Impacts of Wild Horses and Grazing Ungulates on Riparian Areas in Idaho

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by

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Authorization to Submit Thesis

This thesis of Molly Maghen Kaweck, submitted for the degree of Master of Science with a major in Natural Resources and titled "Impacts of Wild Horses and Grazing Ungulates on Riparian Areas in Idaho," has been reviewed in final form. Permission, as indicated by the signatures and dates given below, is now granted to submit final copies to the College of Graduate Studies for approval.

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Abstract

Heavy grazing in riparian areas can lead to soil erosion, loss of bank stability, reduced infiltration, increased downstream siltation, reduced water quality, and drier, hotter habitat conditions. We investigated the impact of observed animals (wild horses, cattle, and wildlife) on riparian attributes (streambank alterations, stubble height, and utilization); and whether the presence of one animal species affect the presence or absence of another species. Prior research on wild horses has failed to address the potential impact wild horses may have on riparian conditions, which is important in the development of grazing permits and management decisions. To assess the impact of wild horses, we measured changes in streambank alterations, herbaceous stubble height, and forage utilization. At two study areas in Idaho, each study area had 4 stream reaches, at each stream reach we documented presence of wild horses, livestock, and wildlife with 16 game cameras. By using game cameras and measuring vegetation we are better determine each animal's potential impacts on riparian condition. Many ungulates used our riparian study areas, including elk, pronghorn, mule deer, wild horses, cattle, as well as upland game birds, wolves, bears, mountain lions. Wild horse presence best predicted the change in riparian attributes (streambank alteration, herbaceous stubble height, and utilization) for five of six AIC_c models run. In only one occurrence did cattle presence predict change better than wild horses for utilization in the Owyhee study area. The potential impact of wild horses on riparian areas could compound known impacts from livestock. Thus, wild horses should be considered when determining management plans dealing with riparian condition.

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Dedication

I would like to dedicate this work to my parents, David and Patricia Kaweck, who with words I cannot explain the amount of encouragement, support, and love helped me through the toughest times. Their constant inspiration helped me continue when I felt discouraged, when I could no longer see the light at the end of the tunnel, and gave me the last bit of dive needed to complete this thesis. I love ya'll more than all the time I spent, words I wrote, and tears I shed over the course of this research!

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CHAPTER 1: Wild Horses - History and Current Knowledge of Impact

Wild Horses in the United States

Wild horses have created controversy in the western United States. As cultural icons of the West, they hold great emotional significance, often eliciting heated debates over how they should be managed on public lands. With few natural factor able to control populations (e.g., cougars, wolves, and disease), herd sizes can double every four years (McInnis, 1984; Turner and Morrison, 2001; National Research Council, 2013). Wild horses are of management concern because of their often large populations, their fast population growth rates, and their potentially harmful impacts on rangelands. For example, larger populations result in greater demand for rangeland forage and water supplies (National Research Council, 2013), and uncontrolled populations are more likely to degrade rangelands through excessive grazing and they quickly degrade preferred habitats (Crane et al., 1997).

Wild horses have roamed North America since their reintroduction by Spanish explorers in the 16th century (Wyman, 1945; Duncan, 1992). Throughout the 20th century, wild horses were a readily available source of working stock and profit for settlers moving out to the western United States. Horses were an important tool for the development of the western United States (Wyman, 1945). As farming transitioned towards mechanized agriculture, horses decreased in value and importance in society. In 1920, this was compounded by the Great Depression when owners unable to feed their horses released them, which led to rapid population expansion and increased competition for land uses. Tension between land users and horses rose with the Taylor Grazing Act of 1934, which started the regulation of livestock grazing on public lands (Beever, 2003). By 1950, wild horses and burros were considered feral and thus had no protection under the law. The indiscriminate, often inhumane, methods used to gather wild horses for slaughter or bucking stock, horrified many citizens (Wyman, 1945). Velma B. Johnston led a letter-writing campaign that prompted the Nevada state legislature to pass the Wild Horse Annie Act of 1959 (BLM, 2015a). This Act prohibited the use of motorized vehicles to hunt free-ranging horses and outlawed the poisoning of watering holes on public lands. The Wild Free-Roaming Horses and Burros Act of 1971 placed the responsibility of protecting and managing wild horses and burros roaming public lands on the Secretary of Interior. This Act declared wild horses and burros to be an "integral part of the natural system of public land" to be managed as a component of public lands and "in a manner that is designed to achieve and maintain a thriving natural ecological balance on the public lands" (Public Law 92-195).

Because wild horses roam in areas also used by wildlife and livestock, it is unclear which species has the greater impact on rangelands. Wild horses and livestock are often most accused. Horses are assumed to have the same influences as cattle on rangeland ecological processes; due to because of their similar diets and physical statures (Beever, 2003). Therefore, to sustain healthy and thriving populations of wild horses, we must better understand their overall role in rangeland ecosystems they inhabit.

Population and Management

Wild Horses in the U.S.

The Bureau of Land Management (BLM) is the agency primarily responsible for the management of wild horses and burros, with the U.S. Forest Service, National Park Service and U.S. Fish and Wildlife Service managing the remaining animals on public lands. The Wild Free-Roaming Horses and Burros Act allowed for population goals, also known as Appropriate Management Levels (AML) or territory capacities, to be set for each Herd

Management Area (HMA). The BLM has developed AMLs, which indicate the level at which wild horses and burros can thrive in balance with other public land uses and resources, including vegetation, wildlife, and livestock. Today, the BLM manages 179 Herd Management Areas throughout 10 western states: Nevada, Wyoming, California, Oregon, Utah, Arizona, Colorado, Idaho, Montana, and New Mexico.

It is challenging to maintain wild horse populations at or below AML, because of high survival and reproduction rates. It has been documented that wild horses over 2 years old have on average a 95% survival rate each year (Garrott and Taylor, 1990; Turner and Morrison, 2001; Linklater et al., 2004; Dawson and Hone 2012). With virtually no natural predators, populations can grow at rates of 15-20% per year; this quickly expands the population beyond the carrying capacity of their statutory range (Turner and Morrison, 2001; National Research Council, 2013). This can mean herd sizes doubling or triple every four to six years (McInnis, 1984). As of 2014, the Department of the Interior estimates a little over 49,000 wild horses and burros roam BLM-managed rangeland (Table 1.1; BLM, 2015). If left unchecked, this number will continue to rise, with populations becoming so abundant they threaten the sustainability of wildlife and livestock production (Duncan, 1992).

Table 1.1 Population estimates of wild horses and burros in 10 western U.S. states as compared to the recommended high Appropriate Management Level (AML) set by the Bureau of Land Management to maintain healthy rangeland and resources. (BLM 2015)

State	Total	High AML
Arizona	4,744	1,676
California	6,008	2,184
Colorado	1,205	812
Idaho	668	617
Montana	160	120
Nevada	25,035	12,796
New Mexico	146	83
Oregon	3,180	2,715
Utah	4,292	1,956
Wyoming	3,771	3,725
TOTAL	49,209	26,684

If wild horse populations are not actively managed, the number of horses will rapidly increase until resources, such as forage supply, become limiting for the large herbivore populations (Duncan, 1992). A comparison between three wild horse populations found when pasture biomass was low, the animals mean body condition was also low (Dawson and Hone, 2012). This relationship with biomass can also be seen with rates of fecundity, recruitment, and annual population growth rates were also associated with higher biomass levels (Duncan, 1992; Dawson and Hone, 2012). If there is more biomass present, then the animal will have a better body condition and is more like to reproduce.

Population control is also difficult because of the free-roaming status of wild horses and burros. Simply stated, it is illegal for anyone other than the BLM to capture wild horses. To maintain the AML of herds and the ecological condition of the range, while meeting multiple use policy obligations, the BLM periodically gathers and removes excess animals from public lands. In 2012, for example, the BLM gathered across all states and removed 8,255 wild horses; 4,176 animals in 2013; and 1,857 animals in 2014 according to the Public Land Statistics (BLM, 2012, 2013, 2014).

Gathering wild horses can be very expensive, ranging in cost from $25,000 to $150,000 per gather, depending on the number of horses involved. These costs consume 6-11% of BLM's wild horse and burro total annual budget. Horses are gathered and then available for adoption by the public, with significantly fewer animals being adopted than gathered in most years. (Figure 1.1; BLM, 2015). The adoptions rates in the early 2000's averaged 8,000 individuals/year; this has dropped by 70%, with only 2,600 individuals adopted annually in recent years (President's Fiscal Year 2017 Budget Request for the Bureau of Land Management, 2016).

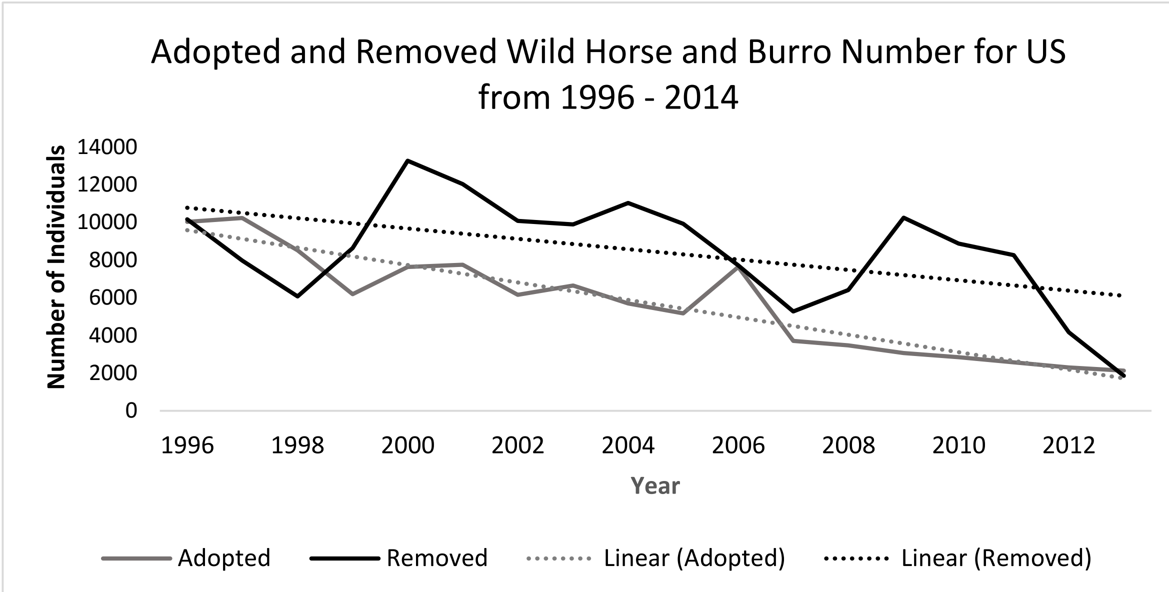

Figure 1.1 Wild horse and burro adoption and removal rate during 1996 – 2014 for the United States. Data retrieved from USDI – BLM 1996 – 2014 Public Land Statistics

Horses that are not adopted are maintained in short- and long-term holding facilities where they remain for the rest of their lives. This care costs the BLM roughly $50,000 per horse over their lifetime (President's Fiscal Year 2017 Budget Request for the Bureau of Land Management, 2016).

In 2015, there were 17,085 wild horses and burros being fed and cared for at short-term corrals and 31,250 wild horses in long-term pastures (BLM, 2015). Roughly 60% of the BLM Wild Horse and Burro Program Budget for the past three years has gone towards the care of horses in holding facilities, and the maintenance of those facilities (National Resource Council, 2013; BLM, 2015a). Within the last decade, funding priorities have forced the BLM to cancel wild horse gathers, which will exacerbate the population problem.

An alternative to gathering and removing horses is the application of contraceptives, which costs roughly $25 per injection, which can be up to a 94% effective the first year, then loses its effectiveness in subsequent year (Elizondo, 2012). Mares must be injected about every 22 month to 3 years (Elizondo, 2012). Contraceptives like porcine zona pellucida (PZP) can be applied through either a dart injected liquid or orally via pellets. Darting, though more successful than oral application, is difficult to accomplish in large wild horse populations. Currently, even the combined use of gatherings and preliminary use of contraceptives has not been effective at maintaining the targeted population levels set by BLM.

Over the last decade, horse and burro populations in 10 western states have risen from 30,000 individuals in 2005 to roughly 49,000 individuals in 2014, a 61% increase in 10 years, even the BLM gathering a large number of animals from 2009 to 2011 (Figure 1.2).

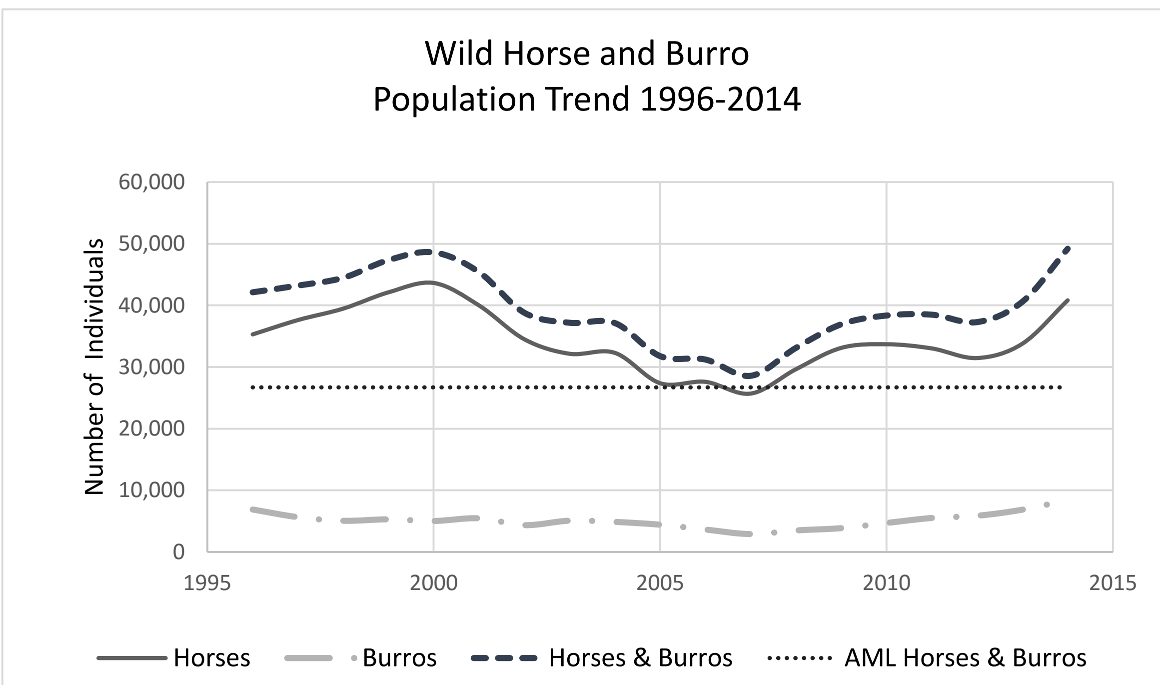

Figure 1.2 Population trends of wild horses and burros for all animals on public lands managed by Bureau of Land Management from 1996 to 2014. Data retrieved from USDI – BLM 1996 – 2014 Public Land Statistics

Wild Horses in Idaho

Horses arrived in Idaho with the influx of miners and homesteaders. Most of Idaho's wild horses are descendants of domesticated animals that either escaped or were released in the 1930s during the Great Depression (Morin, 2006; BLM, 2015a). Breeds seen in Idaho's wild horse population include Belgian, Percheron, Morgan, Quarter horse, and Thoroughbred (Morin, 2006). Idaho's horses were also influenced by early ranchers who cross-bred desired stock to produce more animals who were later sold as cavalry remounts and often intended to pull light artillery (Morin, 2006).

The BLM manages about 5 million hectares (12 million acres) of public lands in Idaho, with 170,284 hectares (420,783 acres) of those lands designated for wild horse management (there are no wild burros in Idaho). However, only 137,145 of those hectares (338,894 acres) provide enough forage and water to sustain wild horses long-term. These areas are designated Herd Management Areas (HMA). Idaho HMAs are home to a constantly fluctuating number of wild horses (Figure 1.3). In 2015, about 670 wild horses were recorded in Idaho (BLM, 2015b).

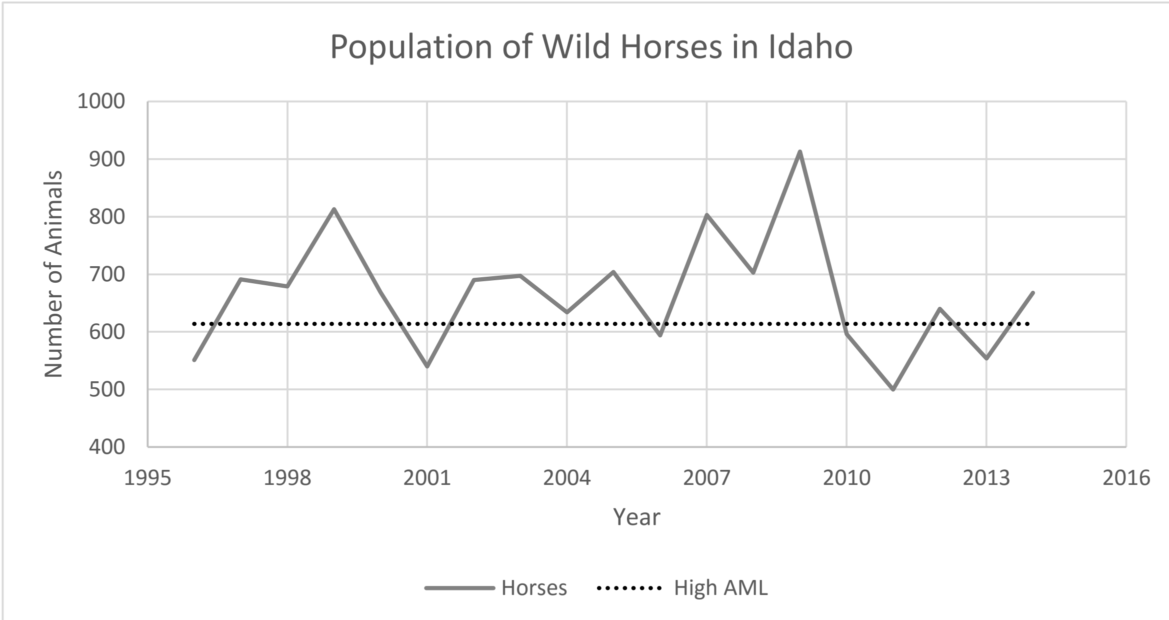

Figure 1.3 Population trend for Idaho's wild horses from 1996 through 2014. Data retrieved from USDI – BLM 1996 – 2014 Public Land Statistics

Wild horses currently present in Idaho roam across six HMAs. Four HMAs are located in BLMs Boise District (Sands Basin, Hard Trigger, Black Mountain, and Four Mile), one in the Twin Falls District (Saylor Creek), and one in the Challis District (Challis). Idaho does not have any long-term holding facilities but does maintain two short-term corrals, one each in Boise and Challis. The Boise Wild Horse Corrals hold adoptable horses and burros from surrounding areas, with BLM frequently holding adoptions to find homes for animals gathered from Idaho's rangelands.

Anatomy and Impact: A Comparison of Wild Horses and Cattle

All across public lands, wild horses and cattle grazing the same rangeland areas. Both species are large generalist herbivores, thus have some physiological similarities, and it has been assumed they have similar impact on rangeland ecological processes (Beever, 2003; Slater and Hudson, 1980). On the contrary, other researchers have concluded that, based upon their use of the landscape, morphology, feeding strategies, evolution, and digestive anatomy, wild horses differ from other animals currently residing in the west and are unique in their influence (Duncan, 1992; Beever, 2003). The inability to manipulate wild horse populations has made it difficult to differentiate their specific impacts on rangelands from those attributable to wildlife and cattle.

Oral Anatomy and Diet

Depending on the season, the diets of horses and cattle overlap from 59-78% (Hubbard and Hansen, 1976; Slater and Hudson, 1980; McInnis and Vavra, 1987). Both species select diets consisting primarily of grass and grass-like plants, with varying amounts of forbs incorporated during spring and summer, and both browse during fall and winter (Lyons et al., 1999; Menard et al., 2002). More than any other forage type, wild horses prefer grasses and sedges, which make up 50% to 90% of their diet (Slater and Hudson, 1980; McInnis and Vavra, 1987; Crane et al., 1997; Lyons et al., 1999). Cattle diets shift by season, and cattle prefer forbs more than grass in spring, and grass and browse more in fall and winter (Lyons et al., 1999). In addition, cattle will browse on several shrub species, horses eat very few shrubs (Slater and Hudson, 1980).

Figure 1.4 Horses have incisors on both the top and bottom of their mouths. While cattle have mouths only have incisors on the bottom. Photos by Molly Kaweck

An animal’s diet is a direct consequence of their digestive anatomy and mouth parts (Lyons et al., 1999). Horses have two sets of incisors, located on both the top and bottom jaw (Figure 1.4), and sensitive, strong, nimble, and prehensile lips, which allow them to grab leaves or shoots and bite them off completely (Figure 1.5). Horses tend to bite vegetation from the top down until the plants are short (stubble heights of 5- to 16-cm [2- to 6.4-in] in summer and 0 to 4-cm [0- to 1.6-in] in fall; Menard et al., 2002). Horses also target short regrowth areas and avoid taller, more lignified plants (Menard et al., 2002). Horses, with their top and bottom incisors, are able to bite plants off all the way to the ground, delaying the plant's ability to recover (Menard et al., 2002). Cows, on the other hand, have incisors that are located only on the bottom jaw (Figure 1.5). A hard leathery pad is located incisors at the top of the mouth instead of incisors. Cows have a relatively immobile upper lip. As a result, cows rely on their tongue to pull vegetation into their mouths (Figure 1.5). Cattle tend to prefer stubble heights between 9- and 16-cm (Menard et al., 2002) and are less successful apprehending forage with their tongue to bring plant to their mouth when grass height is reduced below 10-cm cows, hence, their foraging becomes less efficient (Hall and Bryant, 1995; Clary and Leininger, 2000).

Figure 1.5 Horse's prehensile lips help bring food to the mouth (left), whereas a cow's tongue brings food to its mouth (right). Photos by Molly Kaweck

Digestive Anatomy and Daily Intake

Even though both horses and cattle graze similar vegetation, they use two different herbivore digesting types – horses are hindgut (colon) fermenters and cows are ruminants. Horses have a simple stomach, and ferment their forage in an enlarged cecum situated after the stomach and small intestines (i.e., hindgut). The products created during cecum fermentation are then absorbed in the large sacculated colon. Hindgut fermenters maximize the amount of food consumed to reach their required protein level (Janis, 1976; Duncan et al., 1990). This is accomplished by having a higher feed intake and shorter passage time, with forage passing through a horse twice as fast as it does through a cow (Lyons et al., 1999). Horses' digestive systems allows them to use of lower quality food resources that cannot be effectively digested fast enough by ruminants such as cattle or large wild ungulates such as elk to maintain their metabolic requirement (Lyons et al., 1999). The rapid passage rate of forage in horses allows them to continually eat, not digesting forage entirely, to meet their metabolic requirement. Cattle and other ruminants are limited by the amount of forage their rumen can hold and slower rates of passage. This results in hindgut fermenters being less selective when choosing forage (Janis, 1976).

Cattle have a four-chambered stomach where fermentation occurs (Lyons et al., 1999). Ruminants are able to extract more nutrients from forage through long period of fermentation, anywhere from 24 to 72 hours, than hindgut fermenters (Janis, 1976; Demment and Van Soest, 1985). Forage must be fermented and chewed until it is able to pass through the reticular-omasal orifice. The amount of time it takes cattle to ferment their food limits how much they are physically able eat due to limited fermentation volume (Lyons et al., 1999). As a result, ruminants are more selective in what they eat (Janis, 1976; Lyons et al., 1999).

Horses lack the ability to digest the majority of the forage consumed, requiring them to compensate by consuming more forage than cattle per day (Duncan et al., 1990) this also increases the amount of time spent foraging. Horses spend approximately 50% more time foraging than cattle (Duncan, 1992; Menard et al., 2002); roughly 15 hours per day versus 8-10 hours per day for cattle (Arnold and Dudzinski, 1978).

Also as a result of this difference in their digestive systems, a horse is required to eat 20-65% more forage than a cow of equal size. The average weight of a wild horse ranges from 318- to 454-kg (700 to 1,000-lbs). Daily dry matter intake for horses is about 3-4.5% of their body weight (Holechek, 1988; Duncan, 1992; Menard et al., 2002). This means a 454-kg (1,000-lb) horse will potentially eat 14- to 20-kg (30- to 45-lbs) of forage per day. For a range cow, the average weight is roughly 454- to 590-kg (1,000- to 1,300-lbs). The daily dry matter intake for cattle is about 1.5-3% of their body weight (Holechek, 1988; Duncan, 1992). This means a 454-kg (1,000-lbs) cow will potential eat 7- to 14-kg (15- to 30-lbs) of forage per day.

Spatial Relationships

Seasonal patterns have been observed for cattle and wild horses relative to vegetation types and distance from water sources (Slater and Hudson, 1980; Miller, 1983; Holechek, 1988; Girard et al., 2013). Miller (1983) found that cattle and horses selected different vegetation types in the summer and winter but similar vegetation types in the spring and fall. McInnis and Vavra (1987) have supported this with documentation of significant spatial association of horses and cattle during spring and summer. Horses and cattle have both shown preference for flat landscapes dominated by grass and grass-like species; including wet meadows, riparian areas, and sagebrush steppe communities (Ganskopp and Vavra, 1987; Crane et al., 1997; Menard et al., 2002; Girard et al., 2013, National Research Council, 2013). Horses also have the ability to travel greater distances quickly allowing them to use sites farther from water and steeper landscapes than cattle (Ganskopp and Vavra, 1987; National Research Council, 2013).

Habitat and dietary overlap between wild ungulates and wild horses varies widely and is not well documented. For example, use of habitat by horses and pronghorns (*Antilocapra americana*) overlapped between 33% in summer to 70% in spring (McInnis and Vavra, 1987). Slather and Hudson (1979) found horses occupying sites used by deer (87%), moose (90%), and elk (93%) on a year- round biases. Horses seem to have a broader habitat niche than any other ungulate, using sites used by other species.

Hoof Anatomy and Impact

Horses have solid or undivided hooves, whereas cows have split or cloven-hooves that are divided down the middle (Figure 1.6). The relative impact of animals with solid hooves (horses) versus animals with cloven hooves (cattle) on rangeland ecosystems is not well studied. Both horses and cattle however, have been studied individually and do make an impact on rangelands simply through walking, causing soil compaction which decreases aggregate stability and infiltration (Clary, 1995; Trimble and Mendel, 1995; Beever and Herrick, 2006; Davies et al., 2014). Trampling by animals has multiple impacts on soil attributes that transfer across many ecosystem processes including plant health, diversity, growth,

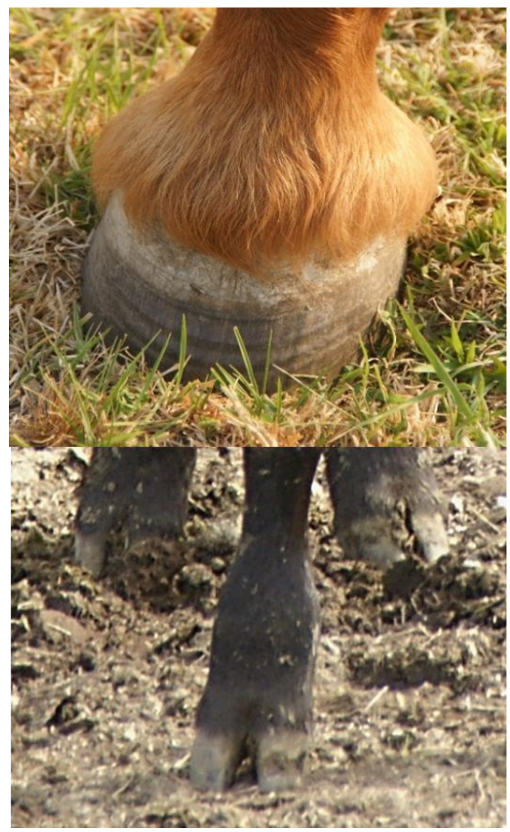

Figure 1.6 Horses have a solid hoof (top), whereas cattle have divided hooves (bottom). Photos by Molly Kaweck

recruitment, water cycling, soil strength, and porosity (Kauffman and Krueger, 1984; Clary, 1995; Trimble and Mendel, 1995).

Many studies reviewing the impact of cattle on soils show that grazing increases soil bulk density (Kauffman and Krueger, 1984; Orodho et al., 1990; Trimble and Mendel, 1995). Compaction from grazing cattle is known to vary depending on grazing intensities, with soil density increasing from 1.09-g/cm^3 (ungrazed sites), to 1.51-g/cm^3 (lightly grazing) and 1.54- to 1.91-g/cm^3 (heavily grazing) (Alderfer and Robinson, 1947; Beever and Herrick, 2006). Compaction is strongly correlated with number of animals present and the percent clay content within the soil (Beever and Herrick, 2006). The presence of wild horses can result in significantly higher soil-surface penetration resistance compared to horse-absent areas (Beever and Herrick, 2006; Davies et al., 2014). Areas with horses contained penetration resistances rates ranging from 15.4 (low elevation) to 3.8 (high elevation) times higher than areas without horses (Beever and Herrick, 2006).

Management Strategies and Limitations

Under the minimal management strategy, free-roaming wild horses may use rangeland resources year-round and move independently throughout the landscape (Beever, 2003; National Research Council, 2013). For example, stocking rate and grazing strategy (when, where, and for how long) are very important in cattle grazing management, yet are rarely applied to grazing of wild horses.

Cattle grazing on rangelands is normally manipulated through fencing, herding, and placement of salt, nutrient supplements, and water (Beever, 2003). Management of cattle can vary depending on the season of use, by pasture, variance of weather across years, and grazing intensity based on a predetermined utilization percent. Depending on the condition of the rangeland, the impact of cattle can be minimized or applied to accomplish certain management goals through such manipulation (Mosley et al., 1999). However, for these grazing systems to be successful they must be tailored for individual areas because not all areas respond consistently (Kauffman and Krueger, 1984; Clary, 1995; Mosley et al., 1999). Unfortunately, wild horses are not as easily managed and little is known about the impact wild horses have on riparian areas or how they use these areas in general (Beever, 2003).

Additionally, wild horses and burros roam on public land which they share with human recreation, mining, forestry, grazing for livestock, and wildlife (National Research Council, 2013). Potential conflicts between the people using the resources on public lands may undermine the legislative mandate for the BLM to maintain a thriving natural ecological balance and multiple-use policy of public lands (National Research Council, 2013).

Landscape Use by Wild Horses, Cattle, and Wildlife

Rangelands typically contain a diverse, mosaics of plant communities. However, certain communities are more desirable to animals than others depending on the availability of cover, water, and forage. Riparian areas are generally desirable and preferred habitats because of the relatively high amounts of forage that stays green longer into the season, water, and normally gentle terrain. (Trimble and Mendel, 1995; Clary and Leininger, 2000; National Research Council, 2013). These desirable attributes raise concern for the potential damage wild horses might cause to riparian areas, especially when added to the grazing impacts of cattle in the area. This high use and demand can quickly lead to damage to the vegetation and stream structure.

Riparian Areas

Riparian areas are the ecologically important zones around rivers, streams, and lakes that constitute less than 2% of public lands, yet their benefits far exceed the area they occupy (Belsky et al., 1999; Poff et al., 2011). These are unique areas that transition dry uplands to aquatic ecosystems. Riparian areas vary greatly in their width, vegetation types, and physical characteristics (e.g., aspect, topography, soil) (Kauffman and Krueger, 1984; Svejcar, 1997; Mosley et al., 1999). These ecosystems are some of the most productive areas on public lands, producing about 20% of the available forage for animals (Kauffman and Krueger, 1984; Svejcar, 1997; Belsky et al., 1999) and containing roughly one-third of the plant species found on western rangelands (Poff et al., 2011). By providing deep, complex root systems, riparian plants reduce stream-bank erosion, filter sediment from water, and stabilize the stream channel (Svejcar, 1997; Belsky et al., 1999). Roughly 70-77% of western bird species and many wildlife species are dependent on products riparian habitats provide (Ohmart, 1996; Belsky et al., 1999; Kauffman and Krueger, 1984). Riparian vegetation is important for wildlife cover, forage, erosion control, water quality, stream-bank stability, and stream condition (Mosley et al., 1999).

Riparian areas support and promote a diversity of products and have intrinsic values for plant, animal, and human communities (Belsky et al., 1999; Poff et al., 2011). These areas are essential in providing clean water, critical wildlife habitat, recreational opportunities, and aesthetic appeal; and support many agricultural practices including timber production, livestock grazing, and irrigation for cropland (Svejcar, 1997; Mosley et al., 1999; Belsky et al., 1999). Therefore, riparian areas are important to the environmental and economic health of the United States (Mosley et al., 1999; Belsky et al., 1999).

The potential impact of animals on riparian areas varies by species, water use, and regimented use (National Research Council, 2013; Beever and Aldridge, 2011; Gooch, 2014). Horses will travel farther from water than cattle, watering daily usually at dawn and dusk (Ganskopp and Vara, 1987; National Research Council, 2013). Riparian areas where horses were present had a lower species richness and diversity, and wildlife spent less time at water, compared to riparian areas fenced from horses (Hall et al., 2016). Horses monopolized water sources up to 73% of the day during high temperature months, limiting available time for wildlife (Hall et al., 2016). Horses are known to be dominant when interacting socially with other species (Meeker, 1979). For example, the presence of horses at water sources will displace some wildlife species (e.g., pronghorn and bighorn sheep) keeping them from drinking, but not others (e.g., sage grouse or coyotes; Ostermann-Kelm et al., 2008; Girard et al., 2013; Gooch, 2014; Hall et al., 2016). Nearly half of all interactions between horses and pronghorn at water in a study by Gooch (2014) resulted in pronghorn leaving the riparian area. Domestic horses placed near water sites utilized by bighorn sheep resulted in a 76% decline in sheep attendance at water (Ostermann-Kelm et al., 2008).

Impacts from Animal Species on Riparian Areas

Grazing and trampling by herbivores can degrade riparian areas to the point where they become unable to capture sediment, enhance infiltration, or dissipate high energy flows (Kauffman and Krueger, 1984; Mosley et al., 1999). Grazing in riparian areas may cause problems such as soil compaction, herbage removal, physical damage to plants, and changes in the succession of woody vegetation (Kauffman and Krueger, 1984; Clary, 1995; Poff et al., 2011). Other negative effects include excessive amounts of nutrient and fecal bacteria, bank deterioration, increase water temperature, and decreases in yield and reproduction of plants (Kauffman and Krueger, 1984; Mosley et al., 1999). These disturbances can ultimately reduce native riparian plant species, cold-water fish, and wildlife. Lack of or incorrect management of grazing animals is a major concern for the continued health of riparian areas.

Impacts from Wild Horses

Similar to cattle, horses may prefer riparian areas because of their abundance of green, and therefore more nutritious, forage as compared to surrounding vegetation (Duncan, 1983; Menard et al., 2002). Crane's research (1997) revealed horses preferred riparian habitats as compared to mountain sagebrush habitats. Riparian areas made up only 1% of Crane's study area but comprised 21% of the resident feral horses' forage. Slater and Hudson (1979) also found horses used wet meadows heavily all year long. Menard et al. (2002) noted horses selected areas with the most digestible forage, resulting in them spending most of the year in marshlands.

Riparian areas used by horses have shown a significant reduction in the presence of grasses and shrubs (Beever and Brussard, 2000), lowered plant species richness, reduced cover of grasses and forbs (Levin et al., 2002; Beever and Herrick, 2006; Levin et al., 2002) and altered the number and species of animals (increase diversity of birds, larger density of crabs, and lower density and richness of fish) using marshes (Levin et al., 2002). On European wetlands, Menard et al. (2002) documented horses using wetlands intensively and impacting many plant species to a greater extent than cattle. Likewise, Rheinhardt and Rheinhardt (2004) and Porter et al. (2014) concluded that the presence of wild horses harmed native plants, with up to 100% biomass loss in marshes (Porter et al., 2014). Turner

(1987) also found trampling by grazing horses significantly reduced above-ground primary production by 20-55%, suggesting that trampling (simulated) was more destructive to the area than the action of grazing. Rheinhardt and Rheinhardt (2004), also found trampling to have a greater impact than grazing.

Drastic responses have been observed in riparian vegetation in several studies where wild horses were removed. For example, at the Sheldon National Wildlife Refuge in Nevada, stubble height was nearly 10 times greater in ungrazed plants when compared to grazed plants after wild horses were gathered, and grazing pressures reduced (USFW, 2014). Beever and Bussard (2000) compared plant heights in upland meadows under three scenarios: 1) no grazing, 2) horses grazing only, and 3) both cattle and horses grazing. Plant heights in areas grazed by horses only were 2.8 times lower than plant heights in areas with no grazing, while plant heights in areas grazed by both horses and cattle were 4.5 times lower than those in area with no grazing (Beever and Bussard, 2000). Very little documentation is available of horses using browse for forage. However, in western Alberta, horses were observed consuming sedges and grasses in winter, whereas moose consumed woody browse in the same areas (Slater and Hudson, 1980).

Wild horses coexist on rangelands with wildlife and livestock. The overlapping use of areas may compound negative impacts on rangelands between wild horses, wildlife, and livestock. Overlap depends on the species. For example, very little overlap was seen between wild horses and deer (Hubbard and Hansen, 1976), wild horses and pronghorns (McInnis and Vavra, 1987; Meeker, 1979), or wild horses and moose (Slater and Hudson, 1980). In Wyoming elk and wild horses had a 40% overlap (Olsen and Hansen, 1977), and a similar 42% overlap was seen between these species in Colorado (Hansen et al., 1977). This variability is most likely a result of wildlife species' (deer, pronghorn, and moose) preference for diets of browse and forbs; whereas wild horse prefer grass and grass-like plants (McInnis and Vavra, 1987; Hubbard and Hansen, 1976; Meeker, 1979; Girard et al., 2013).

Impacts from Cattle

Livestock are well documented to congregate in areas where shade, lower temperature, and abundant forage are present (Kauffman and Krueger, 1984; Belsky et al., 1999; Poff et al., 2011). Riparian areas, with their cool temperatures, damp environment, and abundant forage, attract cattle who may spend 5-30 times as much time there (Roath and Krueger, 1982; Belsky et al., 1999). The congregation of cattle in these areas can often lead to levels of forage removal that the native vegetation cannot support (Belsky et al., 1999). Roath and Krueger (1982) documented cattle use of riparian areas in an Oregon grazing allotment. Only 1.9% of the allotment was designed riparian area but produced 21% of the available biomass, with 81% of the forage being utilized by livestock. Livestock have been known to prefer wet meadows, utilizing 60-80% of the available forage produced with mean stubble heights ranging from 4- to 14-cm depending on plant species (Kauffman et al., 1983). At that point, cattle have been observed to supplement their diet by increasing willow consumption (Roath and Krueger, 1982; Kauffman et al., 1983; Mosley et al., 1999). Preference for willows (*Salix spp*.) and black cottonwood (*Populus trichocarpa*) saplings was documented in an Oregon study by Kauffman et al. (1983).

The intense grazing of riparian areas can reduce vegetation and result in a transition to non-native plant species, decrease water quality, shift channel morphology, and lower the water table (Kauffman and Krueger, 1984; Poff et al., 2011). Kauffman and Krueger (1984) showed overgrazing leads to increased presence of non-native grass species to the point where it started replacing native bunchgrass.

The removal of vegetation and increased soil compaction by livestock will also reduce infiltration of water and increased rate of runoff, leading to surface damage and streambank erosion (Clary and Leininger, 2000). Trimble and Mendel (1995) estimated that peak storm runoff in areas of Arizona heavily grazed would be 2-3 times higher than areas that were lightly grazed. This increased runoff in areas grazed at moderate to high intensities was more likely to generate high energy erosive floods, resulting in hollowing and reshape stream channels.

Soil compaction is linearly correlated with grazing intensity in many types' landscapes, like riparian areas (Kauffman and Krueger, 1984; Orr, 1960; Beever and Herrick, 2006; Bell et al., 2011), which can harm other ecosystem processes. The changes in soil penetration resistance and bulk density affect water infiltration, availability of water and nutrients to roots, plant vigor, and burrowing ability of small mammals (Reed and Peterson, 1961; Trimble and Mendel, 1995; Beever and Brussard, 2004; Beever and Herrick, 2006). Penetration resistance in soil grazed by livestock is known to be 20-50 % greater than resistance in un-grazed soils (Bell et al., 2011).

Impacts from Wildlife

Although often overlooked, native wildlife can impact riparian areas as well (Kay, 1994). Some studies on herbivory in riparian areas have documented the impacts of native wildlife including deer, elk, and moose on woody plant species (Kay and Chadde, 1992; Kay, 1994; Singer et al., 1994; Opperman and Merenlender, 2000; Brookshire and Kauffman, 2002). In Wyoming, browsing by native ungulates had significant impacts on willows, both mature and seedling, to the point of eliminating seed production (Kay and Chadde, 1992; Kay, 1994). Elk and moose have been known to change the herbaceous plant community composition, through grazing and trampling, to one that contains more gazing tolerant or less palatable species (Kay, 1994).

Compounding Impacts from Multiple Herbivores

Although the impacts from individual species are of concern, there is even greater concern with the potential for compounded impacts of wildlife and livestock and the degree to which they may affect a site (Brookshire and Kauffman, 2002; Davis et al., 2014). Concentrated browsing by many types of animals can have long-term impacts on plant growth, reproduction, and potential persistence (Brookshire and Kauffman, 2002). Brookshire and Kauffman (2002) found that in areas with both, wildlife and livestock, browsed willows had significantly smaller stature, with lower height and smaller crown, than areas with only wildlife. Even when studied separately from livestock, wildlife were still found to reduce recovery of riparian areas (Kauffman and Case, 1997). Specifically, they had the greatest influence on multiple attributes of willows (e.g., volume, biomass, height, and reproduction) and black cottonwood height (Kauffman and Case, 1997).

Conclusion

Wild horses represent freedom, power, and beauty, all which embody the western spirit. To sustain healthy and thriving populations of wild horses, we must better understand their overall role in the broader ecosystem. We must examine their management through a holistic lens, including their influence on wildlife, invertebrates, vegetation, nutrient cycling, soil compaction, and rangeland health. Although wild horse populations on Western rangelands are currently smaller than those of livestock, their year-long use of rangelands can have a more profound impact. By law, wild horses cannot be managed to a level comparable with livestock. Combined use by livestock, wild horses, and wildlife may be problematic particularly in riparian areas when carrying capacity is exceeded. If wild horse populations exceed carrying capacity, the corresponding grazing and trampling impacts might result in substantial resource degradation (Rheinhardt and Rheinhardt, 2004). Future management actions may necessitate that use of rangelands by wild horse is better monitored to minimize overuse and improve rangeland health. Thus, wild horse use should be included in management plans addressing rangeland health, specifically in riparian areas.

Several studies have examined the impact wild horses have on the landscape (Slater and Hudson, 1980; Miller, 1983; Ganskopp and Vavra, 1987; McInnis and Vavra, 1987; Crane et al., 1997). This includes the response in riparian vegetation and ecosystem interactions observed in several situations (Beever and Bussard, 2000; Levin et al., 2002; Menard et al., 2002; Loucougaray et al., 2004; Rheinhardt and Rheinhardt, 2004; Beever and Herrick, 2006; Porter et al., 2014; USFW, 2014) and the change in wildlife species and use when horses used the area (McInnis and Vavra, 1987; Ostermann-Kelm et al., 2008; Gooch, 2014; Hall et al., 2016). Although these research efforts were informative, few evaluated the impact of wild horses on riparian condition.

Riparian condition is part of the criteria the BLM uses to justify removal of free-ranging horses and/or alter cattle grazing permits. The National Research Council (2012) recommended that the BLM develop ways to distinguish horse and burro impacts from livestock and wildlife impacts to determine the correct partitioning of grazing resources. However, very little data exists on the impact of wild horses on lotic riparian areas, a useful aid in making management decisions.

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CHAPTER 2: Impact of Wild Horse and Grazing Ungulates on Riparian Areas in Idaho

Free-ranging equids (i.e., often referred to as "wild" or "feral"), roam on public lands in significant, potentially unsustainable, numbers. Starting with their reintroduction to North America in the 16th century, after disappearing in the late Pleistocene age ([10,000-14,000 years ago]; Wyman, 1945; Duncan, 1992) and continuing until the end of the 20th century, the wild horse population was a readily available source of working stock and sellable profit for settlers, farmers, ranchers, military, and miners residing in the West (Wyman, 1945). As the U.S. transitioned to mechanized agriculture, the value and importance of horses in society decreased. To protect these animals from inhumane treatment, Congress passed the Wild Free-Roaming Horses and Burros Act of 1971 declaring wild horses and burros an "integral part of the natural system of public land" (Public Law 92-195). This Act set aside land (Herd Areas) were wild horses and burros were found in 1971; and assigned the Secretary of Interior the responsibility for protecting and managing these animals "in a manner that is designed to achieve and maintain a thriving natural ecological balance on the public lands" (Public Law 92-195).

Many people today still believe wild equids are an intrinsic and esthetic part of the American West. This viewpoint often elicits impassioned debate and enduring criticism of the Bureau of Land Management (BLM) and the management practices they employ (e.g., gathering, contraceptives, and manipulating herd sex ratios) to carry out their responsibilities under the law (Garrott and Taylor, 1990, National Research Council, 2013). With virtually no natural predators, when left unmanaged herd sizes can increase by 15-20% each year, doubling every four years (McInnis, 1984; Beever, 2003; National Research Council, 2013). Over the last decade, horse and burro populations have risen from 30,000 individuals in 2005 to roughly 49,000 individuals in 2014 according to the Public Land Statistics; a 61% increase in less than 10 years (BLM, 1994-2014). This prolific growth can cause local herds to quickly exceed the carrying capacity of their federally allocated range, and adversely impacts the health of public lands. Larger populations result in greater demand for rangeland forage and water supplies (National Research Council, 2013) and run a higher risk of degrading rangelands (Hansen and Mosley, 2000).

Wild horses can impact ecosystems in several ways. Areas used by horses have shown a significant reduction in the presence of grasses and shrubs around riparian areas (Beever and Brussard, 2000), lowered plant species richness and cover of grasses and forbs (Beever et al., 2008; Beever and Herrick, 2006; Levin et al., 2002), and altered the number and species of animals using marshes (Levin et al., 2002). Wild horse impacts to critical riparian areas have also been documented. For example, a drastic response of riparian vegetation was seen at National Wildlife Refuge in Nevada were stubble height was nearly 10 times greater in ungrazed areas compared to areas grazed by horses (FWS, 2012). Likewise, Beever and Bussard (2000) compared plant heights in upland meadows with no grazing, only horses grazing, and both livestock and horse grazing. Areas grazed by just horses were 2.8 times lower than ungrazed plant heights, while plant heights in areas grazed by both horses and cattle were 4.5 times lower than ungrazed plants (Beever and Bussard, 2000).

Riparian areas are the ecologically important zones around rivers, streams, and lakes that constitute a less than 2% of public lands, but their benefits far exceed their acreage

(Belsky et al., 1999; Poff et al., 2011). This habitat supports a variety of plants and animals (including threatened and endangered species) and provides forage, cover, and water for diverse species of wild and domestic animals (Svejcar, 1997; National Research Council, 2013). Riparian areas are important for trapping sediments, slowing runoff, and supporting healthy watersheds. Grazing and trampling by grazing animals can harm these areas to the point where they become non-functional and unable to capture sediment, enhance infiltration, or dissipate high energy flows (Trimble and Mendel, 1995; Mosley et al., 1999; Clary and Leininger, 2000).

Improper grazing by any herbivore species will affect riparian ecosystems by changing, reducing, or eliminating vegetation; widening and shallowing of the stream; increasing water temperature, increase nutrient and sediment loads, and bacterial counts; and acceleration of sedimentation and degradation of spawning areas (Kauffman and Krueger, 1984; Belsky et al., 1999; Mosley et al., 1999). Impacts to water quality may decrease fish biomass and total composition (Belsky et al., 1999; Mosley et al., 1999). Impacts on vegetation may affect plant vigor, biomass, and alter species composition and diversity (Kauffman and Krueger, 1984; Belsky et al., 1999). These disturbances ultimately reduce the quality of critical habitat for riparian plants, aquatic species, and many species of upland wildlife.

Areas used utilized by wild horses are also often used by wildlife and livestock (Duncan, 1992; Beever and Bussard, 2000). This co-occupation makes it difficult to determine which species has the greater impact on rangelands (Beever and Bussard, 2000; Beever and Aldridge, 2011). Wild horses and livestock are often at the first to be accused of degrading riparian areas. Wild horses can significantly impact riparian areas because they have unobstructed year-round access to streams and meadows (Beever and Bussard, 2000; Menard et al., 2002; USFW, 2014). Riparian areas attract animals because of the long term availability of water and green forage (National Research Council, 2013). Horses and cattle prefer riparian areas because plants stay greener longer during the year, and therefore are more nutritious than surrounding vegetation (Roath and Krueger, 1982; Crane et al., 1997; Menard et al., 2002). Wild horses also consume more forage than cattle, due to their digestive morphology which allows faster passage of forage through the digestive tract (Duncan et al., 1990; Lyons et al., 1999; Menard et al., 2002).

Land managers often struggle to balance rangeland health, and forage allotments to wild horses, wildlife, and livestock. These difficulties are often compounded by the lack of information about the type and extent of damage caused by different species of herbivores. In turn, sustaining healthy and thriving populations of wild horses requires a better understanding their role in the rangeland ecosystems they inhabit. With an increased understanding of the impact wild horses have on rangelands, land managers can better create management plans that protect riparian areas and as mitigate damage to wildlife habitat and to our invested ranchers.

The purpose of this study was to evaluate wild horse impacts on riparian areas through three measurements of riparian condition--stubble height, stream bank alterations, and plant biomass. By documenting monthly changes in riparian condition measures over a period of five - seven months in conjunction with photos, which captured the number of animals present each month, to better determine each animal's potential impacts. Specifically, we sought to 1) determine the in the impact, individual or combined, of the observed animals in a month on the change in the measurements of riparian condition (streambank alterations, stubble height, and utilization); and 2) discover how the presence of one animal species might affect the presence or absence of another species.

Materials and Methods

This study examined the impacts of wild horses, cattle, and wildlife on four stream reaches in three wild horse Herd Management Areas (HMA) in Owyhee County, and four stream reaches in one wild horse HMA in Custer County, Idaho (Figure 2.1). All stream reaches reside on Bureau of Land Management (BLM) lands.

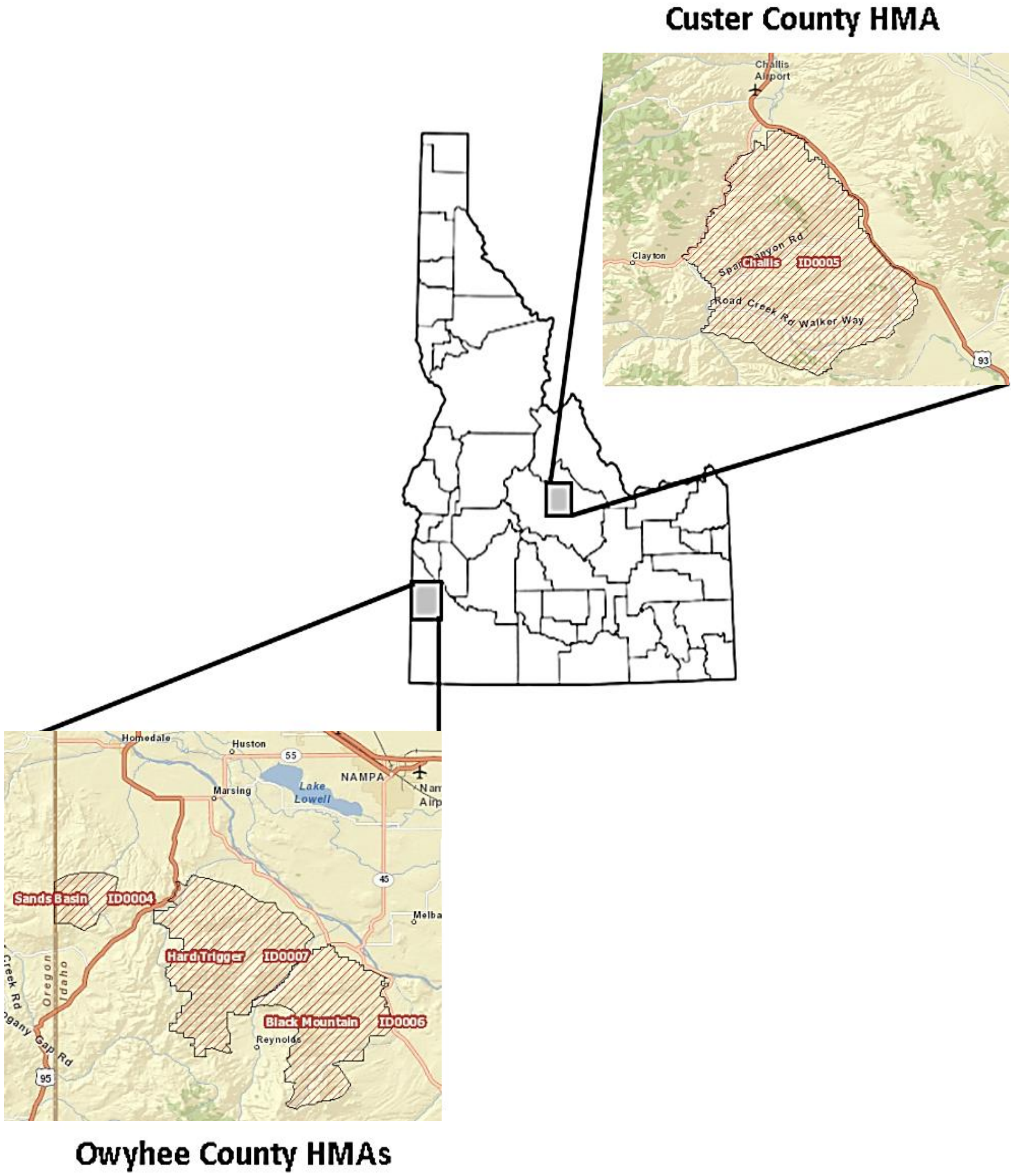

Figure 2.1 The eight stream reaches sampled for this study resided in four wild horse Herd Management Areas (Sands Basin, Hard Trigger, Black Mountain, and Challis) located in two study areas (Challis and Owyhee) in Idaho.

Study Areas

Challis Study Area

The Challis HMA is located in Custer County (Figure 2.1). Horse population in 2015 was estimated at 218 and is within the recommended AML (Table 2.1; BLM, 2015). The HMA's soils were characterized by gravelly, stony, and clay loams (NRCS, 2016). High ridgelines with elevations of 1,400 to 2,500-m surround most of the HMA.

Table 2.1 Horse population estimates for 2015, and recommended appropriate management level (AML) of Idaho Herd Management Areas (HMA) in which stream reaches are located. Information gathered from BLM 2015 Herd Statistics. (http://www.blm.gov/wo/st/en/prog/whbprogram/herd_management/Data.html)

HMA	HMA Area (Acres)	2015 Estimated Horse Population	Appropriate Management Level (AML)
Sands Basin	11,724	53	33-64
Hard Trigger	67,882	143	66-130
Black Mountain	50,904	80	30-60
Challis	167,848	218	185-253

The stream reaches studied within the Challis HMA were located in the Central Mountains climate (NOAA, 2016), and the average temperature (12-month average from 1961 – 2015) is 4°C with an average annual precipitation of 211-mm (8-in; NOAA, 2016). During this 2015 study, the average monthly temperature was 6°C (Figure 2.2), making this a hotter than normal year. The 2015 annual precipitation of 244-mm (10-in), occurring mostly during May.

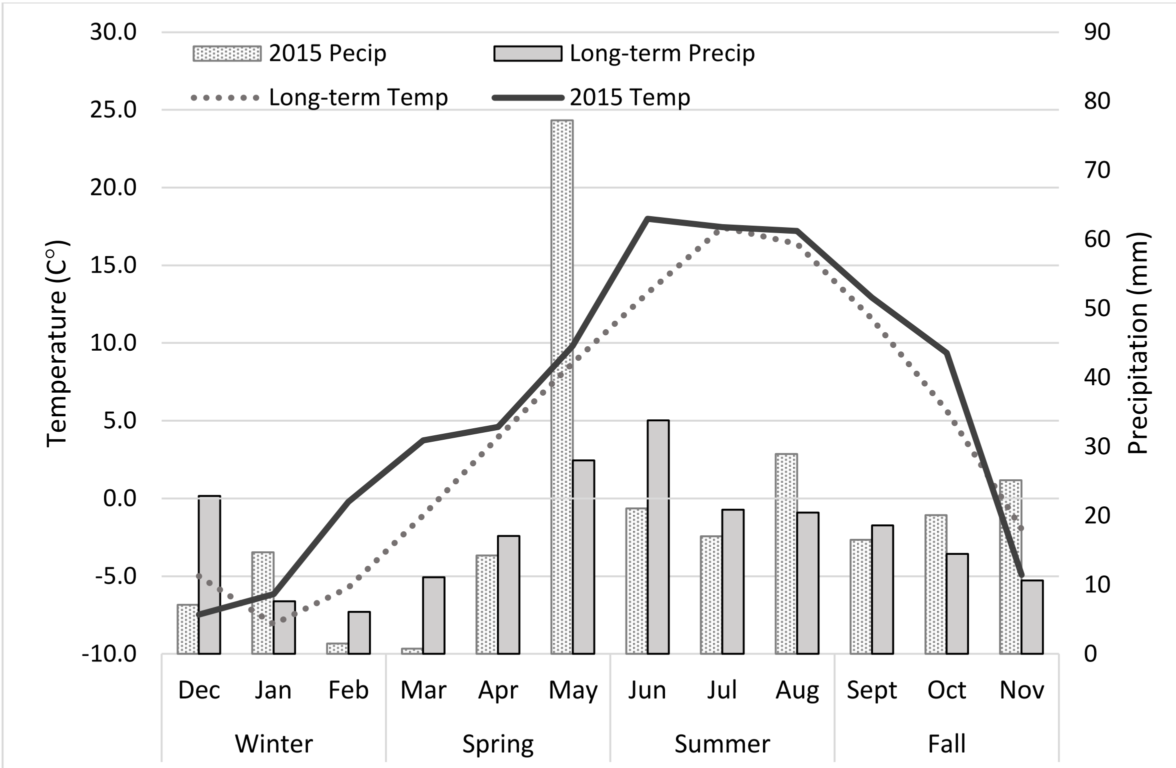

Figure 2.2 The monthly mean temperature and precipitation for December 2014 to November 2015 and long-term (1961 – 2014) monthly mean temperature and precipitation summaries for the Chilly Barton Flat, Idaho area station ID 101671 from Western Regional Climate Center. www.wrcc.dri.edu

The plant overstory was dominated by basin big sagebrush, mountain big sagebrush, Wyoming big sagebrush, three-tip sagebrush (*Artemisia tripartita*) and black sagebrush (*Artemisia nova*) (BLM, 2012; NRCS, 2016). Understory grasses include Idaho fescue, bluebunch wheatgrass, needle-and-threadgrass (*Hesperostipa comata*), Sandberg bluegrass, and Cusick's bluegrass (*Poa cusickii*) (BLM, 2012). Drier sites contain shadscale and silver chickensage (*Sphaeromeria argentea*) with understories of Swallen’s needlegrass (*Achnatherum swallenii*), squirreltail, and bluegrass. High elevation are dominated with Douglas-fir (*Pseudotsuga menziesii*) and curl-leaf mahogany (*Cercocarpus ledifolious*) plant communities (BLM, 2012; NRCS, 2016).

The riparian communities in the Challis HMA contained a variety of woody plants including black cottonwood (*Populus balsamifera*), quaking aspen (*Populus tremuloides*), Douglas-fir, mountain maple (*Acer glabrum*), woods' rose (Rosa woodsia), willow species (Salix spp.), red-osier dogwood (*Cornus sericea*), chokecherry (*Prunus virginiana*), gooseberry (*Ribes spp*.) and currant (*Ribes spp*.) (BLM, 2012; NRCS, 2016). Much of the herbaceous vegetation consisted of hydric species like Nebraska sedge (*Carex nebrascensis*), beaked sedge (*Carex rostrate*), and Baltic rush (*Juncus balticus*) along with many types of mesic forbs and grasses (BLM, 2012; NRCS, 2016). A complete species list for each stream reach is provided in the Appendix. Elevations for stream reaches in this study varied from 1,900 to 2,300-m.

Animals using this area included cattle, wild horses, and a variety of native wildlife species including elk, pronghorn, mule deer, various rodents, and birds (upland game birds, raptors, and songbirds) (BLM, 2012). This area also included predator species such as mountain lions, black bears (*Ursus americanus*), bobcats, coyotes, and gray wolves (*Canis lupus*).

Owyhee Study Areas

Sands Basin, Hard Trigger, and Black Mountain HMAs were located in the northwest corner of Owyhee County (Figure 2.1). Horse populations in 2015, were estimated at 53 in Sands Basin, 153 in Hard Trigger, and 80 in Black Mountain HMAs. With only Sands Basin HMA being within the recommended Appropriate Management Level (AML; Table 2.1; BLM, 2015).

The stream reaches studied in these HMAs were located within the Southwestern Highlands climate division (NOAA, 2016), and the average temperature (12-month average from 1961 – 2015) is 9°C with an average annual precipitation of 268-mm (10.5-in; NOAA, 2016). In 2015, the average monthly temperature was 12°C (Figure 2.3), making this a hotter than normal year. The 2015 annual precipitation total to 248-mm (10-in), occurring mostly during October through December.

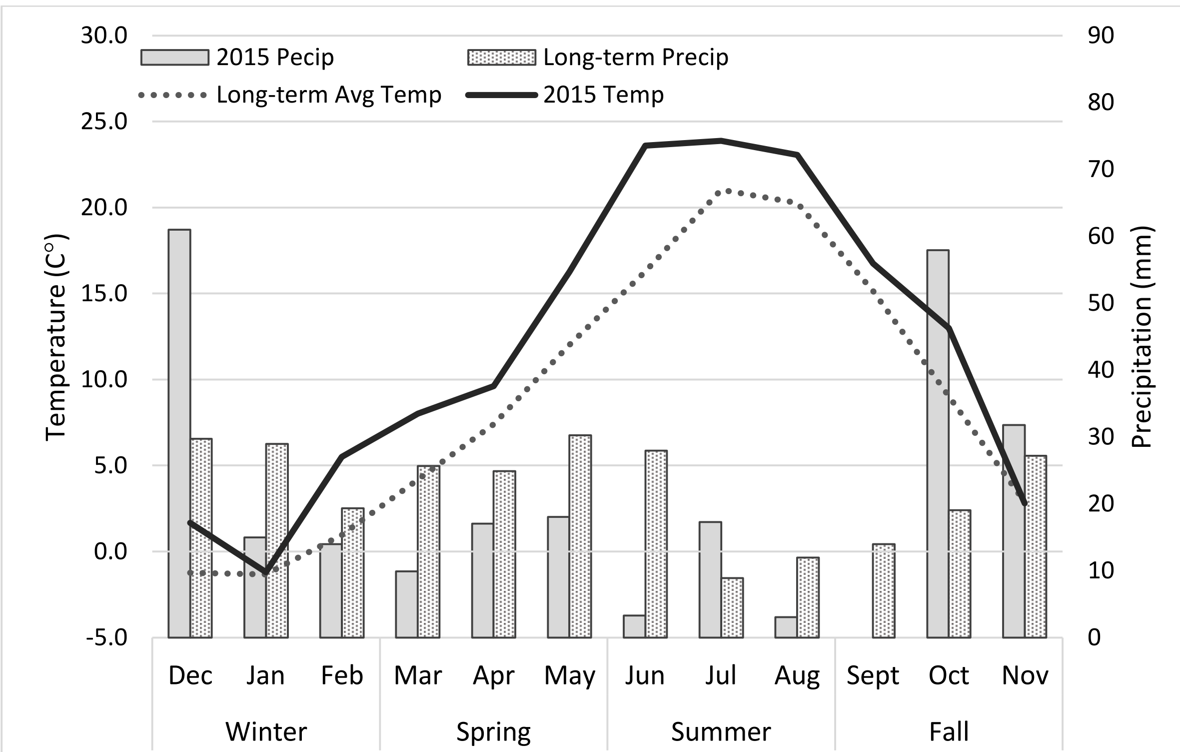

Figure 2.3 Monthly mean temperature and precipitation for December 2014 to November 2015 from Homedale 1 SE, ID weather station (104318) and long-term (1961 – 2014) monthly mean temperature and precipitation summaries for the Reynolds, Idaho area station ID 107648 from Western Regional Climate Center. www.wrcc.dri.edu

These HMAs are predominately rolling sagebrush steppe with steep mountains and rough terrain. These HMAs are characterized by a mixture of soils ranging from gravelly loam to gravelly clay loams, which vary from shallow to moderately deep and are well drained (BLM, 2009; BLM, 2010; NRCS, 2016). Elevation in the Sands Basin HMA varied from 1,200 to 1,700-m, whereas elevations in Hard Trigger and Black Mountain HMAs vary from 650 to 2,050-m.

The plant overstory in Sands Basin was dominated by mountain big sagebrush (*Artemisia tridentata ssp. vaseyana)*[1] and low sagebrush (*Artemisia arbuscula*) (BLM, 2009; NRCS, 2016). Black Mountain and Hard Trigger had a more varied overstory consisting of Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), basin big sagebrush (*Artemisia tridentata ssp. tridentata*) and mountain big sagebrush at higher elevations; and salt desert shrub plant communities dominated by shadscale (*Atriplex confertifolia*), bud sagebrush (*Picrothamnus spp.*), and four-wing saltbush (*Atriplex canescens*) (BLM, 2010; NRCS, 2016). Understory grasses included bluebunch wheatgrass (*Pseudoroegneria spicata*), Sandberg bluegrass (*Poa secunda*), Thurber's needlegrass (*Achnatherum thurberianum*), Idaho fescue (*Festuca idahoensis*), squirreltail (*Elymus elymoides*), and other bunchgrasses (BLM, 2010; NRCS, 2016). Exotic annual grasses included cheatgrass (*Bromus tectorum*) and medusahead (*Taeniatherum caput-medusae*) were present throughout the plant community.

Riparian communities in these HMAs contained a variety of woody plants including various willows (*Salix spp*.), cottonwoods (*Populus spp*.), and an assortment of other shrubs at higher elevations. The herbaceous communities consisted of various rushes (*Juncus spp*.), sedges (*Carex spp*.), and grasses. Noxious weeds were documented in riparian areas and

[1] Scientific name of plants follow http: plants.usda.gov/

include Canada thistle (*Cirsium arvense*), Scotch thistle (*Onopordum acanthium*), perennial pepperweed (*Lepidium latifolium*), poison hemlock (*Conium maculatum*), tamarisk (*Tamarix rammosissima*), and whitetop (*Cardaria draba*) (BLM, 2010). A complete list of plants observed is provided in the Appendix for each of the stream reaches sampled. Elevations for streams that were sampled varied from 1,000 to 1,300-m.

The wild horses within these three HMAs share the range with numerous native wildlife species including mule deer (*Odocoileus hemionus*), pronghorn antelope (*Antilocapra americana*), California bighorn sheep (*Ovis canadensis*), elk (*Cervus canadensis*), coyotes (*Canis latrans*), mountain lions (*Puma concolor*), bobcats (*Lynx rufus*), and upland game birds including greater sage-grouse (*Centrocercus urophasianus*), California quail (*Callipepla californica*), and chukar partridge (*Alectoris chukar*) (BLM, 2009; BLM, 2010).

Stream Setup and Data Collection

To document use of riparian areas by wild horses, cattle, and wildlife a series of camera traps were setup on eight streams in two study areas in Idaho. The effects of these animal groups were document through the monthly sampling of three riparian attributes including streambank alterations, stubble height, and utilization. Initial setup of stream reaches and camera calibration occurred in the fall of 2014. Preliminary data collection of stream reaches was complete in October 2014. Data collection continued in March through October 2015 using the best methods identified during preliminary data collection.

Stream Selection

Stream reaches were selected with guidance from local BLM professionals and ranchers who were concerned with current riparian conditions. Randomization when selecting the stream reaches was done to get a representation of other possible variables (which were not sampled) that may have influenced the distribution or movement of animal types (horses, cattle, and wildlife) throughout the HMAs.

A 100-m (328-ft) length of stream was selected and designated as the “stream reach” (Figure 2.4). Each stream reach selected (8 total) represented an experimental unit within the study. Selection of stream reaches was based on local recommendation, researcher accessibility, and visible sign of animal use. Each stream reach was divided into five, 20-m (65-ft) segments, from which two segments were randomly selected for monitoring. After random selection, segments needed to meet the following criteria to be acceptable for monitoring: year-round running water, > 40% of stream bank visible from a camera, and water being accessible for animals. There were two stream segments that were rejected due to their lack of visibility for game cameras.

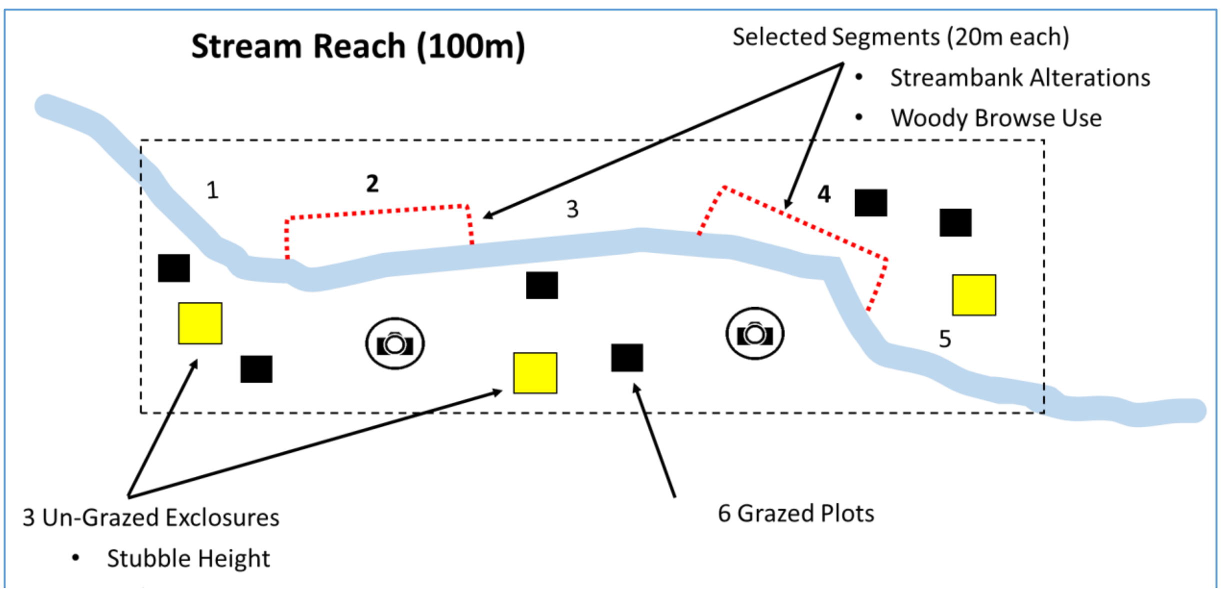

Figure 2.4 The 100-m (328-ft) sampling area, “stream reach” (thin dashed box), of each selected stream broken down into five 20-m (65-ft) stream segments with two randomly selected stream segments in red dotted brackets. Cameras were paired with each of the two stream segments to document animal use. Streambank alterations and woody browse use were sampled within the stream segments. Utilization and stubble height were sampled only in the 3 un-grazed exclosures (solid lined boxes) and 6 grazed plots (black boxes).

The beginning and ending point of each stream segment was marked with a large nail and plastic tab (i.e., cattle ear tag). The GPS coordinates were recorded for the beginning and ending locations (Table 2.2). Two motion sensitive game cameras were placed at each stream reach being studied. One camera was directed at each of the two stream segments in order to observe animal presence at the segment. Cameras were mounted on t-posts roughly 0.5- to 1-m (1.5- to 3-ft) above the ground and often placed in a shrub or by a tree to help discourage animal disturbance (rubbing). Criteria for camera placement included a view 40% of the stream segment, a view that was unobstructed by trees, shrubs, or rocks, and independent with no overlapping view with the other camera on the stream reach.

Table 2.2 Two segments (1 and 2) of each stream reach were selected for monitoring. To mark the start and end points of those segments nails with tags were driven into the ground at those locations. The GPS coordinates for each start and end point were documented. "Location on the stream" refers to the start and end points with "Upper" referring to the upstream point/marker and "Lower" referring to the downstream point/marker.

			Upper		Lower	
County	**Stream Reach**	**Segment**	**Latitude**	**Longitude**	**Latitude**	**Longitude**
Owyhee	Black Mountain	1	43.190887	-116.639076	43.190896	-116.638825
	(Rabbit Creek)	2	43.190882	-116.638857	43.190934	-116.638613
	Farrot Creek	1	43.264050	-116.795825	43.264079	-116.795997
		2	43.264006	-116.796815	43.263947	-116.797040
	Sands Basin	1	43.433409	-116.966106	43.433561	-116.965950
	(Jump Creek)	2	43.433025	-116.966175	43.432865	-116.966225
	Wilson Creek	1	43.330510	-116.747207	43.28041	-116.806937
Challis	Lower Horse Basin	1	44.188707	-114.154776	44.188757	-114.154988
	(Horse Basin Creek)	2	44.188575	-114.155315	44.188591	-114.155583
	Road Creek	1	44.157217	-114.174453	44.157313	-114.174617
		2	44.157511	-114.174907	44.157516	-114.175084
	Corral Basin Creek	1	44.236756	-114.100267	44.236643	-114.100518
		2	44.236733	-114.100714	44.236736	-114.101228
	Horse Basin Creek	1	44.182757	-114.069435	44.182912	-114.069589
		2	44.183118	-114.070008	44.183193	-114.070239

Sampling Stream Segments

Sampling took place within the two randomly selected 20-m (65-ft) stream segments of each stream reach. The sampling frame used included two side-by-side, 20 by 50-cm (8- by 20-in) frames, with an area of 2,000-cm^2 (310-in^2). The center line of the sampling frame was placed on the "greenline". The greenline is described in BLM technical reference as a "linear grouping of live perennial vascular plants, embedded rock, or anchored wood above the waterline on or near the water's edge" (BLM, 2011). Plot frames started at the upstream marker on the left side of the stream (when facing upstream) and were placed every 2-m (roughly two paces or 6-ft) along the stream's greenline in a U-shape until a total of 20 plots frames were placed (approximately 10 plot frames per side) (Figure 2.5). Potential sampling bias was consistent across sampling methods because data were collected by the same person for the duration of the project.

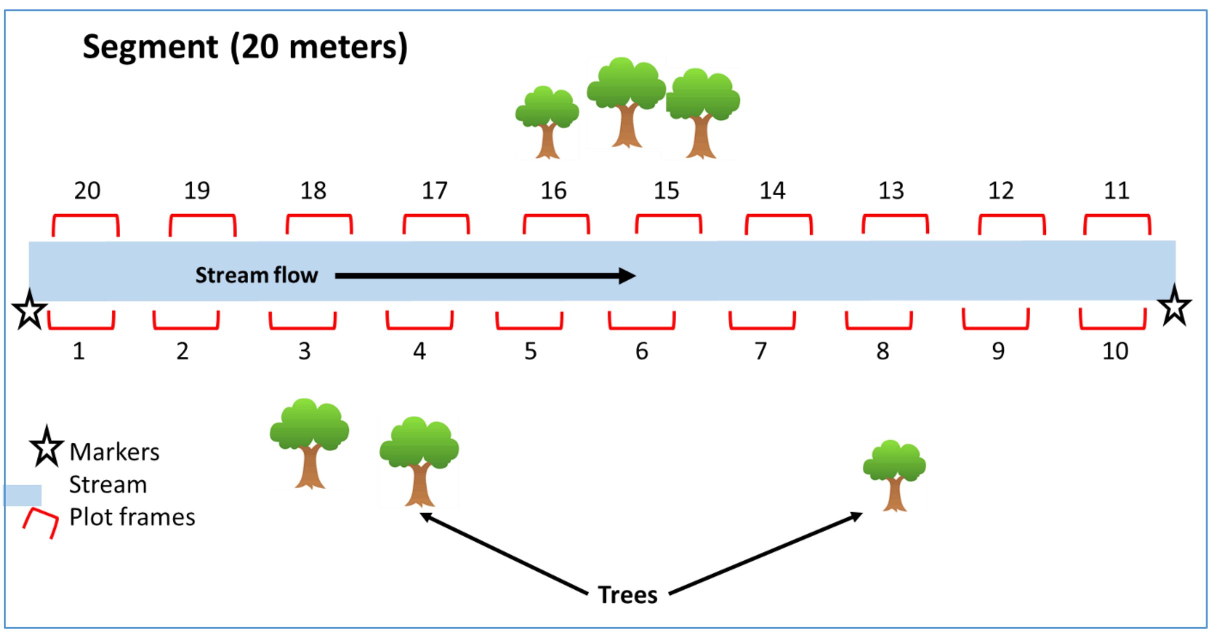

Figure 2.5 Sequence and direction of sampling on the green line for stubble height of grass and grass-likes and streambank alterations on each 20-m (65-ft) stream segment for a total of 20 plots.

Streambank Alteration

Streambank alteration was measured following the Multiple Indicator Monitoring (MIM) protocol, by documenting the number of "alterations" that intercept one of five perpendicular lines running across the frame at 10-cm (4-in) increments (BLM, 2011). The number of alterations was determined by looking down at the entire frame and counting the number of lines within the plot that intersect streambank alterations. Alterations were observed from no closer than 1-m (3-ft) from the ground when looking down (BLM, 2011). Each line, if crossed, was counted only once; even if more than one alteration crossed it. An alteration was considered to be a depression in the streambank exposing bare soil or broken vegetation at least 13-mm (0.5-in) deep, or soil that was compacted by repeated use even though depressions were less than 13-mm (0.5-in) deep (BLM, 2011). Trampling impacts must have been the obvious result of current month use. "Obvious" meaning easily seen, with no doubt.

Measures of streambank alteration were calculated as the percent of length of bank that was altered based on presence or absence of alterations intercepting the five line in the measuring frame. Streambank alteration is a metric that represents the percent of hits (or lines intercepted by hoof-prints) lineally along the greenline.

(Total number of hits) / (Total number of plots) = #, (# / 5)*100 = % Alteration

Utilization

Exclosures represented "control" areas for this study and were used to monitor utilization of grasses and forbs. Three exclosures were installed at each stream reach (Figure 2.6). The three exclosures were placed in areas of relatively homogenous vegetation, comparable to surrounding vegetation for comparability. Criteria for exclosure placement included animal accessibility, within the 100-m (328-ft) stream reach, and within 10-m (32-ft) of the stream. Each exclosure was permanently paired with two grazed plots. Three areas of similar vegetation were selected and a coin flip was used to randomly determine which area became the exclosure and which the two grazed plots.

Exclosures were made with welded mesh panels in the shape of a rectangle; with 51 x 61-cm (20 x 24-in) sides for an area of 3,111-cm^2 (480-in^2) of vegetation (Figure 2.6). Two t-posts were used to anchor opposite corners of the exclosure to keep it from being moved by animals. The grazed plots were marked on opposite corners with nails and tags, to facilitate monthly sampling of grazed and ungrazed plots.

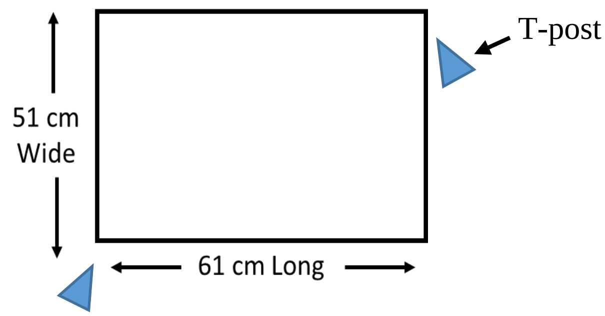

Figure 2.6 A typical exclosure used to create ungrazed controls for each stream reach. Dimensions of the exclosures were 51-cm wide by 61- cm long (roughly 20x24-in) for an area of 3,111-cm^2 (480-in^2).

Vegetation biomass was recorded through ocular estimates, each month, in the grazed and ungrazed plots. For quality assurance, the researcher practiced this methodology until able to consistently estimate available biomass with 70% accuracy in the field. To assure accurate estimation consistency the researcher conducted calibrations at each stream reach, for every month sampling occurred, before ocular estimates were recorded. The researcher continued to calibrate throughout the day. Records of the researcher’s estimates versus actual biomass were retained. Researcher was able to achieve an overall accuracy of 80% for the study. The utilization of herbaceous vegetation will be determine by using the ocular biomass estimates collected in grazed and ungrazed plots. The calculation for utilization is as follows:

((UnGrazed-Grazed)/ UnGrazed)*100) = % Utilization

Herbaceous Stubble Height

Two measures of stubble height were taken for grass and forb groups in both grazed and ungrazed plots (i.e., exclosures). To measure stubble height a roughly 8-cm (3-in) diameter area of each plant group (grass and forb) was gathered, the leaves were stood upright, and the average height of the sample group was determined (BLM, 2011). The average height was measured to the nearest centimeter on a ruler. Seed stalks were not included in the estimate. Stubble heights in the grazed plots were recorded so the reduction of height was documented by month. This change in stubble height was be compared to the number of animals, for each group, to help attribute the amount of change to the species present.

Animal Observations with Game Cameras

Animal use was documented through photography. Bushnell® Trophy Cam HD 8MP Hybrid Night Vision Trail Cameras were used to document animal use on studied stream segments. Cameras were set to take photographs based on motion detection. The motion detection, or sensor level, feature on each camera was programmed to the “Auto” setting. This allowed the sensor sensitivity to be determined by the camera based on the current outside temperature, therefore selecting the best rate of detection throughout the day. Each time the camera was triggered, a sequence of three photographs was taken. This sequence of photographs were used to determine the type of activity in which animals were involved. A four minute “interval” or delay setting between camera triggers was also used. The resultant sequence of events would be: motion trigger, three photographs, four-minute delay, motion trigger, three photographs, and so forth. This interval setting helped identify independent visits, eliminate duplicate photographs of the same animals, and create independent samples of the population. For each set of three photographs only one record was made when observations were logged for analysis. Data were collected on type of animal (horses, cattle, and wildlife), group size (individuals counted per trigger or "animal count"), time of day, and activity. The category "wildlife" denoted native grazing animals such as elk, pronghorn, deer, and moose. All activities were characterized as drinking, grazing, traveling, loafing, other, or unknown (Table 2.3).

Table 2.3 Animal activities were documented for all photos with animals present. Possible activities an animal could be engaged in were grazing, drinking, traveling, loafing, other, or unknown.

Activity	**Description**
Grazing	Animal standing in an upright position with head down or raised and chewing
Drinking	Animal standing in an upright position with head down and mouth in water
Traveling	Animal appears to be moving with the intent of entering or leaving the area
Loafing	Animal is exhibiting lateral or sternal recumbence, or is standing upright resting
Other	If an animal is displaying anything other than above such as fighting, rolling, bucking, nursing, etc.
Unknown	Not able to distinguish activity or is too close to the camera to distinguish activity.

Abnormal animal activity was documented due to the presence of a broken leg bull, who because of its inability to travel far, resided in one stream reach in Owyhee study area often. It was determined that all photos with the bull should be documented even though it was an abnormal situation because removing him would cause his impact to be attributed to another animal. Also, a wildfire burned two other stream reaches in the Owyhee study area, damaging the game camera to the point of no functioning. Photos captured during this time were not used for analysis.

Statistical Analysis

Photos were analyzed to find the frequency of use for each species, total number of animals present, and any spatial overlap between species for each month. Due to the cumulative nature of the riparian attributes it was decided that animal numbers should also be calculated as cumulative. This was accomplished by adding the previous month's animal groups total individuals to the following month's total individuals for wild horses, cattle, and wildlife; as well as for a "grand total" of all animals present. The analysis required a model, which could consider fixed and random variables. A Linear Mixed Effects (LME) model was used to interoperate the relationship between cumulative number of individuals for each of the animal groups (wild horses, cattle, and wildlife) and the changing riparian variables (stubble height, utilization, and streambank alteration; Starkweather, 2010; Winter, 2013; Bates et al. 2015). In the LME model, animal groups (horses, cattle, and wildlife) were considered fixed variables and the stream reaches were considered random with both of the study areas being analyzed separately.

For each LME model the Akaike's information Criteria (AIC) with a correction for small sample size (AIC_c) was determined (Akaike, 1974). The difference in AIC_c scores (Δ_i) were used to identify the best approximate affects model within the animal group combinations (Alderidge and Boyce, 2008). The AIC_c weights (w_i) also helped to assess the probability that a given model was the best within the possible model combinations (Burnham and Anderson, 2002).

An ANOVA was conducted for each of the study areas to determine if the length of time spent by wild horses in the riparian areas differed from the time spent by cattle. The dependent variable used in this model was “time spent by wild horses” with “time spent by cattle” being the independent variable and month being used as a random variable. Time spent by each animal type was calculated by multiplying the number of detections (times the camera was triggered) of that animal type by four minutes (Figure 2.10). While this is not the actual amount of time spent by each animal type, it provides a liberal approximation based on the assumption that animals stayed for the full four minutes.

To observe if one animal groups affected the presence of another, correlations determine the strength and direction of a relationship between two animal groups (Zou et al. 2003). Specifically, a Spearman’s rank correlation coefficient (rho $=\rho$) was used to accounted for any non-linear correlations (Zou et al. 2003; Lehman, 2005). A pairwise correlation analysis was used to examine the relationship between the “total number of individuals” for each of the animal group (horses, cattle, and wildlife).

Results and Discussion

Animal Observations

Sixteen game cameras captured between 122 and 214 sample days per camera for a total of 1,408 camera days across all eight stream reaches. Due to a wildfire event in the Owyhee study area in August of 2015, only 1,346 camera days were usable. The starting and ending dates for the collection of animal observations and riparian attribute data varied by stream reach because of weather and wildfire affecting stream reach accessibility (Table 2.4).

Table 2.4 During the 2015 sampling period, data for riparian variables and animal observations were collected at the end of the month on each of the following stream reaches in Idaho; figures denote the number of photos taken by month over the period of the project for all stream reaches; "X" denotes months when only vegetation data was collected; "*" denotes stream reaches burned in the August wildfire.

Animal Presence		**Month**								
Study Area	**Stream Reach**	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	**Stream Total**
Owyhee	Sands Basin	X	2681	24338	8334	9405	2130			46,888
	Black Mtn.	X	888	4407	11000	3045	2586			21,296
	Farrot Creek	X	3950	22548	1825	888	605*			29,816
	Wilson Creek	X	3750	10997	273	444	1506*			16,970
Challis	Lower Horse			5200	1329	3952	825	990	810	13,106
	Road Creek			7894	3102	3684	2006	1857	1731	20,274
	Horse Basin			Snow	9429	6879	2418	2987	Snow	21,713
	Corral Basin			Snow	4062	1539	586	1143	Snow	7,330
Month Total			11269	75384	39354	29836	12662	6977	2541	**178,023**

Note: Due to weather conditions and unforeseen events not all stream reaches were accessible every month

Over the study period, a total of 178,023 photos were collected (Table 2.4). Among photos taken, 17,891 photos contained images of animals (8,134 in the Challis study area and 9,757 in the Owyhee study area) with a total of 15,715 animals detected in Challis and 28,693 animals in Owyhee. The total number of each species of animals observed varied between the two study areas (Figure 2.7). Of the total individual animals observed in the photos from the Challis study area; 15% were wild horses, 80% were cattle, and 5% were wildlife. Of the total number of animals observed in the photos from the Owyhee study area; wild horses comprised 35%, twice that of Challis, with cattle and wildlife making up 64% and 1% respectively.

In Challis, wild horse observations ranged from 6.0% to 81.1% of the total number animals observed each month with 39.8% on average (Figure 2.8). Wildlife observations in

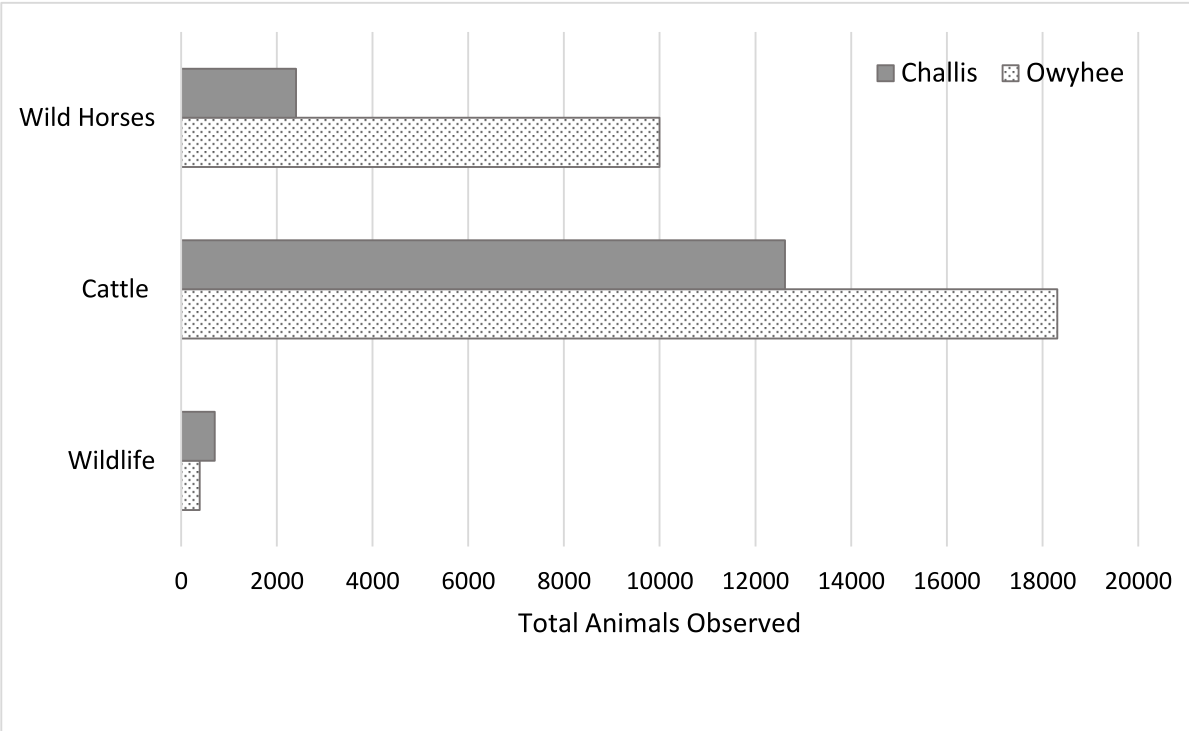

Figure 2.7 Number of individual animals observed of each type (wild horses, cattle, and wildlife) by study area (Challis and Owyhee).

this same area ranged between 1.3% and 20.3% of the total animals observed each month with 11.7% being the average (Figure 2.8). In Owyhee, wild horse observations ranged from 0.3% to 87.6% of the total number of animals observed each month with an average of 51.3% (Figure 2.8). Wildlife observations ranged between 0.9% and 4.1% of the total animals observed each month with 2.0% on average (Figure 2.8).

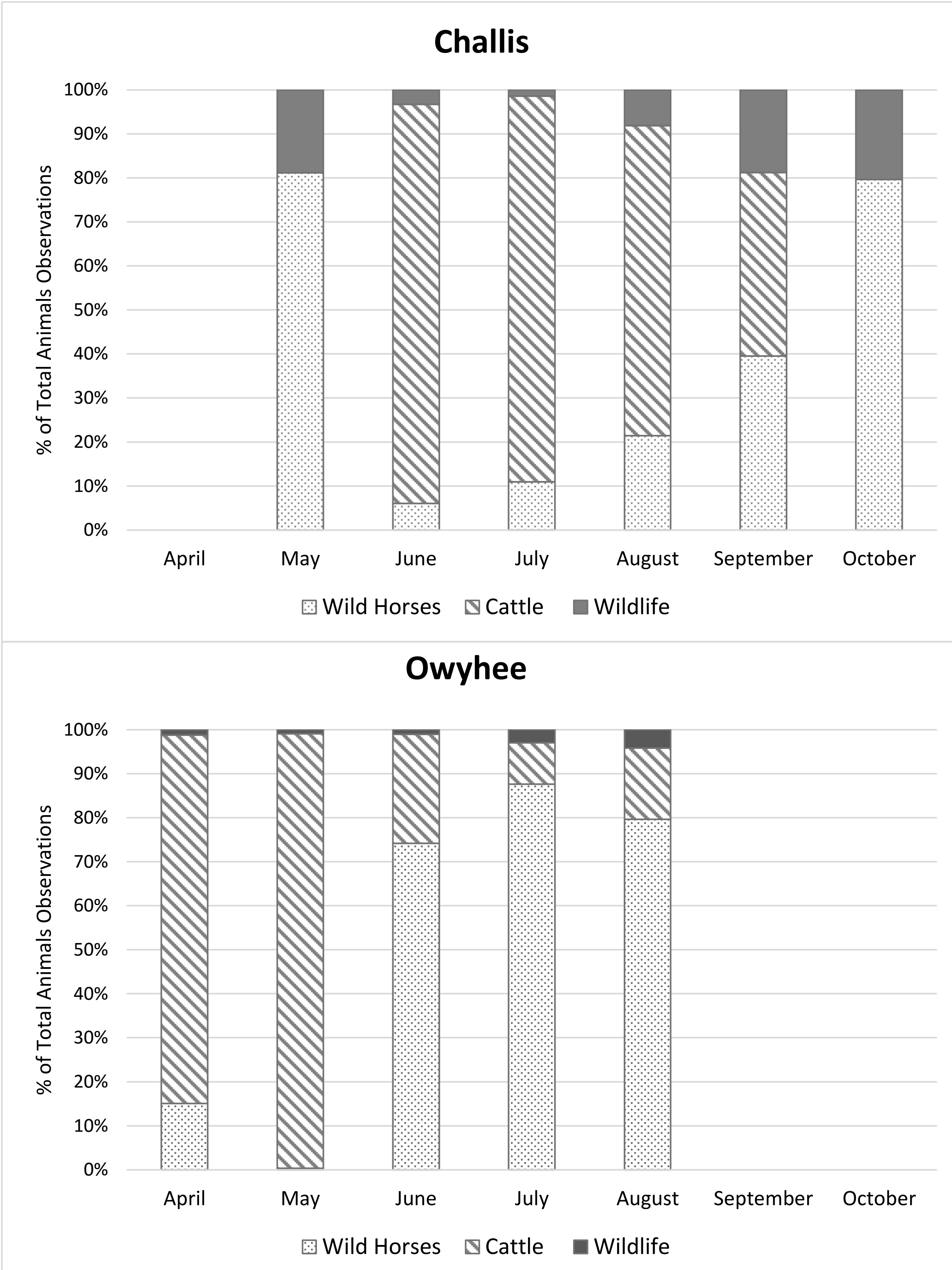

Figure 2.8 A comparison of the number of animals of each type (wild horses, cattle, and wildlife) observed as a percentage of all animals observed in each area each month

In Challis, observations of wild horses were initially very high in May, dropping drastically in June and slowly increasing over the rest of the sampling period. This drop in observations corresponds with the introduction of cattle to the area in June. In Owyhee, observations of wild horses hit its lowest point in May, with less than 1% of the total observations being horses. Only to increased rapidly in June and July, again corresponding to the presence and then gradual reduction and/or removal of cattle in those months.

Cattle Presence

Although movements of horses and wildlife were not intentionally constrained or manipulated, cattle were moved across the study areas according to the BLM's grazing management plan. In the Challis study area, cattle were introduced and grazed all stream reaches in June, July or both (Table 2.4). In the Owyhee study area, only Sands Basin and Wilson Creek had active grazing permits. Cattle were introduced to and grazed Wilson Creek in April; and Sands Basin in May and June (Table 2.5). Black Mountain and Farrot Creek were not grazed during the 2015 grazing season. Stray cattle were present, after cattle were gathered and moved, throughout most of the sampling period.

Table 2.5 Period of cattle grazing: Photos documented cattle presence at the eight stream reaches; "X" = Cattle present during grazing period, "O"=Stray cattle or herding of cattle present.

Cattle Grazing Period		**Months**							
Location	**Stream Reach**	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct
Owyhee	Sands Basin			X	X	O	O		
	Black Mtn.			O	O				
	Farrot Creek								
	Wilson Creek		X	O			O		
Challis	Lower Horse					X	O	O	
	Road Creek					X	O		
	Horse Basin				X	X	O	O	
	Corral Basin				X	O	O	O	

Animal Activities

The activities that wild horses, cattle, and wildlife were engaged in when using a riparian area varied (Table 2.6). In Challis, 51% of wild horse activity involved traveling either into or out of the riparian areas. The activity, traveling, was followed by grazing and loafing at 30% and 10% of observations, respectively. Likewise, cattle were documented traveling in 47% of the observations. Again, this was followed by grazing and loafing at 30% and 17% respectively. This trend continued with wildlife, which traveled in 68% of the observations; followed by equal amounts of grazing (14%) and loafing (14%).

Table 2.6 Animal activity as a percentage of all activity for each animal type (wild horses, cattle, and wildlife) for both study areas (Challis and Owyhee).

		% Activity					
Location	**Species**	Drinking	Grazing	Loafing	Traveling	Other/ Unknown	Total %
Challis	Wild Horses	4	30	10	51	6	100
	Cattle	2	30	17	47	4	100
	Wildlife	3	14	14	68	2	100
Owyhee	Wild Horses	28	24	16	27	6	100
	Cattle	6	31	39	20	4	100
	Wildlife	7	15	22	53	3	100

The Owyhee study area differed slightly from Challis, as traveling was not the most common activity observed. In Owyhee, 75% of the wild horse activity was evenly distributed between traveling, grazing, and drinking; with the remaining 25% made up of the rest of the activities. Cattle were seen loafing and grazing in roughly 70% of all observations. Traveling was still observed in about one quarter of all cattle observations. Wildlife observed in the Owyhee study area were traveling over 50% of the time, followed by loafing and grazing activities which was observed roughly 40% of the time. In both study areas, drinking was one of the least observed activities, occupying between 2% and 7% of all observation, with only wild horses in the Owyhee observed drinking at a higher percentage. Animal activity observations were constrained by the limited view and delay setting on the game cameras. As a result, the true purpose of each animal's presence in the riparian areas may not have been captured.

Total Minutes Observed in Riparian Areas

An ANOVA was used to analyze to see if there was a difference between total minutes observed for wild horses as compared to cattle in riparian areas. In the Challis study area, there was no difference in the time spent by wild horses from the time cattle spent in riparian areas ($P = 0.901$; Table 2.6). Time spent in riparian areas did not vary by month ($P = 0.856$). The Owyhee study area showed similar results. Wild horses and cattle did not differ in their time spent in the riparian areas ($P = 0.658$), and there was no variation by month ($P = 0.534$).

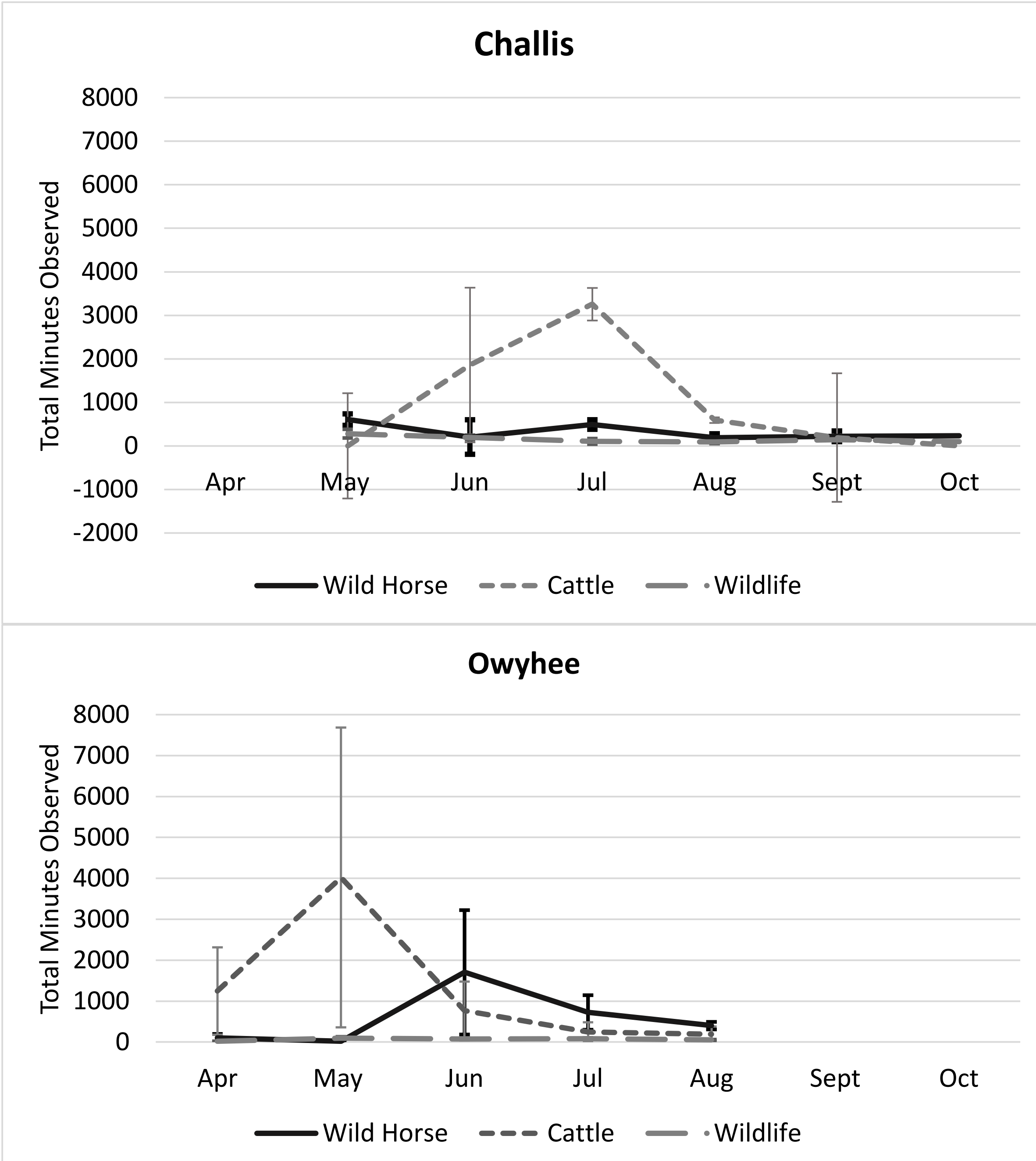

Figure 2.9 Amount of time each animal type (wild horses, cattle, and wildlife) spent, in minutes, in the riparian areas, averaged across stream reaches for each month over the sampling period for both study areas (Challis and Owyhee).

In the Challis study area, the total amount of time spent by animals (wild horses, cattle, and wildlife) in the riparian areas varied by month during the sampling period, ranging from 326 (Oct) to 3,849 (Jul) minutes per month (Figure 2.9; Table 2.7). The time wild horses spent ranged from 189 (Aug) to 604 (May) minutes per month, with an average of 322 minutes. Wild horses spent the most time in these areas in May and July. By comparison, cattle spent between 190 (Sep) to 3,255 (Jul) minutes per month in the riparian area. The highest total time spent by cattle was in June and July. These numbers however, are somewhat misleading because cattle were introduced in large numbers for short grazing periods. Wildlife spent very little time in the riparian areas in Challis, ranging from 92 (May) to 280 (Aug) minutes per month, with a greater presence in May and June.

Table 2.7 Time spent, on average across four stream reaches each month and the total time spent, by wild horses, cattle, and wildlife in riparian areas at the two study areas (Challis and Owyhee*).*

Time Spent, in Minutes, by Animals in Riparian Areas				
	Study Area	Wild Horses	Cattle	Wildlife
Average time each month	Challis	304	1,179	144
	Owyhee	591	1,295	66
Total time	Challis	6,080	23,584	2,872
	Owyhee	11,812	25,896	1,320

The Owyhee study area experienced slightly higher numbers with total animal presence ranging from 645 (Aug) to 4,141 (May) minutes per month (Figure 2.10). Wild horses spent between 23 (May) and 1,705 (Jun) minutes per month in the Owyhee riparian areas, with an average of 590 minutes. The greatest amount of time spent by wild horses occurred in June and July. Cattle on the other hand, spent between 192 (Aug) and 4,022 (May) minutes per month, with an average of 1,294 minutes in these same areas. Cattle spent the greatest amount of time in riparian areas during May and June. Wildlife spent considerably less time in the Owyhee riparian areas, ranging from 22 (Apr) to 96 (May) minutes per month, with an average of 66 minutes. The highest total time spent by wildlife in the Owyhee riparian areas occurred during May and July.

Wild Horse, Cattle, and Wildlife Impacts on Riparian Condition

The difference in climate, landscape, and animal composition between the two study areas required separating analysis of animal impact by location (Challis and Owyhee). No statistical test was used to determine the difference between the two study areas. A LME model and AIC_c were run to determine the best model/relationship of animal groups to explain the change in riparian attributes (streambank alterations, stubble height, and utilization). Eight animal group combinations were compared to determine the best fitting model with AIC_c (Table 2.8). After running the initial model it was determined that the combination "Wildlife" should be removed due to its high correlation with "Horses" in the Challis (P = <0.001; ρ = 0.7) and Owyhee (P = 0.03; ρ = 0.5) study area, giving misleading results.

Table 2.8 Combination of animal presences used to identify the models that best predict the change in streambank alterations for 8 stream reaches within 2 study areas (Challis and Owyhee).

Animal Combinations
Horses
Cattle
Wildlife
Total
Horses & Cattle
Horses & Wildlife
Cattle & Wildlife
Horses & Cattle & Wildlife

Animal Presence on Streambank Alteration

At the Challis study area, the best AIC_c determining the relationship between change in streambank alterations and animal groups was the model containing the "Horses" variable, suggesting a linear relationship with change in alterations (Table 2.9). This was strongly supported with the "Horses" model having high probability of occurrence (w_i = 0.94). The "Cattle" model had the second best AIC_c, but the model had minimal support with a very low Akaike weight (w_i = 0.03). This AIC_c output was also seen in Owyhee study area. The best fitting

AIC_c model was “Horses” with a very high Akaike weight (w_i = 0.94), followed by the “Cattle” model which again had low support (w_i = 0.13).

Table 2.9 The animal combinations model outputs for LME and AIC model to determine the combination that best predicts the change in streambank alterations for 8 stream reaches within two study areas (Challis and Owyhee); “H” = Wild horses, “C” = Cattle, and “W” = Wildlife

Streambank Alterations								
Study Area	**Model Combination**		**LME *P-value***	**Parameter**	**AIC Rank**	**AIC**	**Δi**	***wi***
Challis	**Horses**		0.069	0.0119	1	141.61	0	0.94
	Cattle		0.764	-0.0004	2	148.24	7	0.03
	H&W	Horses	0.052	0.0208	3	149.19	8	0.02
		Wildlife	0.260	-0.0381				
	Total		1.000	0.0000	4	151.28	10	0.01
	H&C	Horses	0.052	0.0130	5	156.52	15	0.00
		Cattle	0.360	-0.0012				
	C&W	Cattle	0.363	-0.0014	6	156.68	15	0.00
		Wildlife	0.294	0.0272				
	H&C&W	Horses	0.075	0.0203	7	165.20	24	0.00
		Cattle	0.915	-0.0002				
		Wildlife	0.363	-0.0354				
Owyhee	**Horses**		0.019	0.0043	1	161.26	0	0.94
	Cattle		0.085	0.0015	2	165.18	4	0.13
	H&W	Horses	0.030	0.0050	3	167.60	6	0.04
		Wildlife	0.550	-0.0600				
	Total		0.300	0.0002	4	169.96	9	0.01
	C&W	Cattle	0.110	0.0014	5	171.42	10	0.01
		Wildlife	0.340	0.0765				
	H&C	Horses	0.040	0.0037	6	175.75	14	0.00
		Cattle	0.180	0.0011				
	H&C&W	Horses	0.070	0.0040	7	182.97	22	0.00
		Cattle	0.210	0.0010				
		Wildlife	0.640	-0.0500				

Wild horses' best predicted the change in streambank alterations. The LME model showed wild horses increasing the level of streambank alteration, while ranking the highest in the AIC model. This relationship was documented for both study areas (Challis and Owyhee).

Horses were observed using the streams every month during sampling, April through October depending on the study area. In Challis, horse presence slowly increased from June to August, and then increased again in October. The trend for wild horse presence closely corresponds with the change in streambank alterations. Cattle arrived in June and their numbers increased until August, with few animal adding to cattle presence in September. The October cattle numbers are only represented by two of Challis stream reaches, since the other two cameras were not accessible in October. The increase in percent of bank altered followed cattle presence but only in July, by the time the second increase in percent of bank altered occurred cattle numbers were stagnate.

In the Owyhee study area, wild horse numbers increased from April to August, but their numbers increase by 50% from June to July. During this same time the percent of altered streambank was at its highest. Horse numbers continued to increase over every month following the same trend seen in the increase percent of bank altered. The presence of cattle increased from May to June, only to increase again from July to August. Like horses, cattle numbers are increasing at the same time as percent of bank altered increases. However, horse numbers are increasing at a higher proportion to their total as compared to cattle and therefore are predicted to have more affect. Wildlife did not appear in great numbers, at either of the study locations, and in comparison with wild horse or cattle the effects of wildlife were negligible.

The impacts from trampling by large ungulates is well documented and has been found to be harmful to some ecosystem processes by reducing plant vigor, decreasing water infiltration, reducing soil strength and porosity, and increasing soil compaction (Kauffman and Krueger, 1984; Orodho et al. 1990; Clary, 1995; Trimble and Mendel, 1995). This study's results found wild horse presence best predicted change in streambank alterations. This study's look into the effect of wild horses on streambank alteration is relatively new investigation. However, multiple studies have documented wild horse presence leading to higher soil-surface penetration resistance as compared to areas without horses (Beever and Herrick, 2006; Davies et al., 2014). Turner (1987) found that trampling in Georgia marshes changed soil composition. Some even believe trampling to be the most harmful bi-product of wild horse presence (Turner, 1987; Rheinhardt and Rheinhardt, 2004; Davis et al., 2014).

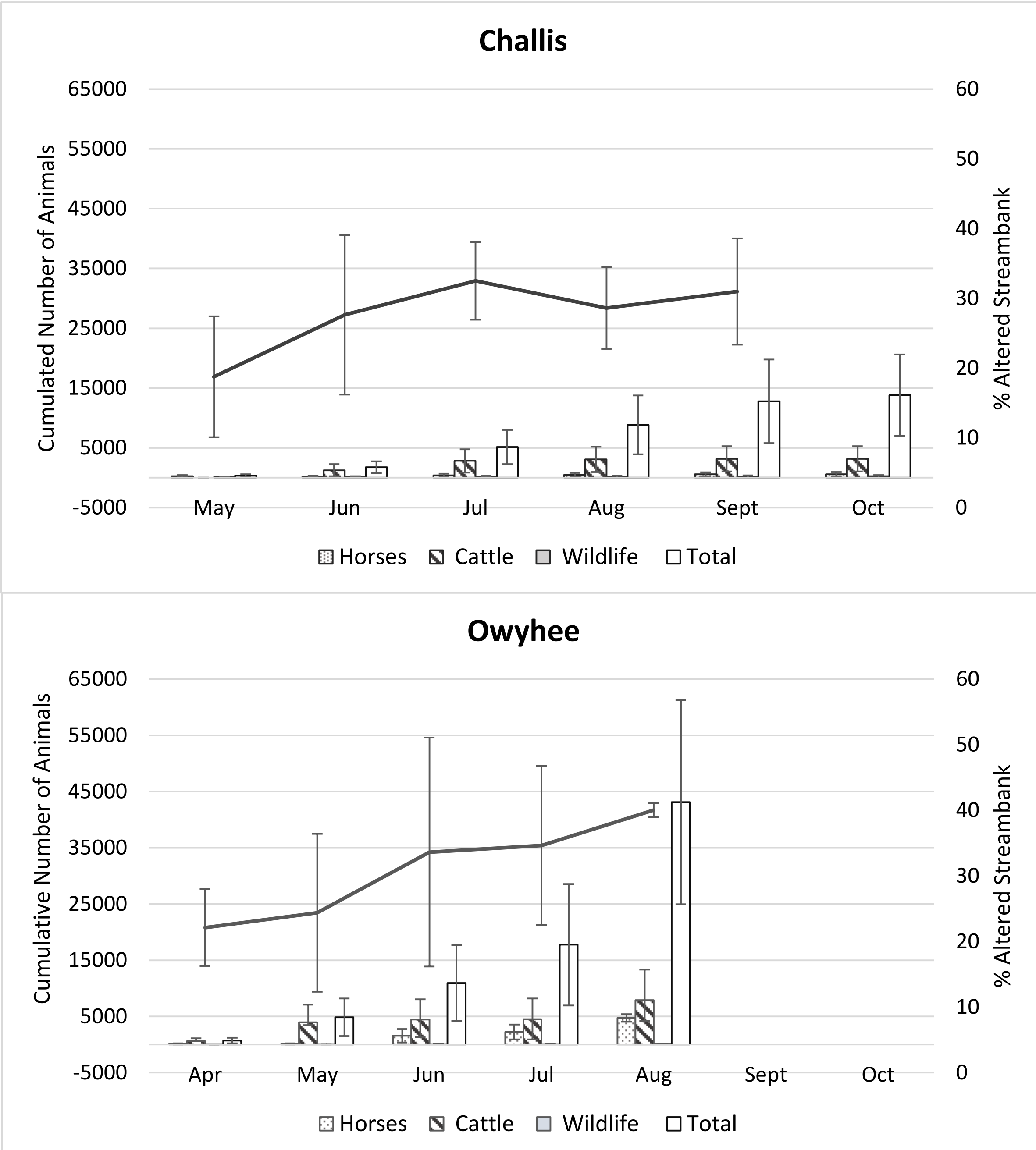

Figure 2.10 Comparison of the two study areas (Challis and Owyhee) by month. The relationship between the number of animals observed and changes in stubble height can be inferred, with the bars depicting the cumulative number of animals observed (wild horses, cattle, wildlife, and total) each month and the line indicating percent of streambank alteration.

Animal Presence on Herbaceous Stubble Height

In Challis, the "Horses" model had the best AIC_c and was determined to be the best model for determining the relationship between animal presence and stubble height (Table

2.10). This was strongly supported with “Horses” model having high probability of occurrence (w_i = 0.94). The “Cattle” model had the second best AIC_c, but the model had minimal support with a low Akaike weight (w_i = 0.15). Very similar results were found for “Total” number of animal present. It was ranked third in AIC_c, but it was equally as relative to the best model as “Cattle”, and had Akaike weight within 0.002 of “Cattle”. This same AIC_c output also occurred in Owyhee study area, with “Horses” having the best fitting AIC_c model (w_i = 0.94), followed by equally ranked “Cattle” (w_i = 0.16) and “Total” (w_i = 0.11).

The change in herbaceous stubble height was best predicted by Wild horse presence. The LME model showed wild horses decreasing the height of stubble, while ranking the highest in the AIC model (Figure 2.11). This relationship was documented for both of the study areas (Challis and Owyhee).

Table 2.10 The animal combinations model outputs for LME and AIC model to determine the combination that best predict the change in stubble height for 8 stream reaches within two study sites (Challis and Owyhee); "H" = Wild horses, "C" = Cattle, and "W" = Wildlife

Herbaceous Stubble Height								
Study Area	**Model Combination**		**LME *P-value***	**Parameter**	**AIC Rank**	**AIC**	**Δi**	***wi***
Challis	**Horses**		0.107	-0.0029	1	130.66	0	0.94
	Cattle		0.007	-0.0019	2	134.33	4	0.15
	Total		0.051	-0.0003	3	134.59	4	0.13
	H&W	Horses	0.909	-0.0005	4	140.48	10	0.01
		Wildlife	0.600	-0.0083				
	C&W	Cattle	0.352	-0.0009	5	143.86	13	0.00
		Wildlife	0.254	-0.0133				
	H&C	Horses	0.072	-0.0032	6	146.62	16	0.00
		Cattle	0.159	-0.0004				
	H&C&W	Horses	0.952	-0.0003	7	156.70	26	0.00
		Cattle	0.320	-0.0010				
		Wildlife	0.501	-0.0124				
Owyhee	**Horses**		0.053	-0.0014	1	133.59	0	0.94
	Total		0.040	-0.0002	2	137.15	4	0.16
	Cattle		0.368	-0.0003	3	137.95	4	0.11
	H&W	Horses	0.050	-0.0020	4	141.15	8	0.02
		Wildlife	0.310	0.0400				
	C&W	Cattle	0.330	-0.0003	5	146.61	13	0.00
		Wildlife	0.630	-0.0200				
	H&C	Horses	0.070	-0.0010	6	151.38	18	0.00
		Cattle	0.380	-0.0002				
	H&C&W	Horses	0.090	-0.0020	7	160.04	26	0.00
		Cattle	0.710	-0.0001				
		Wildlife	0.420	0.0400				

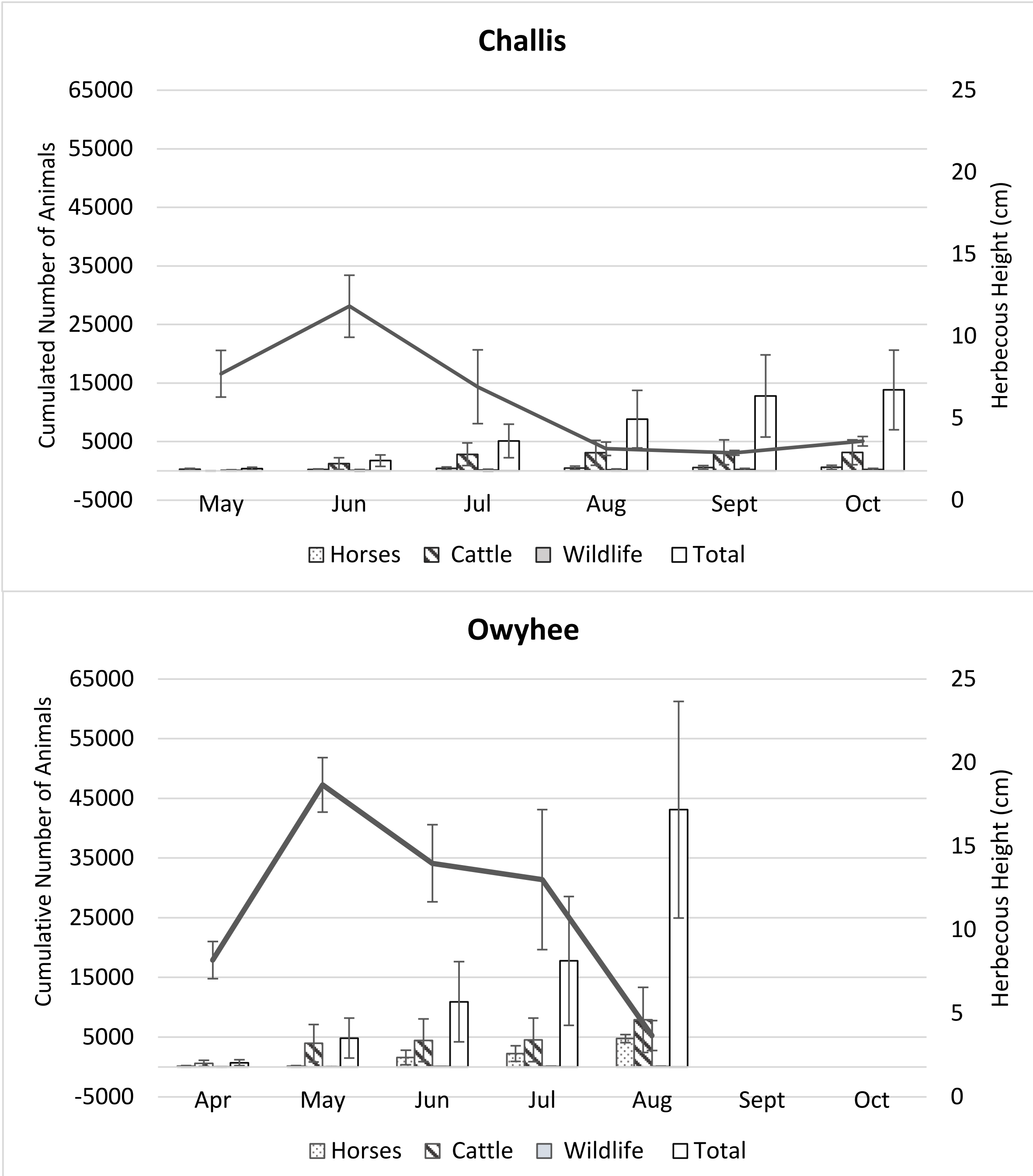

Figure 2.11 Comparison of the two study areas (Challis and Owyhee) by month. The relationship between the number of animals observed and changes in stubble height can be inferred, with the bars depicting the cumulative number of animals observed (wild horses, cattle, wildlife, and total) each month and the line indicating percent of stubble height.

In Challis, wild horse numbers slowly increased from May to October. Stubble high peaked in June and then rapidly declined from June to August when it then proceeds to plateau until October. Wild horse presence increased from June to August while stubble height is decreased demonstrating a reverse trend. Cattle were first seen in June, which corresponds to the start of stubble reduction, and remained constant through August when stubble height hits its lowest point. However, cattle number increased again in September with very little reduction of stubble height.

A similar trend was also seen in the Owyhee study area with horses and cattle presence closely following the trend of the reduction of stubble height. Stubble height reached its highest point in May with a gradual reduction of height starting in June. Wild horses were present through the entire sampling period. However, their numbers steadily increase from May to August which corresponds to the reduction of stubble height. Cattle presence was first seen in June which also corresponds with the reduction of stubble height. From May to July cattle presence remain similar, only to increase substantially in August. This sharp increase in cattle presence was reflected in the sharp decline in stubble height from July to August.

These results agree with previous studies which showed horse presence significantly reduced standing biomass, reduce plant presence, lowered species richness, and plant cover (Beever and Brussard, 2000; Levin et al., 2002; Berver and Herrick, 2006; USFW, 2014). On European wetlands, horses were reported using plants intensively and impacting a greater number of plant species than cattle (Menard et al., 2002). Drastic responses have been observed at the Sheldon National Wildlife Refuge in Nevada, where stubble height was nearly 10 times greater in ungrazed plants when compared to grazed plants after wild horses were gathered, and grazing pressures reduced (USFW, 2014). Likewise, Beever and Bussard (2000) compared plant heights in upland meadows under three scenarios: 1) no grazing, 2) horses grazing only, and 3) both cattle and horses grazing. Plant heights in areas grazed by horses only were 2.8 times lower than plant heights in areas with no grazing, while plant heights in areas grazed by both horses and cattle were 4.5 times lower than those in area with no grazing (Beever and Bussard, 2000).

Animal Presence on Percent Utilization

When the LME model was run to determine what combination of animal groups had the best relationship with change in utilization by month results with AIC_c differed between the Challis and Owyhee study areas. In Challis, the best AIC_c model contained “Horses” model (Table 2.11). This “Horses” model was strongly supported with a high probability of occurrence (w_i = 0.94). Models with “Cattle” and “Total” were ranked next within the AIC_c. The “Cattle” model had the second best AIC_c, but the model had minimal support with a low Akaike weight (w_i = 0.22). In third, was the “Total” animal model, this also had minimal support weight (w_i = 0.15).

However, this was not the case for the Owyhee study area. The best fitting AIC_c model was “Cattle”, which had strong support with Akaike weight (w_i = 0.94), followed by the “Horses” model which had moderate support (w_i = 0.39). The “Cattle and Wildlife” model AIC_c was within 1.3 of the “Horses” model AIC_c but only had half of the support.

Wild horses in Challis, and Cattle in Owyhee, best predicted the change in utilization. In Challis, wild horses were observed using the streams every month during the sampling, May through October (Figure 2.12). The number of wild horses increased from June to August, and then increased again in October. The trend for increased wild horse

Table 2.11 The animal combinations model outputs for LME and AIC model to determine the combination that best predict the change in utilization for 8 stream reaches within two study sites (Challis and Owyhee); "H" = Wild horses, "C" = Cattle, and "W" = Wildlife

Utilization								
Study Area	**Model Combination**		**Lme *P-value***	**Parameter**	**AIC Rank**	**AIC**	**Δi**	***wi***
Challis	**Horses**		0.146	0.0292	1	199.8662	0	0.94
	Cattle		0.138	0.0031	2	202.7881	3	0.22
	Total		0.065	0.0014	3	203.531	4	0.15
	H&W	Horses	0.551	0.0215	4	205.8244	6	0.05
		Wildlife	0.644	0.0549				
	C&W	Cattle	0.343	0.0038	5	209.5208	10	0.01
		Wildlife	0.162	0.0966				
	H&C	Horses	0.090	0.0335	6	211.0411	11	0.00
		Cattle	0.237	0.0046				
	H&C&W	Horses	0.364	0.0332	7	217.6754	18	0.00
		Cattle	0.292	0.0047				
		Wildlife	0.949	0.0077				
Owyhee	**Cattle**		0.000	0.0045	1	180.5899	0	0.94
	Horses		0.001	0.0122	2	182.3562	2	0.39
	C&W	Cattle	0.000	0.0050	3	183.984	3	0.17
		Wildlife	0.090	0.2011				
	Total		0.000	0.0014	4	184.5574	4	0.13
	H&C	Horses	0.001	0.0090	5	186.3357	6	0.05
		Cattle	0.002	0.0040				
	H&W	Horses	0.006	0.0100	6	187.3639	7	0.03
		Wildlife	0.540	-0.1200				
	H&C&W	Horses	0.008	0.0090	7	192.9859	12	0.00
		Cattle	0.002	0.0040				
		Wildlife	0.770	-0.0400				

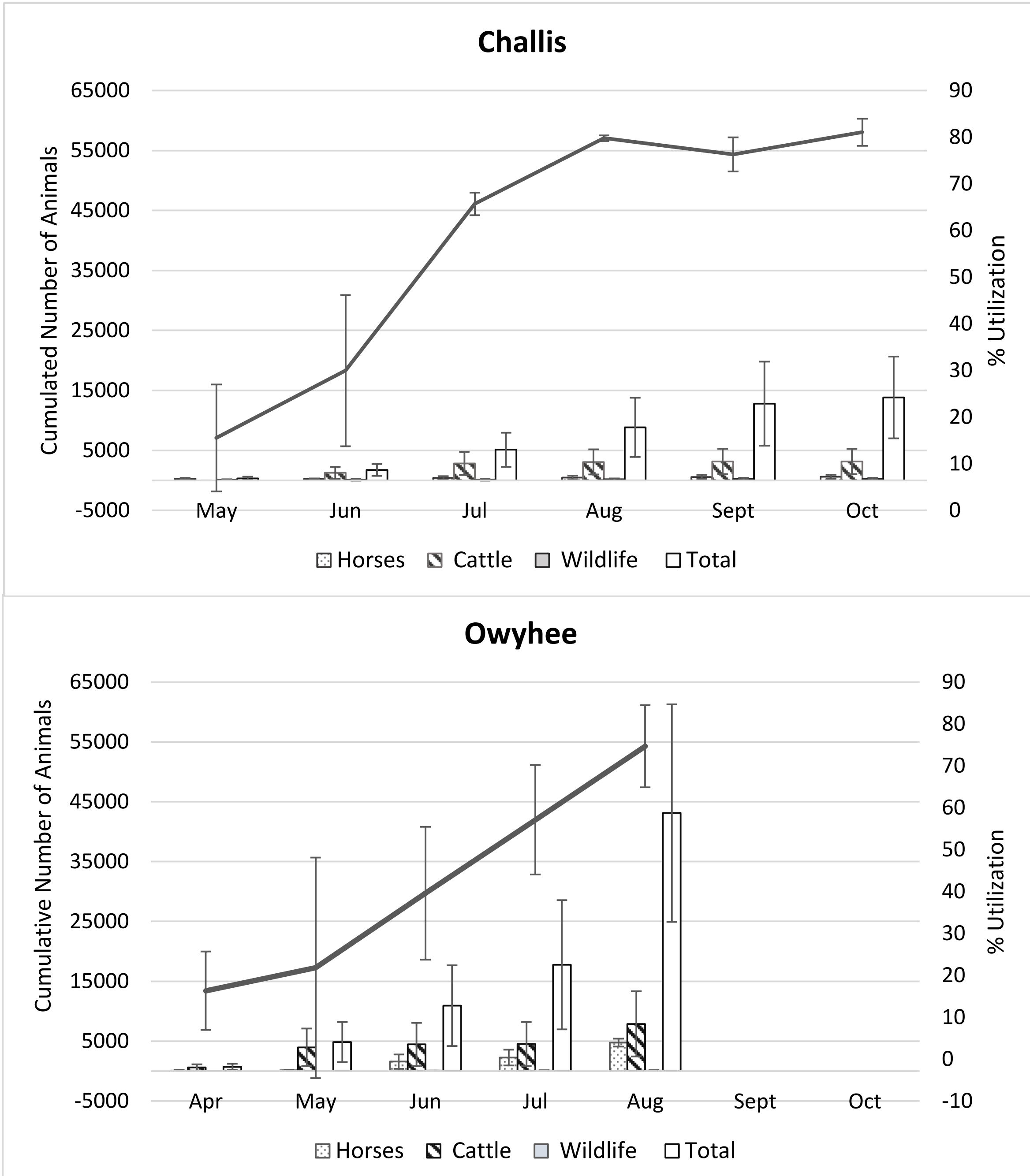

Figure 2.12 Comparison of the two study locations (Challis and Owyhee) by month. The relationship between the number of animals observed and changes in utilization can be inferred, with the bars depicting the cumulated number of animals observed (wild horses, cattle, wildlife, and total) each month and the line indicating percent of utilization.

presence corresponds with the sharp increased utilization from June to July. Utilization again increased in October, which corresponds with a jump in wild horse numbers. Cattle arrived in June and their numbers increased until August, with few animal added to cattle presence in September. The October cattle numbers were only represented by two of Challis stream reaches, since the other two cameras were not accessible in October. Cattle presence was followed by the sharp increase of utilization from June to August, but cattle number remain relatively the same from July to September.

In the Owyhee study area, cattle presence closely following the trend of the increased utilization. Cattle were first seen in April but their numbers quadrupled in May, this corresponded with a rapid but steady increase of utilization from May to August. From June to July cattle presence remained constant, only to increase substantially in August. Again, increased utilization was documented following this increase in cattle presence. Wild horses were present through the entire sampling period. However, their numbers were low, increasing in June, remaining the same in July, and then increasing again in August.

The Challis study area result were consistent with Menard et al. (2002) who also observed horses using many plant species to a greater extent than cattle in European wetlands. Other studies have documented decreasing biomass production with up to 100% biomass loss in marshes (Turner, 1987; Rheinhardt and Rheinhardt, 2004; Porter et al., 2014). However, in Owyhee “Cattle” were the best to predict change in utilization. Cattle have been documented congregating in riparian areas and often removing large amounts of forage (Belsky et al., 1999). Roath and Krueger (1982) documented cattle use of riparian areas in an Oregon grazing allotment. Only 1.9% of the allotment was designed riparian area but produced 21% of the available biomass, 81% of which was utilized by livestock. Livestock have been known to prefer wet meadows, utilizing 60-80% of the available forage produced with mean stubble heights ranging from 4- to 14-cm depending on plant species (Kauffman et al., 1983).

Relation Between of Animal Species Observed on Streams

To determine the relationships between the presence of one animal species on another Spearman's rank correlation coefficient (rho = ρ) was used to accounted for any non-linear correlations.

Effect of Cattle Presence on Wild Horses

In the Challis study area no relationship was found between the presence of wild horses and cattle ($\rho = 0.191$; $P = 0.418$). This was also seen in Owyhee study area, were there was no relationship between the number of wild horse detections and the number of cattle detections ($\rho = 0.083$; $P = 0.726$).

Effect of Wild Horse Presence on Wildlife

In Challis, the number of wild horses observed in photos was not related to the wildlife observed ($\rho = 0.306$; $P = 0.189$), nor were they related in the Owyhee study area ($\rho = 0.130$; $P = 0.582$).

Effect of Cattle Presence on Wildlife

In the Challis study area there was no relationship between the presence of cattle and the presence of wildlife ($\rho = -0.208$; $P= 0.376$). No relationship between cattle and wildlife was seen in Owyhee either ($\rho = -0.343$; $P= 0.138$).

It is possible that the level, by month, at which we choose to analyze animals' presence may be to crude to detect any relationships. With that said, at the month level there were no correlations seen between the detections any of the three animal groups presence for this study.

In previous studies looking at the effect of wild horse presence at riparian areas and wildlife reported; the presence of horses had either negative effects or indirect effects on wildlife (McInnis and Vavra, 1987; Levin et al., 2002; Ostermann-Kelm et al., 2008; Gooch, 2014). For example, the presence of horses at water sources will displace some wildlife species (pronghorn and bighorn sheep) keeping them from drinking, but not others (sage grouse or coyotes; Ostermann-Kelm et al., 2008; Girard et al., 2013; Gooch, 2014; Hall et al., 2016). Nearly half of all interactions between horses and pronghorn at water resulted in pronghorn leaving the riparian area (Gooch, 2014). Domestic horses placed near water sites utilized by bighorn sheep resulted in a 76% decline in sheep attendance at water (Ostermann-Kelm et al., 2008). In Georgia marshes, horse presence altered the number and species of animals (increase diversity of birds, larger density of crabs, and lower density and richness of fish) using marshes (Levin et al., 2002).

When anlyazing presence influence at such a broad level, it does not account for the known variation of use and dependency of the stream reach by species (National Research Council, 2013; Miller, 1983; McInnis and Vavra, 1987; Gooch, 2014). Horses are known to go farther from water sources than cattle (National Research Council, 2013). Horses and cattle are known to stay within a determined distance from a water source, roughly 4.8 km (Miller 1983). Horses may go to water anywhere from twice a day to as little as once every 3 days (Meeker, 1979; Greyling et al, 2007; National Research Council, 2013). Preference to going to water at certain times of day was displayed by horses, cattle, and pronghorn in Oregon. Horses preferred to go to water between noon and sunset, while cattle watered between 0800 and 1700 hrs. Pronghorn went to water shortly after sunrise (McInnis and

Vavra, 1987). It was observed that when cattle were present horses spent significantly more time at water, while pronghorn spent significantly less.

Other factors can affect the presence of animals in riparian areas including temperature, access to site, water availability, and forage availability (National Research Council, 2013). None of these factors were considered in this study and may be important to consider in future research.

Conclusion

This study supports the concept that wild horses have effects on streambank alterations, herbaceous stubble height, and utilization that may be equivalent or surpass that of cattle, especially effects on riparian condition. This is likely due to horses use stream reached longer than cattle, a year-long presence. There were still observed effects on the riparian attributes on stream reaches where cattle were not present during this study only wild horses. Menard et al. (2002) also documented that horse close cropping (sometimes delays the recovery of plants), high rate of biomass removal could affected plants in wetlands to a greater extent than cattle. This was supported by by Rheinhardt and Rheinhardt (2004), who also found horses effecting vegetation through cropping and trampling. Porter et al. (2014) reported horse having a harmful effect on plants and their growth rates, and suggested that negative effect on plant growth would increase as wild horse populations increased. This suggests that wild horses should be of concern for managers especially considering the fact that horse populations continue to grow in many areas. Good management of riparian area may be hindered by the constant presence of wild horses. With an increased understanding of the impact wild horses have on rangelands, land managers can better develop management plans that protect riparian areas, as well as, mitigate damage to wildlife habitat and ensure continued access by invested ranchers. This knowledge may also help the BLM increase the quality of habitat conditions for wild horses by accurately measuring the sustainable carrying capacity of the land.

Future studies are necessary to understand the dynamics occurring between wild horses and cattle while using the same rangeland. A few studies have looked at the impacts made by wild horses separately from other ungulates and have found that when present they negatively impacted plants and plant communities through high biomass removal (Rheinhardt and Rheinhardt 2004; Porter et al. 2014), lowering plant species richness, and reduced cover of grasses and forbs (Beever and Brussard 2000, Levin et al. 2002; Beever and Herrick 2006). It is important to continue to gather information on how the impacts of wild horses and cattle may differ, and the compounded effects of concurrent use by both species. This study was designed to be exploratory and could not directly link specific changes in riparian attributes to specific animal groups (wild horses, cattle, or wildlife). To directly attribute these changes a treatment study would be needed where animal numbers were manipulated. A better understanding of wild horse use of riparian area would need to be as intense in a concentrated area. Being able to track individual movement for cattle and wild horses, through the use of GPS collars would add to our understanding of their behavioral and temporal relationship on the landscape. During the course of this study, the potentially harmful effects of human recreation (e.g., mudding with trucks) could be having a more substantial effect to riparian condition. Limited information is available on the effect of human recreation on riparian areas.

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Appendix

Table 1: Floral Checklist for Sand Basin

Common Name	Scientific Name
Forbs	
Alkali buttercup	*Ranunculus cymbalaria* Pursh
American speedwell	*Veronica americana* Schwein. Ex Benth.
Bull thistle	*Cirsium vulgare* (Savi) Ten.
Bur buttercup	*Ceratocephala testiculata (*Crantz) Roth
Cattail	*Typha latifolia* L.
Clover	*Trifolium* L.
Common dandelion	*Taraxacum officinale* F.H. Wigg.
Common plantain	*Plantago major* L.
Common yellow monkeyflower	*Mimulus guttatus* DC.
Curly dock	*Rumex crispus* L.
Cursed buttercup	*Ranunculus sceleratus* L.
Fuller's teasel	*Dipsacus fullonum* L.
Lambsquarters	*Chenopodium album* L.
Maiden blue eyed Mary	*Collinsia parviflora* Lindl.
Perennial pepperweed	*Lepidium latifolium* L.
Pincushionplant	*Navarretia* Ruiz & Pav.
Redstem stork's bill	*Erodium cicutarium* (L.) L'Hér. ex Aiton
Rough cocklebur	*Xanthium strumarium* L.
Spring draba	*Draba verna* L.
Willowherb	*Epilobium* L.
Grasses	
Annual rabbitsfoot grass	*Polypogon monspeliensis* (L.) Desf.
Barley	*Hordeum* L.
Kentucky bluegrass	*Poa pratensis* L.
Meadow foxtail	*Alopecurus pratensis* L.
Saltgrass	*Distichlis spicata* (L.) Greene
Water whorlgrass	*Catabrosa aquatica* (L.) P. Beauv.
Grass-likes	
Baltic rush	*Juncus balticus* Willd.
Sedge	*Carex* L.

List compiled by Justin J.
Trujillo

Table 2: Floral Checklist for Wilson Creek

Common Name	Scientific Name
Trees	
Cottonwood	*Populus* L.
Coyote willow	*Salix exigua* Nutt.
Willow	*Salix* L.
Shrubs	
Green rabbitbrush	*Chrysothamnus viscidiflorus* (Hook.) Nutt.
Rubber rabbitbrush	*Ericameria nauseosa* (Pall. ex Pursh) G.L. Nesom & Baird
Wild rose	*Rosa woodsii* Lindl.
Wyoming big sagebrush	*Artemisia tridentata* Nutt. subsp. *wyomingensis* Beetle & Young
Forbs	
Alkali buttercup	*Ranunculus cymbalaria* Pursh
American speedwell	*Veronica americana* Schwein. Ex Benth.
Bull thistle	*Cirsium vulgare* (Savi) Ten.
Bur buttercup	*Ceratocephala testiculata* (Crantz) Roth
Cattail	*Typha latifolia* L.
Common dandelion	*Taraxacum officinale* F.H. Wigg.
Common mullein	*Verbascum thapsus* L.
Common plantain	*Plantago major* L.
Common yellow monkeyflower	*Mimulus guttatus* DC.
Curly dock	*Rumex crispus* L.
Cursed buttercup	*Ranunculus sceleratus* L.
Goldenrod	*Solidago* L.
Horsetail	*Equisetum* L.
Rough cocklebur	*Xanthium strumarium* L.
Sweetclover	*Melilotus officinalis* (L.) Lam.
Watercress	*Nasturtium officinale* W.T. Aiton
Western white clematis	*Clematis ligusticifolia* Nutt.
Western yarrow	*Achillea millefolium* L.
White sagebrush	*Artemisia ludoviciana* Nutt.
Yellow salsify	*Tragopogon dubius* Scop.
Grasses	
Annual rabbitsfoot grass	*Polypogon monspeliensis* (L.) Desf.
Cheatgrass	*Bromus tectorum* L.
Field brome	*Bromus arvensis* L.
Kentucky bluegrass	*Poa pratensis* L.
Saltgrass	*Distichlis spicata* (L.) Greene

Squirreltail	*Elymus elymoides* (Raf.) Swezey
Grass-likes	
Baltic rush	*Juncus balticus* Willd.

List compiled by Justin J.
Trujillo

Table 3: Floral Checklist for Farrot Creek

Common Name	Scientific Name
Trees	
Alder	*Alnus* Mill.
Willow	*Salix* L.
Shrubs	
Antelope bitterbrush	*Purshia tridentata* (Pursh) DC.
Black hawthorn	*Crataegus douglasii* Lindl.
Golden currant	*Ribes aureum* Pursh
Wild rose	*Rosa woodsii* Lindl.
Wyoming big sagebrush	*Artemisia tridentata* Nutt. subsp. w*yomingensi*s Beetle & Young
Forbs	
Alkali buttercup	*Ranunculus cymbalaria* Pursh
American speedwell	*Veronica americana* Schwein. ex Benth.
Bull thistle	*Cirsium vulgare* (Savi) Ten.
Canada thistle	*Cirsium arvense* (L.) Scop.
Cinquefoil	*Potentilla* L.
Common dandelion	*Taraxacum officinale* F.H. Wigg.
Common mullein	*Verbascum thapsus* L.
Common plantain	*Plantago major* L.
Common St. Johnswort	*Hypericum perforatum* L.
Common yellow monkeyflower	*Mimulus guttatus* DC.
Curly dock	*Rumex crispus* L.
Cursed buttercup	*Ranunculus sceleratus* L.
Fernleaf biscuitroot	*Lomatium dissectum* (Nutt.) Mathias & Constance
Fiddleneck	*Amsinckia* Lehm.
Grand collomia	*Collomia grandiflora* Douglas ex Lindl.
Horsetail	*Equisetum* L.
Maiden blue eyed Mary	*Collinsia parviflora* Lindl.
Miner's lettuce	*Claytonia perfoliata* Donn ex Willd.
Mouse-ear chickweed	*Cerastium vulgatum* L.
Mustard	*Brassica* L.
Onion	*Allium* L.
Pea	*Lathyrus* L.
Prickly lettuce	*Lactuca serriola* L.
Redstem stork's bill	*Erodium cicutarium* (L.) L'Hér. ex Aiton
Spring draba	*Draba verna* L.
Stickywilly	*Galium aparine* L.
Sweetclover	*Melilotus officinalis* (L.) Lam.

Tall annual willowherb	*Epilobium brachycarpum* C. Presl
Watercress	*Nasturtium officinale* W.T. Aiton
Western columbine	*Aquilegia formosa* Fisch. ex DC.
Western white clematis	*Clematis ligusticifolia* Nutt.
Western yarrow	*Achillea millefolium* L.
White sagebrush	*Artemisia ludoviciana* Nutt.
Willowherb	*Epilobium* L.
Yellow salsify	*Tragopogon dubius* Scop.
Grasses	
Basin wildrye	*Leymus cinereus* (Scribn. & Merr.) Á. Löve
Blue wildrye	*Elymus glaucus* Buckley
Bulbous bluegrass	*Poa bulbosa* L.
Cheatgrass	*Bromus tectorum* L.
Fescue	*Vulpia* C.C. Gmel.
Field brome	*Bromus arvensis* L.
Kentucky bluegrass	*Poa pratensis* L.
Medusahead	*Taeniatherum caput-medusae* (L.) Nevski
Grass-likes	
Baltic rush	*Juncus balticus* Willd.
Sedge	*Carex* L.

List compiled by Justin J. Trujillo

Table 4: Floral Checklist for Black Mountain

Common Name	Scientific Name
Trees	
Coyote willow	Salix exigua Nutt.
Willow	Salix L.
Shrubs	
Rubber rabbitbrush	Ericameria nauseosa (Pall. ex Pursh) G.L. Nesom & Baird
Greasewood	Sarcobatus vermiculatus (Hook.) Torr.
Wyoming big sagebrush	Artemisia tridentata Nutt. subsp. wyomingensis Beetle & Young
Forbs	
American speedwell	Veronica americana Schwein. ex Benth.
Bull thistle	Cirsium vulgare (Savi) Ten.
Bur buttercup	Ceratocephala testiculata (Crantz) Roth
Canada thistle	Cirsium arvense (L.) Scop.
Common dandelion	Taraxacum officinale F.H. Wigg.
Curly dock	Rumex crispus L.
Fiddleneck	Amsinckia Lehm.
Horehound	Marrubium vulgare L.
Horsetail	Equisetum L.
Lambsquarters	Chenopodium album L.
Mustard	Brassica L.
Redstem stork's bill	Erodium cicutarium (L.) L'Hér. ex Aiton
Spiny sowthistle	Sonchus asper (L.) Hill
Western white clematis	Clematis ligusticifolia Nutt.
White sagebrush	Artemisia ludoviciana Nutt.
Whitetop	Cardaria draba (L.) Desv.
Grasses	
Annual rabbitsfoot grass	Polypogon monspeliensis (L.) Desf.
Basin wildrye	Leymus cinereus (Scribn. & Merr.) Á. Löve
Cheatgrass	Bromus tectorum L.
Kentucky bluegrass	Poa pratensis L.
Saltgrass	Distichlis spicata (L.) Greene
Witchgrass	Panicum capillare L.
Grass-likes	
Baltic rush	Juncus balticus Willd.
Sedge	Carex L.

List compiled by Justin J. Trujillo

Table 5: Floral Checklist for Lower Horse Basin

Common Name	Scientific Name
Trees	
Willow	Salix L.
Shrubs	
Sagebrush	Artemisia L.
Forbs	
Alkali buttercup	Ranunculus cymbalaria Pursh
Aster	Aster L.
Blue-eyed grass	Sisyrinchium L.
Common dandelion	Taraxacum officinale F.H. Wigg.
Common plantain	Plantago major L.
Coon's tail	Ceratophyllum demersum L.
Curly dock	Rumex crispus L.
Dwarf hesperochiron	Hesperochiron pumilus (Douglas ex Griseb.) Porter
Horsetail	Equisetum L.
Milkvetch	Astragalus L.
Nettleleaf giant hyssop	Agastache urticifolia (Benth.) Kuntze
Pussytoes	Antennaria Gaertn.
Rocky Mountain iris	Iris missouriensis Nutt.
Shootingstar	Dodecatheon L.
Willowherb	Epilobium L.
Grasses	
Meadow barley	Hordeum brachyantherum Nevski
Saltgrass	Distichlis spicata (L.) Greene
Sandberg bluegrass	Poa secunda J. Presl
Slender wheatgrass	Elymus trachycaulus (Link) Gould ex Shinners
Tufted hairgrass	Deschampsia cespitosa (L.) P. Beauv.
Grass-likes	
Baltic rush	Juncus balticus Willd.
Common spikerush	Eleocharis palustris (L.) Roem. & Schult.
Nebraska sedge	Carex nabrascensis Dewey
Northwest Territory sedge	Carex utriculata Boott
Rush	Juncus L.
Sedge	Carex L.

List compiled by Justin J. Trujillo

Table 6: Floral Checklist for Road Creek

Common Name	Scientific Name
Trees	
Booth's willow	Salix boothii Dorn
Willow	Salix L.
Shrubs	
Wild rose	Rosa woodsii Lindl.
Forbs	
Alkali buttercup	Ranunculus cymbalaria Pursh
Blue-eyed grass	Sisyrinchium L.
Cinquefoil	Potentilla L.
Clover	Trifolium L.
Common dandelion	Taraxacum officinale F.H. Wigg.
Curly dock	Rumex crispus L.
Dwarf hesperochiron	Hesperochiron pumilus (Douglas ex Griseb.) Porter
Field horsetail	Equisetum arvense L.
Hookedspur violet	Viola adunca Sm.
Milkvetch	Astragalus L.
Monkeyflower	Mimulus L.
Pussytoes	Antennaria Gaertn.
Rocky Mountain iris	Iris missouriensis Nutt.
Shootingstar	Dodecatheon L.
Starry false lily of the valley	Maianthemum stellatum (L.) Link
Western columbine	Aquilegia formosa Fisch. ex DC.
White clover	Trifolium repens L.
Willowherb	Epilobium L.
Yellow salsify	Tragopogon dubius Scop.
Grasses	
Sandberg bluegrass	Poa secunda J. Presl
Tufted hairgrass	Deschampsia cespitosa (L.) P. Beauv.
Grass-likes	
Baltic rush	Juncus balticus Willd.
Nebraska sedge	Carex nabrascensis Dewey
Northwest Territory sedge	Carex utriculata Boott
Rush	Juncus L.
Sedge	Carex L.
Woolly sedge	Carex pellita Muhl. ex Willd.

List compiled by Justin J. Trujillo

Table 7: Floral Checklist for Corral Basin

Common Name	Scientific Name
Trees	
Willow	Salix L.
Shrubs	
Currant	Ribes L.
Sagebrush	Artemisia L.
Shrubby cinquefoil	Dasiphora fruticosa (L.) Rydb.
Forbs	
Alkali buttercup	Ranunculus cymbalaria Pursh
Aster	Aster L.
Bluebells	Mertensia Roth
Blue-eyed grass	Sisyrinchium L.
Clover	Trifolium L.
Common dandelion	Taraxacum officinale F.H. Wigg.
Dwarf hesperochiron	Hesperochiron pumilus (Douglas ex Griseb.) Porter
Hookedspur violet	Viola adunca Sm.
Milkvetch	Astragalus L.
Pussytoes	Antennaria Gaertn.
Ragwort	Senecio L.
Rocky Mountain iris	Iris missouriensis Nutt.
Shootingstar	Dodecatheon L.
Willowherb	Epilobium L.
Grasses	
Meadow barley	Hordeum brachyantherum Nevski
Tufted hairgrass	Deschampsia cespitosa (L.) P. Beauv.
Grass-likes	
Baltic rush	Juncus balticus Willd.
Nebraska sedge	Carex nabrascensis Dewey
Northwest Territory sedge	Carex utriculata Boott
Rush	Juncus L.
Sedge	Carex L.

List compiled by Justin J. Trujillo

Table 8: Floral Checklist for Horse Basin

Common Name	Scientific Name
Trees	
Booth's willow	Salix boothii Dorn
Shrubs	
Currant	Ribes L.
Sagebrush	Artemisia L.
Forbs	
Alkali buttercup	Ranunculus cymbalaria Pursh
Aster	Aster L.
Cinquefoil	Potentilla L.
Clover	Trifolium L.
Common dandelion	Taraxacum officinale F.H. Wigg.
Rocky Mountain iris	Iris missouriensis Nutt.
Western yarrow	Achillea millefolium L.
Grasses	
Meadow barley	Hordeum brachyantherum Nevski
Tufted hairgrass	Deschampsia cespitosa (L.) P. Beauv.
Grass-likes	
Baltic rush	Juncus balticus Willd.
Nebraska sedge	Carex nabrascensis Dewey
Northwest Territory sedge	Carex utriculata Boott
Sedge	Carex L.

List compiled by Justin J. Trujillo