Mainstreaming human and large carnivore coexistence through institutional collaboration

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Mainstreaming coexistence of humans and large carnivores in human-dominated landscapes requires cross-sectoral, institutional collaboration.

Abstract

Achieving human-large carnivore coexistence in Human Dominated Landscapes (HDL) is a key challenge for societies globally. This challenge cannot be adequately met with the current sectoral approaches of HDL governance and an academic sector largely dominated by disciplinary silos. In this essay, we urge academia (universities and other research institutions and organisations) to take a more active role in embracing societal challenges around large carnivore conservation in HDL. Drawing on key lessons from populated regions of Europe, Asia and South America with significant densities of large carnivores, we illustrate how academia can help facilitate cross-sectoral cooperation for mainstreaming human large carnivore coexistence. We propose three ways for academia to engage with human-large carnivore coexistence in HDL. First academia should better embrace the principles and

methods of sustainability sciences and create institutional spaces for the implementation of transdisciplinary curricula and projects. Second, researchers should reflect on the research approaches (i.e. disciplinary, interdisciplinary or transdisciplinary) they apply, and how their outcomes could aid leveraging institutional transformations for mainstreaming human-large carnivore coexistence. Third, researchers should engage with various institutions and stakeholder groups for creating novel institutional structures which can respond to the multiple challenges of HDL management, as well as human-large carnivore coexistence. Success in mainstreaming human-large carnivore coexistence in HDL will rest on our collective ability to think and act cooperatively. Such a conservation achievement, if realized, stands to have far reaching benefits for people and biodiversity alike.

Introduction

Human-Dominated Landscapes (HDL) occur across 75% of Earth's terrestrial land surface (Venter et al. 2016). The conservation of large carnivores in HDL represents a prominent societal challenge for three key reasons. First, large carnivores have vital ecological functions, important economic impacts, and are associated with a range of cultural values (Ritchie et al. 2012; Kuijper et al. 2016). Second, large carnivores commonly have wide-ranging distributions (being comparable to humans, Sanderson et al. 2002), may kill or injure people and livestock (Eeden et al. 2017), or can be subjected to conflictual values, interests and management visions (Dickman et al. 2013, Jacobsen and Linnell 2016, Lute et al. 2018). Lastly, the conservation of large carnivores must be addressed within the context of several other societal challenges imposed by global change, including adaptation to climate change, food and water security, equity of resource management, increasing demand for land, conserving biodiversity, and rising human consumption (Fischer et al. 2012; Fazey et al. 2018).

Given the inherent complexities in achieving coexistence between large carnivores and people in HDL, mainstreaming approaches are needed. We use the term mainstreaming to refer to the process of integrating research and management of large carnivores across all sectoral institutions relevant to HDL governance (adapted from the 'biodiversity mainstreaming' of Huntley and Redford 2014). We refer to formal and informal institutions as 'prescriptions that humans use to organize all forms of repetitive and structured interactions including those within families, neighborhoods, markets, firms, sports leagues, churches, private associations, and governments at all scales' (Ostrom 2005). In order to effectively address human-large carnivore coexistence, institutions should reconsider the social role of large carnivores and their place in HDL (Bao et al. 2017), rethink their paradigms, redesign institutional structures to include cross sectoral partnerships that support novel and more equitable resource management options (e.g. Bodin 2017), and foster the establishment of new, genuine links between human society, the environment, and large carnivores (Abson et al. 2017).

Central in achieving coexistence between humans and carnivores is recognition among conservation scientists about the need to embrace social sciences in order to better understand the human dimensions of the conservation of biodiversity (Bennett et al. 2017, Madden and McQuinn 2014). Recent studies have focused on the importance of individual, sociocultural, governance, as well as the legislative and collaborative approaches in efforts to achieve coexistence (Dickman et al. 2013. Redpath et al. 2017, Hovardas 2018, Madden and McQuinn 2014). However, based on a review of articles indexed by the Web of Science (January 2019), we identified that transdisciplinary approaches are still currently rare in the large carnivore academic literature, while other aspects such as leadership and institutions are poorly represented relative to other dimensions of large carnivore research (Figure 1).

While it is widely recognized that academia should have a key role in triggering and guiding societal transformations towards sustainability (Fischer et al. 2012, Fischer et al., 2015), traditional disciplinary and interdisciplinary approaches have limited capacity to address and offer solutions to socially relevant questions in an increasingly complex and uncertain world (Fazey et al. 2018). Sustainability science has the potential to help address the above mentioned complex social and environmental challenges because it is a problem- and solution oriented field (Kates et al. 2001, Clark and Dickson 2003). Transdisciplinary approaches represent the cornerstone of sustainability science (Lang et al. 2012). Transdisciplinarity results from the integration of knowledge from science and society, and the co-production of actionable knowledge in order to address real world problems (Scholz et al. 2006, Lang et al. 2012).

The consideration of leverage points – a hierarchy of system levels which have different potentials to leverage transformational changes in the system (Meadows 1999) – has great application in the context of human-large carnivore coexistence research (Table 1). Such a systems perspective allows a simultaneous understanding of the system level mechanisms resulting in a given situation (i.e. human-large carnivore conflicts), as well as the human intent that can potentially shape the future of the system (Abson et al. 2017, Fischer and Riechers 2019).

The central goal of our essay is to advance human-large carnivore coexistence research and practice by arguing that academia (universities and other research-focused institutions and organizations) can and should engage in facilitating and fostering institutional arrangements that are favorable for human large carnivore coexistence in HDL. While our focus here is on large carnivores, the need to better align institutions is a common requirement across most

contentious and vexing biodiversity conservation issues (e.g. conservation of migratory species, invasive species management).

Our objectives are threefold:

(i) To provide a brief overview of the conventional institutional approaches to managing large carnivores and achieving human-large carnivore coexistence in HDL.

(ii) To present real-world examples of the institutional challenges associated with attempting to mainstream human-large carnivore coexistence. We do this using three case studies from HDL in Europe, Asia, and South America, all of which have significant densities of large carnivores.

(iii) Using (ii), present the key, broader lessons that emerge for academic institutions wanting to increase their capacity to foster institutional collaboration and mainstream human-large carnivore coexistence in HDL.

Conventional approaches to achieving human-large carnivore coexistence in HDL

Conventionally, institutional approaches to the management of HDL have been strictly sectoral: each broad land-use or activity is understood, managed or implemented according to the different values, strategies and paradigms of a specific institution. For example, production forests were primarily managed to maximize the quantity and quality of timber produced (e.g. in Europe (McGrath et al. 2015)). Only recently has forest biodiversity conservation in these production landscapes become a priority due to concerns regarding habitat loss and increasing numbers of threatened species (e.g. in South Asia, Sodhi et al.

2010). Similarly, croplands and grasslands are managed primarily for farming or livestock production, while structural components not *directly* relevant for agricultural production (i.e. trees, wetlands) were largely neglected by agricultural policies (see e.g. the European Union`s Common Agricultural Policy (Beaufoy et al. 2015)). The approach of academia to the management of HDL is also largely sectoral, either through teaching and training (e.g. in agronomy, forestry, biology, wildlife management, ecology, nature conservation) or implementation of uni-disciplinary research programs to understand the various aspects of HDL. This sectoral approach to managing and understanding HDL implies these landscapes and/or their components (e.g. species) are 'compartmentalized' based on their uses, with management decisions being made by private and public bodies with different, but not necessarily compatible and complementary objectives or shared goals. Conflicts and mismatches between various institutions managing HDL often exist because of the differences in priorities and paradigms underlying their actions and policies (i.e. deep leverage points, Abson et al. 2017). A notable case of conflict and lack of genuine collaboration between different sectors is represented by the tensions between agriculture, forestry, nature conservation, and urban development sectors in many parts of the world (Scheele et al. 2018). Furthermore, some institutions operating in HDL have limited interest in carnivore conservation, while others are even hostile to carnivore conservation. This compartmentalized and often conflicted institutional environment of HDL governance is poorly suited for effective conservation of biodiversity and the maintenance of HDL with high natural and cultural values (Hossu et al. 2017).

We illustrate the need for a better understanding of the underlying institutional factors and mechanisms for managing human-wildlife coexistence with three case studies from HDL

with large carnivore populations and human large carnivore conflicts: Romania, India, and Brazil.

Human-large carnivore conflict remains high in Romania after a recent hunting ban

Recent events in Romania illustrate how failure to engage all stakeholders around large carnivore management and conservation in HDL can lead to reactive policy decisions and fuel conflict. In 2016, hunting of brown bears (Romania harbors the largest number of brown bears in the European Union; some ~6000 individuals, Zedrosser et al. 2001), as well as other large carnivores (lynx, wolf) was banned by the Ministry of Environment in part due to weak scientific basis for setting bear quotas (Popescu et al. 2016), the perceived influence of certain economic interests in determining annual cull quotas (i.e. trophy hunting in the case of bears), and intense public campaigns seeking a ban on hunting of protected large carnivores (electronic source, WWF: https://tinyurl.com/y8ytr7qv). As this policy change was implemented without due consideration of other measures to prevent human-large carnivore conflict and efficient compensation, some stakeholders responded by successfully requesting that the Government reinstate hunting. Subsequently, the Romanian Academy approved the removal of 140 bears and 97 wolves for public safety and prevention of further conflict (Romanian Academy 2017), which roughly represents 50% of the previous annual cull quotas. The Ministry of Environment then endorsed a new brown bear conservation action plan clearing the way for higher cull quotas (Ministry of Environment 2018).

In parallel and in sharp contrast to the national approach, at a local scale, the Council of Harghita county, in collaboration with the Association Pogány havas, initiated the *Working Group for the Sustainable Management of the Cultural Landscapes* in response to human-

bear conflicts, as well as to embrace a holistic, social-ecological perspective on managing the outstanding natural and cultural values of the area's rural landscapes. To achieve its goals, the Working Group was founded by representatives of every major institution responsible for the management of HDL and large carnivores, including civil society, academia, wildlife management, hunting, forestry, environmental protection, tourism, rural development, agriculture, and media. The meetings of the Working Group allow media access in order to provide open, factual information for the general public, as well as to raise public awareness of issues related with large carnivore conservation and management. While the Working Group realizes that harmonizing human-large carnivore coexistence without genuine governmental support and financial investment will be difficult, it also recognizes that pro-active steps to tackle this issue are paramount for success at the community level.

Relocating carnivores generates new conflict in India

In India, the world's second most populous country, large carnivores such as tigers, leopards, wolves, and bears (brown, black and sloth) continue to share space with an ever-increasing human population. Religious and cultural norms have usually been cited as a reason for generally low levels of human-large carnivore conflict (given the potential encounter rates). Nevertheless, mitigating human-large carnivore conflicts is a major concern, especially given the loss of human lives, as well as loss of livestock. In most cases, the main strategy of managing conflicts has been the relocation of 'problem' individuals from HDL into regions which are perceived as more natural and suitable for large carnivores (Athreya et al. 2011). In one well-documented example, leopards were trapped from a HDL and relocated to more 'natural' forested habitats, in the mistaken belief that they had 'strayed' from these forested areas, and that non-lethal removal represented a win-win situation for both animals and

people (Athreya et al. 2011). This resulted in a spike in human casualties at the site of the release, as well as in other areas that previously had low rates of human-large carnivore conflicts (Athreya et al. 2011). Thus, a poorly designed management solution, which ignored the relevant stakeholders and institutions created a new set of tragic problems and challenges for human-large carnivore coexistence.

In contrast, the coming together of various institutions to educate, sensitize and pre-empt the occurrence of leopard conflicts in one of the world's most populous cities, Mumbai, is an excellent example of inter-institution cooperation. Leopards in Mumbai's Sanjay Gandhi National Park occur amidst the highest human densities in the world, and conflict has emerged from time to time (Landy et al. 2018; Athreya et al. 2016). However, state wildlife authorities, non-government organizations, researchers, city officials and the news media worked together with the public in generating awareness, changing attitudes, and quickly responding to conflict-creating situations to change the nature of human-large carnivore relationships in the city (Athreya et al. 2016; Bhatia et al. 2013). This initiative called the *Mumbaikars for SGNP* (https://sgnp.maharashtra.gov.in/1221/Living-with-Leopards), offers a useful template of inter-sectoral collaboration in managing relationships between large carnivores and humans, even in the most heavily human dominated landscapes in the world.

Stakeholders in large carnivore recovery in Brazil

Because of the typically vast spatial scales at which large carnivore populations operate, their conservation requires mainstreaming of actions into multiple sectors and consultation with many stakeholders. To illustrate the variety of actors this necessitates, we include an example of a stakeholder analysis for the case of jaguars in Brazil (modified from Bredin et al. 2015;

Bredin et al. 2018). A stakeholder analysis requires considering those that influence jaguar conservation, those that are influenced by jaguar conservation, and those that fall into both categories. Key stakeholders in this case included: (i) Cattle ranchers who are affected by predation and can potentially engage in illegal killing; (ii) Crop farmers who occupy large areas of land, which, as stipulated by Brazilian forest conservation laws, require maintaining certain proportions of forest including along watercourses. These areas can provide significant habitat and corridors for jaguars and their prey. Crop farmers are also responsible for clearing primary forest habitats; (iii) Foresters and forestry management agencies that directly influence primary jaguar habitats; (iv) Fishermen who frequently come into contact with jaguars in the gallery forests that line riverbanks; (v) Tourism operators who may make a living from promoting ecotourism in general and jaguar tourism specifically; (vi) Hydropower and mining developers because their activities can destroy large areas of habitat and require road access that opens up areas of forest for clearing, development and poaching. Water management for agriculture is also a driver of habitat change and conflict distribution; (vii) Financial institutions (in Brazil and overseas) that finance major development activities; (viii) Transport agencies because roads open up areas for development, fragment habitats, and can cause significant mortality through collisions; (ix) Indigenous people who share most of the forests inhabited by jaguars; (x) The landless movement which represents the thousands of people that seek farmland of their own; (xi) Environmentalists and animal welfare groups that seek to promote wildlife conservation and a change in human-animal relationships, respectively; (xii) Law enforcement agencies that potentially enforce jaguar protection laws, forest conservation laws, and prevent cross-border smuggling of jaguar body parts for the emerging market in China. In many parts of the jaguar range in Central and South America, wildlife law enforcement is also intrinsically linked with wider security issues related to organized crime and terrorist groups, in addition to border security concerns

(Linnell et al. 2016). For each group, it is necessary to consider the public and professional constituents (i.e. the individual practitioners on the ground), their interest organizations, their technical agencies, and the government administrations that regulate them, as well as the diversity of scales at which they can be placed from local to regional, national or international. Coordinating large carnivore recovery automatically requires interacting with all these stakeholders and sectors to ensure that conflicts are minimized, and that carnivore habitat suitability and connectivity is maintained. In order to successfully interact with these, one must understand the underlying values, social and cultural contexts, economic interests, and technical, administrative and political constraints affecting each.

Lessons for fostering human-large carnivore coexistence in HDL

While our three case studies differ in certain respects due to their particular regional contexts, together they highlight that a narrow focus that ignores the diversity of key stakeholders and institutions involved in HDL management, can maintain or even amplify human-large carnivore conflict and create social tensions. These study cases also highlight that innovative institutional partnerships can rise as a reaction to a common problem (e.g. Romania, India) and that promoting cross-sectoral collaboration requires the consideration of deeper system levels (i.e. values, paradigms such as highlighted by the Brazilian study case). While acknowledging that academia is just one of the several important sectors relevant to human-large carnivore coexistence in HDL, below, we provide recommendations on how to foster cross-sectoral collaborations in order to mainstream human-large carnivore coexistence in HDL.

Create institutional capacity for transdisciplinary research within academic institutions

Achieving human-large carnivore coexistence in HDL is an archetypical example of the complex social and environmental challenges which often requires participation of non-academic and academic stakeholders to reach solutions which satisfy most key social actors. Academia can use research to engage with real world problems through the lens of disciplinary, interdisciplinary, and/or transdisciplinary approaches (Figure 2 and below). Therefore, to meet the challenge of institutional transformations towards mainstreaming human-large carnivore coexistence in HDL, academic institutions themselves should be examples for effective transformations. We see three interlinked levels at which academia can meet the transdisciplinarity challenge. First, sustainability science (to which 'transdisciplinarity' is indispensable) should be promoted in university curricula, ideally within specifically created units with specific visions and objectives (e.g. centers, working groups, or departments). While similar initiatives are on the rise in recent years (Fischer et al., 2015), such academic institutions are still rare and lacking in many regions of the world where significant large carnivore populations exist within HDL. Second, academic institutions should create safe operating spaces for those academics who are involved in transdisciplinary research. Transdisciplinarity requires genuine engagement with non-academic actors, and this typically requires constant preparation and presence in order to monitor the process of engagement. Unplanned emergencies which require reactive and quick mobilization of the researcher (at the level of knowledge, emotions and physically) can be common, especially within conflict laden institutional, social and environmental contexts. Examples of such activities can be mass media interventions to clarify various aspects of human-large carnivore coexistence, meeting the various demands of stakeholders and society, and conflict resolution. Third, incentives and reward systems should be developed for

scientists implementing transdisciplinary sciences. Research incentives and quality indicators for researchers should account for the obstacles and challenges imposed by real world complexity for transdisciplinary researchers so that their dedication and efforts to advance sustainability are fully recognized by academia (Sharachchandra and Norgaard 2005). A narrow evaluation of researcher impact (i.e. based on papers published in 'high impact factor' journals) should be relaxed and complemented with other quality indicators such as workshops, policy briefs, policy seminars or other types of community engagement activities.

Consider research approaches and system leverage points to assess the significance of research results

When setting research goals to advance human-large carnivore coexistence in HDL, we suggest reflecting on two key interlinked realms: First, decide on the research approach (i.e. disciplinary-interdisciplinary or transdisciplinary) employed to address human-large carnivore coexistence (Figure 2). Second, consider a systems perspective for how research results could leverage change towards harmonizing human-large carnivore coexistence (Figure 2, Table 1). Disciplinary and interdisciplinary approaches can provide important knowledge for understanding several aspects and challenges of human-large carnivore coexistence (see column 1 in Figure 2), but may have limited power to leverage the deeper system changes needed to mainstream coexistence (column 4, Figure 2, Table 1). For example, the disciplines of ecology, geography and statistical modeling can yield robust results on the population dynamics of large carnivores (Popescu et al. 2016), but these results may be perceived with skepticism by other sectors (such as wildlife management, as happened in Romania, T. Hartel, L. Rozylowicz, *personal observation*). Furthermore, social sciences can help in understanding the various types of stakeholders, their interests, values

and the relationships between them (e.g. Jacobsen and Linnell 2016, as well as the Brazilian case study above). However, on their own, these research approaches and results have limited 'power' to leverage those mechanisms which may ultimately bring stakeholders together to form a common vision (deep leverage points, Figure 2, Table 1). Transdisciplinary approaches can complement the limitations of disciplinary approaches because they are built on strong cooperation with real world non-academic actors in co-designing the research project, co-producing knowledge and co-creating solutions (Figure 2). By incorporating the intent (i.e. norms, values and goals embodied in the system and the paradigms underpinning them, Abson et al. 2017, Table 1), transdisciplinary approaches can address deep leverage points which, although they require more time to provide tangible real world changes, also offer more robust grounds for sustainability transformations and their long-term viability. For example, participatory scenario planning can incorporate diverse quantitative and qualitative information, as well as various perspectives, values and goals into the decision making process in a systemic way (Peterson et al. 2003). Co-produced scenarios can represent a shared understanding and provide a common base for discussions and negotiations about the future of carnivores in HDL (Hovardas 2018). Participatory scenario planning can therefore simultaneously address several system levels, including deep and shallow leverage points (Table 1, Figure 2).

The importance of transdisciplinary approaches for 'jointly experimenting transformation' (Schäpke et al. 2018) for sustainability is increasingly recognized. Researchers can be inspired by a diversity of transdisciplinary approaches including 'real world laboratories', '(sustainable) living labs', '(urban) transition labs' and 'transformation labs' (synthetized in Schäpke et al. 2018a,b). Considering the complex and context dependent nature of social-

environmental systems, it is very likely that there will be no universally applicable human-large carnivore coexistence success stories.

Be present in- or contribute to the development of cross-sectoral collaborative institutional structures

The value of collaborative governance structures for addressing regional and local challenges of human-large carnivore coexistence (Redpath et al. 2017), as well as for managing protected areas (Rozylowicz et al. 2017) was recently highlighted. Novel institutions can emerge from the initiatives of one or more institutions. While academia does not always have a direct and facilitative role in their formation, it can contribute to their functioning through training, knowledge sharing, critical thinking and analytical skills, innovation and monitoring (e.g. Nita et al. 2016, Rozylowicz et al. 2017). One form of cross-sectoral governance structure which can represent a promising way to address human-large carnivore coexistence is the community of practice (CofP) (Watkins et al. 2018). CofP represents structured interaction spaces for representatives of different stakeholders and sectors in order to facilitate knowledge flow, learning, sharing skills and experiences, and ultimately contribute to innovative solutions for complex societal problems (Wenger-Trayner and Wenger-Trayner 2015). As shown by the Romanian and Indian study cases, CofP-like governance structures can emerge to respond to the limited capacity or desire of government to address local and regional issues related to the management of large human-large carnivore conflicts. The emergence of novel institutional structures to facilitate human-large carnivore coexistence have been reported for example from Norway, Sweden, Finland, and the USA (Kretser et al. 2014, Redpath et al. 2017). Several community initiatives to facilitate human-large carnivore coexistence could represent 'seeds of a good Anthropocene' (*sensu* Bennett et al. 2016). A

prominent example in this respect is the initiative 'get Bear Smart society' which brings together success stories related to the coexistence of humans and bears across North-America, which could represent sources of inspiration for other regions (http://www.bearsmart.com/managing-communities/success-stories/). Within the European Union, the European Commission established in 2014 the 'EU Platform on Coexistence between People and Large Carnivores', which aims, amongst others, to identify good practices in the management of large carnivores in European regions. Hovardas and Marsden (2018) highlight ten good practice cases collected within the above mentioned EU Platform, which included awareness raising, innovative financing, and involving stakeholders in monitoring and bridging various stakeholder groups. While the formation and functioning of such cross-sectoral platforms are not free of conflicts and challenges (Redpath et al. 2017), they represent optimistic examples regarding multiple sectors embracing a common problem and engage in commonly shared solutions and therefore they address deeper leverage points (Table 1), while searching for sustainable solutions to human-bear coexistence.

Conclusions

There is an urgent need to align key stakeholders and sectors with responsibilities for HDL and large carnivore management in order to mainstream human-large carnivore coexistence. Spatial planning (e.g. the establishment of protected areas, buffer zones, and ecological corridors) is a powerful tool for safeguarding biodiversity values all over the world. However, safeguarding large carnivores in HDL generally requires consideration of land both within and outside of protected areas. We recognize that such mainstreaming is a major challenge for institutions and society, and argue that academia needs to take a more proactive, ambitious role in efforts to mainstream human-large carnivore coexistence in HDL. Urgent

steps are needed at the following levels: (i) to embrace the principles and methods of sustainability sciences, and create institutional spaces for the implementation of transdisciplinary projects, (ii) for researchers to reflect on the research approaches adopted and how research can leverage institutional transformations for mainstreaming human-large carnivore coexistence in HDL, and (iii) for researchers to engage with various institutions and stakeholder groups for creating novel institutional structures which can respond to the multiple challenges of human-large carnivore coexistence. Realizing complex conservation goals like human-large carnivore coexistence stands to have far reaching benefits for people and biodiversity alike.

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FIGURE CAPTIONS

Figure 1. Numbers of scientific articles for various search terms in the Web of Science Core Collection (for the period 1975-2018). We searched 'large carnivore' AND '…', where '…' represents various knowledge dimensions related to large carnivores, such as conservation, human, management and others (accessed on 19th of January 2019).

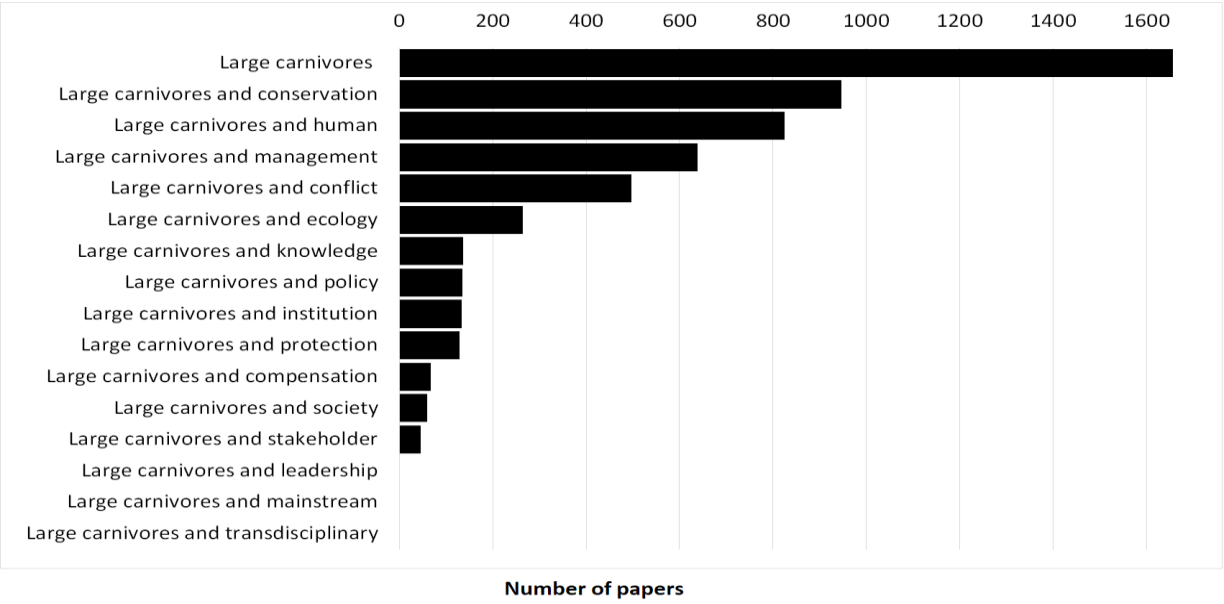

Figure 2. Schematic representation of the research target, research approaches, and possible ways results could advance human-large carnivore coexistence in HDL. While some aspects of human-large carnivore interactions can be approached by disciplinary and interdisciplinary approaches, other aspects need to be approached through the lens of transdisciplinarity. Key differences between the two approaches for mainstreaming human-large carnivore coexistence are the nature of how solutions emerge. In disciplinary and interdisciplinary approaches they are proposed (targeting 'shallow' leverage points'), while they are co-created (targeting 'deep leverage points') through a transdisciplinarity approach. Nevertheless, interactions between different leverage levels can facilitate broader, system level transformations towards mainstreaming human-large carnivore coexistence in HDL.

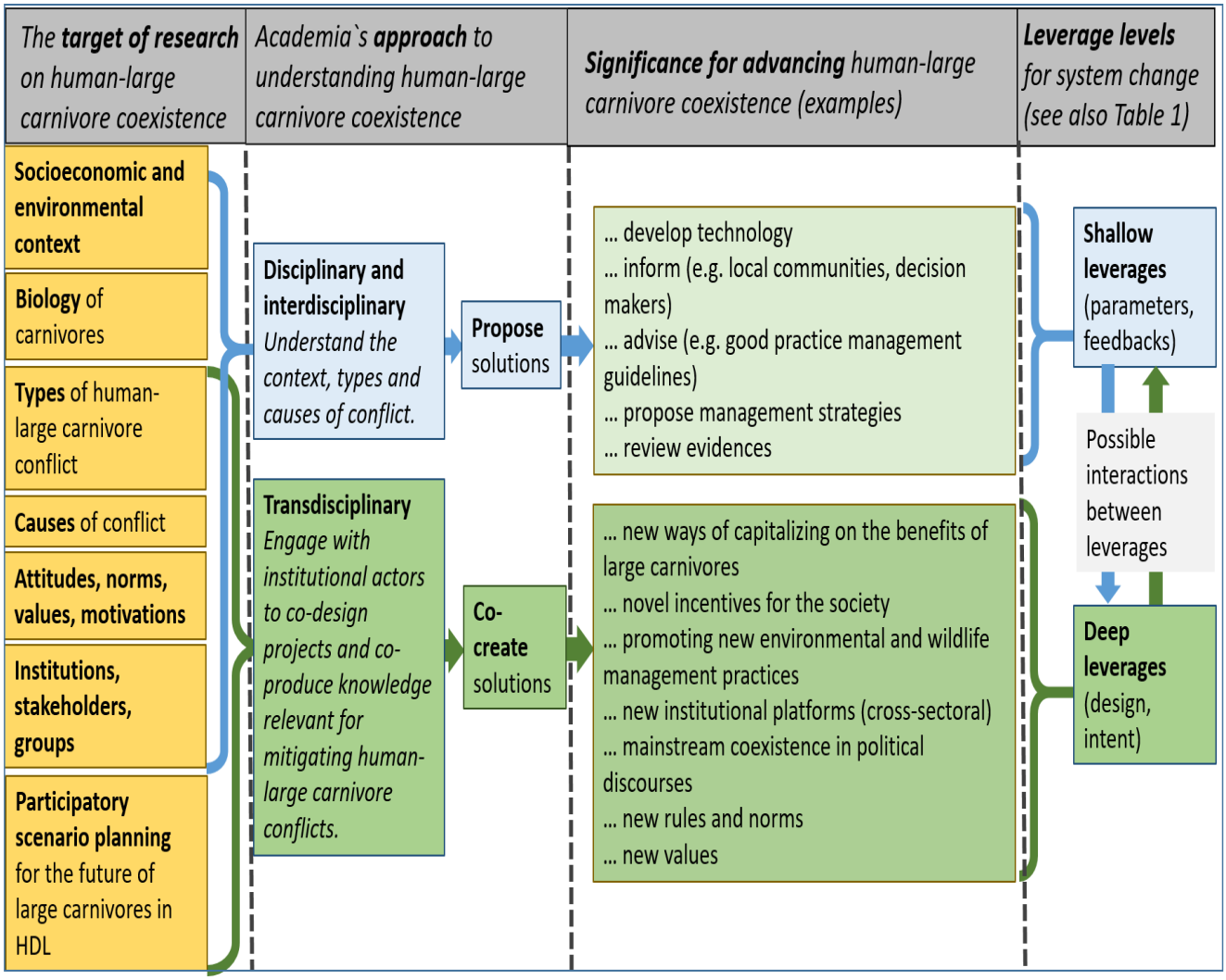

TABLE CAPTION

Table 1. System characteristics and leverage points within which interventions can be made in a system in order to mainstream human-large carnivore coexistence in HDL.

Table 1.

System characteristics[1]		**Leverage points**[2]	**Examples of factors determining human large carnivore coexistence**
Shallow leverage points	Parameters (mechanistic characteristics, typically targeted by policy makers)	Constants, parameters, numbers	• Legal protection of large carnivores • Protected areas set aside for conservation • Payment schemes to compensate damage caused by large carnivores and/or to prevent further losses • Culling quotas
		Sizes of buffers and other stabilizing stocks, relative to their flows	• The population size of the target large carnivore species • The amount and diversity of interest groups around large carnivores • The degree of urbanization within the HDL • Amount of buffer zones delineated to decrease human-large carnivore encounters
		Structure of material stocks and flows and nodes of intersection	• Landscape and urban planning and protected area design in regions with large carnivores
	Feedbacks (intersection between	**Lengths of delays, relative to the rate of system**	• Delays in institutional responses to mitigate human-large carnivore conflicts, despite the fact that knowledge exists about how to achieve

	system elements which drive internal dynamics)	**changes**	it and demand for implemention • Persistence of negative attitudes towards large carnivores in the society, even when damages caused by large carnivores are substantially reduced • Persistence of tensions between institutions responsible to managing HDL • Positive or negative impacts from the (re)-establishment of a landscape of fear when carnivores are present in an HDL
		Strength of negative feedback loops	• The extent to which society can tolerate large carnivores and/or their damages • The vulnerability of the large carnivore population to human caused loss
		Gain around driving positive feedback loops	• The extent at which protecting large carnivores without compensation and prevention measures increases human-wildlife conflicts, which can induce negative perceptions of large carnivores and decreased tolerance towards them and can increase conflicts between institutions and ultimately 'communication paralysis' between stakeholders and institutions
Deep leverage points	Design (social structures and institutions that manage feedbacks and parameters)	Structure of information flows	• Existence and access to knowledge related to large carnivore biology and ecology to all relevant stakeholders and the society • Availability of knowledge about various cultural norms around large carnivores (which may influence decision making) • Transparency around knowledge generation and management interventions related to large carnivores
		Rules of the system	• The establishment of new, formal and informal rules which govern people`s activity in HDL relevant to large carnivores, which may have significant impact on peaceful coexistence
		Power to add, change, evolve, or self-organize	• The capacity of stakeholders and institutions to self-organize and create new types of institutional forms in order to mainstream human-large

		system structure	carnivore coexistence and possibly to buffer higher level policy weaknesses
	Intent (underpinning values, goals and worldviews of actors that shape the orientation of the system)	**The goals of the system**	• The goals of the central governing system (i.e. government) and funding schemes (i.e. large carnivore population and habitat management is the main goal, or mainstreaming human-large carnivore coexistence?) • The goals of various institutions relevant to HDL management where large carnivores occurs
		Mindsets and paradigms underpinning the system	• Paradigms underpinning institutions and sectors relevant to the governance of HDL and large carnivores within them. These paradigms are typically barriers for cross-sectoral collaborations and parthnerships for achieving human-large carnivore coexistence • Individual and collective values, norms, identities and socio-cultural factors related to large carnivores • Relationships between different communities, stakeholders, institutions
		Power to transcend paradigms	• The capacity to critically evaluate paradigms and even shift from them in order to gather a better, more holistic picture about the role of large carnivores in HDL and to form cross sectoral collaborations to co-produce knowledge and co-create human-large carnivore coexistence

[1] The four leverage realms were proposed by Abson et al. (2017)

[2] Leverage points as proposed by Meadows (1999)