

1 **Attitudes towards returning wolves (*Canis lupus*) in Germany: Exposure,**  
2 **information sources and trust matter.**

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Accepted refereed manuscript of:

Arbieu U, Mehring M, Bunnefeld N, Kaczensky P, Reinhardt I, Ansorge H, Böhning-Gaese K, Glikman JA, Kluth G, Nowak C & Müller T (2019) Attitudes towards returning wolves (*Canis lupus*) in Germany: Exposure, information sources and trust matter. *Biological Conservation*, 234, pp. 202-210.

DOI: <https://doi.org/10.1016/j.biocon.2019.03.027>

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22 **ABSTRACT**

23 Understanding how exposure and information affect public attitudes towards returning large  
24 carnivores in Europe is critical for human-carnivore coexistence, especially for developing  
25 efficient and de-escalating communication strategies. The ongoing recolonization of wolves  
26 (*Canis lupus*) in Germany provides a unique opportunity to test the role of different  
27 information sources and trust on people's attitudes towards wolves. We conducted a phone  
28 survey (n=1250) and compared country-wide attitudes towards wolves with attitudes in a  
29 specific region where wolves initially recolonized and have been present since 2000. In  
30 particular, we investigate the relationship between information sources, trust and people's  
31 attitudes while accounting for factors like knowledge, exposure and socio-cultural  
32 determinants of respondents. We found significant differences in attitudes and knowledge  
33 about wolves as well as in the use and frequency of information sources between the two  
34 population samples. Higher knowledge, information from books and films, science-based  
35 information, and higher trust in information sources related positively with positive attitudes  
36 towards wolves. Comparatively, information from press or TV news was associated with  
37 more negative attitudes. Providing science-based information to the public and building trust  
38 in information is likely to be one measure, among others, to dampen extreme attitudes and  
39 improve people's appreciation of costs and benefits of human-carnivore coexistence.  
40 Management of conflictual situations emerging from large carnivore recolonization in Europe  
41 and beyond should consider incorporating assessments of people's use of and trust in  
42 information in addition to existing tools to pave new ways for constructive human-carnivore  
43 coexistence.

44 **KEYWORDS:**

45 Attitudes, Human-wildlife coexistence, Large carnivores, Media, Science communication,  
46 Social survey.

47

## 48 INTRODUCTION

49 Large carnivores are currently recolonizing parts of their former ranges in Europe, benefiting  
50 from stronger protection (Trouwborst 2010) and effective policy (Linnell et al. 2001;  
51 Chapron et al. 2014; Mech 2017). The lack of remote areas where large carnivores could  
52 thrive without human interactions in European human-dominated landscapes results in  
53 carnivores and people sharing the same landscapes (Chapron et al. 2014; Mech 2017).  
54 Coexistence between carnivores and humans can be challenging because of perceived or real  
55 threats carnivores pose to human property or safety (Johansson & Frank 2016; Eklund et al.  
56 2017). Thus, investigating people's attitudes towards large carnivores is necessary for  
57 human-carnivore coexistence. Attitudes are composed of cognitive (i.e. personal beliefs,  
58 opinions, values) and affective components (i.e. emotional states or traits) that can be  
59 influenced by a variety of different factors (Glikman et al. 2012; Bruskotter & Wilson, 2013).  
60 The extent to which people are exposed to and informed about carnivores can affect both  
61 cognitive and affective components of people's attitudes and the potential for human-  
62 carnivore coexistence. Attitudes can ultimately translate into specific behaviour such as  
63 supportive, tolerant or intolerant behaviours (Bruskotter et al. 2013). For instance, people  
64 exposed to increasing carnivore populations (Majić et al. 2011) or living in closer proximity  
65 to carnivores (Karlsson & Sjöström 2007) tend to have lower acceptance for these species.  
66 Novel exposures to carnivores during their recolonization can result in higher damages to  
67 unprotected livestock, in higher competition with hunters for game species and trigger high  
68 levels of uncertainty and fear, often receiving higher media attention and polarizing the  
69 discussion (Bisi et al. 2007; Fernández-Gil et al. 2016). However, these novel exposures and  
70 the underlying variations in people's experience and information sources have rarely been  
71 studied in combination. With expanding carnivore populations in Europe, it is crucial to  
72 investigate factors simultaneously influencing attitudes towards carnivores (Huber et al.  
73 2009; Majić & Bath 2010; Carter & Linnell 2016).

74 The currently recolonizing wolf (*Canis lupus*) population in Germany offers a unique  
75 opportunity to expand understanding of the role of information sources and trust on attitudes  
76 towards recolonizing carnivores in human-dominated landscapes. Recolonization started in  
77 2000 (Reinhardt et al. 2013) with a first reproduction event by a pair of wolves originating  
78 from Poland (Hindrikson et al. 2017). Only 17 years later, the presence of 60 packs has been  
79 confirmed in 7 Federal States throughout Germany ([www.dbb-wolf.de](http://www.dbb-wolf.de)). This rapid  
80 recolonization, also seen in other European countries like Sweden, France or Switzerland

81 (Chapron et al. 2014) creates a very dynamic human-carnivore system, where people living in  
82 different regions experience varying levels of direct and indirect exposure to carnivore  
83 populations and varying levels and sources of information. This situation provides a unique  
84 setting to assess factors affecting societal acceptance within one country and newly colonized  
85 areas (Behr et al. 2017). We focus here on the individual level as a means to assess societal  
86 acceptance towards carnivores. Involving the broader public is a necessary first step to  
87 develop a democratic and legitimate pathway towards coexistence with recolonizing  
88 carnivores (López-Bao et al. 2017a, Redpath et al. 2017, Young et al. 2016b).

89         During recolonization, exposure to wolves, defined here as the extent to which one is  
90 exposed to and has experience with wolves (Kansky & Knight 2014), can be characterized as  
91 direct or indirect. As a direct consequence of their return, people may be more likely to  
92 observe, encounter the animal or experience depredations (Eriksson et al. 2014). An indirect  
93 consequence of their return is the change in the socio-cultural context: experiences lived by  
94 one's relatives or increased media coverage (Houston et al. 2010; Fernández-Gil et al. 2016)  
95 potentially affect people's perceived threat from carnivores. While direct exposures (i.e.  
96 distance to carnivores) and knowledge are known to affect attitudes towards carnivores  
97 (Glikman et al. 2012; Piédallu et al. 2016), to our knowledge, no study has assessed the  
98 importance of different types of exposures, of information sources and the trust people have  
99 in these information on attitudes towards recolonizing carnivores in a single framework.

100         Access to and trust in information is rarely addressed in attitude studies, although  
101 information influences public opinion, beliefs and attitudes in multiple ways and in relation  
102 to a wide range of topics (Happer et al. 2013; Young et al. 2016a). For example, a  
103 communication experiment showed that acceptance of black bears in the United States  
104 increased with exposure to positive framing of bear presence (Slagle et al. 2013). Information  
105 can be conveyed by different media such as press or TV news, traditional or online media,  
106 magazines or by different actors such as one's relatives, NGOs or zoos. People receive  
107 information differently and their trust in an information source depends on the context  
108 (Flanagin & Metzger 2000; Hesse et al. 2005). For instance, a phone survey in Milwaukee  
109 showed that science media were more trusted than information from press or TV news  
110 (Brewer & Ley 2013). Social media can spread accurate or misleading information very  
111 quickly in times of crisis (Castillo et al. 2011; Westerman et al. 2014) and information  
112 content can have important effects in the context of coexistence with carnivores (Fernández-  
113 Gil et al. 2016; Johansson et al. 2016). Communication and trust are fundamental for

114 decision-making in conservation (Addison et al. 2013) and the time is ripe for expanding  
115 knowledge on how people's access to information and people's trust in different sources is  
116 related to their attitudes towards carnivores.

117 We conducted a phone survey to investigate attitudes towards recolonizing wolves in  
118 Germany, and in a specific rural region with the longest coexistence with wolves in. This  
119 specific region has experienced wolf presence and media coverage the longest and had 7 wolf  
120 packs and one territorial pair at the time of the study (monitoring year 2015/2016, DBBW  
121 2017). This region also hosts an independent wolf information centre dedicated to the  
122 diffusion of wolf-related information to the public (<http://www.wolf-sachsen.de/de/>). In this  
123 context, we expected to find notable differences in exposure to wolves and in use and access  
124 to information between people from across Germany and those from the wolf region. Our  
125 main objective was to understand how the combination of exposure, knowledge, information  
126 sources and trust could influence attitudes towards recolonizing carnivores, while controlling  
127 for socio-demographic factors (Kansky & Knight 2014; Dressel et al. 2015).

## 128 **METHODS**

### 129 - *Survey design*

130 The survey targeted two population samples: one representative sample of the overall  
131 German population (n=1,000, "Germany" hereafter) and one representative sample of the  
132 specific region with the longest coexistence with wolves (n=250, Görlitz region in Saxony;  
133 "wolf region" hereafter). The questionnaire included 51 questions divided into 5 sections,  
134 designed to be comparable with previous attitude studies (Kansky & Knight 2014; Dressel et  
135 al. 2015) and to address the knowledge gaps we identified. These sections represent  
136 respondents' i) knowledge on wolves (Section A), ii) information sources on wolves (Section  
137 B), iii) exposure and experience with wolves (Section C), iv) attitudes towards wolves  
138 (Section D) and v) socio-demographic characteristics (Section E) (Methods S1). The phone  
139 survey addressed adults in both population samples.

### 140 - *Factors potentially explaining attitudes towards wolves*

141 We treated answers to questions of Sections A-B-C-E as potential predictors of attitudes  
142 (Table 1). We calculated the distance to the nearest wolf territory in ArcGIS (v. 10.3.1) as the  
143 distance between the respondents' place of residence (given by respondent's postal code) and  
144 the nearest wolf territory (monitoring year 2015/2016, DBBW 2017). We transformed the  
145 three questions related to personal exposure with wolves into binary categorical variables

146 (have seen wolves in captivity or not – C1 –, outside Germany –C2 –, within Germany – C3)  
147 to have sufficient sample size in each category for the multiple regression analysis (Table 1).  
148 We defined three types of exposure, namely exposure as i) living in the wolf region, ii) the  
149 distance to the nearest wolf territory, and iii) personal and relatives' experiences with wolves.

150 To understand respondents' use of information in the two different contexts of this  
151 study (whole Germany vs. wolf region), we performed Chi-squared tests of independence for  
152 level of information (question B1), source of information (question B2) and frequency of  
153 information (question B5), with the underlying assumption that a rejection of the null  
154 hypothesis would mean that the use and frequency of information is different in the two  
155 contexts.

156 We assessed collinearity among categorical predictors using the Cramer's V index of  
157 correlation (function "assocstats", package "vcd"), which is based on Chi-square tests for  
158 categorical data with more than 2 levels. Collinearity was not an issue among categorical  
159 variables (correlation values < 0.50, Table S1). We assessed collinearity among numeric  
160 variables using Pearson's coefficient (function "cor", package "stats") and collinearity was  
161 not an issue either (coefficients < 0.50, Table S2).

#### 162 - *Principal Component Analysis and response variable*

163 To evaluate the internal consistency of the 17 answers relating to respondents' attitudes  
164 towards wolves (Section D except D4, related to distance), we calculated Cronbach's alpha  
165 (package "psych") (Behr et al. 2017, Zeller & Carmines 1980). The reliability was excellent  
166 (0.93), and we performed a Principal Component Analysis (PCA) to summarize the  
167 information on attitudes into principal components explaining most of the variance in the data  
168 and which are used as response variables in multiple linear regressions models (Piédallu et al.  
169 2016; Behr et al. 2017).

#### 170 - *Multiple linear regression models*

171 First, we specified a single model pooling all data to check for differences in respondents'  
172 attitudes between the wolf region and Germany. The model included all predictor variables in  
173 Table 1. We adopted a stepwise procedure for model selection (backward selection based on  
174 Akaike Information Criterion) because we postulated that each answer in the questionnaire  
175 could explain attitudes towards wolves. We detected significant differences in respondents'  
176 attitudes between the wolf region and Germany (Table 2); we therefore used two models to  
177 understand the determinants of attitudes in each population sample. We used the same model

178 selection procedure described above for the two separate models. All analyses were  
179 performed using R and dedicated packages (v.3.3.2, R core Team 2016).

## 180 **RESULTS**

### 181 - *Respondents' characteristics in the two population samples*

182 We excluded 404 incomplete questionnaires and kept 846 questionnaires for analysis (176 in  
183 the wolf region and 670 in Germany, respectively) (see details in Methods S2). Respondents  
184 from the wolf region lived 10 times closer to regions of permanent wolf presence than the  
185 average across Germany (14 km away vs 138 km away respectively; t-test,  $p < 0.001$ ).  
186 Knowledge of wolves was significantly higher in the wolf region than in Germany (average  
187 knowledge score of 4.3 vs 3.4 respectively; t-test,  $p < 0.001$ ). Respondents' socio-  
188 demographic characteristics are described in Table 3.

### 189 - *Information on wolves in the two population samples*

190 The main information source on wolves was the press or TV news (54.5% and 66.9% in wolf  
191 region and Germany, respectively). Yet, respondents used different information sources in  
192 Germany and in the wolf region (Chi-squared test,  $\chi^2 = 95.57$ ,  $p < 0.01$ ), where in the latter  
193 respondents mentioned the wolf information centre as an important source of information  
194 (20.5%) (Fig. 1a). We also found significant differences in the self-reported level of  
195 information ( $\chi^2 = 86.34$ ,  $p < 0.01$ ) and the frequency of information ( $\chi^2 = 63.15$ ,  $p < 0.01$ ),  
196 both being higher in the wolf region than in Germany (Fig. 1b, c). We did not detect any  
197 notable difference in respondents' trust in the different information sources (Fig. 1a).

### 198 - *Attitudes towards wolves in Germany*

199 The variation in attitudes towards wolves could be described along two PCA components.  
200 The first component (Fig. 2) was interpreted as "tolerance towards wolves" and described a  
201 continuum of attitudes from negative feelings such as fear (questions D11 & D12) to positive  
202 attitudes such as the respondents' opinion about wolves in general and in Germany in  
203 particular (question D1 & D2); higher scores indicate more tolerance. The second component  
204 was related to respondents' "desired population trend" as it was primarily associated with this  
205 question (question D6) and the question on means of control in the survey (question D14)  
206 (Fig. S1); higher scores indicate a wish for more wolves in Germany. Tolerance towards  
207 wolves explained 52.9% of the variation across all answers on attitudes, while desired  
208 population trend explained 6.2% of the variation only. We thus kept only the tolerance  
209 variable for further analysis.

210 In the regression model combining data from the wolf region and Germany, exposure  
211 as “distance to the next wolf territory” did not affect attitudes (excluded from model),  
212 whereas exposure as “negative experiences” (e.g. a relative losing an animal after a wolf  
213 attack) negatively affected attitudes (model coefficient  $\beta = -1.59$ , Table 2). More importantly,  
214 exposure as “living in the wolf region” had an effect on attitudes: respondents from the wolf  
215 region had more neutral attitudes towards wolves than in Germany, where attitudes were  
216 mainly positive (Fig. 2, Table 2,  $\beta = -1.14$ ). Knowledge scores ( $\beta = 0.23$ ), information  
217 provided in books and films or diffused on social networks, and trust in information sources  
218 ( $\beta = 0.25$ ) had positive effects on attitudes towards wolves (Table 2).

219 - *Drivers of attitudes towards wolves in the two population samples*

220 Direct individual exposure to wolves had a limited effect on attitudes and was not the most  
221 important factor, as it did not have any effect in either of the two distinct models of attitudes  
222 (excluded from both models), except wolves seen outside Germany in the German model ( $\beta$   
223 = 0.52). Exposure as distance to the next wolf territory was not significant in the wolf region  
224 model, although its effect on attitudes was the strongest ( $\beta = -3.18$ ,  $p=0.17$ , Table 4) and  
225 excluded from the Germany model. Negative experiences with wolf attacks (question C5)  
226 had a relatively strong negative effect on attitudes in both models ( $\beta = -1.34$  and  $\beta = -1.48$  in  
227 wolf region and Germany respectively, Fig. 3). Interestingly, the factor “source of  
228 information” was always on of the five most important factors affecting attitudes towards  
229 wolves in the models selected by the AIC.

230 In the wolf region model, attitudes were significantly related to information sources:  
231 respondents obtaining information from books and films ( $\beta = 1.86$ ) or from the wolf  
232 information centre ( $\beta = 1.23$ ) showed more positive attitudes towards wolves in comparison  
233 to press or TV news (Fig. 3, Table 4). Respondents with higher trust in information sources  
234 had more positive attitudes towards wolves ( $\beta = 0.97$ , Fig. 3).

235 In the Germany model, people with higher knowledge about wolves ( $\beta = 0.25$ ),  
236 feeling well informed ( $\beta = 0.19$ ) and getting information from books and films ( $\beta = 0.66$ , Fig.  
237 3, Table 4) were more tolerant towards wolves.

238

239 **DISCUSSION**

240 Respondents to the phone survey showed overall positive attitudes towards wolves  
241 recolonizing Germany (Fig. 2). However, we found significant differences in attitudes,



242 knowledge, use and frequency of information between respondents from the wolf region and  
243 those from across Germany. In particular, respondents' sources of information and trust in  
244 these information sources were important factors affecting attitudes towards wolves.

245 - *Longer indirect exposure leads to neutral attitudes*

246 Our survey highlights the predominance of positive attitudes towards recolonizing wolves  
247 in central Europe. This result is consistent with previous findings in Germany (Kaczensky  
248 2006) and elsewhere in Europe, like Italy (Glikman et al. 2012) and Croatia (Majić & Bath  
249 2010). We found that the attitudes towards wolves become more neutral in rural landscapes  
250 with an increased duration of coexistence, a common trend in Europe (Dressel et al. 2015).  
251 The finding that neutral, rather than negative attitudes dominate in the wolf-affected rural  
252 population 17 years after wolf recolonization is particularly interesting for human-carnivore  
253 coexistence. While overly negative or positive attitudes might reflect debate polarization and  
254 human-human conflicts (Redpath et al. 2013; Jacobsen & Linnell 2016), neutral attitudes  
255 might hint at a better understanding of carnivore ecology (Majić & Bath 2010) or a successful  
256 process of building trust and conflict mitigation adapted over time (Young et al. 2016a).

257 Overall, our results show that a minority of people in Germany have direct  
258 experiences with wolves (10.9% of respondents claimed to have seen wolves in the wild in  
259 Germany). Direct exposures (i.e. wolf observations or distance to wolves) did not have a  
260 strong influence in our models. Attitudes towards carnivores are thus more likely to reflect  
261 indirect rather than direct exposure to carnivores (Karlsson & Sjöström 2007). In our study,  
262 respondents knowing someone who suffered from wolf depredation (i.e. indirect exposure)  
263 tended to be less tolerant towards wolves (Fig. 3). Hence, indirect exposures and social  
264 contexts play an important role in explaining risk perception and attitudes (Dickman 2010).  
265 Our results thus concur with previous findings claiming that human-carnivore relationships  
266 are dynamic and context-specific (Karlsson & Sjöström 2007; Piédallu et al. 2016), owing  
267 among other factors to rural-urban differences, local history, trust and culture (Lescureux &  
268 Linnell 2013; Piédallu et al. 2016).

269 - *Information sources shape attitudes towards carnivores*

270 The socio-cultural contexts around human-carnivore coexistence can be diverse and defined  
271 by a wide range of political, cultural or economic factors (Lescureux & Linnell 2013), and  
272 one specific factor at stake is the access to and frequency of information. It is critical to  
273 understand the role of information because information on carnivores are often negatively

274 framed (Jürgens & Hackett 2017), which has been demonstrated to have greater influence on  
275 people's attitudes than positive information in psychological, social and political studies  
276 (Soroka 2006). Knowing which information sources are associated with attitudes is a  
277 necessary preliminary step to understand the complexity of information reception and  
278 processing (Metzger & Flanagin 2013). Our study is the first to quantify the role of  
279 information sources in combination to other drivers of attitudes in the context of ongoing  
280 carnivore recolonization in Europe. Few studies have assessed the importance of information  
281 in shaping attitudes towards carnivores (Houston et al. 2010, Johansson et al. 2017), although  
282 media coverage is thought to be an important component of human-carnivore coexistence  
283 (Fernández-Gil et al. 2016). Recent publications in Europe and Northern America have  
284 demonstrated that media coverage of wolf can drastically vary depending on management  
285 (Killion et al. 2018) or local vs. national scales (Chandelier et al. 2018). Carnivores  
286 recolonizing new areas are subject to higher attention from the media (Houston et al. 2010),  
287 which can have strong impacts on public perception of carnivores.

288         We investigated the effects of different sources of information on attitudes, namely  
289 press or TV news, books and films, social networks, discussions with relatives, NGOs, zoos  
290 and wolf information centre. The analysis of the specific information conveyed by these  
291 different sources was outside the scope of this study, but our results clearly hint at an  
292 influence of information sources on attitudes, and further work is required to investigate the  
293 impacts of specific sources and their content on people's emotions and beliefs. Beliefs are  
294 expected to play an important role in determining people's attitudes and behaviour (Doll &  
295 Ajzen, 1992) and understanding how positive or negative beliefs are formed could be critical  
296 in the context of human-wildlife interactions (Apps et al. 2015) and human-carnivore  
297 coexistence in particular. One hypothesis is that one's beliefs is influenced by knowledge  
298 (Guy et al. 2014) and that beliefs could therefore be directly or indirectly influenced by the  
299 type of information provided by different media sources, over a certain period of time. In this  
300 regard, our results show that people obtaining information from books and films were more  
301 tolerant towards wolves than people getting their knowledge on wolves primarily from press  
302 or TV news (Fig. 3). It may be that these respondents are less subject to peaks of publications  
303 in the news following wolf return; alternatively, people with positive attitudes towards  
304 wolves may be more prone to reading books and watching films reporting on carnivores, but  
305 our survey cannot tease these effects apart.

306 Our results show that in the wolf region, respondents had higher knowledge, felt  
307 better and more frequently informed, and used the wolf information centre as an important  
308 information provider. Besides, respondents obtaining information from the wolf information  
309 centre were more tolerant towards wolves (Fig. 3). The credibility and reliability of  
310 information is particularly important in crisis periods (Westerman et al. 2014) and we  
311 contend that such reliable information provider is fundamental in the context of carnivore  
312 recolonization that are subject to higher media coverage (Fernández-Gil et al. 2016). More  
313 generally, these findings have a broad resonance in contexts of human-carnivore coexistence  
314 worldwide, and the establishment of information centres distributing independent (i.e. not  
315 belonging to interest groups), science-based and reliable information on carnivore biology,  
316 status and management in a regular and timely manner should be viewed as an effective tool,  
317 among others like e.g. conflict prevention, damage compensation or participatory decision-  
318 making to facilitate human-carnivore coexistence in Europe and beyond.

319

320 - *Public trust in information sources improves tolerance towards carnivores*

321 Trust in information sources was an important component of attitudes towards wolves (Table  
322 2, Table 4). Evidence-based information is necessary for accurate decision-making in  
323 conservation (Pullin et al. 2004; Sutherland et al. 2004; Cook et al. 2010) and is fundamental  
324 for maintaining people's trust towards the information provided to them. Building trust  
325 among stakeholders has proven a key element in resolving conservation conflicts (Young et  
326 al. 2016a), successfully implementing damage compensation programs (López-Bao et al.  
327 2017b) and reducing fear towards carnivores (Johansson et al. 2017). Our study confirms that  
328 people who felt well informed and trusted their sources of information tended to be more  
329 tolerant towards wolves.

330 Altogether, our findings highlight the importance of indirect exposure to carnivores  
331 for people's attitudes, in the form of information sources that people decide to trust or not.  
332 Our approach linking information, people's trust in information sources and their attitudes  
333 could be extremely useful in contexts involving other carnivore species like bear (*Ursus*  
334 *arctos*), lynx (*Lynx lynx*), and wolverine (*Gulo gulo*) in Europe or puma (*Puma concolor*),  
335 leopard (*Panthera pardus*), lion (*Panthera leo*) or dingo (*Canis dingo*) elsewhere. In  
336 particular, we recommend that managers in charge of carnivore management and education  
337 actively engage with media and other information providers to increase the quality and

338 reliability of information on large carnivore issues. For example, trans-disciplinary  
339 engagement in the form of workshops has proven successful in addressing human-leopard  
340 conflicts around the Sanjay Gandhi National Park in Mumbai (India) for example (Hathaway  
341 et al. 2017). Clear objectives could be 1) to appoint local carnivore experts, designated by  
342 legitimate authorities to engage with the media and verify the accuracy of information  
343 pertaining to large carnivore-related facts; 2) to implement fast and adaptive information  
344 release to counter the quick spread of disinformation from e.g. social media; 3) to encourage  
345 information providers to include more diverse opinions to avoid so-called “one-sided”  
346 information and balance the prevalence of costs and benefits of carnivores. Thus,  
347 management programs with the objective to develop human-carnivore coexistence should  
348 focus on building trust among different stakeholders, including society as a whole. In this  
349 respect, one important step is to ensure the delivery of trusted science-based information on  
350 costs and benefits of large carnivore conservation.

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511

512 **Table 1.** Description of the variables used as potential predictors of respondents' attitudes  
 513 towards wolves in Germany, which correspond to answers on knowledge (Section A),  
 514 sources of information (Section B), exposure and experience with wolves (Section C) and  
 515 socio-demographic factors (Section E) in the questionnaire (see Supporting Information,  
 516 Methods S1).

<b>Predictor variables</b>	<b>Description</b>
Knowledge score	<b>Numeric;</b> Aggregation of correct answers to 6 questions on “wolves in Germany”: <ul style="list-style-type: none"> <li>- Wolves are back since 10-20 years</li> <li>- There are 200-500 individuals wolves (Monitoring year 2015/2016)</li> <li>- 50 km or less accuracy in the distance between place of residence and nearest wolf pack</li> <li>- wolves recolonization is a natural process</li> <li>- wolves feed mainly on big game species</li> <li>- less than 20 persons killed since 1950</li> </ul>
B1 – Feels well informed on wolves	<b>Numeric;</b> Likert scale from 1 to 5
B2 – Origin of knowledge	<b>Categorical;</b> Press or TV news (reference level); books & films; social networks; family & friends; NGO; zoo; regional wolf information office
B3 – Most frequent source of info	<b>Categorical;</b> Press or TV news (reference level); books & films; social networks; family & friends; NGO; zoo; regional wolf information office
B4 – Trust in the information sources	<b>Numeric;</b> Likert scale from 1 to 5
B5 – Frequency of information	<b>Numeric;</b> Count from 1=never to 6=once a day
C1 – Seen a wolf in captivity	<b>Binary;</b> 1=no; 2= yes
C2 – Seen a wolf outside Germany	<b>Binary;</b> 1=no; 2= yes
C3 – Seen a wolf within Germany	<b>Binary;</b> 1=no; 2= yes

C4 – Lost an animal	<b>Binary;</b> 1=no; 2= yes
C5 – Relative lost an animal	<b>Binary;</b> 1=no; 2= yes
Pop_sample – which population sample respondents belong to	<b>Binary;</b> 1= Germany; 2=wolf region
Dist_Wolf – distance to the nearest wolf territory	<b>Numeric;</b> Variable scaled (centred and standardized)
E1 – Age categories	<b>Numeric;</b> Count from 1=18-29 years old to 5=more than 60 years old
E2 – Gender	<b>Binary;</b> 1=male; 2=female
E3 – Highest level of education	<b>Numerical;</b> Count from 1=still in high school to 11=University
E4 – Time spent in nature	<b>Numerical;</b> Count from 1=never to 5=hours a day
E5 – Wolves have the right to live in Germany	<b>Numeric;</b> Likert scale from 1 to 5
E6 – Humans shape the environment to fit their needs	<b>Numeric;</b> Likert scale from 1 to 5
E7 – Important to protect nature	<b>Numeric;</b> Likert scale from 1 to 5
E8 – Hunter	<b>Binary;</b> 1=no; 2=yes
E9 – Livestock owner	<b>Binary;</b> 1=no; 2=yes
E10 – Dog owner	<b>Binary;</b> 1=no; 2=yes
BLAND_Name – Name of the Federal State	<b>Categorical;</b> 16 German Federal states
Pop_size – Local population size	<b>Numeric;</b> 1=less than 2.000 inhabitants; 2=2000-5000; 3=5000-20,000; 4=20,000-50,000; 5=50,000-100,000; 6=100,000-500,000; 7=more than 500,000 inhabitants.

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518

519 **Table 2.** Results of a multiple linear regression of attitudes towards wolves in Germany  
520 against predictors associated with exposure and experience with wolves, knowledge about  
521 wolves, information sources and socio-demographic characteristics, after a stepwise model  
522 selection (model combines both German and wolf region population samples). Coeff = model  
523 estimate; se=standard error. Pop\_sample is a factor with German population sample as a  
524 reference and wolf region population sample for comparison.

Variable	Combined population samples (R <sup>2</sup> -adj. = 0.31)		
	coeff (se)	t-value	p-value
Pop_sample	-1.14 (0.25)	-4.47	< 0.001***
C5-lost animal	-1.59 (0.35)	-4.56	< 0.001***
Knowledge score	0.23 (0.07)	3.14	< 0.01**
B1-feel informed	0.15 (0.09)	1.80	0.07
B2-information source			
- Books & films	0.92 (0.25)	3.62	<0.001***
- Social networks	1.06 (0.40)	2.66	< 0.01**
B4-trust in information	0.25 (0.10)	2.55	0.01*
E1-Age	-0.38 (0.07)	-5.32	< 0.001***
E2-Gender	-0.98 (0.18)	-5.55	< 0.001***
E5-animal rights	1.42 (0.21)	6.79	< 0.001***
E6-exploit environment	-0.64 (0.08)	-7.86	< 0.001***
E7-importance of protecting	0.62 (0.18)	3.48	< 0.001***
E8-hunter	-1.72 (0.66)	-2.59	< 0.01**
E9-livestock owner	-0.46 (0.31)	-1.48	0.14
Pop_size	0.11 (0.06)	1.91	0.06

525

526

527 **Table 3.** Socio-demographic characteristics of respondents from the wolf region (n=176) and  
 528 Germany (n=670) population samples. Age, Highest education level and Local population  
 529 size are averages for each population sample; Gender, Hunter and Livestock owner are  
 530 expressed as proportions of the population sample.  
 531

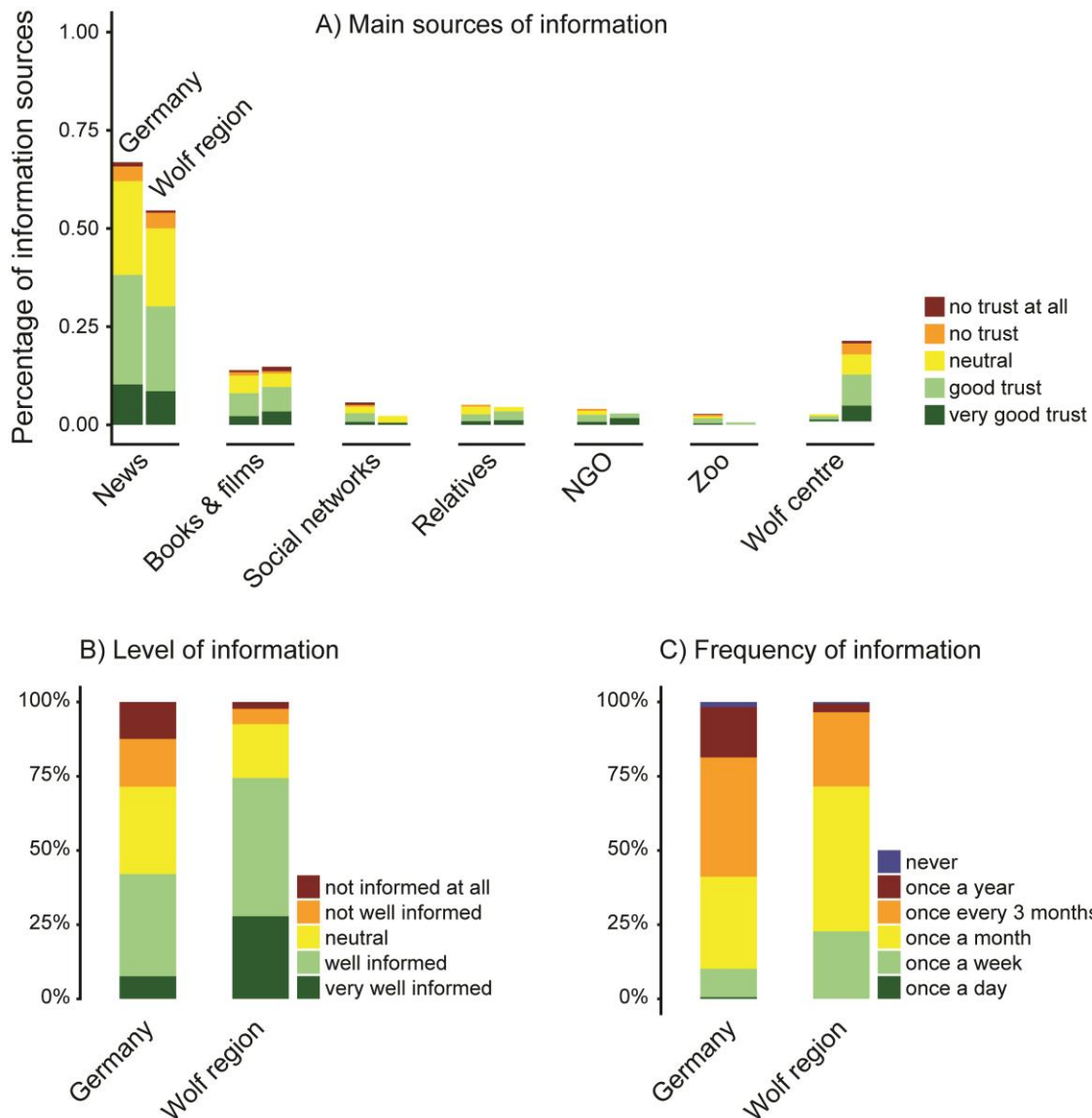
Socio-demographic characteristics	Germany	Wolf region
Age	51.4	55.6
Gender ratio - %Male / %Female	49.1 / 50.9	44.9 / 55.1
Highest education level	6.9 Corresponds to “Abitur”, diploma after 13 years of education	7.1 Corresponds to “Abitur”, diploma after 13 years of education
Local population size	5.5 Corresponds to 50.000 to 100.000 people	4.2 Corresponds to 20.000 to 50.000 people
Hunter (% of population)	2.2	0.0
Livestock owner (% of population)	7.5	15.3

532

533 **Table 4.** Results of two multiple linear regression models (for German population and wolf  
534 region population) of attitudes towards wolves in Germany against predictors associated with  
535 exposure and experience with wolves, knowledge about wolves, information sources, and  
536 socio-demographic characteristics, after stepwise model selections. Coeff = model estimate;  
537 se=standard error; X=variable not retained by the model selection procedure.

	Germany (R <sup>2</sup> -adj. = 0.29)			Wolf region (R <sup>2</sup> -adj. = 0.35)		
	coeff (se)	t-value	p-value	coeff (se)	t-value	p-value
Distance to wolves	X	X	X	-3.18 (2.28)	-1.39	0.17
C2-seen wolves out	0.52 (0.33)	1.59	0.11	X	X	X
C5-lost animal	-1.48 (0.50)	-2.97	< 0.01**	-1.34 (0.52)	-2.58	0.01*
Knowledge score	0.25 (0.08)	3.05	< 0.01**	X	X	X
B1-feel informed	0.19 (0.09)	2.19	0.03*	X	X	X
B2-information source						
- Books & films	0.66 (0.28)	2.34	0.02*	1.86 (0.60)	3.10	< 0.01**
- Wolf information centre	-	-	-	1.23 (0.53)	2.35	0.02*
B4-trust in information	X	X	X	0.97 (0.22)	4.39	< 0.001***
E1-Age	-0.43 (0.08)	-5.58	< 0.001***	X	X	X
E2-Gender	-0.79 (0.19)	-4.07	< 0.001***	-1.33 (0.42)	-3.20	< 0.01**
E3-Education	X	X	X	-0.23 (0.08)	-2.68	< 0.01**
E4-time in nature	-0.24 (0.13)	-1.80	0.07	X	X	X
E5-protect nature	1.43 (0.23)	6.31	< 0.001***	1.20 (0.51)	2.36	0.02*
E6-exploit environment	-0.62 (0.09)	-6.99	< 0.001***	-0.81 (0.20)	-4.07	< 0.001***
E7-importance of protecting nature	0.63 (0.19)	3.24	< 0.01**	X	X	X
E8-hunter	-1.74 (0.66)	-2.63	< 0.01**	X	X	X
E9-livestock owner	-0.65 (0.38)	-1.72	0.09	X	X	X
E10-dog owner	0.42 (0.23)	1.80	0.07	X	X	X
Pop_size	0.16 (0.08)	2.03	0.04*	X	X	X

538

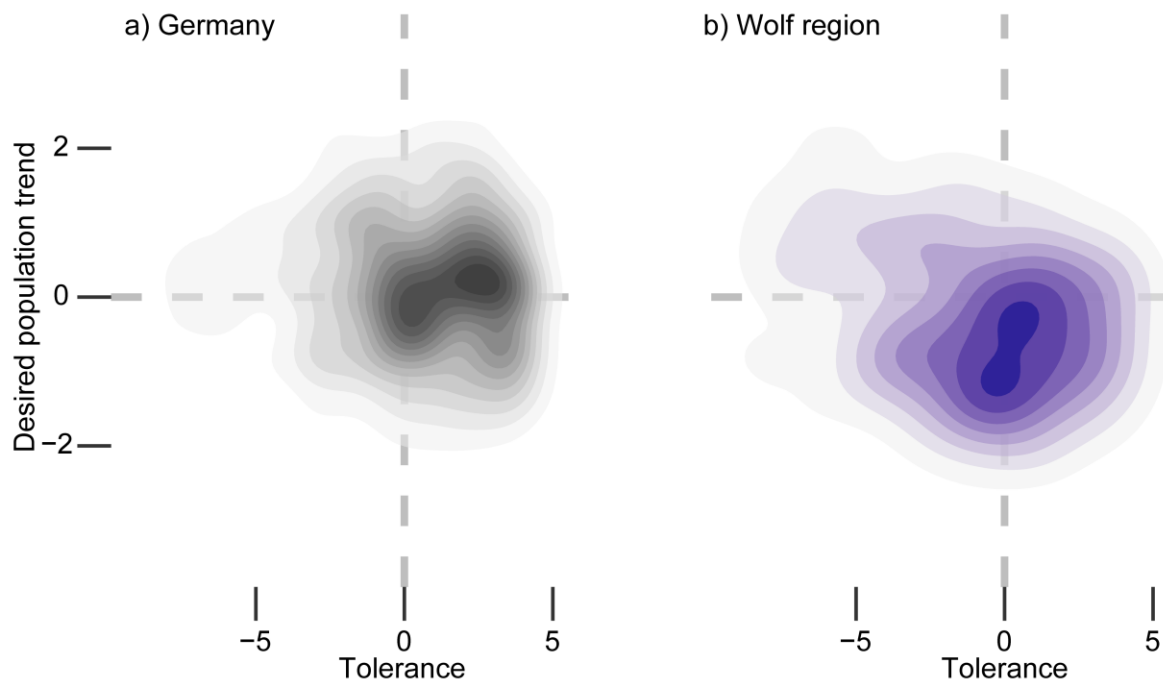


540 **Figure 1.** Differences between Germany and the wolf region population samples in a) their  
 541 main sources of information on wolves and their trust in these sources, b) their self-reported  
 542 level of information on wolves, and c) the frequency at which they receive information on  
 543 wolves. We found significant differences in respondents' use and frequency of information  
 544 between Germany and the wolf region (see Results).

545

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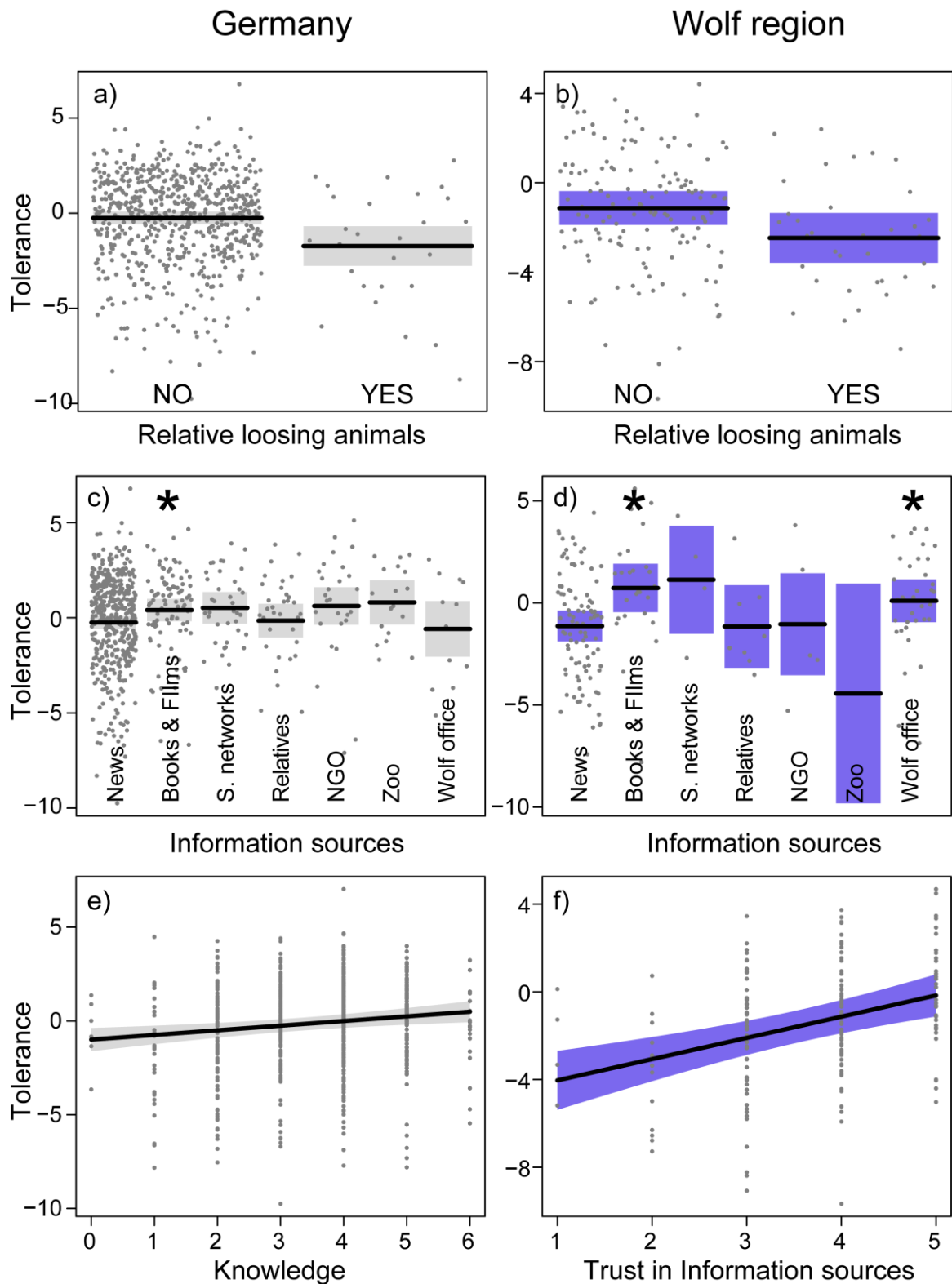




547 **Figure 2.** Differences in attitudes towards wolves between a) Germany and b) the wolf  
 548 region population samples, as shown by Principal Component Analysis results. We display a  
 549 2-dimensional kernel density estimation with darker contour indicating higher density of  
 550 respondents in each plot. X-axis represents a gradient of tolerance towards wolves in  
 551 Germany with higher values reflecting higher tolerance (52.9% of the variation in answers  
 552 related to attitudes). Y-axis represents respondents' opinions concerning their desired wolf  
 553 population trend with positive values indicating a wish for more wolves in Germany (6.2% of  
 554 the variation). Distributions along X-axis were unimodal (dip test,  $p = 0.88$  in German  
 555 sample,  $p = 0.97$  in wolf region sample).

557

558



559  
 560 **Figure 3.** Significant effects of variables related to exposure (a-b), information sources (c-d),  
 561 knowledge (e) and trust in information sources (f) on tolerance towards recolonizing wolves  
 562 in Germany (left panels) and the wolf region (right panels). Graphs show partial residuals and  
 563 mean effects with confidence intervals from multiple linear regressions.