Rewilding the American West

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After taking office, President Biden signed an executive order announcing his America the Beautiful plan to conserve 30% of US land and water by 2030. He challenged Americans to collaboratively "conserve, connect, and restore the lands, waters, and wildlife upon which we all depend" at a national scale (US Departments 2021, p. 9). Here, we take a major step in advancing President Biden's plan by envisioning a bold and science-based rewilding of publicly owned federal lands (hereafter, *federal lands*) in the American West. Beyond concerns for human survival and flourishing, a principled commitment to the natural world and a sense of moral urgency underpins the motivation for our proposal.

In general, rewilding aims to reestablish vital ecological processes that can involve removing troublesome nonnative species and restoring key native species. Our rewilding call is grounded in ecological science and is necessary regardless of changing political winds. Our objective is to follow up on President Biden's vision to conserve, connect, and restore by identifying a large reserve network in the American West suitable for rewilding two keystone species, the gray wolf (*Canis lupus*) and the North American beaver (*Castor canadensis*).

We focus first on the gray wolf, a wide-ranging species requiring extensive areas of habitat. Gray wolves were largely eradicated from the American West following Euro-American colonization and manifest conquest of the West. Through measures afforded by the US Endangered Species Act, in the mid- to late 1990s, gray wolves were reintroduced to portions of the northern Rocky Mountains and Mexican gray wolves (*Canis lupus baileyi*) to portions of New Mexico and Arizona. Nevertheless, the wolf's current range in the 11 Western states is approximately 14% of its historical range (figure 1a). Once likely numbering in the tens of thousands, there may be as few as approximately 3500 wolves in the American West today (supplemental table S1). As an apex predator, wolves can trigger strong ecological effects on prey and plants across a variety of landscapes of western North America (Beschta and Ripple 2009).

Beaver restoration forms a second key feature of our rewilding proposal. Beaver populations had once been robust across the American West but were decimated by an estimated 90% to 98% in the wake of settler colonialism and are now extirpated from many streams (Butler and Malanson 2005). By felling trees and shrubs and building dams, beavers enrich fish habitat, increase water and sediment retention, maintain water flows during drought, provide wet fire breaks, improve water quality, initiate recovery of incised channels, increase carbon sequestration, and generally enhance habitat for many riparian plant and animal species (Castro et al. 2015). Beaver restoration is a cost-effective means of repairing degraded riparian areas. Although riparian areas occupy less than 2% of the landscape, they provide habitat for up to 70% of wildlife species (Poff et al. 2012).

The Western Rewilding Network

To identify prospective habitat for rewilding, we considered potential gray wolf core habitat on federal lands in 11 Western states (see the supplemental material). We began with wolves, because their recovery and persistence require large areas. We then identified areas of contiguous federally managed lands within core wolf habitat that were at least 5000 square kilometers [km^2].

That analysis revealed a potential network of 11 large reserves spanning the American West, which we term the Western Rewilding Network (figure 1b, supplemental figure S1, supplemental table S2). We mapped the spatial links between certain pairs of these 11 reserves using connectivity modeling (figures 1c, supplemental figures S2, S3, and S4).

Finally, we cataloged the threatened and endangered plant and animal species, including subspecies and distinct population segments, that had at least 10% of their ranges within the Western Rewilding Network. For each of these species, we determined threats, at least in part, associated with resource extraction industries, including livestock grazing, logging, mining, and oil and gas drilling (see the supplemental material).

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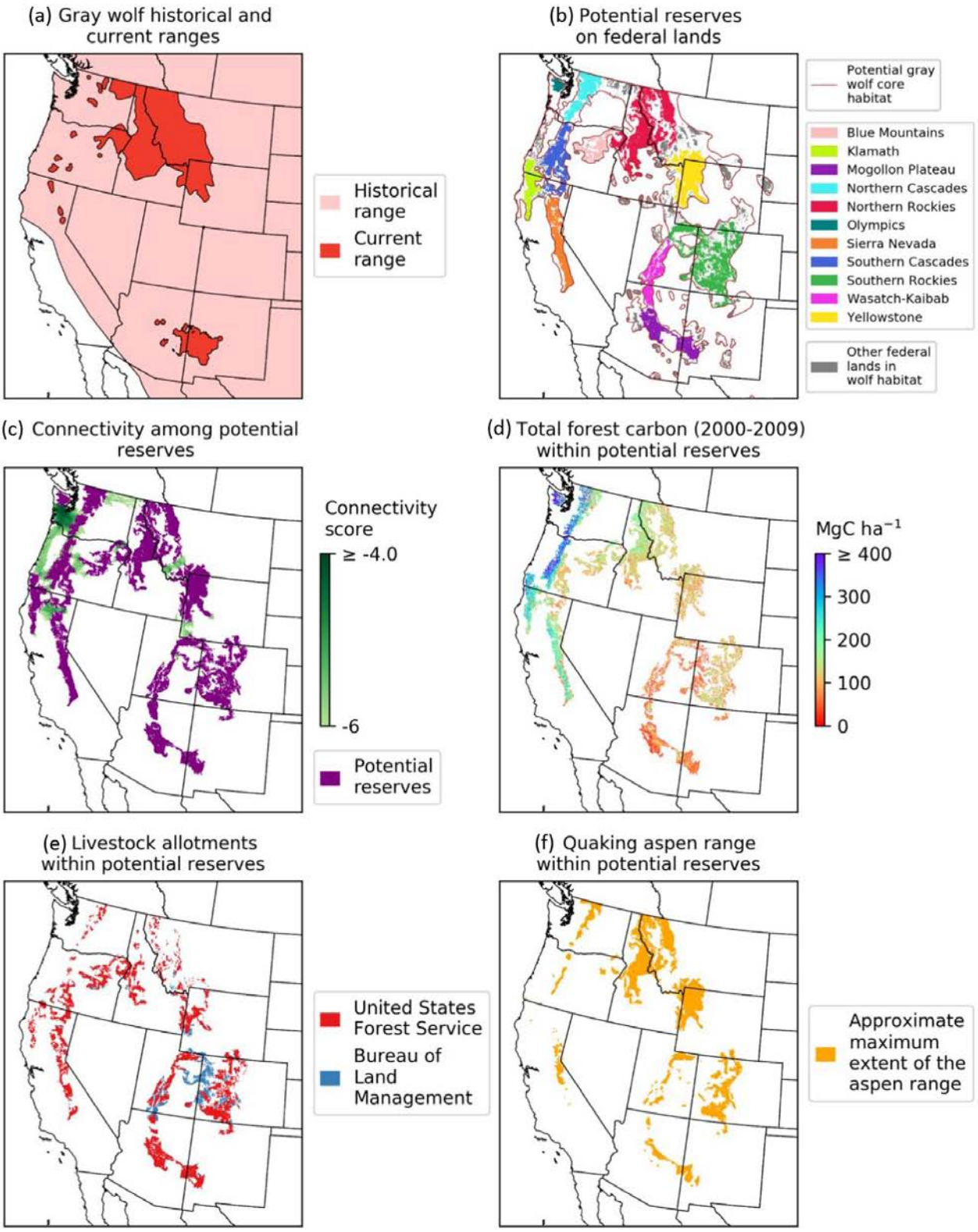

Figure 1. Proposed reserve network for the American West. The gray wolf range (a) could be expanded significantly through the establishment of large reserves corresponding to patches of potential core habitat on federally managed lands that cover at least 5000 square kilometers (b). Most reserves are closely connected to nearby reserves as shown in green (c). The proposed reserves harbor large amounts of forest carbon (d) and successful rewilding will depend on retirement of grazing allotments within potential reserves (e), thus offering great benefits for biodiversity, including aspen (f) and other species. See the supplemental material for data sources.

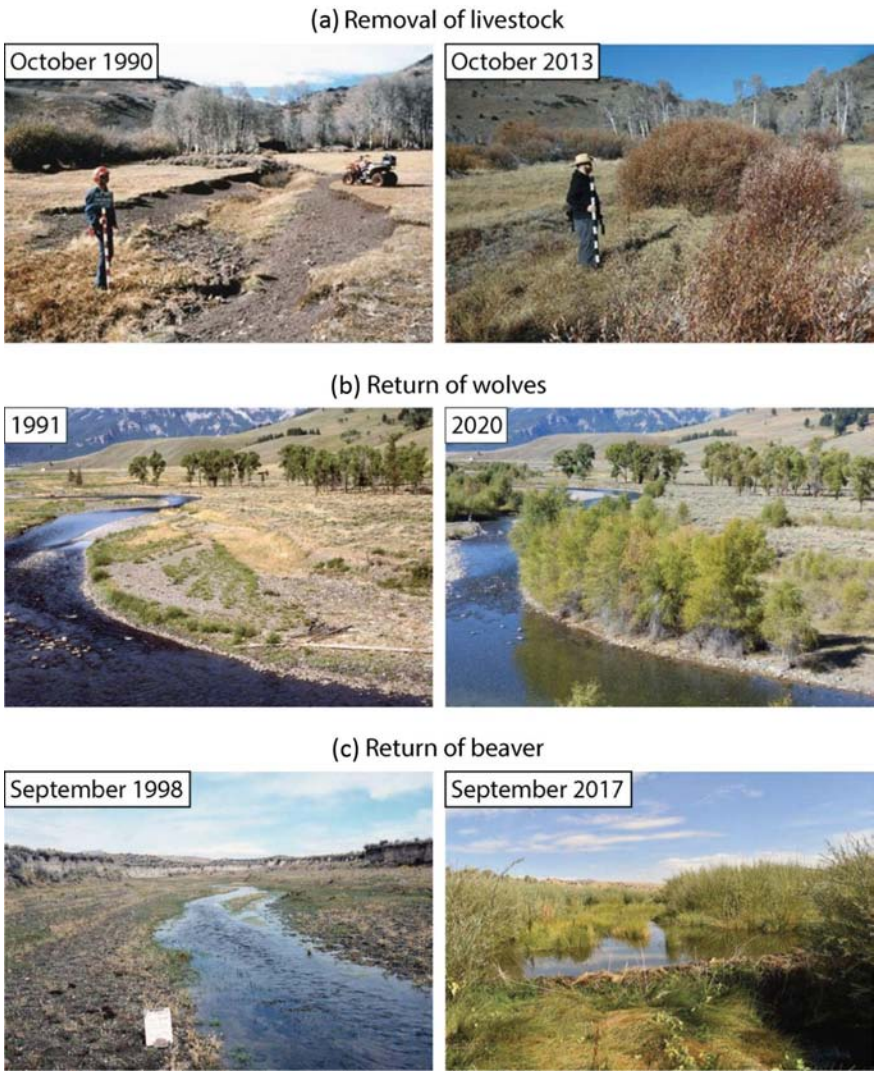

Figure 2. Paired photo examples of recovering riparian or aquatic habitats. The removal of livestock in 1991, Hart Mountain National Antelope Refuge, south-central Oregon (a). The reintroduction of wolves in 1995–1996, northern range of Yellowstone National Park, north-western Wyoming (b). Altered livestock grazing management that allowed sufficient riparian plant community recovery for beavers to return, north-central Nevada (c). Photographs: (a) Removal of Livestock, left photo from US Fish and Wildlife Service, right from photo Jonathan Batchelor; (b) Return of Wolves, left photo from National Park Service, right photo from Robert L. Beschta; (c) Return of Beaver, left and right photos from US Bureau of Land Management.

The Western Rewilding Network currently includes 92 threatened and endangered species across nine taxonomic groups: five amphibians, five birds, two crustaceans, 22 fishes, 39 flowering plants, five insects, 11 mammals, one reptile, and two snail species (supplemental table S3). The reserves with the greatest numbers of threatened and endangered species were the Mogollon Plateau (n = 24) and the Southern Rockies (n = 23). Overall, livestock grazing poses by far the most common threat (48% of species; n = 44), followed by mining (22%; n = 20), logging (18%; n = 17) and oil and gas drilling (11%; n = 10; supplemental figure S5). In 7 of the 11 potential reserves, at least half of the listed species are threatened by livestock grazing (supplemental figure S6). In all of the 11 potential reserves, average stream densities (stream orders 2–7) exceed 50 meters per km^2, suggesting significant opportunities for high density beaver restoration (supplemental figure S7).

Livestock grazing is ubiquitous on federal lands in the American West (figure 1e, supplemental figure S8) and, astoundingly, even occurs within some protected areas, such as wilderness areas, wildlife refuges, and national monuments (supplemental figure S9, table S2). Federal lands with managed livestock allotments often have various ecological impacts because of the multiple direct and indirect effects of these introduced large herbivores. For example, in many areas, livestock grazing causes stream and wetland degradation, affects fire regimes, and inhibits the regeneration of woody species, especially willow (*Salix* sp.; Beschta et al. 2013, Kauffman et al. 2022).

Although the effects of livestock grazing management on riparian areas are well known, there are also possible multitrophic effects on a host of wild animals such as herbivores, pollinators, and predators (Filazzola et al. 2020), as evidenced by the 23 animal species within the proposed reserves at risk from livestock grazing (table S3). Ruminant livestock are also a significant source of greenhouse gas emissions, especially methane, and their ecosystem impacts can exacerbate warmer and drier conditions, potentially shifting landscapes from carbon sinks to carbon sources (Kauffman et al. 2022). Moreover, limiting grazing and logging within strategic areas of federal lands can play an important role in mitigating climate change by protecting existing carbon stocks (figure 1d, supplemental figure S10; Law et al. 2021).

Based on our analysis, we suggest a rewilding plan for the proposed reserve network that includes: (1) retiring livestock grazing allotments on federal land within the proposed reserve network; (2) protecting, reestablishing, or recovering gray wolves,

especially within the network; and (3) reintroducing beaver in suitable habitat within the network. These three rewilding steps could greatly improve ecosystem structure and function, especially in riparian areas (figure 2). It is important to consider the order of the rewilding steps. For example, it generally makes sense to reintroduce beaver after livestock grazing on federal lands has been halted, allowing for a period of initial restoration of riparian woody vegetation on which beaver depend (Small et al. 2016).

Rewilding benefits

The ecological benefits of our rewilding plan would accrue over time, becoming greatest when wolves and beaver are allowed to reach ecologically effective densities (Soulé et al. 2003). In addition to eliminating the adverse effects of livestock grazing within the identified reserve network, it would be important to limit resource extraction industries and off-road vehicles. Because our plan prioritizes potential core areas of wolf habitat that occur mostly in forested areas, it spatially complements the proposed Sagebrush Sea Reserve Network, which is focused on protecting the greater sage grouse (*Centrocercus urophasianus*) and a host of other species in the sagebrush steppe (supplemental figure S11).

Considering our plan suggests reducing grazing allotments on federal lands by 29% (285,000 km^2 out of a total of 985,000 km^2 in the 11 western states), an economically and socially just federal compensation program for those who relinquish their government grazing permits would be appropriate provided these allotments are permanently retired. However, the net economic benefits would be substantial given the social carbon cost of livestock grazing on federal lands (Kauffman et al. 2022). For all allotments, receipts from grazing fees were $125 million less than federal appropriations in 2014 (Glaser et al. 2015). There would also need to be an action plan for managing potential conflict associated with wolves and beavers in cases where they move out of the reserve network.

Our proposed network across the West offers substantial connectivity between pairs of identified reserves, supporting gene flow, climate-related range shifts, and population viability of wide-ranging native species (figure 1c). The Western Rewilding Network would help protect and restore the 44 threatened and endangered species at risk because of livestock grazing (supplemental figure S12). And, over time, it would restore riparian systems, streams, and biodiversity; ameliorate altered fire regimes; and provide climate change mitigation through increased carbon storage. Restoration efforts could also be focused on the high connectivity areas between reserve pairs with land acquisitions or easements, which would form important wildlife corridors benefitting a variety of species (figures 1c and S3, supplemental table S4). In general, rewilding will be most effective when participation concerns for all stakeholders are considered, including livestock ranchers, local communities, hunters and fishers, recreationists, state and local governments, nonprofit organizations, and other private landowners (Fleischner 2010). Indigenous people and their governments would become the key partners.

Retiring allotments on some federal lands would also decrease livestock-related conflicts between humans and large predators. Moreover, adding and preserving wolves could assist in the natural control of overabundant native ungulates. This would allow for native vegetation regrowth of important species such as aspen (*Populus tremuloides*; figure 1f), which supports highly diverse plant and animal assemblages and is in major decline in the West, often because of browsing by livestock and wild ungulates in the absence of wolves (Seager et al. 2013). Restoring another keystone species, the beaver, to streams within the network would bolster and widen the ecological benefits to riparian areas. Currently, wolf management by some of the western state governments is geared toward reducing their numbers, and it is essential that these policies be reversed and federal protected status be fully restored (see the supplement for an overview of the policies).

Although our proposal may at first blush appear controversial or even quixotic, we believe that ultra ambitious action is required (Fleischner 2010). We are in an unprecedented period of converging crises in the American West, including extended drought and water scarcity, extreme heat waves, massive fires triggered at least partly by climate change (Ripple et al. 2021), and biodiversity loss with many threatened and endangered species (table S3). Furthermore, we note that the lands in the proposed network are already owned by the public and meat produced from all federal lands forage accounts for only approximately 2% of national meat production (Leshy and McUsic 2008).

President Biden's America the Beautiful plan needs a bold, scientifically grounded organizing principle like that provided by the Western Rewilding Network and the three steps proposed for rewilding these federal lands. If implemented alongside fine-scale conservation planning, it would restore critical ecological processes with minimal human interference, protect many endangered and at-risk species, increase resilience to climate change, and sustain an array of ecosystem services. Therefore, our plan represents a historic opportunity to rewild significant portions of the American West that could serve as an inspiring model for other regions and would ensure our natural heritage remains intact for future generations.

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Supplemental material

Supplemental data are available at *BIOSCI* online

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