CONSERVATION RESERVE PROGRAM (CRP) GRASSES IN THE COLUMBIA PLATEAU: THE EFFECTS OF TIME, AN INVASIVE ANNUAL GRASS AND BURNING

By

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A thesis submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN ENVIRONMENTAL SCIENCE

WASHINGTON STATE UNIVERSITY
School of Earth and Environmental Science

December 2009

To the Faculty of Washington State University: The members of the Committee appointed to examine the thesis of SHARON JONES SELLEREITE find it satisfactory and recommend that it be accepted.

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ACKNOWLEDGMENTS

I would like to express my gratitude to my committee members for their willingness to share their time, wisdom and expertise to help me achieve my educational goals. In particular, I would like to thank my committee chair, Steve Smith, for his patience, high standards and sense of humor through all the twists and turns this journey took. I would like to thank Dr. John Strand for sharing his knowledge of ecological research and for being the anchor for this committee. I would also like to thank Mark Stannard for his insights into this project and for the always interesting and informative conversations about CRP. I am fortunate to have had the opportunity to learn from these gentlemen. They each brought a unique perspective to the project.

I would also like to thank the following people for their help with this project.

Glenn Riehle, Resource Conservationist, Natural Resources Conservation Service, Pasco, WA and his staff helped locate and interpret file data and answered my questions about CRP. Susan Loper provided the maps of CRP in Franklin County without which we would still be driving around looking for my research sites.

Chris Herron, Vice President, Washington Association of Conservation Districts and landowner, answered my many questions about CRP and CRP grasses and kept me grounded in reality.

Dana Herron, Tri-State Seed Company, Connell, WA, answered my questions about CRP grasses and helped me find the resources I needed to keep this project moving forward

Landowners gave me permission to collect data in their fields.

Dr. Dennis Dauble helped with the beginning stages of the writing process and edited early drafts of the manuscript.

The friends along the way knew the song in my heart and sang it to me when I forgot the words.

Kathy Neary, science woman (Ph.D. Human Genetics) and pastor shared the wisdom gained from her experience earning an advanced degree in a scientific field and provided an environment where I was allowed to grow as a science woman.

My sister Julie supported me through the highs and lows of what turned out to be more of a roller coaster ride than I expected.

My children, April, Carrie and Ian and my grandchildren, Jewel, Cooper, Chloe and Reese were incredibly patient during this process.

My husband, Ken, helped with data collection, edited drafts of the manuscript, and supported me throughout this endeavor. Most of all I want to thank him for encouraging me to go back to the exit sign to find that my dreams were still there and for supporting me in making them grow.

CONSERVATION RESERVE PROGRAM (CRP) GRASSES IN THE COLUMBIA PLATEAU: THE EFFECTS OF TIME, AN INVASIVE ANNUAL GRASS AND BURNING

Abstract

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December 2009

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In the Columbian Plateau of Washington State, perennial grasses are the vegetative cover crop used most often for erosion control in fields enrolled in the USDA Conservation Reserve Program (CRP). This study documents the presence of originally seeded, perennial, CRP-approved grass species in ten eight-to-ten year old fields, and cheatgrass (*Bromus tectorum* L.) an invasive annual species. Canopy cover of seeded species and cheatgrass was compared in the second season post-burn for six burned and six unburned fields. Big bluegrass (*Poa secunda* J. Presl), one of the seeded species, was present in most of the sample points. In the second season after a prescribed burn there was no significant difference in mean percent cheatgrass canopy cover between burned and unburned fields. Mean percent canopy cover of big bluegrass was greater in unburned than burned fields. However, there was no difference in mean percent canopy cover of Snake River wheatgrass (*Elymus wawawaiensis* J. Carlson & Barkworth*)* in burned and unburned fields. The different responses may reflect the presence of new plant growth

that was damaged by fire or buds that are protected from fire by soil or plant litter. Big bluegrass appears to be a good choice for long-term plantings because in this study it was present eight to ten years after seeding. In this study, burning had no effect on cheatgrass canopy cover. Burning reduced big bluegrass canopy cover and had little effect on Snake River wheatgrass canopy cover.

PREFACE

This thesis is in the form of a manuscript to be submitted to the journal *Northwest Science* (ISSN #0029-344X) and is formatted according to their guidelines. It will be submitted with committee members Steven C. Smith, Mark E. Stannard, and Dr. John A. Strand.

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DEDICATION

This project is dedicated to my late parents, Gene and Charlotte Jones, who first taught me, by the example they set, the importance of both savoring and saving the environment.

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Conservation Reserve Program (CRP) Grasses in the Columbia Plateau: The Effects of Time, an Invasive Annual Grass, and Burning

Running footer: Columbia Plateau CRP grasses

4 tables, 10 figures

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Abstract

In the Columbian Plateau of Washington State, perennial grasses are the vegetative cover crop used most often for erosion control in fields enrolled in the USDA Conservation Reserve Program (CRP). This study documents the presence of originally seeded, perennial, CRP-approved grass species in ten eight-to-ten year old fields, and cheatgrass (*Bromus tectorum* L.) an invasive annual species. Canopy cover of seeded species and cheatgrass was compared in the second season post-burn for six burned and six unburned fields. Big bluegrass (*Poa secunda* J. Presl), one of the seeded species, was present in most of the sample points. In the second season after a prescribed burn there was no significant difference in mean percent cheatgrass canopy cover between burned and unburned fields. Mean percent canopy cover of big bluegrass was greater in unburned than burned fields. However, there was no difference in mean percent canopy cover of Snake River wheatgrass (*Elymus wawawaiensis* J. Carlson & Barkworth*)* in burned and unburned fields. The different responses may reflect the presence of new plant growth that was damaged by fire or buds that are protected from fire by soil or plant litter. Big bluegrass appears to be a good choice for long-term plantings because in this study it was present eight to ten years after seeding. In this study, burning had no effect on cheatgrass canopy cover. Burning reduced big bluegrass canopy cover and had little effect on Snake River wheatgrass canopy cover.

Introduction

Soil erosion is a serious environmental problem that can have long-term adverse effects on agricultural ecosystems; erosion is reduced where these lands have a permanent vegetative cover (Pimentel and Kounang 1998). The Conservation Reserve Program (CRP) has effectively reduced soil erosion and improved environmental quality since its inception in 1985 (Soil and Water Conservation Service (SWCS) and Environmental Defense Fund 2008). Participants in the CRP voluntarily retire highly erodible cropland and plant it with vegetative cover crops, usually grasses or trees, for a period of 10-15 years (Young et al. 1994). In Washington state, about 612,168 ha (USDA Farm Service Agency 2009) are enrolled in the CRP. Much of this ground is located in the low precipitation zone of the Columbia Plateau where the climate is semiarid Mediterranean-like, with cold moist winters and warm dry summers (Figure 1). Precipitation ranges from 150-300 mm. Few commercially available perennial grasses are adapted to this climate (Ogle et al. 2007). The most commonly planted species in the drier portions of the Columbia Plateau were crested wheatgrass (*Agropyron cristatum* [L] Gaertn., *A. desertorum* Schult., A. *desertorum x cristatum*), Siberian wheatgrass (*A. fragile* (Roth) Candargy), thickspike wheatgrass (*Elymus lanceolatus* (Scribn. & J.G. Sm.) Gould ssp. *lanceolatus)*, Snake River wheatgrass (*E. wawawaiensis* J. Carlson & Barkworth), bluebunch wheatgrass (*Pseudoroegneria spicata* (Pursh) A. Love), big bluegrass (*Poa secunda* J. Presl) and Sandberg bluegrass (*P. secunda* J. Presl). Nomenclature follows the PLANTS database; USDA Natural Resources Conservation Service 2009.

The persistence, or continued existence, of many grasses in CRP plantings has been studied in rangeland, pasture and reclamation contexts (Hull and Klomp 1966, Hull 1971, Harris and Dobrowolski 1986). Fields of native vegetation exhibit greater biodiversity than monoculture fields, are able to maintain soil fertility through nutrient recycling, and also control insect and weed populations (Daubenmire 1968, Altieri 1999). Biodiversity, native grass cover and invasive annual grasses have been studied in grassland and restoration settings. In both developing grassland and native, undisturbed grassland plant diversity increased as plant cover increased (Tilman et al. 1996). In studies of perennial bunchgrasses in grassland (Borman 1991) and in a study of roadside vegetation (Bugg et al. 1997), the canopy cover of native perennial bunchgrasses was greater than the canopy cover of undesirable annual grasses. More diverse native grass populations also showed higher resource use, including soil mineral nitrogen (Tilman et al. 1996). CRP fields differ from native range and other fields unsuitable for crops because CRP fields were tilled, fertilized, treated with herbicides and seeded to annual crops, in some cases for more than 100 years prior to their enrollment in the CRP. Long term CRP cover in the semiarid Columbia Plateau might not be sustainable because fertilizer and herbicide use are minimal, some soil properties may have been radically altered, and weed pressure is high.

Cheatgrass (*Bromus tectorum* L.), an invasive winter annual grass, occurs throughout the Columbia Plateau and its effect on seedlings of native perennial grasses is well understood (Harris 1967, Harris and Wilson 1970, Booth et al. 2003). Its impact on well established perennial vegetation in Columbia Plateau CRP is less well understood. In a study of grass mixtures, as seeded grasses grew and increased in size, they out-

competed cheatgrass (Hull 1971). When seeded in a restoration setting, the biomass of native grasses increased, as the biomass of undesirable annual grasses decreased (Lulow 2006). In a mixed vegetative community, when the cover of squirreltail (*E. elymoides* (Raff.) Swezey), a native grass, approached 20%, cheatgrass was almost eliminated (Booth et al. 2003). Transition from a desirable stand of perennial grass to a dense stand of cheatgrass can be triggered by such factors as drought, herbivory, poor adaptation of seeded grasses and fire.

The literature is inconsistent in describing the response of perennial bunchgrasses to burning. Burning reduced perennial bunchgrass biomass (g m^{-2}) in the first season after a wildfire (Daubenmire 1975), and following a prescribed burn (Cook et al.1994). In contrast, Uresk et al. (1980) reported an increase in perennial bunchgrass biomass one year after a wildfire. Perennial bunchgrass biomass increased in the second year after a wildfire (Daubenmire 1975, Uresk et al. 1980), and a prescribed burn (Cook et al. 1994). Two years after a wildfire, bluebunch wheatgrass biomass was greater in a burned plot than in an unburned control plot (Daubenmire 1975, Uresk et al. 1980, Cook et al. 1994). However, percent canopy cover of bluebunch wheatgrass was less in a burned plot than in an unburned control plot (Daubenmire 1975). Perennial bunchgrasses mature later and often do not senesce until mid to late June (Hull 1949, Klemmedson and Smith 1964). Time of year, burn temperature and the species burned determined the effect of fire on the basal area of individually burned perennial bunchgrasses (Wright and Klemmedson 1965). Neither the date of the burn nor the temperature resulted in a decrease in the basal area of Sandberg bluegrass. The basal area of large Thurber's needle grass (*Achnatherum thurberianum* (Piper) Barkworth) plants and both large and small needle-and-thread grass

(*Hesperostipa comata* (Trin. & Rupr.) Barkworth) plants showed a significant decrease following burning in June and July. August burning did not have a significant effect on basal area of small plants of either species (Wright and Klemmedson 1965).

Fire severity differs with fuel level and types. Heavy fuels, usually shrubs, reach fire temperatures as high as 500° C while the fire temperatures of light fuels, usually grasses are 100° C or less (Keeley 2001). The lower temperature of grass fires enhances the seed bank of undesirable annual grasses like cheatgrass (Keeley 2001). Even so, prescribed burns have been used to control cheatgrass in CRP fields. Stewart and Hull (1949) reported that mid-September or later burning resulted in a cheatgrass plant density over five times that of an early summer burn. The value of burning CRP stands for cheatgrass control in the Columbia Plateau has not been analyzed.

The objectives of this study were to document the presence of the seeded grass species in eight-to-ten year old CRP stands, compare canopy cover of seeded grass species and cheatgrass and evaluate the response of seeded perennial grasses and cheatgrass to prescribed burns in CRP fields located on the Columbia Plateau of eastern Washington.

Methods and Materials

Terminology

The term "crested wheatgrass" in this manuscript refers to any of the crested wheatgrasses, *A. cristatum, A. desertorum, A. desertorum* x *cristatum* and also includes Siberian wheatgrass (*A. fragile).*

Site Description

Study sites were located in Franklin County, Washington east of state highway 395 (N46° 40, W 118° 49), west of the Pasco-Kahlotus Highway (N46° 44, W118° 34), south of the Franklin/Adams County line (N46° 44, W118° 34) and north of Blackman Ridge Road (N46° 27, W118° 49). Fields were cropped with dry-land wheat prior to enrollment in the CRP. Soil parent material was loess over glaciofluvial deposits except for a few sites where it was loess only or loess mixed with volcanic ash (USDA NRCS 2006b). Most of the soils were coarse silty Xeric Haplocambids with some coarse silty Calcidic Haploxerolls (USDA NRCS 2006b).

Experimental Design

Twenty-two fields were selected for use in this study on the basis of year seeded with CRP grasses, seed mix and burn history. All fields were adjacent to public roads and were accessible by car.

Evaluation of 8-10 year old CRP Stands

Ten fields that were seeded in 1998-1999 or 1999-2000 were selected for survey. Five fields were seeded with a native grass mix, referred to as Conservation Practice 2 (CP2) (Table 1). The remaining five fields were seeded with a mix that included introduced grass species, referred to as Conservation Practice 1 (CP1) (Table 1).

Plant count and canopy cover data were collected between 15 May 2008 and 11 June 2008. Daubenmire (1959, 1968) defined canopy cover as the "percentage of ground included in a vertical projection of imaginary polygons drawn about the total natural spread of foliage of the individual of a species." Grasses were counted if they had green shoots or leaves. In each field, data was collected at five points 20 m apart along each of four temporary 100 m transects. Each transect was perpendicular to the road and to the

direction of seeding with the start point located 50 paces into the field except in fields that were seeded perpendicular to the road, where the transect was placed at a visually estimated 45° angle to the road. The distance (m) of the first data collection point from the transect end point was randomly selected based on the final digit of a $1/100^{th}$ second stopwatch time (Gotelli and Ellison 2004). The distance (m) between transects was randomly generated based on the two digits of a $1/100^{th}$ second stopwatch reading. Plant count data was collected using a 1 m^2 frame with a 20 cm (400 cm^2) grid (Elzinga et. al. 1998) centered on the tape measure (Figure 2). Plants were counted if more than 50% of the basal crown was within the frame (Elzinga et. al. 1998). All perennial grasses within the 1 m^2 frame were counted. Individual cheatgrass plants found within a single marked 20 cm square (400 cm^2) within the frame were also counted. The percent canopy cover of all perennial grasses and cheatgrass within the half of the frame (0.5 m x1.0 m) to the right of the transect was visually estimated (Daubenmire 1968).

Plant Frequency and Density in 8-10 year old CRP Stands - Frequency and density were calculated for the seeded grasses in eight-to-ten year old fields. Daubenmire (1968) defined frequency as "the percentage occurrence of species in a series of samples of uniform size contained in a single stand." In this study, frequency was determined for each field as the percentage of 1 m^2 quadrats containing the grass species. Density is defined as, "the number of individuals per unit area" (Daubenmire 1968). In this study, density was the average number of plants of each species per 1 m^2 quadrat for each of the eight-to-ten year old fields. A two-by-two chi square contingency table using untransformed data was used to evaluate the difference in frequency of big bluegrass between CP1 and CP2 plantings.

Canopy Cover in 8-10 year old CRP Stands - Where necessary to meet the assumptions of normally distributed data of the statistical analysis, an arcsine square root transformation (arcsine √x) was applied to the percent canopy cover for the seeded grasses and cheatgrass in the eight-to-ten year old fields. This transformation was used because the data was expressed as a percentage and covers a range of values (Steel and Torrie 1980). Also, 0.5 was added to all values as part of the transformation because the data included zeros (Steel and Torrie 1980). In this transformation, *x* represents the percent canopy cover plus 0.5. T-tests were used to compare canopy cover data. A significance value of $P = 0.05$ was used for the statistical analyses.

Evaluation of Burned and Unburned CRP Stands

Twelve fields seeded in 2004-2005 were selected for survey. Six of the fields were burned in the fall of 2006 and six were not burned (Table 1). None of the fields had been reseeded. Canopy cover data for the burned and unburned fields was collected between 15 May 2008 and 11 June 2008 as described for the evaluation of 8-10 year CRP stands. The average percent canopy cover for the seeded grasses and cheatgrass in each of the twelve fields was determined. Where necessary to meet the assumption of normally distributed data for the statistical analysis, the data was transformed using the arcsine square root transformation described for the evaluation of 8-10 year CRP stands. Average canopy cover for seeded grasses and cheatgrass in the burned and unburned fields was compared using a t-test.

Results and Discussion

Evaluation of 8-10 year old CRP Stands

Frequency and Density in 8-10 year old CRP Stands - Eight to ten years after seeding, big bluegrass was the most prevalent seeded grass. Ninety percent of the fields had stands of big bluegrass and at least one plant occurred in 139 of the 200 sample points (Table 2). Crested wheatgrass was seeded in 50% of the fields and at least one plant was found in 60 of the 100 sample points. At least one Snake River wheatgrass plant occurred in all fields in which it was planted. Thickspike wheatgrass, the only rhizomatous grass, was seeded in seven fields and was found in one of the 140 sample points (Table 2). This is consistent with previous research showing that thickspike wheatgrass grew well for the first four years and then diminished rapidly (Stannard et al. 1993). Sandberg bluegrass was not included because no plants meeting the research criteria were found.

All of the grasses seeded at 2.24 kg ha^{-1} (Table 1) were present after eight to ten years. Big bluegrass and crested wheatgrass were both seeded at 2.24 kg ha^{-1} (Table 1) as part of the CP1 plantings and were present in most fields (Table 2). Big bluegrass and Snake River wheatgrass were both seeded at 2.24 kg ha^{-1} (Table 1) as part of the CP2 plantings and were present in all fields (Table 2). Thickspike wheatgrass was found in only one field. The mean density of big bluegrass plants was higher in CP1 plantings (6.11 plants m^{-2}) than in CP2 plantings (4.57 plants m^{-2}) (Table 2).

In CP1 field #9, no big bluegrass plants were found, however the frequency and density of crested wheatgrass were highest in this field (Table 2). This is consistent with a study in northeast Washington, in which crested wheatgrass expanded its coverage and there was only a small amount of big bluegrass after ten years (Harris and Dobrowolski 1986). The three CP1 fields in this study with the highest frequency and density of big bluegrass also had the lowest frequency and density of crested wheatgrass (Table 2). This

relationship may be a function of the land management practices used to establish the planting.

Big bluegrass was present in 90% of the eight-to-ten year old fields and was observed with a significantly higher frequency in CP2 plantings than in CP1 plantings (chi-square = 8.515, df=1, *P*=0.004). The mean big bluegrass frequency was 79% when it was seeded with Snake River wheatgrass and 60% when it was seeded with crested wheatgrass (Table 2). One possible explanation for the lesser mean frequency of big bluegrass when grown with crested wheatgrass is the earlier growth of crested wheatgrass relative to big bluegrass (Hull 1949) and the ability of crested wheatgrass to deplete soil moisture (Aguirre and Johnson 1991). Aguirre and Johnson (1991) determined that Hycrest, a crested wheatgrass cultivar, depleted soil moisture to a greater extent than Whitmar, a bluebunch wheatgrass cultivar, when they were grown in monocultures. In a semiarid environment, native grasses planted with Russian wildrye (*Psathyrostachys juncea* (Fisch.) Nevski), a later growing grass, showed greater cover than those grasses planted with the earlier growing crested wheatgrass (Waldron et al. 2005).

Crested wheatgrass is an introduced perennial bunchgrass known for its ability to grow and multiply and use limited resources (Rogler and Lorenz 1983). The mean frequency of crested wheatgrass was 24% and the mean density was 0.65 plants m^{-2} (Table 2). The presence of crested wheatgrass after 10 or more years has been documented in a sagebrush-grass environment where several species of crested wheatgrass were still present 20 to 30 years after seeding even when moderately grazed (Hull and Klomp 1966). It was also present 25 years after seeding and had spread to

adjacent areas (Hull 1971). On three semiarid sites, crested wheatgrass continued to produce a standing crop yield after 10 years (Harris and Dobrowolski 1986).

Snake River wheatgrass is a native perennial bunchgrass previously identified as a bluebunch wheatgrass (Ogle et al. 2007). As shown in Table 2, Snake River wheatgrass was present in low numbers in the eight-to-ten year old CP2 plantings, with a mean frequency of 15% and a mean density of 0.29 plants m^{-2}. These results are consistent with those reported by Hull (1971). In contrast, in a semiarid environment, bluebunch wheatgrass was recommended for long-term plantings because it was a long-lived bunchgrass (Harris and Dobrowolski 1986).

The mean density of crested wheatgrass in CP1 seedings was 0.49 plants m^{-2}, compared to the mean density of 0.30 plants m^{-2} of Snake River wheatgrass in CP2 fields (Table 2). One explanation is that because the roots of bluebunch wheatgrass grow almost parallel to the soil surface for 20 to 30 cm, the plants are farther apart, reducing the number of plants in an area (Harris 1967). Another explanation is that crested wheatgrass took up more above and belowground space and was better able to use available resources than bluebunch wheatgrass (Aguirre and Johnson 1991).

Canopy Cover in 8-10 year old CRP Stands - The relationship between the canopy cover of seeded perennial grasses and the canopy cover of invasive annual grasses like cheatgrass is well documented. Canopy cover of non-native grasses declined with increased cover of native grasses (Lulow 2006). In reseeded grassland, established perennial grasses suppressed undesirable annual grasses (Borman et al. 1991). In a mixed vegetative community, a native bunchgrass had greater canopy cover than cheatgrass (Booth et al. 2003). In a sagebrush-grass environment bluebunch wheatgrass reduced

cheatgrass presence (Hull 1971). In this study, the mean canopy cover of big bluegrass in eight-to-ten year old CRP fields ranged from 0% to 26% (Table 3). A t-test comparing big bluegrass mean canopy cover in CP1 and CP2 fields showed no significant difference (P= 0.597 data transformed) (Figure 3). Crested wheatgrass and Snake River wheatgrass were also part of the original seeding (Table 1). A comparison of the mean canopy cover of crested wheatgrass and Snake River wheatgrass was not significant (P=0.478 data transformed) (Figure 4). More important for cheatgrass suppression is a comparison of the mean combined canopy cover of big bluegrass and crested wheatgrass in CP1 fields and big bluegrass and Snake River wheatgrass in CP2 fields. A t-test showed no significant difference (P=0.996 data transformed) (Figure 5). The mean canopy cover for cheatgrass was also less in CP1 fields than in CP2 fields (Table 3). A t-test was not significant (P=0.842 data transformed) (Figure 6). The trend was that for both CP1 and CP2 fields, where the combined canopy cover was >25%, the cheatgrass canopy cover was <7% (Table 3). Big bluegrass in combination with a crested wheatgrass or Snake River wheatgrass may limit cheatgrass invasion.

Evaluation of Burned and Unburned Stands

Two years after an October prescribed fire, the mean canopy cover of big bluegrass was reduced and the mean canopy covers of Snake River wheatgrass and cheatgrass were minimally affected. Big bluegrass mean canopy cover was 3% in burned fields and 6% in unburned fields. In contrast, the difference in canopy covers for Snake River wheatgrass and cheatgrass was <2% (Table 4).

A comparison of mean canopy cover for big bluegrass in burned and unburned fields showed no significant difference (P=0.149 data transformed) (Figure 7). However,

the trend, using untransformed data, was that an October prescribed fire reduced big bluegrass canopy cover by more than half (Table 4). In contrast, Uresk et al. (1980) showed that two years after a mid-August wildfire, there was little difference in herbage yield of Cusick's bluegrass (*Poa cusickii* Vasey) between burned and unburned fields. Daubenmire (1975) observed greater canopy cover of Sandberg bluegrass (*Poa secunda* Presl.) in burned than unburned fields two years after a July wildfire. Both fires occurred during a time when many perennial grasses are not actively growing (Hull 1949). Daubenmire (1972) observed the development of new bluegrass growth in early October following only light rains.

The timing of a fire can affect its impact on perennial bunchgrasses. Fire damage to perennial bunchgrasses is usually temporary (Stewart and Hull 1949, Schacht and Stubbendieck 1985). Burning during periods of active plant growth has been shown to increase plant mortality (DiTomaso 2006). In spring or fall when perennial grasses are dormant, basal buds survive a fire and are able to resprout (Daubenmire 1975, Keeley 2001). In the second year after a July wildfire in steppe vegetation, Sandberg bluegrass canopy cover was greater in a burned than an unburned field (Daubenmire, 1975). In the second year after a spring prescribed burn Sandberg bluegrass resprouted in both a sagebrush ecosystem (Rau et al. 2008) and a mixed prairie (Schacht and Stubbendieck 1985). Two years after a mid-August wildfire, the herbage yield for Cusick's bluegrass was not significantly different in burned fields than in unburned fields (Uresk et al. 1980). In this study, two years after an October prescribed burn, big bluegrass canopy cover was less in a burned field than in an unburned field. This may be related to the

timing of the prescribed fire as the plants may have been actively growing at the time of the fire.

The effect of fire on Snake River wheatgrass was also evaluated. There was a minimal difference between the mean canopy cover of Snake River wheatgrass in fields burned in October 2006 and unburned fields (Table 4). A comparison of the mean canopy cover for the two treatments was not significant (P=0.990 data transformed) (Figure 8). A minimal difference in bluebunch wheatgrass canopy cover between burned and unburned fields was also found two years after a fall wildfire in a canyon grassland (Menke and Muir 2004) and a July wildfire in steppe vegetation (Daubenmire 1975). Other studies showed an increase in bluebunch wheatgrass biomass two years after a fire (Uresk et al. 1980, Cook et al. 1994). The response of bluebunch wheatgrass to fire may be related to the period of active plant growth and the time of the fire. The growing period for bluebunch wheatgrass lasts until mid-June (Hull 1949) or mid-July (Harris 1967). Uresk et al. (1980) observed that at the time of an August fire, there was little green plant material because the plants had senesced. The minimal reduction in bluebunch wheatgrass canopy cover may also be because the short rhizomes and buds lie below the soil surface and are protected from the effects of fire (Conrad and Poulton 1966).

The mean canopy cover of big bluegrass, Snake River wheatgrass and thickspike wheatgrass combined was 50% greater in unburned than in burned fields (Table 4). A t-test comparing the mean canopy cover showed no significant difference (P=0.106 data transformed) (Figure 9). In the second season after a fire, burning reduced overall perennial grass canopy cover and had little effect on cheatgrass canopy cover (Table 4).

Cheatgrass was present in all of the fields. In the second season after an October prescribed fire, there was no difference in mean cheatgrass canopy cover between burned and unburned fields (Table 4). A t-test was not significant (P=0.702 data transformed) (Figure 10). A prescribed burn had no effect on introduced grass cover (DiTomaso et al. 1999). Menke and Muir (2004) observed little change in cheatgrass cover following a fall wildfire. Results from other studies were different and showed that annual grasses invaded a site a year after a prescribed burn eliminated them (Schacht and Stubbendieck 1985). Young and Evans (1978) observed a major increase in cheatgrass frequency and density two years after burning, but little increase the third and fourth years after burning.

Keeley and McGinnis (2007) studied cheatgrass persistence following fire and determined that prescribed fire resulted in no significant change in cheatgrass canopy cover over several post fire growing seasons (Keeley and McGinnis 2007). Grasses produce a lighter fuel load and lower burn temperatures (Keeley 2001). In the present study, there may be little difference in cheatgrass canopy cover between the burned and unburned fields because the prescribed fire burned in grass and may not have reached the temperatures necessary to reduce or eliminate the cheatgrass seedbank.

Conclusions

Big bluegrass, Snake River wheatgrass and crested wheatgrass were all found in eight-to-ten year old CRP fields, with big bluegrass present in almost all of the fields. The frequency of big bluegrass was higher when it was planted with Snake River wheatgrass than with crested wheatgrass. Crested wheatgrass is an earlier growing perennial bunchgrass than either big bluegrass or Snake River wheatgrass and tends to deplete soil moisture more than Snake River wheatgrass (Aguirre and Johnson 1991). This may

account for the reduced frequency of big bluegrass in eight-to-ten year old fields when planted with crested wheatgrass.

The trend across both the CP1 and CP2 fields was for fields with greater big bluegrass canopy cover to have lesser cheatgrass canopy cover. Land management practices were not a part of this study, but may have affected this trend.

An October prescribed fire was not effective in reducing cheatgrass canopy cover. Two years after the fire, there was minimal difference between cheatgrass canopy cover in burned and unburned fields. These results are consistent with those reported by Daubenmire (1975) who observed little difference in cheatgrass cover two years after a fire and a reduction in cheatgrass cover the third year. For reducing cheatgrass in CRP fields that are growing, prescribed fire is of questionable benefit. Additional research could address ways to prevent or minimize cheatgrass growth when the field is seeded. Possible topics are: the optimum month for seeding CRP, seedbed preparation, land management practices following seeding and the inclusion of early-growing grasses known to outcompete cheatgrass in the seed mix.

Acknowledgements

We would like to thank Glenn Riehle from the Pasco, Washington Natural Resources Conservation Service office for his technical assistance throughout the project. A special thank you to landowners who granted permission to collect data in their fields and who choose to remain anonymous. Thank you to Ken Sellereite for assistance with data collection.

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TABLE 1. Conservation practices and seeding rates.

Year Seeded	Conservation practice (CP)	Number of fields	Burned in 2006	Big bluegrass	Snake River wheatgrass	Crested wheatgrass	Thickspike wheatgrass	Sandberg bluegrass
				Seeding rate kg PLS* ha^{-1}				
1998/1999 or 1999/2000	1	5	-	2.24	0.00	2.24	0.00	0.00
1998/1999 or 1999/2000	2	5	-	2.24	2.24	0.00	1.11	0.67
2004/2005	2	6	No	2.24	3.36	0.00	2.24	1.11
2004/2005	2	6	Yes	2.24	3.36	0.00	2.24	1.11

*PLS – pure live seed

TABLE 2. Frequency and density of seeded perennial bunchgrasses in 8-10 year old CRP fields. Data untransformed. (Frequency – percent sample points containing species. Density = plants $m^{-2.}$)

	Big bluegrass		Snake River wheatgrass	
CP2 fields	Frequency	Density	Frequency	Density
1	95	6.60	10	0.10
2	75	2.55	5	0.20
3	25	0.50	25	0.70
4	100	7.0	25	0.45
5	100	6.20	10	0.05
Mean	79	4.57	15	0.30
			Crested wheatgrass	
CP1 fields				
6	100	12.05	5	0.05
7	80	10.55	25	0.40
8	95	7.35	0	0.00
9	0	0.00	45	0.70
10	25	0.60	45	1.30
Mean	60	6.11	24	0.49

TABLE 3. Percent canopy cover for grasses in 8-10 year old fields. Data untransformed.

Field	Big	Snake River	Thickspike	Crested	Combined	
CP2	bluegrass	wheatgrass	wheatgrass	wheatgrass	grasses*	Cheatgrass
1	24	1	0	not seeded	25	0
2	7	2	0	not seeded	8	9
3	1	1	0	not seeded	2	58
4	25	1	0	not seeded	26	6
5	16	0	0	not seeded	17	28
Mean	15	1	<1	not seeded	16	20
CP1						
6	26	not seeded	0	0	26	0
7	18	0	not seeded	1	19	15
8	10	0	not seeded	0	10	10
9	0	not seeded	0	3	3	25
10	1	0	not seeded	3	4	30
Mean	11	<1	<1	1	12	16

*CP2 combination – Big bluegrass and Snake River wheatgrass
CP1 combination – Big bluegrass and crested wheatgrass

TABLE 4. Percent canopy cover for perennial grasses seeded in 2004-2005 and cheatgrass. Fields burned in 2006. Data untransformed.

Field	Big bluegrass	Snake River wheatgrass	Thickspike wheatgrass	Combined grasses*	Cheatgrass
Burned					
11	1	4	1	6	9
12	4	3	0	6	11
13	3	1	0	4	10
14	3	9	0	12	12
15	1	10	0	11	8
16	1	8	1	10	9
Mean	2	6	<1	8	10
Unburned					
17	0	7	1	9	30
18	9	1	0	10	12
19	1	7	1	10	0
20	14	1	0	15	9
21	4	16	0	20	0
22	5	3	0	9	12
Mean	6	6	<1	12	10

*Big bluegrass, Snake River wheatgrass, thickspike wheatgrass

Figure captions

Figure 1. Mean monthly temperature and precipitation at Connell, WA from 1960 to 2003. (Western Regional Climate Center 2006)

Figure 2. One m^2 frame centered on tape measure with 400 cm^2 grid.

Figure 3. Comparison of big bluegrass mean canopy cover (%) in 8-10 year old CRP fields planted with a CP1 or a CP2 seed mix. Data transformed. Each dot represents mean canopy cover for one field. Line connects treatment means.

Figure 4. Comparison of crested wheatgrass (CP1) and Snake River wheatgrass (CP2) mean canopy cover (%) in 8-10 year old CRP fields. Data transformed. Each dot represents mean canopy cover for one field. Line connects treatment means.

Figure 5. Comparison of mean canopy cover (%) for big bluegrass/crested wheatgrass (CP1) combination and big bluegrass/Snake River wheatgrass (CP2) combination in 8-10 year old CRP fields. Data transformed. Each dot represents mean canopy cover for one field.

Figure 6. Comparison of cheatgrass mean canopy cover (%) in 8-10 year old CRP fields. Data transformed. Each dot represents mean canopy cover for one field. Line connects treatment means.

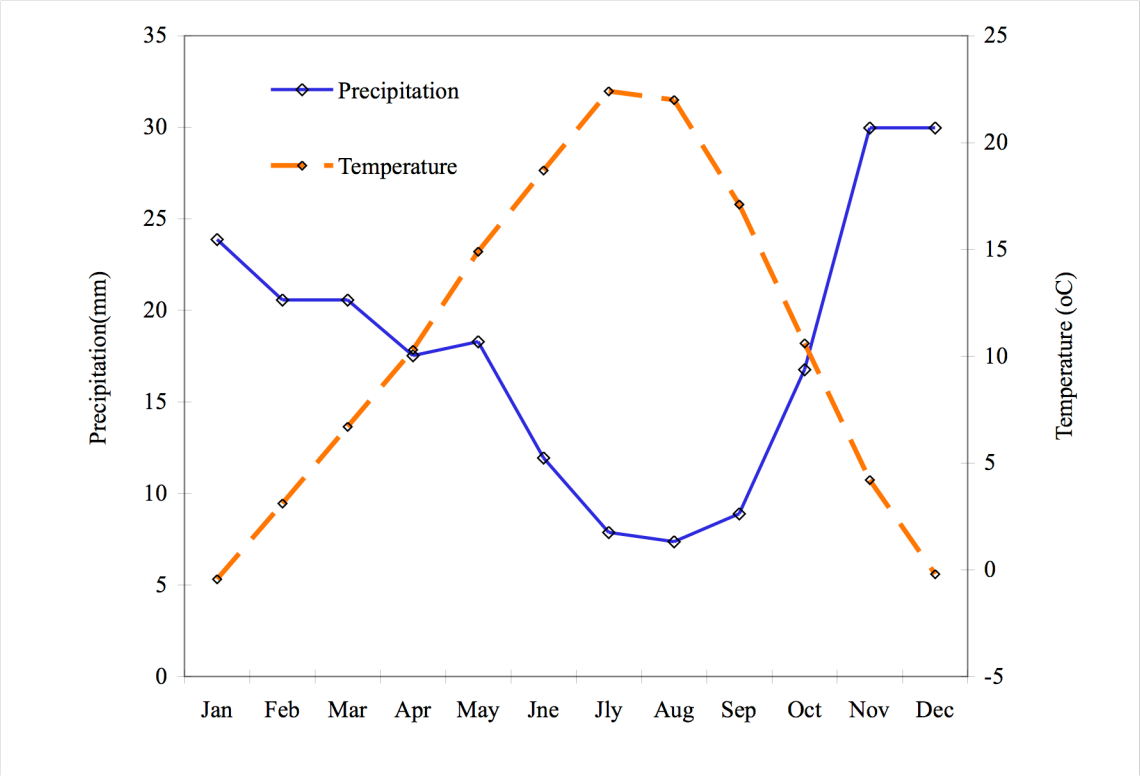
Figure 7. Comparison of big bluegrass mean canopy cover (%) in burned and unburned CRP fields. All fields were seeded in 2004-2005. Fields were burned in 2006. Data transformed. Each dot represents mean canopy cover for one field. Line connects treatment means.

Figure 8. Comparison of Snake River wheatgrass mean canopy cover (%) in burned and unburned CRP fields. All fields were seeded in 2004-2005. Fields were burned in 2006. Data transformed. Each dot represents mean canopy cover for one field. Line connects treatment means.

Figure 9. Comparison of combined grasses (big bluegrass, Snake River wheatgrass, thickspike wheatgrass) mean canopy cover (%) in burned and unburned CRP fields. All fields were seeded in 2004-2005. Fields were burned in 2006. Data transformed. Each dot represents mean canopy cover for one field. Line connects treatment means.

Figure 10**.** Comparison of cheatgrass mean canopy cover (%) in burned and unburned CRP fields. All fields were seeded in 2004-2005. Fields were burned in 2006. Data transformed. Each dot represents mean canopy cover for one field. Line connects treatment means.

Figure 1


Precipitation
Temperature
Precipitation(mm)
Temperature (oC)
35
30
25
20
15
10
5
0
25
20
15
10
5
0
-5
Jan
Feb
Mar
Apr
May
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Jly
Aug
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Oct
Nov
Dec

Figure 2

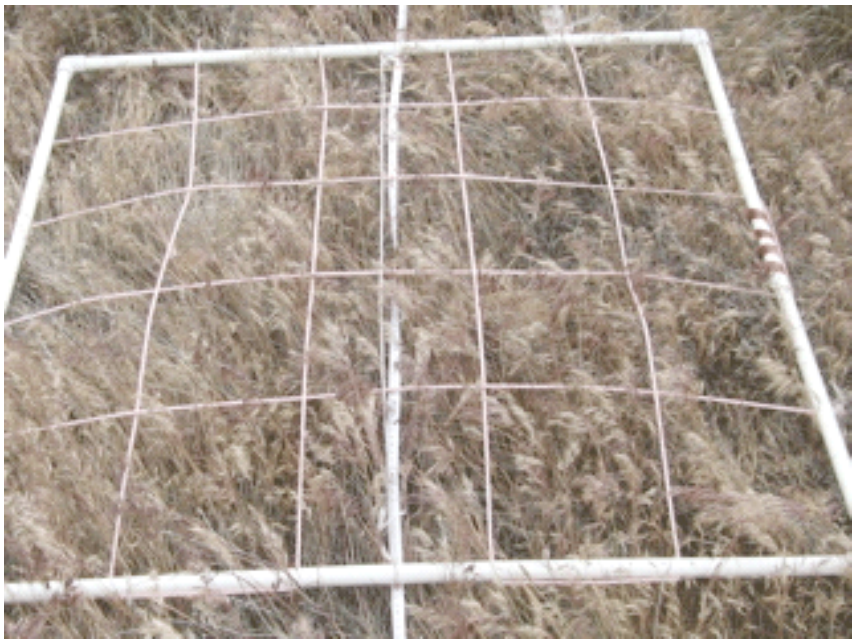


Figure 3

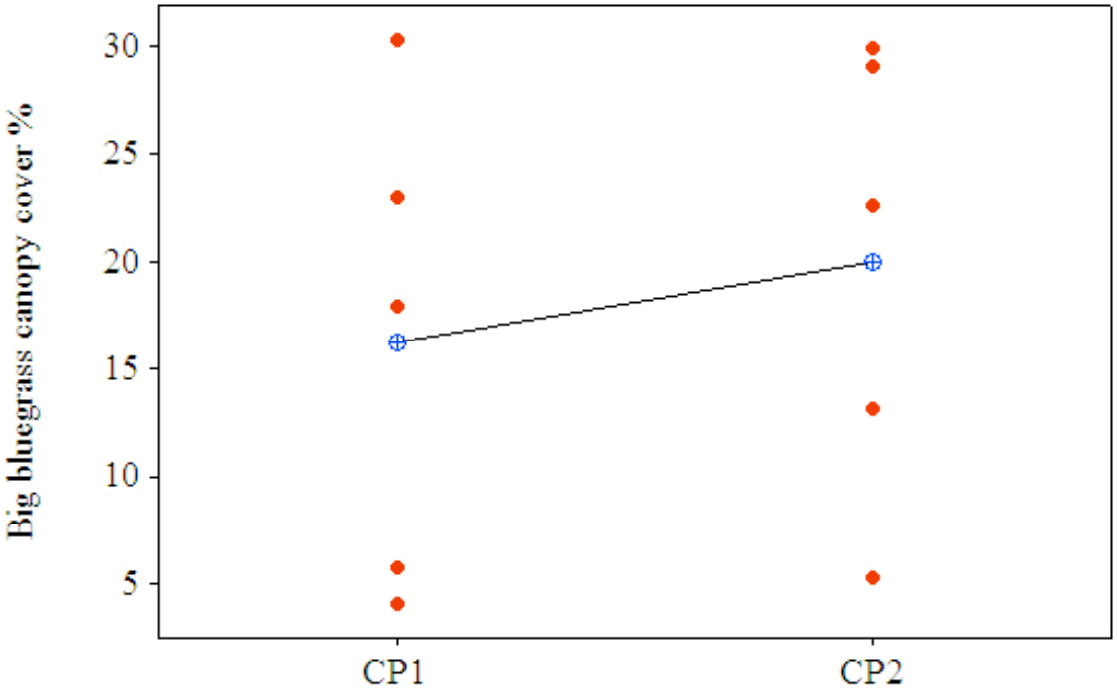


Figure 4

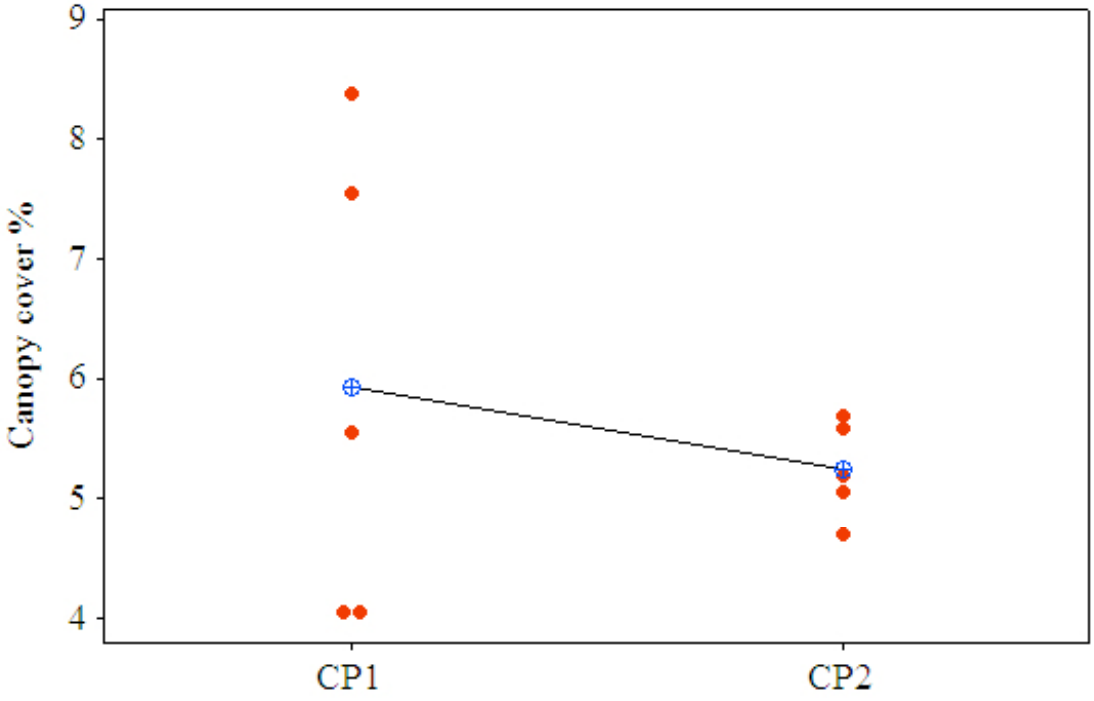


Figure 5

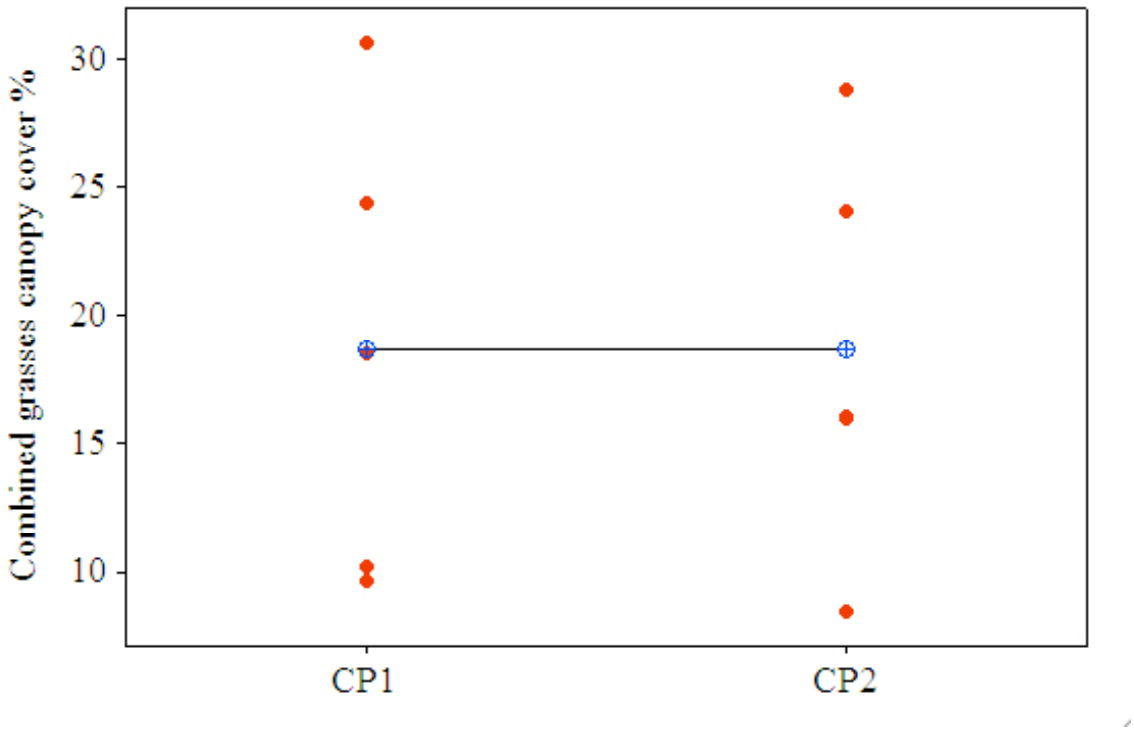


Figure 6

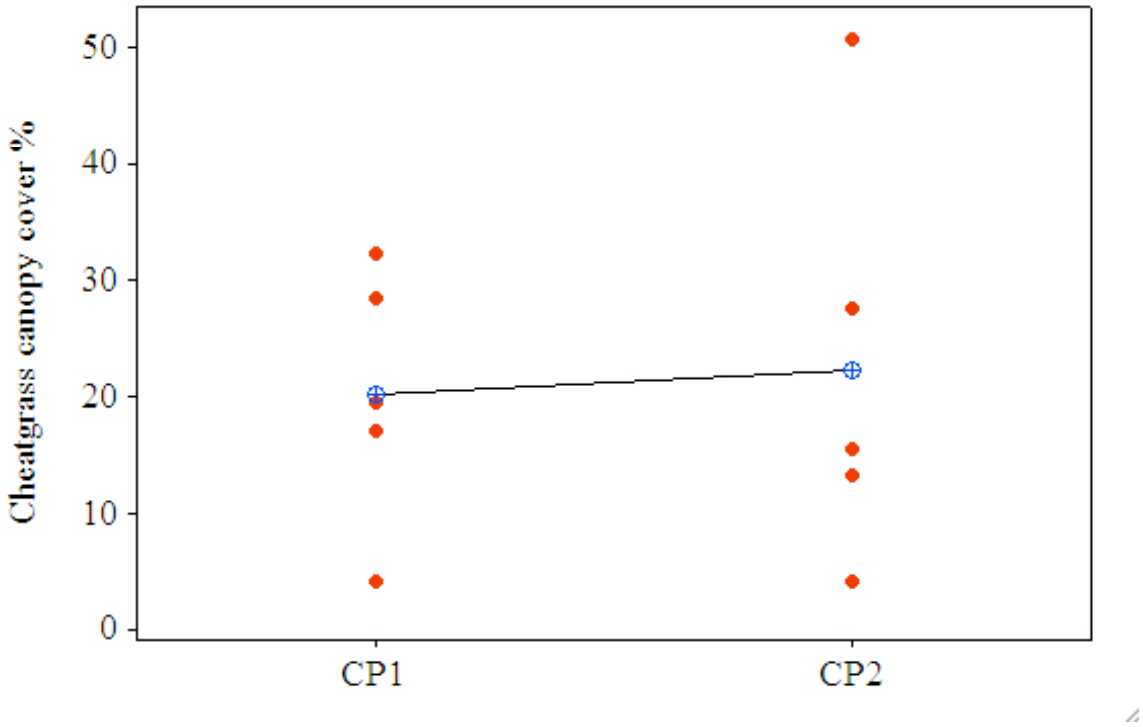


Figure 7

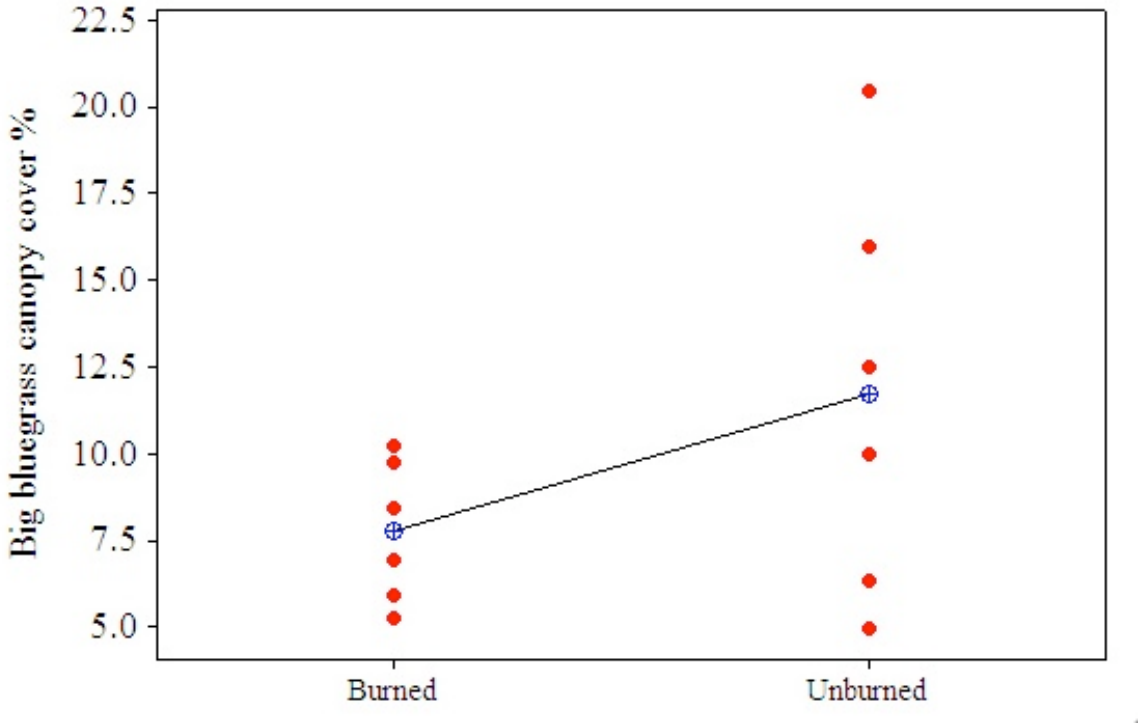

Big bluegrass canopy cover %
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
Burned
Unburned

Figure 8

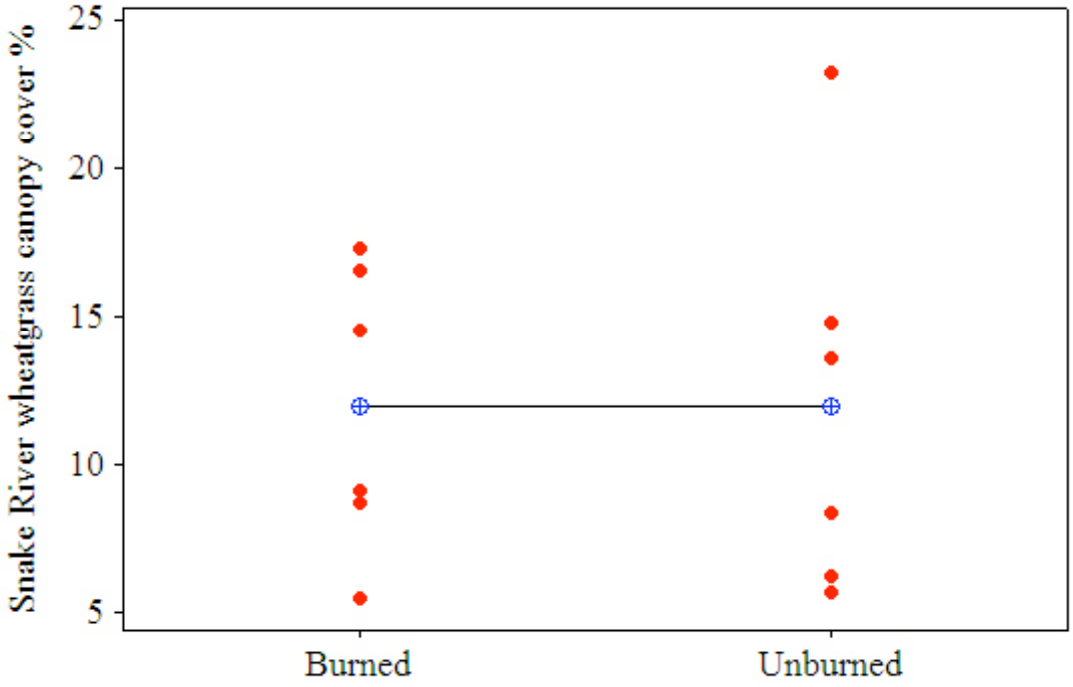

Snake River wheatgrass canopy cover %
25
20
15
10
5
Burned
Unburned

Figure 9

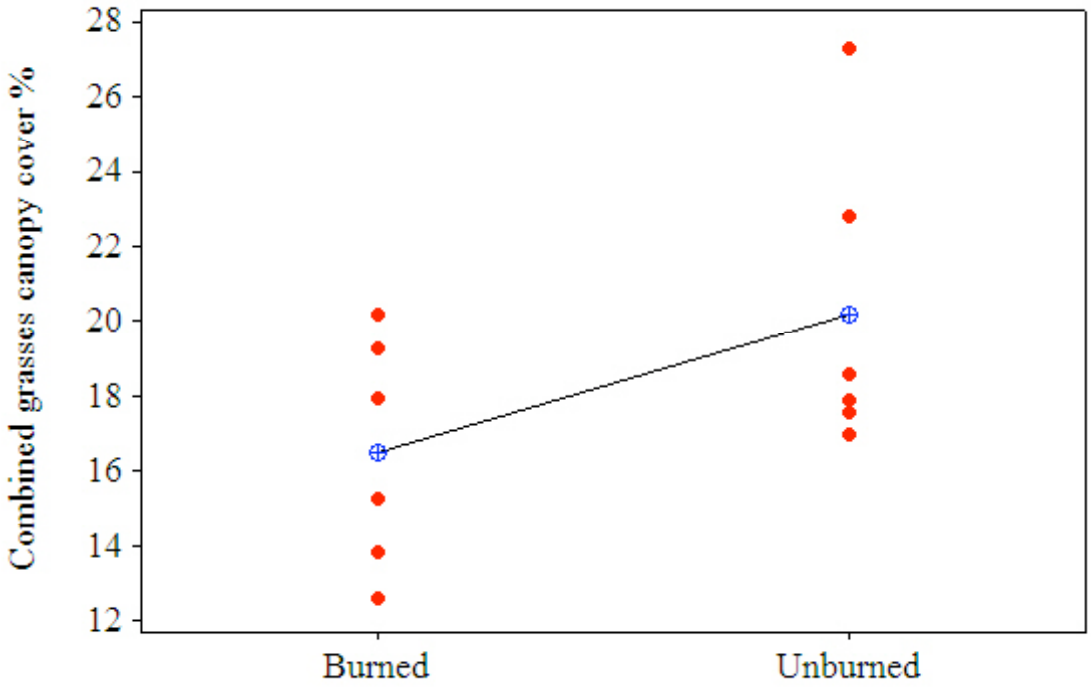
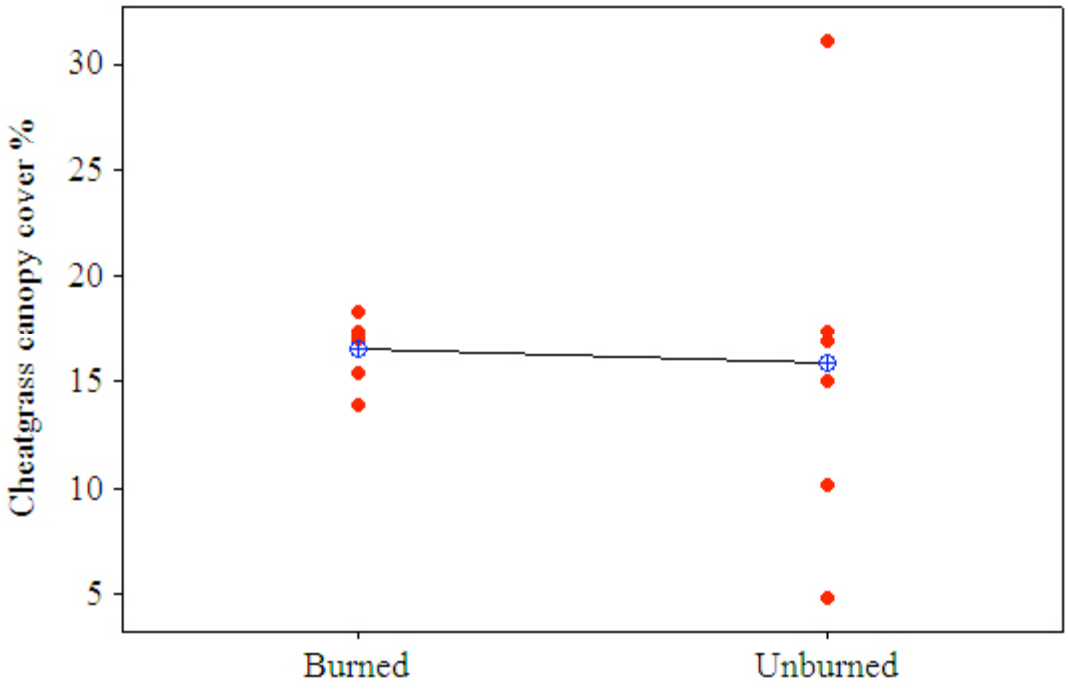

Combined grasses canopy cover %
28
26
24
22
20
18
16
14
12
Burned
Unburned

Figure 10



Appendix A1 Plant Count CP2 Stands 8-10 years old

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Number of plants at sample point				
A	Big bluegrass	0	2	4	3	4
B	Big bluegrass	5	7	8	9	6
C	Big bluegrass	7	8	1	8	6
D	Big bluegrass	5	8	12	9	20
A	Cheatgrass	6	10	1	1	0
B	Cheatgrass	5	10	3	6	8
C	Cheatgrass	0	7	16	2	7
D	Cheatgrass	1	2	5	12	0
A	Snake River	0	0	1	1	0
B	Snake River	0	0	0	0	0
C	Snake River	0	0	0	0	0
D	Snake River	0	0	0	0	0
A	Thickspike	7	3	4	3	0
B	Thickspike	0	0	0	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	0	0	0	0

Snake R. - Snake River wheatgrass

Thickspike - Thickspike wheatgrass

Appendix A2 Plant Count CP2 Stands 8-10 years old

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Number of plants at sample point				
A	Big bluegrass	4	1	2	2	6
B	Big bluegrass	5	0	3	5	8
C	Big bluegrass	0	0	2	3	0
D	Big bluegrass	3	1	5	0	1
A	Cheatgrass	7	15	14	2	16
B	Cheatgrass	15	12	4	2	2
C	Cheatgrass	12	6	10	16	2
D	Cheatgrass	6	7	11	15	8
A	Snake River	0	0	0	4	0
B	Snake River	0	0	0	0	0
C	Snake River	0	0	0	0	0
D	Snake River	0	0	0	0	0
A	Thickspike	0	0	0	0	0
B	Thickspike	0	0	0	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	0	0	0	0

Snake River - Snake River wheatgrass

Thickspike - Thickspike wheatgrass

Appendix A3 Plant Count CP2 Stands 8-10 years old

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Number of plants at sample point				
A	Big bluegrass	0	0	0	0	1
B	Big bluegrass	0	3	0	0	0
C	Big bluegrass	0	2	2	0	0
D	Big bluegrass	0	2	0	0	0
A	Cheatgrass	80	16	26	26	9
B	Cheatgrass	22	30	8	26	30
C	Cheatgrass	12	16	40	3	16
D	Cheatgrass	20	8	22	12	9
A	Snake River	0	0	0	0	0
B	Snake River	0	0	2	0	2
C	Snake River	0	4	2	0	0
D	Snake River	1	0	0	3	0
A	Thickspike	0	0	0	0	0
B	Thickspike	0	0	0	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	0	0	2	0

Snake River - Snake River wheatgrass

Thickspike - Thickspike wheatgrass

Appendix A4 Plant Count CP2 Stands 8-10 years old

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Number of plants at sample point				
A	Big bluegrass	5	9	4	5	8
B	Big bluegrass	4	9	9	7	13
C	Big bluegrass	3	8	7	2	12
D	Big bluegrass	12	7	4	3	9
A	Cheatgrass	5	8	2	0	0
B	Cheatgrass	2	8	3	0	4
C	Cheatgrass	4	3	2	20	0
D	Cheatgrass	2	0	4	6	6
A	Snake River	0	0	3	0	0
B	Snake River	0	0	0	2	0
C	Snake River	0	0	1	1	2
D	Snake River	0	0	0	0	0
A	Thickspike	0	0	0	0	0
B	Thickspike	0	0	0	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	0	0	0	0

Snake River - Snake River wheatgrass

Thickspike - Thickspike wheatgrass

Appendix A5 Plant Count CP2 Stands 8-10 years old

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Number of plants at sample point				
A	Big bluegrass	5	2	12	4	3
B	Big bluegrass	10	7	6	5	7
C	Big bluegrass	10	7	6	10	4
D	Big bluegrass	4	11	5	2	4
A	Cheatgrass	8	16	1	20	30
B	Cheatgrass	0	2	18	4	12
C	Cheatgrass	0	15	0	0	30
D	Cheatgrass	25	0	20	25	28
A	Snake River	0	1	0	0	0
B	Snake River	0	0	0	0	0
C	Snake River	0	0	0	0	0
D	Snake River	0	0	0	0	0
A	Thickspike	0	0	0	0	0
B	Thickspike	0	0	0	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	0	0	0	0

Snake River - Snake River wheatgrass

Thickspike - Thickspike wheatgrass

Appendix B1 Plant Count CP1 Stands 8-10 years old

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Number of plants at sample point				
A	Big bluegrass	19	7	18	15	14
B	Big bluegrass	15	16	10	14	19
C	Big bluegrass	13	12	3	5	10
D	Big bluegrass	6	11	13	12	9
A	Cheatgrass	0	0	0	0	0
B	Cheatgrass	0	0	0	0	0
C	Cheatgrass	0	0	0	0	0
D	Cheatgrass	0	0	0	0	0
A	Crested	0	0	0	0	0
B	Crested	0	0	0	0	0
C	Crested	0	0	0	0	0
D	Crested	1	0	0	0	0

crested - the crested wheatgrasses

Appendix B2 Plant Count CP1 Stands 8-10 years old

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Number of plants at sample point				
A	Big bluegrass	0	1	14	24	16
B	Big bluegrass	0	0	10	16	16
C	Big bluegrass	4	13	11	14	0
D	Big bluegrass	8	11	19	14	20
A	Cheatgrass	27	36	24	1	4
B	Cheatgrass	15	60	21	2	1
C	Cheatgrass	15	20	0	37	24
D	Cheatgrass	0	1	1	12	6
A	Crested	0	2	0	0	0
B	Crested	0	0	2	1	2
C	Crested	0	0	0	0	0
D	Crested	1	0	0	0	0

crested - the crested wheatgrasses

Appendix B3 Plant Count CP1 Stands 8-10 years old

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Number of plants at sample point				
A	Big bluegrass	2	13	15	16	6
B	Big bluegrass	14	3	6	2	10
C	Big bluegrass	9	6	6	3	4
D	Big bluegrass	4	9	16	3	0
A	Cheatgrass	12	10	4	20	4
B	Cheatgrass	8	24	9	30	2
C	Cheatgrass	5	3	6	14	21
D	Cheatgrass	9	18	0	30	18
A	Crested	0	0	0	0	0
B	Crested	0	0	0	0	0
C	Crested	0	0	0	0	0
D	Crested	0	0	0	0	0

crested - the crested wheatgrasses

Appendix B4 Plant Count CP1 Stands 8-10 years old

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Number of plants at sample point				
A	Big bluegrass	0	0	0	0	0
B	Big bluegrass	0	0	0	0	0
C	Big bluegrass	0	0	0	0	0
D	Big bluegrass	0	0	0	0	0
A	Cheatgrass	5	11	12	19	16
B	Cheatgrass	48	28	10	0	28
C	Cheatgrass	0	17	20	65	3
D	Cheatgrass	11	24	8	34	32
A	Crested	1	1	1	1	1
B	Crested	0	0	0	3	3
C	Crested	0	2	0	1	0
D	Crested	0	0	0	0	0

crested - the crested wheatgrasses

Appendix B5 Plant Count CP1 Stands 8-10 years old

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Number of plants at sample point				
A	Big bluegrass	0	2	0	0	2
B	Big bluegrass	0	0	0	0	5
C	Big bluegrass	0	0	0	1	0
D	Big bluegrass	0	0	0	0	2
A	Cheatgrass	26	13	28	22	17
B	Cheatgrass	2	5	2	8	12
C	Cheatgrass	8	22	14	16	8
D	Cheatgrass	9	14	16	6	3
A	Crested	1	0	3	0	11
B	Crested	1	0	0	2	0
C	Crested	1	0	2	2	2
D	Crested	1	0	0	0	0

crested - the crested wheatgrasses

Appendix C1 Percent Canopy Cover CP2 Stands 8-10 years old

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Canopy cover % at sample point				
A	Big bluegrass	48	24	16	64	32
B	Big bluegrass	12	32	24	24	24
C	Big bluegrass	12	16	1	24	8
D	Big bluegrass	24	32	32	16	24
A	Cheatgrass	0	0	0	0	0
B	Cheatgrass	0	0	0	0	0
C	Cheatgrass	0	0	0	0	0
D	Cheatgrass	0	0	0	0	0
A	Snake R.	0	0	16	0	0
B	Snake R.	0	0	0	0	0
C	Snake R.	0	0	0	0	0
D	Snake R.	0	0	0	0	0
A	Thickspike	0	0	0	0	0
B	Thickspike	0	0	0	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	0	0	0	0

Appendix C2 Percent Canopy Cover CP2 Stands 8-10 years old

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Canopy cover % at sample point				
A	Big bluegrass	10	0	0	8	10
B	Big bluegrass	10	0	10	4	20
C	Big bluegrass	0	0	8	8	0
D	Big bluegrass	28	0	12	0	4
A	Cheatgrass	2	48	2	2	8
B	Cheatgrass	8	20	12	0	0
C	Cheatgrass	6	4	8	8	2
D	Cheatgrass	2	16	8	12	2
A	Snake River	0	0	0	32	0
B	Snake River	0	0	0	0	0
C	Snake River	0	0	0	0	0
D	Snake River	0	0	0	0	0
A	Thickspike	0	0	0	0	0
B	Thickspike	0	0	0	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	0	0	0	0

Appendix C3 Percent Canopy Cover CP2 Stands 8-10 years old

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Canopy cover % at sample point				
A	Big bluegrass	0	0	0	0	0
B	Big bluegrass	0	0	0	0	0
C	Big bluegrass	0	0	0	16	0
D	Big bluegrass	0	2	0	0	0
A	Cheatgrass	100	64	40	80	24
B	Cheatgrass	36	60	44	40	36
C	Cheatgrass	48	40	80	12	80
D	Cheatgrass	88	88	80	32	80
A	Snake River	0	0	0	0	0
B	Snake River	0	0	4	0	4
C	Snake River	0	0	0	4	0
D	Snake River	4	0	0	0	0
A	Thickspike	0	0	0	0	0
B	Thickspike	0	0	0	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	0	0	2	0

Appendix C4 Percent Canopy Cover CP2 Stands 8-10 years old

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Canopy cover % at sample point				
A	Big bluegrass	12	22	10	40	24
B	Big bluegrass	24	20	32	30	20
C	Big bluegrass	12	24	48	8	36
D	Big bluegrass	14	40	46	16	28
A	Cheatgrass	14	4	2	2	2
B	Cheatgrass	2	2	0	2	4
C	Cheatgrass	2	4	2	40	0
D	Cheatgrass	2	4	8	16	16
A	Snake River	0	0	0	0	0
B	Snake River	0	0	0	8	0
C	Snake River	0	0	0	0	4
D	Snake River	0	0	0	0	0
A	Thickspike	0	0	0	0	0
B	Thickspike	0	0	0	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	0	0	0	0

Appendix C5 Percent Canopy Cover CP2 Stands 8-10 years old

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Canopy cover % at sample point				
A	Big bluegrass	12	8	28	4	4
B	Big bluegrass	16	16	12	16	32
C	Big bluegrass	32	12	16	48	8
D	Big bluegrass	8	40	8	0	4
A	Cheatgrass	4	56	8	24	52
B	Cheatgrass	0	2	40	8	0
C	Cheatgrass	0	48	0	0	48
D	Cheatgrass	64	0	48	80	72
A	Snake River	0	8	0	0	0
B	Snake River	0	0	0	0	0
C	Snake River	0	0	0	0	0
D	Snake River	0	0	0	0	0
A	Thickspike	0	0	0	0	0
B	Thickspike	0	0	0	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	0	0	0	0

Appendix D1 Percent Canopy Cover CP1 Stands 8-10 years old

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Canopy cover % at sample point				
A	Big bluegrass	44	14	72	36	24
B	Big bluegrass	18	20	20	30	32
C	Big bluegrass	28	24	14	16	16
D	Big bluegrass	24	16	20	28	16
A	Cheatgrass	0	0	0	0	0
B	Cheatgrass	0	0	0	0	0
C	Cheatgrass	0	0	0	0	0
D	Cheatgrass	0	0	0	0	0
A	Crested	0	0	0	0	0
B	Crested	0	0	0	0	0
C	Crested	0	0	0	0	0
D	Crested	0	0	0	0	0
A	Snake River	0	0	0	0	0
B	Snake River	0	0	0	0	0
C	Snake River	0	0	0	0	0
D	Snake River	0	0	0	0	0
A	Thickspike	0	0	0	0	0
B	Thickspike	0	0	0	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	0	0	0	0

crested - one of the crested wheatgrasses

Snake R. - Snake River wheatgrass

Appendix D2 Percent Canopy Cover CP1 Stands 8-10 years old

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Canopy cover % at sample point				
A	Big bluegrass	0	2	20	24	24
B	Big bluegrass	0	0	12	36	20
C	Big bluegrass	6	16	28	24	0
D	Big bluegrass	32	36	32	24	20
A	Cheatgrass	52	20	24	0	2
B	Cheatgrass	52	56	6	2	2
C	Cheatgrass	32	6	2	8	24
D	Cheatgrass	2	2	0	2	2
A	Crested	0	2	0	0	0
B	Crested	0	0	12	0	0
C	Crested	0	0	0	0	0
D	Crested	4	0	0	0	0
A	Snake River	0	0	0	0	0
B	Snake River	0	0	0	0	0
C	Snake River	0	0	0	0	0
D	Snake River	0	0	0	4	0
A	Thickspike	0	0	0	0	0
B	Thickspike	0	0	0	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	0	0	0	0

crested - one of the crested wheatgrasses

Snake River - Snake River wheatgrass

Appendix D3 Percent Canopy Cover CP1 Stands 8-10 years old

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Canopy cover % at sample point				
A	Big bluegrass	8	24	18	28	10
B	Big bluegrass	20	2	10	2	20
C	Big bluegrass	14	8	6	2	2
D	Big bluegrass	8	6	16	4	0
A	Cheatgrass	12	2	0	4	24
B	Cheatgrass	2	12	6	32	4
C	Cheatgrass	4	10	16	8	8
D	Cheatgrass	8	10	0	20	8
A	Crested	0	0	0	0	0
B	Crested	0	0	0	0	0
C	Crested	0	0	0	0	0
D	Crested	0	0	0	0	0
A	Snake River	2	0	0	0	0
B	Snake River	0	0	0	0	0
C	Snake River	0	0	0	0	0
D	Snake River	0	0	0	0	0
A	Thickspike	0	0	0	0	0
B	Thickspike	0	0	0	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	0	0	0	0

crested - one of the crested wheatgrasses

Snake River - Snake River wheatgrass

Appendix D4 Percent Canopy Cover CP1 Stands 8-10 years old

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Canopy cover % at sample point				
A	Big bluegrass	0	0	0	0	0
B	Big bluegrass	0	0	0	0	0
C	Big bluegrass	0	0	0	0	0
D	Big bluegrass	0	0	0	0	0
A	Cheatgrass	16	12	20	8	22
B	Cheatgrass	48	16	12	2	20
C	Cheatgrass	0	40	32	80	16
D	Cheatgrass	18	28	8	32	64
A	Crested	4	4	8	0	12
B	Crested	0	0	0	20	8
C	Crested	0	2	0	0	0
D	Crested	0	0	0	0	0
A	Snake River	0	0	0	0	0
B	Snake River	0	0	0	0	0
C	Snake River	0	0	0	0	0
D	Snake River	0	0	0	0	0
A	Thickspike	0	0	0	0	0
B	Thickspike	0	0	0	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	0	0	0	0

crested - one of the crested wheatgrasses

Snake River - Snake River wheatgrass

Appendix D5 Percent Canopy Cover CP1 Stands 8-10 years old

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Canopy cover % at sample point				
A	Big bluegrass	0	0	0	0	8
B	Big bluegrass	0	0	0	0	12
C	Big bluegrass	0	0	0	0	0
D	Big bluegrass	0	0	0	0	2
A	Cheatgrass	96	32	56	32	8
B	Cheatgrass	8	24	4	12	0
C	Cheatgrass	8	64	40	16	32
D	Cheatgrass	32	44	64	12	24
A	Crested	0	0	0	0	18
B	Crested	8	0	0	8	0
C	Crested	0	0	0	20	0
D	Crested	0	0	0	0	0
A	Snake River	0	0	0	0	0
B	Snake River	0	0	0	0	0
C	Snake River	12	0	0	0	0
D	Snake River	0	0	0	0	0
A	Thickspike	0	0	0	0	0
B	Thickspike	0	0	0	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	0	0	0	0

crested - one of the crested wheatgrasses

Snake River - Snake River wheatgrass

Appendix E1 Can. Cov. seeded 2004-2005 & burned 2006

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Canopy cover % at sample point				
A	Big bluegrass	2	0	0	0	8
B	Big bluegrass	0	0	0	0	0
C	Big bluegrass	0	6	2	0	0
D	Big bluegrass	0	0	0	0	0
A	Cheatgrass	12	40	14	12	0
B	Cheatgrass	26	8	2	10	12
C	Cheatgrass	2	8	2	2	6
D	Cheatgrass	2	8	2	2	8
A	Snake R.	0	0	8	0	12
B	Snake R.	0	0	2	12	8
C	Snake R.	0	0	16	12	0
D	Snake R.	6	0	0	0	0
A	Thickspike	0	0	0	0	0
B	Thickspike	2	8	0	0	0
C	Thickspike	0	0	0	6	0
D	Thickspike	0	0	0	0	0

Appendix E2 Can. Cov. seeded 2004-2005 & burned 2006

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Canopy cover % at sample point				
A	Big bluegrass	8	0	0	4	0
B	Big bluegrass	0	4	0	8	0
C	Big bluegrass	4	2	8	8	0
D	Big bluegrass	12	4	0	12	0
A	Cheatgrass	32	36	24	18	8
B	Cheatgrass	8	12	8	12	0
C	Cheatgrass	4	8	2	0	0
D	Cheatgrass	4	2	4	12	16
A	Snake River	0	0	8	0	4
B	Snake River	0	2	4	8	0
C	Snake River	0	0	6	0	0
D	Snake River	2	10	10	0	0
A	Thickspike	0	0	0	0	0
B	Thickspike	0	0	0	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	0	0	0	0

Appendix E3 Can. Cov. seeded 2004-2005 & burned 2006

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Canopy cover % at sample point				
A	Big bluegrass	0	8	2	2	0
B	Big bluegrass	2	2	0	4	0
C	Big bluegrass	10	6	0	0	0
D	Big bluegrass	8	0	4	6	10
A	Cheatgrass	4	8	10	12	4
B	Cheatgrass	8	8	16	2	2
C	Cheatgrass	6	14	0	24	20
D	Cheatgrass	40	2	10	4	0
A	Snake River	0	0	0	0	0
B	Snake River	0	0	0	10	0
C	Snake River	0	0	0	0	0
D	Snake River	0	2	4	0	0
A	Thickspike	0	0	0	0	0
B	Thickspike	0	0	0	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	0	0	0	0

Appendix E4 Can. Cov. seeded 2004-2005 & burned 2006

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Canopy cover % at sample point				
A	Big bluegrass	0	0	2	0	0
B	Big bluegrass	0	16	8	6	4
C	Big bluegrass	0	0	0	0	0
D	Big bluegrass	0	6	0	0	16
A	Cheatgrass	36	44	52	0	22
B	Cheatgrass	4	0	0	2	2
C	Cheatgrass	2	8	16	4	8
D	Cheatgrass	16	10	8	10	4
A	Snake River	0	0	0	12	16
B	Snake River	8	16	24	12	22
C	Snake River	12	8	6	6	8
D	Snake River	0	16	12	0	8
A	Thickspike	0	0	0	0	0
B	Thickspike	0	0	0	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	2	0	0	0

Appendix E5 Can. Cov. seeded 2004-2005 & burned 2006

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Canopy cover % at sample point				
A	Big bluegrass	0	8	0	0	0
B	Big bluegrass	0	0	0	0	0
C	Big bluegrass	0	0	0	0	4
D	Big bluegrass	2	6	0	0	0
A	Cheatgrass	0	6	8	8	8
B	Cheatgrass	0	0	0	0	0
C	Cheatgrass	2	4	4	40	2
D	Cheatgrass	0	2	8	32	44
A	Snake River	0	4	20	12	10
B	Snake River	0	20	4	4	4
C	Snake River	24	8	4	4	8
D	Snake River	20	20	12	8	6
A	Thickspike	0	0	0	0	0
B	Thickspike	0	0	0	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	0	0	0	0

Appendix E6 Can. Cov. seeded 2004-2005 & burned 2006

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Canopy cover % at sample point				
A	Big bluegrass	0	0	0	0	6
B	Big bluegrass	0	0	0	0	0
C	Big bluegrass	0	0	0	0	0
D	Big bluegrass	0	8	0	0	0
A	Cheatgrass	0	16	4	14	16
B	Cheatgrass	4	8	4	12	10
C	Cheatgrass	6	16	4	12	8
D	Cheatgrass	8	2	24	8	4
A	Snake River	24	0	6	4	4
B	Snake River	8	12	20	14	4
C	Snake River	16	20	8	12	0
D	Snake River	2	0	0	0	0
A	Thickspike	0	0	0	0	16
B	Thickspike	0	0	2	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	8	0	0	0

Appendix F1 Can. Cov. Seeded 2004-2005 and unburned

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Canopy cover % at sample point				
A	Big bluegrass	0	0	0	0	0
B	Big bluegrass	0	2	0	4	2
C	Big bluegrass	0	0	0	0	0
D	Big bluegrass	0	0	0	0	0
A	Cheatgrass	24	28	2	56	2
B	Cheatgrass	24	56	14	14	56
C	Cheatgrass	6	34	64	40	64
D	Cheatgrass	6	2	40	52	6
A	Snake River	4	12	8	2	34
B	Snake River	0	0	12	0	0
C	Snake River	18	12	0	0	0
D	Snake River	6	16	12	0	8
A	Thickspike	4	0	0	0	6
B	Thickspike	0	0	0	4	0
C	Thickspike	8	0	0	0	0
D	Thickspike	0	0	0	0	2

Snake River - Snake River wheatgrass

Thickspike - Thickspike wheatgrass

Appendix F2 Can. Cov. Seeded 2004-2005 and unburned

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Canopy cover % at sample point				
A	Big bluegrass	8	26	8	0	0
B	Big bluegrass	2	8	6	12	2
C	Big bluegrass	16	2	14	28	24
D	Big bluegrass	0	4	0	0	14
A	Cheatgrass	40	4	0	48	44
B	Cheatgrass	4	0	2	0	4
C	Cheatgrass	2	2	4	0	0
D	Cheatgrass	0	40	18	28	6
A	Snake River	0	0	12	0	1
B	Snake River	0	4	0	0	0
C	Snake River	0	0	0	0	0
D	Snake River	0	0	8	0	0
A	Thickspike	0	0	0	0	0
B	Thickspike	0	0	0	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	0	0	0	0

Snake River - Snake River wheatgrass

Thickspike - Thickspike wheatgrass

Appendix F3 Can. Cov. Seeded 2004-2005 and unburned

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Canopy cover % at sample point				
A	Big bluegrass	0	8	0	0	0
B	Big bluegrass	10	0	0	0	8
C	Big bluegrass	0	0	0	0	0
D	Big bluegrass	2	0	0	0	0
A	Cheatgrass	0	0	0	0	2
B	Cheatgrass	0	0	2	0	0
C	Cheatgrass	0	0	0	0	0
D	Cheatgrass	0	0	0	0	0
A	Snake River	0	16	4	8	0
B	Snake River	8	14	8	4	4
C	Snake River	8	0	18	8	0
D	Snake River	6	2	12	12	12
A	Thickspike	8	0	0	0	0
B	Thickspike	0	0	12	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	0	0	4	0

Snake River - Snake River wheatgrass

Thickspike - Thickspike wheatgrass

Appendix F4 Can. Cov. Seeded 2004-2005 and unburned

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Canopy cover % at sample point				
A	Big bluegrass	2	28	4	0	0
B	Big bluegrass	10	32	4	10	30
C	Big bluegrass	16	8	8	20	6
D	Big bluegrass	16	12	26	16	24
A	Cheatgrass	2	2	28	8	56
B	Cheatgrass	4	2	28	10	2
C	Cheatgrass	6	8	2	2	4
D	Cheatgrass	4	2	0	0	4
A	Snake River	0	0	2	0	0
B	Snake River	0	0	0	0	0
C	Snake River	4	0	8	0	0
D	Snake River	0	12	0	0	0
A	Thickspike	0	4	0	0	0
B	Thickspike	0	0	0	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	2	0	0	0	0

Snake River - Snake River wheatgrass

Thickspike - Thickspike wheatgrass

Appendix F5 Can. Cov. Seeded 2004-2005 and unburned

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Canopy cover % at sample point				
A	Big bluegrass	0	6	16	12	0
B	Big bluegrass	0	0	0	6	8
C	Big bluegrass	0	0	0	4	0
D	Big bluegrass	10	4	4	0	4
A	Cheatgrass	2	0	2	0	0
B	Cheatgrass	0	2	0	0	0
C	Cheatgrass	2	0	0	0	0
D	Cheatgrass	0	0	0	0	0
A	Snake River	12	20	8	8	8
B	Snake River	32	24	12	6	20
C	Snake River	20	30	20	32	24
D	Snake River	0	8	8	28	8
A	Thickspike	0	0	0	0	0
B	Thickspike	0	0	0	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	0	0	0	0

Snake River - Snake River wheatgrass

Thickspike - Thickspike wheatgrass

Appendix F6 Can. Cov. Seeded 2004-2005 and unburned

		Distance from start point (m)				
		0-20	20-40	40-60	60-80	80-100
Transect	Species	Canopy cover % at sample point				
A	Big bluegrass	0	4	4	4	8
B	Big bluegrass	16	8	14	4	8
C	Big bluegrass	0	8	4	4	12
D	Big bluegrass	8	0	0	0	0
A	Cheatgrass	2	2	1	1	4
B	Cheatgrass	2	4	4	4	4
C	Cheatgrass	0	2	4	56	12
D	Cheatgrass	8	16	20	32	56
A	Snake River	0	0	0	0	0
B	Snake River	0	0	0	0	0
C	Snake River	0	0	8	0	0
D	Snake River	10	18	22	8	0
A	Thickspike	0	0	0	0	0
B	Thickspike	0	0	0	0	0
C	Thickspike	0	0	0	0	0
D	Thickspike	0	0	0	0	0

Snake River - Snake River wheatgrass

Thickspike - Thickspike wheatgrass