# THE INFLUENCE OF REST AND DEFERMENT ON BEEF CATTLE DIET QUALITY AND COMPOSITION AFTER AN AUGUST WILDFIRE ON PERENNIAL BUNCHGRASS RANGELAND IN SOUTHWESTERN MONTANA

by

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# DEDICATION

To my grandparents: John and Lois Wojack, and Dale and June Kluth. They have each set forth strong examples of love and work ethic that I strive to achieve.

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# ABSTRACT

Current management paradigms suggest deferring burned rangeland for two years after a fire. However, there has been little research into how forage quality changes within the first two years after a fire and how it affects livestock diet quality, botanical composition, and foraging efficiency. Study 1 evaluated the differences between unburned and burned pastures during the first year after a fire, and Study 2 evaluated the differences in rested and unrested pastures. Pastures were arranged in a randomized complete block design contrasting June versus September, burn versus unburn (Study 1), and one-year rest versus no rest (Study 2). Pastures were grazed in either June or September by cow-calf pairs for two days at a time. Cattle diet composition and masticate samples were collected during 20-minte bite-count periods using six ruminally cannulated cows in each pasture prior to and after two-day grazing periods. Composition of diets upon pasture entry differed among treatments ($P < 0.01$) with June diets having greater proportions of forbs than September diets. In addition, June diets with no deferment had greater forb composition than June diets with one year deferment ($P < 0.01$). Crude protein in June diets was substantially greater than that in September diets ($P < 0.01$) and within the June grazing period, highest for the non-deferred treatment ($P < 0.01$). June diets had lower neutral detergent fiber (NDF) concentrations than September diets ($P < 0.01$) and within the June grazing treatments, the first year after burning was lowest in NDF content ($P < 0.01$). There were no differences in ash concentration averaging 16.46% across all treatments and years ($P \geq 0.07$). There was no effect of grazing treatment on grams per bite ($P \geq 0.34$) averaging 1.36 grams per bite for pre- and post-grazing treatments. Season of use and timing of grazing following a wildfire impacts cattle diet composition and quality, with the greatest impact in the spring following a wildfire. Cattle diets in the burned sites were high quality (higher CP, lower NDF) during the growing season immediately following a wildfire.

# CHAPTER ONE

## GENERAL INTRODUCTION

Rangelands are considered the most abundant land type in the world, covering approximately 70% of the world's land cover, and 30% of the United States (Holechek et al., 2009). Although the terrain and erratic precipitation of rangelands are considered unsuitable for cropland, they still serve as a vital resource for the livestock industry. Forage production is estimated to be worth $116/ha (Maher et al., 2013), making these rangelands a valuable resource for livestock production as well as wildlife habitat and recreation. Because of rangeland diversity, land managers are often tasked with optimizing both livestock production and wildlife habitat (DelCurto et al., 2023; Krausman, 1996). Due to their arid and semi-arid natures, rangelands are also subject to various environmental disturbances like drought and wildfire.

Over the past century, global temperatures have risen, with most projections predicting a 1.5°C increase in temperatures globally by 2050 (Lindsey & Dahlman, 2020). Historically, higher temperatures and drier conditions have been positively related to wildfire size and frequency (Westerling et al., 2006). These predictions have incited concern regarding the management of these rangelands both pre- and post-wildfire. Currently, recommendations are to rest pastures for two years after a fire. During this time, livestock producers are often required to search for other grazing land, decrease their herd size, or feed cattle. None of these options are considered ideal when trying to maintain production and minimize input costs. The economic and ecological value of these lands has brought the management of post-fire rangelands under increased scrutiny.

Previous work has been conducted in the Northern Mixed-Grass Prairie, the Northern Great Basin, and sagebrush-steppe in Idaho. Many of these studies have cited minimal impacts from grazing on native vegetation, but the research has not expanded into areas like the perennial bunchgrass rangelands of Southwestern Montana. Rangelands are diverse, so more research is needed to evaluate the impacts of post-fire herbivory on various rangeland ecotypes. An important aspect of understanding how plant communities are affected by herbivory is knowing what species the animal is consuming and the nutritive status of the forage. This research provides more insight on how burn status, seasonal deferment, and annual rest impacts the botanical composition and quality of beef cattle diets on deep-rooted perennial bunchgrass plant communities in Southwestern Montana. The results of this research will provide land managers with information that allows them to reconsider their post-fire management strategies.

# CHAPTER TWO

# LITERATURE REVIEW

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Abstract

In the United States, rangelands comprise of 30% of the total land cover and serve as a valuable resource for livestock, wildlife, water, and recreation. Rangelands vary in climate and are often subject to disturbances like drought and wildfire. Historic wildfire trends have indicated an increase in wildfire size and frequency, raising societal and ecological concerns about the management of these lands, both pre- and post-wildfire. While there has been investigation into the effects of grazing prior to a wildfire on fire severity and plant mortality, there is limited research related to grazing post-wildfire even though current management paradigms suggest deferring grazing rangeland for two years after a wildfire to avoid additional stress on native plant species. Based on the diversity found across rangeland ecotypes and the history with wildfire, the two-year deferment recommendation may need to be reconsidered for some ecosystems. In recent research, species found in perennial bunchgrass rangelands like bluebunch wheatgrass (*Pseudoroegneria spicata*) and Idaho fescue (*Festuca idahoensis*) may be less susceptible to post-fire grazing than initially thought, necessitating the need for research into different rangeland ecosystems.

## Introduction

Rangelands are typically characterized by native vegetation and rainfall that is too low or erratic to support crops (Britannica, 2022). This definition encompasses the grasslands, shrublands, savanna woodlands, and deserts that make up almost 70% of the earth's land cover (Holechek et al., 2011). In the United States, 30% of the total land cover is considered rangeland, approximately 311 million hectares (NRCS). Though a common land cover, rangelands are primarily found in the western half of the United States (Holechek et al., 2011). Erratic precipitation patterns and vegetation make livestock grazing one of the key economic enterprises for the land. The passage of the Taylor Grazing Act (1934) led to the public domain to be divided into districts to regulate and prevent overgrazing. Since then, government agencies like the National Forest Service (NFS) and Bureau of Land Management (BLM) have become the primary overseers for public rangelands. In 2020, these two agencies supported 24,250 livestock grazing permittees with 15.7 million AUMs on public rangelands (Grazing Statistical Summary FY2020, 2021; Public Land Statistics 2021, 2022). Though permits are authorized for various livestock species, 92% of public grazing land is used by beef cattle (2017 Census of Agriculture, 2019). As a major agricultural industry, beef cattle production in the United States generates approximately $34.7 billion each year (2017 Census of Agriculture, 2019). Maher and coworkers (Maher et al., 2021) estimate the value of forage production in western rangelands to be approximately $3.8 billion annually.

Livestock production is not the only economic value for rangelands; wildlife, recreation, water, and other ecosystem services bring the total economic value of rangelands to $24.5 billion annually (Maher et al., 2021). In addition, western rangelands are home to over 3,000 wildlife

species ranging from large herbivores and small vertebrates to migratory songbirds and pollinators (Krausman, 1996). The high prevalence and value of wildlife on these rangelands puts additional pressure on rangeland managers to balance the optimization of livestock production and maintenance of wildlife habitat (DelCurto et al., 2023; Krausman, 1996). In addition to terrestrial species, rangeland conditions have a direct impact on aquatic species habitats (Bixby et al., 2015; Bowers, 1979). Though little research has delved into the impacts of fire on aquatic habitats, it is known that wildfires can mobilize nutrients and increase erosion (Bixby et al., 2015). Sediment from burned areas makes its way through watersheds, potentially altering habitats (Figure 1) (Bixby et al., 2015).

**Figure 1.1.** Rangeland wildfire (Photo courtesy of Mark Goertel, BLM 2006)

Rangelands also provide water resources for agricultural, city, and industry use (Williams & Allred, 1968). Precipitation received in these watersheds is often drained into waterways or through the soil into underground springs (Williams & Allred, 1968). The condition of the soil and vegetation communities in these rangelands is crucial when evaluating the quality and quantity of water for human use (Holechek et al., 2011; Williams & Allred, 1968). Strong plant communities and healthy soils reduce the incidence of flooding, erosion and subsequent silting of rivers, and coliform bacteria counts in reservoirs (Holechek et al., 2011).

## Methods

To date, most of the literature regarding the ecological concern of herbivory post-wildfire has centered on the arid and semi-arid rangelands of the United States, Canada, and to a lesser extent, Australia. These drier rangelands are more ecologically susceptible to vegetation and/or soil changes in response to disturbances such as wildfire and herbivory. Due to the social and political structure of land management for these areas, the management of herbivory post-wildfire has been a contentious issue for livestock managers and private/public land managers. A search for “ecology” and keywords “beef cattle”, “grazing”, “rangelands”, “post-wildfire” and “wildfire” was conducted on May 28, 2024 using the Web of Science search engine. This search yielded 164 results. Most research was conducted in the United States and Canada. Therefore, this review focuses on post-fire grazing on arid and semi-arid rangeland vegetation and soil in the United States.

## History of Fire and Rangelands

Though fires can have detrimental environmental impacts, it has been widely reported that aboriginal burning was practiced in North American for thousands of years (McAdoo et al., 2013; Pyne, 1995). In fact, Pyne (1995) argues that our current idea of a pristine wilderness is "a fundamental part of a national creation myth" and that the American wilderness has been cultivated and modified by human-caused fire for thousands of years. After all, fire was the most powerful tool humans possessed at the time (McAdoo et al., 2013). The American wilderness has not been occupied by Native Americans who left no trace; rather, its landscape has been defined by their use of fire (Pyne, 1995). Thus, the idea of removing human influence contrasts with the historical evidence of human-caused fires that were prevalent across North America, long before Europeans arrived.

Early Americans were not careless in their application of fire, however; their application varied among ecosystems and was greatly dependent on the resource they were managing (Williams, 2000). There are various reasons for the early use of fire, with the most notable being to modify ecosystems and "improve game grazing/browsing potential" (McAdoo et al., 2013; Williams, 2000). Early Americans noticed that fire stimulated the next year's productivity and used this knowledge to alter the grazing behavior of large herbivores (McAdoo et al., 2013; Pyne, 1995; Stewart, 2002). By burning an area, they could increase the amount of new growth in an area, attracting wildlife to these areas.

Historically, wildfires would become an increasing concern for sustainability of natural resources and public safety. In 1910, a wildfire nicknamed the "Big Burn" consumed 3 million acres of timberland in northern Idaho and Montana (Egan & Dean, 2009). In response to the Big

Burn's devastation, the US Forest Service implemented an aggressive wildfire suppression policy: the 10 AM Policy. This policy required that following discovery, all fires had to be suppressed by 10 AM the following day. This rule was followed throughout the twentieth century (Lueck & Yoder, 2015). This strategy succeeded in nearly eradicating recurring fire from these ecosystems that had evolved to exist with fire. As a result, fine fuels did not burn regularly, leading to an accumulation of these fuels (Omi, 2015). This surplus of fuels, paired with changing climate, has contributed to the increase in both wildfire size and frequency. Dennison and coworkers (2014) reported that wildfires have increased by 35,500 km2 per year and 7 fires per year. For perspective, wildfires burned an average of 3.1 million hectares per year over the past ten years, a substantial increase from the approximate 445,154 hectares burned in 1984 (Wildfires and Acres, 2023).

## Climate and Fire

Since 1880, average global temperatures have risen by an average of 0.08 °C each decade, resulting in a 1.12 °C total increase (Lindsey & Dahlman, 2020). This excess heat has been credited with shifts in snow cover, rainfall, and streamflows. Westerling and coworkers (2006) have identified a positive relationship between temperature, drought prevalence, and wildfires. In warmer years, spring snowmelt tends to occur earlier, lowering fuel moisture and lengthening wildfire season (Westerling et al., 2006). From 1970 to 2003, 56% of wildfires occurred in years with early snowmelt, with 73% of all early springs occurring after 1986 (Westerling et al., 2006). It is difficult to predict future wildfire behavior, but current models for 2050 show a 1.5 °C increase in global temperature (Lindsey & Dahlman, 2020). Historical trends imply that this increase in mean temperature may lead to earlier snowmelt, prolonged drought,

and greater incidence of wildfire (Dennison et al., 2014; Lindsey & Dahlman, 2020; Wuebbles et al., 2017).

Reflecting the historical increase in wildfires, the U.S. federal budget for wildfire suppression and prevention has grown from $728 million to over $2.5 billion (Office, 2022). The cost of fire-caused damages is more difficult to calculate, but the National Oceanic and Atmospheric Agency (NOAA) estimated $11.6 billion for damages in the 2021 wildfire season (2023). In 2018, one of the most devastating years for wildfires in the western U.S., damage costs reached $29 billion (2023). It is important to note that none of these estimates can accurately account for societal impacts like supply chain disturbances, health hazards, ecological alterations, and livestock displacement. Thus, all economic estimates should be considered conservative (Maher et al., 2021).

## Current Recommendations

Though the economic consequences of wildfires are significant, the ecological impacts are equally important. Since rangelands serve as the primary forage source for various livestock and wildlife species, proper management of both pre- and post-wildfire landscapes is critical. Most research has focused on land management prior to burning, either by prescribed or wildfire, but there has been little research into management strategies after a wildfire specifically related to wildlife and/or livestock grazing.

For most public rangelands, the post-fire management strategy follows the recommendations outlined in Blaisdell's Managing Intermountain Rangelands (Blaisdell, 1982). Blaisdell (1982) recommends deferring grazing for two years after a fire, a suggestion that both the NFS and BLM have adopted into their management models. However, there is little research

to support or discount this recommendation. Blaisdell (1982) argues that "only a small amount of forage is produced the first year, and grazing may cause serious damage to soil and desirable perennials". However, literature indicates that plants have variable responses to fire. Some work has reported that rangelands experience an initial depression in plant cover immediately after a fire, but recovery is rapid, often within the first three years (Bates & Davies, 2014; Bates et al., 2009; Li et al., 2021; Li, Angerer, & Wu, 2022; Seefeldt et al., 2007). Li and coworkers (2022) evaluated the impacts of different burn severities on vegetation and observed that perennial forbs and grasses reached cover values similar to pre-fire values after three years. The description of vegetation recovery under proper grazing management by Bates and coworkers (2007) indicated more uncertainty about Blaisdell's recommendations. Rangelands in the United States vary greatly in plant species composition, fuel load potential, precipitation, topography, and geology. This makes Blaisdell's blanket recommendation difficult to accept for all rangelands without further investigation (Davies et al., 2010; Li et al., 2021; Li, Angerer, & Ben Wu, 2022).

## Ecological Impacts and Management of Post-Fire Rangelands

Though most literature has been focused on the impact of large wildfires on forest ecosystems, there has been an increasing amount of work investigating fires occurring on rangeland ecosystems (Donovan et al., 2020; Li, Angerer, & Ben Wu, 2022; Li, Angerer, & Wu, 2022; Vermeire et al., 2011, 2014). It is widely accepted among ecologists that some North American grasslands have evolved under the influences of grazing animals and ecological disturbances like drought and fire (Anderson, 2006; Gleason, 1922; McAdoo et al., 2013; Pyne, 1995). The adaptive responses of perennial grasses reflect a coevolutionary relationship between fire and grasses (Gleason, 1922), as well as between herbivores and grasses (Stebbins, 1981). To

discourage defoliation, grasses have evolved to grow underground perennating tissues and silica in stalk and leaf epidermal cells, but that adaptation leads to the production of plant material that exceeds average annual decomposition (Stebbins, 1981). Gleason (1922) reports that perennial grass can regenerate through underground tissues, even if the aboveground biomass was completely burned. In addition, Gleason (1922) argues that this indicates perennial grass species are more resilient than originally perceived within the Great Plains.

Donovan and others (2020) investigated the resilience of plant communities that underwent large-scale wildfires across the Great Plains. Immediately after a fire, perennial grass and forb density declined, while annual species production was minimally depressed (Donovan et al., 2020). Bare ground and shrub cover both increased immediately post-fire but decreased to normal levels within three years. Although immediate responses were seen among all functional groups, Donovan and others (2020) report finding no evidence of persistent shifts in Great Plains vegetation caused by wildfires. This research is supported by other work in the Great Plains (Fuhlendorf et al., 2009; Vermeire et al., 2011, 2014). Though total standing forage decreased after a fire, this depression is attributed to the absence of standing dead material (Vermeire et al., 2011). While Vermeire and coworkers (2011) did see a shift in plant species composition within two years, the work done by Donovan and others (2020) suggests that communities will return to pre-fire composition after several years, even with the presence of grazing.

In Wyoming big sagebrush steppe, Bates and coworkers (2020) evaluated the long-term (2002-2018) succession after a fire. For the duration of the study, they reported that total herbage and perennial bunchgrass yields were approximately two times greater in the burned than unburned sites (Bates et al., 2020). However, plant composition was altered within this

timeframe: native perennials consisted of 90-95% of total plant composition prior to the fire but was reduced to 78% due to a post-fire increase of desert alyssum (*Alyssum desertorum*) and cheatgrass (*Bromus tectorum*) (Bates et al., 2020; Conrad & Poulton, 1966). Differences in plant community resiliency to wildfire between the sagebrush steppe and Great Plains suggest that post-fire management needs to be rangeland ecosystem specific.

Research into the impacts of wildfires on soil characteristics and microbial communities has been conducted in Australia's semiarid farmland (Prendergast-Miller et al., 2017). Initial depression in fungal and bacterial populations were exhibited in burned pastures, and the shift in bacterial and fungal structures was greater in burned pastures than unburned sites. This difference is attributed to increases in soil pH and nitrogen pools because of the wildfire (Prendergast-Miller et al., 2017). The severity of a fire also has an impact on bacterial and fungal communities (Whitman et al., 2019). Whitman and coworkers (2019) report that as fire severity increases, microbial communities become increasingly dissimilar to unburned communities.

## Herbivores on Post-Fire Rangelands

Based on historians' knowledge of Native American burning to alter herbivory, several studies have been conducted to determine the strength and mechanisms of the fire-grazing interaction (Allred et al., 2011; Fuhlendorf et al., 2009; McGinty et al., 1983; Powell et al., 2018). Native bison, domestic cattle, and elk exhibit a strong preference for recently burned areas (Allred et al., 2011; Long et al., 2008; Vermeire et al., 2004). Cattle reduced standing biomass in burned areas by 78% compared to 19% in unburned areas in the same pastures (Vermeire et al., 2004), suggesting cattle consumed more forage in recently burned sites compared to unburned sites. However, this preference decreases as forages mature and decrease

in quality (Allred et al., 2011; Powell et al., 2018). Elk consistently used burned forage stands more than control stands in the spring, but used both stands equally by the summer (Long et al., 2008).

Further work has shown that grazing the year after a fire does not have significant impacts on plant production or vigor parameters when grazed at a light (17%) to moderate (34%) utilization (Gates et al., 2017; Vermeire et al., 2014). Vermeire and coworkers (2014) did report a depression in biomass for needle-and-thread (*Hesperostipa comata*), but only at high (50%) utilization. Gates and others (2017) saw an initial depression in standing forage, 35% in year one and 19% in year two, but attributed this to the 53% more standing dead found in the ungrazed pastures. For both studies, summer grazing had minimal or no impact on plant communities in the Northern-Mixed grass prairie.

Most post-fire grazing research has been conducted in the Great Plains of North America, which supports the Northern Mixed-Grass ecosystem. However, vegetation communities characterized by perennial bunchgrass species like bluebunch wheatgrass (*Pseudoroegneria spicata*), Idaho fescue (*Festuca idahoensis*), and needle-and-thread occur outside of the Norther Great Plains biome. Although these bunchgrass species are found across various ecotypes, most post-fire management research on bunchgrass-dominated rangeland has been conducted in the Northern Great Basin (Bates et al., 2020; Bates & Davies, 2014; Bates et al., 2009; Cruz & Ganskopp, 1998; Davies et al., 2007; Davies et al., 2021; Launchbaugh et al., 2008; Roselle et al., 2010).

In the Northern Great Basin, potential impact of grazing on vegetation succession were investigated with seven years of cattle grazing in Wyoming big sagebrush steppe after a

prescribed fire (Bates & Davies, 2014). Three different grazing treatments were used, neither the low (15-30%) nor moderate (30-50%) levels of grazing impacted native herbaceous species composition and productivity (Bates & Davies, 2014; Bates et al., 2009). Reproductive stalk weight and canopy cover for these two treatments were comparable to the control site, indicating similar vigor and production levels. However, the high stocking rate (50-70%) had negative effects on reproductive stalk weight and canopy cover but did not impact basal cover and density (Bates & Davies, 2014).

Conrad and coworkers (1966) focused their post-wildfire research on two key bunchgrass species: bluebunch wheatgrass and Idaho fescue in Northern Oregon. After a wildfire in July, considerable growth was seen by the following June. They reported lower survival rates of existing Idaho fescue plants compared to bluebunch wheatgrass: 82% and over 95%, respectively. Bluebunch wheatgrass decreased in basal area, indicating reduced vigor, but plant density remained similar to pre-burn values. Conrad and coworkers (1966) concluded that Idaho fescue mortality and vigor was more affected by fire than bluebunch wheatgrass.

Conversely, Mueggler (1975) states that bluebunch wheatgrass is more susceptible than Idaho fescue to defoliation. Mueggler (1975) estimates the average time for bluebunch wheatgrass to recover to normal vigor is six years, but only three years for Idaho fescue. However, damage to these plants depends on intensity, frequency, and time of use; bluebunch wheatgrass defoliated to 28% original plant height is more susceptible than Idaho fescue defoliated by 75% during flower development (Mueggler, 1975). Timing seems to be a key factor when grazing bluebunch wheatgrass where the greatest physiological impact of defoliation is before and during the boot stage of phenology (Jirik & Bunting, 1994; McCarty & Price,

1942). When defoliation was conducted on bluebunch wheatgrass after a fire, Jirik and Bunting (1994) saw no significant difference in biomass production, basal area, tiller number, or mortality between plants defoliated in the fall and control sites. However, early (boot stage) defoliation reduced these parameters (Bunting et al., 1998; Jirik & Bunting, 1994).

When sheep grazed a recently burned sagebrush steppe in Idaho, Roselle and coworkers (2010) reported slight impacts on vegetation recover. Bluebunch wheatgrass cover continued to increase in grazed areas despite drought conditions. This increase was slightly suppressed by sheep grazing at 40% utilization, but a general increase in cover was reported. In the same trial, sheep showed a high preference for early-growing forbs, reducing overall forb production by 73%. This research supports resting for one growing season to avoid altering plant species composition, specifically the reduction of forbs. Roselle and others (2010) argue that fall grazing may not have a negative impact on sagebrush steppe plant communities.

Fuhlendorf and others (2009) support the idea of using fire to manage livestock grazing in the Great Plains. They suggest that the use of pyric herbivory, or “herbivory shaped by fire”, be implemented in rangeland ecosystems to reintroduce the evolutionary disturbance regimes that promote heterogeneity and biological diversity (Fuhlendorf et al., 2009). Allred and coworkers (2011) further support the use of fire to modify grazing behavior in cattle, citing a greater use of recently burned steep slopes. One paper even reports that the available biomass does not affect selection: cattle preferred burned areas over unburned sites with significantly more forage (Powell et al., 2018). From a soil erosion perspective, however, Stavi and coworkers (2016) caution that livestock grazing after a fire can increase soil erosion and land degradation at all utilization levels used in their study (6, 17, and 35%).

## Statement of the Problem

Gates and coworkers (2017) address the need for reconsidering the two-year deferment post-wildfire. In the Northern-Mixed grass prairie, plant vigor and productivity remain generally unaffected by fire or increased (Gates et al., 2017; Vermeire et al., 2014). Grazing post-fire had few impacts on vegetation in this area, and even improved diversity, indicating rest was not required to maintain productivity and cover (Gates et al., 2017). Bates and coworkers (2009) further support this recommendation by claiming that grazing one growth cycle after a fire will not negatively affect herbaceous plant recovery in Wyoming big sagebrush steppe. However, there has been little to no research done to evaluate the impacts of post-fire grazing on the perennial bunchgrass rangelands within the Rocky Mountain Lower Montane, Foothill and Valley ecosystem.

A confounding source of variation in wildfire recovery is diet selection and grazing behavior of livestock and wildfire using the area post-fire. Determining what forages animals prefer after a fire provides valuable insight into how herbivores will utilize the specific plants within the vegetation community. In turn, this information can be used to model the potential impacts grazing herbivores have on plant communities after a wildfire event (Figure 2).

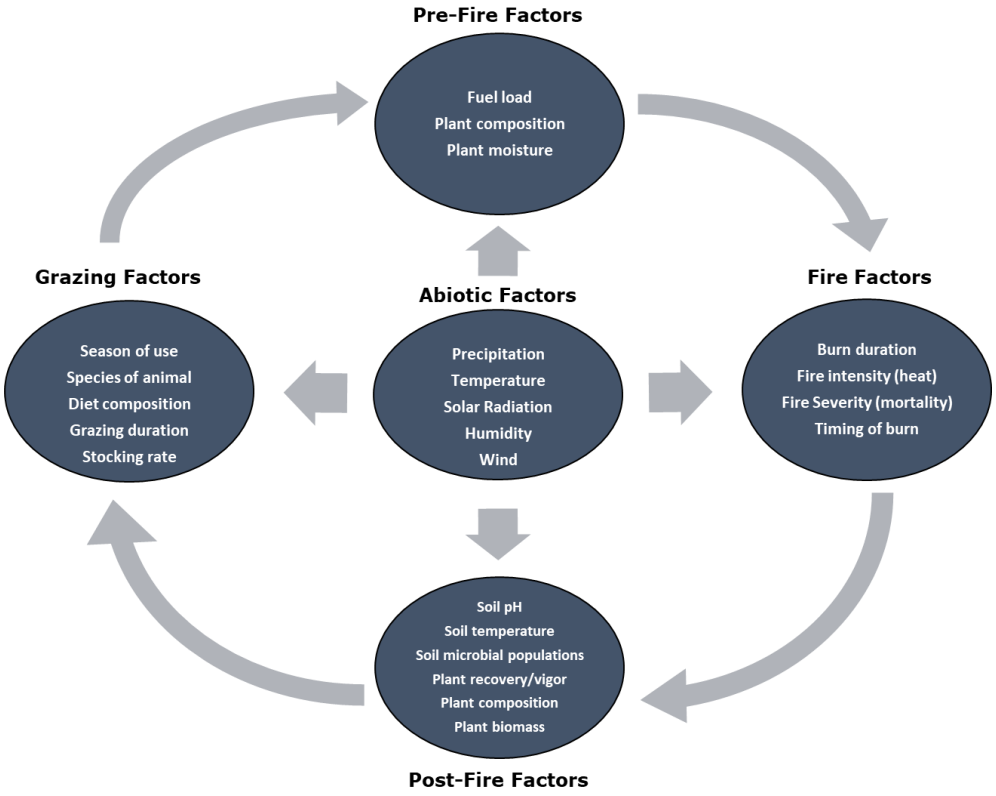


**Figure 1.2.** Various potential interactions of wildfire, herbivory, and abiotic factors, both post- and pre-wildfire grazing management.

## Conclusions

With the projected increase in wildfire frequency and intensity, as well as its ecological impact on arid and semi-arid rangelands, it is important to reassess post-fire management strategies for maintaining or enhancing vegetation communities and soils in these ecosystems. While current paradigms promote a two-year deferment to minimize stress on native plant species, there is little research validating or dismissing this recommendation. Rangelands, comprising 30% of the total U.S. land cover, are crucial for livestock, wildlife, water, and recreation. Historically, fire has shaped these landscapes, and understanding the relationship between post-wildfire grazing and vegetation recovery can prove useful for future management.

Existing studies primarily focused on the Great Plains ecosystem indicate that post-fire grazing can have minimal impacts on plant communities, potentially improving diversity and productivity. However, the diverse ecosystems of the Rocky Mountain region necessitate research to tailor post-fire management strategies to ensure the sustainable use of these rangelands.

Therefore, this study was conducted to investigate the differences in botanical composition and quality of beef cattle diets between burned and unburned rangelands. Because the deferment is designed to allow key perennial bunchgrass species adequate time to recover after a fire, we sought to determine if those species were selected for and thus put at a further disadvantage by grazing. We also sought to investigate any differences is the quality of diets between burned and unburned areas. This is to determine if there is a nutritional advantage to grazing rangelands after a fire, and if there are differences by season of use. It is our hope that the results from this study will provide information for rangeland managers to consider when faced with managing post-fire rangeland.

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# CHAPTER THREE

# FORAGING BEHAVIOR, BOTANICAL COMPOSITION AND QUALITY OF BEEF CATTLE DIETS ON BURNED OR UNBURNED FOOTHILL RANGELANDS IN JUNE AND SEPTEMBER

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Grasses

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## Abstract

Current management paradigms suggest deferring grazing rangeland for two years after a wildfire to avoid additional stress on native plant species, but there is little to no research supporting these recommendations. This experiment was conducted within and adjacent to the burn area of an August 2020 wildfire to evaluate the differences in diet quality, botanical composition, and foraging efficiency of beef cattle on both burned and unburned rangeland. A randomized complete block design with a 2x2 factorial arrangement of treatments contrasting burn versus no burn and June versus September grazing periods was used. Pastures (4 ha) within the burn area were grazed in either June 2021 or deferred to September 2021. Grazing occurred for two days by 20 cow/calf pairs in June and 16 cow/calf pairs in September. Cattle diet composition and masticate samples were collected during 20-minute bite-count periods using six ruminally cannulated cows in each pasture prior to and after two-day grazing periods. Cannulated cows grazed a pasture adjacent to the burn area to compare diet quality and composition between burned and unburned rangeland. Forb consumption was higher in burned than unburned diets for June ($P < 0.01$), but there was no difference in September diets ($P = 0.58$). There was a date by grazing period interaction in which forbs were a greater percentage of the diet prior to grazing than after ($P < 0.01$). Cattle grazing unburned pastures in June tended to take more bites per minute ($P = 0.07$) than in burned pastures. In September, the opposite was observed; cattle took more bites per minute in burned pastures than unburned pastures ($P < 0.01$). Grams per minute did not differ between September treatments ($P = 0.26$), but cattle did consume more grams per minute in unburned pastures in June ($P < 0.01$). The ash content of diets tended to be higher in burned pastures in June ($P = 0.07$) but did not differ in September diets ($P = 0.54$). Diets were lower in NDF for June burned pastures ($P < 0.01$), but there was no difference between treatments in September ($P = 0.41$). ADF tended to be lower in June than September ($P = 0.05$) but did not differ between treatments ($P = 0.2$). Diets were higher in crude protein for June burned pastures than unburned pastures ($P < 0.01$). However, there was no difference between September treatments ($P = 0.27$).

## Introduction

In recent years, there has been a significant increase in wildfires in the United States, with an average of 3.1 million hectares burned annually compared to 445,154 hectares in 1984 (Wildfires and Acres, 2023). In response, the federal budget for wildfire suppression and prevention rose from $728 million in 1984 to $6.5 billion (Office, 2022). Historically, wildfire behavior has been positively associated with drought, average temperature, and earlier snowmelt (Westerling et al., 2006). With a projected 1.5°C increase in global temperatures by 2050 (Lindsey & Dahlman, 2020), these trends are expected to continue, leading to accelerated fire return intervals to under 20 years (Dennison et al., 2014; Wuebbles et al., 2017). In comparison, return intervals between high severity fires for the past 10,000 years are estimated to have been between 100 and 300 years (Westerling et al., 2011).

Often characterized by native vegetation and erratic precipitation patterns, arid and semi-arid rangelands are susceptible to changes in vegetation and soil from ecological disturbances like wildfire and herbivory (Britannica, 2022; Holechek et al., 2011). Of the 311.6 million hectares of rangeland in the United States, 35.5% are under management by federal agencies (Grazing Statistical Summary FY2020, 2021; Public Land Statistics 2021, 2022). The federal recommendation for post-fire management of most of these public lands is to defer grazing for two years after a fire (Blaisdell, 1982). The justification behind this recommendation is to allow perennial plant communities adequate recovery time post-fire. However, there has been little research to support or discount this recommendation. Literature indicates plants respond variably to fire, furthering the importance of investigating the impacts of post-fire grazing on the behavior of livestock grazing rangelands dominated by deep-rooted perennial bunchgrasses.

Annually, public rangelands support 15.7 million livestock animal unit months (AUM), serving as a critical asset for the United States' livestock industry (Grazing Statistical Summary FY2020, 2021; Public Land Statistics 2021, 2022). Estimates place the value of forage on these public rangelands to be approximately $116/ha (Maher et al., 2013). As livestock grazing is a primary management tool of these lands, its deferment may have both ecological and economic consequences. A rest period may seem intuitive to avoid the cumulative effect of fire and grazing, but literature suggests that plants respond variable to fire (Bates & Davies, 2014; Bates et al., 2009; Li et al., 2022; Roselle et al., 2010; Seefeldt et al., 2007). In the United States, rangelands vary greatly in plant species composition, fuel load potential, precipitation, topography, and geology. This diversity makes it difficult to apply the current recommendation broadly.

Although somewhat limited, there is previous research into how wildfires alter foraging behavior, quality, and botanical composition of diets in herbivores (Gates et al., 2017; Long et al., 2008; Roselle et al., 2010; Vermeire et al., 2004). In the Northern Great Basin, sheep grazing post-fire rangelands were found to prefer early growing forbs, reducing subsequent forb production by up to 73% (Roselle et al., 2010). Fall grazing had little effect on range condition, but Roselle and coworkers (Roselle et al., 2010) hypothesize that continued spring grazing may alter long-term range condition. This aligns with previous findings that sheep are relatively selective in their diets. Conversely, cattle have been reported as being generalist grazers when compared to sheep, and tend to prefer a grass diet. However, more recent work has shown that cattle are discriminatory during the vegetative stage of plant phenology, with selection decreasing as plant phenological stages progress (Cruz & Ganskopp, 1998).

Vermeire and coworkers (2004) reported higher utilization of burned areas in pastures grazed by cattle from April to September but did not investigate differences within the grazing season.

Rangeland composition and structure can be altered over time by selective grazing (McNaughton & Georgiadis, 1986). However, little research has been conducted to determine the degree of selectivity that cattle exhibit on post-fire rangelands. This information is important for managers to consider when implementing grazing strategies (Holechek & Varvra, 1982). Therefore, the objectives of this study were to evaluate the impact of wildfire on grazing behavior, diet composition and quality by comparing burned and adjacent non-burned rangeland and timing, with sampling conducted during the growing season (June) and senescence (September). We hypothesized that 1) cattle diets would be of higher quality on spring diets compared to fall diets, and 2) botanical composition would differ in the spring but be similar in the fall once plants reached senescence.

## Materials and Methods

### Wildfire and Study Design

The Bradley Creek fire began on 23 August 2020, and was contained on 27 August after burning 756 hectares of rangeland southeast of Norris, MT. The fire burned a portion of Montana State University's Red Bluff Research Ranch located approximately 48 km west of Bozeman, Montana. The cause of the Bradley Creek fire is unknown. During fire activity, mean temperature was 20.6°C, with maximum and minimum temperatures at 30.1°C and 11.2°C, respectively (PRISM, 2020).

This study was conducted within the burn area located on the Red Bluff Research Ranch property and the study location had not been grazed for two years prior to the wildfire. The elevation of the study area is approximately 1,500 m with average annual precipitation being approximately 440 mm (Norris Madison PWHS Period of Record Monthly Climate Summary). Dominant grasses for the study area are bluebunch wheatgrass (*Pseudoroegneria spicata*), Idaho fescue (*Festuca idahoensis*), needle-and-thread (*Hesperostipa comata*), and green needlegrass (*Nassella viridula*). The most common forbs include milkvetch (*Astragalus spp*.), common dandelion (*Taraxacum officinale*), aster (*Symphyotrichum ascendens*), goldenrod (*Solidago canadensis*), and dotted gayfeather (*Liatris spp*.).

Following the fire, eight 4-hectare pastures were constructed within the burn area and arranged in a randomized complete block design. Fences were built with mild-tensile electric wire to prevent unprescribed grazing in deferred pastures. Portable stock tanks were used for water and filled daily from an irrigation pump. No mineral supplementation was provided. To compare season of use, pastures were grazed in either June 2021 or September 2021 by cow-calf pairs for two days. In June, 20 cow-calf pairs grazed each pasture (98 AUM $\cdot$ ha$^{-1}$). This number was decreased to 16 pairs in September to account for calf growth/intake and maintain similar levels of pasture utilization. The unburned pasture was left ungrazed.

Diet Composition

Prior to each grazing treatment, six four-year old ruminally cannulated Angus crossbred cows were used to estimate nutritional and botanical composition of diets. Bite-count methodology for determining botanical composition was similar to that described by Wickstrom et al. (1984) and Canon et al. (1987). All six ruminally cannulated cows were used for each

treatment pasture. Grazing bouts were 20-minutes, and technicians were randomly assigned a cow for each bout. Technicians had been trained in plant identification and cows were accustomed to being in close proximity with technicians. Each technician recorded the number of bites of each plant species for the entire grazing bout on a handheld recorder (Findholt et al., 2004). Overall botanical composition was calculated by dividing the number of bites of each plant by total bites of the diet sample.

Diet Quality

Diet quality samples were collected from each cannulated cow for each pasture prior to and after cow-calf grazing periods. The ruminal contents of each cow were completely evacuated before being allowed to freely graze each pasture for 20 minutes while observed by a technician. All rumen contents from each grazing bout were collected as a diet quality sample. Ruminal samples were dried in a forced-air oven (55°C) for 96 hours and ground to pass a 1 mm screen in a Wiley mill. Rumen samples were analyzed in duplicate for organic matter. Sequential fiber (NDF and ADF) was analyzed using the Ankom 200 Fiber Analyzer (Ankom Co., Fairport, NY, USA). Samples were sent to a commercial laboratory (Dairy One, Ithaca, NY, USA) and analyzed for nitrogen content.

Foraging Efficiency

Hand-plucked samples were collected for the major forage species present in cannulated cow diets from each pasture. A total of 50 simulated bites were collected for each species from random sites throughout the study area. Samples were dried in a forced-air oven at 55°C in paper bags and weighed to obtain a dry weight. Samples were ground to pass a 1-mm screen in a Wiley mill and sent for nitrogen content analysis to the commercial laboratory previously mentioned.

Bites per minute were calculated by dividing the total number of bites per grazing bout by 20 minutes. Grams per minute were calculated by dividing the total dry weight of the masticate sample by 20 minutes. Grams per bite were calculated by dividing the dry weight of the masticate sample by the total number of bites taken.

### Statistical Analysis

The effect of season of use (June vs. September) and burn status (burned vs unburned) on diet composition, diet quality, and foraging efficiency were analyzed using analysis of variance (ANOVA) with a generalized linear mixed model corresponding to a completely randomized design with a 2 x 2 factorial treatment arrangement of season of use, burn status, and their interaction as fixed effects and individual cow as a random effect (Bates et al., 2015). All data were plotted and transformed if needed to satisfy assumptions of normality and homogeneity of variance. Individual animals were considered the experimental unit. An alpha $\leq 0.05$ was considered significant. Tendencies were reported when significance was $p \leq 0.10$. The Tukey method was used to separate means when alpha was $< 0.05$ (Lenth & Lenth, 2018). All statistical analyses were performed in R (Team, 2021).

## Results

### Diet Composition

Diet composition by forage class is presented in Table 1. Sedge consumption differed ($P = 0.03$) across between seasons and burn status, but post-hoc analysis revealed no difference. Cattle consumed a diet higher in forbs in JB than JUB ($P < 0.01$). For September, burn status had no effect on botanical composition ($P = 0.95$). Cattle consumed similar percentages of Idaho

fescue between JUB and JB ($P = 0.79$). Diets consisted of less Idaho fescue on SB than SUB ($P < 0.01$). Needle and thread consumption was greater on burned pastures than unburned pastures ($P = 0.03$). There was no difference ($P \geq 0.16$) between burn status and season of use for Western wheatgrass consumption. Cattle grazing in June consumed diets with similar percentages of bluebunch wheatgrass despite burn status ($P = 0.21$). While grazing in September, cattle consumed a greater percentage of bluebunch wheatgrass in SB than SUB ($P < 0.01$).

For forbs, cattle consumed a greater proportion of forbs in June than September ($P < 0.01$). In June, cattle consumed more forbs in JB than JUB ($P < 0.01$). There was no difference in forb consumption between burn status in September ($P = 0.54$). Aster consumption was greater in June diets than September diets ($P < 0.01$) but did not differ between burn status ($P \geq 0.42$). There was no difference between seasons or burn status for purple coneflower ($P \geq 0.18$). Goldenrod was not present in June diets but was present in September ($P < 0.01$). Dandelion represented a greater percentage of diets in JB than JUB ($P < 0.01$). However, in September, dandelion was not present in the diet.

Diet Quality

Diet quality is presented on an organic matter basis in Table 2. Ash content of masticate samples was similar between burn status and season of use ($P \geq 0.12$). JB diets were lower in NDF than in JUB diets ($P < 0.01$). As expected, NDF content was higher in September than in June ($P < 0.01$). NDF was similar between SB and SUB diets. ADF content showed a tendency to differ between June and September ($P = 0.07$) but did not differ by burn status within seasons ($P = 0.23$). CP content was higher in both burned (JB and SB) treatments than unburned (JUB

and SUB) treatments ($P < 0.01$). June CP content was higher than September CP content ($P < 0.01$).

Foraging Behavior

Cattle grazing behavior is shown in Table 3. Cattle consumed fewer grams per minute in JB pastures than JUB ($P < 0.01$). There was no difference in grams per minute between September treatments ($P = 0.6$). Number of bites per minute did not across treatments differ ($P = 0.11$). Cattle took fewer bites per minute in JB sites than JUB ($P < 0.01$). The opposite was seen in September: cattle took more bites per minute in SB pastures than SUB ($P < 0.01$). Bite size differed by treatment ($P < 0.01$), but no difference between dates was detected ($P = 0.99$). Cattle grazing burned sites took smaller ($P < 0.01$) bites than when grazing unburned sites.

Figures and Tables

**Table 3.1.** Percentage of grass and forb composition of beef cattle diets on burned and unburned rangeland in June and September at the Red Bluff Research Ranch, southwest Montana (data from 2021).

| | June | | September | | | *P* values[1] | | |
|---|---|---|---|---|---|---|---|---|
| **Item** | **B[2]** | **UB[3]** | **B** | **UB** | **SEM[4]** | **B** | **S** | **B x S** |
| Grasses/Grasslikes | **20.95$^{d}$** | **67.01$^{c}$** | **87.16$^{b}$** | **90.55$^{a}$** | **4.68** | **< 0.01** | **< 0.01** | **< 0.01** |
| *Carex filifolia* | 0.20 | 0.66 | 0.45 | 0.03 | 0.20 | 0.08 | 0.24 | 0.02 |
| *Festuca idahoensis* | 6.50$^{c}$ | 11.7$^{c}$ | 43.69$^{b}$ | 72.24$^{a}$ | 3.99 | 0.36 | < 0.01 | < 0.01 |
| *Hesperostipa comata* | 0.57$^{c}$ | 10.15$^{b}$ | 22.94$^{a}$ | 13.33$^{b}$ | 3.14 | 0.03 | < 0.01 | < 0.01 |
| *Pascopyron smithii* | 3.15 | 0.57 | 5.65 | 2.32 | 1.51 | 0.23 | 0.16 | 0.81 |
| *Pseudoroegneria spicata* | 2.27$^{b}$ | 4.27$^{ab}$ | 6.17$^{a}$ | 1.53$^{b}$ | 1.11 | 0.21 | < 0.01 | < 0.01 |
| Forbs | **79.05$^{a}$** | **32.99$^{b}$** | **12.84$^{c}$** | **9.45$^{c}$** | **4.68** | **< 0.01** | **< 0.01** | **< 0.01** |
| *Astragalus spp.* | 21.45 | 15.94 | 0.22 | 0.39 | 4.74 | 0.42 | < 0.01 | 0.55 |
| *Echinacea purpurea* | 2.28 | 2.29 | 0.26 | 0 | 1.29 | 0.99 | 0.18 | 0.93 |
| *Solidago canadensis* | 0 | 0 | 5.11 | 2.96 | 1.21 | 0.99 | < 0.01 | 0.38 |
| *Symphyotrichum ascendens* | 0 | 0.05 | 6.25 | 3.03 | 1.89 | 0.99 | < 0.01 | 0.39 |
| *Taraxacum officinale* | 53.34$^{a}$ | 11.63$^{b}$ | 0$^{c}$ | 0$^{c}$ | 5.14 | < 0.01 | < 0.01 | < 0.01 |

[1] Treatment (B) of burn or unburned, and season of use (S) of June or September
[2] Burned pastures
[3] Unburned pastures
[4] Pooled standard error of the means presented
[a,b] Means that lack common superscripts differ for treatment x season of use ($P < 0.05$)

**Table 3.2.** Nutrient composition of beef cattle diets on burned and unburned rangeland pastures in June and September at the Red Bluff Research Ranch, southwest Montana (data from 2021).

| | June | | September | | | *P* values[1] | | |
|---|---|---|---|---|---|---|---|---|
| **Item** | **B[2]** | **UB[3]** | **B** | **UB** | **SEM[4]** | **B** | **S** | **B x S** |
| Ash (%, DM) | 17.2 | 15.1 | 16.6 | 15.9 | 0.93 | 0.12 | 0.57 | 0.47 |
| NDF (%,OM) | 62.6[c] | 71.5[b] | 80[a] | 77.9[ab] | 2.06 | < 0.01 | < 0.01 | < 0.01 |
| ADF (%, OM) | 45.9 | 42.6 | 49.9 | 48.3 | 1.99 | 0.23 | 0.07 | 0.67 |
| CP (%, OM) | 22.2 | 19.3 | 12.6 | 11.8 | 0.55 | < 0.01 | < 0.01 | 0.06 |

[1] Treatment (B) of burn or unburned, and season of use (S) of June or September
[2] Burned pastures
[3] Unburned pastures
[4] Pooled standard error of the means presented
[a,b] Means that lack common superscripts differ for treatment x season of use ($P < 0.05$)

**Table 3.3.** Grams dry matter per minute (g · min-1), bites per minute (bite · min-1), and grams per bite (g · bite-1) consumed by beef cattle grazing burned and unburned pastures in June and September at the Red Bluff Research Ranch, southwest Montana (data from 2021).

| | June | | September | | | *P* values[1] | | |
|---|---|---|---|---|---|---|---|---|
| **Item** | **B[2]** | **UB[3]** | **B** | **UB** | **SEM[4]** | **B** | **S** | **B x S** |
| g · min$^{-1}$ | 7.93$^{c}$ | 23.86$^{b}$ | 29.28$^{a}$ | 25.82$^{a}$ | 2.53 | < 0.01 | < 0.01 | < 0.01 |
| bite · min$^{-1}$ | 8.23$^{c}$ | 15.83$^{c}$ | 34.33$^{a}$ | 22.52$^{b}$ | 3.47 | 0.11 | < 0.01 | < 0.01 |
| g · bite$^{-1}$ | 1.00 | 1.53 | 1.00 | 1.16 | 0.11 | < 0.01 | 0.99 | 0.08 |

[1] Treatment (B) of burn or unburned, and season of use (S) of June or September
[2] Burned pastures
[3] Unburned pastures
[4] Pooled standard error of the means presented
[a,b] Means that lack common superscripts differ for treatment x season of use (P < 0.05)

**Table 3.4.** Percent crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), and total digestible nutrients (TDN) of hand-plucked forages by species in control (unburned) and burned pastures at the Red Bluff Research Station, southwest Montana (data from 2021).

| | Unburned | | | | Burned | | | |
|---|---|---|---|---|---|---|---|---|
| **Forage Species** | **CP[1]** | **NDF[2]** | **ADF[3]** | **TDN[4]** | **CP** | **NDF** | **ADF** | **TDN** |
| **June** | | | | | | | | |
| Grasses/grasslikes | | | | | | | | |
| *Festuca idahoensis* | 8.1 | 58 | 33.9 | 57 | 12.3 | 57.3 | 32.1 | 57 |
| *Hesperostipa comata* | 9.2 | 62.9 | 33.2 | 56 | 12 | 60.4 | 30.8 | 56 |
| *Nassella viridula* | 10.7 | 63.2 | 32.2 | 56 | 13.5 | 59.5 | 29.8 | 57 |
| *Pseudoroegneria spicata* | 8.3 | 60.8 | 38.1 | 56 | 13.1 | 61 | 32 | 56 |
| *Pascopyrum smithii* | 12 | 59.4 | 32.4 | 57 | 12.9 | 58.4 | 30.4 | 57 |
| Forbs | | | | | | | | |
| *Astragalus spp.* | 19.4 | 33.5 | 27.5 | 64 | 20.1 | 33.1 | 24.9 | 64 |
| *Taraxacum officinale* | 16.2 | 32.6 | 25.7 | 64 | 14.7 | 32.7 | 24.1 | 64 |
| *Tragopogon porrifolius* | 14.7 | 28.2 | 19 | 66 | 15 | 32.6 | 24.4 | 64 |
| **September** | | | | | | | | |
| Grasses/grasslikes | | | | | | | | |
| *Festuca idahoensis* | 7.2 | 34.7 | 34.7 | 57 | 9.5 | 57.6 | 33.8 | 57 |
| *Hesperostipa comata* | 7.1 | 39 | 39 | 55 | 7.1 | 59.9 | 38.1 | 56 |
| *Pseudoroegneria spicata* | 4.8 | 63.9 | 39.5 | 55 | 5.8 | 64.9 | 38.5 | 55 |

[1] Crude protein
[2] Neutral detergent fiber
[3] Acid detergent fiber
[4] Total digestible nutrients

## Discussion

In our study, cattle exhibited a high preference for forbs during the growing season, which is consistent with other research (Cruz & Ganskopp, 1998; Roselle et al., 2010). This forb preference could explain the elevated CP levels in the burned spring pastures. The primary forage source was dandelion and milkvetch during the growing season and shifting to bluebunch wheatgrass and Idaho fescue by senescence. Comparing June pastures, there was greater forb consumption in the burned areas than in the unburned areas. We hypothesize that this was a result of forage quality and availability in the burned pastures. During the 2021 growing season, the research area was in a severe to exceptional drought, according to the U.S. Drought Monitor (U.S. Drought Monitor, 2024). Based on visual observations, forbs were more succulent and abundant than native perennial bunchgrasses at the time of the spring grazing bouts. These new-growth forbs were also higher in quality than perennial bunchgrasses, and cattle selected heavily for them in burned pastures.

One of the key perennial bunchgrasses for this study area is bluebunch wheatgrass. According to some literature, the natural recovery after a fire for bluebunch wheatgrass is typically two to three growing seasons (Uresk et al., 1980; West & Hassan, 1985), though Bunting and others (Bunting et al., 1998) reported bluebunch wheatgrass was sensitive to early grazing based on reduced productivity and increased mortality. As bluebunch wheatgrass is moderately susceptible to defoliation during the growing season, decreased vigor may result from heavy utilization during the growing season (McCarty & Price, 1942). Jirik and Bunting (Jirik & Bunting, 1994) investigated the effects of post-fire defoliation on bluebunch wheatgrass

and reported an effect during the growing season, but found no differences in biomass production, basal area, tiller number, or plant mortality from fall defoliation.

In this study, cattle showed high levels of selectivity during the growing season: they preferred forbs over the more abundant perennial bunchgrass species. Key species (bluebunch wheatgrass, Idaho fescue, needle and thread) only comprised approximately 9.34% of the average growing season diets on burned rangeland. Comparatively, these grasses comprise 26.12% of diets for the unburned sites. The cattle's lower utilization of key bunchgrass species during the most susceptible stage of plant growth could support low-density spring grazing after a wildfire.

Grazing behavior also differed between treatments with cattle taking more bites per minute and consuming more grams per minute on the unburned sites than the burned sites in June. The difference in spring grazing behavior could be attributed to the greater available forage in the unburned areas as well as the greater quality of forage found in the burned range. Cattle were able to consume higher quality diets with fewer bites in burned pastures. In September, however, cattle took more bites per minute in the burned pastures, but grams per minute was similar across treatments. These observations, paired with the similar forage nutritional quality found in fall burned and unburned sites, may indicate that any nutritional benefit to grazing recently burned rangeland does not extend through plant senescence (Roselle et al., 2010).

Based on this study, diet quality was improved for cattle grazing during the growing season immediately post-wildfire. This could be due to the high consumption of forbs in the burned areas, greater crude protein content of new growth, as well as the lack of standing dead in the burned areas. In the spring, cattle were able to consume higher quality diets with fewer bites,

negatively affecting foraging rate (bites per minute). The implication from this study is that cattle may be able to graze the spring after a wildfire without negatively impacting certain perennial bunchgrass species. The high percentage of forbs in the spring diet suggests that there may be minimal impact on key perennial bunchgrass species during spring grazing, which does not support the justification for the recommendation of a two-year deferments. Additionally, the high quality of diets on burned spring rangeland may serve as a nutritional advantage for livestock. Grazing the spring after a wildfire may allow land producers to capture the additional quality of new growth.

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# CHAPTER FOUR

# THE INFLUENCE OF REST AND DEFERMENT ON BEEF CATTLE DIET QUALITY AND COMPOSITION AFTER A RANGELAND FIRE

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Grasses

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## Abstract

Research has shown that forage quality increases after a fire. Greater crude protein content in forage can be beneficial for livestock, and even attract herbivores to recently burned areas. However, there has been little research into how forage quality changes within the first two years after a fire and how it affects livestock diet quality or composition. Therefore, this project was conducted within a burn area of an August 2020 wildfire to evaluate the effect of seasonal deferment and annual rest on diet quality, botanical composition, and foraging efficiency of beef cattle grazing burned rangeland. A randomized complete block design was used comparing June grazing versus September grazing with cow/calf pairs, and no deferment versus a one-year deferment of grazing. Sixteen 4-hectare pastures were used, with eight being grazed in 2021 and 2022, and eight only grazed in 2022. Pastures were grazed in either June or September by cow-calf pairs for two days at a time. Pastures were stocked at 0.53 AUM · $ha^{-1}$ for all treatments. Cattle diet composition and masticate samples were collected during 20-minte bite-count periods using six ruminally cannulated cows in each pasture prior to and after two-day grazing periods. Composition of diets upon pasture entry differed among treatments ($P < 0.01$) with June diets in greater proportions of forbs than September diets. In addition, June diets with no deferment had greater forb composition than June diets with one year deferment ($P < 0.01$). Crude protein in June diets were substantially greater than September diets ($P < 0.01$) and within the June grazing period, highest for the non-deferred treatment ($P < 0.01$). June diets had lower neutral detergent fiber (NDF) concentrations than September diets ($P < 0.01$) and within the June grazing treatments, the first year after burning was lowest in NDF content ($P < 0.01$). There was no difference in ash concentration for all treatments and years ($P \geq 0.07$) averaging 16.46% ash content. There was no effect of grazing treatment on grams per bite ($P \geq 0.34$) averaging 1.36 grams per bite for pre- and post-grazing treatments. Season of use and timing of grazing following a wildfire has an impact on cattle diet composition and quality with the greatest impact in the spring following a wildfire.

## Introduction

Globally, rangelands are considered the most abundant land type, at approximately 70% of total land cover (Holechek et al., 2011). In the United States, there are approximately 312 million hectares (ha) of rangelands with a combined 110.9 ha being managed by the Bureau of Land Management and U.S. Forest Service (*Grazing Statistical Summary FY2020*, 2021; *Public Land Statistics 2021*, 2022). These public lands are of great value to the livestock industry, supporting approximately 15.7 million animal unit months (AUM). Maher and coworkers estimate that rangelands contribute $3.8 billion in forage annually to the $34.7 billion United States beef industry (Maher et al., 2021).

Since the "Big Burn" in 1910 (Egan & Dean, 2009), wildfire management and mitigation has become increasingly important to the public and government agencies alike (Lueck & Yoder, 2015). In 1984, the Congressional Budget Office reported spending $728 million (adjusted for 2023 inflation) to prevent and suppress wildfires on 445,154 ha. In 2023, the same office reported that spending increased to $2.5 billion for wildfire mitigation on 3.1 million ha (Office, 2022). In the past 140 years, global temperatures have increased by 1.12° C (Lindsey & Dahlman, 2020) and climate projections predict a global temperature increase of 1.5° C by 2050 (Lindsey & Dahlman, 2020). Research has indicated that greater wildfire prevalence is related to increased temperature, decreased precipitation, and warmer and drier springs, all of which are predicted to increase (Dennison et al., 2014; Westerling et al., 2006; Wuebbles et al., 2017). This has increased concern regarding management of public lands, specifically arid and semi-arid rangelands that are more susceptible to fluctuations in temperature and precipitation. Currently, the recommendations for managing a post-fire rangeland are to defer grazing for two years

(Blaisdell, 1982). This is to avoid putting key deep-rooted perennial bunchgrass species under additional stress. However, there is little research to support or dispute these recommendations.

As the primary economic enterprise of rangelands, livestock grazing and its relationship with fire has been investigated, however, most literature focuses on the effects of livestock grazing prior to fire (Davies et al., 2020; Davies et al., 2010; Davies et al., 2015, 2016). Some research has been conducted investigating the effects of grazing after a fire on rangeland communities (Bates & Davies, 2014; Bates et al., 2009; Davies et al., 2007; Vermeire et al., 2014). Some research investigated how wildfires alter foraging behavior, quality and botanical composition of herbivore diets (Allred et al., 2011; Gates et al., 2017; Roselle et al., 2010)

In the Northern Mixed-Grass Prairie, cattle and bison grazing post-fire rangeland preferred more recently burned sites over sites with greater time since burning (Allred et al., 2011). Allred and coworkers (2011) hypothesized that this preference was a result of the greater forage quality available, despite lower plant availability. This indicates that the quality of forage was emphasized in cattle preferences over forage quantity. These finding align with other research (Cruz & Ganskopp, 1998) that indicates that cattle selectivity is highest during the growing season, decreasing as plant phenology progresses.

Most research in semi-arid rangelands has been conducted in the Northern Mixed-Grass Prairie and the Northern Great Basin, but there has been little no investigation into the impacts of post-fire grazing on the perennial bunchgrass rangelands within the Rocky Mountain Lower Montane, Foothill and Valley ecosystem. The diet selection and grazing behavior of herbivores using an area post-fire is important to evaluate when determining the impact of grazing after fire. Information from the herbivore's diet composition and diet quality can be used to model what

impacts grazing may have on post-fire plant communities. Additionally, the introduction of a seasonal deferment or an annual rest could alter the botanical composition and quality of the animal's diet. Therefore, the objectives of this study were to evaluate the impact of rest and deferment on grazing behavior, diet composition, and quality of beef cattle grazing post-fire rangelands in southwestern Montana.

## Materials and Methods

### Wildfire and Study Design

Approximately 48 km west of Bozeman, the Bradley Creek wildfire burned 756 hectares (ha) of rangeland from 23 August, 2020 to 27 August, 2020. Mean ambient temperature during the fire was 20.6°C, with maximum and minimum temperatures at 30.1°C and 11.2°C, respectively (PRISM, 2020). Part of Montana State University's Red Bluff Research Ranch (Red Bluff) was located within the burn area. This study was conducted within the burn area, and grazing had not occurred for two years prior to the fire in that area. Precipitation is approximately 440 mm annually, and elevation of the study site is 1,500 m (Western Regional Climate Center, 2017). The study site is characterized by bluebunch wheatgrass (*Pseudoroegneria spicata*), Idaho fescue (*Festuca idahoensis*), needle-and-thread (*Hesperostipa comata*), junegrass (*Koeleria macrantha*) and green needlegrass (*Nassella viridula*). Major forbs include milkvetch (*Astragalus spp*.), common dandelion (*Taraxacum officinale*), western aster (*Symphyotrichum ascendens*), goldenrod (*Solidago canadensis*), and dotted gayfeather (*Liatris spp*.).

Sixteen pastures were constructed within the burn area with mild-tensile electric wire. Each pasture was 4 ha in size. Pastures were arranged in a completely randomized complete

block design with a 3x2 factorial arrangement contrasting a one-year rest vs. no rest (year one and year two), and June vs. September (Figure 3.1).

Grazing trials with cow-calf pairs occurred in June and September of 2021 and 2022, with no overlap in season of use. Pastures were either grazed for both years or rested during 2021. Therefore, our grazing treatments were as follows: 1) June grazing first year following wildfire (JY1), 2) September grazing first year following wildfire (SY1), 3) Second year of June grazing following wildfire (JY2), 4) Second year of September grazing following wildfire (SY2), 5) June grazing with a 1 year rest (JR), 6) September grazing with 1 year rest (SR). Pastures were stocked (0.53 AUM·ha$^{-1}$) with 20 cow-calf pairs, and 16 in September to account for calf growth and increased forage intake. Water was sourced from an irrigation pump into portable stock tanks. Cattle received no mineral supplementation.

Diet Composition

Six four-year old ruminally cannulated Angus crossbred cows were used to conduct bite-counts following methodology similar to that in Wickstrom et al. (1984) and Canon et al. (1987). Bite counts were conducted before and after cattle turnout to estimate the nutritional quality and botanical composition of diets. Grazing bouts lasted for 20 minutes per pasture, and all six cows were used. During grazing bouts, technicians recorded each bite and species consumed by an assigned animal on a handheld recorder (Findholt et al., 2004). For each pasture, the number of bites for each plant was divided by the total bites to calculate the overall botanical composition of the diet. Plant composition of pastures was calculated by dropping Daubenmire frames (20 cm x 50 cm) at 20 m intervals from a center stake in each pasture. Five clippings were taken in each

direction (North, South, East, West) to an overall distance of 100 m. Short-lived perennial grasses and sedges were combined into a grasses/grasslikes category.

Diet Quality

Before each grazing bout, the ruminal contents were completely evacuated from each cow. After each grazing bout, the entire ruminal contents were collected as the masticate sample. These samples were then dried for 96 hours in a forced-air oven at 55°C before being ground to pass through a 1 mm screen in a Wiley mill. Samples were analyzed on an organic matter basis in duplicate with a low-quality forage standard for neutral detergent fiber (NDF), acid detergent fiber (ADF), and crude protein (CP).

Foraging Efficiency

Hand-plucked samples were collected for the major forage species present in cannulated cow diets (≥ 80% of diets). from each pasture. A total of 50 simulated bites were collected for each species from random sites throughout the study area. Samples were dried in a forced-air oven at 55°C in paper bags and weighed to obtain a dry weight. Samples were ground to pass a 1-mm screen in a Wiley mill and sent for nitrogen content analysis to the commercial laboratory previously mentioned. Bites per minute were calculated by dividing the total number of bites per grazing bout by 20 minutes. Grams per minute were calculated by dividing the total dry weight of the masticate sample by 20 minutes. Grams per bite were calculated by dividing the dry weight of the masticate sample by the total number of bites taken.

Statistical Analysis

The effect of season of use (June vs. September), rest (one-year and no rest), and timing (pre-grazing vs. post-grazing) on diet composition, diet quality, and foraging efficiency were analyzed using analysis of variance (ANOVA) with a generalized linear mixed model corresponding to a completely randomized block design with a 3 x 2 factorial treatment arrangement with season of use, burn status, and their interaction as fixed effects and individual pasture as a random effect (Bates et al., 2015). All data were plotted and transformed if needed to satisfy assumptions of normality and homogeneity of variance. Individual pastures were considered the experimental unit. An alpha $\leq 0.05$ was considered significant. The Tukey method was used to separate means when alpha was $< 0.05$ (Lenth & Lenth, 2018). All statistical analyses were performed in R (Team, 2021).

## Results

Diet Composition

Diet botanical composition is shown in Tables 1 and 2, and displayed a grazing time by treatment interaction ($P < 0.01$) for most plant components. Prior to turnout, cattle consumed more forbs ($P < 0.01$) in June than in September for all treatments except for JR and SR ($P = 0.26$; Table 1). In June, cattle consumed the most forbs prior to grazing in Y1, followed by Y2 compared to the Rest pastures ($P < 0.01$). In September, there was no difference in forb and grass composition for all pre-grazing diets ($P \geq 0.67$) with grasses composing approximately 90% of the diets.

After grazing, cattle diets were similar in forb composition for all June treatments ($P \geq 0.31$; Table 2). Forb content in JR diets was similar to SR and SY2 diets ($P \geq 0.24$). JY1 and JY2

forb consumption was higher than SY1 and SR pastures ($P < 0.01$), but similar to SY2 pastures. There was no difference in forb composition for post-grazing September pastures ($P \geq 0.99$).

Diet Quality

Diet quality is shown in Table 3. Ash content was approximately 16.1% across all treatments ($P \geq 0.17$). Between June and September, NDF was lower in June ($P < 0.01$). Within pre-grazing June treatments, NDF was 8.0% lower in JY1 compared to JR ($P < 0.01$). Similarly, post-grazing JY1 diets were 8.6% lower in NDF than JR ($P < 0.01$). Timing and rest did not affect NDF content in September diets, NDF was 78.9% across all September treatments ($P \geq 0.98$). ADF content was similar across all treatments for the pre-grazing period ($P \geq 0.27$). Pre-grazing June diets averaged 43.9% ADF, and pre-grazing September diets averaged 50.4% ADF. For post-grazing diets, season of use and rest status did not affect ADF content, averaging 52.0% across all treatments ($P > 0.12$).

CP content differed between season of use and rest ($P < 0.01$). Prior to cattle turnout, June diets averaged 19% CP and September diets averaged 11.3% ($P < 0.01$). Within pre-grazing June treatments, JY1 diets contained 6.3% more CP than JR and 3.3% more CP than JY2 ($P < 0.01$). For September, pre-grazing diets in SY1 and SR were higher in CP content than SY2 ($P < 0.01$). After cattle grazing, June diets were higher than September, but similar between rest status ($P \geq 0.64$), averaging 15.2% CP. September diets also did not differ ($P \geq 0.11$), averaging 8.8% CP.

Forage quality for plant species that comprised of over 80% of the diet is shown in Table 4. In Y1 pastures during the spring, forbs were 4.8% higher in CP and 26.4% lower in NDF content than the grasses. In Y2, forbs were no longer higher in CP, but were 31.6% lower in NDF than grasses. Overall forage quality was higher in June than September. For September, grasses

were lower in quality than grasses for both years. From Y1 to Y2, grass quality shifted from 7.5% CP and 60.8% NDF to 3.4% CP and 75.5% NDF. Forb quality also declined from 11.5% CP and 31.1% NDF to 7.9% Cp and 30.2% NDF.

Foraging Efficiency

Foraging efficiency is shown in Table 5. Prior to turnout, cattle consumed fewer grams per minute in JY1 than both JY2 and JR ($P < 0.01$). However, there was no difference ($P = 0.98$) between JY2 and JR. Cattle consumed more ($P < 0.01$) grams per minute on JR pastures than both SR and SY2 pastures. There was no difference ($P = 0.56$) prior to turnout in grams per minute consumed between JR, JY2 and SY1. After grazing, cattle consumed approximately 9.25 grams per minute in June ($P \geq 0.41$). On average, cattle consumed more ($P < 0.01$) grams per minute in September than in June, except for JY2 ($P \geq 0.11$). Prior to turnout, cattle took the most bites per minute in SY1 and the fewest in JY1 compared to all other treatments ($P < 0.01$). There was no difference between bites taken per minute for JY2, JR, SY2, and SR ($P \geq 0.13$). After grazing, there was no difference ($P \geq 0.24$) in bites taken per minute between treatments. For grams per bite, there was no difference between all treatments, during either pre- or post-grazing bouts ($P \geq 0.34$).

Figures and Tables

| Block 1 | | | | Block 2 | | | | Block 3 | | | | Block 4 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JR | SR | S | J | S | J | JR | SR | J | SR | S | JR | JR | S | J | SR |

**J:** June unrested (grazed years 1 and 2)
**JR:** June rested (grazed year 2)
**S:** September unrested (grazed years 1 and 2)
**SR:** September rested (grazed year 2)

**Figure 4.1.** Study design: pastures arranged in a randomized complete block design with a 2 x 2 factorial arrangement contrasting June versus September grazing, and one-year rest versus no rest.

**Table 4.1.** Percentage of grass and forb composition of beef cattle diets on burned rangeland in June and September prior to cow/calf pair turnout at the Red Bluff Research Ranch, southwest Montana.

| | Year 1 | | Year 2 | | Rest | | | *P* values[1] | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Item** | **June** | **Sept** | **June** | **Sept** | **June** | **Sept** | **SEM[2]** | **Pre/Post** | **Treat** | **Pre/Post x Treat** |
| **Pre-Grazing[3]** | | | | | | | | | | |
| Grasses/grasslikes | **20.95$^{c}$** | **87.20$^{a}$** | **49.30$^{d}$** | **85.21$^{a}$** | **66.74$^{b}$** | **78.84$^{ab}$** | **5.09** | **0.07** | **< 0.01** | **< 0.01** |
| *Carex filifolia* | 0.19 | 0.45 | 0 | 0.94 | 0 | 1.30 | 1.07 | 0.14 | < 0.01 | 0.03 |
| *Hesperostipa comata* | 0.57$^{c}$ | 22.94$^{d}$ | 1.78$^{bc}$ | 1.48$^{c}$ | 3.6$^{abc}$ | 2.97$^{abc}$ | 2.19 | 0.21 | 0.08 | < 0.01 |
| *Festuca idahoensis* | 6.53$^{d}$ | 43.69$^{ceg}$ | 10.07$^{d}$ | 50.02$^{efg}$ | 17.74$^{abd}$ | 37.30$^{bceg}$ | 5.47 | < 0.01 | < 0.01 | < 0.01 |
| *Koeleria macrantha* | 0.15$^{e}$ | 0.90$^{de}$ | 8.42$^{ade}$ | 13.89$^{acde}$ | 28.18$^{bc}$ | 29.24$^{b}$ | 3.54 | 0.11 | < 0.01 | 0.02 |
| *Pascopyrum smithii* | 3.14 | 5.65 | 6.84 | 1.24 | 2.71 | 0.75 | 1.91 | 0.77 | < 0.01 | < 0.01 |
| *Poa spp.* | 0.31$^{a}$ | 4.69$^{ab}$ | 5.96$^{ab}$ | 4.3$^{ab}$ | 2.58$^{a}$ | 1.40$^{a}$ | 1.57 | 0.17 | < 0.01 | 0.07 |
| *Pseudoroegneria spicata* | 2.35$^{b}$ | 6.17$^{abc}$ | 7.52$^{abc}$ | 2.73$^{b}$ | 10.26$^{ac}$ | 2.17$^{b}$ | 1.8 | 0.44 | < 0.01 | 0.17 |
| Forbs | **79.05$^{a}$** | **12.80$^{d}$** | **50.70$^{b}$** | **14.79$^{c}$** | **33.27$^{c}$** | **21.16$^{cd}$** | **5.09** | **0.07** | **< 0.01** | **< 0.01** |
| *Astragalus spp.* | 21.45$^{a}$ | 0.22 | 0.71 | 0 | 1.26 | 0 | 2.06 | 0.93 | 0.98 | < 0.01 |
| *Solidago canadensis* | 0 | 5.11 | 4.06 | 2.34 | 2.44 | 3.12 | 1.71 | 0.78 | < 0.01 | < 0.01 |
| *Symphyotrichum ascendens* | 0$^{a}$ | 3.25$^{abc}$ | 0.08$^{a}$ | 12.22$^{c}$ | 0.42$^{a}$ | 10.52$^{bc}$ | 1.87 | 0.78 | 0.37 | 0.11 |
| *Taraxacum officinale* | 53.34$^{d}$ | 0$^{b}$ | 46.05$^{d}$ | 0.56$^{b}$ | 27.81$^{c}$ | 0.06$^{b}$ | 4.42 | 0.02 | < 0.01 | < 0.01 |

[1] Graze status (Pre/Post) of pre-grazing or post-grazing and treatment (Treat). Treatments are as follows: 1) June grazing directly following wildfire, 2) September grazing following wildfire, 3) June grazing directly following wildfire second year, 4) September grazing directly following wildfire second year, 5) June grazing with a 1-year rest, 6) September grazing with 1-year rest.
[2] Pooled standard error of the means presented
[3] Prior to turnout of cow/calf pairs

**Table 4.2.** Percentage of grass and forb composition of beef cattle diets on burned rangeland in June and September after cow/calf pair grazing at the Red Bluff Research Ranch, southwest Montana.

| | Year 1 | | Year 2 | | Rest | | | *P* values[1] | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Item** | **June** | **Sept** | **June** | **Sept** | **June** | **Sept** | **SEM[2]** | **Pre/Post** | **Treat** | **Pre/Post x Treat** |
| **Post-Grazing[3]** | | | | | | | | | | |
| Grasses/grasslikes | **70.83$^{c}$** | **93.41$^{c}$** | **64.77$^{c}$** | **91.06$^{abc}$** | **76.95$^{bc}$** | **91.88$^{ab}$** | **5.09** | **0.07** | **< 0.01** | **< 0.01** |
| *Carex filifolia* | 5.77$^{a}$ | 0.66$^{b}$ | 3.55$^{ab}$ | 3.16$^{ab}$ | 2.01$^{ab}$ | 0$^{ab}$ | 1.07 | 0.14 | < 0.01 | 0.03 |
| *Hesperostipa comata* | 11.67$^{a}$ | 10.66$^{ab}$ | 6.27$^{abc}$ | 6.68$^{abc}$ | 7.11$^{abc}$ | 1.81$^{abc}$ | 2.19 | 0.21 | 0.08 | < 0.01 |
| *Festuca idahoensis* | 32.73$^{abce}$ | 55.49$^{fg}$ | 12.64$^{ad}$ | 64.01$^{fg}$ | 22.44$^{abcd}$ | 74.58$^{f}$ | 5.47 | < 0.01 | < 0.01 | < 0.01 |
| *Koeleria macrantha* | 0.57$^{de}$ | 0.08$^{e}$ | 15.27$^{abcd}$ | 6.13$^{ade}$ | 20.9$^{abc}$ | 10.38$^{abcde}$ | 3.54 | 0.11 | < 0.01 | 0.02 |
| *Pascopyrum smithii* | 7.57 | 15.18$^{a}$ | 3.48 | 2.51 | 2.02 | 3.00 | 1.91 | 0.77 | < 0.01 | < 0.01 |
| *Poa spp.* | 1.90$^{a}$ | 1.11$^{a}$ | 10.64$^{b}$ | 3.16$^{ab}$ | 5.38$^{ab}$ | 1.76$^{ab}$ | 1.57 | 0.17 | < 0.01 | 0.07 |
| *Pseudoroegneria spicata* | 2.81$^{b}$ | 9.94$^{ac}$ | 4.02$^{bc}$ | 0.31$^{b}$ | 11.84$^{a}$ | 3.07$^{abc}$ | 1.8 | 0.44 | < 0.01 | 0.17 |
| Forbs | **29.17$^{a}$** | **6.59$^{c}$** | **35.23$^{a}$** | **8.94$^{abc}$** | **23.05$^{ab}$** | **8.12$^{bc}$** | **5.09** | **0.07** | **< 0.01** | **< 0.01** |
| *Astragalus spp.* | 1.69 | 0 | 0.13 | 0.02 | 1.48 | 0 | 2.06 | 0.93 | 0.98 | < 0.01 |
| *Solidago canadensis* | 0$^{b}$ | 1.72$^{b}$ | 13.05$^{a}$ | 1.43$^{b}$ | 1.81$^{b}$ | 0.08$^{b}$ | 1.71 | 0.78 | < 0.01 | < 0.01 |
| *Symphyotrichum ascendens* | 3.43$^{ab}$ | 4.04$^{ab}$ | 1.14$^{a}$ | 7.35$^{abc}$ | 1.11$^{a}$ | 3.40$^{abc}$ | 1.87 | 0.78 | 0.37 | 0.11 |
| *Taraxacum officinale* | 6.59$^{ab}$ | 0$^{b}$ | 19.06$^{ac}$ | 0.11$^{ab}$ | 15.24$^{abc}$ | 0.30$^{ab}$ | 4.42 | 0.02 | < 0.01 | < 0.01 |

[1] Graze status (Pre/Post) of pre-grazing or post-grazing and treatment (Treat). Treatments are as follows: 1) June grazing directly following wildfire, 2) September grazing following wildfire, 3) June grazing directly following wildfire second year, 4) September grazing directly following wildfire second year, 5) June grazing with a 1-year rest, 6) September grazing with 1-year rest.
[2] Pooled standard error of the means presented
[3] After grazing of cow/calf pairs

**Table 4.3.** Nutrient composition of beef cattle diets on rested and unrested burned rangeland pastures in June at the Red Bluff Research Ranch, southwest Montana.

| | Year 1 | | Year 2 | | Rest | | | *P* values[1] | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | June | Sept | June | Sept | June | Sept | SEM[2] | Pre/Post | Treat | Pre/Post x Treat |
| **Ash (% DM[3])** | | | | | | | **1.08** | **0.17** | **0.29** | **0.08** |
| Pre[4] | 17.24 | 16.57 | 14.38 | 15.88 | 15.24 | 17.43 | | | | |
| Post[5] | 14.55 | 16.22 | 16.45 | 17.84 | 16.61 | 16.15 | | | | |
| **NDF (% OM[6])** | | | | | | | **1.83** | **< 0.01** | **< 0.01** | **< 0.01** |
| Pre | $62.41^{c}$ | $80.00^{a}$ | $68.03^{bc}$ | $78.89^{a}$ | $70.18^{b}$ | $79.59^{a}$ | | | | |
| Post | $71.30^{bc}$ | $81.15^{a}$ | $77.60^{ab}$ | $78.70^{abcd}$ | $79.90^{a}$ | $80.68^{a}$ | | | | |
| **ADF (% OM)** | | | | | | | **1.99** | **< 0.01** | **0.02** | **< 0.01** |
| Pre | $45.89^{bcd}$ | $49.97^{ab}$ | $44.26^{bcd}$ | $49.51^{bcd}$ | $41.82^{d}$ | $51.85^{a}$ | | | | |
| Post | 46.59 | 51.83 | 48.97 | 59.20 | 51.90 | 53.29 | | | | |
| **CP (% OM)** | | | | | | | **0.53** | **0.09** | **< 0.01** | **< 0.01** |
| Pre | $22.16^{a}$ | $12.63^{d}$ | $18.85^{b}$ | $9.76^{e}$ | $15.92^{c}$ | $11.63^{d}$ | | | | |
| Post | $15.83^{a}$ | $11.14^{bc}$ | $15.01^{a}$ | $7.78^{bc}$ | $14.86^{a}$ | $7.41^{c}$ | | | | |

[1] Graze status (Pre/Post) of pre-grazing or post-grazing and treatment (Treat). Treatments are as follows: 1) June grazing directly following wildfire, 2) September grazing following wildfire, 3) June grazing directly following wildfire second year, 4) September grazing directly following wildfire second year, 5) June grazing with a 1-year rest, 6) September grazing with 1-year rest.
[2] Pooled standard error of the means presented
[3] Percent dry matter
[4] Prior to turnout of cow/calf pairs
[5] After cattle grazing
[6] Percent organic matter

**Table 4.4.** Percent crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF) of hand-plucked forages by species in burned pastures for 2021 (Year 1) and 2022 (Year 2) at the Red Bluff Research Station, southwest Montana.

| | Year 1 | | | Year 2 | | |
|---|---|---|---|---|---|---|
| **Forage Species** | **CP[1]** | **NDF[2]** | **ADF[3]** | **CP** | **NDF** | **ADF** |
| **June** | | | | | | |
| **Grasses/grasslikes** | **12.6** | **59.3** | **31.3** | **11.4** | **64.3** | **36.5** |
| *Carex filifolia* | - | - | - | 14.2 | 63.2 | 32.7 |
| *Hesperostipa comata* | 12.0 | 60.4 | 30.8 | 10.2 | 70.2 | 35.1 |
| *Festuca idahoensis* | 12.3 | 57.3 | 32.1 | 8.8 | 64.2 | 39.2 |
| *Koeleria macrantha* | - | - | - | 10.5 | 59.7 | 40.8 |
| *Pascopyrum smithii* | 12.9 | 58.4 | 30.4 | 15.1 | 62.1 | 32.3 |
| *Poa spp.* | - | - | - | 9.1 | 63.3 | 39.6 |
| *Pseudoroegneria spicata* | 13.1 | 61 | 32 | 11.6 | 67.7 | 35.6 |
| **Forbs** | **17.4** | **32.9** | **24.5** | **10.0** | **32.7** | **25.4** |
| *Astragalus spp.* | 20.1 | 33.1 | 24.9 | 8.8 | 32.9 | 30.5 |
| *Solidago canadensis* | - | - | - | 7.7 | 29.5 | 18.0 |
| *Taraxacum officinale* | 14.7 | 32.7 | 24.1 | 13.6 | 35.8 | 27.8 |
| **September** | | | | | | |
| **Grasses/grasslikes** | **7.5** | **60.8** | **36.8** | **3.4** | **75.5** | **43.0** |
| *Bouteloua gracilis* | - | - | - | 6.2 | 77.8 | 36.8 |
| *Hesperostipa comata* | 7.1 | 59.9 | 38.1 | 2.5 | 76.3 | 42.8 |
| *Festuca idahoensis* | 9.5 | 57.6 | 33.8 | 4.3 | 68.4 | 39.6 |
| *Koeleria macrantha* | - | - | - | 2.7 | 78.7 | 47.3 |
| *Poa spp.* | - | - | - | 2.9 | 78 | 47.4 |
| *Pseudoroegneria spicata* | 5.8 | 64.9 | 38.5 | 1.9 | 73.7 | 43.9 |
| **Forbs** | **11.5** | **31.1** | **24.0** | **7.9** | **30.2** | **21.5** |
| *Solidago canadensis* | 13.1 | 29.8 | 23.1 | 6.3 | 28.5 | 20.4 |
| *Symphyotrichum ascendens* | 9.9 | 32.4 | 24.8 | 9.4 | 31.9 | 22.6 |

[1] Crude protein
[2] Neutral detergent fiber
[3] Acid detergent fiber

**Table 4.5.** Grams dry matter per minute (g · min$^{-1}$), bites per minute (bite · min$^{-1}$), and grams per bite (g · bite$^{-1}$) consumed by beef cattle grazing rested and unrested pastures in June and September after wildfire at the Red Bluff Research Ranch, southwest Montana.

| | Year 1 | | Year 2 | | Rest | | | *P* values[1] | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | June | Sept | June | Sept | June | Sept | SEM[2] | Pre/Post | Treat | Pre/Post x Treat |
| **g · min$^{-1}$** | | | | | | | **2.30** | **< 0.01** | **< 0.01** | **< 0.01** |
| Pre[3] | 8.31$^{b}$ | 29.63$^{a}$ | 27.26$^{a}$ | 15.25$^{b}$ | 25.60$^{a}$ | 10.20$^{b}$ | | | | |
| Post[4] | 6.67$^{d}$ | 14.70$^{abc}$ | 11.31$^{bcd}$ | 24.65$^{ab}$ | 9.77$^{cd}$ | 20.10$^{a}$ | | | | |
| **bite · min$^{-1}$** | | | | | | | **2.49** | **< 0.01** | **< 0.01** | **< 0.01** |
| Pre | 8.05$^{b}$ | 34.17$^{a}$ | 19.75$^{d}$ | 17.65$^{cd}$ | 18.31$^{cd}$ | 10.52$^{bc}$ | | | | |
| Post | 10.37$^{bc}$ | 19.32$^{b}$ | 12.94$^{bc}$ | 20.20$^{abc}$ | 7.05$^{c}$ | 16.36$^{bc}$ | | | | |
| **g · bite$^{-1}$** | | | | | | | **0.45** | **0.34** | **0.84** | **0.74** |
| Pre | 1.31 | 1.31 | 1.74 | 0.88 | 1.77 | 1.77 | | | | |
| Post | 1.34 | 1.02 | 1.06 | 1.31 | 1.41 | 1.45 | | | | |

[1] Graze status (Pre/Post) of pre-grazing or post-grazing and treatment (Treat). Treatments are as follows: 1) June grazing directly following wildfire, 2) September grazing following wildfire, 3) June grazing directly following wildfire second year, 4) September grazing directly following wildfire second year, 5) June grazing with a 1-year rest, 6) September grazing with 1-year rest.
[2] Pooled standard error of the means presented
[3] Prior to turnout of cow/calf pairs
[4] After cattle grazing

**Table 4.6.** Percentage of grass and forb composition on burned rangeland in June and September at the Red Bluff Research Ranch, southwest Montana.

| Treatment | Grasses | Forbs | SEM | *P*-value |
|---|---|---|---|---|
| **June** | | | **6.28** | **< 0.01** |
| Year 1[1] | 60.86 | 39.14 | | |
| Year 2[2] | 73.09 | 26.91 | | |
| Rest[3] | 80.4 | 19.6 | | |
| **September** | | | **6.28** | **< 0.01** |
| Year 1 | 62.22 | 37.78 | | |
| Year 2 | 89.07 | 10.93 | | |
| Rest | 69.07 | 30.93 | | |

[1] Pastures grazed directly after a fire, year 1
[2] Pastures grazed directly after a fire, year 2
[3] Pastures rested for one year after a fire before grazing,

## Discussion

Based on this study, the season of use and timing of grazing following a wildfire has an impact on cattle diet composition and quality with the greatest impact in the spring following a wildfire. As expected, dietary CP content was substantially greater and NDF was lower in June compared to September, with the highest CP content and lowest NDF in the June Y1 treatment. This could be explained by the high preference for early growing forbs (Cruz & Ganskopp, 1998). Additionally, new growth has a greater leaf to stem ratio, or lower fiber and greater CP content. Pastures in the first year after the fire had no standing dead, meaning cattle only had access to high-quality new growth. This selection for forbs did not extend into the fall for any treatments. CP also did not differ between the second-year spring treatments, indicating that resting the pasture until the next growing season does not impact dietary CP content for the second year. Diets in the fall were all similar in quality and composition, being dominated by grass with higher NDF and lower CP content than spring diets.

Despite pastures being dominated by perennial bunchgrasses (Table 6), cattle preferred forbs such as common dandelion during the spring grazing period. Post-grazing June diet collections were lower in forb concentrations, and visual observations indicate the shift from a forb-dominated diet to one higher in grass could be due to forbs being heavily grazed by cow-calf pairs. However, production data was not collected to determine the shift in plant communities immediately after grazing with cow-calf pairs. The resilience of perennial bunchgrasses to post-fire grazing along with the high preference for forbs observed in this study indicate that grazing after a fire may not affect plant vigor and growth (Gates et al., 2017; Vermeire et al., 2014). While this study only represents the first two years following a wildfire,

the limited grazing pressure on perennial bunchgrass species during the growing season implies that a two-year rest after a wildfire should be reconsidered for perennial bunchgrass systems of the Southwestern Montane Foothills.

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# CHAPTER FIVE

## SUMMARY AND CONCLUSION

Livestock production in the United States generates approximately $258 billion annually, with 17% attributed to beef cattle production (USDA ERS, 2023). The 311 million hectares (ha) of rangelands that are found throughout the Western United States are critical to this region's beef production system. Rangelands are unable to be used for crop production due to their precipitation patterns and often rugged terrain. This variability in precipitation, geography, and topography has caused livestock production to become the primary economic enterprise for these areas. Rangelands are often subject to environmental disturbances like wildfire. With projected increases in global temperatures and subsequent shifts in fire intervals, the management of burned rangeland is important to consider (Lindsey et al., 2020; Wuebbles et al., 2017).

Currently, the recommendations are to defer grazing for two years after a wildfire (Blaisdell, 1982). This management paradigm is based on the concept of not putting key plant species under additional stress. However, these rangelands are valuable for livestock and wildlife, with some studies estimating rangelands to be worth over $100/ha (Maher et al., 2013). The value of this forage and the historical relationships between rangelands and wildfire have brought these recommendations under scrutiny. Previous research has been conducted on the norther-mixed grass prairie, the Great Basin in Oregon, and even the sagebrush steppe in Idaho (Gates et al., 2017; Vermeire et al., 2014; Roselle et al., 2010; Bates et al., 2008). The research projects described in chapters 2 and 3 sought to evaluate the impacts of burn status, rest, seasonal deferment, and season of use on beef cattle diet quality, botanical composition, and foraging behavior.

In the spring, cattle consume higher quality diets that are dominated by early growing forbs like common dandelion. These diets are especially high in crude protein (CP) in the spring immediately after a wildfire. Fall diets are primarily grass, and similar between burned and unburned pastures. In burned pastures that are rested for an entire year before being grazed during the growing season, diet quality returns to comparable levels with unburned pastures.

From this we can conclude that cattle grazing burned rangeland may have a lower impact on key perennial bunchgrass species than previously thought. The preference for forbs during the growing season may allow for low pressure spring grazing after a fire. Managers should consider that higher grazing pressure may shift cattle's preference to perennial bunchgrasses based on availability of the forbs. In the fall, there is no dietary advantage to grazing burned pastures, but grazing during plant senescence has little impact on subsequent plant vigor (Jirik & Bunting, 1994). Overall, rest after a wildfire may be applicable to other rangeland ecosystems, but producers should evaluate their operations to determine what management strategy would be most beneficial for their plant communities and livestock.

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