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Understanding drivers of human tolerance to gray wolves and brown bears as a strategy to improve landholder–carnivore coexistence

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Abstract
Despite recent recovery of large carnivores throughout Europe such as the brown bear (*Ursus arctos*) and the gray wolf (*Canis lupus*), some of their populations are still threatened and their viability depends on human tolerance to share mixed landscapes. We investigated the drivers of landholders' tolerance in Abruzzo (Italy), a region with a long history of cohabitation, by applying the Wildlife Tolerance Model (WTM) (Kansky et al., 2016, *Biological Conservation*, *201*, 137–145). Using structural equation modeling we assessed relationships between WTM variables. This framework hypothesizes that exposure to a species and experiences with a species drive perceptions of benefits and costs, and ultimately tolerance. We then sought to understand similarities and differences in tolerance drivers between the two species and across two areas that differed in the duration of human–carnivore cohabitation. Results showed both similarities and differences in drivers between species and areas, resulting in seven management proposals to foster tolerance. Increasing intangible benefits and positive experiences were two strategies that were similar for both species and areas, while five strategies differed across species and areas. Our methodological approach can be applied in other landscapes with other species to determine the extent to which multispecies management across landscapes is possible.

KEYWORDS
Apennine brown bear, biodiversity conflicts, conservation psychology, gray wolf, human–wildlife conflict, intangible benefits, intangible costs, Wildlife Tolerance Model

1 | INTRODUCTION

Large carnivores are among the most symbolic species living on our planet, and elicit strong and divergent reactions from people (Boitani, 1992; Ripple et al., 2014). They fulfill a pivotal role influencing patterns and processes of ecosystems through regulation of the trophic cascade, and other ecosystem services (Lozano et al., 2019; Ripple et al., 2014) such as zoonoses regulation and agricultural production which, in turn, benefit human well-being and health (O'Bryan et al., 2018). Despite their important role, they are often perceived as damage-causing wildlife because of their predation of livestock and danger to people (Lozano et al., 2019). This type of human–wildlife conflict has historically resulted in the decline of large carnivore populations (Mech, 2017). Globally, 61% of large carnivore species (body mass >15 kg) are listed as threatened by the International Union for Conservation of Nature (IUCN) (Ripple et al., 2014). In Europe, thanks to changes in legislation, land-use and public opinion, populations of large carnivores, including brown bear (*Ursus arctos*) and gray wolf (*Canis lupus*, hereafter wolf) display stable and increasing population trends (Chapron et al., 2014; Navarro & Pereira, 2012). The ability to persist in human-dominated landscapes (López-Bao, Kaczensky, Linnell, Boitani, & Chapron, 2015) is notable for the wolf, with 10 populations across 28 human-dominated European countries (Chapron et al., 2014). However, in areas recently recolonized by these species, and where people's traditional practices for coexistence have been lost, carnivore conservation faces serious challenges (Chapron et al., 2014). Moreover, large carnivores typically present low-density populations whose individuals require vast home ranges. Therefore, management interventions must be designed to cover multiple jurisdictions and involve intranational and international efforts to secure their long-term survival (Linnell & Boitani, 2012).

A meta-analysis by Kansky, Kidd, and Knight (2014) found that wolf and bear species provoked highly negative attitudes among 13 species of carnivores, surpassed only by coyote and hyenas. In Italy, every year, illegal and accidental killing removes between 15 and 20% of wolves (Ciucci, 2015), with livestock predation considered the primary reason for retaliatory killing (Mech, 2017). Persistence of large carnivores therefore requires that conservation professionals understand the drivers of people's tolerance toward these species (Bruskotter & Wilson, 2014; Ripple et al., 2014; Treves & Bruskotter, 2014).

We investigated drivers of tolerance toward the gray wolf and the autochthonous Apennine brown bear (*Ursus arctos marsicanus*, hereafter bear) in the cultural landscape of Abruzzo, a region of Central Italy with a long history of human–carnivore interaction. In Italy, these species are, respectively, listed as "vulnerable" and "critically endangered" on the IUCN Red List (Rondinini, Battistoni, Peronace, & Teofili, 2013). In Abruzzo, in particular, while wolves are still affected by intense human-caused mortality (Galaverni, Caniglia, Fabbri, Milanesi, & Randi, 2016), brown bears are not predicted to increase substantially in the future (Gervasi & Ciucci, 2018) due to human-caused mortality (Ciucci & Boitani, 2008), and low levels of cub survival (Gervasi et al., 2017). Whereas previous social studies toward these species in Abruzzo focused on landholders' attitudes toward bears (Glikman et al., 2019) and their support for carnivore conservation (Glikman et al., 2012), we used the Wildlife Tolerance Model (WTM) (Kansky et al., 2016) as a theoretical framework to understand the drivers of landholders' tolerance toward wolves and bears.

The WTM was developed to discern key drivers of tolerance in a context of damage-causing mammalian wildlife, and it can be used as a "diagnostic tool" to inform management interventions (Kansky et al., 2016). Compared to other models, this is a comprehensive framework built on two meta-analyses of attitudes and their drivers in human–wildlife conflicts (Kansky et al., 2014; Kansky & Knight, 2014). In addition, the WTM incorporates variables identified as important from other disciplines not commonly applied in attitude surveys (Kansky et al., 2016). Furthermore, its adaptability to different contexts allows an easy implementation at different scales and for different species. Therefore, we opted for such framework in our study. The framework consists of two submodels: the Outer and the Inner models (Figure 1). The Outer model focuses on how people's experience with wildlife shapes their perception of costs and benefits, and how these, in turn, drive tolerance here defined as "the ability and willingness of an individual to absorb the extra potential or actual costs of living with wildlife" (Kansky et al., 2016). Experience accounts for the frequency of exposure to wildlife and emotionally charged events, such close encounters. Costs and benefits are considered in their tangible and intangible dimensions. However, the former focuses on the monetary aspects of coexistence with wildlife, the latter refers to emotions and perceived nonmonetary aspects. The Inner model considers other factors such as empathy, habits, and values that might further affect tolerance.

In our study, we focused on two protected areas (PAs): the National Park of Abruzzo, Lazio and Molise (hereafter PNALM) and the nearby Natural Reserve of Monte Genzana Alto Gizio (RMGAG). Although almost adjacent, the two areas differ in their histories of coexistence. The former is a long-established national park (1923) where significant conservation efforts have been implemented since the early 1970s, and where residents have cohabitated with large carnivores at high densities. The latter was founded in 1996 to protect an area between the PNALM and the Majella National Park (Riserva Naturale Regionale Monte Genzana Alto Gizio, 2018) and, after decades of disappearance, has only recently seen a recolonization by bears (Di Domenico, Antonucci, Fabrizio, Latini, & Monaco, 2016).

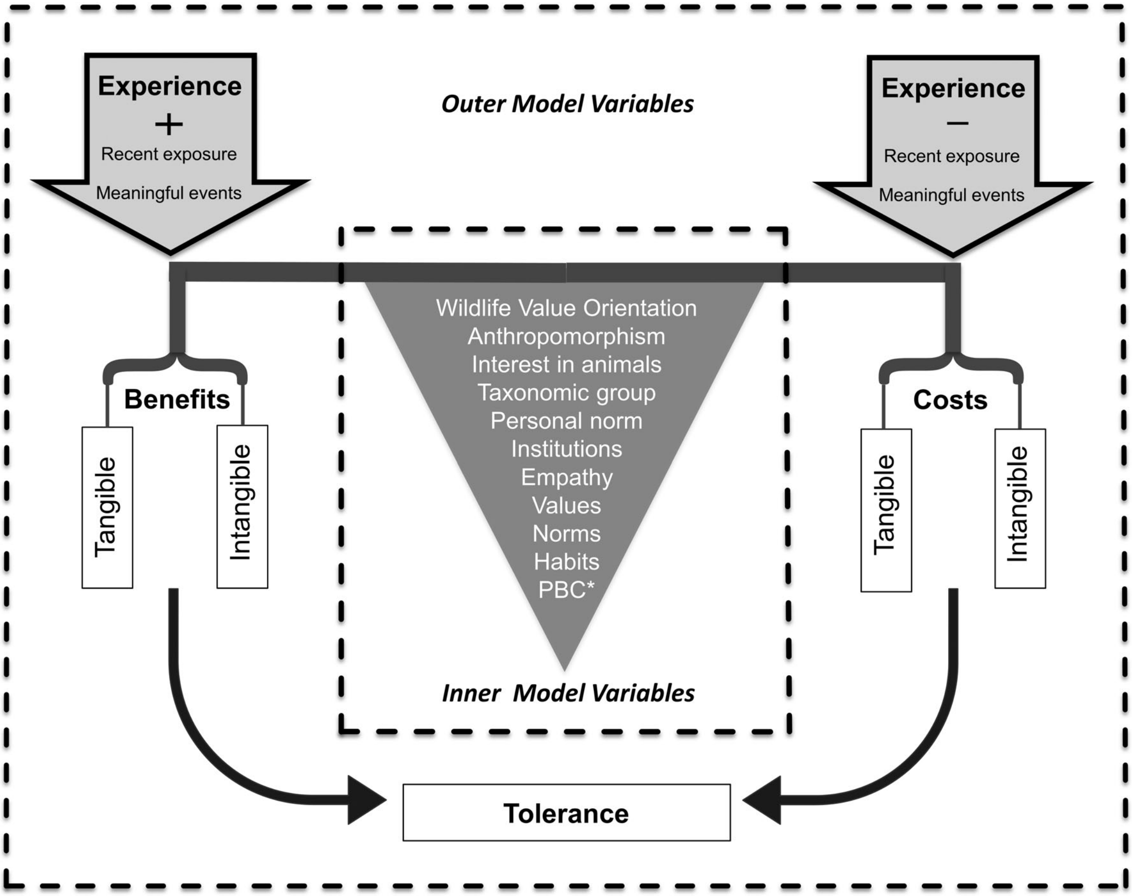

FIGURE 1 The Wildlife Tolerance Model (Kansky et al., 2016): Outer and Inner models. The order of the Inner model variables is random. *PBC, perceived behavioral control

Our objectives were to (a) identify the types of experiences, benefits, and costs that drive tolerance of landholders to both species; (b) develop an understanding of the similarities and differences in the drivers of tolerance both between the two species and across two areas. This understanding will allow us to (c) propose a mix of mechanisms founded upon these drivers to develop a stewardship strategy that could be implemented across both areas. This approach would enable conservation authorities and organizations to most cost-efficiently and effectively promote tolerance to ensure the persistence of the two species. Specific hypotheses that were tested using the WTM were that (H1) landholders' experience with a species drives their perception of its costs and benefits; and (H2) landholders' perception of costs and benefits of living with a species drives their tolerance toward the species (Kansky et al., 2016).

2 | METHODS

2.1 | Study area

The cultural landscape of Abruzzo is located in Central Italy. The area is mainly mountainous with deciduous forests dominating the landscape, covering more than half of the PNALM area and its surroundings (Mancinelli, Boitani, & Ciucci, 2018). In Abruzzo, despite local communities still maintaining traditional husbandry practices (e.g., contained livestock guarded by sheepdogs and shepherds, and enclosed in shelters at night), a form of livestock management consisting of bigger, free-ranging, and unattended herds has developed (Boitani, 1992). In PNALM sheep still represent the livestock category with the highest density followed by goats, cattle, and horses, with the last two having increased in recent decades (Ducoli, 2010) and usually left free-ranging (Ciucci, Mancinelli, Boitani, Gallo, & Grottoli, 2020).

The region is home to 38 wolf packs (185–248 individuals; Galaverni et al., 2016) and at least 8 of those occur in PNALM (35–50 individuals; Ciucci et al., 2020). Locally, residents show positive attitudes toward the species and its conservation (Glikman et al., 2012). However, despite its protected status and the implementation of the compensation scheme since 1974 (Boitani, 1992), farmers' tolerance appears to be low, and illegal killing continues (Latini, Sulli, Gentile, & Di Benedetto, 2005). PNALM also represents a critical stronghold for the bear as most individuals occur within the park's core and buffer zones

(Ciucci et al., 2017). Largely before the 17th century, human persecution has been the primary cause of the decline and isolation of the Apennine population from other European bear populations (Benazzo et al., 2017; Ciucci & Boitani, 2008). Despite legal protection provided throughout Italy since 1939 and, in particular, by the establishment of PNALM in the 1920s, this small and relict population still remains "critically endangered" (Rondinini et al., 2013). The estimated 51 remaining individuals (Ciucci et al., 2015) occur in an area less than 5,000 km^2, mainly within the national park and adjacent areas, including RMGAG (Ciucci et al., 2017). Since 2015, bears are regularly present in RMGAG (Di Domenico et al., 2016), where at least one wolf pack is also known to occur (A. Di Croce, personal communication). Despite sheep and goats being the most heavily preyed-upon domestic animals, a few food-conditioned and human-habituated bears raid villages to forage on poultry and rabbits, causing social upset (Latini et al., 2005). Compensation schemes are available for carnivore predation in RMGAG and outside the national park, and are managed by the regional government (Ciucci et al., 2017). Similarly to the wolf, even with legal protection and compensation payments, human-caused killing, comprising illegal and accidental killing, is likely the main hindrance to the recovery of this endangered population (Ciucci & Boitani, 2008; Gervasi & Ciucci, 2018). The effectiveness of compensation programs, which aim to increase tolerance to damage-causing wildlife, has been questioned in the area (Latini et al., 2005) and in Italy (Boitani, Ciucci, & Raganella-Pelliccioni, 2010).

2.2 | WTM and landholders survey

We adapted the questionnaire from Kansky et al. (2016) to develop the WTM for the socioecological context of the study area. We included all the main variables of the Outer model, namely, experience, costs, benefits and tolerance. We operationalized experience through three variables: exposure, positive meaningful events (PME), and negative meaningful events (NME). We operationalized both costs and benefits by considering their tangible and intangible dimensions. We describe these variables in Table 1, and the full questionnaire is in Supporting Information. Although the questionnaire was mainly quantitative, researchers allowed respondents to elaborate on the topics addressed. Such qualitative information supported the interpretation of WTM results.

Our target respondents were residents who farmed for either commercial or non-commercial purposes. We chose this specific target group because variation in tolerance has been shown to differ among stakeholder types

TABLE 1 List and description of the Wildlife Tolerance Model's (WTM) Outer model variables applied in the survey

Outer model variables	Generalized description
Exposure (EXPO)	Interaction frequency and spatial proximity of an individual with a species.
Negative meaningful events (NME)	Negative emotionally charged experiences, such as traumatic encounters with the species, which may have occurred at any time during an individual's lifetime.
Positive meaningful events (PME)	Positive emotionally charged experiences, such as an unforgettable meaningful nature experience with wildlife, which may have occurred at any time during an individual's lifetime.
Tangible costs (TC)	Direct costs incurred from living with wildlife such as monetary loss through livestock loss to wildlife.
Intangible costs (IC)	Non-monetary factors such as stress and fear, which result from direct and indirect interactions with wildlife and opportunity cost.
Tangible benefits (TB)	Monetary benefits for the individual and the community as compensations, equipment for mitigating damages received from organization or income due to wildlife-tourism.
Intangible benefits (IB)	Positive emotions and non-monetary benefits referring to the value of a species for the individual, the community, mankind, and nature.
Tolerance (TOL)	Tolerance is measured through four main parameters: (a) tolerance to the killing of problem species under different contexts, (b) the population size of a species that person is willing to accept; (c) tolerance to species visit and fresh tracks; (d) tolerance to varying levels of livestock damage.

(Kansky & Knight, 2014). To access respondents, we used lists of landholders that received compensation payments from PNALM and/or were provided with electric fences by RMGAG. Such lists were estimated to represent approximately around 70 and 100% of targeted commercial and noncommercial farmers (D. D'Amico, personal communication; A. Di Croce, personal communication). Through snowball sampling, we then accessed additional landholders who met our criteria. We piloted the study in April 2018 through face-to-face interviews and self-administered questionnaires. The main survey took place from April to June 2018. We used a multimethod approach (Fetters & Molina-Azorin, 2017) to canvass potential participants (≥18 years old). If the landholders agreed to take part in the research, we then asked whether the preference was for a face-to-face interview or for a physical or digital self-administered questionnaire. We arranged interviews according to participants' availability in a place of their choice. For the self-administered questionnaires, we performed weekly reminders by telephone. If the participants did not complete the questionnaire, we asked if they would prefer an interview.

2.3 | Data analysis

To assess relationships between the WTM variables we used the partial least square structural equation modeling (PLS-SEM). This analysis is a variance-based SEM procedure based on an iterative sequence of ordinary least squares (OLS) regressions, which aims to maximize the dependent variable's variance (Hair Jr., Hult, Ringle, & Sarstedt, 2016). PLS-SEM is suited for exploratory research, like this WTM study case, and ensures statistical power with sample sizes below 250 observations (Hair Jr. et al., 2016; Reinartz, Haenlein, & Henseler, 2009). PLS-SEM consists of two elements: the measurement and the structural models. The former defines the relationship between the variables, which the PLS-SEM aims to assess, and the indicators that are the manifest variables measured through the surveys (Table S1). The latter focuses only on variables and describes the relationships between them (Hair Jr. et al., 2016).

We used the statistical software SmartPLS 3 (Ringle, Wende, & Becker, 2015) to build PLS models and to test hypotheses. We treated missing values by using the mean replacement method. For each variable, percentages of missing values were less than the 5% threshold below which the results of PLS-SEM are unlikely to change given different replacement methods (Hair Jr. et al., 2016 based on Hair Jr. et al., 2010). Following Hair et al.'s (2016) recommendations, we set PLS algorithm parameters, and removed observations with more than 15% of missing values, and variables with more than 5% of missing data. We assessed the reliability of the PLS measurement model considering four criteria across three WTM Outer model variants, where indicators were systematically removed: indicator reliability, internal consistency, convergent validity, and discriminant validity (Tables S2–S7). In the structural model, we evaluated relationships between constructs with β-path coefficients (standardized values ranging between −1 and +1). We conducted bootstrap analyses and inferred path coefficients' significance by assessing if the bias-corrected confidence intervals overlapped at zero. We evaluated WTM variables' variance and thus the predictive power of the model through an adjusted coefficient of determination (R^2_{adj}), which is not biased by the number of variables that lead to the dependent variable, Tolerance. Lastly, to explore significant differences between the two PAs, we conducted a multigroup analysis (MGA), specifically, the nonparametric PLS-MGA method (significance level $\alpha = .05$). We report PLS-SEM and MGA parameters in Supporting Information (Tables S11 and S14). We computed descriptive statistics using RStudio (R Core Team, 2019).

3 | RESULTS

The research team collected a total of 244 surveys (231 face-to-face interviews, 13 self-administered questionnaires) and analyzed 243 of them. We discarded one that had missing values (>15% threshold). Cooperation rate, as the proportion of interviewed participants out of the total of those that were contacted and eligible (The American Association for Public Opinion Research, 2016), was 74%. Most respondents were males (87.2%), aged between 40–50 ($n = 48$) and 50–60 ($n = 53$). For 76.9% of landholders, income from farming represented less than half of their total income ("Income Indicators" section in Supporting Information).

3.1 | Results from PLS-SEM measurement model

A full account of the PLS-SEM Measurement Model reliability scores, and indicators removed due to missing values or failure to meet reliability criteria is reported in Supporting Information (Tables S2–S7). Each area's sample size was large enough to detect $R^2 = .25$ for significance level of 5% for the Tolerance variable with statistical power of 80% (Hair Jr. et al., 2016). Accordingly, we reported the PLS structural model results for PNALM ($n = 167$) and RMGAG ($n = 76$) separately.

3.2 | Results from PLS-SEM structural model

Overall, the WTM Outer model' variables collectively accounted for about 50% of the variance for Tolerance, ranging between 44 and 55% of the variance for

Tolerance ($R^2_{\text{adj Wolf-PNALM}}$ = .55; $R^2_{\text{adj Wolf-RMGAG}}$ = .47; $R^2_{\text{adj Bear-PNALM}}$ = .44; $R^2_{\text{adj Bear-RMGAG}}$ = .54).

3.2.1 | Multigroup analyses

Multigroup analyses resulted in three significantly different path coefficients in the wolf WTM and two significant differences in the bear model. For wolves, the positive paths from exposure to intangible costs ($\beta_{\text{difference}} = |\beta_{\text{PNALM}} - \beta_{\text{RMGAG}}| = .303$, $p = .010$) and the negative path from exposure to tolerance ($\beta_{\text{difference}} = .339$, $p = .980$) were significantly stronger in PNALM than in RMGAG, while the positive path from NME to intangible costs ($\beta_{\text{difference}} = .209$, $p = .985$) was significantly stronger in RMGAG than in PNALM (Table 2).

For the bear WTM, the positive exposure to PME path ($\beta_{\text{difference}} = .357$, $p = .017$) and the NME to intangible benefits path ($\beta_{\text{difference}} = .341$, $p = .996$) were significantly stronger in PNALM (Table 2).

3.2.2 | Similarities between species and areas

We found eight paths with similar patterns between species and areas. Two of these were significant while five were not (Figure 2, Table 2). The two significant paths were: (a) a positive path between NME and intangible costs in PNALM ($\beta_{\text{wolf}} = .097$; CI = 0.041, 0.171; $\beta_{\text{bear}} = .163$; CI = 0.064, 0.312) and in RMGAG ($\beta_{\text{wolf}} = .306$; CI = 0.103, 0.407; $\beta_{\text{bear}} = .293$; CI = 0.006, 0.476); and (b) a positive path between intangible benefits and tolerance (PNALM: $\beta_{\text{wolf}} = .333$; CI = 0.187, 0.492; $\beta_{\text{bear}} = .385$; CI = 0.233, 0.547; RMGAG: $\beta_{\text{wolf}} = .361$; CI = 0.068, 0.623; $\beta_{\text{bear}} = .630$; CI = 0.402, 0.954). The remaining five paths were not significant in both areas for both species: (c) exposure to NME, (d) exposure to tangible benefits, (e) NME to tangible costs, (f) PME to tangible costs, (g) PME to tangible benefits, and (h) exposure to PME (Figure 2, Table 2).

TABLE 2 Summary of variable path coefficients (β) and their significance level for the two species in each protected area (PA)

	Wolf				Bear			
	PNALM		RMGAG		PNALM		RMGAG	
	β	p	β	p	β	p	β	p
EXPO → IB	**−.263**	**Yes**	.037	No	.050	No	−.148	No
EXPO → IC^W	**.503**	**Yes**	.200	No	.190	No	−.070	No
EXPO → NME	.107	No	.083	No	−.048	No	−.069	No
EXPO → PME^B	.077	No	.036	No	.274	No	−.083	No
EXPO → TB	−.092	No	−.038	No	−.034	No	−.158	No
EXPO → TC	**.366**	**Yes**	.365	No	**.353**	**Yes**	.081	No
EXPO → TOL^W	**−.372**	**Yes**	−.033	No	.005	No	−.292	No
NME → IB^B	**−.194**	**Yes**	.160	No	−.268	Yes	.072	No
NME → IC^W	**.097**	**Yes**	**.306**	**Yes**	**.163**	**Yes**	**.293**	**Yes**
NME → TB	**−.123**	**Yes**	.208	No	**−.184**	**Yes**	−.117	No
NME → TC	.065	No	.403	No	.044	No	.284	No
NME → TOL	**−.163**	**Yes**	.167	No	**−.250**	**Yes**	−.135	No
PME → IB	**.139**	**Yes**	.097	No	.052	No	.083	No
PME → IC	−.149	No	**−.208**	**Yes**	−.054	No	−.171	No
PME → TB	.051	No	.101	No	−.030	No	.062	No
PME → TC	−.085	No	−.046	No	−.041	No	.053	No
PME → TOL	**.181**	**Yes**	.160	No	**.211**	**Yes**	**.214**	**Yes**
IC → TOL	**−.399**	**Yes**	**−.282**	**Yes**	**−.234**	**Yes**	−.174	No
IB → TOL	**.333**	**Yes**	**.361**	**Yes**	**.385**	**Yes**	**.630**	**Yes**
TB → TOL	.034	No	**.300**	**Yes**	.097	No	−.036	No
TC → TOL	**−.126**	**Yes**	.169	No	−.113	No	.029	No

Note: Significant relationships are highlighted in bold. Paths with gray highlights indicate significant differences emerged from the MGA, Superscript B for bear differences and superscript W for wolf differences. Refer to Table 1 for variable abbreviations and descriptions.

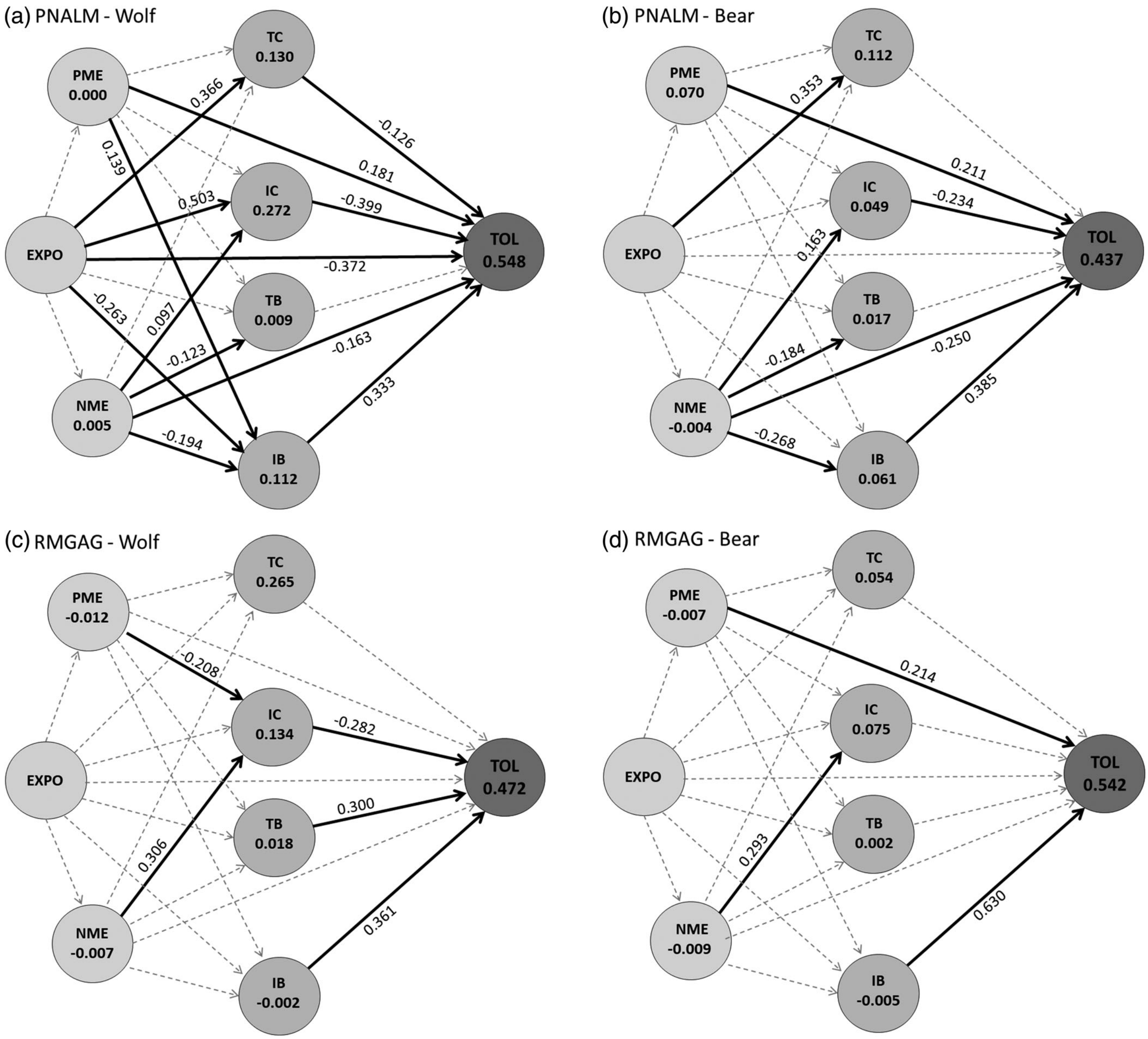

FIGURE 2 Partial least squares structural equation models of variables in the two PAs for both species. Tangible costs (TC), intangible costs (IC), tangible benefits (TB), intangible benefits (IB), exposure (EXPO), negative meaningful events (NME), positive meaningful events (PME), tolerance (TOL). Values within the circles are the adjusted coefficients of determination (R^2_{adj}). Lines joining circles are the path coefficients linking the latent variables. Bold lines represent significant path coefficients and short-dashed gray lines represent nonsignificant path coefficients. Nonsignificant path coefficients are reported in Supporting Information

3.2.3 | Similarities between species but differences between areas

We found four paths that were similar for both species but differed between the two areas. For all these, the coefficients were significant in PNALM for both species but not in RMGAG. Thus, for wolf and bear in PNALM, higher exposure predicted higher tangible costs (β_{wolf} = .366; CI = 0.197, 0.508; β_{bear} = 0.353; CI = 0.017, 0.507), higher NME predicted lower tolerance (β_{wolf} = −.163; CI = −0.247, −0.035; β_{bear} = −.250; CI = −0.400, −0.012), lower intangible benefits (β_{wolf} = −.194; CI = −0.278, −0.039; β_{bear} = −.268; CI = −0.374, −0.109), and lower tangible benefits (β_{wolf} = −0.123; CI = −0.189, −0.003; β_{bear} = −0.184; CI = −0.278, −0.072). These relationships were not significant in RMGAG (Figure 2, Table 2).

3.2.4 | Differences between areas and species

Of the 21 paths in our model, nine differed for both species and areas. Five paths were neither significant for bears and wolves in RMGAG nor for bears in PNALM, but were significant for wolves in PNALM.

These were (a) the path between exposure and intangible benefits (β_{wolf} = −.263; CI = −0.401, −0.097), (b) exposure and tolerance (β_{wolf} = −.372; CI = −0.496, −0.203), (c) exposure and intangible costs (β_{wolf} = .503; CI = 0.355, 0.611), (d) PME and intangible benefits (β_{wolf} = .139; CI = 0.026, 0.244), (e) and between tangible costs and tolerance (β_{wolf} = −.126; CI = −0.232, −0.012) (Figure 2, Table 2).

Two paths were not significant for bears and wolves in PNALM and bears in RMGAG but were significant for wolves in RMGAG. These were (f) the path from PME to intangible costs (β_{wolf} = −0.208; CI = −0.379, −0.072), and (g) from tangible benefits to tolerance (β_{wolf} = .300; CI = 0.016, 0.591). Furthermore, one pathway was significant for bears and wolves in PNALM and for bears in RMGAG but was not significant for wolves in RMGAG. This was (h) the pathway from PME to tolerance (Figure 2, Table 2). Lastly, (i) the path from intangible costs to Tolerance was significant for bears and wolves in PNALM and for wolves in RMGAG but not for bears in RMGAG (Figure 2, Table 2).

4 | DISCUSSION

Understanding human tolerance to damage-causing species is a prerequisite for developing strategies to promote landholder–carnivore coexistence (Riley & Decker, 2000). We applied the WTM to identify drivers of landholders' tolerance toward wolves and bears in the cultural landscape of Abruzzo. The WTM exposed the similarities and differences between wolves and bears, and between PNALM and RMGAG, two PAs with different coexistence histories. We were able to understand the extent to which variables from the model differentially drive tolerance and, in this way, determine which management approaches could be applied across species and areas. These results pointed to seven management recommendations to promote tolerance toward large carnivores in the Abruzzo landscape (Table 3). Based on the literature and our knowledge on the subject we elaborate on what specific strategies might be tried to achieve our recommendations.

The utility of the WTM is that it is a universal, adaptable framework, and is currently contributing to the accumulation of multiple case studies. Overall, similarly to other studies, our investigation in the Abruzzo landscape confirmed the substantial role of the intangible dimension of costs and benefits in shaping tolerance, and also highlighted a newfound importance of meaningful experiences, especially positive ones.

4.1 | Increase perceived intangible benefits for both species in both areas

A significant positive relationship existed between intangible benefits and tolerance for both species in both areas, meaning the greater the influence of positive emotions (e.g., happiness) and perceived nonmonetary value, the greater landholders' tolerance was to both species. Increasing intangible benefits is therefore our first

TABLE 3 List of management recommendations and potential actions associated with the two species in each protected area

	Bear		Wolf		
Recommendations	**PNALM**	**RMGAG**	**PNALM**	**RMGAG**	**Examples of actions**
Increase intangible benefits	×	×	×	×	Mixed-approach aimed at reducing NME and exposure, and increasing PME
Increase positive meaningful events (PME)	×	×	×	×	Licenced guided wildlife treks targeting locals
Reduce intangible costs	×	×		×	Improve social capital among landholders
Reduce negative meaningful events (NME)	×		×	×	Improve effectiveness of sheepdog use
Reduce exposure			×		Removal of attractants from farms and properties
Reduce tangible costs			×		Reduction of NME and predation events; assessment of compensation scheme effectiveness
Increase tangible benefits				×	Design of community-based ecotourism activities

Note: × symbols show where recommendations apply.

recommendation and should be a priority in both areas for both species. The relationship between intangible benefits and tolerance was particularly strong for bears in RMGAG (β = .63) with some participants describing bears as "beautiful" and part of a "communal heritage" (ID63) and also "sacred" (ID89). A possible explanation might be due to the immediate support (e.g., provision and set up of electric fences) landholders received from RMGAG and the NGO Salviamo L'Orso (Save the Bear) soon after bears arrived in the area (Di Domenico et al., 2016). This timely support could have contributed in establishing trust in these organizations, thus enabling landholders' underlying intrinsic appreciation (intangible benefits) of bears to develop before negative experiences and resentment eroded expression of these intangible benefits (e.g., Rode, Gómez-Baggethun, & Krause, 2015).

People's cultural, existence, and historical values have been identified in other European cultural landscapes as driving positive perceptions of human–bear coexistence, for example in Transylvania, Romania (Dorresteijn, Milcu, Leventon, Hanspach, & Fischer, 2016). More generally, intangible benefits have been reported driving tolerance in other WTM case studies, for example, Chacma baboons (*Papio hamadryas ursinus*) in South Africa and elephants (*Elephas maximus*) in Bangladesh (Kansky et al., 2016; Saif, Kansky, Kidd, & Knight, 2019; unpublished work: van Gelder 2019; Wiseman-Jones 2018). As from the WTM outer model, there are three potential routes to increase intangible benefits: (a) increase PME, (b) decrease NME, (c) reduce exposure (Figure 2). Our results indicated these routes differ for each species and area, and these are discussed in the remaining sections. Education programs to increase intangible benefits of wildlife are possible but their long-term success is not known (Britto dos Santos & Gould, 2018), thus their effectiveness should be assessed over time.

4.2 | Increase frequency and impact of positive meaningful events for both species in both areas

PME drove tolerance directly for both species in PNALM and for bears in RMGAG, similarly to positive interactions with bears in Romania (Dorresteijn et al., 2016) and wolves in Germany (Arbieu, Albrecht, Mehring, Reinhardt, & Mueller, 2020). PME also indirectly reduced intangible costs for wolves in RMGAG (Figure 2). These events were typically unexpected encounters in wilderness or urban areas that elicited positive emotions, including happiness, amazement, and excitement. Wildlife viewing treks, such those currently undertaken by licensed guides in PNALM, could create PME. Maintaining and re-targeting these activities for local landowners in PNALM, and establishing these in RMGAG could promote positive events with landholders and the broader community. This approach is cost-efficient compared to other mechanisms such as financial incentives, as they can be operated by commercial, private, and NGO initiatives for profit, reducing the financial burden on government. Still, the contribution to PME of these activities would require evaluation. Additionally, research investigating specific experiences associated with PME would contribute to better design of such activities.

4.3 | Reduce intangible costs for both species in PNALM and wolves in RMGAG

Intangible costs should be reduced for wolves and bears in PNALM and for wolves in RMGAG. Wolves in both areas presented strong negative path coefficients (β_{PNALM} = −.4; β_{RMGAG} = −.28). The relationship between intangible costs and tolerance did not manifest for bears in RMGAG, despite evidence of intolerance (Salviamo L'Orso, 2018, 2019). Intangible costs include emotions of worry, frustration, fear, and the emotional pain of losing animals and months/years of work time, especially from frequent predation events, as well as the additional time and effort spent preventing damage. Such costs affect psychosocial well-being. Their influence on human-wildlife conflicts remain largely unexamined (Barua, Bhagwat, & Jadhav, 2013; Kansky & Knight, 2014), but has been recently reported in other WTM case studies (Kansky et al., 2016; Saif et al., 2019; unpublished work: van Gelder 2019; Wiseman-Jones 2018). Similarly, Behr, Ozgul, and Cozzi (2017) found that fear and perceived harmfulness were negative drivers of wolf acceptance in Switzerland. In PNALM, where respondents have long been exposed to bears and wolves, respondents reported greater intangible costs associated with concern for their animals (e.g., domestic/sheep dogs and livestock), which has been reported in other studies (e.g., Frank, Johansson, & Flykt, 2015). While some respondents acknowledged predation as the natural behavior of wolves, others anthropomorphized the species, identifying them as "aggressive," "mischievous," or even "evil." Given a certain stimulus, emotional experiences, including those associated with wildlife, are the result of automatic emotional appraisal, bodily responses, and cognitive processes (Jacobs & Vaske, 2019). The latter, which include for example beliefs, are affected by learning (e.g., experiences, cultural transmission) whereas automatic emotional appraisal, which acts faster than the cognitive system, is based on criteria called emotional dispositions that are inherited or learned. Therefore, a strategy could be to investigate whether these negative emotions are constituted in cognitive processing and/or in emotional dispositions of landowners, which form their automatic appraisals. The resulting information can guide sound measures to reduce their negative relationship with tolerance.

Poor social capital between landholders was reported in PNALM (ID167). As intracommunity relationships can provide emotional support for individuals affected by damage-causing mammals (Gogoi, 2018), improving landholders' cooperation could reduce negative emotions and opportunity costs (e.g., time spent monitoring herds and maintaining fences), thus intangible costs. Although some respondents were satisfied by the level of intracommunity collaboration, others lamented a lack of collaboration with other stakeholders such as wildlife managers and municipality administrators. Others complained wildlife was prioritized to the detriment of local residents, and felt disappointed given poor economic growth and declining communities. Social learning institutions can improve social capital through collaboration (Knight & Cowling, 2006). As Thondhlana et al. (2020) suggested, a relational approach aimed to improve relations whilst allowing social learning opportunities may represent another strategy to reduce intangible costs. Such an approach may build positive relations between stakeholders and consequently better compromising on non-material costs based on a robust understanding of diverse values and interests

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4.4 | Reduce NME with wolves in both areas and bears in PNALM

Direct negative path coefficients existed between NME and tolerance, and the indirect mediating effect of intangible costs on tolerance (Figure 2). In both areas, the average number of NME was 2.3 times higher for wolves (mean = 1.70, *SD* = 13.52) than for bears (mean = 0.74, *SD* = 3.60) (Table S21). Such events included direct encounters, indirect evidence of predation events, or property damage that resulted in negative emotions such as fear, anger or frustration. Reducing NME also improves perceptions of tangible benefits (see Section 4.1). As such, mechanisms aimed at reducing negative interactions with wolves in both areas, and bears in PNALM are required.

Traditional livestock management practices can facilitate coexistence (Dorresteijn et al., 2014). Livestock can be the main driver of wolf presence (Eggermann, Guerra, Kirchner, & Petrucci-fonseca, 2011) so wider use of sheepdogs could be beneficial as they may be more effective than shepherds at reducing wolf–livestock conflict (van Eeden et al., 2018). Insight from recent research on sheepdogs, for example, older individuals being more associated with flocks (Zingaro, Salvatori, Vielmi, & Boitani, 2018), could guide more specific actions. Decreasing NME with bears requires diminishing the attractiveness of properties, for example, using electric fences or other prevention methods.

Easing specific, related concerns in advance of interactions with carnivores could assist in reducing the negative effects of these experiences. Educating landholders as to how to behave when encountering bears and wolves could reduce fear and worry when these experiences do occur. This would require framing such information effectively by, for example, highlighting attributes that resonate with the targeted audience (Kusmanoff, Fidler, Gordon, Garrard, & Bekessy, 2020).

4.5 | Reduce exposure to wolves in PNALM

Exposure was defined as the frequency of interactions with, or signs of presence of, a species at three spatial scales (home, property, and farm area). The case of wolves in PNALM was the only situation where exposure significantly and directly drove tolerance, or indirectly influenced tolerance through mediating variables (tangible costs, intangible costs, and intangible benefits). Exposure to wolves needs to be reduced to increase tolerance. This result highlights the importance of supporting efforts to decrease the likelihood of human properties attracting large carnivores. For example, technical measures seeking to reduce such attractiveness of human properties have consisted of enforcing removal of livestock carcasses, disposal of house food waste, and strengthening of poultry pens. Supporting this approach, there is evidence that abandoned livestock carcasses have already altered wolf hunting behavior (Ciucci et al., 2020), and human-habituated or food-conditioned bears have entered villages to prey on poultry (Latini et al., 2005). However, to this end, adoption rate and landowners' commitment are key. Considering the role of psychological norms and control beliefs in determining livestock management behaviour (Perry, Moorhouse, Loveridge, & Macdonald, 2020), collaboration and consultations between stakeholders are a means to improve technical solutions and ensure that their implementation is systematic within PNALM. These processes can also help define criteria for a least-desirable option to reduce exposure as nonlethal removal (e.g., captivity) of bold and/or habituated individuals.

4.6 | Reduce perceived tangible costs of wolves in PNALM

The case of wolves in PNALM was the sole situation presenting a significant path between tangible costs (i.e., monetary expenditure) and tolerance. Interestingly, it is the only one out of 12 WTM species studied where a significant effect of monetary loss on tolerance was found (Kansky et al., 2016; Saif et al., 2019; unpublished work: van Gelder 2019; Wiseman-Jones 2018). Hostility to dangerous species can manifest from reliance on a single livelihood strategy (Dickman, 2010). However, only 23.08% of respondents reported farming as their main source of income (Supporting Information). Despite this similarity in context to the baboon case (Kansky et al., 2016), financial loss led to reduced tolerance toward wolves, but not bears. This finding also contrasts a study from Agarwala, Kumar, Treves, and Naughton-Treves (2010) which found that, in a similar context of historical presence of wolves, having suffered damage did not change people's attitude toward the species.

Our measure of tangible costs included the financial cost of damage and the number of mitigation mechanisms implemented. Some respondents accepted such costs or considered them part of farming. For others, they were unbearable, causing them to change, reduce, or, for one participant, abandon livestock farming. Intuitively this result indicates that current compensation schemes should be maintained to alleviate such costs. However, views differed in relation to compensation, with some landholders wanting increases in the value of payments to ensure farming sustainability, while others thought payments should be conditional on, or unnecessary when, implementing preventive measures. Considering the complexity inherent in such long-established schemes, we recommend a cautious approach to avoid a simplistic interpretation of our results. Such schemes may fail to increase tolerance when not integrated with other conservation measures (Boitani et al., 2010; Marino, Braschi, Ricci, Salvatori, & Ciucci, 2016). However, it is likely that landholders expect compensation. Abolishing it might further erode the relationship between landholders and wildlife management institutions. Thus, in accordance with Ravenelle and Nyhus (2017), we advocate a more holistic approach to monitoring and evaluation of the social and ecological outcomes of these schemes. Such evaluation should also test the widespread assumption that predation on domestic animals is additive rather than contributory (Treves & Santiago-Ávila, 2020).

Most importantly, the reduction of economic costs should focus at the root cause of both costs and NME: predation itself. This could be addressed jointly with the reduction of NME (as described in Section 4.4). Free-ranging husbandry (including unguarded lambing and foaling) is still present and has developed over the years (Boitani, 1992; Ciucci et al., 2020). Therefore, it is essential to enable the adoption of husbandry methods compatible with PAs and large carnivores by working with stakeholders in a cultural and social meaningful way. To this end, König et al. (2020) provide a conceptual framework to determine damage prevention implementation levels.

4.7 | Increase tangible benefits of wolves in the RMGAG

Lastly, we recommend increasing tangible benefits for wolves in RMGAG due to the significant positive link with tolerance (Figure 2). Tangible Benefits consisted of two indicators measuring perceived economic benefits for the individual and the community. These did not affect landholders' tolerance for bears in either area or for wolves in PNALM, indicating limited significance of tangible costs and benefits in driving tolerance. The result appears interesting as, from qualitative responses, tourism—especially bear-related and in PNALM—was considered the principal financial benefit, mainly for the community. This concurs with Frank and Glikman's (2019) study in the same PA where 80% of respondents thought bear presence boosted tourism. Conversely, in RMGAG wolf-related tourism is very limited, so monetary benefits might represent an opportunity to increase tolerance. In PNALM, however, some respondents lamented that only a few people directly benefited from tourism. This falls into other evidence of inequality in financial benefits within communities in contexts of human–wildlife interactions (Jordan, Smith, Appleby, van Eeden, & Webster, 2020). To prevent similar scenarios, RMGAG should establish a priori strategies to address inequality within the community. The adoption and adaptation of a social equity framework such as Zafra-Calvo et al.'s (2017) is likely to help managers to develop strategy and assessment indicators that account for financial/distributional aspects, without neglecting procedural (e.g., effective participation) and recognition (e.g., acknowledgement of sociocultural diversity) aspects.

5 | CONCLUSIONS

Effective human–wildlife coexistence strategies are founded upon understanding the behavior of people and of damage-causing animals and how these interact to affect tolerance. The WTM provides a practical and reliable method for identifying the drivers of tolerance. Such evidence enables development of a complementary mix of mechanisms that can form the basis of a strategy for promoting tolerance in landholders. We offer the recommendations herein as suggestions to be explored and tested in shared safe "spaces" (sensu Toomey, Knight, & Barlow, 2017) where science, local knowledge, and other ways of knowing are equally valued in the search for an optimal mechanism mix (Young et al., 1996).

This study investigated drivers of landholders' tolerance toward two large carnivores in two PAs of the Abruzzo region (Italy) with the aim of understanding the extent to which these could be managed similarly. Our results shed light on the role of personal experiences in driving benefits and costs of coexistence, and the importance of the intangible dimension of costs and benefits in shaping landholders' tolerance. These findings stress the need for wildlife managers and stakeholders to differentiate between the tangible and intangible dimensions of human-wildlife interactions, without focusing only on the former.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

AUTHOR CONTRIBUTIONS

Filippo Marino, Ruth Kansky, Irene Shivji, Antonio Di Croce. Paolo Ciucci, Andrew T. Knight: reviewed and contributed to the manuscript and its revisions. Ruth Kansky, Filippo Marino, Irene Shivji, Andrew T. Knight: designed the project and its research questions. Filippo Marino, Irene Shivji, Ruth Kansky: designed the survey. Filippo Marino and Irene Shivji: conducted data collection. Filippo Marino: conducted data analysis. Filippo Marino and Ruth Kansky: led the writing of the manuscript.

DATA AVAILABILITY STATEMENT

Survey responses are not made accessible online. Upon request, the main author can provide anonymous data via email.

ETHICS STATEMENT

The study was approved by the ethics committees of the Faculty of Natural Sciences, Imperial College London.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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