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Synthesis

Multiple-use management of western U.S. rangelands: wild horses, wildlife, and livestock

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Abstract: Since 1959, the U.S. Congress has legislated the treatment and management of wild horses (*Equus ferus caballus*) and burros (*E. asinus*; WHB). While the legislation has ensured WHB a place as western rangeland icons, subsequent congressional actions, in response to public lobbying, have limited federal managers' ability to manage WHB populations under the U.S. public land multiple-use doctrine. Federal land managers tasked with managing for multiple and competing interests on public lands of the western United States must not only consider WHB habitat requirements, but also wildlife species diversity and livestock grazing. Developing multiple-use management strategies while fulfilling other mandates will require balancing rather than maximizing a single resource use or user. Grazing by wild and domestic animals can modify plant community composition and structure, and overabundant populations negatively impact rangeland–watershed function and wildlife habitats. Negative effects on wildlife may include avoidance of water sources by wildlife, forage loss and altered plant communities, altered bird communities, and impacts to soils and insects. Effective management for riparian and rangeland health includes managing both the abundance and the distribution of large grazers. Unless large grazers (including WHB) are managed, range condition and wildlife habitat are at risk. While livestock can be moved and removed, and big game can be hunted, the management and removal of WHB populations continues to face strong public opposition. The management of WHB under the federal land multiple-use doctrine will require implementing innovative, diverse, and tough management strategies founded in the biological and social sciences. This special issue of *Human–Wildlife Interactions* explores these issues in depth. This paper frames the context in which WHB management must be achieved under the U.S. public land multiple-use doctrine.

Key words: burros, ecological impacts, *Equus asinus*, *Equus ferus caballus*, feral burros, feral horses, habitat, impacts, management, overabundance, populations, wildlife

Wild or feral horses (*Equus ferus caballus*) and burros (*E. asinus*; WHB) have been a part of the western U.S. landscape since their introduction, along with other domestic stock, by Spanish explorers 500 years ago (Haines 1938, Dobie 1952, Bureau of Land Management [BLM 2017]). Early feral horse populations, derived from Spanish bloodlines, were augmented with intentional and unintentional releases of domesticated draft and saddle horses by the military and settlers through the mid-twentieth century (Dobie 1952, Young and Sparks 2002, BLM 2017). Before 1959, free-roaming WHB were largely unregulated. They were released, grazed, captured, killed, sold, and otherwise used by the inhabitants of the region as they pleased (Dobie 1952, BLM 2017).

In the 1950s, Velma Bronn Johnson ("Wild Horse Annie") and other concerned citizens began raising public awareness regarding the perceived inhumane capture and treatment of free-ranging herds. In January 1959, in response to an organized and effective public relations campaign, Nevada Congressman Walter Baring introduced a bill prohibiting the use of motorized vehicles to hunt WHB on all public lands (BLM 2017). The House of Representatives unanimously passed the Hunting Wild Horses and Burros on Public Lands Act (1959), also known as the Wild Horse Annie Act. The bill became Public Law 86-234 (https://www.gpo.gov/fdsys/pkg/STATUTE-73/pdf/STATUTE-73-Pg469.pdf) on September 8, 1959. However, the law did not include recommendations that Congress initiate a program to protect or manage WHB. Subsequent efforts to increase protection

for wild horses included the establishment of the Nevada Wild Horse Range in 1962 within the Nellis Air Force Range, Nevada, USA (BLM 2017) and in 1968 the Pryor Mountain Wild Horse Range in Montana and Wyoming, USA (Massingham 2006).

Congress extended management and protection measures to all free-ranging WHB by enacting the Wild Free-Roaming Horses and Burros Act (Act) of 1971 (BLM 1971). Congress declared that "wild free-roaming horses and burros shall be protected from capture, branding, harassment, or death; and to accomplish this they are to be considered in the area where presently found, as an integral part of the natural system of the public lands." The Act regulated the management, protection, and study of "unbranded and unclaimed horses and burros on public lands in the United States," and directed the Secretaries of Interior and Agriculture (the Secretaries) to "maintain thriving natural ecological balance on the public lands."

Act amendments

The Act has been amended several times since 1971 (see Norris 2018). The Federal Land Policy and Management Act (FLPMA; 1976) amended the (WHB) Act, authorizing BLM use of helicopters to capture and motorized vehicles to transport horses to corrals. The Public Rangelands Improvement Act of 1978 (PRIA; Public Law 95–514) further amended the Act, providing authority to the Secretaries for the use of fertility control, removal, and adoption of excess animals, including the humane destruction of old, sick, lame, and even healthy animals if deemed necessary to maintain rangeland health (BLM 2017). The PRIA (1978) called for the inventory and management of WHB populations at Appropriate Management Levels (AML) on BLM Horse Management Areas (HMA) and U.S. Forest Service (USFS) Wild Horse and Burro Territories. However, efforts to remove and dispense of excess animals from the range faced persistent scrutiny, disapproval, and legal challenges by a public concerned with the fate of free-ranging herds and the treatment of captured animals.

In 2004, Senator Conrad Burns of Montana attached a rider to the Consolidated Appropriations Act of 2005 (the Burns Amendment),

Figure 1. The Bureau of Land Management estimates 73,000 free-roaming feral horses (*Equus ferus caballus*) currently inhabit public rangelands that have a maximum Appropriate Management Level of <27,000 animals. This situation is contributing to rangeland deterioration (*photo courtesy of R. Danvir*).

which amended the Act requiring BLM to sell excess animals >10 years old or which have been offered for adoption 3 times unsuccessfully (Congressional Record 2006). In response, the "Rahall Amendment" was passed to limit implementation of the Burns Amendment by preventing appropriated funds to be used to facilitate the sale and slaughter of protected WHB (Congressional Record 2006). Since 2006, nearly every federal Agriculture Appropriations Bill has contained language prohibiting the use of federal funds to facilitate the inspection of horse meat, effectively ending horse slaughter in the United States.

BLM compliance

From the time of the enactment of the Act in 1971, the BLM and USFS have attempted to comply with conflicting Congressional directives to protect free-roaming WHB, remove and dispose of excess animals, and be fiscally responsible, but without resorting to unrestricted sales, slaughter, and processing of horses into commercial products. In 2008, the Government Accountability Office (GAO) reported the BLM was not in compliance with the 2004 Burns Amendment because the BLM was limiting the sale of excess horses to comply with the Rahall appropriations language effectively banning horse slaughter (GAO 2008). The GAO, however, conceded that the BLM had a dilemma, needing to balance their directive to conserve wild horses and burros with their directives to maintain AML and fiscal responsibility. The GAO suggested the

Figure 2. As of October 2017, the Bureau of Land Management also was caring for an additional 45,500 animals (44,500 horses [*Equus ferus caballus*] and 1,000 burros [*E. asinus*]) in off-range pastures and holding facilities such as this one located near Delta, Utah at an estimated lifetime cost of $50,000 per animal (*photo courtesy of E. Thacker*).

BLM "develop cost-effective alternatives to the process of caring for wild horses removed from the range in long-term holding facilities and seek the legislative changes that may be necessary to implement those alternatives" (GAO 2008).

The WHB conservation efforts of the BLM have been somewhat successful. Population surveys in the early 1970s indicated a free-roaming population of about 17,000 wild horses and 8,000 burros, as compared to the March 2017 estimated free-roaming population of >59,000 horses and >13,000 burros (BLM 2017).

Unfortunately, these 73,000 free-roaming WHB occur on range with a maximum AML of <27,000 animals (BLM 2017; Figure 1). As of October 2017, the BLM also was caring for an additional 45,500 animals (44,500 horses and 1,000 burros) in off-range pastures and holding facilities at an estimated lifetime cost of $50,000 per animal (BLM 2017; Figure 2). Given the annual cost of off-range WHB care, the current rate of adoptions (about 2,500/year) and the rate of WHB population increase (the wild horse population can potentially double every 4 years), the program has become environmentally and economically unsustainable (Garrott and Oli 2013).

In 2013, the National Academy of Science (NAS) released a 2-year evaluation of the science, methodology, and decision-making approaches of the Wild Horse and Burro (WHB) Program (NAS 2013). This excerpt from the preface of the report seems as applicable now as in 2013: "…it is clear that the status quo of continually removing free-ranging horses and then maintaining them in long-term holding facilities, with no foreseeable end in sight, is both economically unsustainable and discordant with public expectations. It is equally evident that the consequences of simply letting horse populations, which increase at a mean annual rate approaching 20 percent, expand to the level of 'self-limitation'—bringing suffering and death due to disease, dehydration, and starvation accompanied by degradation of the land—are also unacceptable. Those facts define the point from which we must begin the journey…" The inability of the BLM and the USFS to fully implement the management activities authorized under the Act increasingly threatens rangeland health (Davies et al. 2014), wildlife habitat (Boyd et al. 2017), species diversity (Hall et al. 2016), and rural livelihoods—and the problem is increasing at approximately 20% per year.

In this commentary, I broadly frame the issues, concerns, and challenges surrounding WHB management. I also identify opportunities to implement the intent of the Act and integrate WHB management with the needs of wildlife and other public land users.

Public lands: multiple-use or WHB sanctuaries?

The BLM and USFS are required to manage for conflicting interests such as multiple use, WHB, native wildlife (Endangered Species Act of 1973 [ESA; 16 U.S.C. § 1531 et seq.]), and livestock grazing (Taylor Grazing Act of 1934 [Public Law 73-482], Straube 2017). The Federal Land Policy and Management Act of 1976 (FLPMA; Public Law 94-579) defines multiple-use as "management of the public lands and their various resource values so that they are utilized in the combination that will best meet the present and future needs of the American people."

The management of public lands for multiple-use is also implicit in the Act. The Act required the BLM to "maintain thriving natural ecological balance in combination with other uses." To comply with the Act, the BLM implements management at minimum feasible levels, consults with state wildlife agencies to protect natural ecological balance of all wildlife species, and conducts research designed to evaluate management options. However, opinions differ considerably among WHB advocates, interest groups, and stakeholders regarding what constitutes thriving natural ecological balance and management at minimum feasible levels, or even the relevance of multiple use—with some arguing that wild horse management should take precedence within HMAs (BLM 2017).

The Act clearly endorses multiple-use of U.S. public lands, stating that "wild horses and burros shall be considered comparably with other resource values in the formulation of land use plans" on BLM HMAs and USFS Territories. In addition, the Act allows the Secretaries to "designate and maintain specific ranges on public lands as sanctuaries for their protection and preservation," which may be managed "principally but not necessarily exclusively" for WHB (https://www.blm.gov/programs/wild-horse-and-burro/about-the-program/myths-and-facts, fact #14). Four areas have been so designated: the Pryor Mountain Wild Horse Range, the Nevada Wild Horse Range, the Little Book Cliffs Wild Horse Range (in Colorado) and the Marietta Wild Burro Range (in Nevada).

Central to understanding the need for WHB management is the concept that grazing animals (herbivores) affect their environment. Ungulates (i.e., hoofed animals) affect ecosystems and can modify plant community composition and structure (Holechek et al. 1989, Augustine and McNaughton 1998). This includes both wild and domestic ungulates. In terms of land health, whether wild horses are considered native, introduced, or feral is less important than how they are managed. Prolonged herbivory (grazing or browsing) by overabundant populations of ungulates, whether WHB (Davies et al. 2014, Boyd et al. 2017), white-tailed deer (*Odocoileus virginianus*; Waller and Alverson 1997), feral hogs (*Sus scrofa*; Wolf and Conover 2003) or cattle (*Bos* spp.; Holechek et al. 1989) can alter plant community structure and function and affect the ability of the land to support their own or other wildlife species.

Wild horses and wildlife

Wild horses can negatively affect wildlife and wildlife habitat (Hall et al. 2016, Boyd et al. 2017). Documented effects include competition with and avoidance by wildlife of water sources (Miller 1983, Ostermann-Kelm et al. 2008, Perry et al. 2015, Hall et al. 2016, Gooch et al. 2017), forage loss and altered plant communities (Beever and Brussard 2000, Davies et al. 2014, Scasta et al. 2016), altered avian (bird) communities (Zalba and Cozzani 2004), altered small mammal communities (Beever and Brussard 2004), impacts to soils and insects (Beever and Herrick 2006), and sagebrush (*Artemisia* spp.) ecosystems (Beever and Aldridge 2011, Boyd et al. 2017). Examples of wildlife potentially impacted by WHB include federally endangered species like the desert tortoise *(Gopherus agassizii)* and species of conservation concern like the greater sage-grouse (*Centrocercus urophasianus*). Greater sage-grouse habitat overlaps 30% of WHB management areas (Beever and Aldridge 2011).

The presence and activities of wild horses on the condition of western U.S. mesic habitats (moist soils, meadows) may have the greatest impacts on wildlife and their habitats (Hall et al. 2016, Boyd et al. 2017). In arid environments like the Great Basin, mesic meadows, streams (riparian habitats), and other wetlands comprise <5% of the land area but are vitally important to the survival of hundreds of species

Figure 3. The presence and activities of feral horses (*Equus ferus caballus*) on the condition of western U.S. mesic habitats (moist soils, meadows) may have the greatest impacts on wildlife and their habitats (*photo courtesy of L. Hall*).

(Donnelly et al. 2016). Wild horses use mesic habitats daily for water and forage and spend larger periods of time in the mesic habitats of arid regions (Hall et al. 2016). Ostermann-Kelm et al. (2008) reported a 76% decrease in use of water sources by bighorn sheep (*Ovis canadensis*) when horses were present. Even solitary horses may displace California bighorn sheep, mule deer (*Odocoileus hemionus*), and pronghorn (*Antilocapra americana*; Berger 1985).

Separating impacts: wild horse or domestic livestock?

Because domestic cattle and sheep (*O. aries*) also use mesic habitats on a daily basis, it can be difficult to separate the impacts of horses from cattle on mesic habitats where both occur. However, studies conducted in landscapes containing wild horses but not livestock (e.g., the Sheldon National Wildlife Refuge, Nevada, USA [Davies et al. 2014] and Dugway Proving Ground [DPG], Utah, USA; Hall et al. 2016) suggested the presence of wild horses can restrict wildlife access to water sources and alter the condition of mesic and adjacent upland habitats (i.e., loss of plant cover, structure, and diversity; Figure 3).

The study area within the Sheldon National Wildlife Refuge (SNWR; Figure 4) consisted of 80,000 ha and is located in northern Nevada, USA (Boyd et al. 2017). The SNWR was grazed by wild horses and wild ungulates, but not cattle or sheep. Domestic cattle or sheep were removed from the SNWR between 1990 and 1994 (Boyd et al. 2017). Boyd et al. (2017) reported significantly lower vegetation height and greater bare ground on SNWR horse-grazed mesic areas than where horses were excluded (fenced out). Bird species diversity on areas grazed by horses also was lower than areas where horses were excluded.

Gooch et al. (2017) found the presence of horses at water sites on the SNWR was associated with increased pronghorn vigilance and less time spent feeding. Pronghorns left the area without drinking >40% of the time if horses were present at water sites. Horse presence may reduce pronghorn vigor and fitness, and competition for scarce resources like mesic sites will likely increase as horse populations build.

The Dugway Proving Ground (DPG) is located in northwestern Utah (Figure 5). The DPG is owned and managed by the Department of Defense and livestock grazing has been excluded for >60 years (Hall et al. 2016). Hall et al. (2016) used trail cameras to monitor wildlife use of horse-accessible water sites and at water sites where horses were excluded. They monitored >30 water sites; wildlife had access to all water sources while horses could only access

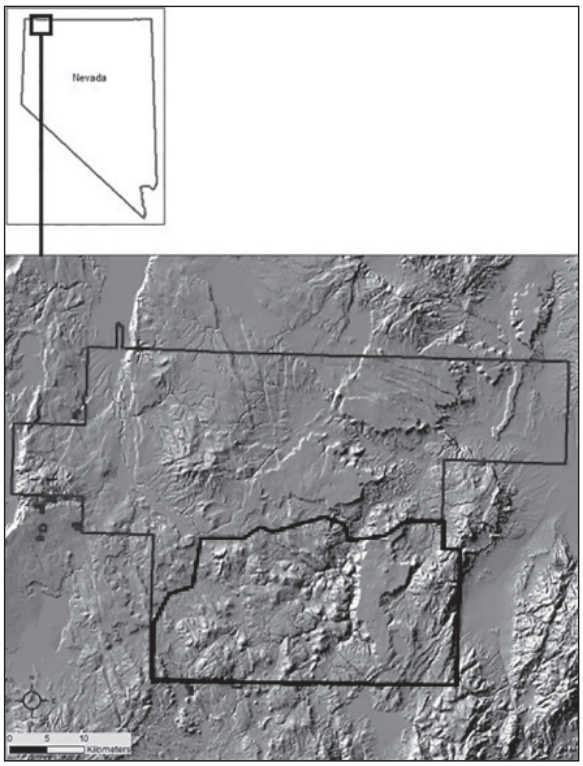

Figure 4. Sheldon National Wildlife Refuge (larger perimeter polygon), study area (smaller polygon), and location on map of Nevada, USA (Davies et al. 2014).

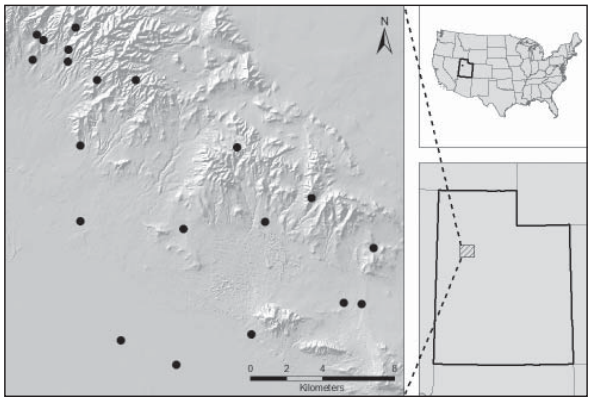

Figure 5. Map of Dugway Proving Grounds and location in Utah, USA (*image used by permission of L. K. Hall*).

half. Forty avian and 13 mammalian species were documented using DPG water sources. Significantly fewer wildlife species (birds and mammals) used water sources where horses were present, and wildlife visited water sites without horses more often (and stayed longer) than sites with horses. Additionally, horses stayed at water sources longer than wildlife, wildlife avoided water sources when horses were present, horses were present up to 73% of the day during the heat of the summer, and horses often occupied all available drinking space at water sites. By displacing other wildlife at water sources, horses decreased the richness and diversity of wildlife species at water sources occupied by horses (Hall et al. 2016).

Native ungulates (i.e., pronghorn and mule deer) used DPG water source less frequently when horses were present (Hall et al. 2018). Pronghorn also shifted the time of day they used water sources to avoid horses. As temperatures increased, horse activity at water sources increased, further restricting native ungulate access to limited water (Hall et al. 2018), a concerning finding particularly in light of forecasted climatic changes and extremes (Intergovernmental Panel on Climate Change [IPCC] 2013). Results from these 2 livestock-free study areas suggest that high horse densities at water sources and continuous (year-long) use by horses of mesic habitats can reduce habitat quality and wildlife use, potentially reducing the condition, production, abundance and diversity of wildlife species dependent on mesic habitats in arid environments.

Managed grazing

Grazing management on public domain lands formally began when the Taylor Grazing Act of 1934 (Public Law 73-482) was enacted to "stop injury to the public grazing lands by preventing overgrazing and soil deterioration, to provide for their orderly use, improvement and development, to stabilize the livestock industry dependent upon the public range, and for other purposes" (http://www.documentcloud.org/documents/2723416-Taylor-Grazing-Act.html).

The Taylor Grazing Act (and subsequent amendments) asserted federal regulatory authority over public lands, established grazing rights and fees, and led to managed grazing infrastructure, intensity, distribution, and season of use. Range management on public lands is largely focused on managing the number of cattle, WHB, and native grazers like elk (*Cervus elaphus*) at levels compatible with forage availability. Stocking rates and population targets are based primarily on the abundance of graminoids (grasses and grass-like plants) since graminoids are a primary forage for cattle, WHB, and elk (Scasta et al. 2016). Not only are WHB competing with cattle for graminoid forage, but WHB are also

competing with wildlife, as rangeland grasses are important as food or cover for elk and other wildlife species (Beever and Brussard 2004, Zalba and Cozzani 2004, Scasta et al. 2016).

Many western rangelands historically experienced periodic grazing by large ungulates (Hobbs et al. 1991, West 1999). Key range management principles include maintaining appropriate stocking rates and managing animal distribution to provide opportunities for plant recovery (Holechek et al. 1989, Natural Resources Conservation Service [NRCS] 2016). Excessive animal numbers (high populations or stocking rates) using the same locations continuously, year after year, can reduce plant cover and soil health leading to increased erosion and invasive plants (Holechek et al. 1989, NRCS 2016). Alternatively, recovery or rest periods may improve plant biomass and vigor (NRCS 2016), increase plant cover, and improve soil health (Jocobo et al. 2006, Teague et al. 2010, Swenson et al. 2015, Danvir et al. 2018). Since most WHB herds continuously graze the same areas, year after year, generally at population levels above AML, these basic range management principles (managing population size, distribution, and recovery periods) are not occurring.

Management for healthy populations and rangelands

Our ability to manage animal abundance and distribution varies significantly between cattle, native grazers, and WHB. As a group, livestock are manageable, as stocking rates (number of livestock per unit area) can be adjusted annually to match forage resources, and livestock distribution can be managed to provide periods of plant recovery. While managing the distribution of native ungulates is less precise, population size can be managed by hunting, predators, and weather. Currently, neither population size nor distribution of WHB are readily or consistently managed, potentially leading to degraded mesic and upland range conditions along with dehydration, suffering, and death. This is already occurring in some HMAs exceeding AML (The Wildlife Society 2014, Davies et al. 2014, Boyd et al. 2017).

Rotational grazing and building riparian pastures are tools that can be used to provide recovery periods from ungulate grazing and to improve riparian condition (Holechek et al. 1989, Leonard et al. 1997, Booth et al. 2012) and wildlife habitat (Krausman et al. 2009, Dahlgren et al. 2015). While not currently practiced with wild horses on federal HMAs, practices like herding, water developments, and riparian pastures may offer a means of providing pasture deferment and recovery from horse grazing while still largely maintaining free-roaming herds.

WHB population management scenarios

The management for long and short-term WHB population goals may be summarized using the following 3 scenarios:

1. Recruitment = Removal (long-term goal, maintains a stable population)
2. Recruitment > Removal (current condition, population increases annually)
3. Recruitment < Removal (short-term goal, reduces population to AML)

Scenario 1 describes the long-term goal, a stable population where births are compensated by horse mortalities or removals. Scenario 2 describes the current situation of continually increasing populations. Achieving population stability at or near AML requires Scenario 3, where removals exceed recruitment, until AML is reached. Figure 6 depicts the contemporary negative relationship between public acceptance and management effectiveness of a range of practices that could be implemented to achieve Scenario 3.

The least publicly objectionable methods of population management (i.e., adoption and fertility control) can slow population growth rates but have not stabilized or reduced populations (NAS 2013, Garrott 2018). High birth and recruitment rates of young foals and low rates of adult mortality are still allowing herds to increase and exceed AML (NAS 2013). By relying only on adoptions and fertility control, horse populations could remain above AML for decades and will require tens of millions of dollars in annual labor and off-range holding costs. Achieving AML within the foreseeable future will require continued removal of excess horses from the range and likely require unrestricted sales and humane euthanasia in combination with long-term or permanent sterilization.

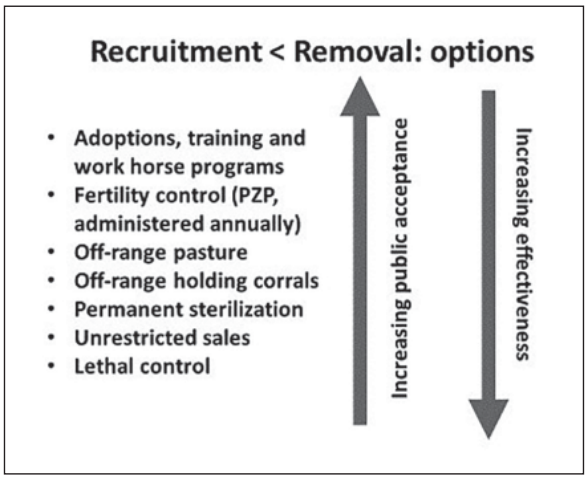

Figure 6. Comparison of public acceptance vs. management effectiveness of a range of wild horse (*Equus ferus caballus*) and burro (*E. asinus*) management practices.

WHB management options

Removing cattle from public lands

Frequently suggested by WHB advocates as a solution to WHB overabundance (BLM 2017), the argument is that without competition from cattle, wild horse roundup and removals would no longer be required because BLM range resources would adequately support free-roaming wild horse populations. This management option can be likened to "kicking the can down the road." Despite federal legislation mandating multiple-use of U.S. public lands, it remains that the removal of cattle will not slow the annual 20% horse recruitment rate and horse population growth (NAS 2013). Unmanaged WHB reproduction would still allow WHB populations to increase, dominate water sites (Hall et al. 2016), and overgraze graminoid forage (Scasta et al. 2016), reducing range and soil health and wildlife diversity and abundance. Removing cattle from public lands without horse population management simply delays the inevitable point at which horses become resource limited. Within as little as 10 years, the now much larger wild horse population would again face increased risks of dehydration and starvation.

Natural control by predation

Predators that overlap the range of wild horses do kill some wild horses and burros, but it is unlikely predators alone can stabilize or reduce WHB populations. Most documented predation is on foals and not adult horses; however, reducing horse populations requires removing adult animals (NAS 2013). Wolves (*Canis lupus*) have been observed killing feral horses in Alberta, Canada (Webb 2009). Mountain lions (*Puma concolor*) have been shown to limit the growth of 1 wild horse population in Great Basin mountainous terrain (Turner et al. 1992, Turner and Morrison 2001). However, because few HMAs overlap high-density populations of cougars, wolves, or bears (*Ursus* spp.), the NAS (2013) concluded it is unlikely that predators alone could maintain horse populations at healthy levels.

Let nature take care of excess WHB

As wild or feral horse populations begin to push the ecological limits of the land (ecological carrying capacity), body condition, survival and birth rates decline (NAS 2013). The NAS (2013) report stated "The literature and case studies show that although density dependence can regulate population sizes, responses will probably include increased numbers of animals in poor body condition and high numbers of animals dying from starvation." In highly variable environments like the American West, extreme weather events (e.g., drought, fire, and deep snow) make carrying capacity a moving target (NAS 2013). These weather events can drastically reduce ecological carrying capacity for a time, reducing animal condition and increasing mortality. Reduced recruitment and higher mortality rates under these conditions may slow population growth but could also increase emigration—prompting surviving horses to move beyond HMA boundaries looking for greener pastures (Hennig et al. 2018). Reliance on density-dependent population limitation alone is likely to appear inhumane, resulting in suffering from hunger and thirst, and may spread WHB problems onto adjacent, non-HMA public and private lands. This approach could negatively affect hundreds of other, smaller species, the health and functionality of the range, and the economic condition of many rural western landowners (Garrott 2018, Jakus 2018, Scasta et al. 2018).

The NAS (2013) and the BLM (2017) agree that wild horse populations will not self-regulate in an environmentally and humanely acceptable

manner. They have few natural predators, and the probable trajectory without human management intervention includes inadequate forage resources, declining range productivity and condition, leading to deterioration of horse condition and starvation. This may be unacceptable from a legal, humane, or ecological standpoint.

Let's use birth control?

Fertility control is often proposed as a publicly acceptable means of controlling WHB population growth (Humane Society of the United States [HSUS] 2013, NAS 2013, BLM 2017, Bechert and Fraker 2018, Kane 2018). The most widespread fertility control vaccine, porcine zona pellucida (PZP), has been administered by federal staff and volunteers in select, smaller wild horse herds in locations where darting or trapping horses at water sources was feasible (HSUS 2013, BLM 2017, Kane 2018). The vaccine can reduce reproduction and population growth rate in treated horses for 1-3 years (Ransom 2011, Garrott and Oli 2013). The efficacy of PZP to reduce WHB population growth was studied in the McCullough Peaks HMA, Wyoming, USA, the Little Book Cliffs (Colorado, USA) and Pryor Mountain Wild Horse Ranges (Ransom 2011). An average of 30% of females were contracepted with PZP annually in the 3 populations. Population growth rates were reduced 4–9% post-treatment as compared to pre-treatment years, but were still positive (Ransom 2011). However, repeated PZP vaccinations of females extended the duration of infertility far beyond the targeted management period, and when females did give birth, foals were born late in the year out of sync with forage growth. The use of PZP also appeared to increase adult mare survival, especially in older (>20-year-old) mares (Ransom 2011, Nuñez 2018). Managers have reported re-darting and re-trapping mares for subsequent dosing became increasingly difficult through time (NAS 2013). Administering PZP at a range-wide scale would likely require increasing the frequency of gathers (Garrott and Oli 2013), branding or marking horses (to identify individuals), and a significant annual cost.

The NAS (2013) assessment of fertility control concluded: "It is important to note that, when the committee prepared its report, no fertility-control methods that were highly effective, easily deliverable, and affordable were available for use across all BLM Herd Management Areas. In addition, there were no fertility control-methods that did not alter the behavior or physiology of free-ranging horses and burros in some way." However, potentially negative impacts from using PZP appear less impactful than the negative effects on horse health and land health by continued unregulated population growth (Garrott and Oli 2013, NAS 2013). In assessing the impacts of fertility control, or indeed any potential management action, we must weigh the potential negative results of the action with the grave negative impacts of the current trajectory of continually increasing populations.

Given the costs, logistical and legal challenges associated with repeated gathers and administering PZP to mares every 1–3 years, BLM managers continue to seek longer-term or permanent (i.e., chemical or surgical sterilization) control measures. Further research and experimentation is underway to develop longer-lasting or permanent fertility control solutions (BLM 2017, Kane 2018). Because population size is more dependent on adult survival than foaling rate (NAS 2013), and fertility control can increase adult female survival rate (Ransom 2011), fertility control alone is unlikely to reduce wild horse numbers rapidly enough to achieve AML or preserve range integrity (Garrott and Oli 2013, NAS 2013, Garrott 2018). Once populations are reduced to AML by other means, cost effective long-term management could certainly include term-limited and permanent sterilization of some horses to stabilize herd size in some HMAs.

How about combining management options?

Clearly, WHB management must include options that reduce both WHB populations and their reproductive rate (NAS 2103, Garrott 2018). Although unpopular with some WHB advocates, proactive options proposed by others should begin, such as; removal and training of WHB as work animals and for humanitarian purposes (both within and beyond U.S. borders), as food for endangered predators (e.g., reintroduced California condors [*Gymnogyps californianus*] and zoo-

based predator conservation programs), or unrestricted sale of unadoptable animals. It is becoming increasingly clear that to choose the "No Action" alternative is to "kill wild horses with kindness." There is an argument to be made that training wild horses and burros for use in forest and rangeland restoration initiatives and recreation programs, homeland security, or giving horses and burros to neighboring agronomic rural countries is preferable to idle lives spent in long-term WHB holding facilities or starvation on overpopulated rangelands.

At the crossroads

This issue of *Human–Wildlife Interactions* explores in-depth some of the issues identified in my commentary. The contributing authors explore the biology, behavior, ecology, sociology, and economics of the science, management, and policy of the contemporary management of WHB. The management of WHB is at a crucial point. If Congress continues to ignore the scientific findings, and the purpose and intent of the Act, WHB populations will continue to increase at the expense of land health, wildlife habitat, native species diversity, and rural economies. Regardless of anyone's definition of "thriving natural ecological balance," it is unachievable without active WHB management (NAS 2013). Countless stories have been written about the successful conservation and subsequent management of large ungulates like the American bison (*Bison bison*), bighorn sheep, elk, deer, and pronghorn—all species once considered imperiled. Likewise, we have conserved, and now must sustainably manage our WHB populations, balanced with other uses, for future generations of Americans.

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