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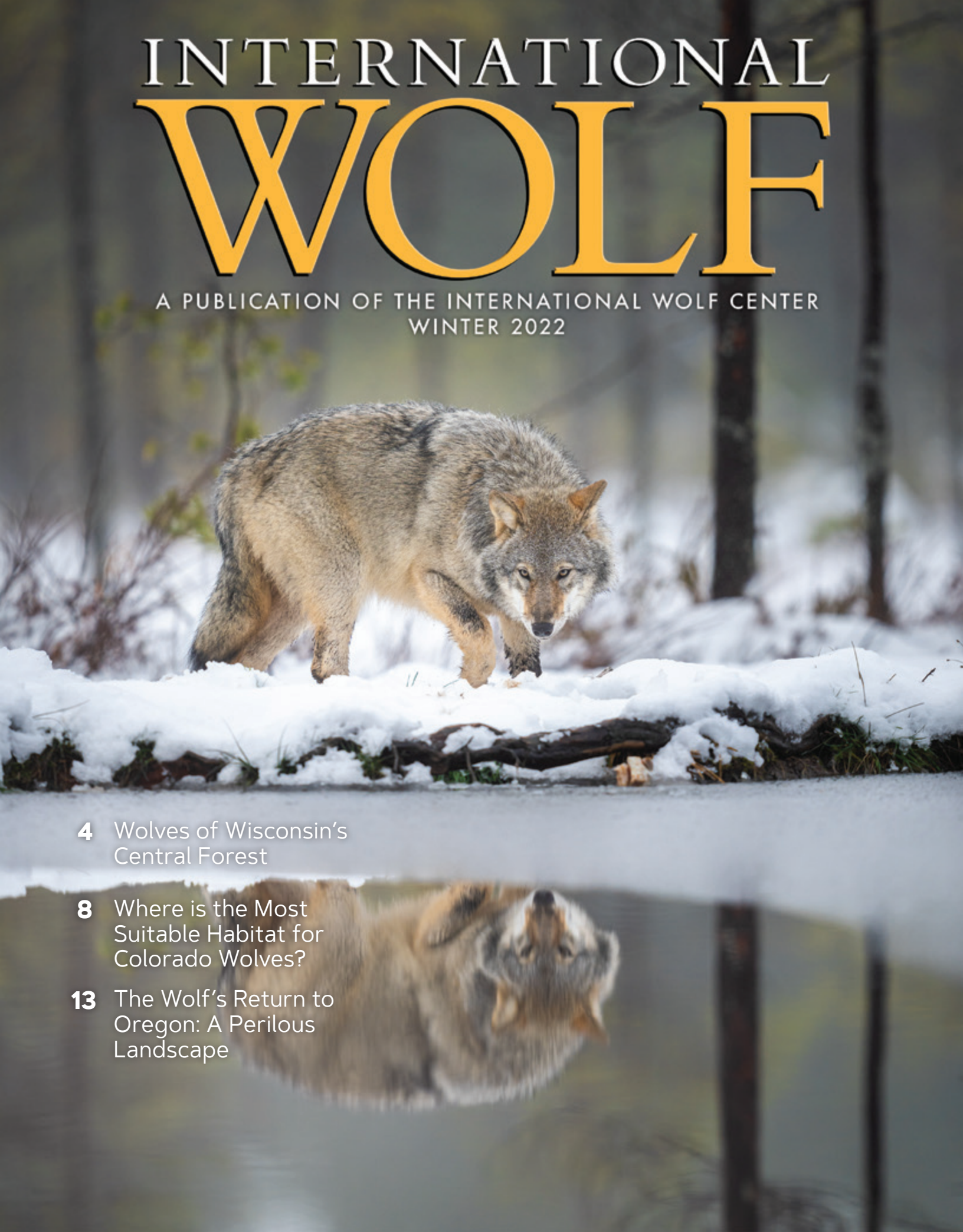
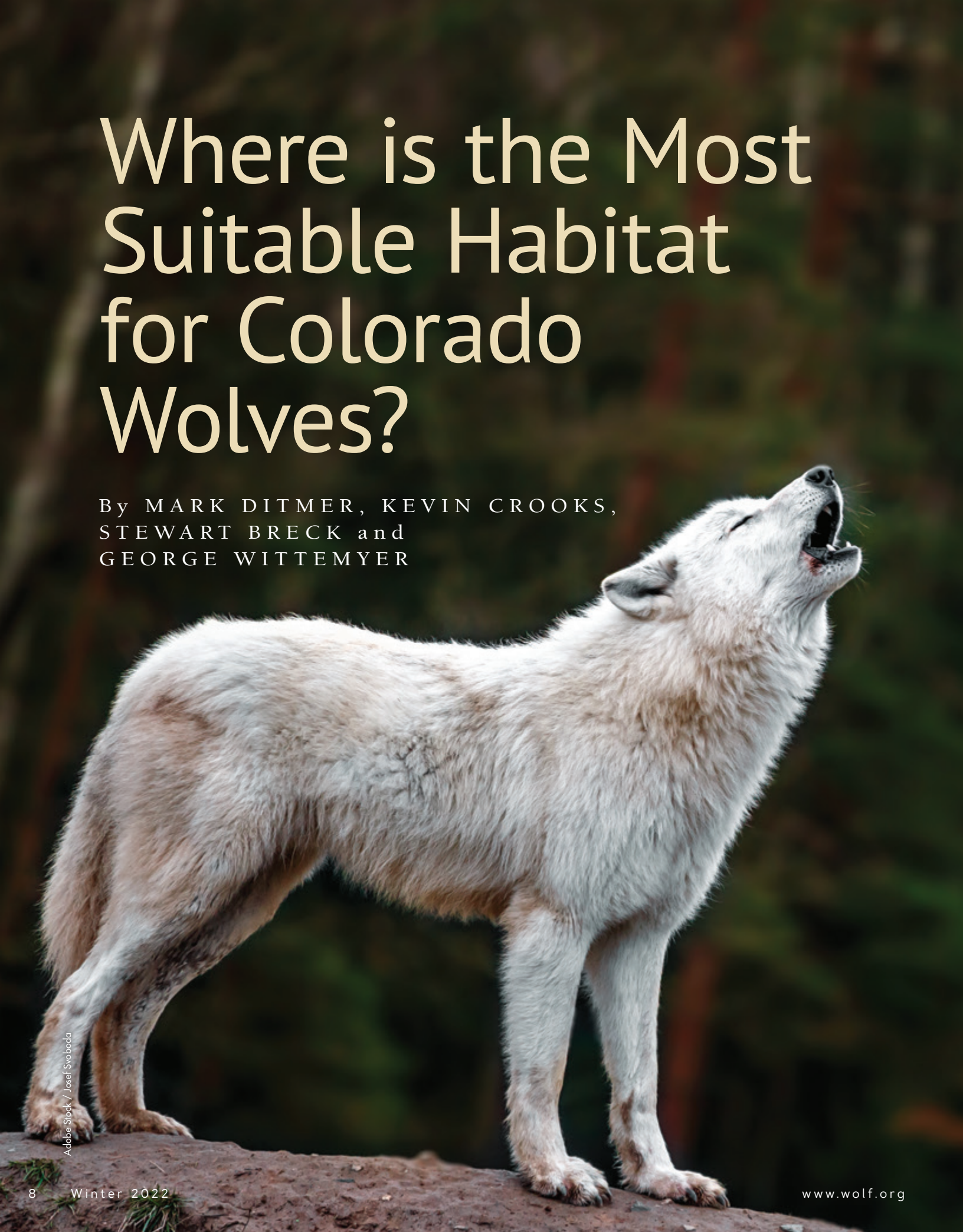


Where is the Most Suitable Habitat for Colorado Wolves?

By MARK DITMER, KEVIN CROOKS, STEWART BRECK and GEORGE WITTEMYER



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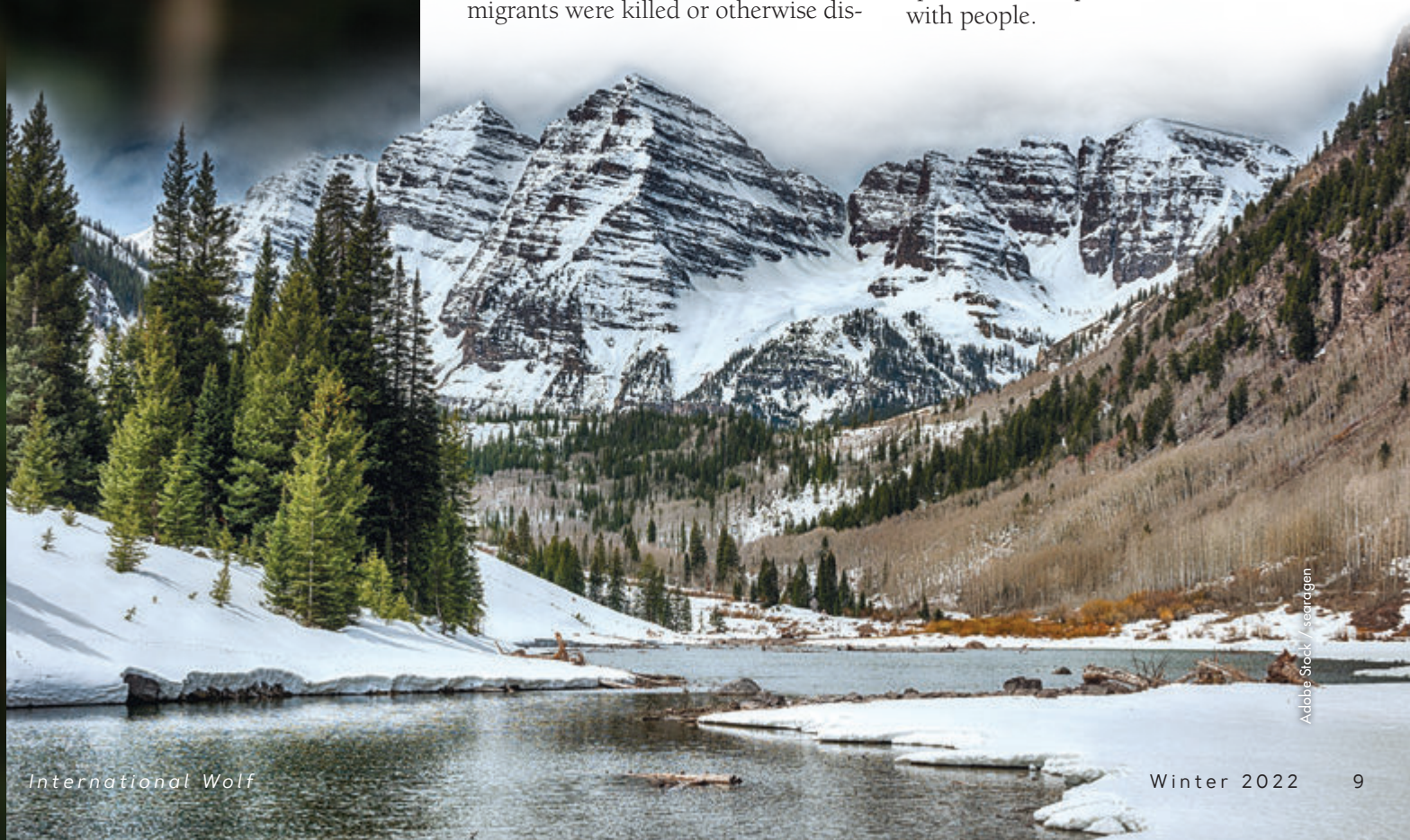
In November 2020, an unprecedented event in the history of wolf management and conservation took place. That month, more than three million citizens in Colorado voted on a ballot initiative that would require the state wildlife agency to reintroduce gray wolves into western Colorado by the end of 2023. The controversial ballot initiative passed by 50.9% of the vote. This was the first time that voters have directly decided to restore wolves, or indeed any native species, in the U.S.

Wolves are native to Colorado and historically distributed throughout all major habitat types in the state. Due to perceived threats to livestock and game, wolves were extirpated from Colorado by the mid-1940's via government-sponsored predator control. Since that time, a few wolves have dispersed into the state from the Greater Yellowstone Ecosystem, where wolves were reintroduced in the 1990's. Most of these migrants were killed or otherwise disappeared. However, in June 2021, a pair of wolves in northern Colorado near the Wyoming border produced the first confirmed litter of pups in the state in at least 80 years. Given the passage of the 2020 ballot initiative, more wolves are in store for Colorado in the coming years.

Determining social-ecological habitat suitability for wolves

Wolves were once the most widely distributed land mammal worldwide, occurring throughout the Northern Hemisphere. Despite their remarkable ability to live in a variety of habitats, from arctic tundra to deserts, ultimately people determine where wolves can live. In the western U.S., the best habitat for wolves is typically public lands where there is abundant prey and open space and less potential for conflict with people.



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In advance of reintroduction to Colorado, our research team at the Center for Human-Carnivore Coexistence at Colorado State University aimed to develop a social-ecological model that integrated ecological suitability for wolves and conflict risk with humans to predict suitable habitat for wolf restoration (Figure 1).

Ecological suitability in our model was determined primarily by prey availability. Elk and deer are important prey for wolves in the Northern Rocky Mountains and are the potential prey species with the highest densities in Colorado. Using statewide population estimates for elk, mule deer and white-tailed deer from Colorado Parks and Wildlife, we developed seasonal maps of prey availability. We then refined ecological suitability based on landscape features that influence habitat use and hunting success of wolves as well as habitat preferences of their prey. These factors included snow cover, vegetation, slope and the human footprint (i.e., road and housing density).

Conflict risk was estimated by several factors that increase the probability of negative interactions between wolves and people. Wolf predation on livestock is the primary source of conflict globally. We therefore estimated livestock density in Colorado, including animals in public-land grazing allotments managed by the U.S. Forest Service and the Bureau of Land Management. We also mapped land ownership in Colorado, assuming higher conflict risk in private lands and lower risk in protected areas. Finally, voting results from the ballot initiative, representing over 72% of eligible voters, provided a unique opportunity to index human tolerance of wolves. We used precinct-level voting data to generate statewide maps of public support for the ballot initiative. We assumed that areas with higher voting percentages in favor of wolf restoration equated to greater tolerance of wolves and less conflict risk.

Habitat Suitability and Conflict Hotspots in Colorado

Outputs from our model predicted that ecological suitability for wolves in Colorado was highest in the Western Slope north of Interstate 70 for both summer (Figure 2A) and winter (Figure 2B). This northwest region supports the highest densities of elk and deer, with terrain suitable for wolves to hunt and relatively low housing and road densities. Yet, this same region also has high conflict risk due to high livestock densities on public lands, lower tolerance for wolf reintroduction, and less protected land compared to the southwest region. Consequently, our models predicted conflict hot spots (darker purple in Figure 2) throughout much of the northwest region in both seasons.

In comparison, southwest Colorado contained more areas where conflict risk was low and ecological suitability was high, representing areas of high social-ecological suitability (darker green in Figure 2). The southwest region had less conflict risk due to lower livestock density on public land compared to northwest Colorado, and lower road and housing density compared to the urban Front Range. Further, prey abundance in the southwest, although less than in the northwest, is still high. The southwest region also tended to have higher tolerance for wolf reintroduction, especially in the resort regions of Aspen and Vail, and around the southwestern city of Durango.

Compared to the Western Slope, ecological suitability on the Front Range was low due

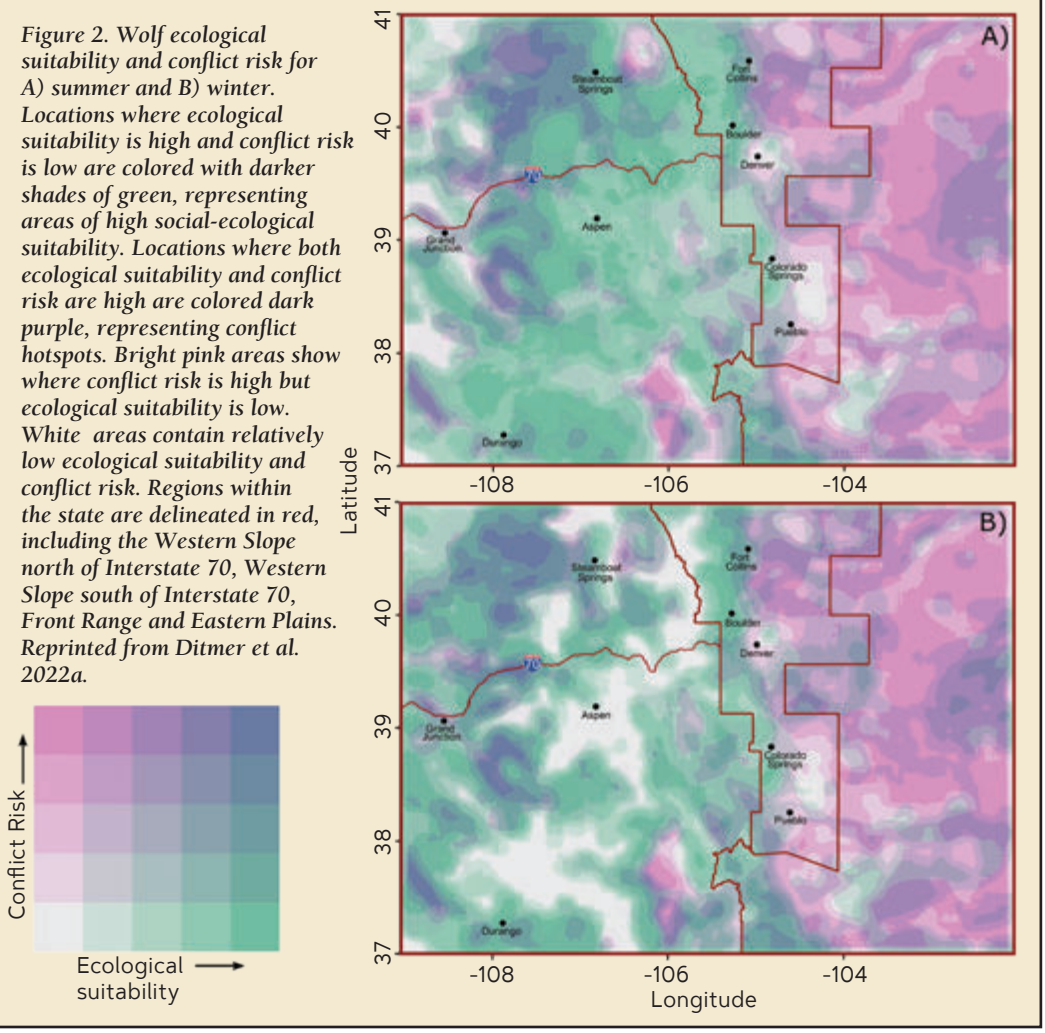

Figure 2. Wolf ecological suitability and conflict risk for A) summer and B) winter. Locations where ecological suitability is high and conflict risk is low are colored with darker shades of green, representing areas of high social-ecological suitability. Locations where both ecological suitability and conflict risk are high are colored dark purple, representing conflict hotspots. Bright pink areas show where conflict risk is high but ecological suitability is low. White areas contain relatively low ecological suitability and conflict risk. Regions within the state are delineated in red, including the Western Slope north of Interstate 70, Western Slope south of Interstate 70, Front Range and Eastern Plains. Reprinted from Ditmer et al. 2022a.

to lower prey densities and extensive urban development. The Front Range therefore had fewer areas considered to be high social-ecological suitability for wolves. Finally, the Eastern Plains were dominated by areas where conflict risk is high and ecological suitability is low (bright pink in Figure 2) due to low prey density and low human tolerance. Our models therefore predict that the Eastern Plains are the least likely to support resident wolf populations.

Guiding wolf restoration in Colorado

Our analysis found that the Colorado Western Slope—the target for wolf restoration—contained areas of ecologically suitable habitat for wolves and relatively low conflict risk with humans. Colorado has more than 24 million acres of public lands, mostly federally owned and in the western part of the state. Colorado also supports sufficient prey for wolves, including more than 400,000 mule deer and more than 300,000 elk, the largest elk population of any U.S. state. The largest big-game herds inhabit the Western Slope.

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The Western Slope, however, also contains areas of conflict risk between humans and wolves, particularly where livestock density is high. Mapping conflict risk associated with livestock is especially important in Colorado because large areas of public lands contain grazing allotments where free-ranging livestock might be vulnerable to wolves. Impacts on livestock from wolves creates costs borne by livestock producers, including mortality from wolf predation and other, indirect losses. These costs are unevenly distributed and localized, with some producers suffering greater losses than others. Although wolf predation is a small economic cost to the livestock industry as a whole, the effects on individual producers can be substantial. Our models suggest locations where proactive, non-lethal management could be targeted to reduce livestock losses. Such approaches often focus on modifying wolf, livestock and/or human behavior to minimize encounters. They include tools such as fladry (flagging), range riding, carcass management and livestock husbandry.

Attempting reintroductions in areas with low human tolerance can worsen conflict, resulting in increased retaliatory killing of wolves. Obtaining accurate, fine-resolution, spatially explicit data on tolerance, however, is challenging. The Colorado ballot initiative provided an unprecedented opportunity to measure a proxy of tolerance for wolves. Without developing this measure of tolerance, and combining it with livestock density and land ownership in our conflict risk model, only ecological suitability would have served as the basis of our habitat assessment. The highest area of ecologi-

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cal suitability was the northwestern part of the state. However, by integrating conflict risk into our ecological models, we identified other areas—notably southwest Colorado—that provided greater social-ecological suitability for wolves with less predicted conflict. While this suggests that the southwest region may hold the best opportunity for viable wolf reintroduction, some elk herds in the region are below population objectives set by Colorado Parks and Wildlife, raising concern for some wildlife managers and hunters. Targeted management and public engagement efforts will be necessary to reduce conflict and balance competing desires of various stakeholders in the area.

Our model did not forecast future climate and human development and their effect on habitat suitability for wolves and their prey. Given projected human population growth and changing climatic conditions in Colorado, such analyses would be valuable next steps. Future work should also evaluate landscape connectivity among habitat patches and where wolves might disperse as they colonize areas beyond where they are released. How such dispersal may influence conflict risk in newly colonized habitat is important to consider, as well.

The recent arrival of several wolves and a subsequent litter of pups in northwestern Colorado is noteworthy. Our models, however, predict a high risk of conflict for wolves that naturally colonize this region via Wyoming. Indeed, these newly arrived wolves have killed several livestock in the area, and efforts are ongoing to help reduce such conflict. Incorporating both social and ecological factors into predictive habitat models can help guide ongoing efforts to restore wolves to Colorado. More generally, continued development of such socio-ecological habitat models can lend valuable insight to wolf management and conservation throughout their range, particularly in landscapes increasingly dominated by humans. ■

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