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Meta-Analysis of Diet Composition and Potential Conflict of Wild Horses with Livestock and Wild Ungulates on Western Rangelands of North America[☆]

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ABSTRACT

Wild horse (*Equus ferus caballus*) management in western North America is an escalating concern for ecological integrity on these landscapes. Identifying potential diet overlap among horses, livestock, and wildlife will inform management decisions to optimize multiple interests. To understand dietary relationships, we conducted a quantitative synthesis of microhistological fecal studies for wild horse, beef cattle (*Bos* spp.), domestic sheep (*Ovis aries*), elk (*Cervus elaphus*), pronghorn (*Antilocapra americana*), and mule deer (*Odocoileus hemionus*) diet composition on western rangelands of North America. Our search yielded 60 studies from 14 states, 1 Canadian province, and 2 Mexican states with 392 unique species-season samples. We summarized plant species into graminoid, forb, and browse functional groups. For wild horses, seasonal diet composition means for graminoids (77–89%), forbs (4–15%), and browse (3–10%) did not vary seasonally for any plant group ($P \leq 0.05$). Univariate analyses and the calculation of effect sizes corroborated our finding that graminoid composition explained the potential overlap of wild horses with cattle regardless of season, with sheep and elk in the spring, with sheep in the summer, and with elk in the fall and winter. Although data indicate wild horse diets are primarily composed of graminoids, several studies reported unusual, regionally specific shifts in response to winter snow that limited graminoid accessibility, leading to higher browse composition. Season, plant composition, and ungulate assemblage may all influence dietary competition between wild horses and other large ungulate sharing western North American rangelands; however, the low and nonsignificant heterogeneity values at alpha 0.01 for cattle:horse effect size comparisons suggest that cattle and horses respond to regional and seasonal variation similarly—a result not observed for other ungulate:horse comparisons. Our meta-analysis provides a robust data set for evaluations of diet composition for wild horses, livestock, and wildlife, whereas no empirical studies have assessed all species together.

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Introduction

Management of wild horses (*Equus ferus caballus*) is an ecological and sociological issue of escalating concern on western North American rangelands and other areas of the world such as eastern North American salt marshes, Africa, Asia, Argentina, Australia, and New Zealand (Turner, 1988; Linklater et al., 2004; Zalba and Cozzani, 2004; Mallon and Zhigang, 2009; Hampson et al., 2010; Odadi et al., 2011). In North America, wild equids became extinct about 10 000 years ago, and extant wild horse populations are the result of

introductions of domesticated horses by Spaniards in the 1500s, repeated escapes from domestic herds, and successive commingling with present free-roaming herds (Haines, 1938; Wagner, 1983; Beaver, 2003). The Wild Free-Roaming Horses and Burros Act of 1971 directs the federal management of these wild equids as part of the natural system (Public Law 92-195). More recently, the Federal Land Policy and Management Act of 1976 (Public Law 94-579) and the Public Rangelands Improvement Act of 1978 (Public Law 95-514) have further established the enforcement authority of the Bureau of Land Management (BLM) to remove excess wild horses, from both public and private lands, when populations exceed appropriate management levels to maintain the ecological integrity of western rangelands.

Since 1971, the BLM has removed 195 000 wild horses from western rangelands and offered many of these horses to the public for adoption (Garrott and Oli, 2013). However, a struggling adoption program coupled with annual population growth rates that can exceed 20% has

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relegated many horses to temporary holding facilities (Eberhardt et al., 1982; Garrott and Taylor, 1990; Garrott et al., 1991). Removal of horses alone is not anticipated to effectively meet population objectives, and more recent strategies have included fertility control (Gross, 2000; Bartholow, 2010). As of March of 2015, there were approximately 47 329 wild horses and 10 821 wild burros roaming western rangelands, more than twice the national appropriate management levels of 26 715 wild horses and burros. Furthermore, there are currently 46 298 in temporary holding corrals or long-term pastures—as many that are currently free roaming (BLM, 2015). Federal expenditures for the adoption and relocation program in FY 2013 were \$76 million, with \$51 million accounting for holding, gathering, and removal costs. The annual cost of managing horses in temporary holding facilities is expected to exceed \$1 billion by 2030 (Garrot and Oli, 2013).

Management of the escalating wild horse population in the United States is critical because federal lands are mandated to be managed for multiple uses, including livestock grazing and providing habitat for native wildlife species (Bastian et al., 1991). Many studies have quantified diet composition of wild horses, but not all studies have compared wild horse diet composition with livestock and/or wildlife; they have only measured overlaps for a certain season of the year or for only a subset of co-occurring ungulates (Hansen, 1976; Hansen et al., 1977; Salter and Hudson, 1980; Krysl et al., 1984; Stephenson et al., 1985a). Further complicating wild horse management in some areas is the movement of horses across the largely unfenced matrix of public-private land ownership known as “checkerboard,” a relic of the Union Pacific Railroad (Calef, 1952). Evidence also suggests that wild horses may disproportionately use features of the landscape, such as riparian areas and wet meadows, more than other areas, thus having negative effects on riparian function (Crane et al., 1997; Hampson et al., 2010).

Given the burgeoning wild horse population, a federal mandate to manage for multiple uses, variation in diet compositional comparisons of wild horses with other ungulate across regions and seasons, and the inevitable seasonal diet overlap between wild horses and livestock and native wildlife, we sought to quantify diet overlap of the most common large rangeland ungulate in western North America. The primary objective of our study was to identify potential dietary overlap between wild horses and livestock and wild ungulates across seasons, geographical boundaries, and limitations of prior studies. We systematically reviewed and synthesized microhistological fecal studies for wild horse, beef cattle (*Bos* spp.), domestic sheep (*Ovis aries*), elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), and pronghorn (*Antilocapra americana*) diet composition on western rangelands of North America. To understand broad ecological interactions on western rangelands, we used univariate and meta-analytic effect size calculations to compare functional group diet composition of these six ungulate in spring, summer, fall, and winter and on an annual basis.

Materials and Methods

Literature Search Criteria

We searched the peer-refereed and gray literature (theses, dissertations, reports, and proceedings) using Google Scholar and Web of Science scholastic search engines for wild horse diet studies based on the following combinations of search terms: Animal species searched individually for “wild horse” (or “feral horse,” “horse,” or “equid” singularly), “cattle” (or “cow”), “sheep” (or “livestock”), “elk” (or “wapiti” or “Cervus”), “pronghorn” (or “antelope” or “Antilocapra”), “mule deer” (or “deer” or “Odocoileus”), and “ungulate” or “herbivore.” Each individual animal species term was also used in combination with “diet composition” and “microhistological,” and searches were conducted with and without the term “rangeland.” We also searched the bibliographies of relevant papers for other potential sources of data that might have been missed with the initial search protocol. To be included, studies must have presented percentage diet composition or availability data

for graminoid, forb, and browse plant functional groups and presented data for at least one season (spring, summer, fall, winter). We only considered studies from the western United States; Alberta and British Columbia, Canada; and northern Mexico. The literature search and data extraction process were conducted between August 2014 and August 2015.

We intentionally restricted our search to studies that used the microhistological fecal analysis technique, thus removing studies that solely evaluated diets through bite counts, forage use (e.g., visual observations of feeding sites and plant selection), ingesta samples, and rumen content analysis. Restricting our study to this single technique was important because studies have shown disagreements with other techniques, particularly esophageal fistula sampling and forb estimates (McInnis, 1977; Vavra et al., 1978). Microhistological studies use a microscopic comparison of fecal plant fragments to reference specimens to determine botanical diet composition, especially for dominant plant species across western North America since the 1930s (Johnson, 1982). Microhistological procedures are advantageous because they are practical for free-roaming animals, are less intrusive than esophageal-fistulation for in vitro estimation, are less subject to observer error than forage use estimates, do not disrupt behavior of grazing animals, and are ideal for comparing multiple ungulate using the same rangeland (Crocker, 1959; Anthony and Smith, 1974; Smith and Shandruk, 1979; Mayes and Dove, 2000).

From a practical standpoint, fecal microhistological analysis has been suggested to be one of the best techniques for quantifying dietary composition of large ungulate on rangelands (Holechek et al., 1982b; Mohammad et al., 1995). However, this technique is not without its limitations including that a portion of plant fragments may remain unidentifiable, differential digestion of different fragments by species may be influenced by maturity, observer skill and bias can influence accuracy, and some studies have demonstrated disagreement between fecal analyses with the analyses of stomach contents (Holechek et al., 1982b, 1982c; Mayes and Dove, 2000). However, Mayes and Dove (2000) concluded in a detailed review that microhistological fecal analysis can be used for both ruminants and nonruminants as the limitations to the technique apply regardless of digestive strategy. Furthermore, a recent study concluded that microhistological fecal analyses can be a useful tool to determine the botanical diet composition of horses (Morrison, 2008). We did not censor cattle dietary information by animal age or class because the fecal samples from wild horses and native ungulates were not censored in such a way. Thus, we included mature cows, yearling stocker cattle, heifers, and/or calves from beef cattle studies.

Data Analyses

Our statistical analyses were designed to answer three specific questions: 1) Do wild horse, livestock, and native wildlife diets fluctuate seasonally? 2) Are seasonal mean plant functional group components for wild horse, livestock, and native wildlife diets similar? 3) What is the magnitude of the diet comparison effect on an annual basis for livestock and native wildlife that potentially share rangelands with wild horses?

We pooled plant species data from scientific studies that met our search criteria by plant functional groups to make generalizations about animal species diet composition across different plant communities. Specifically, we grouped grasses and grasslike plants inclusive of grasses (Poaceae), sedges (Cyperaceae), and rushes (Juncaceae) as graminoids; herbaceous, broad-leaved flowering plants as forbs; and woody plants and cacti (Cactaceae) as browse (including all woody deciduous and coniferous shrub and tree species). Because some studies reported total diets with plant functional group components that did not equal 100% due to the lack of reporting rare or uncommon food species, we corrected percentages as the percent of the total diet accounted for following Christianson and Creel (2007). This correction results in all diets summing to 100% but assumes that unreported portions of the diet were composed of equal proportions of graminoids, forbs, or browse.

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