Received: 14 June 2021 | Revised: 12 October 2021 | Accepted: 9 December 2021

DOI: 10.1002/eap.2532

COMMUNICATION

ECOLOGICAL APPLICATIONS
ECOLOGICAL SOCIETY OF AMERICA

Socio-ecological drivers of public conservation voting: Restoring gray wolves to Colorado, USA

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Handling Editor: Juan Corley

Abstract

Understanding factors that influence real-world public conservation behaviors is critical for developing successful conservation policies and management actions. Citizens of Colorado, USA recently passed a ballot initiative to restore the gray wolf to its former range within the state. The >3 million votes offer an unprecedented opportunity to test factors that influenced decisions to support or oppose this conservation action. We created spatial linear regression models to assess the relationship between support for wolf restoration and (1) the presidential vote, (2) distance to conservation intervention (i.e., proposed wolf reintroduction and existing wolves), and measures of (3) livelihood and (4) demographics using precinct-level data. Our results demonstrate the strong relationship between support for wolf restoration and political support for the Democratic candidate for president in the 2020 election, and highlight how other factors, including increased age, participation in elk hunting, and proximity to the reintroduction region were associated with less support. Our findings underscore the critical role of politicization on public conservation action and the need to develop outreach and engagement strategies to mitigate polarization.

KEYWORDS
ballot initiative, conservation initiative, politicization, public conservation behavior, species reintroduction, voting patterns, wolf reintroduction, wolf restoration

INTRODUCTION

In November 2020, Coloradans voted to pass Proposition 114, which mandates that the state wildlife agency, Colorado Parks and Wildlife, develop a plan to reintroduce and manage gray wolves (*Canis lupus*) starting by the end of 2023. Although the use of ballot measures to instigate or change a wildlife management action have increased during the last several decades (Manfredo et al., 2017, 2020), this measure was the first time voters have decided to restore a native species in the United States. Previous public opinion polls had found high levels of public support for restoring wolves to the state (Meadow et al., 2005; Niemiec et al., 2020a; Pate et al., 1996), but the Proposition passed with only 50.9% of the total vote, suggesting that the public was divided in their attitudes toward restoration.

The public vote on Proposition 114, for which more than 3 million citizens cast ballots on whether to restore wolves to Colorado, provided a unique opportunity to examine the social and ecological factors driving a real-world, directly measurable public conservation behavior

(i.e., an action taken by people that impacts a conservation outcome; Schultz, 2011). Human behavior can have direct impacts (e.g., through killing of carnivores) or indirect impacts (e.g., through influencing policy or funding) on conservation outcomes; in this case, we focus on the behavior of voting, which has indirect impacts. While there is a growing body of social science literature examining human conservation behavior, it is rare for studies to measure actual actions at the scale provided by vote data. Rather, the majority of conservation social science research examines self-reported behavior, behavioral intentions, or attitudes (Kidd et al., 2019; Niemiec et al., 2020b; Nilsson et al., 2020). Self-reported behaviors and behavioral intentions are not always strongly correlated with actual behavior (Bamberg & Möser, 2007; Nilsson et al., 2020) due to cognitive biases, such as people's desire to be viewed favorably by others (i.e., social desirability bias), which impact their ability to accurately remember and report their behavior. Furthermore, many people with strong attitudes and behavioral intentions do not engage in conservation behaviors, often due to numerous other barriers and motivations such as social (e.g., social norms, social identity) and contextual (e.g., ecological or institutional constraints) factors that can drive people's decision-making (Kollmuss & Agyeman, 2002). Despite these limitations, reliance on attitudes, intentions, and self-reports is common due to the costliness and difficulty of obtaining direct measures of behavior (Nilsson et al., 2020).

Existing social science research on wolves provides insight into the likely factors influencing voter decisions and the outcome of Colorado's ballot measure. Studies have found that support for wolf conservation can vary by livelihood and is generally lower among ranchers and hunters, who are often concerned about wolf depredation on livestock and wolves leading to a reduction in deer and elk populations (Bruskotter et al., 2009; Niemiec et al., 2020a; Williams et al., 2002). Livestock and hunting are key economic activities in many areas where wolves could be reintroduced, but so too is non-consumptive outdoor recreation. Areas with more recreation employment and tourism, such as mountain resort towns, may be more amenable to wolf restoration due to the potential for tourism boosts from wolves and the prevalence of non-consumptive outdoor activities (e.g., hiking, wildlife watching). Indeed, survey-based studies have found that people with more non-consumptive values toward wildlife tend to be more supportive of wolf conservation (Manfredo et al., 2020).

In addition to livelihoods, general demographics have been found to affect attitudes and beliefs toward wolves. For example, attitudes tend to become more negative with increased age (van Eeden et al., 2021) and more rural residence (Meadow et al., 2005; Pate et al., 1996), and more positive with increased education (Hamilton et al., 2020). Past research also has found a link between political affiliation and the support for wolf management strategies (Hamilton et al., 2020; van Eeden et al., 2021). van Eeden et al. (2021), for example, found that, among residents of Washington state, voters self-identifying as Democrats were more likely to hold positive attitudes toward wolves and management than those identifying with other political parties. Additionally, Hamilton et al. (2020) found that among Oregon residents, political party affiliation (which the authors refer to as "sociopolitical identity") was the strongest predictor of preferences concerning wolf management strategies after controlling for several demographic (e.g., age, sex, education) variables and land ownership. Specifically, the authors found that being Republican was associated with greater support of wolf elimination, and having mostly "same-party" friends intensified the effects on supporting wolf elimination.

In addition to general demographic representation, economic livelihood factors, and political affiliation, geographic proximity to the areas where the conservation action would occur can influence public behaviors and attitudes. Prior studies have found that people living in areas with wolves tend to have more negative attitudes toward wolf conservation compared with people living outside these regions (Karlsson & Sjöström, 2007; Williams et al., 2002). This effect may be due to increased concern about the negative impacts of wolves on their livelihoods (Niemiec et al., 2020a), direct negative experiences with wolves (Eriksson et al., 2015), and interactions with other people with increased concern or negative experiences with wolves (Williams et al., 2002). Furthermore, studies have found that the anticipated presence of wolves can enhance negative discourse about wolves in the media in those areas, potentially fueling more negative attitudes (Houston et al., 2010). This is particularly relevant in Colorado where the restoration will focus on the rural West Slope, far from the most populous parts of the state in the urban Front Range.

Here, we investigate the social and ecological factors driving a directly observable measure of public conservation action: the public's voting behavior on wolf restoration via Proposition 114 in Colorado. We build on the existing conservation social science literature to identify and examine four different types of drivers of conservation behavior: (1) presidential vote (measured as the 2020 presidential candidate vote); (2) demographics (e.g., age, education, population density); (3) livelihood (including occupation, hunter status, and participation in the recreation and tourism industry); and (4) distance to conservation intervention (i.e., where wolves will be restored

based on language of the Proposition and where wolves have immigrated in Colorado previously). While a growing number of studies have examined the influence of these and other factors on public attitudes and beliefs toward wolves, wolf management, and wolf reintroduction (Bruskotter et al., 2009; Hamilton et al., 2020; Niemiec et al., 2020a; van Eeden et al., 2021), no studies to our knowledge have explored the relative influence of these factors on a high-resolution measure (i.e., votes) of actual (as opposed to self-reported) public behavior related to species conservation.

METHODS

Voting results by precinct and presidential vote

The vote totals for and against Proposition 114 were available from the Colorado Secretary of State's website. We associated vote data to 2020 precinct boundaries available from the *New York Times* (Watkins et al., 2021). We then divided the count of votes for Proposition 114 by the total votes for or against the ballot initiative to create the proportion of wolf restoration support by precinct (Figure 1a). The precinct boundary file provided by the *New York Times* also included the vote totals for the presidential candidates. Instead of using party affiliation, which was not available in our databases, we used the presidential vote to represent political affiliation or orientation, as it may have been a more current representation of the overall political climate, because voters might not update their affiliation or may change political leanings as the platforms of political parties shift through time. Refer to Table 1 for complete information on each variable considered.

Demographics

We downloaded spatially explicit data on the population of Colorado from the United States Census Bureau's 2010 decennial census and the 5-year American Community Survey (ACS) for the year 2019 using the package *tidycensus* (Walker & Herman, 2021) in program R (R Core Team, 2020; Table 1). Precinct boundaries often contained multiple or partial data from across units used in the census and ACS, so we overlaid precinct boundaries and summarized each raster at the precinct level. Refer to Appendix S1: Section S1 for further details.

Livelihood

We used an index of livestock presence on the landscape and calculated the mean of the index per precinct to

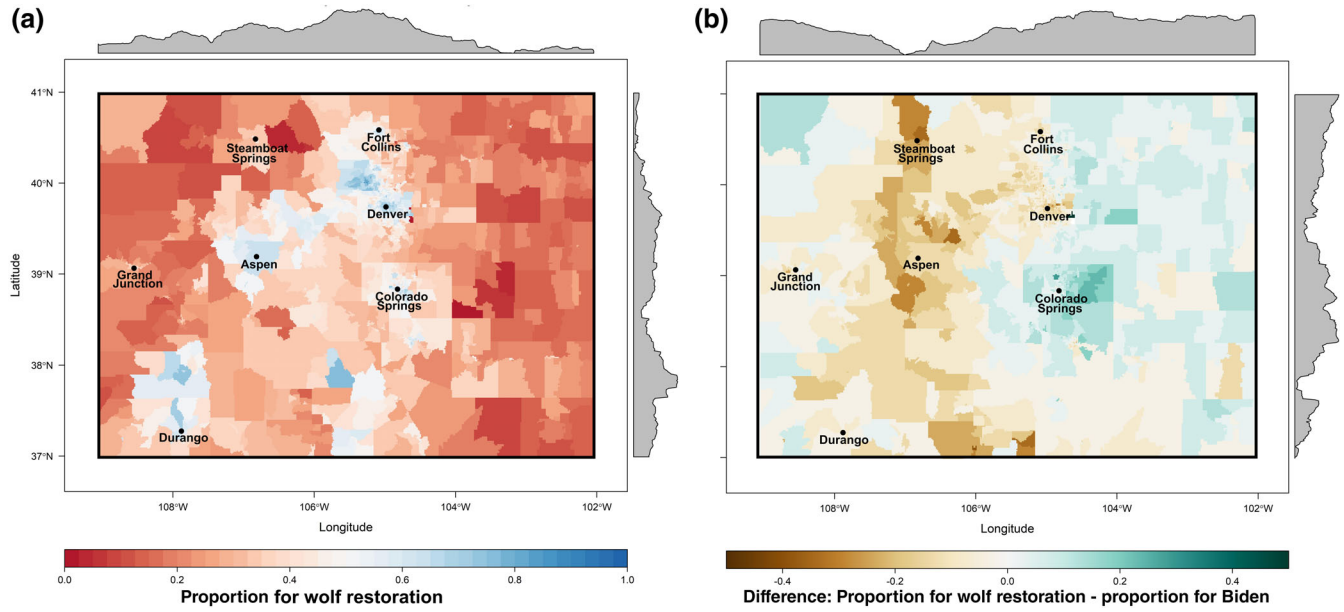

FIGURE 1 Maps depicting the precinct-level vote of the proportion for the ballot initiative to restore wolves to the state of Colorado, USA (a) and the difference in support for wolf restoration after subtracting support for President Biden (b). The precinct-level vote for the ballot initiative was used as the response variable (proportion of votes for wolf restoration) in our spatial models. We created a primary model that included the influence of political affiliation and an exploratory model that excluded it. Gray histograms around the borders show the mean values longitudinally and latitudinally

TABLE 1 Description and summaries of the data used to create variables in the model of support for wolf restoration voting in Colorado, USA in 2020

Group & Description	Original units	Original spatial resolution	Original source	Mean (precinct level)	Data range (precinct level)	Hypothesized influence on wolf restore (±) support
Response						
Proportion "YES" wolf restore count	Proportion	Precinct	Colorado Secretary of State	0.50	0.02–0.999	***
Presidential vote						
Proportion Biden vs. all presidential candidates	Proportion	Precinct	*New York Times*	0.55	0.035–1	Positive
Demographics						
Median age	Years	Census block	Census 2010	41.48	11.5–86.5	Negative
Average proportion of people with a bachelor's degree or higher	Proportion	Group block	ACS 2015–2019	0.30	0–0.78	Positive
Median income	US dollars	Group block	ACS 2015–2019	84,166	13146–250,000	Positive
Human population density	Density (population/area)	Census block	Census 2010	1.83	0–22.35	Positive
Livelihood						
Deer population % above/below CPW target	Proportion	Deer data analysis unit	CPW	0.06	−0.87 to 0.93	Positive
Deer hunter density	Hunters/area	Deer data analysis unit	CPW	0.45	0.024–1.59	Negative
Deer hunter effort	Ratio (total hunt days/total hunters)	Deer data analysis unit	CPW	5.41	2.07–6.23	Negative
Elk population % above/below CPW target	Proportion	Elk data analysis unit	CPW	0.09	−0.34 to 2.0	Positive
Elk hunter density	Density	Elk data analysis unit	CPW	0.44	0.01–3.92	Negative
Elk hunter success	Percentage (No. hunters with kill/No. total hunters)	Elk data analysis unit	CPW	22.82	7.2–54.1	Positive
Index of livestock presence	Habitat suitability model	50 m^2	BLM, USFS, USDA	0.03	0–0.53	Negative
Average proportion of people in recreation industry	Proportion	Census tract	ACS 2015–2019	0.05	0–0.38	Positive
Mean elevation (another proxy for recreation)	Meters	30 m^2	USGS	1770	1055–3580	Positive

(Continues)

TABLE 1 (Continued)

Group & Description	Original units	Original spatial resolution	Original source	Mean (precinct level)	Data range (precinct level)	Hypothesized influence on wolf restore (±) support
Distance to conservation intervention						
Distance to reported wolf pack	km	Point distance	NA	458.10	17.5–891.9	Positive
Binary: precinct in West Slope (1) or not (0)	State regions	50 m^2	NA	0.16	0–1	Negative
Public land coverage	Proportion	50 m^2	CoMap	0.14	0–1	Negative

estimate the importance of ranching livelihoods within each precinct. We also created several variables related to the primary areas of big game hunting in Colorado using public data from Colorado Parks and Wildlife (CPW).

Livelihood data that best represented recreation industry employment were only available from the ACS at the census tract level and included a count of individuals working in the arts, entertainment, recreation, and accommodation and food services. As a second metric representing areas with more potential recreation and tourism (e.g., hiking, skiing), we calculated the mean elevation (m) of each precinct using a digital elevation model at a 30-m resolution, assuming more outdoor recreation surrounding high-elevation mountain resort towns. We hypothesized that areas with more outdoor recreation employment and tourism would be more likely to vote for wolf restoration, due to the potential for tourism boosts from wolves and the prevalence of non-consumptive outdoor activities (e.g., hiking, wildlife watching). Refer to Appendix S1: Section S1 for further details.

Distance to conservation intervention

We created two variables to represent the distance to conservation intervention (i.e., wolf restoration in Colorado). The first was based on the Euclidean distances between each precinct's centroid coordinates to the region in northwestern Colorado where a small group of wolves that had dispersed from an adjacent state had been recently sighted and highlighted in the news media. We also included a binary variable representing precincts in the West Slope of Colorado, which will be the focus of restoration efforts. Additionally, we calculated the percentage of public lands within each precinct, given that wolf restoration will occur on public lands. Refer to Appendix S1: Section S1 for further details.

Statistical analysis

We created spatial linear regression models using the 'fitme' function in the R package *spaMM* (Rousset & Ferdy, 2014) to assess the relationships between support for Proposition 114 and our covariates at the precinct level (3200 precincts in Colorado after removing 146 due to missing data). These models included pairwise correlations based on a 'Matérn' function that used the scaled Euclidean distances among precinct centroids. Our primary model used the logit-transformed proportions of votes for wolf restoration as the response variable and covariates associated with political affiliation, demographics, livelihood, distance to conservation intervention, and the 'Matérn' correlation structure. As an exploratory analysis, we also modeled the vote for wolf restoration but excluded political affiliation. We used quadratic terms for distance to wolf pack, population density, and elevation because their relationship with the wolf restoration vote may not be linear based on preliminary plots. We assessed correlation and centered and scaled all continuous variables using z-transformations before analyses to better compare effect sizes; West Slope voters [binary] was the only non-continuous variable. Refer to Appendix S1: Section S1.2 for further statistical analysis details.

RESULTS

Voting patterns closely aligned with our hypotheses about support for the wolf restoration ballot initiative. Presidential voting patterns had the largest effect on support for wolf restoration (Figure 2). Coloradans who voted for President Biden were far more likely to support Proposition 114 ($\widehat{\beta} = 0.63$, 95% CI 0.60, 0.66; Figure 3), although heterogeneity in this relationship existed (Figure 1b). Within the primary model that accounted for

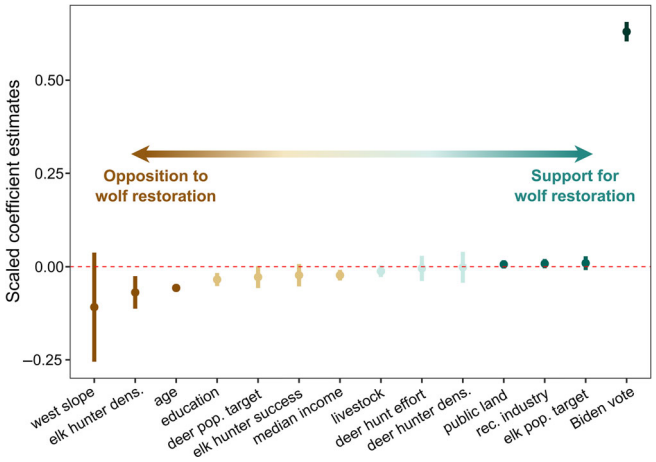

FIGURE 2 Coefficient estimates (and 95% confidence intervals) of the scaled and centered variables from the model assessing the relationships in the precinct-level votes for wolf restoration in Colorado, USA

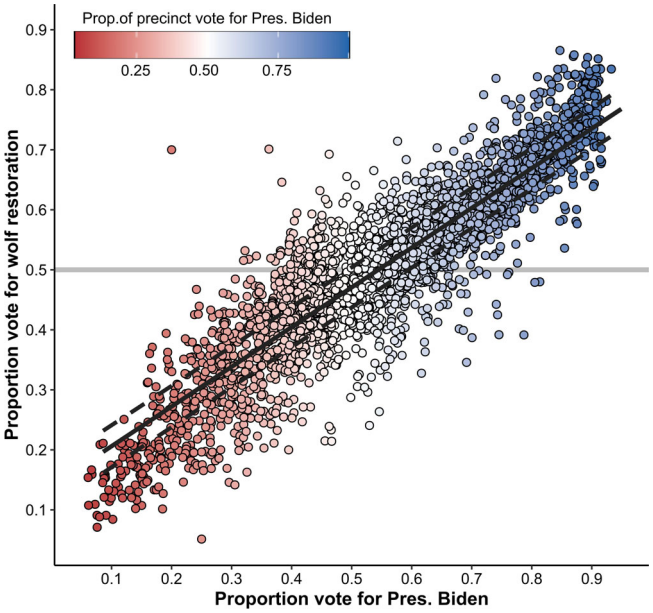

FIGURE 3 Scatterplot of the relationship between the vote for the wolf restoration initiative (*y*-axis) and the vote for President Biden (*x*-axis) in Colorado, USA at the precinct level (1 point = 1 precinct). Dark lines represent the mean (solid) and 95% pointwise confidence interval marginal effects (dashed) from our model of support for wolf restoration. Data are plotted on their original scales and all other covariates were held at their mean values

the presidential vote, covariates from each of the other categories (demographics, livelihood, distance to conservation action) were also related to support for wolf restoration (Figure 2). Proxies for distance to conservation action had strong effects, with less support for the ballot initiative closer to probable restoration areas (West Slope voters: $\widehat{\beta} = -0.11$, 95% CI −0.25, 0.04, Figure 2; distance to wolf pack: $\widehat{\beta}_{poly1,2} = -0.33, -2.08$ 95% $CI_{poly1,2}$–3.04, 2.38; −4.07, −0.09; Figure 4c), but there was a large amount of variation in support within West Slope precincts resulting in 95% CIs that overlapped zero.

Older Coloradans were less likely to support wolf restoration regardless of whether the presidential voting covariate was included in the model (median age per precinct; $\widehat{\beta} = -0.06$, 95% CI −0.07, −0.05; Figures 2 and 4b) or not ($\widehat{\beta} = -0.11$, 95% CI −0.13, −0.10; Appendix S1: Figures S2 and S3b). The influence of level of education on wolf restoration was dependent on whether presidential voting records were included in the model. Without considering presidential support, Coloradans that attained higher education levels supported wolf restoration ($\widehat{\beta} = 0.02$, 95% CI −0.01, 0.04; Appendix S1: Figures S2 and S3), although the 95% CI overlapped zero. However, when presidential vote was included, the relationship became negative ($\widehat{\beta} = -0.03$, 95% CI −0.05, −0.02; Figure 4e), suggesting that voters for President Biden with lower educational attainment had relatively more support for wolf restoration than voters in precincts with higher educational attainment. Similarly, the negative relationship between median income and support for wolf restoration became much stronger when presidential vote was excluded ($\widehat{\beta} = -0.06$, 95% CI −0.08, −0.04; Appendix S1: Figures S2 and S3c) relative to when it was included ($\widehat{\beta} = -0.02$, 95% CI −0.01, −0.04; Figures 2 and 4f).

Areas with greater population density had a non-linear positive relationship with support for wolf restoration ($\widehat{\beta}_{poly1,2} = -0.20, 0.49$, 95% $CI_{poly1,2}$ −0.80, 0.41; 0.04, 0.94; Figure 4d). The only livelihood variable with 95% CI's that did not overlap zero was the number of elk hunters in a precinct. Areas with more elk hunters were less likely to support wolf restoration ($\widehat{\beta} = -0.07$, 95% CI −0.11, −0.03; Figure 4a). However, without accounting for the presidential vote, the livelihood variables representing the outdoor recreation industry had a positive effect on the wolf restoration vote (% in the recreation [and service] industry; $\widehat{\beta} = 0.03$, 95% CI 0.02, 0.05; Appendix S1: Figure S3e), while the effect of elevation was non-linear, showing the most support for wolf restoration at both lower elevations associated with the Front Range area and precincts with the highest elevations (>2800 m; $\widehat{\beta}_{poly1,2} = -4.61, 3.32$ 95% $CI_{poly1,2}$–8.54, −0.69; 0.99, 5.65). Only when we excluded presidential voting patterns did our proxy for livestock production result in a significant, but generally small, negative effect on wolf restoration support ($\widehat{\beta} = -0.04$, 95% CI −0.06, −0.02; Appendix S1: Figure S3f).

DISCUSSION

Despite the growing body of social science literature on the drivers of public conservation behavior, few direct

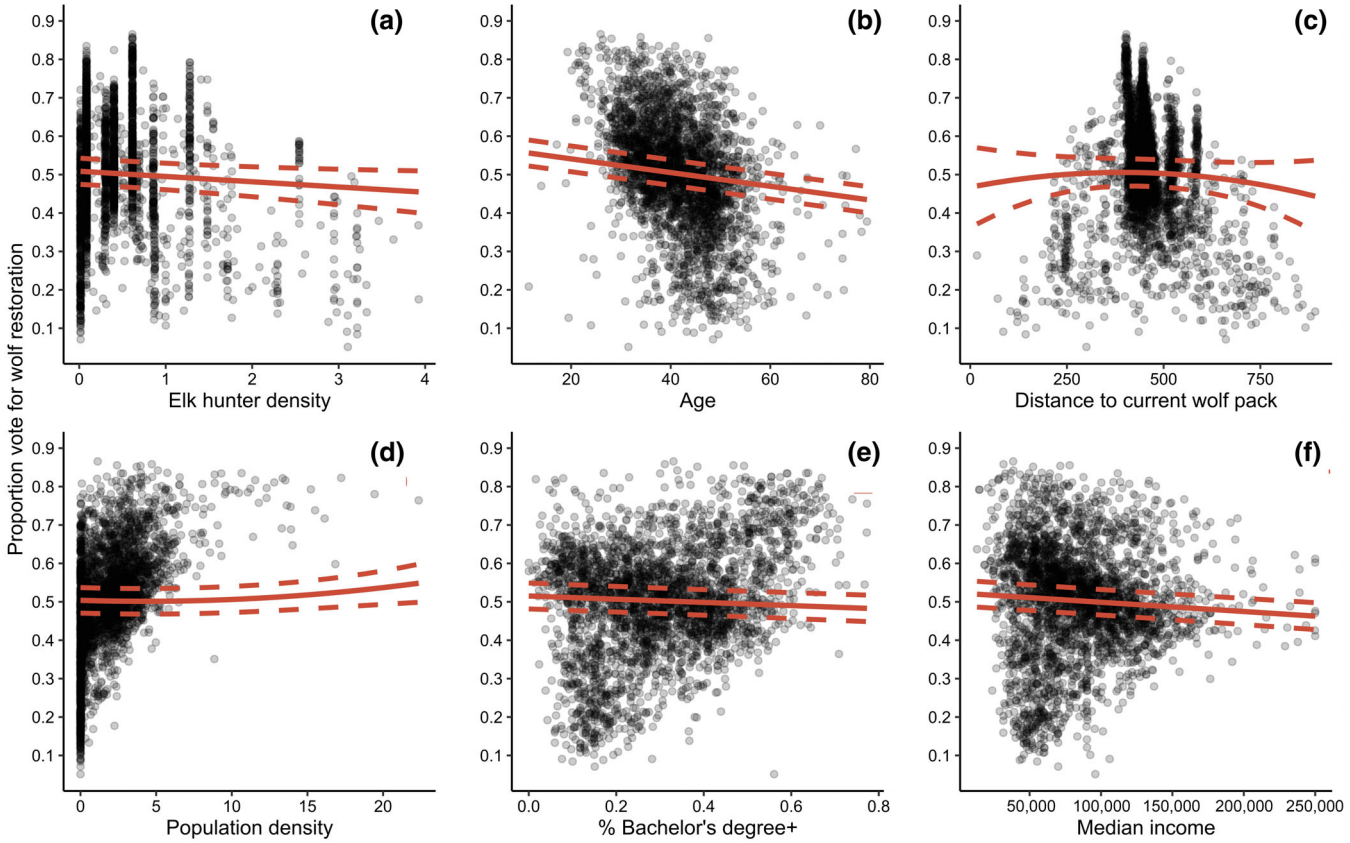

FIGURE 4 (a–f) Effect plots showing the relationship between each covariate of interest and the proportion of vote for wolf restoration in Colorado, USA at the precinct level. All variables on their original scales and all other covariates within each effect plot were held at their mean values. Red lines represent the mean (solid) and 95% pointwise confidence interval marginal effects

measures of public conservation action are available at scale (large numbers representing large areas), limiting the scope of research on this topic. Leveraging public voting records for wolf restoration via Proposition 114 in Colorado, a form of conservation action, we examined the relative impact of the presidential voting patterns, demographics, livelihoods, and distance to conservation intervention across the state on the 3 million recorded votes. We found that votes for wolf restoration were most associated with support for the presidential candidates. Specifically, individuals who voted for the 2020 Democratic presidential candidate were more likely to vote for Proposition 114. This finding supports recent survey-based studies, which have suggested that political party affiliation and sociopolitical identity are the strongest predictors of support for wolf management in other states (Hamilton et al., 2020; van Eeden et al., 2021).

Our findings on the impact of various demographics, livelihood strategies, and distance to the conservation initiative generally aligned with prior survey-based work (Meadow et al., 2005; Niemiec et al., 2020a; Williams et al., 2002) and media analyses (Houston et al., 2010) on public attitudes toward wolf restoration and conservation. Specifically, we found that votes in favor of wolf restoration tended to be positively associated with younger, more urban populations and negatively associated with elk hunters and proximity to current wolves and proposed wolf restoration. These findings highlight the need for outreach to focus on hunters and individuals who currently live or anticipate living with wolves. Identifying key opinion leaders in these communities (Dalrymple et al., 2013) and providing them with social support networks to reach out to others (Niemiec et al., 2019) with scientific information about coexistence with wolves may be critical for facilitating attitude and behavior change.

Interestingly, we did not find a significant effect of indicators of ranching livelihoods (i.e., livestock presence) on voting behavior when accounting for the presidential vote. However, the lack of a significant effect of livestock presence in our primary model is likely to be due in part to its strong correlation with political affiliation, as would be expected in rural ranching communities with more conservative political affiliations (Liu et al., 2014). Indeed, results from our exploratory model without accounting for the presidential vote revealed that

areas with more livestock had a significant, albeit small, negative relationship with support for wolf restoration. This result does not completely align with survey-based studies indicating strongly reduced support for wolf restoration among ranchers (Meadow et al., 2005) as well as documented widespread media coverage of the negative impacts of wolves on ranching livelihoods in advance of the ballot initiative (Niemiec et al., 2020a). Concerns about the impacts of wolves to ranchers may be shared in broader social circles in rural communities such that membership in these social networks might be more important than being a rancher specifically. Of particular interest for future investigation is which ranching communities had the relatively highest support for wolf restoration.

A limitation of our paper is that we were unable to measure more fine-scale attitudes and beliefs that have been suggested to influence public behavior related to wolf restoration and biodiversity conservation. For example, studies highlight the critical role of public trust in wildlife agencies and other organizations in influencing public support and actions related to wolf conservation, wildlife management, and natural resource conservation more broadly (Sponarski et al., 2014; Vaske et al., 2007). As the ballot initiative was not an action instigated or supported by the state wildlife agency, members of the public may have questioned whether experts in the field supported the reintroduction effort. Other studies have highlighted the role of identity-based conflict among stakeholder groups in driving public acceptance of wolf and wildlife management strategies (Lute & Gore, 2014; Madden & McQuinn, 2014). Future research could integrate spatially explicit measures of attitudes and beliefs, such as agency trust and intergroup perceptions driving social conflict, to examine the relative impact of these perceptions compared with political affiliation, demographics, livelihoods, and distance to the conservation initiative.

Our study provides one of the first large-scale analyses of the impact of various social and ecological factors on a real-world public behavior that influenced a conservation outcome. The observed politicization of wolf restoration in our study relates to a broader trend of increased politicization of science (Gauchat, 2012) and poses a significant challenge for conservation efforts. Specifically, politicization of issues can result in deeply entrenched viewpoints that are difficult to sway using scientific information and education alone (Gauchat, 2012). Although conservation decisions can be considered inherently political because they are based on values and decision-making on how people relate to nature (Adams, 2015), the restoration and management of large carnivores, especially wolves, is an especially politically charged and partisan action (Hamilton et al., 2020; van Eeden et al., 2021); building public support and behavior change for highly politicized conservation initiatives will therefore require novel strategies that move beyond public information provision. Research from fields such as social psychology, communications, and political science can lend insight into strategies that could be adapted for politicized biodiversity conservation initiatives (Bolsen & Druckman, 2015). For example, Feinberg and Willer (2013) identified different moral foundations (i.e., values) among political parties that are important to take into consideration when framing messages about environmental issues. Bolsen and Druckman (2015) highlighted numerous strategies for addressing the politicization of science, including: focusing on more local aspects of issues, given that people tend to be less driven by politicization when thinking about local outcomes; ensuring information comes from varying sources with different political agendas; and facilitating deliberations among people with diverse political perspectives, given that people are more likely to process information in an even-handed manner when they anticipate having to explain their beliefs to others. Our results suggest that research into these and other interventions for counteracting politicization of biodiversity conservation initiatives may be critical moving forward in an increasingly divisive political climate.

ACKNOWLEDGMENTS

We thank John B. Vincent who assisted with data acquisition and coding along with two anonymous reviewers who provided useful edits.

AUTHOR CONTRIBUTIONS

All authors contributed to the conceptualization. Mark A. Ditmer led the formal analysis. Mark A. Ditmer and Rebecca M. Niemiec wrote the initial draft with input from George Wittemyer and Kevin R. Crooks. All authors reviewed and edited the manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data (Ditmer et al., 2021) are available in Dryad at https://doi.org/10.5061/dryad.xpnvx0kh4.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

How to cite this article: Ditmer, Mark A., Rebecca M. Niemiec, George Wittemyer, and Kevin R. Crooks. 2022. "Socio-Ecological Drivers of Public Conservation Voting: Restoring Gray Wolves to Colorado, USA." *Ecological Applications* 32(3): e2532. https://doi.org/10.1002/eap.2532