

**LONG-TERM MONITORING OF CANYON GRASSLANDS
AT CRAIG MOUNTAIN, IDAHO: EIGHTH-YEAR DATA**

by

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ABSTRACT

In 2002, we resampled 12 permanent vegetation monitoring plots that were established in bunchgrass steppe communities on Craig Mountain in 1994. Craig Mountain is an uplift separating the Salmon and Snake rivers and rising 4,500 feet above river level. Breaklands on either side support extensive bunchgrass steppe, portions of which remain in excellent ecological condition. Four grassland habitat types are represented by the plots. In August, 2000, seven of the plots burned in the Maloney Creek Fire, allowing us to look at vegetation change over time in both burned and unburned plots. Nested plot frequency was used to measure the abundance of vascular plants, mosses, and lichens. Chi-square tests were used to compare 1994 and 2002 frequencies for all native grasses, all annual bromes (*Bromus* spp.), mosses, lichens, and selected forbs. Statistically significant changes were observed for some species in some plots, although the complement of species present remained mostly constant. Among native species, changes were seen primarily for native bunchgrasses on burned plots, although the direction of change was not completely consistent. Sandberg's bluegrass (*Poa secunda*) increased overall. The non-native annuals Japanese brome (*Bromus japonicus*) and cheatgrass (*Bromus tectorum*) have also increased overall, both in unburned and burned plots. The most imminent threat of community degradation may be the annual weed yellow starthistle (*Centaurea solstitialis*), establishment of which appeared to be enhanced by fire. The microbiotic soil crust was severely damaged by fire.

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Background

During and after his tenure with the University of Idaho Department of Range Resources, Dr. Ed Tisdale established a series of vegetation study plots between 1962 and 1981 to support his research leading to a classification system of grasslands in the canyons of the Snake, Clearwater, Salmon, and Grande Ronde rivers (Tisdale 1986). Several of his research plots were located on Craig Mountain, much of which is now the Craig Mountain Wildlife Management Area (WMA) and managed primarily for wildlife habitat. These sites were originally located in areas representing relatively undisturbed and uniform plant community conditions. In the early 1990s, wildlife, habitat/vegetation, timber, and other resources were systematically inventoried at Craig Mountain to provide the Idaho Department of Fish and Game (IDFG) with information needed to draft an ecologically based management plan for the area (IDFG 1998). As part of this comprehensive effort and a proposed vegetation monitoring strategy, IDFG established permanent vegetation monitoring plots at 12 of Tisdale's original research plot sites in 1994 (Mancuso and Moseley 1994). The plots were established to assess conditions and provide a baseline to monitor trends in grassland communities, probably the most vulnerable habitat on Craig Mountain. In 2002, we resampled all 12 monitoring plots to document vegetation changes and identify trends in plant community composition. This monitoring effort provides information that will assist land managers at Craig Mountain in meeting their habitat and biodiversity management objectives.

Five of the 12 vegetation monitoring plots (1-5) are located in or near the Gaiser Segment of the WMA, between Redbird Creek and Crows Canyon. The other seven plots (6-12) are located on Wapshilla Ridge near upper China and Cottonwood creeks (Appendix A). We refer to these plots as Craig Mountain-Tisdale plots. Plots 6-12 burned in the Maloney Creek Fire in August 2000, but plots 1-5 have not burned since at least 1993. The plots have not been subject to livestock grazing for at least 8 years.

Craig Mountain is located south of Lewiston, Idaho, in southern Nez Perce and western Lewis counties. It is bounded on the west by the Snake River Canyon and the east by the Salmon River Canyon. Characterized by deep and dissected topography, elevations range from approximately 900 to 5,400 feet. Lower elevations are dominated by bunchgrass grassland ecologically classified as "canyon grasslands." At higher elevations, grassland continues on southerly aspects while northerly aspects support stands of Douglas-fir (*Pseudotsuga menziesii*). The upland plateau is dominated by coniferous forests.

Canyon grassland communities at Craig Mountain are some of the best representations known in terms of condition and extent. The flora includes 14 species considered rare in Idaho (Mancuso and Moseley 1994) most of which are associated with bunchgrass communities. Elements of both the Hell's Canyon and Palouse prairie flora are represented. One plant species, Spalding's catchfly (*Silene spaldingii*), is listed as threatened by the U.S. Fish and Wildlife Service.

Tisdale proposed a classification of habitat types or “potential natural vegetation.” “All areas with the potential of supporting one specific kind of vegetation are considered to belong to a particular habitat type, regardless of the current successional stage of the vegetation” (Tisdale 1986). Habitat types are grouped into “series” named for the dominant species. The Craig Mountain-Tisdale plots are dominated either by bluebunch wheatgrass (*Agropyron spicatum* [AGSP]¹) or Idaho fescue (*Festuca idahoensis* [FEID]). These 12 plots represent four habitat types, presented in Table 1.

Table 1. Habitat types represented by the Craig Mountain-Tisdale plots

Habitat Type	Plot Numbers											
	1	2	3	4	5	6	7	8	9	10	11	12
AGSP-OPPO			X									
AGSP-POSA-BASA		X										
FEID-AGSP	X			X	X				X	X	X	X
FEID-KOCR						X	X	X				

The driest habitat represented in the *Agropyron spicatum* series is the *Agropyron spicatum*/*Opuntia polyacantha* (AGSP-OPPO) habitat type, a dry grassland type characterized by high rock, gravel, and bare soil cover, widely spaced bluebunch wheatgrass, scarce Sandberg’s bluegrass (*Poa secunda*—formerly *Poa sandbergii*), and few perennial forbs. Prickly-pear cactus (*Opuntia polyacantha*) is often present (Tisdale 1986). A high constancy and cover of arrowleaf balsamroot (*Balsamorhiza sagittata*) differentiates the *Agropyron spicatum*/*Poa sandbergii*/*Balsamorhiza sagittata* (AGSP-POSA-BASA) habitat type from the AGSP-OPPO type. Mosses, lichens, and litter cover the ground surface (Tisdale 1986).

Moister sites support habitat types in the *Festuca idahoensis* series. Bluebunch wheatgrass is still abundant, but Idaho fescue is also present and usually dominant. In the *Festuca idahoensis*/*Agropyron spicatum* (FEID-AGSP) habitat type, total grass cover is higher than in the AGSP series, perennial forbs are fairly well represented, and little bare ground shows because of high litter cover. There is also less rock, gravel and bare soil cover. Prairie junegrass (*Koeleria cristata*) may be present, but is scarce. The *Festuca idahoensis*/*Koeleria cristata* (FEID-KOCR) habitat type is distinguished by the dominance of Idaho fescue; constant presence of prairie junegrass, bluebunch wheatgrass, and Sandberg’s bluegrass; and an abundance of perennial forbs. The low shrubs birch-leaved spiraea (*Spiraea betulifolia*), snowberry (*Symphoricarpos albus*), and rose (*Rosa nutkana* and *Rosa woodsii*) may be present, but with low frequency, constancy, and cover (Tisdale 1986).

¹ Recent taxonomic changes have resulted in *Agropyron spicatum* currently being called *Pseudoroegneria spicata*. Because series and habitat types were named using the older name, we use *A. spicatum* here to avoid confusion.

Methods

In 1994, the Idaho Conservation Data Center (IDCDC) established twelve, 30 m x 20 m macroplots as near as possible to Tisdale's original plots. Each macroplot has five 20 m long transects that run perpendicular to the 30 m baseline. A fencepost marks the starting point of the baseline and one corner of the associated macroplot, while rebar stakes (covered with rubber hose painted red) mark the starting point for each transect along the baseline. All bearings and other directional measurements are made using a compass set at zero degrees declination. Coordinates of latitude and longitude, obtained with a GPS unit for each plot, can be found in Appendix A. Plot descriptions, layouts, and location information can be found in Appendix B.

Ten microplots are sampled along each transect, resulting in a total of 50 microplots per macroplot. Frequency data are collected using a nested plot frame (Appendix C) with four sizes: 10 x 10 cm; 25 x 25 cm; 25 x 50 cm; and 50 x 50 cm. Frequency information is obtained by recording the smallest nested plot frame size in which a measured attribute occurs. Data are collected for all herbaceous vascular plant species, mosses, soil lichens, litter, bare ground, gravel, and rock. Forb seedlings are recorded separately from established plants.

The line intercept canopy method (Bonham 1989) is used to estimate shrub cover. In 2002 we used this method for subshrubs as well. The distance in centimeters that each live shrub intercepts the plane of the transect lines, divided by the total length of the transect lines in centimeters, multiplied by 100, is equal to percent cover.

In addition, a total plant species list with corresponding cover class values is recorded for each macroplot using WHTF FORM III – Ocular Plant Species Data, and site characteristics are recorded using WHTF FORM II – Community Survey Form (Bourgeron *et al.* 1991; Appendix D). Photos of each plot are taken from established photopoints.

We resampled the Craig Mountain-Tisdale plots between May 20 and June 12, 2002. We repeated nested plot frequency data collection on all 12 plots and completed WHTF Form III. Photos were taken of each plot and a set of slides submitted each to the IDCDC and the BLM, Upper Columbia-Salmon Clearwater District. We used a spray bottle with distilled water to hydrate mosses and lichens to make them more easily visible and to help determine if they were alive. We collected voucher plant specimens and deposited them at the University of Idaho Herbarium (ID). See Appendix E for a description of additional data collection protocols.

Five plots contain a rare plant tracked by the IDCDC—greenband mariposa lily (*Calochortus macrocarpus* var. *maculosus*). For this species we recorded density (plants/0.25 m²) as well as frequency.

We summarized the frequency data for each plot and performed chi-square goodness of fit tests (Zar 1999) on important species (i.e., indicator species and weeds). If

we suspected that a species' absence from a particular plot could have resulted from being overlooked or misidentified in one of the sampling years, it was not tested for that plot. We chose the most appropriate nested plot size for each species tested by selecting a plot size that returned a frequency of 30% to 80%, or as high as possible if under 30%, thus maximizing our ability to detect change (Elzinga *et al.* 1998). We used 1994 data to choose the nested plot size, or 2002 data for species not present in 1994.

Results

Results of chi-square tests on frequency of important species are presented in Table 2 and discussed below. Chi-square contingency tables for those species can be found in Appendix F. The results of shrub cover measurements are presented in Table 3. Baseline density data for greenband mariposa lily (*Calochortus macrocarpus* var. *maculosus*) are presented in Table 4.

- Native bunchgrasses—bluebunch wheatgrass and Idaho fescue showed no significant change in frequency in most plots, but a change in one or both species was detected for burned plots 6, 7, and 8. Frequency of Sandberg's bluegrass increased in both burned and unburned plots except for a few plots where no change was detected. Prairie junegrass frequency increased in two burned plots.
- Non-native annual grasses—frequency of Japanese brome (*Bromus japonicus*) and cheatgrass (*Bromus tectorum*) increased in both burned and unburned plots except for a few plots where no change was detected.
- Native forbs—twelve native forbs were tested, all but one are perennial, and all represent established plants, not seedlings. Six perennial forbs showed a significant change in at least one plot. The only decreases observed were in burned plots. Nine-leaved lomatium (*Lomatium triternatum*) increased in three out of four unburned plots, and in one out of four burned plots. Greenband mariposa lily, a rare local endemic, increased in frequency in one burned and one unburned plot. The annual threadleaf phacelia (*Phacelia linearis*) increased in all three burned plots in which it was analyzed. Plot 1 saw an increase in three major perennial forbs.
- Weedy forbs—yellow starthistle (*Centaurea solstitialis*) stayed the same or decreased (one plot) in unburned plots. It increased significantly in four of the five burned plots in which it occurs. Jim Hill mustard (*Sisymbrium altissimum*) was present only in the burned plots. It increased significantly in two of those plots. Dry chickweed (*Cerastium sicutum*), an annual weed not recorded in any of the plots in 1994, has invaded plot 2.
- Mosses and lichens increased in all unburned plots, but decreased or remained the same in burned plots.
- Shrubs—rubber rabbitbrush (*Chrysothamnus nauseosus*) decreased in one unburned plot.

Table 2. Results of chi-square tests for selected species

Species	Plot											
	Unburned					Burned in 2000						
Native grasses	1	2	3	4	5	6	7	8	9	10	11	12
<i>Agropyron spicatum</i>	-	-	-	-	-	↑	↓	-	-	-	-	-
<i>Festuca idahoensis</i>	-	-		-	-	↑	↓	↑	-	-	-	-
<i>Poa secunda</i>	↑	-	-	↑	↑		↑	↑	-	↑	↑	↑
<i>Koeleria cristata</i>						↑	-	↑				
Non-native grasses												
<i>Bromus brizaeformis</i>							↓	-	-	↑	↓	-
<i>Bromus japonicus</i>		↑	↑	↑	↑	↑	↑	-	↑	↑	↑	↑
<i>Bromus tectorum</i>		↑	↑	↑	↑		-		-	↑	↑	↑
Total annual bromes (spp. not differentiated in 1994)	↑											
Non-vascular species												
Moss	↑	↑	↑	↑	↑	↓	↓	↓	↓	-	-	-
Lichen	-		↑	↑	↑	↓	↓	↓	↓	↓	-	↓
Weedy forbs												
<i>Centaurea solstitialis</i>	-		-	-	↓		-		↑	↑	↑	↑
<i>Sisymbrium altissimum</i>							-		↑	↑	-	-
<i>Cerastium siculum</i>		↑										
Native forbs												
<i>Achillea millefolium</i>	-		-	↑	-	-	↓		-	-	-	-
<i>Astragalus arthuri</i>				-								
<i>Astragalus sheldonii</i>	↑	-			-			-				-
<i>Balsamorhiza sagittata</i>	↑	-	-	-	-		-		-	-	↓	↓
<i>Calochortus macrocarpus</i> var. <i>maculosus</i>				↑								↑
<i>Crepis bakeri</i> ssp. <i>idahoensis</i>	-											
<i>Eriogonum heracleoides</i>							-					
<i>Frasera albicaulis</i>							-	-				
<i>Lomatium dissectum</i> var. <i>dissectum</i>										-		
<i>Lomatium triternatum</i>	↑	-		↑	↑	↑	-		-		-	
<i>Lupinus sericeus</i>	-	-		-					↓	-	-	
<i>Phacelia linearis</i>									↑	↑		↑
<i>Selaginella densa</i>			-									

- Difference not significant ($p < .05$) between 1994 and 2002

↑ Significant increase ($p < .05$) from 1994 to 2002

↓ Significant decrease ($p < .05$) from 1994 to 2002

No symbol: not present or not analyzed due to recording discrepancies

Table 3. Percent shrub cover measured by line-intercept

Shrub Species	Year	Percent Cover				
		3	4	7	8	10
<i>Chrysothamnus nauseosus</i>	2002	1.04	0.90			
<i>Rosa</i> sp.	2002				0.10	
<i>Spiraea betulifolia</i>	2002			0.83		
<i>Symphoricarpos albus</i>	2002			1.52	0.29	0.32

Table 4. Frequency and density of greenband mariposa lily (*Calochortus macrocarpus* var. *maculosus*) in the five plots in which it occurs.

	Plot 4	Plot 9	Plot 10	Plot 11	Plot 12
Frequency*	40%	0	22%	8%	42%
Density**	26	0	13	7	36

* Percentage of microplots in which species occurred.

** Number of plants counted in 50, 50 x 50 cm plots (i.e., plants/12.5 sq m).

Discussion

The primary purpose of this project is to assess and monitor long-term changes in grassland communities at Craig Mountain. A recent wildfire that affected seven of the twelve monitoring plots allowed us to look at fire as one of the agents of change. Because prescribed fire is currently being used as a management tool on Craig Mountain, this study is pertinent to its effects on different elements of grassland vegetation. Below we discuss our results by life form and origin (native/non-native) in the context of fire.

Native bunchgrasses

Our monitoring study did not detect a significant difference in Idaho fescue or bluebunch wheatgrass frequency in any of the unburned plots between 1994 and 2002 (Table 2). Of the seven burned plots, plot 6 showed an increase in both species, plot 7 a decrease in both, and plot 8 an increase in Idaho fescue only. The other four burned plots showed no change.

Most researchers have found that Idaho fescue and bluebunch wheatgrass decrease in cover after fire, but return to their former cover after a few years. Reports vary on which of the two species is more susceptible to burning. Decreases in Idaho fescue cover following burns were found by several observers (Antos *et al.*, 1983; Conrad and Poulton 1966; Countryman and Cornelius 1957; Johnson 1998). Pechanec (1954) found one-half to two-thirds of Idaho fescue plants were killed on three experimental

burns. After 9 years, they had not returned to former levels. Ponzetti *et al.* (1998) reported 11% mortality in burned Idaho fescue clumps, and a significant reduction in crown cover. Hill *et al.* (2003) found Idaho fescue basal cover in burned FEID-AGSP plots to be significantly lower than in unburned plots one year after the Maloney Creek Fire at Craig Mountain. However, after two years, Idaho fescue basal cover in the burned plots had significantly increased.

Bluebunch wheatgrass basal area or canopy cover was also found to decrease after burning in most studies (Britton *et al.* 1990; Conrad and Poulton, 1966; Mueggler and Blaisdell 1958; West and Hassan 1985). Johnson (1998) found that light and moderate burns enhanced growth, but that severe burns had a negative effect. Uresk *et al.* (1980) found that basal area decreased after fire and stayed below unburned levels for two years, but phytomass increased in the second year after burning, then decreased almost to unburned levels by the third year. Hill *et al.* (2003) found that bluebunch wheatgrass cover in burned FEID-AGSP plots remained less than half of that in unburned plots both one and two years after the Maloney Creek Fire. Conrad and Poulton (1966) found that the basal diameter of bluebunch wheatgrass was reduced by 52% after a fire, but density remained much the same. Ponzetti *et al.* (1998) and Antos *et al.* (1983) did not find significant difference in crown cover after fire.

Frequency of Sandberg's bluegrass increased in three of the unburned and five of the burned plots (Table 2). Wright and Klemmedson (1965) found no change in Sandberg's bluegrass basal area from burns in June, July, or August. Ponzetti *et al.* (1998) found a slight increase after fire, as did Young and Evans (1978). Antos *et al.* (1983) found an increase to 265% of unburned controls one year after a fire. Three years after, however, the percentage had decreased to 173%. Daubenmire (1975) found that "*Poa* prospered after the fire." After four years, basal frequency was twice that of *Poa* in the unburned area, but by the twelfth year the "stimulation had essentially disappeared."

Prairie junegrass is a short-lived perennial bunchgrass (Weaver 1968). It occurs in only three plots, all of which burned, and increased in two of them. It is apparently tolerant of natural-season burns (Young 1983), but Britton *et al.* (1990) found that May burning reduced basal area 42%. Antos *et al.* (1983) reported junegrass cover on burned plots to be 186% that of the cover on unburned control plots one year after a June wildfire. Three years later, junegrass cover on burned plots decreased to 115% of that on unburned plots.

Non-native grasses

Annual bromes were the most conspicuous group of non-native grasses in the plots. Kentucky bluegrass (*Poa pratensis*), an aggressive spreader that increases with grazing and can dominate mesic bunchgrass communities, does not occur in any of the plots, nor do any other non-native perennial grasses.

Japanese brome was the most frequently recorded brome species; it occurred in every macroplot in both 1994 and 2002, and increased in all but one during that period.

Tisdale recorded it at 11 of the 12 sites where we established plots. Hill *et al.* (2003) found Japanese brome density and frequency in burned plots in a FEID-AGSP community to be significantly higher than in unburned plots two years after the Maloney Creek Fire. Japanese brome is a Eurasian winter annual grass that is a problem in North America in pastures, croplands, meadows, and overgrazed rangelands (Baskin and Baskin 1981). Like cheatgrass and bluebunch wheatgrass, it germinates in the fall. However, Romo and Eddleman (1987) found that Japanese brome seedlings did not inhibit bluebunch wheatgrass seedling establishment. Japanese brome seems to be widely distributed and have a more sparse growing pattern than cheatgrass, which often grows in dense patches when well established.

Cheatgrass frequency increased in four unburned and three burned plots. It showed no significant change in two of the burned plots. Cheatgrass seedlings can out-compete bluebunch wheatgrass seedlings. They can germinate at lower temperatures and their roots penetrate deeper before winter (Harris and Wilson 1970; Pyke and Novak 1994). In the spring, it develops deep roots quickly. Hulbert (1955) excavated unfertilized roots as deep as 1.5 meters near Lewiston, Idaho. In addition, cheatgrass can germinate at a wider range of temperatures than Japanese brome, rattlesnake brome, bluebunch wheatgrass, and Idaho fescue, and its germination rates are higher in that range (Martens *et al.* 1994). Early germination and rapid root elongation make cheatgrass highly competitive with native perennial grasses.

It is well established that cheatgrass has altered the ecosystems and fire regimes in sagebrush steppe (Billings 1994; D'Antonio and Vitousek 1992; Pellant 1990; Pellant and Hall 1994; Stewart and Hull 1949; Tausch *et al.* 1995; Young 1994). It matures and dries in the spring and early summer. When well established, it presents a continuous dry fuel that is highly flammable, should fire be ignited. Cheatgrass cover typically increases after fire, creating a cheatgrass-driven fire frequency interval that becomes shorter as cheatgrass becomes more abundant (Whisenant 1990). Like cheatgrass, Japanese brome matures early and contributes to the dry fuel load between native plants. At Craig Mountain, both annual bromes may be contributing to an altered fire regime with a more frequent return interval and higher severity.

Rattlesnake brome (*Bromus brizaeformis*) was present in 6 of the 7 plots that burned, but was neither plentiful nor frequent. It seemed to be negatively affected by fire, but the results were equivocal.

Native forbs

Among the unburned plots, forbs either increased or did not change (Table 2). Five of the eleven perennial species tested increased in at least one unburned plot. Most of these were in plots 1 and 4 which each saw an increase in three of the major perennial forbs tested.

Native forbs might be expected to tolerate or even exploit a late-summer fire. However, a few perennial forbs decreased significantly in burned plots—yarrow (*Achillea*

millefolium) in plot 7, silky lupine (*Lupinus sericeus*) in 9, and arrowleaf balsamroot (*Balsamorhiza sagittata*) in 11 and 12. Because all of these occur in unburned plots as well, where they did not exhibit a significant decrease, a fire effect is implicated.

Nine-leaved lomatium increased in four of the eight plots in which it occurs, including one burned plot. Antos *et al.* (1983) found an initial increase in cover of nine-leaved lomatium in the autumn following a June fire, but a return to unburned levels by the next summer. Hill *et al.* (2003) found density of nine-leaved lomatium in burned plots, in a FEID-AGSP community, to be significantly less than in unburned plots one year after the Maloney Creek Fire. After two years density had decreased even further.

Greenband mariposa lily increased significantly in two plots, one burned and one unburned, and appeared in two other burned plots (10 and 11) where it had not previously been recorded. Greenband mariposa lily also occurs in plot 9, but not in microplots (Table 4). Variation in phenology between years is a possible explanation for the observed increase in abundance, as greenband mariposa lily was in early vegetative to bud stage at the time of sampling. However, it seems unlikely that phenology would have been advanced in 2002 given the cool, wet spring. Hill *et al.* (2003) found no significant difference in density between burned and unburned plots for this species.

The annual threadleaf phacelia increased in three burned plots, and was not analyzed in unburned plots, where it had not been recorded in 1994. It was common in most plots in 2002, but seldom recorded in 1994. It is difficult to draw any conclusions about the abundance of annuals, as they can be extremely variable between years. Also, threadleaf phacelia was vegetative at the time of sampling and thus difficult to identify. Two years after the Maloney Creek Fire, Hill *et al.* (2003) found that mean basal cover, frequency, and density of threadleaf phacelia in a FEID-AGSP community was significantly higher in burned than in unburned plots.

Weedy forbs

Yellow starthistle increased dramatically in burned plots that contained only trace amounts of this species in 1994 (plots 9, 10, 11, and 12). All represent the FEID-AGSP habitat type. Increases were statistically significant for each of these four plots. In 1994, two yellow starthistle plants were noted in the plot 12 macroplot, but none in the microplots. In 2002, it was found in 30% of the microplots, and 571 plants were counted in one transect. Tisdale reported no yellow starthistle in any of his plots.

The other three burned plots are in the FEID-KOCR habitat type. This is the most mesic of the grassland types at Craig Mountain, characterized by a higher forb cover than the other bunchgrass types. In two of these FEID-KOCR plots, yellow starthistle was not recorded in either 1994 or 2002. In the other it increased, but not significantly. These findings support the assertion made by Roché *et al.* (1994), that the more mesic bunchgrass habitat types resist starthistle infestation longer than drier, more open grasslands.

Yellow starthistle decreased significantly in one unburned plot (plot 5), located in a fairly mesic northeast facing FEID-AGSP community. Changes were not significant in three other unburned plots (1, 3, and 4) and it was absent in plot 2. Hill *et al.* (2003) found that yellow starthistle frequency and density in a FEID-AGSP community were significantly higher in burned than in unburned plots two years after the Maloney Creek Fire.

Cheatgrass appears to set the stage for yellow starthistle infestation in some cases. We have observed that cheatgrass patches often convert to yellow starthistle patches at Craig Mountain. Cheatgrass apparently competes successfully with starthistle in shallow soils, but rooting depth and seed production of yellow starthistle give it the competitive advantage in deeper soils (Sheley and Larson 1995).

Dry chickweed was not recorded in any of the monitoring plots in 1994. It was found in 50% of the microplots in plot 2 in 2002. In 1973, Hitchcock and Cronquist reported it “rare with us,” occurring in Pullman, Washington; Union County, Oregon; and near La Grande, Oregon (Hitchcock and Cronquist 1973). It was fairly common on the ridge in the Gaiser Segment, near some plowed ground, but we have not observed it elsewhere on Craig Mountain.

Jim Hill mustard (also called tumbledustard), another weedy, annual forb, was present or increased in five burned plots, but was not present in any of the unburned plots. Antos *et al.* (1983) recorded Jim Hill mustard in burned plots to be 800% of that in unburned controls one year after a fire, but three years later, it had returned to pre-burn levels. After an August fire on Lewiston Hill, Idaho, Daubenmire (1975) found rooted frequency on the burned side of a burn line to be 58% compared to 27% on the unburned side. Jim Hill mustard is thought to set the stage for later cheatgrass colonization (Piemeisel 1951). Jim Hill mustard can grow on bare soil (such as burned soil), but cheatgrass requires either ground microrelief or some litter cover to germinate (Young *et al.* 1976; Evans and Young 1984).

Mosses and Lichens

Arid and semi-arid grasslands support a microbiotic crust composed of mosses, lichens, algae, fungi, cyanobacteria, and occasionally liverworts; they aid in soil stabilization, affect seed germination, affect water relations, and, in some cases, fix atmospheric nitrogen into a form usable by plants (Anderson and Rushforth 1977; Belnap 1993; Evans and Johansen 1999; Harper and Marble 1988; Johansen *et al.* 1984; Ladyman and Muldavin 1996). Different species and combinations of species occur in different communities and climate regimes, but the moss *Tortula ruralis* is common to many Great Basin and northwest bunchgrass microbiotic communities (Evans and Johansen 1999; Link *et al.* 2000). It was the most common moss in the Craig Mountain-Tisdale plots. Two other mosses, *Homalothecium aeneum* and *Brachythecium albicans*, commonly occur in the more mesic sites. The lichens *Cladonia fimbriata* and *Leptogium lichenoides* were also occasionally observed. *Cladonia fimbriata* appears to pioneer on bare soil patches, and *Leptogium lichenoides* is a nitrogen-fixing gelatinous lichen.

Moss and lichen frequency appeared to increase since 1994 in all unburned plots. This increase may have been a sampling artifact, in that we sampled during rainy conditions in 2002 and otherwise sprayed plots with distilled water to make the mosses more visible. *Tortula ruralis* is brownish and very inconspicuous when dry, but the leaves spread widely and are bright green when hydrated.

Frequency of both mosses and lichens declined in burned plots. This is consistent with reports in the literature that both are intolerant of fire, and to be expected since their growth is primarily above ground or within 1 cm of the surface (Johansen and Rayburn 1989), and therefore highly vulnerable.

Moss cover has been found to decrease dramatically after fires. Ponzetti *et al.* (1998) found that both *Tortula ruralis* and *Brachythecium albicans* decreased significantly after a cool-season (October) prescribed burn. Hill *et al.* (2003) also found significant decreases in *T. ruralis* and *B. albicans*. Two years after the Maloney Creek Fire, no mosses were recorded in burned plots. Antos *et al.* (1983) found *Tortula ruralis* and *Brachythecium albicans* almost completely eliminated by fire. They found that mosses returned to preburn cover after three years, but the composition was altered to weedy, cosmopolitan mosses. *Brachythecium albicans*, the preburn dominant, was only 5% of its original cover after three years.

Lichens also decrease after burns (Schulten 1985; St. Clair *et al.* 1993). Ponzetti *et al.* (1998) found that *Cladonia* spp. decreased by 80% after a cool season prescribed burn. Hill *et al.* (2003) found no lichens in burned plots two years after the Maloney Creek Fire. Antos *et al.* (1983) found *Cladonia* spp. to be absent one year after a fire, and only 7% of unburned cover after three years.

Microbiotic soil crusts are slow to recover from disturbance. Algae may recover within 2-5 years (Johansen *et al.* 1984, Johansen *et al.* 1993). Belnap (1994) estimated that it would take 35-65 years for cyanobacteria to recover. Estimates for lichen recovery vary from 45-85 years (Belnap 1994). Mosses may require years or decades to return to pre-disturbance cover (Belnap 1994). Callison *et al.* (1985) found no crust recovery in a blackbrush community in Utah 19.5 years after a fire. Kaltenecker and Wicklow-Howard (1994) found *Tortula ruralis* just beginning to establish 11-14 years after fire in southwestern Idaho. Often, the mosses that replace pre-burn mosses, or that are found in annual brome stands, are weedy, cosmopolitan species rather than those characteristic of undisturbed communities (Antos *et al.* 1983; Evans and Johansen 1999; Johansen *et al.* 1984; Kaltenecker and Wicklow-Howard 1994).

Shrubs

Shrubs are a minor component in all plots and are absent in three. No shrub species was estimated at more than 1% of the macroplot. Rubber rabbitbrush (*Chrysothamnus nauseosus*) and snowberry (*Symphoricarpos albus*) were the most

common shrubs (Table 3). Wyeth buckwheat (*Eriogonum heracleoides*) and prairie sagewort (*Artemisia ludoviciana*) were common subshrubs.

Bare soil and litter

Frequency plots were not effective for comparing bare soil or litter. Both were present in nearly all of the smallest nested plots (10 x 10 cm), which resulted in nearly 100% frequency for both. However, the nature and depth of the litter were different between burned and unburned plots.

Effects of fire on community distribution and composition

Natural bunchgrass communities appear to be relatively stable. Tisdale stated, “The grassland types described appear to be highly stable, with boundaries that are not likely to change without a sizeable shift in climate. Interfaces between grassland and conifer forest, which are common in the canyon ecosystem, also appear stable and usually quite sharp.” He concluded that fire has not been a major influence on the canyon grasslands, and stated that “Whatever the primeval situation may have been, fire has been a minor factor in the century since white settlement began....No signs of major changes in composition or boundaries of the major grassland communities appear to have resulted from this presumed decrease in fire frequency” (Tisdale 1986). Antos *et al.* (1983) also found that “almost all species which changed in cover, either up or down, on the burn the year after the fire (1978), converged in cover values on and off the burn by 1980.” Daubenmire (1975) studied a relatively pristine *Agropyron-Poa* stand that burned in a July 1961 fire. He concluded that burning “had relatively little impact on the *Agropyron-Poa* stand, except to change the balance among the species.” In his book *Steppe Vegetation of Washington*, Daubenmire (1970) argued against the opinion that Palouse Prairie was man-made by peoples periodically burning grasslands to stave off sagebrush intrusion. He thought there was “no evidence that the distribution of vegetation types or species in eastern Washington is related to the past use of fire. The types of stable vegetation that characterize the landscape mosaic can be quantitatively related to climate and soil in a way that provides an ecologically rational interpretation of the pattern.” In a study of soil moisture in relation to vegetation distribution, he concluded that soil drought was responsible for the distribution of grasslands, because seedlings of trees characteristic of the dry margin of the forest germinated in the spring and their roots did not elongate fast enough to keep ahead of the advancing soil drought (Daubenmire 1968).

Our data support the concept that canyon grasslands are relatively stable plant communities. We detected some change in native vascular plant frequencies over an 8-year period, and fire seemed to evoke more change, especially in the frequencies of native grasses. In spite of this, there were few, if any, native plants that disappeared after burning, or that appeared only after burning. However, this does not hold true for the microbial crust layer. Mosses and lichens were eliminated in most burned sites, or survived only as remnants in sheltered microsites between rocks. Ponzetti *et al.* (1998) recommend against applying fire to intact native grassland communities because of the importance of crust cover for soil stability and weed protection.

Our data show an increase in weeds over time, particularly in the abundance of yellow starthistle. Japanese brome and cheatgrass have increased in general, both in unburned and burned plots. Yellow starthistle establishment appears to be enhanced by fire, particularly in drier grassland habitat types. Jim Hill mustard also increased after the fire.

The Maloney Creek Fire occurred during the natural fire season when many species of the bunchgrass communities are dormant. Growth and reproduction for many species in the relatively dry bunchgrass zones are keyed to periods of maximum moisture. On Craig Mountain, moisture peaks in winter and spring. By mid summer, the majority of annual species are dead: most perennial species are dormant. Dormant plants may be less affected by fire than plants that are actively growing. In addition, many grassland plants have deep root systems, another characteristic that may help them survive fires.

Very few vegetation studies on the effects of grazing, fire, or other disturbances have been done in canyon grasslands or comparable bunchgrass communities such as Palouse Prairie. The majority have been done in shrub steppe (primarily sagebrush) or in steppe with different grass composition, such as rough fescue (*Festuca scabrella*)-dominated grasslands. Comparing results between the canyon grasslands at Craig Mountain and other ecosystems such as sagebrush-steppe is complicated or confounded by many differences and variables. These include fundamental community structure and composition differences, as well as potential differences in the season and severity of burning, weather patterns, grazing or grazing history, and fuels.

Recommendations

1) In order to evaluate the effects of fire on a wider range of Craig Mountain communities, monitoring plots should be established in unburned Douglas fir/ninebark (*Pseudotsuga menziesii*/*Physocarpus malvaceus*) forest sites and in low-elevation, unburned FEID-KOCR communities, particularly those that support the rare plants Spalding's catchfly (*Silene spaldingii*) or Palouse goldenweed (*Haplopappus liatrifolius*).

2) It would be better to collect data later in the season, perhaps in late June at lower elevations and early July on Wapshilla Ridge. Many early spring annuals such as blue-eyed Mary (*Collinsia parviflora*) would be senescent, but many more species would be easier to differentiate or identify if they were more mature. This is particularly true for annual bromes; *Agoseris*, *Microseris*, and *Crepis* species; broadfruit mariposa lily (*Calochortus nitidus*); northwest mariposa (*C. elegans*); long-leaved fleabane (*Erigeron corymbosus*); twin arnica (*Arnica sororia*); and prairie junegrass. The annuals Clarkia (*Clarkia pulchella*), threadleaf phacelia (*Phacelia linearis*), and narrow-leaf collomia (*Collomia linearis*) would also be easier to identify when more mature.

3) Density counts would be helpful to document changes in annual bromes, yellow starthistle and other annual weeds; rare plants such as broadfruit mariposa lily,

greenband mariposa lily, and Idaho hawksbeard (*Crepis bakeri* ssp. *idahoensis*); and nine-leaved lomatium.

4) Estimates of moss and lichen ground cover in the 50 x 50 cm plots would help in detecting differences between years or treatments. Although a few burned plots showed moss frequency to be more or less equal in 1994 and 2002, it was rare to find more than a pinch of surviving *Tortula ruralis* in 2002. Cover data would probably paint a more accurate picture of changes in cryptogams.

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Appendix A

Maps of plot locations

1. Latitude and longitude coordinates of Craig Mountain-Tisdale plots
2. Map 1: Plots 1, 2, 3, 4, and 5
3. Map 2: Plots 6, 7, and 8
4. Map 3: Plots 9, 10, 11, and 12

Appendix B

Location, description, and layout of the
Craig Mountain-Tisdale plots, and comments

Appendix C

Diagram of nested plot frame

Appendix D

Forms WHTF II–Community Survey Form and
WHTF III–Ocular Plant Species Data

Appendix E

Details of data collection protocols

Details of data collection protocols

Along the plot baseline, the foot location (beginning) of each transect is marked with a rebar stake painted red. Transect #1 is the lowest random number chosen between 1-29. For example, if the five random numbers are 4, 9, 19, 24, 28, then transect #1 is at the 4 m mark (4 m from the fencepost), transect #2 at the 9 m mark, and so forth. Transect end points are marked with rebar bent into an L shape. Transect end points are important because there is a great deal of inaccuracy in using an azimuth to orient the transect. [Bring transect footmarks along to resample plots. It is extremely difficult to find the short pieces of rebar without knowing the locations.]

There are 10 microplots, 2 m apart, placed along each transect, beginning at the 1 m tick on the tape. Microplot data are therefore recorded at all the odd meter integers between 1 and 20, resulting in a total of 50 microplots per macroplot.

To obtain frequency data, the plot frame is placed along the tape with the 10 x 10 cm corner of the frame flush with the appropriate meter tick on the tape. Plot frames are placed on the right side of the tape as one looks from the start point to the end point (downhill in most cases). Attributes are recorded only in the smallest nested plot size in which they occur at any particular transect point. Plants must be rooted in the plot to be counted.

We recorded seedlings and established plants separately for several perennial forb species: *Balsamorhiza sagittata*, *Astragalus sheldonii*, *Astragalus arthuri*, *Lomatium dissectum*, *Lomatium triternatum*, *Lithospermum ruderale*, and *Achillea millefolium*. Seedlings for some of these species (e.g., *Achillea millefolium*) were very abundant. We had no problem making a call between seedling and established plant. In many cases, the nested-plot size for seedlings is indicated simply by putting it in parentheses on the frequency data sheet.

We used a spray bottle of distilled water to look for mosses when conditions were dry. Weather conditions were noted. We looked under litter to find mosses, lichens, gravel, and rock, but not bare soil. Current-year annuals that were senescent were recorded.

We considered gravel to be <3 inches in diameter, and rock over 3 inches.

Transect lines used to locate microplots were also used to record line-intercept data for shrubs (*Chrysothamnus nauseosus*, *Gutierrezia sarothrae*, *Rosa* spp., *Spiraea betulifolia*, and *Symphoricarpos albus*) and subshrubs (*Artemisia ludoviciana*, *Eriogonum heracleoides*). Shrubs were also recorded when rooted in nested plots. Shrubs with low cover such as *S. albus* and *A. ludoviciana*, are probably better estimated by frequency in nested plots.

For plots with green-band mariposa lily (4, 9, 10, 11, and 12) we recorded the number of plants occurring in each 50 x 50 cm microplot to obtain an estimate of density. We did the same for yellow-star thistle in plots 9, 11 and 12.

We used the entire 30 m x 50 m macroplot to record canopy cover class using WHTF Form III. All plants observed in the macroplot were recorded. This form was also used to note phenology, as plants in flower are undoubtedly estimated higher than those past flower. Due to the early phenological stage, grass canopy cover was not much greater than basal cover.

There is also less doubt about proper i.d. for plants with flowers. *Koeleria cristata* and in some cases *Poa secunda* were inconspicuous at the time the sampling was conducted. Voucher specimens were made for many of the forbs and deposited at the University of Idaho Herbarium (ID).

We did not possess photopoint information at the time of sampling, so photopoints were different than in 1994. Notes on position, landmarks, azimuths, and focal lengths were made on the slides. Sets of slides will be submitted IDCDC and BLM.

All data sheets are archived at the IDCDC in the Plant and Community Monitoring Files, along with Tisdale's original data.

Appendix F

Chi-square contingency tables