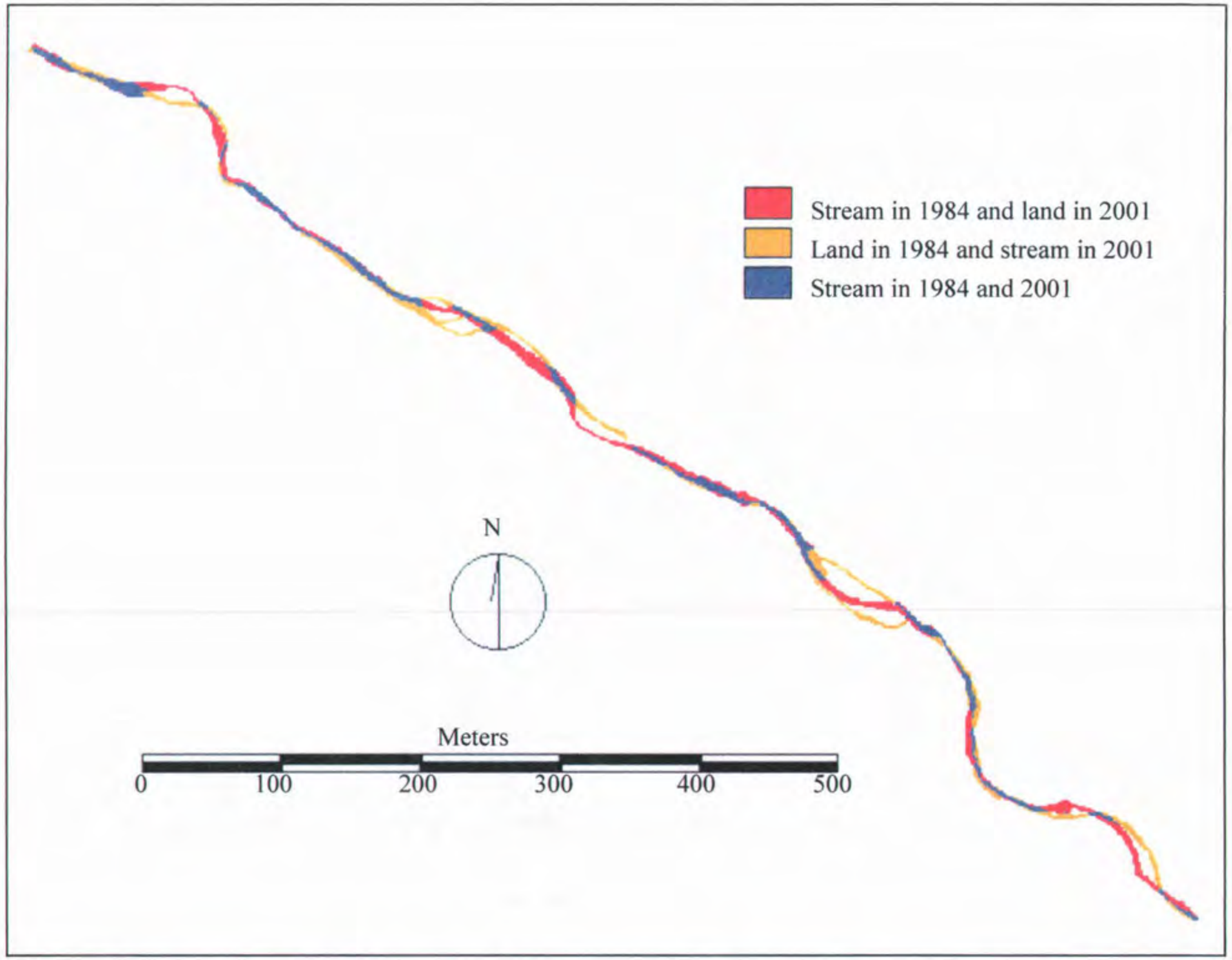

Figure 3.7. Overlay of Meadow Creek stream channels representing aerial photos taken in 1984 and 2001

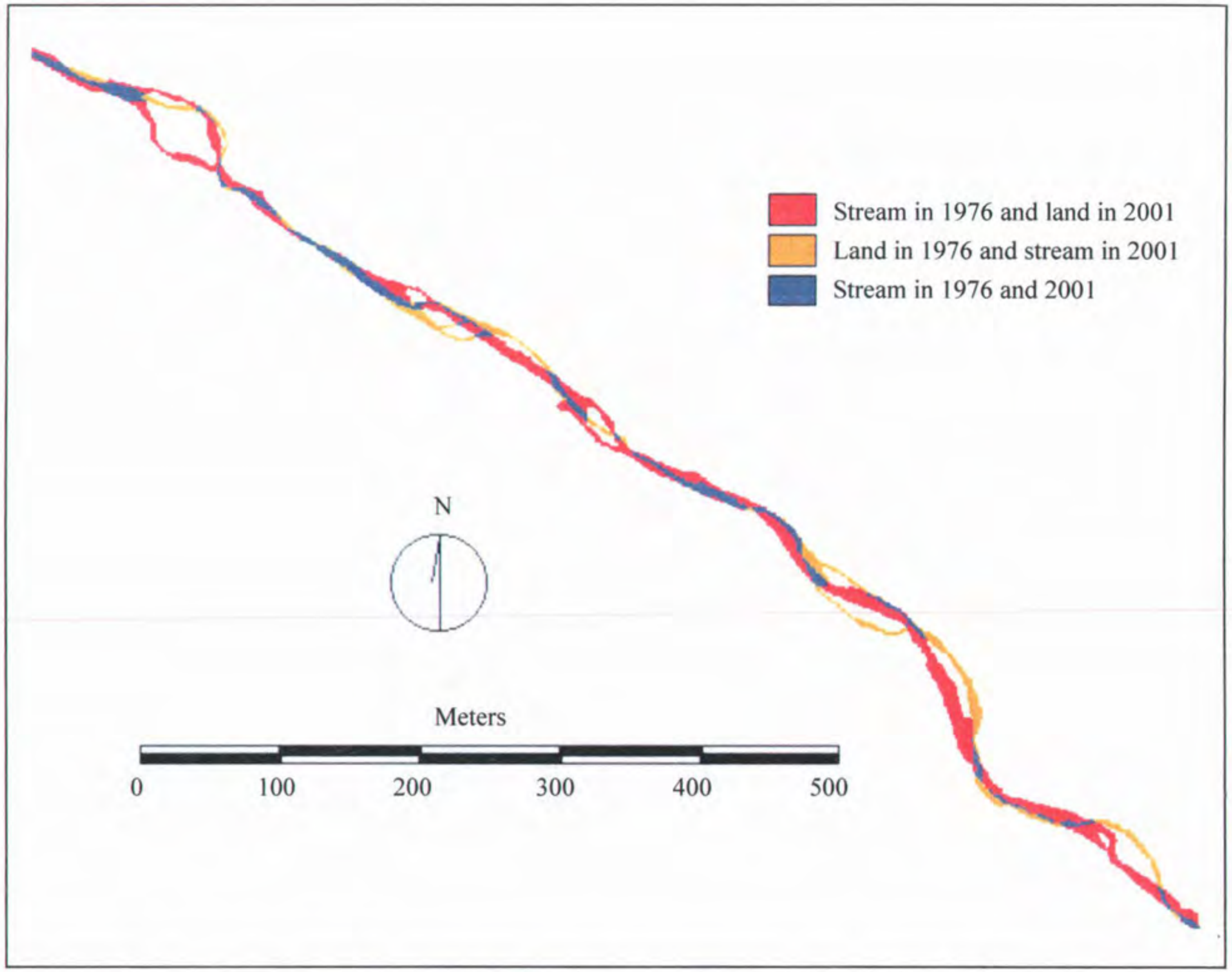

Figure 3.8. Overlay of Meadow Creek stream channels representing aerial photos taken in 1976 and 2001

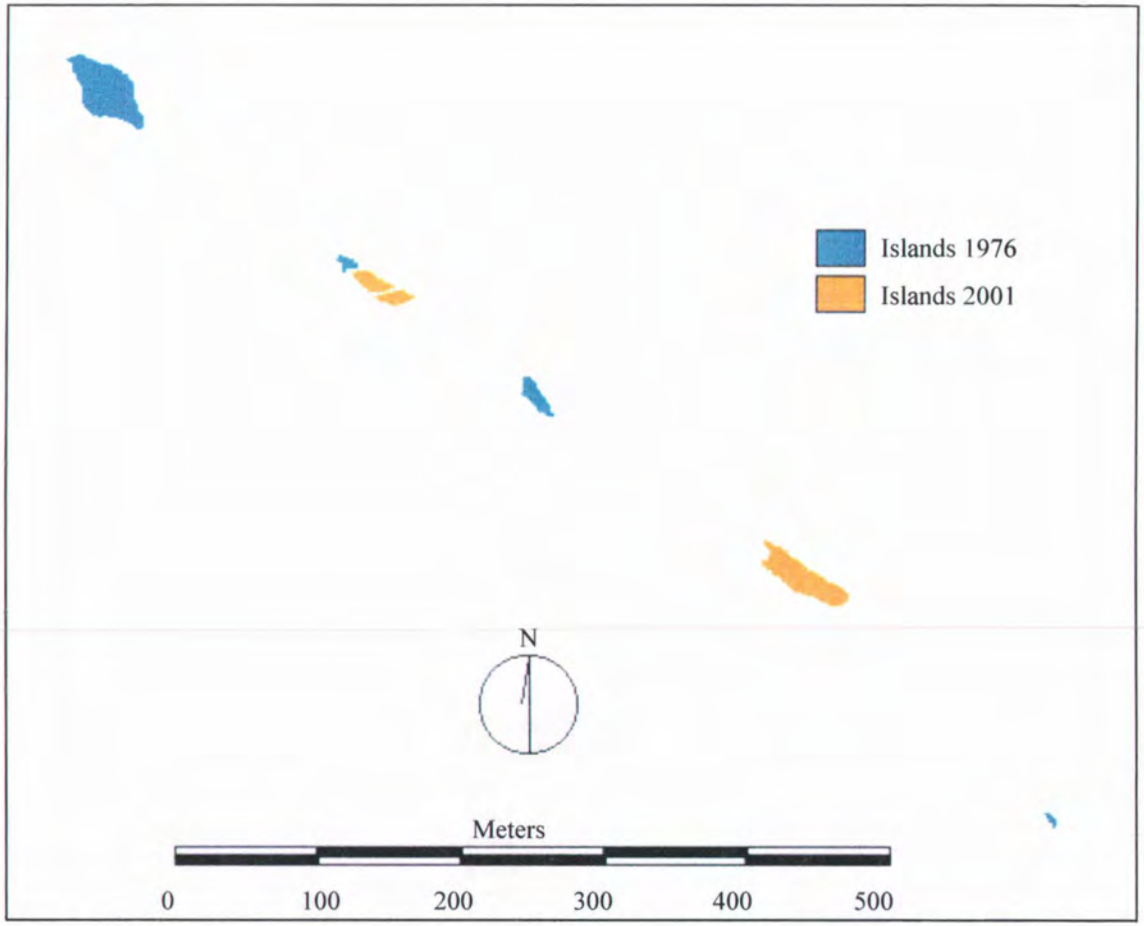

Figure 3.9. Change in island location at Meadow Creek between 1976 and 2001

Within the grazed pastures, the southern bank is close to a rock wall and little movement can be made in this direction; therefore the majority of lateral movement must be on the northern bank. Remnants of a splash dam are present on Meadow Creek in the grazed pasture. The portion of stream that flows through the ungrazed control is less influenced by the rock wall on the south bank, possibly allowing greater lateral movement of the stream. The farthest down stream spot of the ungrazed control is forced to go under a bridge and at this point, a road on the north also affects the channel near the bridge.

The stream bank deterioration on this system indicates that grazing does not significantly increase bank erosion (Buckhouse *et al.* 1981). Instead, they concluded that over-winter effects of high flow, ice flow and the channel's physical form contribute to the erosive effects seen in this system.

Photo Points

Photo points 1, 2 and 2a will be used to observe changes from total exclusion of grazing from both cattle and big game (Phase III pasture 5). Photo point 2a is downstream around the bend from photo point 2. Photo points 3 thru 6 were taken to document changes in structure in the cattle only grazing pastures (Phase III pasture 1 thru 4). Photo point 5a is upstream and looking back towards photo point 5. Photo point 7a and 7b are a panoramic view within a game only grazing pasture (Phase II pasture 5).

Photo point 1 (Figures 3.10 thru 3.14) showed the affects of shrub growth and minor channel movement. In 1976 (Figure 3.10) the creek was running through the center of the photo and vegetation is at the channel's edge. By 1983 (Figure 3.11) the channel moved toward the shrubs at the left and bare rock remains where the channel previously ran. The years of 1988 (Figure 3.12) and 1993 (Figure 3.13) showed shrub growth on both banks and still the old channel of 1978 remains bare. By 2000 (Figure 3.14) Meadow Creek was getting considerable shading on the left bank and shrubs along the right bank are continuing their previous steady growth. Expansion of vegetation onto the old channel in 1978 was slowly occurring. The most identifiable feature throughout all of these pictures is the rapid growth of woody vegetation along Meadow Creek; however since the photo in 1983 limited recruitment of juvenile shrubs can be identified.

Photo point 2, also taken in the exclosure, shows the recovery of streambanks and vegetation recolonization of streambanks. In 1976 (Figure 3.15), stream banks showed evidence of heavy cattle use. Due to the date when photo was taken, it was difficult to determine amount of shrubs along creek. By 1984 (Figure 3.16) the stream banks were steeper and shrub growth was present. In 1987 (Figure 3.17) vegetation was moving out on the gravel bar.

Beginning in 1990, photo point 2 was moved downstream and around the bend from where it originally was and will be called 2a for purposes of this document. From the 10 year span from 1990 to 2000 (Figures 3.18 thru 3.20), dramatic changes are apparent in regard to shrub growth and vegetation on the gravel bar. The vegetation on the gravel bar in 2000 was different than the previous two photo points.

The gravel bar had grass and juvenile shrubs in 2000. In 1990, the gravel bar was dominated by weeds and forbs and in 1995 the plant community was predominantly grasses.

Photo point 3 is in the grazed section of Meadow Creek. In 1975 (Figure 3.21), the year the fences were constructed, shrubs along the right bank were small and probably eaten down. However, by 1983 (Figure 3.22) the shrub component along the bank was considerably greater than in 1975. Woody vegetation in 1990 (Figure 3.23) appears not to have grown much since 1983, but by 1995 (Figure 3.24) the shrubs appear to be more dense. In the 2000 photo (Figure 3.25) a shrub grew to the point where its branches were hanging out into the stream, also vegetation along the opposite bank was now down along the water.

Photo point 4 shows the revegetation of an old stream channel. In 1975 (Figure 3.26) part of the creek channel was to the left side of the photo, by 1983 (Figure 3.27) the stream channel was completely vegetated and shrubs have grown substantially. However, in 1991 (Figure 3.28) the old stream channel was opened up and most of the vegetation present in 1983 was removed. This could have been caused by the 25-year flood event in spring of 1991. Photo point 4a is upstream and looking back towards photo point 4. In 1990 (Figure 3.29) there was an ample amount of vegetation along the stream bank and vegetation was along the stream channel. By 1995, due to continual movement of the stream channel (Figure 3.30) some of the vegetation along the channel was removed. Channel movement caused a pine tree to fall over. Between 1995 and 2000 (Figure 3.31), that large pine tree prevented passage of other woody debris from being carried further down stream. Currently there are a number of large logs at this spot. The logs are most likely from the project that placed woody debris in Meadow Creek in 1990. Also during this time, the stream channel has moved slightly and removed the shrub that was present in the earlier two photos. In the 1995 and 2000 photos the channel moved against the bank and the natural process of bank sloughing was present.

Photo point 5 documented the effects of cattle grazing on riparian meadow forage regeneration. In 1978 (Figure 3.32) the photo was taken in July and there was little grass left and the cows were beginning to eat the shrubs. The dominant vegetation on the gravel bar as seen on the left side of the picture was forbs. However, by 1983 (Figure 3.33) grasses and shrubs were beginning to dominate the site, and by 1989 (Figure 3.34) grasses had completely recovered the gravel bar and this area now has a shrub component.

Photo point 6 (Figures 3.35 thru 3.37) is located immediately downstream from the splash dam. In all years, there was shrub vegetation on the left side of the photo, and the right bank was essentially a bare gravel bar. In 1995, there was a little vegetation trying to establish on the right bank, but in 2000 vegetation was no longer present. With this photo point being directly downstream from the splash dam it is not unexpected to see a bare gravel bar. The splash dam acts as a funnel and any large flows are intensified and exaggerated here because the splash dam is narrow and does not allow overland flow to aid in the dissipation of energy, therefore the erosive potential below the splash dam will be greatly increased.

Photo point 7 was not initially taken at the onset of the main photos and is located in Phase II pasture 5 (Figure 3.2). This pasture has been ungrazed by cattle since 1975 and the only ungulate herbivory influences on vegetation and stream channel was from wildlife. This photo point was a collection of panoramic shots taken from approximately the same location. The first grazing season photo was taken in 1986 and then continued every year, but in 1985 it was photographed in the spring. Beginning in the early 1990's the photo point was moved slightly from its previous location. In 1986 (Figure 3.38 and 3.39) the left bank, in the photo, was under cut and there was good vegetation cover on top of the bank. The gravel bar on the right bank was showing some revegetation and some grass was growing right along side the stream. There were some small forbs on the gravel bar as well. Since leaves had fallen off of the shrubs, it was difficult to determine their abundance. However, some shrubs were present but relatively small. However, in 1991 (Figures 3.40 and 3.41) there are more shrubs present and they appeared to be significantly larger. The pine tree that was present in 1986 (Figure 2.38) fell in the spring and some woody debris were trapped by it. The stream channel was currently going above and below the fallen tree. The gravel bar was bare at this time, but at the far bend the grass grew down to the waters edge and a patch of weeds were no longer present. The channel continues to erode the left bank through 1996 (Figure 3.42). Grass was beginning to move towards the fallen tree. The gravel bar (Figure 3.43) was still bare and suggests the vegetation has reached some barrier. In 2000 (Figures 3.44 and 3.45) the grass filled in behind the woody debris, but on the gravel bar the majority of the vegetation was still at the same location as in 1996. With careful inspection, some small forbs were beginning to establish out on the gravel bar.

CONCLUSIONS

Even though the length and sinuosity changes are greatest in the ungrazed areas, the formation and removal of islands suggests that stream dynamics are driving the changes observed at Meadow Creek and not cattle grazing. It appears that vegetation is responding positively, shrub growth is occurring regardless of grazing, and overall woody vegetation has become an important component of the riparian vegetation. Meadow Creek appears to be recovering from historical overgrazing of the riparian areas.

Figure 3.10. Photo Point 1, taken on 7/1978

Figure 3.11. Photo Point 1, taken on 7/1983

Figure 3.12. Photo Point 1, taken on 8/1988

Figure 3.13. Photo point 1, taken on 7/1993

Figure 3.14. Photo point 1, taken on 7/2000

Figure 3.15. Photo point 2, taken on 11/1976

Figure 3.16. Photo point 2, taken on 7/1984

Figure 3.17. Photo point 2, taken on 7/1987

Figure 3.18. Photo point 2a, taken on 7/1990

Figure 3.19. Photo point 2a, taken on 7/1995

Figure 3.20. Photo point 2a, taken on 7/2000

Figure 3.21. Photo point 3, taken on 7/1975

Figure 3.22. Photo point 3, taken on 7/1983

Figure 3.23. Photo point 3, taken on 8/1990

Figure 3.24. Photo point 3, taken on 7/1995

Figure 3.25. Photo point 3, taken on 7/2000

Figure 2.26. Photo point 4, taken on 7/1975

Figure 2.27. Photo point 4, taken on 7/1983

Figure 3.28. Photo point 4, taken on 7/1991

Figure 3.29. Photo point 4a, taken on 7/1990

Figure 3.30. Photo point 4a, taken on 7/1995

Figure 3.31. Photo point 4a, taken on 7/2000

Figure 3.32. Photo point 5, taken on 7/1978

Figure 3.33. Photo point 5, taken on 7/1983

Figure 3.34. Photo point 5, taken on 7/1989

Figure 3.35. Photo point 6, taken on 7/1991

Figure 3.36. Photo point 6, taken on 7/1995

Figure 3.37. Photo point 6, taken on 7/2000

Figure 3.38. Photo point 7a, taken on 9/1986

Figure 3.39. Photo point 7b, taken on 9/1986

Figure 3.40. Photo point 7a, taken on 7/1991

Figure 3.41. Photo point 7b, taken on 7/1991

Figure 3.42. Photo point 7a, taken on 8/1996

Figure 3.43. Photo point 7b, taken on 8/1996

Figure 3.44. Photo point 7a, taken on 7/2000

Figure 3.45. Photo point 7b, taken on 7/2000

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CHAPTER 4

SUMMARY

From these experiments it appears that sustainability of riparian resources can be achieved with proper management. Within the pastures of Phase III it appears that the level of grazing, stocking rate, may have been of greater importance than grazing system in the recovery of the system. Even though stocking rates did not vary, the grazing was not great enough to cause further deterioration of the riparian area. This study also implies the importance of managing riparian areas as separate pastures.

The use of grazing systems on forested rangelands did not appear to have any affect on overall animal gains, and in some cases may enhance gains. Mature cow weight gain is more affected by season with heifers being moderately affected and suckling calves being least. This may be due to the increased requirements of lactation. Calves and yearling heifers both have a requirement for growth but the main difference between them was the ability of the calves to supplement their diet with milk. Therefore the calves were able to maintain, to some degree, their rate of growth.

The effect of specialized grazing systems, in these studies, allowed for similar distribution patterns in average years as the free ranging animals. However, as conditions change, unrestricted animals were able to change patterns of use to accommodate the changes in the environment.

Forage quality cannot be overlooked. In general the crude protein content and *in vitro* DMD of bluebunch wheatgrass and Idaho fescue declined as the grazing season progressed. There was also a difference between north- and south-facing slopes, with the north-facing slopes having higher crude protein content and *in vitro* DMD. The differences between slopes may be due to differences in soil moisture holding capacity, increased soil depth and increased canopy cover. These differences can be extremely important later in the season after forage on the grassland pastures has been removed and/or dried up.

Although the effect of grazing was only evaluated for a single portion of the creek, it still allows for some insight as to how the channel characteristics are maintained. It is evident, by the aerial photos and photo points, that grazing has had negligible effects on restricting shrub growth. In both the no graze control and the grazed sections, shrubs are now an important component of the riparian community. The changes in the channel appear to be maintained through natural processes, as evident by the removal and creation of islands.

As stated earlier, the inflexibility of management makes it difficult to properly manage cattle across a diverse landscape. However, by using specialized grazing systems, that use differences in forage quality, the sometimes negative effects of grazing can be removed. Shrub regrowth, channel narrowing, channel length increasing, and recovery of a riparian community can happen in the presence of cattle.

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APPENDICIES

APPENDIX A: CATTLE WEIGHTS

Table A.1: Yearling heifer weights (kg) by weigh period from 1982 to 1986 for Phase IV pastures in Meadow Creek

Treatment[a]	Year	Weight 1	Weight 2	Weight 3	Weight 4	Weight 5
Managed	82	386	443	481	481	507
Managed	82	417	459	485	499	515
Managed	82	392	438	475	488	501
Managed	82	288	337	363	369	383
Managed	82	306	351	364	387	408
Managed	82	337	381	396	415	430
Managed	82	307	343	358	374	390
Managed	82	362	408	423	440	457
Managed	82	353	404	428	454	466
Managed	82	274	318	340	362	377
Managed	82	277	318	329	357	369
Managed	82	323	369	391	414	424
Managed	82	284	318	339	362	369
Managed	82	323	365	404	415	431
Managed	82	363	418	438	465	481
Managed	82	338	398	418	438	453
Managed	82	302	338	363	370	389
Managed	82	246	273	292	309	318
Managed	82	350	399	425	445	455
Managed	82	326	375	401	417	432
Managed	82	337	382	400	396	413
Managed	82	318	360	379	401	414
Managed	82	352	379	408	427	442
Managed	82	332	363	375	401	400
Managed	82	332	376	394	414	424
Managed	82	287	331	355	366	367
Managed	83	377	406	434	455	467
Managed	83	380	389	414	448	469
Managed	83	397	411	425	435	462
Managed	83	401	414	437	462	486
Managed	83	395	412	453	468	476
Managed	83	362	371	410	431	447
Managed	83	404	430	457	474	491
Managed	83	393	406	436	456	479
Managed	83	429	454	469	482	508
Managed	83	433	460	487	523	523

Table A.1 cont.

Managed	83	401	425	444	455	479
Managed	83	375	408	432	456	472
Managed	83	406	416	459	494	511
Managed	83	365	384	406	433	450
Managed	83	403	422	449	478	491
Managed	83	378	402	424	445	461
Managed	83	352	369	387	410	425
Managed	83	333	359	385	391	411
Managed	83	346	356	368	394	413
Managed	83	374	403		425	448
Managed	83	358	370	381	408	416
Managed	83	326	340		357	369
Managed	83	341	357	383	403	424
Managed	83	346	363	373	401	405
Managed	83	389	408	431	456	463
Managed	83	319	336	363	361	356
Managed	84	322	349	391	408	445
Managed	84	344	358	399	413	442
Managed	84	326	348	379	395	422
Managed	84	318	352	390	409	445
Managed	84	332	358	392	401	424
Managed	84	327	342	385	397	425
Managed	84	326	349	381	402	435
Managed	84	345	358	389	398	433
Managed	84	316	335	372	388	411
Managed	84	365	385	417	436	473
Managed	84	383	411	450	464	495
Managed	84	353	375	408	427	458
Managed	84	322	360	399	411	447
Managed	84	306	337	363	384	409
Managed	84	342	363	399	419	450
Managed	84	339	353	408	430	465
Managed	84	336	347	390	408	424
Managed	84	312	325	393	408	432
Managed	84	371	387	440	454	479
Managed	84	360	379	415	425	459
Managed	84	310	326	372	393	413
Managed	84	342	355	361	377	408
Managed	84	376	401	435	446	476
Managed	84	312	327	364	381	413

Table A.1 cont.

Managed	84	326	358	393	404	430
Managed	84	284	295	324	339	361
Managed	85	399	450	460	483	479
Managed	85	387	430	428	457	458
Managed	85	358	408	411	444	446
Managed	85	357	399	408	434	435
Managed	85	385	438	449	471	469
Managed	85	431	453	479	497	463
Managed	85	427	485	493	513	499
Managed	85	378	409	416	451	442
Managed	85	376	424	420	454	454
Managed	85	376	421	435	456	454
Managed	85	421	458	476	500	476
Managed	85	386	446	444	471	463
Managed	85	334	367	374	404	397
Managed	85	326	363	383	391	381
Managed	85	400	452	461	494	466
Managed	85	342	401	407	430	426
Managed	85	396	451	454	477	475
Managed	85	406	440	446	473	466
Managed	85	389	420	435	460	444
Managed	85	381	422	441	455	460
Managed	85	340	386	394	422	422
Managed	85	331	385	387	417	411
Managed	85	460	519	503	518	525
Managed	85	425	492	499	515	503
Managed	85	373	413	427	444	451
Managed	85	360	405	423	450	452
Managed	86	375	390	414	415	408
Managed	86	369	396	408	423	408
Managed	86	418	436	455	469	445
Managed	86	461	474	515	511	503
Managed	86	430	448	477	483	472
Managed	86	396	422	440	456	448
Managed	86	419	440	460	489	468
Managed	86	442	450	478	494	477
Managed	86	388	408	427	446	435
Managed	86	448	475	499	502	494
Managed	86	368	383	406	422	420
Managed	86	351	378	407	430	417

Table A.1 cont.

Managed	86	372	396	412	425	430
Managed	86	408	432	466	478	473
Managed	86	408	424	460	472	462
Managed	86	374	391	416	423	426
Managed	86	422	452	484	499	476
Managed	86	370	395	424	426	415
Managed	86	376	400	429	438	418
Managed	86	407	425	454	471	454
Managed	86	360	381	408	433	410
Managed	86	443	471	492	515	499
Managed	86	358	386	408	425	425
Managed	86	406	436	461	482	454
Managed	86	396	426	460	463	461
Managed	86	386	415	445	445	435
Free Choice	82	398	444	473	492	502
Free Choice	82	408	444	476	464	492
Free Choice	82	383	409	433	442	453
Free Choice	82	306	350	362	379	394
Free Choice	82	316	360	373	399	399
Free Choice	82	336	378	401	389	414
Free Choice	82	309	354	370	389	408
Free Choice	82	372	426	443	457	461
Free Choice	82	347	391	422	430	447
Free Choice	82	243	284	303	318	335
Free Choice	82	283	324	362	363	379
Free Choice	82	316	356	386	391	413
Free Choice	82	316	364	401	397	418
Free Choice	82	299	340	363	377	393
Free Choice	82	363	405	419	445	455
Free Choice	82	339	391	399	407	417
Free Choice	82	301	323	351	367	381
Free Choice	82	242	296	313	317	340
Free Choice	82	379	430	444	442	461
Free Choice	82	297	340	376	376	365
Free Choice	82	329	366	388	410	425
Free Choice	82	318	369	391	391	403
Free Choice	82	363	398	421	440	454
Free Choice	82	331	367	388	409	410
Free Choice	82	326	361	382	396	408
Free Choice	82	295	330	351	363	379

Table A.1 cont.

Free Choice	83	402	416	446		
Free Choice	83	406	426	450	470	483
Free Choice	83	397	413	454	479	489
Free Choice	83	374	397	420	439	449
Free Choice	83	409	436	450	482	492
Free Choice	83	376	408	435	465	469
Free Choice	83	431	446	469	495	496
Free Choice	83	382	385	408		
Free Choice	83	390	408	443	465	474
Free Choice	83	370	397	419	437	446
Free Choice	83	362	369	398	421	416
Free Choice	83	400	440	440	468	479
Free Choice	83	389	405	436	445	459
Free Choice	83	424	430	453	464	473
Free Choice	83	346	373	386	416	427
Free Choice	83	353	369	400	418	419
Free Choice	83	328	351	363	386	390
Free Choice	83	379	401	420	437	454
Free Choice	83	395	406	431	439	452
Free Choice	83	401	383	428	454	456
Free Choice	83	312	328	347	368	384
Free Choice	83	382	405	422	448	459
Free Choice	83	338	363	380	400	408
Free Choice	83	335	359	375	395	408
Free Choice	83	375	396	411	428	430
Free Choice	83	322	347	359	381	386
Free Choice	84	320	335	371	399	413
Free Choice	84	342	354	398	408	434
Free Choice	84	329	348	379	399	411
Free Choice	84	313	324	374	389	408
Free Choice	84	342	363	395	408	421
Free Choice	84	317	320	361	376	399
Free Choice	84	327	342	391	407	434
Free Choice	84	352	370	411	427	434
Free Choice	84	303	323			
Free Choice	84	357	372	411	414	449
Free Choice	84	390	408	460	463	494
Free Choice	84	349	379	403	418	444
Free Choice	84	323	347	389	393	421
Free Choice	84	310	326	371	384	401

Table A.1 cont.

Free Choice	84	337	356	404	408	442
Free Choice	84	348	366	408	414	440
Free Choice	84	318	341	381	408	425
Free Choice	84	318	332	381	393	411
Free Choice	84	372	391	435	448	465
Free Choice	84	354	363	429	440	463
Free Choice	84	329	348	390	396	412
Free Choice	84	332	340	385	395	420
Free Choice	84	371	389	445	454	494
Free Choice	84	312	319	357	363	390
Free Choice	84	330	337	384	400	416
Free Choice	84	275	291	338	352	362
Free Choice	85	369	397	413	420	426
Free Choice	85	388	429	429	462	450
Free Choice	85	389	416	443	454	467
Free Choice	85	386	408	420	454	453
Free Choice	85	318	345	347	376	388
Free Choice	85	408	442	454	472	474
Free Choice	85	396	414	444	460	454
Free Choice	85	412	432	460	496	488
Free Choice	85	377	406	418	424	445
Free Choice	85	384	424	445	446	442
Free Choice	85	363	393	407	420	428
Free Choice	85	397	439	454	474	482
Free Choice	85	417	453	467	499	497
Free Choice	85	371	401	409	433	430
Free Choice	85	383	423	436	453	455
Free Choice	85	384	421	421	453	438
Free Choice	85	386	420	430	454	454
Free Choice	85	397	417	434	458	459
Free Choice	85	376	411	423	447	440
Free Choice	85	360	399	411	427	431
Free Choice	85	369	415	422	454	458
Free Choice	85	379	420	424	441	442
Free Choice	85	398	437	451	461	467
Free Choice	85	385	425	435	461	454
Free Choice	85	357	383	400	425	442
Free Choice	85	379	413	422	440	439
Free Choice	86	422	454	482	484	484
Free Choice	86	358	367	386	389	383

Table A.1 cont.

Free Choice	86	347	381	405	407	394
Free Choice	86	391	429	435	426	
Free Choice	86	427	412	447	464	466
Free Choice	86	434	463	481	474	484
Free Choice	86	433	454	466	494	481
Free Choice	86	469	499	523	543	528
Free Choice	86	389	419	446	437	462
Free Choice	86	374	408	440	428	423
Free Choice	86	430	452	477	473	484
Free Choice	86	353	391	416	430	408
Free Choice	86	410	448	460	451	449
Free Choice	86	432	451	461	478	476
Free Choice	86	404	443	457	479	487
Free Choice	86	404	420	433	454	444
Free Choice	86	332	362	366	382	384
Free Choice	86	394	396	419	441	455
Free Choice	86	390	419	441	455	445
Free Choice	86	408	431	439	463	464
Free Choice	86	411	454	481	486	487
Free Choice	86	414	424	443	469	454
Free Choice	86	371	401	430	429	416
Free Choice	86	424	444	469	468	475
Free Choice	86	389	420	442	462	450
Free Choice	86	337	356	380	390	390

[a] Managed = Managed grazing system, Free Choice = Free choice grazing system

Table A.2: Yearling heifer weights (kg) by weigh period from 1982 to 1985 for Phase II pastures in Meadow Creek

Treatment[a]	Year	Weight 1	Weight 2	Weight 3	Weight 4	Weight 5
Deferred	82	343	383	405		
Deferred	82	300	329	358		
Deferred	82	302	347	369		
Deferred	82	315	362	405		
Deferred	82	274	314	345		
Deferred	82	331	371	398		
Deferred	82	381	420	444		
Deferred	82	328	367	405		
Deferred	82	304	350	379		
Deferred	82	342	392	418		
Deferred	82	274	318	352		
Deferred	82	297	332	370		
Deferred	82	193	227	257		
Deferred	82	218	258	289		
Deferred	82	308	352	369		
Deferred	82	322	364	390		
Deferred	82	369	408	451		
Deferred	82	352	390	417		
Deferred	83			446	459	456
Deferred	83			408	440	439
Deferred	83			408	426	420
Deferred	83			418	438	429
Deferred	83			408	420	419
Deferred	83			387	408	384
Deferred	83			373	383	378
Deferred	83			400	414	401
Deferred	83			370	368	363
Deferred	83			398	402	398
Deferred	83			379	396	397
Deferred	83			363	380	364
Deferred	83			391	408	399
Deferred	83			381	395	386
Deferred	83			406	424	412
Deferred	83			368	388	383
Deferred	83			429	452	432
Deferred	83			379	398	389
Deferred	83			380	393	384
Deferred	84	318	341	358		
Deferred	84	338	344	370		

Table A.2 cont.

Deferred	84	304	316	337		
Deferred	84	288	294	329		
Deferred	84	379	388	416		
Deferred	84	363	366	399		
Deferred	84	363	372	404		
Deferred	84	352	363	384		
Deferred	84	338	347	371		
Deferred	84	327	342	363		
Deferred	84	359	368	399		
Deferred	84	351	358	385		
Deferred	84	371	392	404		
Deferred	84	321	342	360		
Deferred	84	401	408	434		
Deferred	84	372	393	414		
Deferred	84	316	341	371		
Deferred	84	412	441	459		
Deferred	84	347	368	388		
Deferred	84	327	337	358		
Deferred	85			397	420	426
Deferred	85			406	427	418
Deferred	85			436	468	468
Deferred	85			403	414	413
Deferred	85			393	399	390
Deferred	85			379	402	405
Deferred	85			464	487	477
Deferred	85			420	446	437
Deferred	85			370	395	394
Deferred	85			394	413	408
Deferred	85			390	411	408
Deferred	85			386	413	410
Deferred	85			453	487	470
Deferred	85			363	390	379
Deferred	85			364	384	385
Deferred	85			394	411	406
Deferred	85			390	430	417
Deferred	85			408	419	410
Deferred	85			419	440	430
Deferred	85			425	445	445
Rest Rotation	82	356	395	427	448	437
Rest Rotation	82	290	336	364	381	375
Rest Rotation	82	303	334	363	376	357

Table A.2 cont.

Rest Rotation	82	315	360	394	407	403
Rest Rotation	82	315	361	406	417	424
Rest Rotation	82	296	309	328	350	341
Rest Rotation	82	263	269	290	308	291
Rest Rotation	82	322	360	392	400	384
Rest Rotation	82	374	409	448	468	468
Rest Rotation	82	343	368	391	407	407
Rest Rotation	82	307	338	368	374	365
Rest Rotation	82	344	382	425	438	446
Rest Rotation	82	286	318	348	361	359
Rest Rotation	82	301	331	367	381	367
Rest Rotation	82	193	226	248	260	258
Rest Rotation	82	214	244	271	277	274
Rest Rotation	82	313	352	382	395	396
Rest Rotation	82	318	362	396	401	401
Rest Rotation	82	351	393	416	445	431
Rest Rotation	82	361	389	415	427	412
Rest Rotation	83	407	408	432	454	450
Rest Rotation	83	392	398	430	454	453
Rest Rotation	83	372	385	408	432	433
Rest Rotation	83	363	371	388	410	416
Rest Rotation	83	328	332	360	372	375
Rest Rotation	83	337	341	362	384	394
Rest Rotation	83	362	368	385	406	411
Rest Rotation	83	379	384	414	431	433
Rest Rotation	83	357	363	389	399	391
Rest Rotation	83	368	367	386	397	407
Rest Rotation	83	363	365	392	408	400
Rest Rotation	83	392	401	415		
Rest Rotation	83	355	363	386	404	400
Rest Rotation	83	363	363	394	398	407
Rest Rotation	83	387	392	406	433	422
Rest Rotation	83	396	399	415	427	429
Rest Rotation	83	371	394	417	436	434
Rest Rotation	83	346	361	360	371	381
Rest Rotation	83	363	385	405	428	427
Rest Rotation	83	381	389	405	419	414
Rest Rotation	84	331	346	374	385	400
Rest Rotation	84	308	320	342	360	363
Rest Rotation	84	320	328	367	383	394
Rest Rotation	84	318	328	346	361	376

Table A.2 cont.

Rest Rotation	84	379	396	424	440	453
Rest Rotation	84	364	386	402	419	440
Rest Rotation	84	335	355	368	385	396
Rest Rotation	84	362	381	404	409	426
Rest Rotation	84	343	363	384	388	399
Rest Rotation	84	331	348	376	397	404
Rest Rotation	84	355	371	392	396	406
Rest Rotation	84	371	375	397	411	426
Rest Rotation	84	352	372	400	419	434
Rest Rotation	84	325	361	386	394	397
Rest Rotation	84	400	391			
Rest Rotation	84	361	374	397	420	421
Rest Rotation	84	312	318	339	358	369
Rest Rotation	84	383	399	421	426	447
Rest Rotation	84	356	363	388	393	408
Rest Rotation	84	309	326	349	363	388
Rest Rotation	85	353	420	438	460	464
Rest Rotation	85	367	418	420	435	453
Rest Rotation	85	334	400	403	426	435
Rest Rotation	85	367	414	420	445	450
Rest Rotation	85	375	433	432	454	450
Rest Rotation	85	383	430	444	464	470
Rest Rotation	85	324	365	374	404	396
Rest Rotation	85	352	391	386	409	411
Rest Rotation	85	390	454	454	488	487
Rest Rotation	85	343	402	407	430	441
Rest Rotation	85	314	373	391	406	406
Rest Rotation	85	333	398	398	430	424
Rest Rotation	85	356	409	408	430	435
Rest Rotation	85	338	374	397	411	408
Rest Rotation	85	283	327	341	365	373
Rest Rotation	85	307	363	363	386	397
Rest Rotation	85	313	363	366	398	395
Rest Rotation	85	320	376	383	410	408
Rest Rotation	85	341	403	404	420	420
Rest Rotation	85	327	372	377	406	401
Season Long	82	311	350	362	376	364
Season Long	82	312	337	357	367	363
Season Long	82	302	324	342	363	344
Season Long	82	272	303	319	337	326
Season Long	82	352	392	421	448	436

Table A.2 cont.

Season Long	82	190	216	234	240	237
Season Long	82	305	328	360	369	369
Season Long	82	356	386	415	435	416
Season Long	82	313	348	371	386	376
Season Long	82	358	386	408	430	420
Season Long	83	396	401	434	463	455
Season Long	83	363	386	408	431	420
Season Long	83	359	354	358	388	380
Season Long	83	374	384	399	436	426
Season Long	83	334	329	333	367	375
Season Long	83	365	370	405	428	430
Season Long	83	407	408	430	455	454
Season Long	83	328	340	353	379	382
Season Long	83	361	363	386	421	426
Season Long	83	379	392	406	447	451
Season Long	84	323	342	363	379	391
Season Long	84	310	324	351	363	363
Season Long	84	379	396	414	437	459
Season Long	84	352	368	395	408	434
Season Long	84	337	354	370	389	406
Season Long	84	353	375	396	408	420
Season Long	84	392	413	436	446	460
Season Long	84	365	391	408	440	452
Season Long	84	310	322	346	363	376
Season Long	84	313	334	347	370	385
Season Long	85	306	340	347	372	363
Season Long	85	346	401	417	440	435
Season Long	85	353	397	411	437	442
Season Long	85	348	404	416	446	435
Season Long	85	304	344	354	372	367
Season Long	85	364	421	426	445	442
Season Long	85	361	423	440	466	459
Season Long	85	393	453	465	496	499
Season Long	85	314	363	378	407	402
Season Long	85	318	364	391	410	408

[a] Deferred = Deferred grazing system, Rest Rotation = Rest rotation grazing sytem, Season Long = Season long grazing system

Table A.3: Cattle weights (kg) by weigh period from 1987 to 1990 for Complementary grazing experiment in Meadow Creek

Treatment[a]	Rep	Year	Weight 1	Weight 2	Weight 3	Weight 4	Weight 5
Deferred	1	1987	492	472	484	496	457
Deferred	1	1987	515	552	563	562	530
Deferred	1	1987	569	587	578	596	552
Deferred	1	1987	522	561	558	585	537
Deferred	1	1987	499	494	516	532	482
Deferred	1	1987	442	490	494	515	488
Deferred	1	1987	422	461	460	495	453
Deferred	1	1987	469	518	499	510	503
Deferred	1	1987	435	462	469	502	477
Deferred	1	1987	358	374	391	400	378
Deferred	1	1987	517	538	534	547	490
Deferred	1	1987	420	441	445	448	419
Deferred	1	1987	411	425	423	420	396
Deferred	1	1987	383	399	408	417	411
Deferred	1	1987	381	408	409	429	407
Deferred	1	1987	386	408	408	417	442
Deferred	2	1987	621	636	649	637	590
Deferred	2	1987	608	635	638	628	592
Deferred	2	1987	569	583	591	581	526
Deferred	2	1987	572	606	596	591	560
Deferred	2	1987	531	550	541	552	495
Deferred	2	1987	483	521	527	534	513
Deferred	2	1987	442	494	506	499	483
Deferred	2	1987	454	477	504	509	476
Deferred	2	1987	397	411	431	433	398
Deferred	2	1987	424	449	463	481	451
Deferred	2	1987	454	481	477	492	460
Deferred	2	1987	406	417	440	436	410
Deferred	2	1987	395	408	431	411	396
Deferred	2	1987	445	496	488	503	464
Deferred	2	1987	449	491	497	489	470
Deferred	2	1987	390	408	420	408	402
Deferred	1	1988	527	544	566	540	495
Deferred	1	1988	560	577	592	571	543
Deferred	1	1988	630	651	656	635	604
Deferred	1	1988	562	563	579	569	533
Deferred	1	1988	529	533	507	520	471
Deferred	1	1988	577	589	590	574	549

Table A.3 cont.

Deferred	1	1988	554	584	606	601	559
Deferred	1	1988	564	574	608	574	546
Deferred	1	1988	495	502	512	499	479
Deferred	1	1988	446	463	496	487	464
Deferred	1	1988	490	504	525	501	475
Deferred	1	1988	441	454	479	466	438
Deferred	1	1988	525	535	540	531	496
Deferred	1	1988	434	470	478	479	455
Deferred	1	1988	459	491	493	498	470
Deferred	1	1988	411	414	451	435	420
Deferred	2	1988	491	513	522	528	501
Deferred	2	1988	461	490	494	499	459
Deferred	2	1988	540	566	590	571	549
Deferred	2	1988	494	511	528	523	496
Deferred	2	1988	424	418	454	441	387
Deferred	2	1988	519	536	547	562	521
Deferred	2	1988	454	493	502	505	468
Deferred	2	1988	368	409	437	416	383
Deferred	2	1988	440	456	469	465	430
Deferred	2	1988	499	551	573	557	501
Deferred	2	1988	485	528	537	533	485
Deferred	2	1988	396	440	452	453	428
Deferred	2	1988	403	408	451	460	420
Deferred	2	1988	442	479	487	474	462
Deferred	2	1988	423	438	463	466	433
Deferred	2	1988	445	493	508	498	475
Deferred	1	1989	476	514	515	513	538
Deferred	1	1989	533	606		465	463
Deferred	1	1989	522	586			
Deferred	1	1989	401	457			
Deferred	1	1989	479	533	538	510	539
Deferred	1	1989	472	534			
Deferred	1	1989	565	635	654	625	618
Deferred	1	1989	522	569	590	604	616
Deferred	1	1989	465	529	528	544	533
Deferred	1	1989	401	457	439	452	485
Deferred	1	1989	494	563	563	572	575
Deferred	1	1989	401	447	453	463	478
Deferred	1	1989	440	499	497	492	520
Deferred	1	1989	454	508	515	510	508

Table A.3 cont.

Deferred	1	1989	413	475	492	499	497
Deferred	1	1989	413	469	459	470	499
Deferred	2	1989	445	507	489	492	463
Deferred	2	1989	526	590	591	598	559
Deferred	2	1989	490		520	529	523
Deferred	2	1989	590	668	656	661	647
Deferred	2	1989	538	621	590	577	583
Deferred	2	1989	510	566	578	578	558
Deferred	2	1989	497	560	552	537	538
Deferred	2	1989	515		596	606	605
Deferred	2	1989	494		582	583	582
Deferred	2	1989	479	544	544	544	537
Deferred	2	1989	506	577	579	576	576
Deferred	2	1989	460	507	534	541	551
Deferred	2	1989	438	499	500		
Deferred	2	1989	469	534	549	532	534
Deferred	2	1989	474	551	544	540	530
Deferred	2	1989	481	547	544	553	544
Plant Comm	1	1987	549	561	590	590	542
Plant Comm	1	1987	526	561	565	595	518
Plant Comm	1	1987	526	541	560	572	500
Plant Comm	1	1987	456	497	529	541	481
Plant Comm	1	1987	370	415	417	412	369
Plant Comm	1	1987	442	476	503	506	469
Plant Comm	1	1987	433	454	478	499	495
Plant Comm	1	1987	435	464	480	494	471
Plant Comm	1	1987	517	564	580	589	540
Plant Comm	1	1987	458	475	490	507	447
Plant Comm	1	1987	445	497	511	523	477
Plant Comm	1	1987	420	463	487	497	450
Plant Comm	1	1987	463	498	513	516	473
Plant Comm	1	1987	435	449	470	474	443
Plant Comm	1	1987	433	476	492	493	457
Plant Comm	1	1987	415	449	463	467	459
Plant Comm	2	1987	483	504	526	510	479
Plant Comm	2	1987	506	530	559	528	486
Plant Comm	2	1987	442	489	481	501	475
Plant Comm	2	1987	365	397	400	408	380
Plant Comm	2	1987	406	446	453	425	421
Plant Comm	2	1987	433	454	487	456	415

Table A.3 cont.

Plant Comm	2	1987	374	406	413	413	378
Plant Comm	2	1987	469	497	501	508	486
Plant Comm	2	1987	592	620	621	624	578
Plant Comm	2	1987	617	622	619	640	579
Plant Comm	2	1987	424	437	448	438	422
Plant Comm	2	1987	440	488	508	503	464
Plant Comm	2	1987	376	407	420	421	408
Plant Comm	2	1987	429	455	467	454	444
Plant Comm	2	1987	438	472	491	478	446
Plant Comm	2	1987	435	458	475	455	437
Plant Comm	1	1988	628	640	634	634	590
Plant Comm	1	1988	590	641	602	613	585
Plant Comm	1	1988	448	493	470	474	454
Plant Comm	1	1988	580	630	593	596	572
Plant Comm	1	1988	527	539	528	533	494
Plant Comm	1	1988	613	655	624	633	587
Plant Comm	1	1988	620	635	613	633	593
Plant Comm	1	1988	545	569	550	557	532
Plant Comm	1	1988	526	562	544	556	528
Plant Comm	1	1988	412	472	454	459	430
Plant Comm	1	1988	424	474	463	440	445
Plant Comm	1	1988	483	523	494	494	474
Plant Comm	1	1988	456	477	481	489	450
Plant Comm	1	1988	500	532	511	521	487
Plant Comm	1	1988	398	440	443	446	425
Plant Comm	1	1988	444	471	479	513	483
Plant Comm	2	1988	484	548	549	543	508
Plant Comm	2	1988	531	585	590	581	547
Plant Comm	2	1988	496	510	499	547	517
Plant Comm	2	1988	484	544	557	544	518
Plant Comm	2	1988	406	440	429	441	423
Plant Comm	2	1988	527	575	606	582	520
Plant Comm	2	1988	483	523	517	525	490
Plant Comm	2	1988	435	442	460	433	396
Plant Comm	2	1988	380	425	435	431	417
Plant Comm	2	1988	435	471	480	473	452
Plant Comm	2	1988	458	477	494	470	472
Plant Comm	2	1988	412	452	460	421	436
Plant Comm	2	1988	481	508	523	512	495
Plant Comm	2	1988	387	431	434	408	396

Table A.3 cont.

Plant Comm	2	1988	464	506	534	511	501
Plant Comm	2	1988	430	471	486	482	462
Plant Comm	1	1989	590	632	619	618	607
Plant Comm	1	1989	528	576	588	578	576
Plant Comm	1	1989	494	553	547	557	566
Plant Comm	1	1989	583	656	644	663	645
Plant Comm	1	1989	547	588	595	590	619
Plant Comm	1	1989	467	496	512	499	528
Plant Comm	1	1989	479	534	547	551	564
Plant Comm	1	1989	517	583	590	601	585
Plant Comm	1	1989	522	612	590	606	625
Plant Comm	1	1989	506	557	590	590	599
Plant Comm	1	1989	406	448	461	449	479
Plant Comm	1	1989	383	450	486	482	484
Plant Comm	1	1989	415	474	499	500	530
Plant Comm	1	1989	479	558	562	554	566
Plant Comm	1	1989	524	573	591	599	598
Plant Comm	1	1989	465	499	512	538	552
Plant Comm	2	1989	544	584	625	624	635
Plant Comm	2	1989	553	608	639	641	666
Plant Comm	2	1989	578	606	658	651	686
Plant Comm	2	1989	499	526	556	544	554
Plant Comm	2	1989	515	558	590	596	626
Plant Comm	2	1989	411	465	467	449	473
Plant Comm	2	1989	513	583	597	587	620
Plant Comm	2	1989	569	614	665	649	663
Plant Comm	2	1989	476	539	581	552	600
Plant Comm	2	1989	501	552	593	596	630
Plant Comm	2	1989	522	575	640	627	664
Plant Comm	2	1989	488	521	558	552	556
Plant Comm	2	1989	440	472	520	499	544
Plant Comm	2	1989	429	476	514	511	512
Plant Comm	2	1989	467	500	544	544	552
Plant Comm	2	1989	397	449	473	477	494

[a] Deferred = Deferred rotation grazing system, Plant Comm = Plant community grazing sytem

Table A.4: Calf weights (kg) by weigh period from 1987 to 1990 for Complementary grazing experiment in Meadow Creek

Treatment[a]	Rep	Year	Weight 1	Weight 2	Weight 3	Weight 4	Weight 5
Deferred	1	1987	163	198	227	253	260
Deferred	1	1987	116	137	164	179	175
Deferred	1	1987	129	163	191	211	226
Deferred	1	1987	159	190	226	252	259
Deferred	1	1987	129	166	196	220	228
Deferred	1	1987	122	157	181	196	209
Deferred	1	1987	132	168	201	227	230
Deferred	1	1987	109	142	176	196	207
Deferred	1	1987	113	144	177	200	212
Deferred	1	1987	107	137	168	193	212
Deferred	1	1987	113	143	181	205	217
Deferred	1	1987	100	137	166	191	204
Deferred	1	1987	138	176	209	239	250
Deferred	1	1987	104	134	167	187	196
Deferred	1	1987	100	136	171	191	201
Deferred	1	1987	91	121	150	175	187
Deferred	2	1987	116	153	181	197	208
Deferred	2	1987	138	152	186	208	212
Deferred	2	1987	145	181	213	231	238
Deferred	2	1987	118	156	181	201	211
Deferred	2	1987	138	167	200	220	225
Deferred	2	1987	98	122	146	159	161
Deferred	2	1987	154	188	222	245	252
Deferred	2	1987	141	178	209	230	247
Deferred	2	1987	113	144	179	200	210
Deferred	2	1987	136	181	216	236	241
Deferred	2	1987	107	143	178	203	219
Deferred	2	1987	100	136	171	196	207
Deferred	2	1987	104	137	175	195	206
Deferred	2	1987	132	168	202	225	230
Deferred	2	1987	91	124	154	176	181
Deferred	2	1987	120	160	195	221	239
Deferred	1	1988	122	138	174	188	181
Deferred	1	1988	152	190	222	232	236
Deferred	1	1988	164	200	232	251	245
Deferred	1	1988	140	179	211	227	235
Deferred	1	1988	161	200	229	247	243
Deferred	1	1988	138	176	212	230	236

Table A.4 cont.

Deferred	1	1988	127	162	191	215	216
Deferred	1	1988	120	152	179	193	200
Deferred	1	1988	110	136	162	181	185
Deferred	1	1988	128	168	196	226	229
Deferred	1	1988	119	150	178	200	198
Deferred	1	1988	135	172	205	227	229
Deferred	1	1988	136	172	198	216	211
Deferred	1	1988	106	136	163	181	186
Deferred	1	1988	134	174	202	223	210
Deferred	1	1988	108	142	179	203	199
Deferred	2	1988	154	187	222	240	241
Deferred	2	1988	152	193	236	256	262
Deferred	2	1988	128	161	200	224	229
Deferred	2	1988	161	204	240	269	269
Deferred	2	1988	157	197	227	259	264
Deferred	2	1988	139	173	209	228	229
Deferred	2	1988	147	181	211	241	238
Deferred	2	1988	168	213	254	272	276
Deferred	2	1988	128	161	192	210	218
Deferred	2	1988	127	171	209	237	239
Deferred	2	1988	109	142	175	193	203
Deferred	2	1988	96	128	155	181	190
Deferred	2	1988	104	133	154	177	187
Deferred	2	1988	104	136	169	190	191
Deferred	2	1988	98	131	161	181	182
Deferred	2	1988	128	161	196	230	237
Deferred	1	1989	116	166	181	207	230
Deferred	1	1989	152	209	230	260	283
Deferred	1	1989	113	150			
Deferred	1	1989	125	168	194	217	241
Deferred	1	1989	136	184	215	247	279
Deferred	1	1989	125	167			
Deferred	1	1989	136	186	209	233	269
Deferred	1	1989	109	164	171	202	227
Deferred	1	1989	113	155			
Deferred	1	1989	111	159		220	243
Deferred	1	1989	122	175	194	214	246
Deferred	1	1989	125	174	205	225	247
Deferred	1	1989	116	173	193	226	258
Deferred	1	1989	98	136	170	193	221

Table A.4 cont.

Deferred	1	1989	98	144	174	200	233
Deferred	1	1989	98	136	171	234	234
Deferred	2	1989	150	200	230	261	283
Deferred	2	1989	122		212	259	262
Deferred	2	1989	104	156	181	214	227
Deferred	2	1989	156		247	274	294
Deferred	2	1989	147	193	227	259	290
Deferred	2	1989	141	186	221	241	272
Deferred	2	1989	109	150	181	206	230
Deferred	2	1989	127	181	215	242	272
Deferred	2	1989	125	160	188	217	244
Deferred	2	1989	113		196	230	262
Deferred	2	1989	125	176	207	231	263
Deferred	2	1989	79	113	136	158	180
Deferred	2	1989	91	136	175	191	215
Deferred	2	1989	102	144	175	206	228
Deferred	2	1989	122	175	209	241	259
Deferred	2	1989	104	144	167	196	218
Deferred	1	1990	132	168	181	187	191
Deferred	1	1990	148	181	209	227	235
Deferred	1	1990	120	165	188	214	214
Deferred	1	1990	157	191	222	236	238
Deferred	1	1990	150	184	215	239	237
Deferred	1	1990	155	181	197	224	220
Deferred	1	1990	133	175	206	230	231
Deferred	1	1990	153	189	227	252	252
Deferred	1	1990	138	160	195	227	231
Deferred	1	1990	93	124	142	156	159
Deferred	1	1990	115	130	153	171	181
Deferred	1	1990	121	150	166	181	
Deferred	1	1990	86	122	154	171	
Deferred	1	1990	103	136	157	172	
Deferred	1	1990	106	145	163	183	188
Deferred	1	1990	107	154	181	198	198
Deferred	2	1990	127	153	183	207	203
Deferred	2	1990	124	161	191	219	219
Deferred	2	1990	146	181	208	235	236
Deferred	2	1990	141	175	204	233	234
Deferred	2	1990	132	156	183	211	212
Deferred	2	1990	144	181	213	236	232

Table A.4 cont.

Deferred	2	1990	142	181	217	247	236
Deferred	2	1990	129	166	197	222	215
Deferred	2	1990	134	181	218	246	232
Deferred	2	1990	130	163	188	220	218
Deferred	2	1990	119	143	169	181	170
Deferred	2	1990	104	136	161	179	176
Deferred	2	1990	120	156	181	207	199
Deferred	2	1990	106	138	162	190	189
Deferred	2	1990	100	136	165	188	185
Deferred	2	1990	125	168	201	228	235
Plant Comm	1	1987	161	194	231	244	253
Plant Comm	1	1987	143	181	222	242	248
Plant Comm	1	1987	152	194	234	257	277
Plant Comm	1	1987	118	149	184	197	210
Plant Comm	1	1987	136	172	200	216	220
Plant Comm	1	1987	100	136	174	187	197
Plant Comm	1	1987	100	127	158	175	184
Plant Comm	1	1987	98	131	169	188	197
Plant Comm	1	1987	136	170	201	216	232
Plant Comm	1	1987	134	171	208	209	220
Plant Comm	1	1987	122	149	178	187	199
Plant Comm	1	1987	127	166	204	220	235
Plant Comm	1	1987	150	184	227	244	269
Plant Comm	1	1987	122	142	180	195	213
Plant Comm	1	1987	100	124	158	167	182
Plant Comm	1	1987	116	140	181	200	217
Plant Comm	2	1987	166	205	236	269	271
Plant Comm	2	1987	134	174	201	232	249
Plant Comm	2	1987	91	121	143	171	171
Plant Comm	2	1987	134	169	201	236	243
Plant Comm	2	1987	122	158	193	227	225
Plant Comm	2	1987	125	160	196	228	239
Plant Comm	2	1987	107	143	178	204	213
Plant Comm	2	1987	129	152	175	205	213
Plant Comm	2	1987	147	181	209	234	248
Plant Comm	2	1987	132	168	194	221	232
Plant Comm	2	1987	138	178	205	235	245
Plant Comm	2	1987	125	161	191	227	229
Plant Comm	2	1987	150	189	223	254	271
Plant Comm	2	1987	107	139	176	202	216

Table A.4 cont.

Plant Comm	2	1987	93	126	154	181	190
Plant Comm	1	1988	160	205	227	257	255
Plant Comm	1	1988	140	181	202	227	235
Plant Comm	1	1988	161	206	234	266	269
Plant Comm	1	1988	154	191	227	251	260
Plant Comm	1	1988	132	162	191	209	216
Plant Comm	1	1988	129	167	198	227	227
Plant Comm	1	1988	148	181	223	247	247
Plant Comm	1	1988	126	176	202	226	239
Plant Comm	1	1988	141	183	214	239	249
Plant Comm	1	1988	93	117	138	161	165
Plant Comm	1	1988	131	171	191	225	225
Plant Comm	1	1988	146	188	212	249	249
Plant Comm	1	1988	133	173	202	221	223
Plant Comm	1	1988	114	156	181	201	212
Plant Comm	1	1988	120	158	181	214	215
Plant Comm	1	1988	109	142	169	195	201
Plant Comm	2	1988	163	205	244	272	282
Plant Comm	2	1988	132	163	185	209	212
Plant Comm	2	1988	140	176	197	227	237
Plant Comm	2	1988	153	186	225	251	257
Plant Comm	2	1988	142	186	219	239	260
Plant Comm	2	1988	171	210	249	272	289
Plant Comm	2	1988	131	168	204	227	240
Plant Comm	2	1988	124	161	191	214	231
Plant Comm	2	1988	136	177	210	239	246
Plant Comm	2	1988	109	141	178	196	199
Plant Comm	2	1988	152	192	228	259	268
Plant Comm	2	1988	147	186	222	254	266
Plant Comm	2	1988	124	162	191	218	230
Plant Comm	2	1988	99	132	152	165	180
Plant Comm	2	1988	116	157	186	215	221
Plant Comm	2	1988	125	167	201	227	231
Plant Comm	1	1989	138	190	227	249	279
Plant Comm	1	1989	98	144	177	200	235
Plant Comm	1	1989	111	154	181	206	234
Plant Comm	1	1989	138	186	226	249	281
Plant Comm	1	1989	118	142	179	196	227
Plant Comm	1	1989	122	178	208	231	263
Plant Comm	1	1989	107	152	182	210	237

Table A.4 cont.

Plant Comm	1	1989	129	181	211	238	272
Plant Comm	1	1989	107	152	186	215	247
Plant Comm	1	1989	120	172	204	229	272
Plant Comm	1	1989	93	141	168	188	227
Plant Comm	1	1989	107	149	184	221	248
Plant Comm	1	1989	109	167	196	225	254
Plant Comm	1	1989	111	158	184	215	246
Plant Comm	1	1989	109	158	162		
Plant Comm	1	1989	116	172	196	234	263
Plant Comm	2	1989	136	186	227	227	280
Plant Comm	2	1989	136	193	222	250	274
Plant Comm	2	1989	138	191	230	251	295
Plant Comm	2	1989	138	190	231	254	285
Plant Comm	2	1989	159	218	253	279	300
Plant Comm	2	1989	152	208	254	273	334
Plant Comm	2	1989	141	194	233	259	313
Plant Comm	2	1989	107	149	181	193	233
Plant Comm	2	1989	134	180	219	235	274
Plant Comm	2	1989	127	175	208	227	275
Plant Comm	2	1989	104	147	227	203	238
Plant Comm	2	1989	134	189	230	264	301
Plant Comm	2	1989	102	145	181	200	238
Plant Comm	2	1989	104	148	189	215	248
Plant Comm	2	1989	88	124	157	174	209
Plant Comm	2	1989	93	130	163	183	225
Plant Comm	1	1990	111	136	150	168	168
Plant Comm	1	1990	137	172	201	218	
Plant Comm	1	1990	147	181	203	225	222
Plant Comm	1	1990	154	182	227	251	269
Plant Comm	1	1990	138	167	181	196	199
Plant Comm	1	1990	128	156	196	210	217
Plant Comm	1	1990	132	169	200	225	235
Plant Comm	1	1990	131	177	214	235	241
Plant Comm	1	1990	133	164	194	217	
Plant Comm	1	1990	111	144	171	187	194
Plant Comm	1	1990	127	162	192	208	214
Plant Comm	1	1990	117	156	186	205	200
Plant Comm	1	1990	131	164	210	225	232
Plant Comm	1	1990	109	141	170	187	191
Plant Comm	1	1990	93	119	139	153	158

Table A.4 cont.

Plant Comm	1	1990	120	164	199	223	
Plant Comm	2	1990	161	202	243	263	265
Plant Comm	2	1990	141	181	215	229	227
Plant Comm	2	1990	149	184	227	230	233
Plant Comm	2	1990	143	189	229	256	260
Plant Comm	2	1990	117	149	181	195	
Plant Comm	2	1990	152	190	231	262	269
Plant Comm	2	1990	127	171	212	237	240
Plant Comm	2	1990	125	155	191	208	205
Plant Comm	2	1990	115	157	194	219	217
Plant Comm	2	1990	161	198	238	261	256
Plant Comm	2	1990	97	124	152	169	164
Plant Comm	2	1990	122	166	203	225	220
Plant Comm	2	1990	115	150	179	198	193
Plant Comm	2	1990	116	163	205	221	237
Plant Comm	2	1990	88	112	136	147	169
Plant Comm	2	1990	89	116	142	155	157

[a] Deferred = Deferred rotation grazing system, Plant Comm = Plant community grazing sytem

APPENDIX B: FORAGE QUALITY

Table B.1. Crude Protein Content and *in vitro* DMD of Idaho Fescue on grassland and forest pasture during 1982 and 1983

Year	Pasture	Julian Date	% CP (DM)	IVDMD (%)
82	Grassland	181	7.97	48.13
82	Grassland	183	8.48	45.52
82	Grassland	189	7.73	45.87
82	Grassland	196	8.74	41.46
82	Grassland	203	8.74	36.73
82	Grassland	210	7.99	37.79
82	Grassland	217	7.84	36.33
82	Grassland	224	8.33	37.81
82	Grassland	231	6.54	35.87
82	Grassland	238	6.96	29.99
82	Grassland	245	6.72	34.91
82	Grassland	253	6.27	35.88
82	Grassland	259	5.81	30.09
82	Grassland	266	5.61	33.18
82	Grassland	273	6.14	33.23
83	Grassland	188	5.97	40.06
83	Grassland	195	6.94	39.48
83	Grassland	202	6.85	34.06
83	Grassland	209	6.48	37.24
83	Grassland	216	6.15	34.81
83	Grassland	223	5.28	31.61
83	Grassland	230	5.40	34.48
83	Grassland	237	5.84	30.98
83	Grassland	244	6.66	37.17
83	Grassland	251	5.63	35.23
83	Grassland	258	6.46	37.10
83	Grassland	264	6.18	34.21
83	Grassland	271	7.27	37.32
83	Grassland	279	5.24	34.78
83	Grassland	286	5.22	34.39
82	Forest	181	7.92	45.28
82	Forest	189	8.17	47.81
82	Forest	196	8.05	46.39
82	Forest	203	7.24	43.31
82	Forest	210	7.94	39.51
82	Forest	217	7.85	38.88

Table B.1 cont.

82	Forest	224	7.73	41.72
82	Forest	231	6.71	41.81
82	Forest	238	6.60	38.04
82	Forest	245	6.81	45.41
82	Forest	253	5.67	39.63
82	Forest	259	5.40	40.25
82	Forest	266	5.38	35.89
82	Forest	273	5.80	42.66
83	Forest	188	7.84	45.44
83	Forest	195	8.38	46.54
83	Forest	202	7.61	41.82
83	Forest	209	7.62	42.22
83	Forest	216	6.84	38.70
83	Forest	223	6.98	40.42
83	Forest	230	6.79	34.89
83	Forest	237	7.74	33.86
83	Forest	244	6.86	35.45
83	Forest	251	7.41	37.91
83	Forest	258	7.01	32.46
83	Forest	264	6.15	37.01
83	Forest	271	6.67	35.28
83	Forest	279	6.74	39.36
83	Forest	286	6.11	37.66

Table B.2: Crude Protein Content and *in vitro* DMD of bluebunch wheatgrass on grassland and forest pasture during 1982 and 1983

Year	Pasture	Julian Date	% CP (DM)	IVDMD (%)
82	Grassland	181	8.58	59.27
82	Grassland	183	8.72	57.09
82	Grassland	189	8.65	53.95
82	Grassland	196	8.81	48.59
82	Grassland	203	8.97	53.10
82	Grassland	210	8.81	49.32
82	Grassland	217	7.40	49.32
82	Grassland	224	8.61	47.52
82	Grassland	231	5.93	44.06
82	Grassland	238	5.65	47.60
82	Grassland	245	6.21	44.96
82	Grassland	253	5.85	44.97
82	Grassland	259	4.80	42.59
82	Grassland	266	4.90	40.61
82	Grassland	273	5.52	43.65
83	Grassland	188	10.22	57.22
83	Grassland	195	6.91	50.97
83	Grassland	202	6.38	48.89
83	Grassland	209	6.83	49.08
83	Grassland	216	6.24	45.82
83	Grassland	223	5.12	40.87
83	Grassland	230	5.87	41.93
83	Grassland	237	6.64	42.86
83	Grassland	244	6.14	44.19
83	Grassland	251	4.59	41.46
83	Grassland	258	5.39	40.07
83	Grassland	264	4.17	34.60
83	Grassland	271	4.17	33.31
83	Grassland	279	3.69	38.20
83	Grassland	286	4.30	36.07
82	Forest	181	9.68	58.16
82	Forest	189	9.30	57.73
82	Forest	196	8.80	55.21
82	Forest	203	11.49	53.71
82	Forest	210	8.55	49.43
82	Forest	217	7.51	48.44
82	Forest	224	8.75	48.01
82	Forest	231	7.25	51.46

Table B.2 cont.

82	Forest	238	7.00	49.21
82	Forest	245	7.51	47.17
82	Forest	253	6.41	43.57
82	Forest	259	6.42	46.91
82	Forest	266	6.38	45.32
82	Forest	273	7.67	48.24
83	Forest	188	7.88	53.09
83	Forest	195	8.93	48.62
83	Forest	202	8.76	54.09
83	Forest	209	7.67	51.90
83	Forest	216	6.80	47.71
83	Forest	223	5.81	44.20
83	Forest	230	7.28	43.88
83	Forest	237	7.14	43.59
83	Forest	244	7.07	44.34
83	Forest	251	6.18	49.05
83	Forest	258	5.94	41.53
83	Forest	264	4.37	39.09
83	Forest	271	3.75	38.13
83	Forest	279	3.82	37.88
83	Forest	286	3.43	30.97

APPENDIX C: HEIFER OBSERVATIONS

Table C.1. Amount of hours that observed heifers spent in either the grassland or forested pasture in free choice grazing system for 1982 and 1983.

		Grassland Pasture hrs			Forest Pasture hrs		
Season	Year	1	2	3	1	2	3
1	1982	18	36		9	18	
1	1982		33	22.7		7.5	5.2
1	1982	40.5	108.5		0	0	
1	1982		0.8	1.1		66.8	66.5
1	1982			18.7			44.3
1	1982	102.6	63	0	0	29.3	18.1
1	1982		19.4	4.8		41.3	2
1	1982			118.4			0
1	1982		135	27		0	0
1	1982	65.4	16		67.5	38	
1	1982		108	33.8		0	0
1	1982	0	0.3		123.5	64.7	
2	1982		0	0		130	26
2	1982		14	75.6		12	54.4
2	1982	0	0.2		121.3	58.3	
2	1982		0.2	30		25.8	100
2	1982		39.3	26		88	0
2	1982		117.1	21		11.7	4.9
2	1982	0	0		113.1	52	
2	1982		0.7	0		100.7	56.3
2	1982		40.8	130		0.7	0
2	1982		38.3	50		5	2.1
2	1982	104	56.5		0	2.8	
2	1982		24.3	50		16.8	80
2	1982	15	95.1		11	35	
2	1982	26	130		0	0	
2	1982		2.3	0		34.1	130
2	1982	10	73		22.5	57.1	
2	1982	84	42		20	10	
3	1982		35	7		95	19
3	1982		108.3	22.5		21.8	3.6
3	1982		26	26.4		0	81.6
3	1982	0	0		104	52	
3	1982	4.9	6		99.1	46	
3	1982	52	26		0	0	
3	1982		0			117	
3	1982		130	26		0	0

Table 1 cont.

3	1982		26	130		0	0
3	1982	104	52		0	0	
3	1982		86.7			2.2	
3	1982		39	116.6		0	0.3
3	1982	26	130		0	0	
3	1982	101.1	52		3	0	
3	1982	26	130		0	0	
3	1982		0	0		39	117
3	1982	0	12.3		26	117.7	
3	1982	65	52		0	0	
3	1982		0			104	
3	1982	69.5	91		0	0	
1	1983	2.5	68.45		62.5	61.52	
1	1983		0	0		130	39
1	1983		59.4	31.5		51	27
1	1983	56	50.8		48	43.95	
1	1983		12.8	77.2		39.3	52.8
1	1983	0	14.2	6	52	115.9	20
1	1983	0	0		117	104	
1	1983	130.8	69		5	3.1	
1	1983		48	125.2		4	2.45
1	1983	130	108		0	0	
1	1983	52	130	26	0	0	0
1	1983	130	78		0	0	
1	1983	0	0	0	52	130	26
1	1983		52	70.6		0	0
1	1983	0.4	0		103.7	78	
1	1983	17.5	96.9	26	34.5	33.2	0
1	1983		31.1	124.6		21.3	5.5
1	1983	117	78.6		0	0.4	
1	1983	0	17.8		130	60.2	
1	1983		56.3	130		0	0
1	1983		42	123.8		2.8	6.3
2	1983	125.7	86.7		0	0	
2	1983	0	3.5	45.3	32.5	126.5	0.2
2	1983		39	130		0	0
2	1983		65	120.1		0	9.9
2	1983	117	91		0	0	
2	1983			17			25.3
2	1983		65	125.3		0	4.6
2	1983	52	130	26	0	0	0
2	1983		19.5	130		0	0
2	1983	117	78		0	0	

Table 1 cont.

2	1983	0	5	14.8	52	125.2	8.7
2	1983		60.7	69		0	61
2	1983	0	46.9	26	52	83.1	0
2	1983	117	91		0	0	
2	1983	0	0		117	91	
2	1983	0	11.3	26	52	118.7	0
2	1983		81	135		0	0
3	1983		103.3	128.3		0.5	0
3	1983	54	133.7	25.9	0	1.3	1.1
3	1983	0	0	0	54	135	27
3	1983	67.5	6.8		0	0	
3	1983	30	127.6	26	9	2.5	0
3	1983		78	75		0	41.9
3	1983	0	0		91	117	
3	1983		78	105.9		0	11.2
3	1983		66.5	65.4		24.5	51.6
3	1983	0	14.4	7	52	115.65	19
3	1983	33.9	95	19	12.5	35	7
3	1983	17.5	85.4		47.5	31.7	
3	1983		21	55.3		57	54.4
3	1983	67	117		6.7		
3	1983		8.4	46.3		51.4	13.7
3	1983	42.5	130	7.8	0	0	0
3	1983		8.2	73.1		0	24.2
3	1983	29.6	33		34.5	38.5	

APPENDIX D: PERMANENT BLOCK COORDINATES

Table D.1. UTM coordinates and precision for permanent blocks placed out in Phase III of Meadow Creek

Block ID	Coordinates X	Coordinates Y	Coordinates Z	SD[a]	Horizontal Precision (m)
block 01	380635.269	5013569.627	1114.212	0.032529	0.462
block 02	380634.266	5013595.255	1113.926	0.034629	0.379
block 03	380606.261	5013620.451	1114.249	0.059104	0.93
block 04	380582.21	5013624.65	1114.807	0.033771	0.93
block 05	380587.329	5013657.041	1112.976	0.014864	0.766
block 06	380568.147	5013673.072	1113.098	0.043769	0.822
block 07	380547.679	5013670.035	1114.655	0.022815	0.569
block 08	380530.416	5013681.815	1115.264	0.022821	0.73
block 09	380534.154	5013698.773	1115.644	0.023914	0.646
block 10	380490.379	5013702.598	1115.854	0.014803	0.482
block 11	380502.928	5013719.587	1115.738	0.054568	0.851
block 12	380487.316	5013724.998	1115.203	0.034785	0.578
block 13	380478.384	5013736.107	1113.947	0.083362	0.906
block 14	380458.809	5013729.662	1116.176	0.050441	0.978
block 15	380390.278	5013772.976	1118.183	0.046193	0.983
block 16	380465.407	5013794.999	1116.579	0.023194	0.546
block 17	380428.119	5013810.624	1116.86	0.010913	0.34
block 18	380370.22	5013859.529	1119.396	0.114565	0.926
block 19	380338.499	5013879.19	1118.887	0.128317	1.689
block 20	380293.494	5013873.872	1123.296	0.014013	0.485
block 21	380247.245	5013931.459	1119.774	0.017738	0.169
block 22	380226.756	5013960.21	1121.043	0.058044	0.764
block 23	380215.909	5013984.326	1119.83	0.009359	0.527
block 24	380186.171	5013973.576	1122.443	0.126587	0.951
block 25	380160.61	5014001.337	1120.315	0.015147	0.379
block 26	380145.381	5013975.288	1119.859	0.022993	0.511
block 27	380112.272	5013990.749	1121.023	0.04067	1.058
block 28	380124.764	5014018.771	1121.186	0.028594	0.923
block 29	380137.867	5014040.152	1120.741	0.034925	0.538
block 30	380102.915	5014032.945	1119.68	0.048943	0.776
block 31	380076.35	5014051.309	1120.763	0.055487	1.153
block 32	380094.718	5014102.106	1121.757	0.018811	0.644
block 33	380048.748	5014062.451	1121.33	0.018232	0.75
block 34	379993.358	5014105.32	1124.453	0.135178	1.645
block 35	380026.184	5014084.93	1121.709	0.041484	0.759
block 36	379963.616	5014118.772	1121.686	0.021228	0.73
block 37	379945.054	5014133.528	1122.395	0.018275	0.591

Table 1 cont.

block 38	379967.593	5014169.503	1122.869	0.053735	1.023
block 39	379928.472	5014176.946	1122.673	0.054039	0.545
block 40	379908.785	5014156.041	1122.444	0.081194	1.038
block 41	379882.509	5014161.327	1123.444	0.050186	0.832
block 42	379894.301	5014191.914	1122.693	0.113268	0.652
block 43	379937.581	5014221.249	1120.801	0.069757	1.024
block 44	379858.01	5014198.86	1124.991	0.141264	0.807
block 45	379870.573	5014245.4	1126.593	0.15491	1.279
block 46	379813.267	5014228.923	1123.219	0.031557	0.49
block 47	380366.986	5013805.956	1118.23	0.049773	0.841
block 48	380664.354	5013610.91	1114.49	0.041956	0.372
block 49	380299.106	5013906.073	1119.173	0.033266	0.207
block 50	380399.628	5013835.928	1117.676	0.022945	0.846

[a] Standard Deviation