

# Modernization, Risk, and Conservation of the World's Largest Carnivores

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*Large carnivores are threatened worldwide by a variety of human-driven factors, including persecution, which regularly results when they come into conflict with people. Although human activities are almost universally viewed as negatively affecting carnivore conservation, we contend that conservation outcomes for carnivores are improved when social and economic forces reduce the risks associated with these species and facilitate the acquisition of values favorable to their conservation. We make three specific propositions: (1) Societal tolerance for carnivores is affected by the distribution of risks and benefits associated with these species, (2) modernization and its associated social changes reduce the risks associated with large carnivores and their conservation, and (3) modernization induces lasting effects on conservation by changing societal values. We review existing evidence and present cross-sectional data showing that variation among nations in large carnivore conservation outcomes are related to three facets of modernization believed to reduce the risks associated with large carnivores.*

**Keywords:** large carnivores, modernization, risk, agriculture, urbanization

**L**arge (weighing 15 kilograms, kg, or more) terrestrial carnivores (hereafter *carnivores*) are among the most imperiled species worldwide (Ripple et al. 2014). Human persecution of carnivores occurs globally, motivated in part by the threat that carnivores can pose to livestock, pets, people, and the ungulates that humans hunt (Treves and Karanth 2003). Increasing human populations and their associated loss and fragmentation of habitat (Crooks et al. 2011), along with the depletion of wild prey (Karanth et al. 2004), also contribute to carnivores' endangerment and paint a bleak picture for the future of these species (Ripple et al. 2016). However, recent advances in the conservation of carnivores in portions of Europe and North America (Chapron et al. 2014, Ripple et al. 2014) and the persistence of some carnivore populations in densely populated portions of Europe (e.g., Llaneza et al. 2012), Asia (e.g., Carter et al. 2012b), and South America (e.g., Boron et al. 2016) illustrate that human populations can coexist with these species, at least under certain conditions. But what conditions facilitate human–carnivore coexistence and ultimately further carnivore conservation?

Numerous studies point to human populations and their activities as the main causes of biodiversity loss (e.g., Barnosky et al. 2012) and extinction risk for a wide variety

of fauna (Czech et al. 2000, Woodroffe 2000). Indeed, some scholars give the impression that economic growth and development are fundamentally and inherently antithetical to conservation (e.g., Czech et al. 2000, Ehrlich and Ehrlich 1991). For example, Pulliam (2014) recently wrote of the director of the US Fish and Wildlife Service.

“Director Ashe [said] he sees a ‘giant clash’ between those who favor conservation and those who favor economic development and that he believes that conservationists ‘must accept a world with fewer wolves, salmon, and spotted owls.’ The Director ... went on to say that, in the name of compromise, we must accept ‘a world with less biodiversity.’”

Such thinking risks being inappropriately fatalistic about the future of conservation; moreover, it perpetuates what may well be a false dichotomy between economic growth and modernization (i.e., a suite of social changes, including the occupational specialization, rising educational levels, and rising wealth that accompany industrialization) on one side and the conservation of biodiversity on the other.

In the case of carnivores, the fatalistic view is buttressed by research showing a positive relationship between carnivore extinction probability and human population density, which suggests to some that “extinction risks for carnivores will continue to increase, even though human population

growth is projected to decelerate during the new millennium” (Woodroffe 2000, p. 165). From such a perspective, human populations and activities emerge as anathema to carnivore conservation. An alternative perspective arises from analyses of the same data, which suggest that patterns of carnivore extinction are better explained by carnivore management policy and enforcement than by human population density (Linnell et al. 2001).

The importance of conservation policy as a tool to mitigate the impacts of human populations on carnivores is exemplified by the history of cougar (*Puma concolor*), grizzly bear (*Ursus arctos horribilis*), and gray wolf (*Canis lupus*) conservation in the United States. Throughout the nineteenth century, state and local governments employed bounties in attempts to eradicate carnivores (Kellert et al. 1996). So effective were these policies that by 1931—the same year the US Congress passed legislation directing the “destruction or control” of predatory animals—cougars, wolves, and grizzly bears had already been eliminated from the vast majority of the contiguous US states (Bruskotter et al. 2014). In contrast, following the passage of the US Endangered Species Act in 1973 (16 USC 1531-1544, 87 Stat. 884) and analogous state legislation, carnivore populations began to re-occupy some of their former habitat.

Similar eradication efforts occurred in parts of Europe, with regional extinctions spanning the nineteenth and twentieth centuries (e.g., Boitani 1995, Linnell et al. 2001, Fernández and Azua 2010). As with North America, Europe today hosts growing carnivore populations (accounting for more than 40,000 individuals altogether; Chapron et al. 2014) despite dense human populations and a lack of large wilderness areas. Taken together, these successes suggest that humans in developed countries can coexist with carnivores, at least in places where conservation policies provide sufficiently strong protections (Linnell et al. 2001, López-Bao et al. 2015).

One explanation for recent successes in carnivore conservation in developed countries is that such successes reflect a societal shift in attitudes toward carnivores (Kellert et al. 1996). Attempts to document changes in attitudes toward carnivores have yielded inconsistent results (see, e.g., Majic and Bath 2010, Treves et al. 2013), an indication that social and ecological conditions influence how attitudes change within societies over time. Nevertheless, recent analyses in the United States suggest attitudes toward wolves improved dramatically over the past four decades (a more than 40% increase in the proportion of Americans responding favorably; George et al. 2016), which coincided with more favorable policy for wolves. This research suggests that changes in attitudes toward carnivores may have helped catalyze favorable conservation actions. However, even if one assumes a relatively strong causal link between human attitudes and public policy, we are still left wondering what social and ecological conditions prompted changes in human attitudes in the first place.

Understanding the multiple forces driving the conservation of carnivores requires an interdisciplinary framework

(Carter et al. 2014)—one that recognizes the importance of social and ecological forces in shaping human–nature relationships and, ultimately, conservation outcomes for these species. Here, we discuss how social and ecological changes might affect the conservation of carnivores, with a focus on modernization, which precipitates dramatic change in social life through increased wealth, urbanization, and mass education and ultimately results in changes in societal values (Inglehart and Welzel 2005). Generally, we contend that variability from nation to nation in carnivore conservation outcomes can be partially explained by social and ecological conditions that affect (a) both the perceived and actual risks people associate with carnivores and (b) societal values regarding the welfare and use of wildlife. In what follows, we detail three propositions concerning how social and ecological forces may affect societal tolerance for carnivores, thereby facilitating favorable conditions for carnivores. We present new empirical evidence that partially supports these propositions and discuss this evidence relative to the potential negative impacts of modernization on carnivore conservation.

### **Proposition 1: Human tolerance for carnivores is affected by the distribution of risks and benefits associated with these species**

We begin with the intuitive proposition that, collectively, societies generally work to minimize hazards perceived as being both (a) threatening to human well-being and (b) subject to some degree of control via management. Conceptually, when hazards are wild animals and when associated risks are perceived to be high, we should anticipate those in power to work to minimize or even eradicate such species—especially when the benefits associated with these species are perceived to be low. Conversely, when perceived risks are low and especially when perceived benefits are high, societies will seek to conserve species—or at least not actively work toward their eradication. Indeed, that real and perceived risks influence attitudes (at the individual level) and policies (at the societal or group level) directed at wildlife has long been an assumption in the literature on human–wildlife conflict. This literature emphasizes that risks or threats must be interpreted broadly, not merely limited to human safety (Treves and Karanth 2003). Although “conflicts” are often defined relative to the risks or threats species pose to human populations, they also include the competition between humans and wildlife for specific resources (e.g., livestock or game; Clark et al. 1996; note: the phrase “human–wildlife conflict” is often misappropriated to describe conflicts between humans over wildlife conservation [Redpath et al. 2015]). We use it here to generally describe human–wildlife interactions that involve some risk to human beings).

The distinction between assessed and perceived risk is not trivial in this context. *Risk* is commonly characterized simply as the probability a negative event will occur. *Assessed risk* refers to the systematic quantification of risk and is commonly used by health professionals to characterize

the probability that an individual with certain attributes (risk factors) will be affected by a hazard. *Perceived risk*, in contrast, refers to the subjective judgments an individual makes about the characteristics of a hazard, including both the perceived probability of being affected by a hazard and the perceived severity of the encounter. Perceived risk can and often does differ substantially from assessed risk and is systematically biased by attributes of hazards (Bruskotter and Wilson 2014).

This proposition is supported by research indicating that the perceived risks and benefits of carnivores are important predictors of individuals' tolerance for these species (Carter et al. 2012a, Zajac et al. 2012, Inskip et al. 2016) and their support for carnivore conservation policies (Slagle et al. 2012). This research is grounded in psychological theory on hazards and indicates that the perceived risks and benefits explain substantial portions of the variance in individuals' tolerance for a variety of hazards (Siegrist et al. 2002, Bruskotter and Wilson 2014).

Together, psychological research on hazard acceptance and applied research on human–wildlife conflicts help illuminate why some societies are more tolerant of carnivores than others. Consider that the actual risks associated with carnivores are accrued primarily by those living in proximity to these species—generally speaking, in the least densely occupied and least developed areas. In the case of smaller carnivores (i.e., those weighing less than 15 kg), risks are largely limited to the predation of smaller livestock or pets and zoonotic disease transmission, whereas larger carnivores (i.e., those weighing 15 kg or more) can pose a substantial risk to human safety (Löe and Röskaft 2004, Penteriani et al. 2016). In contrast to risks, the benefits of carnivores are generally indirect (e.g., they influence ecological processes that can benefit people; Beschta and Ripple 2010) and include what social scientists refer to as *existence value*. These benefits are difficult to quantify let alone predict (Peterson et al. 2014) and are accrued by society in general, as opposed to local peoples. Under some circumstances, large carnivores also generate considerable economic value via ecotourism (e.g., Duffield et al. 2008); however, such benefits are limited to places with the landscape features, wildlife populations, and infrastructure required to draw such tourism.

The uneven distribution of risks and benefits is a property of many environmental hazards (e.g., forest fires and floods) and may explain why urban populations are consistently more tolerant of carnivores than rural populations are (Williams et al. 2002, Karlsson and Sjöström 2007). Because risk–benefit judgments explain individuals' tolerance for carnivores, any socioecological change that promotes widespread changes in risk–benefit perceptions should, in turn, affect societal tolerance for carnivores (i.e., attitudes toward these species and support for their conservation) and, ultimately, improve conservation outcomes. The proposition that the risks and benefits associated with carnivores influence societal tolerance for carnivores is fundamental to our model; it is the primary mechanism through which

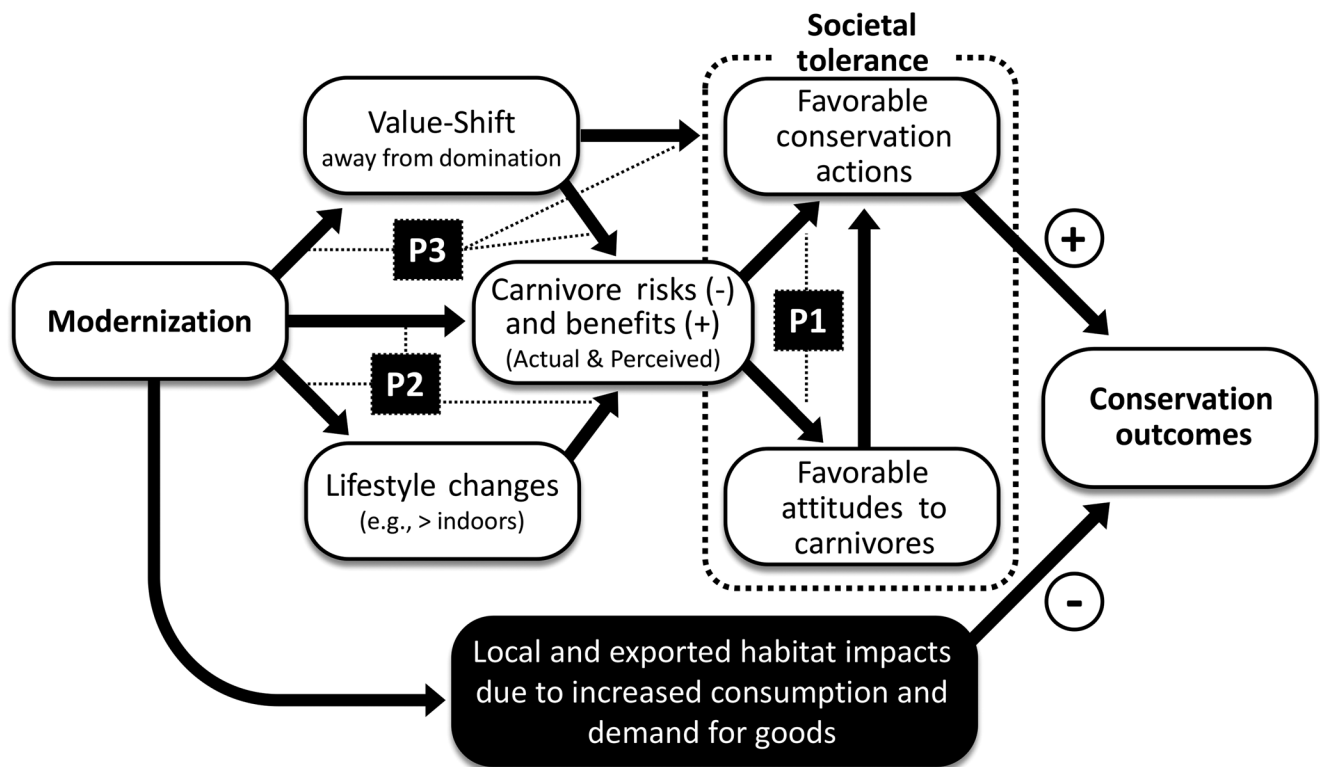
modernization is hypothesized to positively influence carnivore conservation (figure 1). Put another way, we hypothesize that the positive influence of modernization on societal tolerance for carnivores is mediated by the risks and benefits associated with these species.

## **Proposition 2: The social changes associated with modernization reduce the risks associated with carnivores and their conservation**

Underlying the second proposition of this framework is the idea that certain social and economic processes will affect the risks associated with coexisting with carnivores both at the individual and societal level. When these processes result in reduced risk for large proportions of human populations, efforts to conserve species should become more socially palatable. According to Inglehart and Welzel (2005), societies go through a predictable process as they modernize: “Socioeconomic development starts from technological innovations that increase labor productivity; it then brings occupational specialization, rising educational levels, and rising income levels” (p. 19). Modernization is driven, in part, by economic development, which precipitates a variety of changes, including (but not limited to) industrialization, urbanization, and mass education, and ultimately results in changes in cultural values (Inglehart 1997). Although some aspects of modernization (e.g., increased affluence and habitat modification) have long been viewed as important drivers of biodiversity loss and species endangerment (Ehrlich and Ehrlich 1991, Czech et al. 2000), we reason that modernization may also positively influence the conservation of some species inasmuch as it alters the risks and benefits associated with those species (figure 1).

In the case of carnivores, we anticipate that risks are affected by multiple facets of modernization. First, modernization prompts mechanization of the agricultural sector (i.e., the transformation from human- to machine-based agricultural practices), resulting in fewer humans being involved in the planting and harvest of crops and thereby reducing overall societal risk (Kushnir et al. 2010). In addition to reducing the number of people involved in agriculture, mechanization may also reduce risk by removing those individuals who are most vulnerable to predation risk from the labor force—that is, child laborers. The motivation to persecute carnivores should be most pronounced where people live sympatrically with carnivores and where prevailing social and economic conditions lead to high levels of risk—whether assessed or perceived—associated with carnivores. Therefore, by moving jobs away from the fields and people out of rural areas, agricultural mechanization should at least reduce a society's assessed carnivore risks.

Second, the infrastructure required to support high human densities (e.g., waste treatment and removal, potable water, and electricity) also serves to reduce risk by concentrating people in areas where most carnivore species are unlikely to persist (i.e., cities). Although the growth of urban areas does contribute to habitat loss and fragmentation (Woodroffe



**Figure 1.** A conceptual model outlining how modernization affects the conservation of large carnivores. The black boxes depict the three propositions discussed in the text, and the arrows represent proposed influence (and testable hypotheses). Importantly, this model is provided as a visual heuristic to help explain how the social changes brought about by modernization might affect the conservation of carnivores; it is not intended as an exhaustive description of all conceivable pathways by which modernization might affect carnivores, nor does it describe how these effects might change under different social and ecological conditions.

2000), we argue this spatial pattern of dense human populations also has a psychological effect. Specifically, by reducing human proximity to carnivores and therefore assessed risk, the perceived risk of these species is lessened, and the perceived benefits become more salient (see Bruskotter and Wilson 2014). In summary, by facilitating physical separation of human and carnivore populations, urbanization reduces overall societal risk, thereby promoting greater tolerance for these species.

Finally, modernization generates technological innovation and the subsequent proliferation of modern technological conveniences (e.g., air conditioning, passenger cars, electricity, and the Internet) that serve to promote indoor lifestyles, which may further reduce the risks associated with carnivores. Researchers interested in human activity patterns have found that the average adult US resident, for example, spends approximately 87% of their time indoors and another 6% behind the wheel of a motor vehicle (Klepeis et al. 2001), thereby minimizing human safety risks even in places with abundant carnivore populations. Conversely, in countries with poor infrastructure and more primitive agricultural systems (those with greater dependence on human labor), we should anticipate more interactions with carnivores and

therefore greater societal risk (Löe and Röskaft 2004). For example, a study of lion (*Panthera leo*) attacks in Tanzania revealed that ownership of fewer assets, poor house or hut construction, and sleeping outdoors increased one's risk of being attacked (Kushnir et al. 2010). Under such conditions, we anticipate greater pressure to minimize carnivore populations.

In summary, we anticipate that by increasing agricultural mechanization and urbanization and promoting lifestyle changes (e.g., greater time spent indoors), modernization acts to physically separate human populations from carnivores, ultimately reducing both the real and perceived risks associated with these species. Over time, this separation should promote greater human tolerance for these species (i.e., fewer negative attitudes and more favorable conservation policies) and better conservation outcomes.

### **Proposition 3: Modernization induces lasting effects on conservation by changing societal values**

As we argued above, we contend that modernization within a society can affect both the assessed and perceived risks associated with specific species. Moreover, research has also shown that hand in hand with these changes, modernization



leads to new social values—specifically values associated with increased concern about environmental issues (Inglehart 1995, Inglehart and Welzel 2005). *Values* are overarching motivational goals that influence a broad array of evaluative judgments (Schwartz 2012). For example, values that guide human relationships with the environment such as mastery versus harmony (Schwartz 2007) could also influence assessments of risk across many topics, including wildlife, climate change, agricultural practices, drought, and energy. Consequently, we anticipate that the changes in societal values driven by modernization could affect tolerance for carnivores both directly (by fostering more supportive conservation attitudes and policies) and indirectly (by lowering risk and increasing benefit perceptions; see figure 1).

Historically, values are deeply embedded in the structure of culture and endure for long periods of time. However, the twentieth century saw a remarkable period of accelerated modernization that profoundly affected societal values (Inglehart and Welzel 2005). Inglehart and Welzel (2005) contended that when existential threats are high, societies tend to focus on “materialist” or subsistence-based concerns; when subsistence challenges are low, societies tend to prioritize higher-order concerns, referred to as “postmaterialist” values that emphasize egalitarianism and intellectual autonomy. Consistent with their hypotheses, global data show that postmaterialist values within nations tended to increase with modernization that accelerated after World War II (Inglehart and Welzel 2005).

Recent research indicates that modernization is also associated with shifting values about wildlife (Manfredo et al. 2009), and those shifts may influence tolerance for human–carnivore conflicts (Manfredo et al. 2016). Specifically, Manfredo and colleagues (2009) found that increased levels of education, income, and urbanization in the United States were associated with increased “mutualism” values—that is, values that emphasize care and compassion for wildlife. These researchers theorize that modernization creates social conditions that foster mutualism values—specifically, direct contact and interactions between people and wildlife are replaced with indirect contact (in risk-free environments), tendencies to anthropomorphize increase and facilitate humanizing of wildlife, and an increased need for affiliation in urban environments evokes empathy for animals generally (Manfredo et al. 2009).

Two aspects of changing values may have a complicating influence on carnivore conservation around the globe. First, the shift toward “mutualistic” values exacerbates an already prominent rural–urban divide on issues pertaining to wildlife tolerance specifically and environmental issues generally (Dietsch et al. 2016). In areas where urban residents make up large majorities, we anticipate that national conservation policies will tend to follow urban preferences (in which people tend to be more tolerant of carnivores) over the preferences of rural minorities, thereby leading to more favorable conservation outcomes for carnivores. However, the power differential may be offset by policies that empower

local interests over national interests. Moreover, conservation policies that are viewed as unfair by local residents may be met with local resistance (Krange and Skogen 2011) and generate a “not-it-my-backyard” response.

Second, value shift has generated other structural and motivational changes that have sparked the ascendance of social conflict. Part of the growth of postmaterialist values is an increase in “self-expressive” values—values focused on individual autonomy. With this change, people may be less willing to accept policies for the collective good and more likely to focus on advancing their own interests. This could result in an increased plurality of views within societies (e.g., materialist versus postmaterialist or domination versus mutualism) and is reflected in, for example, the rapid growth of nongovernmental organizations and discord in US politics after World War II (Boli and Thomas 1997). Therefore, although we anticipate value shift to have a net positive effect on the conservation of carnivores, it may also help bring about greater social conflict concerning the conservation and management of these species.

### Discussion: Evidence and implications for carnivore conservation and coexistence with humans

Evidence for proposition 1 (tolerance for carnivores is affected by perceived risks) is abundant and largely detailed above (Carter et al. 2012a, Slagle et al. 2012, Zajac et al. 2012, Inskip et al. 2016). The evidence required to empirically evaluate proposition 2 (modernization affects societal tolerance for carnivores and conservation outcomes by changing risk) is much harder to come by. For example, data on carnivore abundances are difficult, time consuming, and expensive to collect, and country-level data on the assessed and perceived risks of carnivores are only available for a handful of nations. However, a recent project that aggregated data on the International Union for Conservation of Nature (IUCN; see Ripple et al. 2014) listing status of the world’s largest carnivores provided us the means to conduct the first empirical test of this proposition. These data show that the overall conservation status of carnivores in a country is positively related to three facets of modernization hypothesized to affect risks associated with carnivores, and the associations between conservation status and three facets of modernization discussed in proposition 2 remain even after gross domestic product (GDP) *per capita* is controlled (box 1; figure 2; table 1).

Although these preliminary analyses are consistent with our propositions, they have a number of limitations. First, our use of a global measure of conservation status masks variation *among* countries. To illustrate, a species that is locally imperiled in one country has the same IUCN conservation status in a country where it is abundant. For example, most of the large carnivores in Europe (i.e., gray wolves; brown bears; and Eurasian lynx, *Lynx lynx*) would likely be classified as threatened by the IUCN if it were not for abundant populations in other large refuge countries with expansive habitat (e.g., Russia). Second, the use of global

**Box 1. Modernization and national-level carnivore conservation outcomes.**

We derived the variable *conservation outcomes* from IUCN classifications of the world's 27 largest mammalian carnivores (list adapted from Ripple et al. 2014); specifically, we calculated the proportion of carnivores within each country that are classified as *threatened* or *near threatened* where one or more species persists. These data were correlated with three facets of modernization that potentially reduce the risks associated with carnivores: agricultural mechanization, the proliferation of modern technological conveniences, and the development of basic infrastructure and urbanization. The analyses indicate support of the proposed hypothesis that modernization can *improve* conservation outcomes for carnivores under certain conditions. Specifically, these data show that conservation outcomes are improved in countries with (a) more urbanized (condensed) human populations, with better infrastructure; (b) a greater proliferation of modern technological conveniences; and (c) greater mechanization of the agricultural sector. Our analyses indicate that these relationships remain even when controlling for a country's *per capita* GDP (for details, see the supplemental materials). Absolute Pearson's *R* values were greater than or equal to .48 when GDP was not controlled and greater than or equal to .29 when GDP was controlled, suggesting that these three facets of modernization have a "medium" to "large" effect on the conservation status of carnivores (see Cohen 1988). However, the three facets of modernization we describe are strongly correlated with each other (*r* values > .59), and other factors that cannot be ruled out potentially explain this relationship (see the Discussion section).

conservation status can also mask variation *within* countries, which can be especially dramatic in geographically large countries. The United States, for example, is home to robust populations of gray wolves and grizzly bears; these species are not threatened with extinction within the country. However, both species occupy a tiny fraction of the former (pre-European settlement) range. A related issue with our dependent measure is that it does not capture prior localized extinctions. However, it is important here to note that prior extinctions occurred under different social and ecological conditions. Moreover, prior extinctions likely reduce overall assessed risks associated with carnivores, which could make the conservation of remaining species easier, politically.

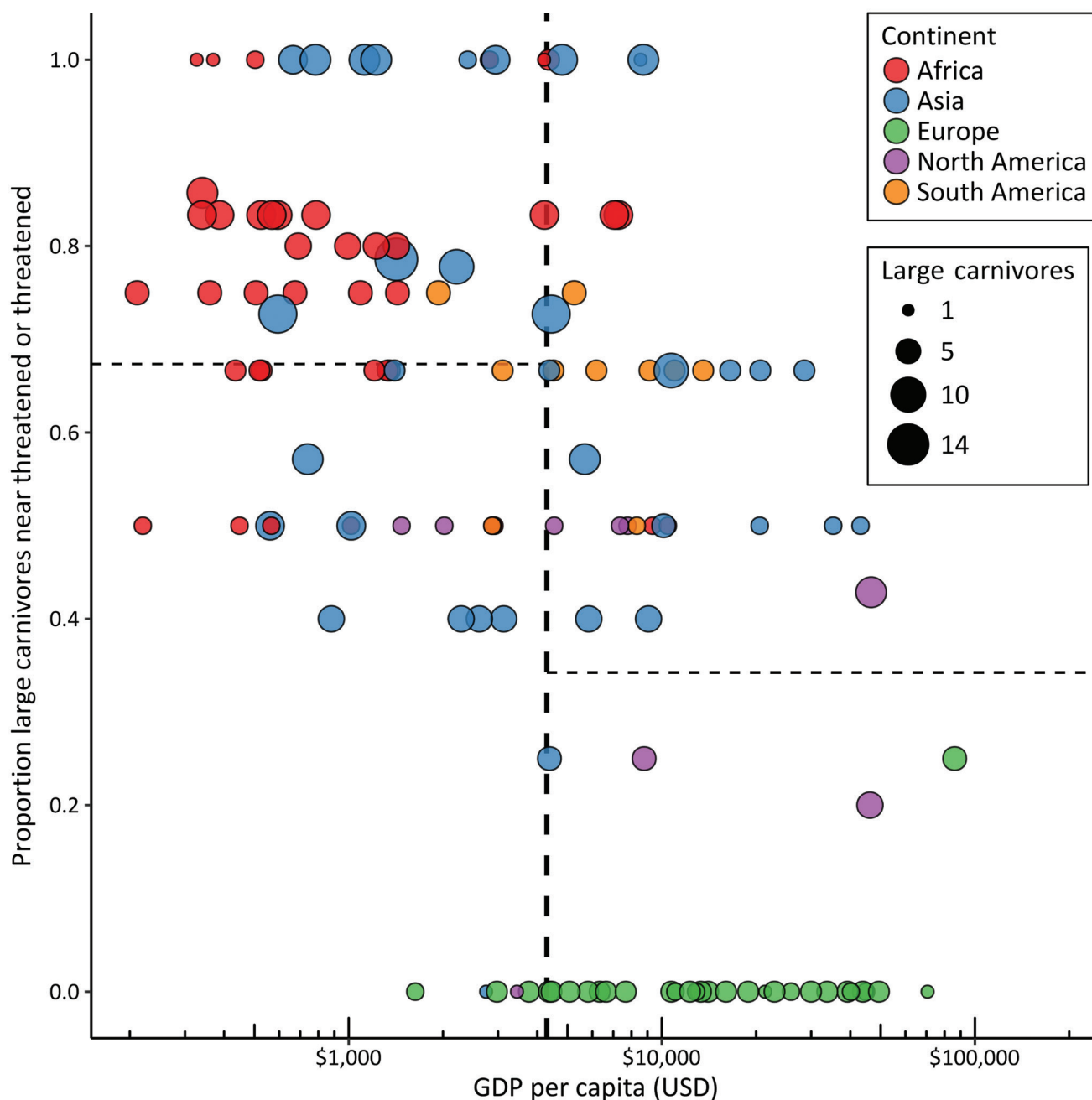
A final issue with global status is that the larger the geographic range of a species, the more that particular species will affect conservation status scores. Therefore, results are likely to be particularly sensitive to the removal of widespread species (typically generalists), whereas species confined to just a few countries are less impactful overall. This issue is likely an important driver of results for the numerous European countries that have gray wolves, brown bears, and Eurasian lynx. Globally, these three species are listed as species of least concern because of their abundant populations and intact habitat in larger countries in northern latitudes. Nevertheless, the relationship between conservation status and GDP (here a proxy for modernization) is evident in figure 2, even if countries in Europe and North America are removed.

The data linking modernization to value change (proposition 3) at the societal level are also robust (Inglehart and Welzel 2005); however, research on the association between wildlife values and modernization thus far is limited geographically (generally to the United States and Europe). Research conducted across 19 states in the American West provides evidence linking the forces of modernization to changes in wildlife values (Manfredo et al. 2009). But are such values associated with human tolerance for carnivores? Recent research indicates that, consistent with proposition

3, domination values are positively associated with support for lethal control of wildlife (including carnivores), whereas mutualism values are associated with policies that place restrictions on humans when human endeavors conflict with wildlife conservation (Manfredo et al. 2016). Likewise, data from a 2014 study of more than 1200 US adults indicate that positive attitudes toward three carnivores (i.e., wolves, coyotes, and cougars) are positively associated with mutualism and negatively associated with domination values, although the correlation coefficients are indicative of relatively "small" effects (figure 3; Cohen 1988). Collectively, these data suggest at least tentative support for proposition 3—that is, modernization changes how societies value wildlife, and the values associated with modernization can promote greater tolerance of carnivores.

We have described both individual-level and macro-level social processes that have occurred in the past century and argued that these processes have likely affected the conservation of carnivores. However, it is not our intention to imply that modernization will lead to homogenous human culture or even that all human cultures must eventually follow the same path in their treatment of carnivores as a result of modernization. Specific policies, responses, and preparations for human–carnivore interactions will be strongly influenced by cultural context, especially the mutually constructed relationships that have emerged between people and carnivores over centuries. That is, we anticipate that change will only occur within the confines of a given society's institutions, laws, traditions, technologies, and myths. New forms of human–carnivore interactions will likely carry the patterns and structure of a society's past forms. Therefore, although scientific findings about carnivore ecology and behavior might be generalizable beyond country boundaries, specific human responses to carnivores will be culturally bounded, varying dramatically from place to place.

We do not envision modernization as a singularly positive force on carnivore conservation. Indeed, concurrent negative effects are well known and empirically documented



**Figure 2.** The relationship between economic prosperity and large carnivores' endangerment (i.e., proportion listed as either threatened or near threatened) at lower (below median) and higher (above median) levels of per capita gross domestic product. The horizontal dotted lines represent the mean proportion of large carnivores listed as either threatened or near threatened at lower (on the left) and higher (on the right) levels of economic prosperity.

(figure 1). Urbanization and infrastructure development often destroy and fragment habitats in ways that negatively affect carnivores, even to the degree that remnant habitat patches within protected areas are insufficient to sustain wide-ranging carnivore species (Woodroffe and Ginsberg 1998). Modernization can also intensify agricultural production by creating greater demand for food commodities (meat protein, in particular), thereby directly affecting carnivores

through habitat homogenization and loss (Sala et al. 2005), or greater political pressure to control carnivore depredations. The effects of modernization on rural communities could also promote local resistance to these species under certain conditions. For example, Krange and Skogen (2011) have contended that the combination of rural depopulation, local unemployment, and conservation efforts that favor protection over resource use can lead to local resistance to

**Table 1. Pearson's correlations between variables of interest and the proportion of large carnivores in each country that are listed as "threatened" or "near threatened" by the International Union for Conservation of Nature.**

Variable	Measures <sup>c</sup>	Proportion Listed as Threatened or Near Threatened				PCA <sup>a</sup>		
		<i>n</i>	<i>r</i>	<i>p</i>	<i>n</i>	partial <i>r</i> <sup>b</sup>	<i>p</i>	Factor loading Percentage $\sigma$
Mechanization of agriculture <sup>d</sup>		128	-.5	≤ .001	123	-.29	≤ .001	63
	Tractors per 100 km <sup>2</sup> of arable land	90	-.34	≤ .001	86	-.14	.19 (ns)	0.79
	% not employed in agriculture	108	-.53	≤ .001	104	-.36	≤ .001	0.79
Modern technological conveniences		128	-.66	≤ .001	123	-.59	≤ .001	93
	% broadband subscribers	128	-.64	≤ .001	123	-.55	≤ .001	0.97
	% internet users	128	-.61	≤ .001	123	-.45	≤ .001	0.96
	Passenger vehicles per 1000 people	122	-.67	≤ .001	117	-.57	≤ .001	0.96
Basic infrastructure or urbanization		128	-.48	≤ .001	123	-.32	≤ .001	68
	% with improved sanitation	126	-.55	≤ .001	121	-.41	≤ .001	0.91
	% rural population with access to drinking water	126	-.48	≤ .001	121	-.34	≤ .001	0.81
	% with electricity	70	-.24	.04	65	.01	.96 (ns)	0.79
	% residing in urban areas	128	-.42	≤ .001	123	-.23	.01	-0.79
GDP Per Capita <sup>c</sup>		126	-.46	≤ .001				NA

<sup>a</sup>Separate principle components analyses were conducted in SPSS version 21.0 for each factor of interest; Varimax rotation was used and factors with eigenvalues more than 1.0 were retained; the regression method was used to create scores for each latent factor.

<sup>b</sup>Partial correlation (controlling for gross domestic product per capita).

<sup>c</sup>Data source: World Development Indicators, The World Bank (<http://data.worldbank.org>).

<sup>d</sup>Correlation between PCA-derived factors: Mechanization of agriculture and modern technological conveniences,  $r = .73$ ; modern technological conveniences and basic infrastructure or urbanization,  $r = .68$ ; mechanization of agriculture and basic infrastructure or urbanization,  $r = .59$ .

carnivores, even within wealthy nations. Such resistance may help explain the decreases in tolerance for wolves witnessed in some rural parts of the United States (Treves et al. 2013) and highlights another possible mechanism by which modernization might negatively affect carnivores at the local (site) level.

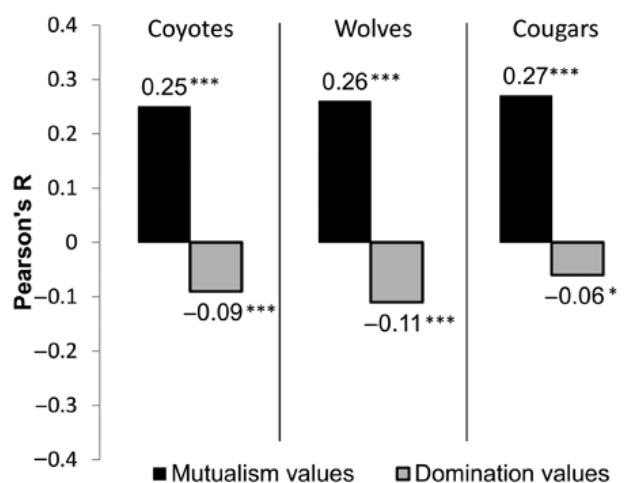
The impacts of modernization on carnivores can extend well beyond the boundaries of modernized countries. From a historical perspective, modernized countries have diminished extractive natural-resource industries domestically and increased the importation of commodities internationally, where they can be obtained more cheaply (Krausmann et al. 2009). Therefore, the growth of commodity-extraction industries in developing countries may come at the expense of the carnivores that exist therein.

The emergent implication of such findings is that modernization is wholly antithetical to conservation—a bleak outlook for those interested in promoting conservation while meeting human needs. However, worldwide patterns in the conservation status of carnivores provide tentative evidence for a different picture, at least where carnivores are concerned. They suggest that certain elements of modernization may facilitate carnivore conservation by making people less vulnerable, minimizing the risks associated with these species. These analyses are also consistent with recent research indicating that carnivores are recovering and even

thriving in parts of Europe and North America (Chapron et al. 2014). Unfortunately, these data also show that in countries where carnivore endangerment is highest (i.e., greater than 50% of species threatened), carnivore richness is also greatest—meaning carnivore endangerment is highest where there is the most to lose.

The propositions outlined here imply that insulating people from natural hazards—in this case, carnivores—reduces the hazards associated with nature and subsequently may improve our attitudes about nature and its conservation. That view seems antithetical to the popular idea that conservation is fundamentally inhibited by a deficit of nature (Louv 2005). The propositions outlined are also relevant for a debate among conservation scientists, in which one camp argues that the best strategy for conservation is to separate nature from human populations by setting aside protected areas (i.e., spare the land) and the other camp argues that conservation goals are best met by people learning to live with nature (i.e., share the land). Where carnivores are concerned, Ogada and colleagues (2003) have contended that “reducing the numbers of predators shot, speared, poisoned and trapped by people is the single most pressing need to halt global carnivore declines.” Our propositions, combined with the evidence reviewed here, suggest that carnivore conservation may be facilitated by insulating humans from carnivores, but not necessarily geographic separation between





**Figure 3.** The relationship between positive attitudes toward three large carnivores and wildlife value orientations (mutualism and domination) among adult residents of the United States. The positive values indicate that as a value orientation becomes stronger, attitudes toward that species become more positive (all values significant  $p < .05$ ). The data were collected in February of 2014 by GfK, a public polling firm. The results include responses from 1287 adult US residents; for a detailed account of methods used in this study, see George and colleagues (2016).

humans and carnivores. Put simply, carnivore conservation goals may be met when social and economic forces reduce the risks associated with these species and facilitate the acquisition of values favorable to their conservation. This could be accomplished through the geographic segregation of people and carnivores (as when predominantly rural societies urbanize) and via other means (e.g., the proliferation of modern technological conveniences or the establishment of protected areas that restrict human activities) that reduce human encounters with carnivores and the associated risks.

The details of our empirical analysis are undoubtedly influenced by the specific metrics used to quantify conservation success. Understanding precisely what counts as conservation success is fundamentally important and worthy of its own discourse. Nevertheless, the primary lesson of our analyses is just as assuredly robust to decisions about quantifying conservation success. That lesson is that recognizing the inevitability of modernization should not imply the inevitability of impaired conservation. The point, for emphasis, is that modernization need not be a wholly negative force. Modernization might bring about a variety of social and ecological changes, some beneficial and others deleterious to conservation. The scientific challenge is to identify more precisely which elements are detrimental and which are favorable to conservation; the policy challenge is to institute conservation policies and practices that simultaneously mitigate detrimental effects while promoting the positive effects of modernization. Research that accurately

and reliably characterizes carnivore populations, their associated risks, and societal values over time is needed to determine more precisely how the facets of modernization described here affect conservation outcomes.

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### Supplemental material

Supplementary data are available at BIOSCI online.

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