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Perspective

Conservation challenges emerging from free-roaming horse management: A vexing social-ecological mismatch

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ABSTRACT

Horses have been associated with human societies for millennia, and for many have come to symbolize wildness, power, resilience, and freedom. Although equids were extirpated from North America 10,000–12,000 years ago, descendants of domestic horses now roam freely in the USA and 17 other countries across six continents. In landscape-scale and experimental investigations, free-roaming horses (*Equus caballus*) have been shown to induce numerous alterations to native-ecosystem components and processes through influences on soil, water, plants, and other aspects of biodiversity. However, we argue that the management of free-roaming horses both in the U.S. and globally has been complicated by "socio-ecological mismatches." Such mismatches arise from an inability to reconcile conflicting processes and functions in a social-ecological system, often reflecting differences in the spatio-temporal scales at which diverse components operate. Here, we describe three types of mismatches, and illustrate how the ecological dynamics of aridlands generally fit poorly with existing approaches to horse management and policy. Such mismatches complicate cost-effective management of free-roaming horses and the ecosystems they inhabit, and reduce the palette of potential solutions.

1. Introduction and justification

Horses (*Equus caballus* Linnaeus) are one of several charismatic introduced species that have generated multi-faceted conservation and management controversies. Currently, wild native horses roam only where they have been reintroduced to their native Mongolian steppe habitat. In contrast, because of their central role in human history, free-roaming horses have been introduced to 18 countries, including all continents except Antarctica (Beever, 2013). Where they occur, free-roaming horses influence global conservation outcomes and protected-areas management. Within these areas, they can influence ecosystem structure, composition, and function at short and longer–term timescales (Fig. 1) (e.g., Beever and Aldridge, 2011; Davies et al., 2014; Hall et al., 2016; Levin et al., 2002; Loydi and Zalba, 2009; Nimmo and Miller, 2007; Rogers, 1991; Zalba and Cozzani, 2004). In terms of introduced equids' conservation relevance in North America, management areas in the USA alone dedicated in the 1970s to the management of free-roaming horses and burros (i.e., with legacies of recent and/or current introduced-equid grazing) span 36.67 million hectares, and horses and burros now still graze about half of that extent, including most of the federal-lands portion of one of the most endangered ecosystems of North America (Noss and Cooperrider, 1994). Within the United States, the social and ecological dynamics of free-roaming-horse management have resulted in intractable management challenges. For example, land-use and management priorities on public lands, including biodiversity conservation, hunting, grazing, water-quality protection, and even recreation, may conflict with the ecological alterations created by free-roaming horses. The Wild Free-Roaming Horses and Burros Act (hereafter, "the Act"), passed in 1971, lays the foundation for management options for the public agencies charged with managing most free-roaming horses and burros – the Bureau of Land Management (BLM) and, secondarily, the U.S. Forest Service (USFS). The Act mandates the BLM and USFS to maintain free-roaming horse and burro numbers below or within the narrow range of the Appropriate Management Level (AML), which is designated for each particular Herd Management Areas (HMA). Fig. 2 illustrates areas managed

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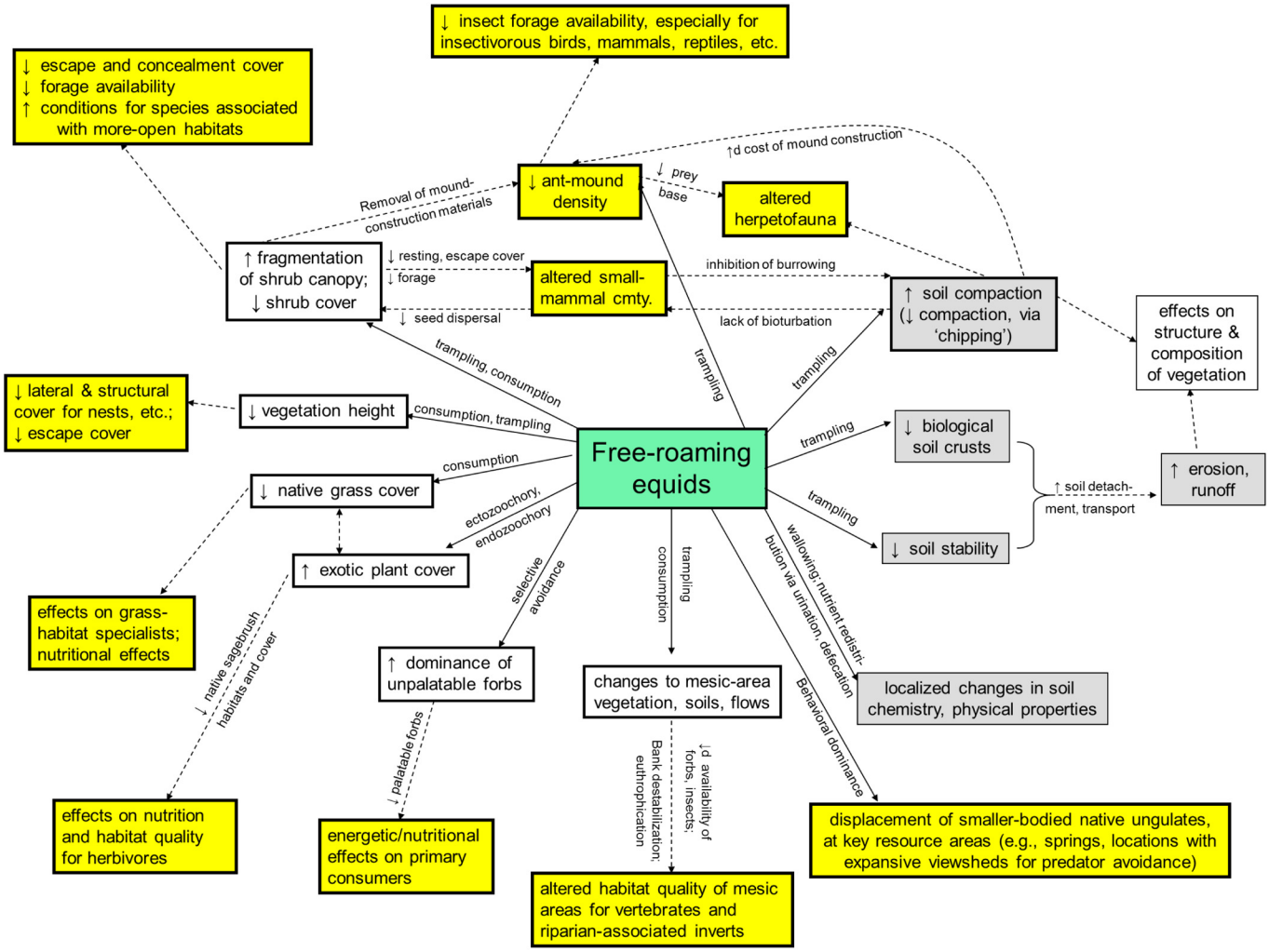

Fig. 1. Conceptual ecological model that identifies 1) the mechanisms by which individual ecosystem components may be affected, and 2) the inter-relationships among ecosystem components, as well as their relationships with free-roaming horses and burros. Solid lines indicate direct effects, whereas dotted lines indicate indirect effects. White-filled boxes indicate vegetation-related components of the ecosystem, grey boxes indicate soils-related components, and yellow boxes indicate animal-related components. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

for equids by BLM or USFS.

Although not subject to the Act, Native American tribes within U.S. borders also struggle with management of free-roaming horses. In the Navajo Nation, for example, the 2007 closure of the last U.S. horse abattoir due to a 2005 Act that cut funding for federal inspections (H. R. 2744-45 SEC. 794 2005–2006) has limited the ability of tribes to sell excess horses. Stimulated by 1) public demand to eliminate horse slaughter, and 2) the inability to sell horses at a reasonable price or affordably reduce their numbers, the population of free-roaming horses on the 7 million ha of the Navajo reservation has reached high numbers. Horse numbers were estimated to be 38,223 horses of all ages in July–August 2016 (90% CI: 32,188 to 52,033 animals; Wallace et al., 2017), and population size is anticipated to double within 5 years (Baca, 2017). The horses apparently compete with other domestic animals and wildlife for limited water and vegetation, and threaten traditional food plants. The tribe has struggled to fund reductions and to cope with pressures from wild-horse advocates (Baca, 2017). Similar problems are faced by tribes in the northwest and elsewhere.

For the BLM, the apparently least-contentious options for keeping herd sizes within AML are limited to immunocontraception and, more pervasively, periodic removal of animals from the range into captivity (Garrott and Oli, 2013). Allowing horse populations to self-regulate through starvation when the available forage is exceeded by the growing demand (by herbivores) is not only unpalatable to the public, but is also precluded by the 1971 Act. Removals, in comparison, are expensive and time-intensive, including the costs of horse gathering, feeding, and medical care while in captivity. Additional costs may include the time and expertise needed to work with passionate stakeholders to find compromise and to address lawsuits and other legal challenges. Current management approaches have left approximately 40% (44,580 individuals) of all "free-roaming" horses maintained in captivity to prevent starvation, damage to aridland ecosystems (especially after wildfires or drought), and competition with native ungulates (BLM, 2018b). Animals in captivity are in holding corrals or (mostly) in expansive holding pastures on ranches in the southern Great Plains. Although an average of 5495 rounded-up horses per year were adopted out to private owners during 1978 through 2007, adoption rates fell to only 2472 horses per year during 2008 through 2017 (BLM public statistics, 11 May 2018). In addition to these animals, an additional ~453 rounded-up horses per year were sold to trusted buyers during 2005 through 2017 (BLM public statistics, 11 May 2018). Given how dramatically the 16–22% annual horse-population growth rate (averaged across 10 U.S. states; NRC, 2013) is outpacing adoptions and sales, program costs are rising exponentially. Considering only BLM costs for keeping horses in captive-holding facilities, Garrott and Oli (2013) project an estimated cost of $1.1 billion between 2013 and 2030,

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