Why so negative? Exploring the socio-economic impacts of large carnivores from a European perspective

Abstract: With populations of wild carnivores growing in Europe, public debates on human-wildlife conflicts are becoming polarized around economic damages and risks to human safety. This article explores the state of knowledge on the broader socio-economic impacts of four European large carnivore species (wolf, bear, lynx and wolverine). It develops a comprehensive categorization of the socio-economic impacts of large carnivore presence, combining impact assessment approaches from project planning with a conceptualization of biodiversity values (e.g. Nature's Contributions to People). Nineteen impact categories are grouped according to 1) economic impacts, 2) health and well-being impacts, and 3) social and cultural impacts. A review of the academic literature since 1990 identified 82 articles that assessed the socio-economic impacts of the four species, 44 from Europe and 33 from North America. Our analysis reveals a bias towards investigations of negative economic impacts, in most cases of wolves. To contrast the information provided by science with perspectives from conservation practice, relevance ratings for the impact categories were elicited among expert practitioners. Several categories considered relevant by the survey respondents are underrepresented in the academic literature. These include mostly positive impacts regarding the benefits from wildlife tourism and commercial activities, game population control, regional and product marketing, cultural heritage and identity, education and research, and social cohesion. This incongruity between supply and demand for scientific information likely reinforces biased public perception of large carnivores. We recommend a stronger research focus on the socio-economic benefits of large carnivores, drawing on diverse impact metrics.

Keywords: large carnivores, socio-economic impacts, conservation management, human-wildlife conflict

1. Introduction

Managing human coexistence with large carnivores (LCs) is a major conservation challenge, in Europe as in many other parts of the world (Peterson et al. 2010, Chapron et al. 2014; Bautista et al. 2019). Conflicts around the presence of large carnivores arise especially in human-dominated landscapes (Kuijper et al. 2019) and often lead to emotionally charged political disputes (Eriksson 2016). A prominent example is the debate around the return of the wolf to parts of Europe that it has not inhabited for a significant period of time (Fernándes-Gil et al. 2018; Skonhoft 2006).

The broader spectrum of socio-economic impacts generated by the presence of LCs is an important yet underrepresented component in conservation management and in debates about human-wildlife conflicts. By assessing who is affected by large carnivores and in what ways, a socio-economic impact assessment can help provide a more complete picture of and scientific evidence for the wider implications of recovering carnivore populations. Lozano et al. (2019) systematically reviewed the research on human-carnivore relations globally. For instance, they found that studies tend to use methods from the natural rather than the social sciences and that two clusters of academic research deal with conflicts related to the grey wolf and with damages to human property by carnivores. They also write that due to the focus on human-carnivore conflicts, important beneficial relations between humans and carnivores may be overlooked.

Impact assessments have traditionally been used as a policy or planning instrument to estimate – and potentially avoid or mitigate – the negative environmental and social consequences of development projects (Slootweg et al 2001, Vancley 2002). Applying impact assessment approaches to the context of large carnivore management therefore requires some adaptation. On the one hand, in line with the original use for project appraisal, impact assessments related to large carnivore management can estimate the effects of specific management interventions such as limiting population size, limiting geographical range by fencing, or using livestock guard dogs. Moreover, impact assessments can also be used to understand and communicate the effects of a general presence of LCs (vs. non-presence) or to highlight specific aspects that are of interest to the scientific, political or public debate around LC presence. Depending on these differences in purpose and scope, impact assessments may seek to assess many impacts of LCs or only specific ones; they can look at the impacts that have occurred in the past or predict the potential impacts of a future scenario, or they may compare different situations. One of the challenges faced when conducting an impact

assessment is that the impacts typically include both material and non-material elements. Material impacts tend to be easier to measure, such as loss of income from damage to livestock or crops (Karamanlidis et al. 2011; Skonhoft 2006), or revenues generated by LC-related tourism activities (Mech 1999). The quantification of non-material impacts is more controversial. For instance, the psychological effects of a sheep farmer's fear and his or her shock and anger when the herd is attacked cannot easily be measured in monetary terms (Johansson 2012), nor can the joy and awe experienced by nature lovers when they spot rarely seen wildlife (Williams et al. 2002).

This article explores and synthesizes the state of knowledge on a wide array of socio-economic impacts – both positive and negative – of large European carnivores. Our work was part of a wider effort, undertaken for the *EuroLargeCarnivores LIFE* project[1], to inform and guide LC management regarding the socio-economic impacts of LCs. We began by developing a categorization of socio-economic impacts tailored to the issue of LC presence (see section 2). This builds on approaches used in socio-economic impact assessments for project planning and on recent advances in the conceptualization of biodiversity values (e.g. Nature's Contributions to People). The categorization was used as an analytical framework for a literature review. In section 3 we present the methodology and results of the literature review. The review examined the amount and the thrust of scientific research on LC in Europe and in North America with respect to LC species (wolf, bear, wolverine and lynx), socio-economic impact types as well as methods and type of data used for the analysis. For the European studies a more detailed analysis is presented of the prevalence of socio-economic impacts for the four LC species. In section 4, we present the results of a survey among LC conservation experts. The survey respondents rated the importance of the impact categories for the LC species in their respective European region, which we then compared with the occurrence of these categories in the scientific literature. Section 5 discusses the insights from the review and the survey and draws some conclusions.

2. Categorizing the socio-economic impacts of large carnivores

A comprehensive list and categorization of relevant socio-economic impacts is useful to increase awareness of the full range of impacts and as a conceptual basis for impact assessments (Vanclay 2002). We were unable, however, to find either a comprehensive list of

[1] See URL: https://www.eurolargecarnivores.eu/en/

impacts or a suitable categorization covering all the different facets of large carnivore impacts. For the purpose of developing such a list and a categorization, we proceeded as follows. In a first step, we sought to acquire a broad understanding of socio-economic impacts and of possible categorization concepts by looking at two distinct strands of literature: the social impact assessment literature and recent concepts related to the valuation of biodiversity. In a second step, we used expert consultations with partners in the EU Life project and a screening of the LC literature to scope the different impacts of European large carnivores as well as the impact pathways, i.e. the changes in the social-ecological system leading to those impacts. In a third step, we combined the lessons from the two previous steps and developed a categorization to cover the impact types thus identified.

Prominent articles and guidance documents from the social impact assessment literature (see e.g. Vanclay 2002, Interorganizational Committee on Principles and Guidelines for Social Impact Assessment 2003, AGDEH 2005, NOAA 2007, Vanclay et al 2015) portray how impact assessments generally rely on a wide range of categories. They suggest that any categorization needs to be constructed depending on the context at hand, and emphasize a number of challenges and caveats when it comes to listing and structuring social impacts. Importantly, it is useful to distinguish between the change processes leading to human impacts and the actual impacts (Slootweg et al 2001), which “must be experienced or felt” by people (Vancley 2002, p. 201). Even then, any catalogue of social impacts may be incomplete due to the way changes in the social-ecological systems can create other changes, directly or indirectly. For instance, continuous attacks by wolves on livestock may contribute to the abandonment of farming and rural to urban migration, with follow-up effects such as loss of rural culture and food sovereignty. When it comes to predicting the strength of socio-economic impacts, it must be kept in mind that people can react to changes or anticipate them and take countermeasures. Last but not least, it is not obvious at which conceptual level impacts should be measured and reported. For instance, job loss is very frequently reported as an impact per se but could also be broken down into its consequences, such asloss of family income (or increase in poverty) and loss of meaning in existential terms. These in turn could be said to reduce life satisfaction or increase personal misery. Taking this thinking to the extreme, one might even attempt to break down any causal chain of socio-economic consequences into changes in pleasure or pain (Bentham 1789) or to changes in what economists term individual “utility” (Fishburn 1970). Impact assessments with a practical purpose, however, will have to decide which impact types to report so that they have meaning for the intended audience. The seven categories of indicative social impacts presented by

Vanclay (2002) seemed to us to be a particularly useful reference point for specifying impact types.

From the literature on valuation concepts developed by the academic and science policy communities on biodiversity conservation, we considered primarily the concept of ecosystem services in its different facets (MA 2005; TEEB 2011; UK NEA 2011, Haines-Young and Potschin 2018), the more recent concept of Nature's Benefits to People (NCP) (Pascual et al. 2017, Díaz et al. 2018) as well as related conceptual contributions on the relational and social values of nature (Chan et al. 2016; Kenter et al. 2015; Arias-Arévalo et al. 2018; Himes and Muraca 2018). These concepts were particularly helpful for gaining insights into the non-material benefits associated with the presence of LCs. While both strands of literature mention the need to consider positive and negative effects, the impact assessment literature leans more toward negative impacts and the biodiversity valuation literature toward positive ones.

In order to identify specific impacts related to the presence of European large carnivores, we consulted experts from partner countries in the EU Life project and asked them to describe the positive and negative consequences of large carnivore presence in their respective country setting. Out of this input we compiled an initial list of socio-economic impacts, which we complemented by screening the description of impacts considered in the academic literature on LC impacts (see literature review below).

Selecting a particular categorization was challenging due to the striking number of generic categorizations in both the impact assessment literature and the biodiversity valuation literature. Moreover, due to the challenges encountered when structuring the impacts, as mentioned above, any choice was, to some extent, a matter of subjective judgement. To construct our categorization, we took as a starting point the relevant categories of the Nature's Contributions to People (NCP) framework (Diaz et al 2018). We distinguish between changes in the social-ecological system due to a (higher) presence of LCs and the resulting social impact, in the sense of what is felt or experienced by people as a consequence of these changes (see columns 2 and 3 in Table 1). The use of NCP categories here may be useful in itself to researchers and practitioners interested in applying the NCP framework to large carnivore management. Table 1 shows that specific changes in the social-ecological system prompted by an LC presence (column 2) can have several impacts on people in terms of who is affected, how, and whether the impact is positive or negative (columns 3 to 5).

158

159 *--- Table 1 about here ---*

160

161 For the purpose of our study, we decided to rearrange the impacts according to a
162 categorization closer to the social impact assessment literature. We condensed the main
163 categories presented by Vanclay (2002) and defined three overarching impact categories: 1.
164 Economic impacts, 2. Health & well-being impacts, and 3. Social & cultural impacts.[2] Within
165 these overarching categories, we defined sub-categories to cover the full list of specific LC
166 related impacts (see Table 2). We emphasize here that impact lists should not be regarded as
167 precise checklists for specific future impact assessments, but will always require adaptations
168 based on the specific situation and information needs in a given context (Vanclay 2002,
169 Interorganizational Committee on Principles and Guidelines for Social Impact Assessment
170 2003).

171 Finally, the classification of impacts into positive or negative consequences for humans is a
172 fundamentally anthropocentric concept, neglecting bio-centric value. For instance, large
173 carnivores can be relevant from the perspective of ecosystem health: they can act as seed
174 dispersers, they may alter biodiversity in a place, and they may even produce changes at the
175 ecosystem scale (Ripple and Beschta 2012, Greg et al. 2020). These impacts on the ecosystem
176 would only be reported in a socio-economic impact assessment if they have consequences for
177 people (see second column of Table 1).

178

179 *--- Table 2 about here ---*

180

181 **3. Literature review**

182 **3.1. Method**

183 The review followed the methodological guidelines for literature reviews by Moher et al.
184 (2009). The literature search was restricted to academic articles published since 1990.
185 Although the review focuses on the four European LC species (i.e., wolves, bears, wolverines

[2] This bears resemblance to the three types of "well-being value" (economic, health, shared (social) value) from ecosystem services distinguished by the UK NEA (2011).

and lynxes), we also included studies from non-European countries covering these species. We expected that socio-economic impacts even of different sub-species (e.g. brown bears and black bears) may be similar, so that one can also learn from non-European studies about which impact types are important and how they can be assessed. We defined a list of search terms divided into three search levels (see Table 3), applying the search terms to the Web of Science, Scopus and Google Scholar databases. The search commands were built using Boolean operators so that search terms were connected within each level by 'OR' and between the three levels by 'AND'. This meant that the results include at least one word from each level. Google Scholar did not allow search terms long enough for our search command, and so we reduced the command to the most important terms from the first two levels.

--- Table 3 about here ---

The first search in these three databases yielded 424 results. Correction for duplicates reduced the number of articles to 308. Skimming the list of references to relevant articles ('snowballing') led to an additional 74 articles, and from other sources we added six more articles. Of these 388 articles, 235 were excluded when a screening of their titles and abstracts revealed that they did not deal with the topic of socio-economic impacts (n=182), were articles that appeared before 1990 (n=27), addressed irrelevant species (n=21), or were textbooks (n=5) that were no longer available.

The remaining 153 articles were read in full. We extracted socio-economic impact categories and methods as well as other characteristics of the article including study region, the species addressed, ex-ante vs. ex-post analysis, and type of data (qualitative or quantitative). We had to exclude another 71 articles which, having been read in full, did not meet the criterion of assessing at least one type of socio-economic impact in sufficient depth. Some of these articles only mentioned the relevance of socio-economic impacts in a superficial manner, some assessed animal well-being and the impacts of humans on carnivores instead of carnivores' impacts on humans, and some studied people's attitudes or perceptions related to large carnivores in general rather than related to their impacts. Within the analytical

framework, attitude changes were not included as impacts per se.[3] The final database included 82 academic articles, for which Appendix 1 provides a complete list of references.

--- Figure 1 about here ---

3.2. Results

Our search produced 44 European studies and 33 studies from North America. It also included five studies from other regions outside Europe (e.g. India and Eastern Turkey), which are very heterogenous and difficult to compare with the European context. They are therefore not analysed further in the paper, although we include them in Appendix 2 in the supplementary material to this article.[4]

None of the studies attempted to provide a comprehensive picture of all socio-economic impacts. The studies looked at between 1 and 8 of the total of 19 impact categories defined in the previous section (mean: 2.7). While most studies (59) focused on one LC species, some also addressed two (9), three (4), or all four (10) of them. We do not present - or meta-analyse - the actual values of all socio-economic impacts that were found in the studies we reviewed. The results of particular studies differ in impact types, geographical and temporal scope, as well as methods and indicators. We focus primarily on the question of which impact categories were assessed. We also report whether the studies were based on qualitative or

[3] Understanding people's attitudes and attitude change is key to understanding and mitigating wildlife conflicts. Attitudes, however, are an abstract (psychological) concept compared to the impacts we are considering here, and they can link to other impacts in different ways. Eiser (1986, p.13) defines attitude as "a subjective experience involving an evaluation of something or somebody […] individuals actively perceiving, interpreting and evaluating their external world." Individuals may form attitudes towards large carnivores based partly on what they know and feel about the different impacts, among other influences (education, media, etc.). In that sense, attitude changes are a second-order effect, meaning that they are a consequence of the impacts, not an impact per se. On the other hand, once people have a certain attitude, this can influence the perceived severity of impacts. For instance, someone with a deep and strongly negative attitude towards wolves may have very strong negative emotions when seeing wolf tracks or may be more likely to be involved in conflicts that cause social tensions (Inskip and Zimmerman 2009). Despite the fact that we did not include attitudes as an explicit impact in our review, we found that 45% of all the articles we reviewed assessed attitudes or attitude changes towards LCs. This shows that there is considerable interest in this topic in the field of human-carnivore interaction.

[4] Appendix 2 consists of a look-up table with filter functions that make it possible to narrow down a personal search directly to relevant subsets of the 82 articles according to specific interests. For instance, filtering for studies on income from tourism or other commercial activities related to wolves would yield five matching articles.

quantitative analysis, and whether they were based on an ex-ante estimation of future impacts or ex-post evaluation of impacts that occurred in the past.

Table 4 presents a comparison of the relative frequencies between European and North-American studies with respect to the species they dealt with, the impact categories they assessed (across all four species), and study characteristics.

--- *Table 4 about here* ---

By and large, the numbers show similar patterns for European and North-American studies. The wolf is the dominant species in the reviewed literature, studied in 86% and 73% of all the articles, respectively for European and North-American studies. Bears appear in 48% and 39% of the studies. Lynxes (32% / 9%) and wolverines (21% / 6%) are investigated less often, in particular in North-American studies.

The review reveals a strong tendency in both regions to investigate the economic impacts of LC (75% in Europe / 91% in North America). Most of these studies look at negative economic impacts (75% / 85%) and far fewer of them at positive economic impacts (23% / 24%). A significant number of studies (52% / 67%) assess *only* negative economic impacts. One striking difference between European and North American studies relates to health & well-being effects, which are studied far more often in Europe (55% vs. 27%). This difference is driven mainly by a higher number of European articles assessing negative (15 vs. 4 studies) and positive emotions (14 vs. 5 studies) towards LC. Social & cultural impacts are studied in both regions with similar frequency (46% / 42%), yet the North American studies are more balanced between negative and positive impacts (27% vs. 21%) compared to the European studies (43% vs. 9%). This is mainly due to the fact that 19 European studies assess negative impacts related to social and political tensions (compared to only 9 studies in North America). Overall, studies from both regions assess negative impacts roughly twice as often as positive impacts (93% vs. 48% / 97% vs. 46%). The patterns regarding qualitative vs. quantitative studies and ex-ante estimations vs. ex-post evaluations are similar: in both regions, quantitative studies and ex-post evaluations are in the majority.

Regarding the 44 European studies, Table 5 presents a more detailed overview of the absolute and relative frequencies of studies dealing with different impact types for the four species. It

turns out that for all four species and in all three impact domains (i.e. economic, health & well-being, social & cultural), the number of negative impacts assessed is larger than the number of positive impacts. If we compare the two most prominently studied LCs (wolf and bear), the overall pattern is very similar, with a focus on negative economic impacts (mainly due to livestock damage and costs of conservation management). For both species, many studies address positive or negative emotions. Social and cultural impacts are addressed more frequently in studies dealing with wolves (53% vs. 29%), which is primarily due to assessments of social and political tensions (50% vs 29 %). Meanwhile, positive social and cultural aspects and positive impacts in general were rarely studied in the academic literature. The right-hand column of Table 5 shows that three of the impact categories ("benefits for regional and product marketing", "health benefits", and "value for education and research") were not assessed in any of the European academic studies.

--- *Table 5 about here* ---

4. Expert judgments on the relevance of impact categories

The previous section showed the relative prominence of different impact categories in the academic literature and revealed that some impacts are rarely dealt with. Although this is interesting per se, it also leads to the question of how the treatment of LC impacts in the literature correlates with their practical relevance in LC management. In order to explore the relevance of the different impact categories on the ground, we conducted a survey among the staff of EuroLargeCarnivores LIFE project partners from 15 European countries. Although the sample size is limited, the results show general trends regarding the perceived relevance of the impact categories for the different species. This allows for some cautious conclusions regarding which impacts seem underrepresented in scientific studies.

--- *Table 6 about here* ---

4.1. Method

Table 5 presents a list of the project regions. The project partners received a survey document which asked them to provide general information on the situation around the presence of LCs

in their project region (e.g. species, geographical scope, sources of conflict, etc.). They were then asked to go through the table of impact categories (see Table 2) and rate the importance of each impact for their region on a scale from 0 (no relevance) to 5 (highest relevance). In addition to the information provided in Table 1, all the respondents had received examples of each impact category as well as guidance containing explanations on socio-economic impacts and the purpose of assessing them.

The experts were conservation practitioners working in the WWF country offices who are in close contact with the conservation managers on the ground. Their main responsibility (also within the EU LIFE project) is to understand the LC conflicts in all their various facets, to help develop conflict mitigation measures, and to improve human-carnivore co-existence. While the experts personally may lean towards a pro-conservation stance, they have a comprehensive view of the situation and the different perspectives, and they are arguably less likely to favour certain impacts compared to any specific stakeholder groups (e.g. hunters, shepherds), because they are not directly affected in economic terms. The respondents were also asked to explain and justify their ratings by describing what this impact means in their context, who is impacted, and what empirical evidence (if any) they have to back it up. They were encouraged to discuss the issues and to consolidate their ratings within their team and with stakeholders. We acknowledge that the ratings of the conservation-oriented specialists in this study may not necessarily coincide with ratings from wider stakeholder groups. We would encourage future research to validate or improve these relevance ratings, for instance via surveys involving a more representative sample rather than conservation experts alone.

--- *Table 6 about here* ---

4.2. Results

The data consists of twelve responses for wolves, four for bears, and one each for lynx and wolverine. For the sake of completeness, we present in Table 7 the average ratings of all impact categories for each species. Due to the low number of observations, however, we will not further interpret lynx and wolverine.

--- *Table 7 about here* ---

In the case of wolves, management costs and livestock damage as well as social/political tensions were given a high rating on average. There were also a number of positive impacts with relatively high scores (average above 2.0): benefits from tourism and commercial activities, benefits from game population control, positive emotions, and education and research. Health impacts, both positive and negative, were attributed low relevance. Bears tended to have high impact scores for many impact categories. Livestock damage received the highest rating, probably related largely to damage to beehives. With regard to economic impacts, damage to crops and equipment was also seen as highly relevant, as well as management costs and losses from game hunting. There were also relatively high scores for economic benefits with respect to tourism and commercial activities, benefits from game population control, regional and product marketing, and gains in employment. With regard to health and well-being impacts, physical harm was rated as fairly relevant (mean rating of 2.8). Negative and positive emotions were rated as equally relevant (mean: 2.3). As regards social and cultural impacts, the role of bears was rated as high in terms of social and political tensions, but the bear was also seen as important for research and education, social cohesion, and cultural heritage and identity.

Only survey respondents from three project regions (Slovakia, Greece, Ukraine) rated both wolf and bear.[5] We do not want to overemphasize the results of this small sample, but it was surprising that the average ratings of the three responses for the bear attributed high impacts both on the positive and the negative side. For instance, physical harm and negative emotions in the three regions were rated far more relevant for bears than for wolves (2.0 vs. 0.3 and 1.7 vs. 0.7 respectively). Wolves only scored higher with respect to negative economic impacts due to livestock damage (5.0 vs. 4.0) and losses from game hunting (1.7 vs. 1.3), and with respect to positive economic impact due to game population control (2.7 vs. 2.0).

In relation to wolves we also compared the frequency with which the different impact categories are addressed in the 38 wolf-related European academic articles with the average relevance ratings from the experts (see Figure 2). This comparison is based, of course, on very different measures. Nevertheless, it indicates the extent to which the focus of the academic debate coincides with expert judgements. Major differences between the length of a grey box (indicating the relative frequency of articles) and the black bar (indicating the average

[5] There are more European countries where both species are present (e.g. Italy, France, Poland). Survey respondents rated only those species that are explicitly included in the EU LIFE project for each project region.

relevance rating) reveal discrepancies in the sense of gaps in academic research on a particular category. The left-hand side of the figure illustrates that several negative impacts rated as highly relevant (management costs, livestock damage, negative emotions, social/political tensions) are also covered by a large number of academic studies. Only for a few negative impacts does the frequency of academic studies not correspond to their relevance as rated by the expert practitioners, in particular for losses from game hunting and loss of employment. The right-hand side of the figure indicates that the research gaps are particularly frequent for positive impacts. For instance, benefits from tourism and commercial activities, benefits from game population control, and value for research and education are rated with average relevance scores of 2.0 or higher, but are far less frequently studied in the academic literature compared to the negative impacts with similar relevance ratings.

--- Figure 2 about here ---

5. Discussion and conclusions

We explored the socio-economic impacts of four European large carnivores (LC) species (wolves, bears, wolverines and lynxes) using three complementary elements: a comprehensive list and categorization of socio-economic impacts, a review of the scientific literature assessing socio-economic impacts, and relevance ratings by European experts in conservation practice.

One conclusion from our examination of the literature was the lack of a systematic and comprehensive categorization of the socio-economic impacts of large carnivores. We therefore developed a new categorization based on frameworks from the impact assessment literature and valuation concepts from biodiversity research. We identified 19 impact categories that could be grouped according to 1) economic impacts, 2) health & well-being impacts, and 3) social & cultural impacts. We also presented a categorization of large carnivore impacts according to categories proposed by the concept of Nature's Contributions to People (NCP) (Diaz et al 2018). The NCP framework is a internationally prominent effort to systematically take account of the diverse values people attribute to nature. Its application to the context of large carnivore impacts is an example of how the NCP concept can be adapted to specific conservation management requirements. The article thus offers two

proposals for structuring LC impacts which can be applied or adapted for future efforts. The paper also discusses a number of challenges for specifying appropriate impact categories.

A second insight is that published scientific studies of LC impacts, in Europe and North America alike, tend to focus on economic impacts, on negative aspects, and on wolves. The main differences between European and North American studies are that more European studies assess effects on people's emotions (both positive and negative) and social and political tensions. We can only speculate that this difference in academic interest may be related to more proximity or to direct contact between humans and LC in the more densely populated European areas.

Furthermore, scientific studies rarely cover a broader set of positive and negative impacts; study design and research interest do not reflect such a broader focus. In consequence, in the case of many sites where impacts were studied we cannot know whether there are other impacts or not. The scientific knowledge base on the interconnections between large carnivores and human societies is thus an incomplete puzzle, whose existing pieces may be well elaborated but do not form a balanced overall picture.

In contrast, the practitioner survey indicates that LC presence generates multiple and diverse positive and negative impacts throughout Europe. Many categories considered relevant by the survey respondents are underrepresented in the academic literature, in particular, several impacts considered as positive: benefits from tourism and commercial activities, benefits from game population control, benefits from regional and product marketing, cultural heritage and identity, educational and research benefits, and social cohesion. In this regard, then, current LC research does not fully reflect the knowledge needs of LC management in Europe.

Why are (negative) economic impacts so frequently studied and other impacts neglected? We propose here some possible reasons, which could stimulate future research. One reason for the focus on negative economic impacts might be that the phenomena behind economic damage caused by LC (in particular to livestock) stimulates academic interest in various scientific disciplines: among ecologists focusing on the population dynamics of LC and the ecological system, and among social scientists dealing with people's livelihoods and socio-economic systems. It could also be that the dominance of negative economic impacts in the public debate guides academic interest in this direction, which, ironically, may in turn reinforce their emphasis in public perceptions. A third reason could be that some positive impacts tend to be hoped for in the future (e.g. tourism-related income and job opportunities) but in many places

have not yet materialized. While Wolf safaris are quite well established in Scandinavia, they only play a limited role in nature tourism in Germany, where more than a dozen wilderness/zoological parks feature fenced-in wolves as their main attraction. With respect to benefits from game population control by wolves, these effects are mainly examined from an ecological perspective, but we know of no study that makes the link to (commercial) benefits for people in terms of reduced damage to the forest or crops. A last potential explantion of the research gap on positive LC impacts relates in particular to positive immaterial impacts, such as cultural heritage, and educational or research values. These impacts are hard to quantify. As our review reveals, there has been little application of tools like socio-cultural valuation of ecosystem services to the field of conservation biology and to the topic of large carnivores in particular so far. Operationalizing social and cultural impacts remains a major research challenge (see e.g. Cabana et al. 2020). Even recent concepts devised with the intention of addressing positive human-nature interactions, such as 'cultural ecosystem services', 'nature's contributions to people' (NCP), or 'relational values', often lack the level of detail that would allow operationalization in terms of indicators and methods. Conservation research can certainly benefit from an exchange with scientists from different disciplines and from local/traditional/indigenous knowledge holders regarding the multiple values of nature (see e.g. Morales-Reyes 2018). A comprehensive assessment of socio-economic impacts of large carnivores is only possible if there are concepts and methods designed to capture the non-material impacts of LCs and to incorporate multiple impact metrics.

The impacts of LC on people's emotions turned out to be a special case in the sense that European studies assessed both positive and negative emotions almost equally often. We hence cannot speak of a research gap on this impact category and need to point out that this impact is closely related to the ample research on attitudes towards LC. In Finland, the share of the total population with fear of wolves rose from 32% to 47% between 2009-2013, without any significant change in the wolf population, but largely due to increased media coverage (Hiedanpää et al 2016). In Sweden, proximity to and more direct experience with wolves and bears reduces their general public acceptance (Eriksson et al 2015) – which has been confirmed even for young generations in a survey on pupils' attitudes in Germany (Randler et al 2020). Fear can clearly inhibit the interest, enjoyment, appreciation, or sense of awe regarding LCs. We would encourage further research on the emotional effects and also on the underlying reasons behind the emotions as well as the developments over time.

Finally, a more balanced scientific assessment of the multiple negative and positive socio-economic effects of LCs can reveal the trade-offs and synergies involved in large carnivore management responses. This would enhance our understanding of which actor groups in society benefit and which groups lose out (Lozano et al 2019). The presence of large carnivores and any management intervention will affect different social groups or milieus at the same time but in very different ways, e.g. loss of income for some and increase in joy at the presence of LCs for others. These differences of who benefits (e.g. emotionally) and who loses (e.g. by paying with one's livelihood) are often how conflicts arise between different stakeholder groups (Peterson et al. 2010). Stakeholders may still differ, of course, in how they interpret impacts. Whereas some attribute wolf attacks to the presence of the species per se, others conclude that the impacts are due to a lack of appropriate conservation management. Moreover, people will weigh the severity of multiple impacts differently and often with a self-serving bias (Babcock and Loewenstein 1997). Nonetheless, understanding the full spectrum of socio-economic impacts and the trade-offs involved can be an important step towards identifying innovative management measures, conflict resolution mechanisms, and governance schemes to reconcile the interests of different groups in society. The material developed in this paper is intended to help the academic and non-academic community dealing with large carnivore conflicts on their quest towards more comprehensive assessments, and eventually to improve human-carnivore co-existence.

Acknowledgements: The authors are grateful to all the representatives of the partner organizations of EU LIFE Euro Large Carnivores for their efforts in completing the survey and for engaging in interesting discussions on the socio-economic impacts of large carnivores. Insightful comments and suggestions on an earlier version of the paper were made by Laszlo Patko, Carol Grossmann and Panagiota Maragou. The paper has benefited from constructive comments made by three anonymous reviewers. We thank Charlotte Schuessler for research assistance and Kathleen Cross for language edits.

486

487

References

AGDEH (2005). Socio-economic Impact Assessment Toolkit. A guide to assessing the socio-economic impacts of Marine Protected Areas in Australia. Australian Government Department of the Environment and Heritage. https://parksaustralia.gov.au/marine/management/resources/scientific-publications/socio-economic-impact-assessment-toolkit-guide-assessing-socio-economic-impacts-marine/ (accessed 5 June 2020).

Arias-Arévalo, P., Gómez-Baggethun, E., Martín-López, B., Pérez-Rincón, M. (2018). Widening the evaluative space for ecosystem services: a taxonomy of plural values and valuation methods. *Environmental Values* 27 (1), 29–53.

Babcock, L., Loewenstein, G. (1997). Explaining bargaining impasse: the role of self-serving biases. *Journal of Economic Perspectives* 11 (1), 109–126.

Bautista, C., Revilla, E., Naves, J., Albrecht, J., Fernández, N., Olszańska, A. et al. (2019). Large carnivore damage in Europe: Analysis of compensation and prevention programs., *Biological Conservation* 235, 308–316.

Bentham, J. (1789). An introduction to the principles of morals and legislation. Clarendon Press.

Boman, M., Bostedt, G., Persson, J. (2003). The bioeconomics of the spatial distribution of an endangered species: the case of the Swedish wolf population. *Journal of Bioeconomics* (5), 55–74.

Cabana, D., Ryfield, F., Crowe, T.P., Brannigan, J. (2020). Evaluating and communicating cultural ecosystem services. *Ecosystem Services* 42, 101085.

Chan, K. M., Balvanera, P., Benessaiah, K., Chapman, M., Díaz, S., Gómez-Baggethun, E. et al. (2016). Opinion: Why protect nature? Rethinking values and the environment. *Proceedings of the National Academy of Sciences of the United States of America* 113 (6), 1462–1465.

Chapron, G., Kaczensky, P., Linnell, J. D. C., von Arx, M., Huber, D., Andren, H. et al. (2014). Recovery of large carnivores in Europe's modern human-dominated landscapes. *Science* 346 (6216), 1517–1519.

Díaz, S., Pascual, U., Stenseke, M., Martín-López, B., Watson, R. T., Molnár, Z. et al. (2018). Assessing nature's contributions to people. *Science* 359 (6373), 270–272.

Eiser, J. R. (1986). Social psychology: Attitudes, cognition and social behaviour. Cambridge University Press (S.13)

Eriksson, M. (2016). Rurality and collective attitude effects on wolf policy. *Sustainability* 8 (8), 711.

Eriksson, M., Sandström, C., & Ericsson, G. (2015), Direct experience and attitude change towards bears and wolves, *Wildlife Biology* 21(3), 131-137.

Fernándes-Gil, A., Cadete da Rocha Pereira, D., Dias Ferreira Pinto, S. M., Di Silvestre, I. (2018). Large Carnivore Management Plans of Protection: Best Practices in EU Member States. European Parliament. https://op.europa.eu/en/publication-detail/-/publication/29b11762-437b-11e8-a9f4-01aa75ed71a1 (accessed 5 June 2020).

Fishburn, Peter C. (1970). Utility Theory for Decision Making. Huntington, NY: Robert E. Krieger.

Gregr, E., Christensen, V., Nichol, L., Martone, R., Markel, R., Watson, J., Harley, C., Pakhomov, E., Shurin, J., Chan, K. (2020), Cascading social-ecological costs and benefits triggered by a recovering keystone predator, *Science* 368, 1243-1247.

Haines-Young, R., Potschin, M. (2018). Revision of the common international classification of ecosystem services (CICES V5. 1): a policy brief. *One Ecosystem 3*, e27108.

Hiedanpää, J., Pellikka, J., & Ojalammi, S. (2016). Meet the parents: Normative emotions in Finnish wolf politics. *TRACE Journal for Human-Animal Studies* 2.

Himes, A., Muraca, B. (2018). Relational values: the key to pluralistic valuation of ecosystem services. *Current Opinion in Environmental Sustainability* 35, 1–7.

Inskip, C., Zimmermann, A. (2009). Human-felid conflict: a review of patterns and priorities worldwide. *Oryx* 43, 18–34.

Interorganizational Committee on Principles and Guidelines for Social Impact Assessment (2003). Principles and guidelines for social impact assessment in the USA: The Interorganizational Committee on Principles and Guidelines for Social Impact Assessment. *Impact Assessment and Project Appraisal* 21 (3), S. 231–250.

Johansson, M., Sjöström, M., Karlsson, J., Brännlund, R. (2012). Is Human Fear Affecting Public Willingness to Pay for the Management and Conservation of Large Carnivores?. *Society & Natural Resources* 25 (6), 610–620.

Karamanlidis, A. A., Sanopoulos, A., Georgiadis, L., Zedrosser, A. (2011). Structural and economic aspects of human-bear conflicts in Greece. *URSUS* 22 (2), 141–151.

Kenter, J. O., O'Brien, L., Hockley, N., Ravenscroft, N., Fazey, I., Irvine, K. N. et al. (2015). What are shared and social values of ecosystems?. *Ecological Economics* 111, 86–99.

Kojola, I., Hallikaine, V., Helle, T., Swenson, J. E. (2018). Can only poorer European countries afford large carnivores?. *PloS one* 13 (4).

Kuijper, D.P.J., Churski, M., Trouwborst, A., Heurich, M., Smit, C., Kerley, G.I.H., Cromsigt, J.P.G.M. (2019). Keep the wolf from the door: How to conserve wolves in Europe's human-dominated landscapes?. *Biological Conservation* 235, 102–111.

Lozano, J., Olszańska, A., Morales-Reyes, Z., Castro, A. A., Malo, A. F., Moleón, M. et al. (2019). Human-carnivore relations: A systematic review. *Biological Conservation* 237, 480–492.

MA (2005): Ecosystems and human well-being. Synthesis. Millenium Ecosystem Assessment. Washington DC: Island Press.

Mech, L. D. (1999). Estimated costs of maintaining a recovered wolf population in agricultural regions of Minnesota. *Wildlife Society Bulletin* 26 (4), 817–822.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS med* 6 (7), e1000097.

Morales-Reyes, Z., Martín-López, B., Moleón, M., Mateo-Tomás, P., Botella, F., Margalida, A., Donázar, J.A., Blanco, G., Pérez, I., Sánchez-Zapata, J.A. (2018). Farmer perceptions of the ecosystem services provided by scavengers: What, who, and to whom. *Conservation letters* 11(2), e12392.

NOAA (2007). Guidance for social impact assessment. National Oceanic and Atmospheric Administration. Silver Spring, MD. http://s3.amazonaws.com/nefmc.org/01-111-02_SIA_Guidance.pdf (accessed 5 June 2020).

O'Neill, J., Holland, A., Light, A. (2008). Environmental values. Routledge. London and New York.

Pascual, U., Balvanera, P., Díaz, S., Pataki, G., Roth, E., Stenseke, M. et al. (2017). Valuing nature's contributions to people: the IPBES approach. *Current Opinion in Environmental Sustainability* 26-27, 7–16.

Peterson, M.N., Birckhead, J.L., Leong, K., Peterson, M.J., Peterson, T.R. (2010). Rearticulating the myth of human-wildlife conflict. *Conservation Letters* 3, 74–82.

Randler, C., Wagner, A., Rögele, A., Hummel, E., & Tomažič, I. (2020). Attitudes toward and Knowledge about Wolves in SW German Secondary School Pupils from within and outside an Area Occupied by Wolves (Canis lupus), *Animals* 10(4), 607.

Ripple, W., Beschta R. (2012), Trophic cascades in Yellowstone: The first 15 years after wolf reintroduction, *Biological Conservation* 145, 2005 – 213.

Røskaft, E., Händel, B., Bjerke, T., Kaltenborn, B. P. (2007). Human attitudes towards large carnivores in Norway. *Wildlife Biology* 13 (2), 172–185.

Skonhoft, A. (2006). The costs and benefits of animal predation. An analysis of Scandinavian wolf re-colonization. In: *Ecological economics* 58 (4), 830–841.

Slootweg R., Vanclay F., van Schooten M. (2001). Function evaluation as a framework for the integration of social and environmental impact assessment. *Impact Assessment and Project Appraisal* 19(1), 19– 28.

TEEB (2011). The economics of ecosystems and biodiversity in local and regionalpolicy and management. Wittmer, H., & Gundimeda, H. (Eds.). London: Earthscan.

UK NEA (2011). The UK national ecosystem assessment: synthesis of the key findings. UNEP-WCMC, Cambridge. http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx (accessed 5 June 2020).

Vanclay, F. (2002). Conceptualising social impacts. *Environmental Impact Assessment Review* 22, 183– 211.

Vanclay, F., Esteves, A., Aucamp, I., Franks, D. (2015). Social Impact Assessment. Guidance for assessing and managing the social impacts of projects. International Association for Impact Assessment. https://www.researchgate.net/publication/274254726_Social_Impact_Assessment_Guidance_for_Assessing_and_Managing_the_Social_Impacts_of_Projects (accessed 5 June 2020).

Williams, C. K., Ericsson, G., Heberlein, T. A. (2002). A quantitative summary of attitudes toward wolves and their reintroduction (1972-2000). *Wildlife Society Bulletin* 30 (2), 575–584.

Table 1. Social-ecological changes and social impacts resulting from large carnivore presence.

	Change in the social-ecological system	**Social impact,** i.e. what is experienced or felt by people as a consequence of the change in the socio-ecological system	Who is affected?	Category[1] &Direction[2]
Regulating NCP	**10 - Regulation of detrimental organisms and biological processes**			
	LC transmit diseases to dogs and other domesticated animals.	**Commercial costs and losses** from death of domesticated animals	Farmers, herders, dog owners	E -
		Negative emotions (sadness, anger) from death of animals	Farmers, herders	HW -
	Wolves reduce the number of ungulates.	**Commercial benefits** due to fewer damage to trees and crops.	Farmers	E +
		Health benefits due to fewer injuries/deaths from deer or moose-related car accidents.	Car drivers	HW +
		Commercial costs and losses due to fewer ungulates for hunting.	Hunters	E -
		Commercial losses when the land leases for hunting are reduced.	Land owners	E -
		Commercial benefits when LC contribute to disease control among ungulate populations.	Hunters, land owners	E +
		Negative emotions from less enjoyment of hunting or hunters' perception that it is their role to regulate ungulate population.	Hunters	HW -
Material NCP	**12 - Food and feed**			
	Wolves and wolverines kill livestock (cattle, sheep, etc.).	**Commercial costs and losses**, including opportunity costs of time spent on management of damages	Farmers, herders, hunters	E -
		Loss of employment in farming and herding	Farmers, hunters	E -
		Public costs related to compensation schemes and administration	Tax payers	E -
		Negative emotions (stress, fear, anger)	Farmers, herders	HW -
		Negative health effects due to psychological stress	Farmers, herders	HW -
	Bears damage beehives and scratch trees.	**Commercial costs and losses**	Beekeepers, private or public land owners (tree damage)	E -
		Loss of employment in apiculture	Beekeepers	E -
	13 - Materials and assistance			
	Bears damage staples, fences, etc.	**Costs from material damage**	Farmers, forest owners, equipment and property owners	E -
	Bears and wolves are involved in collisions with vehicles.	**Costs from material damage**	Vehicle owners	E -
		Negative health effects (injuries, deaths, psychological harm)	Local people, tourists	HW -
	LC require management activities by public and private actors.	**Commercial costs and losses** due to livestock protection measures (fencing, guard dogs, patrolling, etc.), including opportunity costs of time spent	Farmers, herders	E -
		Public costs related to compensation schemes, wildlife infrastructure (e.g. green bridges), etc.	Government authorities, tax payers	E -
		Social cohesion due to opportunities for discussion, mutual understanding, and collaboration among stakeholder groups.	Local communities	SC +
	LC presence generates the opportunity for LC hunting (where legal).	**Commercial benefits** due to income from hunting tourism.	Hunters, Hunting tourism sector and associated supply chains (restaurants, hotels, shops for hunting gear, etc.)	E +
		Public income through sales of licenses.	Authorities selling concessions	E +
Non	**15 - Learning and inspiration**			

	LC presence interests and inspires people (locally and beyond).	**Positive emotions** from inspiration, e.g. for stories and celebrations.	Local people, tourists, hunters	SC +
		Educational and research benefits from learning about LC and understanding nature.	School children, interested adults, university students, scientists	SC +
		Commercial benefits due to income from inspirational and educational activities (books, films, LC information centers, etc.)	Local economy and associated supply chain	E +
		Gains in employment related to inspirational and educational activities (books, films, LC information centers, etc.) and related to scientific research	Local workforce, scientists	E +
	16 - Physical and psychological experiences			
	Bears (and possibly wolves) attack humans.	**Negative health effects** (injuries, death, psychological harm)	Local people, tourists	HW -
		Negative emotions (stress, fear, anger) related to attacks on humans.	Local people, tourists	HW -
	LC presence attracts local people and visitors for wildlife-related experiences.	**Positive emotions** from experiences with LC related activities (hearing wolves howl, discovering tracks, hunting) and a sense of awe toward wild nature with LCs.	Local people, tourists	HW +
		Health benefits when people engage in LC related recreational activities (hiking etc.)	Local people, tourists	HW +
		Positive emotions from knowing that a LC species exists, is present in the region or is being reintroduced.	Wildlife lovers	HW +
		Commercial benefits due to income from activities directly connected to LC presence (e.g. wolf howling safaris)	Tourism operators	E +
		Commercial benefits due to income from indirectly benefiting activities in tourism or associated supply chains (e.g. food, equipment, accommodation)	Tourism sector or associated supply chains	E +
		Gain in employment directly or indirectly related to LC presence.	Employees in tourism or associated supply chains	E +
	LC presence demotivates people's engagement in certain activities.	**Negative emotions** (stress, fear) and/or less enjoyment of outdoor activities.	Local people, tourists, herders, farmers, hunters	HW -
	LC presence (esp. bears, wolves) leads to social or political conflicts.	**Social and political tension** at local or regional level, e.g. urban vs. rural, hunters/farmers vs. conservationists, old vs. young	People directly or indirectly involved in conflicts	SC -
		Public costs related to conflict resolution processes and mediation	Government authorities, tax payers	E -
		Negative emotions (stress, anger) due to direct or indirect involvement in LC related human conflicts	People involved in conflicts	HW -
		Social cohesion due to opportunities for discussion, mutual understanding, and collaboration among stakeholder groups.	Local communities	SC +
	17 – Supporting identities			
	LC can be part of people's local/ regional /national identity.	**Positive emotions** connected to identification with local history, stories, cultural heritage	Local people, general public	HW +
		Social cohesion due to common identity, including joint use of local symbols, stories, narratives	Communities	SC +
		Commercial income from the use of LC-related images or symbols in regional marketing or for promoting regional products.	Local economy	E +
	LC are part of people's religious or spiritual identity.	**Positive emotions** from religious or spiritual experiences.	General public	HW +
		Social cohesion within religious or spiritual communities.	General public	SC +

[1]Categories: **E**conomic, **H**ealth & **W**ell-being, **S**ocial & **C**ultural. [2]Direction of impact: negative (-), positive (+)

Table 2. Overview of categories of socio-economic impacts

No	Impact category	This impact covers/is due to…
1.	**Economic impacts**	
Negative impacts		
1.1	Costs of LC management	• Commercial costs and losses due to livestock protection measures (fencing, guard dogs, patrolling, etc.), including opportunity costs of time spent • Public costs related to livestock protection measures, wildlife infrastructure (e.g. green bridges), etc. • Public costs related to conflict resolution processes and mediation
1.2	Costs and losses from livestock damage	• Private costs and losses from death of domesticated animals due to livestock attacks. • Public costs related to compensation schemes and administration • Opportunity costs of time spent on management of damages. • Death of domesticated animals (including dogs) due to disease transmitted by LC.
1.3	Costs and losses from crop damage	• Private or public costs or losses when plantations or beehives are destroyed by bears. • Damage to trees on private or public land scratched by bears.
1.4	Costs from equipment damage	• Private or public costs and losses from damage to staples, fences, etc. by bears or wolves. • Costs of vehicles damaged by collisions with LC.
1.5	Costs and losses related to game hunting	• Private losses in game and income for hunters due to fewer ungulates. • Less income for private and public land owners when the land leases for hunting are reduced due to fewer ungulates.
1.6	Loss of employment	• Loss of employment in farming and herding due to wolf or wolverine attacks. • Loss of employment in apiculture due to bear damages.
Positive impacts		
1.7	Benefits from tourism and other LC related commercial activities	• Commercial income from inspirational and educational activities (books, films, LC information centers, etc.) • Commercial income from activities directly connected to LC presence (wolf howling safaris, nature walks, souvenirs, etc.) • Commercial income from activities indirectly benefiting from LC presence (hotels, restaurants, etc.)
1.8	Benefits from LC hunting	• Commercial income from hunting tourism. • Public income through sales of licenses.
1.9	Benefits from game population control	• Private or public benefits due to fewer damage to trees and crops by reduced ungulate population. • Private or public benefits when LC contribute to disease control of ungulate populations.
1.10	Benefits from regional/product marketing	• Private and public income from the use of LC-related images or symbols in regional marketing or for promoting regional products.
1.11	Gain in employment	• Gains in employment related to inspirational and educational activities (books, films, LC information centers, etc.) • Gains in employment related to scientific research on LC. • Gain in employment directly or indirectly related to LC presence (nature tourism, LC information centers, etc.)

2. Health & well-being impacts		
Negative impacts		
2.1	Negative health effects	• Injuries, death, or psychological harm due to LC attacks on humans. • Health effects of psychological stress due to livestock attacks. • Injuries, death or psychological harm due to car collisions with LC.
2.2	Negative emotions related to LC presence and interactions	• Negative emotions (sadness, anger, stress, fear) from death of livestock and guard dogs, due to attacks or transmitted disease. • Negative emotions (stress, fear, anger) related to presence of LC attacks on humans. • Negative emotions (fear, less pleasure) when people refrain from outdoor activities due to LC presence. • Negative emotions (stress, anger) due to LC related human conflicts
Positive impacts		
2.3	Health benefits	• Health benefits due to fewer injuries/deaths from deer or moose-related car accidents. • Health benefits when people engage in LC related recreational activities.
2.4	Positive emotions related to LC presence and interactions	• Positive emotions from knowing that a LC species exists, is present in the region or is being reintroduced. • Positive emotions from experiences with LC related activities and a sense of awe toward wild nature with LCs. • Positive emotions connected to identification with local history, stories, cultural heritage. • Positive emotions from LC related religious or spiritual experiences. • Positive emotions from inspiration, e.g. for stories and celebrations.
3. Social & cultural impacts		
Negative impacts		
3.1	Social and political tension	• Social and political tension due to LC related conflicts at local or regional level, e.g. urban vs. rural, hunters/farmers vs. conservationists, old vs. young.
Positive impacts		
3.2	Cultural heritage and identity	• Contribution to people's sense of place, belonging, and connectedness through the use of local symbols, stories, narratives in local and regional culture or within spiritual or religious communities
3.3	Educational and research benefits	• Educational and research benefits from learning about LC and understanding nature.
3.4	Social cohesion	• Social cohesion due to opportunities for discussion, mutual understanding, and collaboration among stakeholder groups (for instance when management has to be decided or even when conflicts become resolved) • Social cohesion due to common identity, including joint use of local symbols, stories, narratives (also within spiritual or religious communities)

608

609 *Table 3 - Search terms used to build search commands using Boolean operators*

1st level terms	**2nd level terms**	**3rd level terms**	**exemplary search command**
carnivore predator bear wolf wolverine lynx	assessment impact analysis consequences effects conflict damage monitoring	socio-economic social economic benefit cost perception attitude psychological “ecosystem services"	TI=((carnivore OR predator OR bear OR wolf OR wolverine OR Lynx) AND (assessment OR impact OR analysis OR consequences OR effects OR conflict OR damage OR monitoring) AND (socio-economic OR social OR economic OR benefit OR costs OR perception OR attitude OR psychological OR "ecosystem services"))

610

611

612 *Table 4 – Comparison of relative frequencies between European and North-American studies*
613 *regarding species, impact categories, and study characteristics*

	Europe (n=44)	**North-America (n=33)**
Species	(1.86 per article)	(1.27 per article)
wolves	86.4%	72.7%
bears	47.7%	39.4%
lynxes	31.8%	9.1%
wolverines	20.5%	6.1%
Impact categories		
Economic	**75.0%**	**90.9%**
negative	75.0%	84.8%
positive	22.7%	24.2%
Health & well-being	**54.5%**	**27.3%**
negative	40.9%	15.2%
positive	31.8%	15.2%
Social & cultural	**45.5%**	**42.4%**
negative	43.2%	27.3%
positive	9.1%	21.2%
overall negative	93.2%	97.0%
overall positive	47.7%	45.5%
Study characteristics		
qualitative	43.2%	45.5%
quantitative	68.2%	72.7%
ex-ante	34.1%	24.2%
ex-post	72.7%	81.8%

614

Table 5 – Frequencies with which academic articles address the impact categories The first number in each cell is the frequency in absolute terms of articles that assess a particular impact category for a specific species. The table presents in brackets the corresponding relative frequency with respect to all articles dealing with the species (e.g. 17 out of 38 articles on wolves assess the costs of LC management = 44.7%). The right-hand column presents the frequencies of articles presenting a particular impact category for one or more of the four species. Note that this is not necessarily the sum of the frequencies for the four species, since articles may cover the same impact category for several species. Similarly, the cumulative numbers of higher-level categories within each column (for instance economic impacts for wolves) are not necessarily the sums of the sub-categories, since many articles address several sub-categories.

No.	Impact category	Wolf (38 articles)	Bear (21 articles)	Lynx (14 articles)	Wolverine (9 articles)	all species (44 articles)
1. Economic impacts		**27** (71.1%)	**16** (76.2%)	**9** (64.3%)	**4** (44.4%)	**33** (75.0%)
Negative impacts		**27** (71.1%)	**16** (76.2%)	**9** (64.3%)	**4** (44.4%)	**33** (75.0%)
1.1	Costs of LC management	**17** (44.7%)	**8** (38.1%)	**4** (28.6%)	**2** (22.2%)	**20** (45.5%)
1.2	Livestock damage	**20** (52.6%)	**11** (52.4%)	**7** (50%)	**4** (44.4%)	**23** (52.3%)
1.3	Crop damage	**0**	**1** (4.8%)	**0**	**0**	**1** (2.3%)
1.4	Equipment damage	**1** (2.6%)	**2** (9.5%)	**1** (7.1%)	**0**	**3** (6.8%)
1.5	Losses from game hunting	**5** (13.2%)	**1** (4.8%)	**1** (7.1%)	**0**	**6** (13.6%)
1.6	Loss of employment	**1** (2.6%)	**0**	**0**	**0**	**1** (2.3%)
Positive impacts		**8** (21.1%)	**4** (19.0%)	**1** (7.1%)	**0**	**10** (22.7%)
1.7	Benefits from tourism and commercial activities	**4** (10.5%)	**1** (4.8%)	**0**	**0**	**4** (9.1%)
1.8	Benefits from LC hunting	**0**	**2** (9.5%)	**0**	**0**	**2** (4.5%)
1.9	Benefits from game population control	**5** (13.2%)	**1** (4.8%)	**1** (7.1%)	**0**	**5** (11.4%)
1.10	Regional and product marketing	**0**	**0**	**0**	**0**	**0**
1.11	Gain in employment	**1** (2.6%)	**0**	**0**	**0**	**1** (2.3%)
2. Health & well-being impacts		**21** (55.3%)	**12** (57.1%)	**9** (64.3%)	**6** (66.7%)	**24** (54.5%)
Negative impacts		**16** (42.1%)	**9** (42.9%)	**7** (50.0%)	**4** (44.4%)	**18** (40.9%)
2.1	Negative health effects	**4** (10.5%)	**4** (19%)	**3** (21.4%)	**1** (11.1%)	**6** (13.6%)
2.2	Negative emotions	**14** (36.8%)	**7** (33.3%)	**5** (35.7%)	**4** (44.4%)	**15** (34.1%)
Positive impacts		**12** (31.6%)	**6** (28.6%)	**3** (21.4%)	**3** (33.3%)	**14** (31.8%)
2.3	Health benefits	**0**	**0**	**0**	**0**	**0**
2.4	Positive emotions	**12** (31.6%)	**6** (28.6%)	**3** (21.4%)	**3** (33.3%)	**14** (31.8%)
3. Social & cultural impacts		**20** (52.6%)	**6** (28.6%)	**6** (42.9%)	**6** (66.7%)	**20** (45.5%)
Negative impacts		**19** (50.0%)	**6** (28.6%)	**6** (42.9%)	**6** (66.7%)	**19** (43.2%)
3.1	Social and political tensions	**19** (50%)	**6** (28.6%)	**6** (42.9%)	**6** (66.7%)	**19** (43.2%)
Positive impacts		**4** (10.5%)	**1** (4.8%)	**1** (7.1%)	**1** (11.0%)	**4** (9.1%)
3.2	Cultural heritage and identity	**2** (5.3%)	**1** (4.8%)	**1** (7.1%)	**1** (11.1%)	**2** (4.5%)
3.3	Education and research	**0**	**0**	**0**	**0**	**0**
3.4	Social cohesion	**2** (5.3%)	**0**	**0**	**0**	**2** (4.5%)

Table 6 – Regions and species for which EU LIFE project partners provided impact ratings

Regions	
Tyrol, Austria	Wolf
Croatia	Bear
Alpine regions, France	Wolf
Brandenburg, Germany	Wolf
Mainland, Greece	Wolf, bear
North Hungarian Mountains	Wolf
Northern Piemonte, Italy	Wolf
Wolf Management Zone, Norway	Wolf
Lubusz and Westernpomerania, Poland	Wolf
Duero River, Portugal	Wolf
Apuseni Mountains, Romania	Bear
Reindeer Herding Area, Scandinavia	Wolverine
Western Carpathians, Slovakia	Wolf, bear, lynx
Castilla y León, Spain	Wolf
Ukrainian Carpathians	Wolf, bear

628

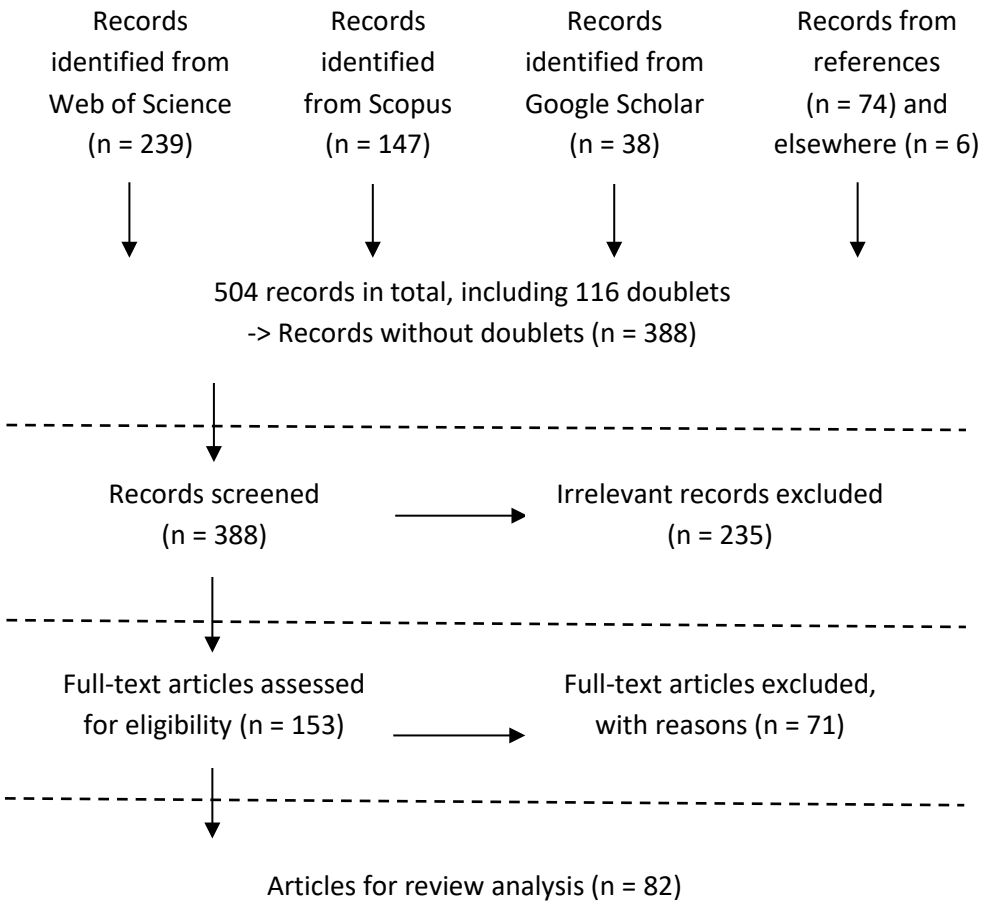
629 *Table 7 – Mean ratings with standard deviation (in brackets) for the four LC species*

No.	Impact category	Wolf (n = 12)	Bear (n = 4)	Lynx (n = 1)	Wolverine (n = 1)
1. Economic impacts					
Negative impacts					
1.1	Costs of LC management	**3.3** (1.4)	**3.5** (1.5)	**2**	**4**
1.2	Livestock damage	**4.1** (1.3)	**4.3** (0.7)	**1**	**5**
1.3	Crop damage	**0.3** (0.5)	**3.3** (1.3)	**0**	**0**
1.4	Equipment damage	**0.7** (0.6)	**2.3** (1.0)	**1**	**0**
1.5	Losses from game hunting	**1.8** (1.4)	**2.0** (1.1)	**0**	**0**
1.6	Loss of employment	**1.7** (0.8)	**1.8** (1.2)	**0**	**0**
Positive impacts					
1.7	Benefits from tourism and commercial activities	**2.0** (1.0)	**3.0** (1.9)	**3**	**4**
1.8	Benefits from LC hunting	--	--	--	--
1.9	Benefits from game population control	**2.3** (1.3)	**2.3** (0.7)	**1**	**0**
1.10	Regional and product marketing	**1.3** (0.9)	**2.8** (1.2)	**1**	**3**
1.11	Gain in employment	**1.7** (1.1)	**2.5** (1.0)	**0**	**3**
2. Health & well-being impacts					
Negative impacts					
2.1	Negative health effects	**0.3** (0.6)	**2.8** (1.3)	**0**	**0**
2.2	Negative emotions	**1.8** (1.4)	**2.3** (1.2)	**0**	**0**
Positive impacts					
2.3	Health benefits	**0.5** (0.6)	**1.5** (1.5)	**2**	**0**
2.4	Positive emotions	**2.4** (1.3)	**2.3** (1.2)	**2**	**0**
3. Social & cultural impacts					
Negative impacts					
3.1	Social and political tensions	**3.8** (1.2)	**3.8** (1.0)	**0**	**5**
Positive impacts					
3.2	Cultural heritage and identity	**1.8** (1.4)	**2.3** (1.3)	**1**	**0**
3.3	Education and research	**3.3** (1.3)	**3.8** (1.2)	**5**	**3**
3.4	Social cohesion	**1.5** (1.3)	**2.5** (1.3)	**3**	**0**

630

631

632 *Figure 1 – Review flowchart (adapted from Moher et al. 2009)*



633

634

Figure 2 – Comparison, for wolves, between the relative frequency with which the impact categories are dealt with in the academic literature (grey boxes) and the average relevance scores from the survey (black bars)