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## Using Spatial, Economic, and Ecological Opinion Data to Inform Gray Wolf Conservation

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### Abstract

Public opinion can be an influential factor in wildlife management decisions. Evaluating public opinions can help legitimize, or delegitimize, management and facilitate long-term conservation goals. This is especially true for the controversial issues surrounding the management of predators. We surveyed Montana, USA, residents during summer of 2013 to measure public opinion regarding economic and ecological impacts of the gray wolf (*Canis lupus*), and current management of this species. Although opinions were polarized in some areas, a greater percentage of Montanans think that wolves negatively affect the economy, but impact tourism (which contributes to the economy) positively. These differences may reflect the belief that rancher economic losses from wolf predation of cattle is greater than overall tourism gains related to wolves (e.g., wolf-watching), in addition to the perception of wolves negatively affecting big game (e.g., elk [*Cervus canadensis*]). Results also show that a slightly greater percentage of Montanans feel that wolves positively rather than negatively affect the ecosystem. Regarding specific practices, more Montanans than not have a positive opinion of maintaining wolves on the landscape and also support hunting of wolves. More Montanans hold negative rather than positive opinions, however, regarding wolf trapping. This result was most evident in western Montana as assessed by a spatial distribution of opinions by county and has implications for current wolf management and nontarget species. Results of ordinal regression analyses revealed that big game hunters, males, and those who held negative opinions of the effect of wolves on the Montana ecosystem and economy were significantly more likely to support both hunting and trapping practices. Living in western Montana predicted positive opinions of hunting, but alternatively, negative opinions of trapping. These results provide an understanding of public opinion of wolf management by county as well as statistical inferences that can be useful for informing more regionally oriented management practices.

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## Keywords

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Public opinion is an influential component in wildlife management decisions (McCool and Guthrie 2001). Opinions regarding wildlife in the western United States, however, are often contentious and divisive, making management decisions difficult. One particularly divisive issue is that of apex predators and a variety of issues they represent. Apex predators affect ecological systems, are associated with biodiversity and, therefore, important for ecosystem and human health (Ripple and Beschta 2003, Chivian and Bernstein 2008, Estes et al. 2011). However, an apex predator can have adverse effects on rancher revenues through livestock losses (Muhly and Musiani 2009). The gray wolf (*Canis lupus*), through extirpation, reintroduction, and listing and delisting as a protected endangered species remains at the forefront of this controversy (Houston et al. 2010).

Wolf management decisions are frequently litigated and highly politicized (Wilson 1997, Nie 2003) and, as a result, special interest groups can be oversampled when gathering public input regarding wolf conservation (Bruskotter et al. 2007). Assessing representative public opinions can help clarify assertions that policy reflects the voices of select groups. Public input is also important for improving legitimacy and credibility of wildlife management's long-term conservation goals and has potential to improve environmental outcomes (Messmer et al. 1997, Susskind et al. 1999, Parkins and Mitchell 2005, McKinney and Field 2008). When there is a transparent link between public input and policy, levels of satisfaction with natural resource management also tend to increase (McCool and Guthrie 2001, Smith and McDonough 2001).

## Public Opinions Concerning Wolves

A variety of response items, which are sometimes combined into multi-item measures of latent psychological constructs, have been used to quantify opinion, attitudes, values, tolerance, and public support associated with wolves (Bath and Buchanan 1989, Lohr et al. 1996, Wolstenholme 1996, Bath and Farmer 2000, Decker et al. 2006, Slagle et al. 2012). Some of these scales were similar in measurement of positive to negative dispositions toward wolves, making comparisons across studies straightforward (see Williams et al. 2002 regarding how similarities in some scales allow for a comparison across studies). The purpose of our study was not to provide a theoretical framework of various constructs (e.g., opinions, values) as they relate to wolves, nor to provide an exhaustive literature review related to these constructs. Rather, we aimed to understand current public opinion related to the economic and ecological effects of wolves and how these issues may influence opinions regarding wolf management in Montana, USA, to inform policymakers concerning conservation and management.

Debate surrounding wolves is complex and multifaceted. One particularly divisive aspect is perceptions of the economic impacts wolves have on the state of Montana as well as the region (Muhly and Musiani 2009). On one hand, negative attitudes and opinions of wolves may often stem from adverse effects wolves can have on rancher livelihoods (e.g., cattle

predation, decreased livestock weights or reproduction; Kellert 1985, Bath 1989, Williams et al. 2002, Muhly and Musiani 2009, Laporte et al. 2010). On the other hand, positive attitudes and opinions can stem from benefits of wolves to the tourism industry (e.g., visitation to the region for wolf viewing [Duffield et al. 2006]), and conservation groups highlight impacts of wolves on the tourism industry to demonstrate economic impetus for maintaining wolf populations (Defenders of Wildlife 2013). Another reason wolves generate conflicting attitudes is that wolves can negatively affect hunters' perceptions of game population numbers, but can also be seen as favorable for opportunities to hunt the predator, both of which can affect the economy via tourism as a result of out-of-state visitors traveling to hunt game species or wolves (Holsman 2000, Treves and Martin 2011). Additionally, Slagle et al. (2012) found that benefits associated with wolves were more predictive of political actions, both for and against wolves, than associated risks or costs of wolves. Still others suggest that sanctification or demonization of the wolf is overly extreme and influential in weighing the various effects of wolves (Mech 2012). These opposing views and economic tensions create conflicts among livestock producers, wolf conservation groups, tourists, and hunters, making conservation efforts difficult. To address these critical economic issues, we assessed public opinion regarding effects wolves have on the economy as a whole, as well as the perceived impacts on tourism.

Adding to the complexity, the role of science as well as the importance of ecological effects of wolves in wildlife management is disputed and fosters continued conflict (Bruskotter 2013). Therefore, another important influence of the public's opinion toward wolves is the public's perception of their ecological effects. Although researchers have documented the benefit of predators for wildlife species and vegetation (Ripple and Beschta 2003, Estes et al. 2011, Ripple et al. 2014), these ecological benefits may be discounted as a result of the cost associated with living with predators (Treves et al. 2013). To better understand this issue, we also examined the public's opinion regarding the effect of wolves on associated ecosystems.

## Current Wolf Management in Montana

In April 2011, a reissue of the 2009 gray wolf delisting from the Endangered Species Act was passed by the U.S. Congress (Aasheim 2011). Delisting from federal protection transpired by placing a legislative rider on a "must pass" budget bill (Bruskotter 2013). These actions spawned heated public debates and have been heavily criticized by conservation groups and scientists (Bruskotter 2013). The 3 most recent years of data for wolf harvest (2012–2014) revealed that 661 wolves were killed including 128 shot, 97 trapped in 2012; 143 shot, 87 trapped in 2013; and 130 shot, 76 trapped in 2014 (Montana Department of Fish, Wildlife and Parks 2012, 2013, 2014). Predator control (e.g., hunting) is an approach purported to facilitate societal acceptance of predators; however, the swift move from strict wolf protection to large-scale harvest is historically unparalleled (Creel and Rotella 2010).

Bisi et al. (2007) noted that some individuals affected by wolf conservation feel they are unable to influence management decisions and their opinions are not considered. Some frustration related to wolf management can result from unclear justification of hunting and

trapping activities (Treves and Martin 2011, Way and Bruskotter 2012, Bruskotter 2013). To contribute to greater clarity of extirpation practices, Bruskotter (2013) suggested setting current hunting and trapping regulations with public input concerning the method and location of take. For these reasons, another goal of the present study was to understand public opinion related to current hunting and trapping regulations in Montana.

In summary, with yearly shifts in wolf management policies, it is important to monitor the public's perception of economic, ecological, and management shifts that result from changing wolf populations and policy. It is also critical to understand how conservation efforts, current practices, and public opinion align. Public opinion regarding management practices helps to influence adherence to policy (Treves et al. 2013), legitimize long-term conservation and management goals (Messmer et al. 1997, Agrawal and Gibson 1999), and inform policymakers for upcoming management seasons by specific extirpation technique (e.g., hunting vs. trapping; Bruskotter 2013). For these reasons, our study was designed to evaluate public perspectives related to economic and ecological effects of maintaining wolves in Montana as well as public opinions of current management techniques. We also collected basic demographic variable and location information for detailed analyses of public opinion by county to more precisely inform local management (Williams et al. 2002, Treves et al. 2004).

Our study objectives, therefore, were to use novel datacollection techniques to 1) characterize Montana residents' opinions regarding wolves, wolf management practices, and the economic and ecological impact of wolves; 2) provide a visual representation of the spatial distribution of opinions regarding wolf management practices by location to inform policymakers; and 3) test a theoretical model of Montana resident characteristics that significantly predict opinions regarding hunting and trapping practices. We hypothesized that overall there would be greater support for wolf hunting as opposed to trapping practices, greater support for wolves in western as opposed to eastern Montana, and individuals who felt more negatively about the economic and ecological impacts of wolves would be more likely to support both hunting and trapping practices.

## STUDY AREA

Montana residents were surveyed to assess their opinions of wolf management within the state. Montana is located in the northwestern portion of the United States and spans approximately 236,638 km<sup>2</sup>. Wolves were primarily located in western Montana, although because of their vast range, they can also travel to eastern parts of the state (Montana Department of Fish, Wildlife and Parks 2011).

A large portion of the human population of Montana also resided in the western portion of the state, with high county populations in Missoula, Gallatin, and Flathead counties, near which there are also known wolf packs. Some major tourist-dependent communities were also concentrated in the western portion of the state including Gallatin, Park, Glacier, and Flathead counties, which are near Yellowstone and Glacier National Parks. Livestock were located throughout Montana, although concentrated areas of livestock also occupied western areas of the state (e.g., Beaverhead and Ravalli counties). Populations of wild ungulates

(e.g., mule deer [*Odocoileus hemionus*], and elk [*Cervus canadensis*]) were also distributed throughout the state, including western portions of Montana that overlapped with wolves, cattle, and humans; such ranges can shift seasonally (Montana Department of Fish, Wildlife and Parks 2016b, c). Elk in particular occupied western portions of the state. Public and private lands ranged throughout Montana.

## METHODS

Surveyors intercepted 2,837 Montana residents during May, June, and July 2013 at gas stations and rest areas across the state. We chose gas stations and rest areas as survey locations because they were distributed throughout the state, considered to be travel-neutral sites, and any Montana resident driving a car could participate. We used independent and national gas station chains in Montana to increase the likelihood of intercepting various individuals and ensure random sampling methods. Surveyors visited these designated gas stations and rest areas throughout the state and randomly numerous times a week during the study period. The amount of time spent at each designated site varied across days for randomization purposes. The day of the week and time of day were also randomized across each gas station and rest area site. This method of data collection has been used extensively in previous research designed to understand economic effects of resident and nonresident spending behavior in the state of Montana (Wilton and Nickerson 2006); however, it has never been used to characterize opinions related to wildlife in the state of Montana. This method was chosen because of the minimal time and response cost to the participant, typically resulting in a response rate much greater than mail-back (e.g., Manfredo et al. 2003) or phone surveys (e.g., Manfredo et al. 1999).

Surveyors collected data for each participant individually on an iPad (Apple, Inc., Apple Campus, Cupertino, CA, USA). The surveyor approached individuals as they filled their car with gas or at rest areas and read a brief introductory script asking if they would like to share their opinions regarding wolves. If the participant answered yes, the surveyor would proceed to ask 6 general questions regarding their opinions on wolves, including current management practices, as well as economic and ecological impacts, followed by basic demographic questions (e.g., age). Surveyors were experienced in data collection and encouraged participants to respond with just their opinions (i.e., reminded participants there are no correct or incorrect answers) to promote unbiased responses. The survey took approximately 3–4 min to complete on average. Surveyors also recorded the number of refusals. The University of Montana Institutional Review Board approved all procedures used in this study (IRB Protocol #104–13).

## Data Analysis

We first generated descriptive statistics to characterize opinions of Montana residents. To represent the population of Montana, we weighted these data by gender and by county population based on the most recent U.S. Census Bureau estimates (e.g., Silver et al. 2002, Mislove et al. 2011). To avoid overweighting counties in which relatively fewer responses were obtained, we only applied gender- and county-level weighting to descriptive statistics (i.e., inferential statistics described below used unweighted data). We used a 5-point

response scale to capture participant opinions: (1) very negative, negative, neutral, positive, or very positive (5). Several questions were not strictly opinion-based. For those questions in which some individuals may not have all the relevant information to provide an opinion, a “Don’t Know” response option was also available. For ease of data presentation and interpretation, we combined very negative–negative responses and very positive–positive responses (e.g., Treves et al. 2013).

To provide management with a detailed understanding of opinions related to specific extirpation techniques by location, we generated spatial distributions of opinions on hunting and trapping using ArcGIS (version 10.1; ESRI, Redlands, CA, USA). We generated averaged values for each county based on opinions, and we also weighted data by gender to represent Montana’s population. To visually display these relationships across Montana, we used the inverse distance weighted interpolation tool to construct an interpolated surface based on average values. Seat cities for each county were used to generate latitude and longitude coordinates (denoted by black dots on the map). Four counties had 3 respondents and were omitted from analysis because of limited sample size (also black dots for these counties were omitted from the map).

We also conducted nonparametric correlations (Kendall’s *tau*) to examine significant, unadjusted (i.e., unweighted) associations between central management opinions (opinions of hunting and trapping), demographic characteristics, and opinions regarding wolves’ impact on tourism, the economy, and the ecosystem. We then conducted ordinal logistic regression in a specified model to test participant opinions and characteristics that were predictive of views regarding hunting and trapping wolves. Specifically, the predictors used in the ordinal regression model were age, gender, identification as a big game hunter (Yes = 1, No = 0), identification as a wildlife watcher (Yes = 1, No = 0), whether the participant lived in the western or eastern half of Montana (a dichotomized geographic comparison for data analysis purposes, West = 1—all counties west of Liberty County, East = 0) and finally participant opinions of how wolves affect tourism, the ecosystem, and the state’s economy (Negative = 1, Neutral = 2, Positive = 3). The “Don’t Know” response is qualitatively outside of the ordinal negative to positive ranking system, so we excluded these responses from the ordinal regression analyses.

## RESULTS

Of the 2,837 individuals approached, 2,589 completed the survey for a response rate of 91.3%. Fifty-five of the 56 Montana counties were represented in the data collection, and within these counties 87% had 5 respondents (9 [16%] had >100 respondents, 32 [58%] had between 10 and 99 respondents, and 7 [13%] had between 5 and 10 respondents). Sixty-nine percent of the total participants were male and 31% female. U.S. Census Bureau estimates show roughly equal distribution of gender throughout each county (i.e., ~50:50 ratio of male to female); thus, to better represent counties with fewer responses and females, these descriptive data were weighted by gender and county population based on the most recent U.S. Census Bureau estimates (e.g., Silver et al. 2002). The mean overall age was close to 47 years old (range = 18–90).



Percentages of respondent opinions for questions regarding the effect of wolves on the state's economy, tourism, and ecosystems (Fig. 1; margin of error at the 95% CI, 1.92%), showed a greater number of residents thought wolves affect Montana's economy more negatively than positively (36% vs. 21%), but a sizable percentage of residents were neutral on the issue (30%). Alternatively, residents were more likely to say that wolves in Montana positively affect the state's tourism industry (45% positive vs. 11% negative). Montanans were slightly more likely to indicate that wolves positively (41%) rather than negatively (38%) affect the ecosystem, and 17% were neutral. For each of the aforementioned questions, a small portion of individuals also selected the "Don't know" response.

Montanan's opinions of wolves and current management techniques show that more Montanans felt positively about maintaining a population of wolves than do not (45% vs. 33%) and a vast majority held positive opinions of hunting wolves (72%; Fig. 1). Slightly more Montanans, however, felt negatively than positively about trapping wolves (46% vs. 41%). The percentage of neutral responses across all questions ranged from 11% (opinion of hunting wolves) to 35% (effect of wolves on the tourism). To avoid overweighting data from counties that had relatively fewer respondents, we also examined these same questions without weighting the data to either gender or population county-level estimates. Percentages and patterns of unweighted relative to the gender- and county-level weighted data remained roughly identical across each question (Fig. 1).

For a more nuanced approach to understanding different perspectives regarding hunting versus trapping management techniques, a heat map of Montanan opinions by location was generated using ArcGIS (Fig. 2). Opinions were strongly positive in favor of hunting practices, which was fairly ubiquitous throughout the state. Opinions were fragmented across the state, however, regarding trapping. Western Montana, particularly the northwestern corner and southern portions near Yellowstone National Park, showed more negative than positive sentiments toward trapping. Opinions represented in areas of the midwestern and eastern portions of Montana showed that while trapping was viewed positively, these sentiments were less pronounced relative to hunting in the same areas.

Positive opinions regarding hunting and trapping were both significantly correlated with being male and identifying as a big game hunter (Table 1). Positive opinions regarding hunting and trapping were also significantly associated with negative opinions regarding the effect of wolves on tourism, the economy, and the ecosystem. Many, but not all, variables with significant bivariate associations remained significant in the fully specified model for opinions regarding both hunting and trapping.

Results of the ordinal regression show that females were significantly less likely than males to have a positive opinion of hunting wolves (odds ratio [OR] = 0.59,  $P < 0.001$ ; Table 2). Those who identify as big game hunters relative to those who do not were more likely to have a positive opinion of hunting wolves (OR = 4.76,  $P < 0.001$ ). Negative opinions concerning the effect of wolves on the ecosystem (OR=0.44,  $P < 0.001$ ) and the economy (OR = 0.67,  $P < 0.001$ ) predicted more positive opinions of hunting wolves. Those living in western relative to eastern counties (OR = 1.31,  $P = 0.03$ ), were also more likely to support

hunting wolves. Age, identification as a wildlife watcher, and opinions regarding effects of wolves on tourism did not significantly predict opinions regarding hunting wolves.

Similar to opinions regarding hunting wolves, females were significantly less likely to hold positive opinions of trapping wolves ( $OR=0.58$ ,  $P<0.001$ ; Table 3), with big game hunters more likely to hold positive opinions of trapping ( $OR = 3.67$ ,  $P<0.001$ ). Negative opinions concerning the effect of wolves on the ecosystem ( $OR = 0.58$ ,  $P<0.001$ ), the economy ( $OR=0.76$ ,  $P<0.001$ ), and tourism ( $OR = 0.63$ ,  $P<0.001$ ) predicted more positive opinions of trapping wolves. Contrary to the specified hunting model, those who live in western portions of Montana were less likely to support trapping ( $OR = 0.69$ ,  $P<0.001$ ). Age and identification as a wildlife watcher were the only characteristics that did not predict opinions regarding trapping wolves.

## DISCUSSION

This study extends our understanding of current Montana resident opinions regarding wolves, and can help inform conservation and management decisions on this divisive issue. Several notable findings emerged. First, Montanans felt that wolf populations affect the economy negatively, tourism positively, and the ecosystem slightly more positively than negatively. Second, more Montanans supported having wolves on the landscape than did not. Third, Montanans throughout the state felt positive about hunting, but more felt negative about trapping and marked differences in opinions regarding trapping emerged when separated by location within the state. Finally, ordinal logistic regression analyses revealed that identification as a big game hunter and gender (i.e., male) were major predictors of positive opinions regarding both hunting and trapping wolves, as were negative opinions of wolves' effect on the ecosystem and the economy (and tourism in the case of trapping). A comparison of the hunting versus trapping predictive models revealed that when controlling for other variables, those in the western half of the state were more likely to hold a positive opinion of hunting, but less likely to hold a positive opinion of trapping.

More residents felt wolves negatively affect Montana's economy, but more residents also felt that wolves positively affect tourism. Both ranching and tourism are critical aspects of the Montana economy: these differences may reflect the belief that real or perceived rancher economic loss from wolf predation of cattle is greater than real or perceived overall tourism gains related to wolves (e.g., wolf-watching). In 2013, >11 million out-of-state visitors came to Montana and spent >US\$3 billion (Grau 2014). Thirty-six percent of these visitors noted they were vacationing in Montana because of the wildlife (Grau 2014). Similar visitor, economic, and wildlife viewing numbers were also obtained in 2014 (Grau 2015), although visitors were likely viewing various wildlife and it is unclear from these surveys how many are attracted to Montana specifically for the potential of viewing wolves. In a separate study, however, Duffield et al. (2006) showed that grizzly bears (*Ursus arctos*) and wolves were the top species that visitors would most like to view while visiting Yellowstone National Park, demonstrating the draw of wolves. Alternatively, confirmed rancher losses from 1995 to 2007 show that, on average, 24.8 cattle and 38.4 sheep are killed per year from wolf predation (these numbers do not include missing or unconfirmed kills; Montana Department of Fish, Wildlife and Parks 2009). Updated information from Montana Department of Fish,



Wildlife and Parks (2014) showed that these numbers increased in 2013 (confirmed kills, 50 cattle, 24 sheep), but subsequently decreased in 2014 (37 cattle, 8 sheep). Although Montana Fish, Wildlife and Parks report the overall kills of livestock by year, which provides an extremely useful metric, it was impossible from these aforementioned references (Montana Department of Fish, Wildlife and Parks 2009, 2014) to also calculate the percentage of kills versus herd and flock size, as well as exactly what percentage of depredated livestock was on private land versus public land. It is noted, however, that most confirmed depredations occurred on private land, where the likelihood of detecting injured or dead livestock was presumably greater than on remote public-grazing allotments (Montana Department of Fish, Wildlife and Parks 2014, Bradley et al. 2015).

Livestock weights and reproductive success can also decrease as a result of wolves on the landscape because of increased stress and energy costs (Laporte et al. 2010), which also contribute to economic losses. Importantly, economic losses are borne almost exclusively by ranchers, although compensation programs for confirmed livestock kills currently exist in Montana. Negative attitudes toward wolves are often influenced by the real and perceived negative economic repercussions resulting from wolf predation of livestock (Gipson et al. 1998, Muhly and Musiani 2009) in addition to the potential real and perceived economic loss associated with decreases in Montana elk herds (e.g., Fritts et al. 1997, lost revenue from hunting). Devising mechanisms to redistribute revenue spent from wolf-watching to ranchers may facilitate greater acceptance of wolf conservation by ranchers and other residents. Future research should address the possibility of revenue generated by out-of-state visitors viewing wildlife directly benefiting local populations that rely on the land for income (Naidoo and Adamowicz 2005) as a means to increase support of wolf conservation, because these privately owned lands also represent important intact habitat for wolves (Muhly and Musiani 2009).

Slightly more residents felt wolves positively rather than negatively affect the ecosystem. Still, over one-third were in the negative group. Individuals who felt wolves negatively or neutrally affected the ecosystem (as well as those who do not know) represented large portions of the public who could benefit from education of the ecological benefits of predators (Ripple and Beschta 2003, Estes et al. 2011), and as a result the potential exists to improve an overall understanding of wolves with a greater support for management decisions and conservation in Montana. Research has shown, however, that those with strongly held attitudes about natural resources are unlikely to change them, and usually interpret new information inconsistent with their attitudes in a biased way (Teel et al. 2006). Regardless, future surveys of this kind would benefit from control questions gauging participant knowledge of predator effects, including questions about livestock damages and biodiversity impacts influenced by wolves.

More residents felt positively about maintaining a population of wolves in Montana than did not. This finding is somewhat divergent with a study published by Montana Fish, Wildlife and Parks that indicated the majority of individuals were not tolerant of wolves on the Montana landscape (Lewis et al. 2012). Differences in the study conducted by Lewis et al. (2012) compared with our study may be due to variations in the terminology employed to assess opinions. Lewis et al. (2012) asked about tolerance for wolves on the Montana

landscape [“On a scale from 1 (very intolerant) to 5 (very tolerant), how tolerant are you with wolves being on the Montana landscape?”], while we asked about positive or negative opinions of wolves in Montana [“What is your opinion about maintaining a population of wolves in Montana?” 1 (very negative) to 5 (very positive)]. As noted by Treves et al. (2013), the use of the word tolerance is currently disputed in the literature (Bruskotter and Fulton 2012, Treves 2012), as well as the resulting inferences derived from using this term; and the present results lend support for assessing positive or negative opinions rather than tolerance.

Montanans widely supported hunting throughout the state although this is not the case for trapping. The public felt more negatively about trapping, particularly in western Montana. Current distributions show that wolf populations largely exist within the western portion of the state (Montana Department of Fish, Wildlife and Parks 2011). Previous research has shown that individuals who live in close proximity to wolves feel more negatively toward wolves (Skogen and Thrane 2007), which may influence their support of lethal control. The present data suggest, however, that the nature of the wolf kill strongly influences opinions regardless of proximity to wolves. Support for trapping may also be inflated when questions assessing resident opinions of hunting and trapping are combined (as in Lewis et al. 2012), and it is therefore necessary to separate the extirpation method to best understand public opinion to clearly inform conservation and management practices (Bruskotter 2013).

Montana resident opinions regarding trapping were more negative than positive, especially in portions of northwestern and southwestern Montana. The same traps set for wolves also risk trapping nontarget species (Montana Department of Fish, Wildlife and Parks 2014) such as dogs, mountain lions (*Puma concolor*), or Canada lynx (*Lynx canadensis*, currently listed as a threatened species with habitat in western portions of MT). The risk of trapping nontarget species may contribute to the negative sentiment held by Montanans regarding trapping. Previous research has shown that negative sentiments regarding hunting and trapping are not new—Tucker and Pletscher (1989) found that 38% of hunters in Flathead County of northwestern Montana and 27% of residents expressed that it is wrong to hunt or trap wolves. A more recent study found there is declining support for trapping in Utah, USA (Bruskotter et al. 2007). These results are useful in comparing sentiments toward wolves across time, although methodological differences across studies make direct comparisons difficult (see also Bath and Phillips 1990, for results of a MT resident survey regarding reintroduction of wolves to Yellowstone National Park [43.7% supported and 40.3% opposed reintroduction]). In our results, where large portions of the public held negative sentiments toward trapping wolves in the same areas that exhibited risk of trapping other nontarget species and important habitat, wolf policymakers can use fine-grained maps as generated in our study to develop more precise management zones (Treves et al. 2004). In this way, wolf management in Montana can better reflect current public opinion and conservation goals across species and habitats, which will prove more credible and sustainable in the long term (Messmer et al. 1997).

Ordinal logistic regression analyses revealed that big game hunters (as opposed to those who do not identify as game hunters) and males were more likely to support both hunting and trapping when controlling for other variables. The fact that females were less likely to

support hunting or trapping practices aligns with previous research showing that females have stronger preservation attitudes toward nonhuman species relative to males (e.g., Czech et al. 2001). As predicted, those who held negative opinions on the effect of wolves on the ecosystem and economy were also more likely to support hunting and trapping practices—demonstrating that perceived effects of wolves across these important dimensions may drive management opinions.

Western resident locations (i.e., more urban locations) predicted positive opinions regarding hunting, but more negative opinions regarding trapping (replicating previous results indicating differences in wildlife opinions and attitudes across urban versus rural locations; Manfredo et al. 2003). These differences provide mounting evidence that those who support hunting do not necessarily support trapping. Positive opinions regarding the effect of wolves on tourism was also predictive of negative opinions toward trapping. Many tourism-dependent communities, including those surrounding Glacier and Yellowstone National Parks, are located in western counties. Negative opinions of trapping wolves in western areas, therefore, may be influenced by those who benefit from revenue generated by tourism resulting from nearby wolf populations (e.g., wolf-watching). These results combined with our examination of the spatial distribution of hunting and trapping opinions show that western (and more urban) areas of Montana may benefit from, and improve public sentiment toward, wolf management by reducing trapping practices in these areas. Although these analyses examined a simple dichotomy in location (west vs. east), the complexity of the influence of location was not easily captured, especially given the overlap of geographic distribution of humans, wolves, cattle, and wild ungulates outlined previously.

Public opinion research on wildlife has largely been used to inform policy and define management goals (Messmer et al. 1997, Treves et al. 2013). However, this type of public perception of hunting and trapping research should also be used in conjunction with other social and ecological measures, such as the costs associated with wolf recovery, livestock depredation, and tourism impacts from hunting. Such research would also be useful in gauging the extent to which public perception is consistent with the actual ecological effects (costs and benefits) of wolves, and could therefore be useful in not only understanding why the conflicts exist, but also how they can be reduced.

## MANAGEMENT IMPLICATIONS

Interestingly, in the course of writing this manuscript, Montana Fish, Wildlife and Parks changed their quotas and season length near Yellowstone and Glacier National Parks in response to the killing of 12 “Yellowstone” wolves just north of the park in the 2012–2014 seasons (see Montana Department of Fish, Wildlife and Parks 2016a, for quotas). Our results provide an impetus for continually reevaluating wolf management not only by geographic location but also by kill technique. These data also suggest, however, that public opinion can differ based on how questions are asked. Our study offers direct implications for wolf conservation, management, and research design. Namely, the separation of extirpation practices by location (Bruskotter 2013) is critical for designing justifiable management practices. Reconsideration of current management practices by extirpation technique and location (e.g., reduction in number of takes by trapping in western Montana for upcoming

hunting seasons) may attenuate some of the tensions regarding current wolf management. This information can be used to form policies for wolf management in Montana and can be replicated in other states that have wolf management concerns to help guide their decision strategies. Development of a revenue stream from wolf-watching and other related recreational activities set aside for rancher losses due to predation may increase acceptance of wolves in the future by both ranchers and the public. Although such an approach may take time to implement, this could serve as a promising avenue of future research for increasing acceptance of wolf conservation and management as tourism continues to increase each year in Montana.

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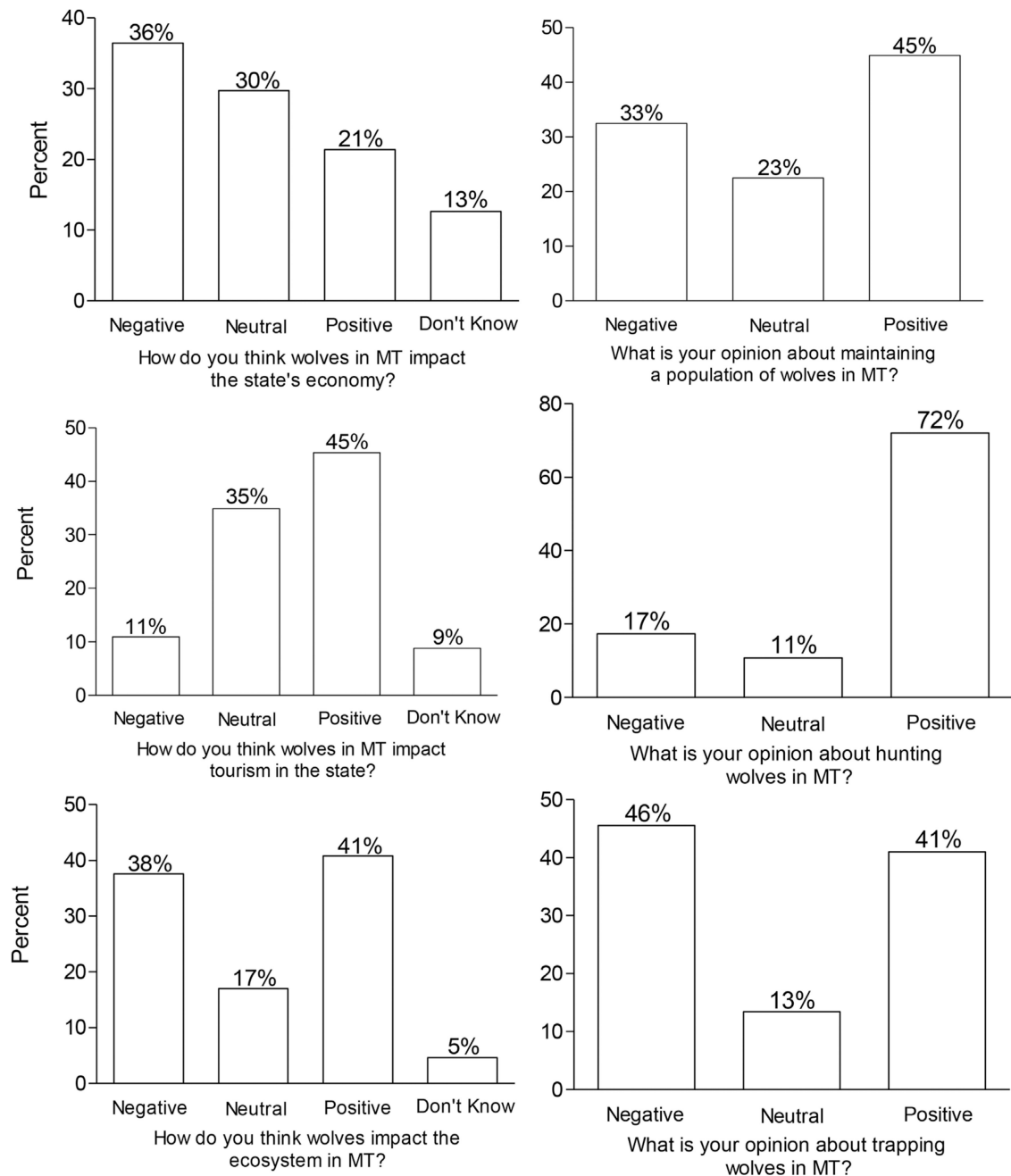
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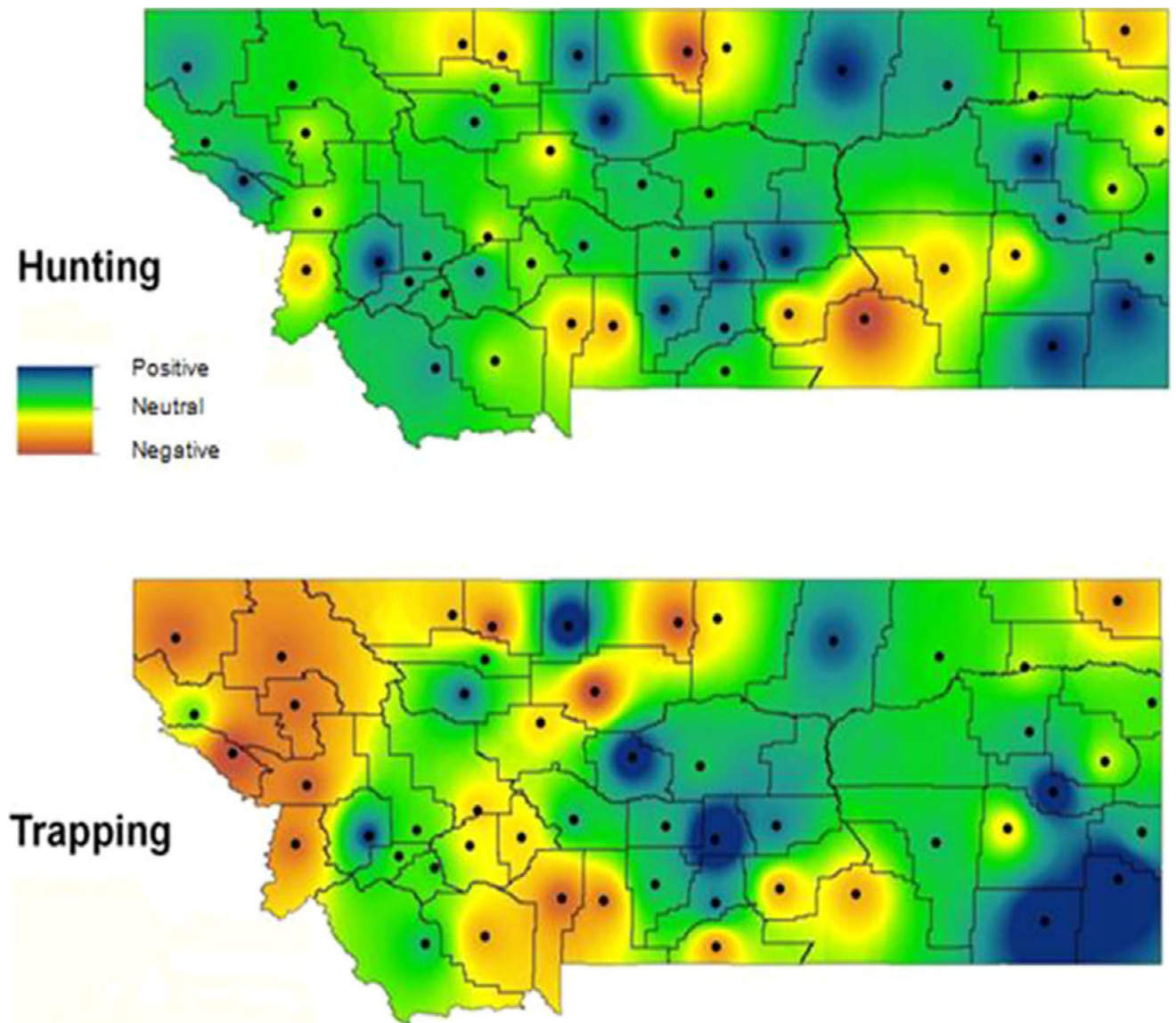
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**Figure 1.**

Montana residents responded to a brief survey that examined public opinion regarding wolves. Participants were surveyed at travel neutral gas stations and rest areas across the state of Montana, USA, during random times of the day and week. Data were collected from May to July 2013. Bars represent percentages of respondent opinions to each of the 6 questions (listed beneath each panel) regarding wolves. A 5-point Response Scale was used to capture participant opinions: (1) very negative, negative, neutral, positive, very positive (5). To represent the population of Montana, these data were weighted by gender and county population based on the most recent U.S. Census Bureau estimates. Several questions were

not strictly opinion-based. For those questions for which some individuals may not have had all the relevant information to provide an opinion, a “Don’t Know” response option was also available. For ease of data presentation and interpretation, very negative–negative responses and very positive–positive responses were combined.



**Figure 2.**

Montana residents responded to a brief survey that examined public opinion regarding wolves. Participants were surveyed at travel-neutral gas stations and rest areas across the state of Montana, USA, during random times of the day and week. Data were collected from May to July 2013. Spatial distribution of opinions based on average values (generated from a negative to positive 5-point Response Scale used to capture participant opinions) by county for hunting (top) panel and trapping (bottom) panel are displayed. Averaged values were generated for each county based on opinions, and data were also weighted by gender to represent Montana's population. To visually display these relationships across the state of Montana, the inverse distance weighted interpolation tool was used to construct an interpolated surface based on average values. Dark blue–green, yellow, and orange–red represent positive, neutral, and negative opinions, respectively. Seat cities for each county were used to generate latitude and longitude coordinates (denoted by black dots on the map).

Four counties had <3 respondents and were therefore omitted from analysis because of limited sample size (also black dots for these counties were omitted from the map).

**Table 1**

Montana residents responded to a brief survey that examined public opinion regarding wolves. Participants were surveyed at travel-neutral gas stations and rest areas across the state of Montana, USA, during random times of the day and week. Data were generated from a negative to positive 5-point Response Scale used to capture participant opinions and were collected from May to July 2013. Nonparametric correlations (Kendall's *tau*) were then conducted to examine significant unadjusted associations between central management opinions of hunting and trapping, demographic characteristics, and opinions regarding wolves' impact on tourism, the economy, and the ecosystem.

Variable	1	2	3	4	5	6	7	8	9	10
1. Opinion about hunting?	1.000									
2. Opinion about trapping?	0.433 *	1.000								
3. What is your age?	0.060 *	0.029	1.000							
4. Gender	-0.220 *	-0.237 *	-0.074 *	1.000						
5. Big game hunter?	0.360 *	0.386 *	-0.020	-0.341 *	1.000					
6. Wildlife watcher?	0.034	-0.020	0.065 *	-0.005	0.158 *	1.000				
7. Urban or rural	0.031	-0.077 *	-0.065 *	0.014	0.001	0.064 *	1.000			
8. Impact tourism?	-0.184 *	-0.262 *	-0.075 *	0.060 *	-0.142 *	0.074 *	0.025	1.000		
9. Impact the ecosystem?	-0.364 *	-0.352 *	-0.084 *	0.124 *	-0.253 *	0.021	0.025	0.312 *	1.000	
10. Impact the economy?	-0.287 *	-0.297 *	-0.085 *	0.087 *	-0.185 *	0.035	0.034	0.349 *	0.513 *	1.000

\*  $P < 0.01$ .

No asterisk,  $P > 0.05$ .



**Table 2**

Montana residents responded to a brief survey that examined public opinion regarding wolves. Participants were surveyed at travel-neutral gas stations and rest areas across the state of Montana, USA, during random times of the day and week. Data were generated from a negative to positive 5-point Response Scale used to capture participant opinions and were collected from May to July 2013. The specified 8-predictor ordinal logistic regression model that examined age, gender, hunter status, wildlife watcher status, eastern or western Montana residence, and opinions on how wolves affect tourism, the ecosystem, and the state's economy was used to test opinions and characteristics that were predictive of hunting views.

Variable	$\beta$	SE	Wald $\chi^2$ (df=1)	P	Odds ratio
Age	0.005	0.004	2.15	0.14	1.005
Gender (1=F, 0=M)	-0.534	0.123	18.86	<0.001	0.586
Hunter (1=Yes, 0=No)	1.560	0.134	134.77	<0.001	4.759
Wildlife watcher (1=Yes, 0=No)	0.166	0.158	1.104	0.29	1.181
West or East (1=W, 0=E)	0.266	0.126	4.49	0.03	1.305
Wolves impact tourism	-0.176	0.096	3.32	0.07	0.838
Wolves impact ecosystem	-0.814	0.084	94.46	<0.001	0.443
Wolves impact economy	-0.394	0.087	20.56	<0.001	0.674
Threshold 1	-5.403	0.454			
Threshold 2	-4.521	0.448			

**Table 3**

Montana residents responded to a brief survey that examined public opinion regarding wolves. Participants were surveyed at travel-neutral gas stations and rest areas across the state of Montana, USA, during random times of the day and week. Data were generated from a negative to positive 5-point Response Scale used to capture participant opinions and were collected from May to July 2013. The specified 8-predictor ordinal logistic regression model that examined age, gender, hunter status, wildlife watcher status, eastern or western Montana residence, and opinions on how wolves affect tourism, the ecosystem, and the state's economy was used to test opinions and characteristics that were predictive of trapping views.

Variable	$\beta$	SE	Wald $\chi^2$ (df=1)	P	Odds ratio
Age	-0.003	0.003	0.79	0.37	0.997
Gender (1=F, 0=M)	-0.538	0.110	23.99	<0.001	0.584
Hunter (1=Yes, 0=No)	1.300	0.102	161.13	<0.001	3.669
Wildlife watcher (1=Yes, 0=No)	-0.229	0.135	2.86	0.09	0.795
West or East (1=W, 0=E)	-0.375	0.104	13.08	<0.001	0.687
Wolves impact tourism	-0.463	0.074	39.55	<0.001	0.629
Wolves impact ecosystem	-0.544	0.061	79.46	<0.001	0.580
Wolves impact economy	-0.269	0.071	14.53	<0.001	0.764
Threshold 1	-4.576	0.355			
Threshold 2	-3.833	0.350			