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Essay

Mainstreaming human and large carnivore coexistence through institutional collaboration

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Abstract: *Achieving coexistence between large carnivores and humans in human-dominated landscapes (HDLs) is a key challenge for societies globally. This challenge cannot be adequately met with the current sectoral approaches to HDL governance and an academic community largely dominated by disciplinary sectors. Academia (universities and other research institutions and organizations) should take a more active role in embracing societal challenges around conservation of large carnivores in HDLs by facilitating cross-sectoral cooperation to mainstream coexistence of humans and large carnivores. Drawing on lessons from populated regions of Europe, Asia, and South America with substantial densities of large carnivores, we suggest academia should better embrace the principles and methods of sustainability sciences and create institutional spaces for the implementation of transdisciplinary curricula and projects; reflect on research approaches (i.e., disciplinary, interdisciplinary, or transdisciplinary) they apply and how their outcomes could aid leveraging institutional transformations for mainstreaming; and engage with various institutions and stakeholder groups to create novel institutional structures that can respond to multiple challenges of HDL management and human–large carnivore coexistence. Success in mainstreaming this coexistence in HDL will rest on the ability to think and act cooperatively. Such a conservation achievement, if realized, stands to have far-reaching benefits for people and biodiversity.*

Keywords: apex predator, environmental policy, human–wildlife conflict, leverage points, sustainability science, transdisciplinary, wildlife management

Incorporación de la Coexistencia entre Humanos y Carnívoros Mayores por Medio de la Colaboración Institucional

Resumen: *Un reto importante para las sociedades mundiales es lograr la coexistencia entre los carnívoros mayores y los humanos en los paisajes dominados por el hombre (HDL, en inglés). Este reto no puede enfrentarse adecuadamente con las actuales estrategias sectoriales que se usan en la gobernanza de los HDL y con una comunidad académica dominada principalmente por sectores disciplinarios. La academia (las universidades y demás instituciones y organizaciones de investigación) debería realizar un papel más activo en la aceptación de los retos sociales que rodean a la conservación de los carnívoros mayores en los HDL al facilitar la cooperación intersectorial para incorporar la coexistencia entre humanos y dichos carnívoros.*

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A partir de las lecciones aprendidas en las regiones pobladas por densidades abundantes de carnívoros mayores en América del Sur, Asia y Europa, sugerimos que la academia debería aceptar de mejor manera los principios y métodos de las ciencia de la sustentabilidad y crear espacios institucionales para la implementación de currículos y proyectos; reflexionar sobre las estrategias de investigación (es decir, disciplinaria, interdisciplinaria o transdisciplinaria) que aplican y cómo sus resultados podrían ayudar en fomentar las transformaciones institucionales para la incorporación; y participar junto a varias instituciones y grupos de accionistas para crear estructuras institucionales novedosas que puedan responder a los múltiples retos del manejo de los HDL y de la coexistencia entre humanos y carnívoros mayores. El éxito en la incorporación de esta coexistencia en los HDL dependerá de la habilidad para pensar y actuar cooperativamente. Tal logro de conservación, si se alcanza, promete tener beneficios de largo alcance para las personas y para la biodiversidad.

Palabras Clave: conflicto humano-fauna, ciencia de la sustentabilidad, manejo de fauna, política ambiental, puntos de ventaja, superdepredador, transdisciplinario

摘要: *在人类主导景观中实现人与大型食肉动物的共存, 是全世界面临的一个重要挑战。然而, 目前对人类主导景观的部门管理方法和主要由学科领域主导的学术团体尚不足以应对这一挑战。学术界 (大学及研究组织机构) 应通过促进跨部门合作, 在应对人类主导景观中大型食肉动物保护的社会挑战中发挥更积极的作用, 以实现人类与大型食肉动物共存的主流化。借鉴欧洲、亚洲和南美洲人口与大型食肉动物密集地区的经验, 我们建议学术界应进一步采取可持续发展的原则和方法, 创造制度空间以开展超学科课程和项目;思考所应用的研究方法 (单一学科、交叉学科和超学科) 及其研究成果如何帮助推动有利于主流化的机构改革;另外, 还应与各种机构和利益相关群体合作, 创造新的制度结构, 以响应人类主导景观管理和人与大型食肉动物共存的挑战。在人类主导景观中实现共存的成功与否将取决于思考和行动协作的能力。如果能够实现这样的保护成就, 将对人类和生物多样性产生深远的好处。* **【 *翻译: 胡怡思; 审校: 聂永刚* 】**

关键词: 顶级捕食者, 环境政策, 人类与野生动物冲突, 超学科, 平衡点, 可持续发展科学, 野生动物管理

Introduction

Human-dominated landscapes (HDLs) occur across 75% of Earth's terrestrial land surface (Venter et al. 2016). The conservation of large carnivores in HDLs represents a prominent societal challenge for 3 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 (comparable to humans) (Sanderson et al. 2002), may kill or injure people and livestock (van Eeden et al. 2018), and can be the subject of conflicting values, interests, and management visions (Dickman et al. 2013; Jacobsen & Linnell 2016; Lute et al. 2018). Third, 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 HDLs, approaches to address coexistence need to be mainstreamed. 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). To effectively address complex social–environmental issues, such as human–large carnivore coexistence, institutions should reconsider the social role of large carnivores and their place in HDLs (López-Bao et al. 2017), rethink their own 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 and the environment and large carnivores (Abson et al. 2016).

Central to achieving coexistence between humans and carnivores is recognition among conservation scientists of the need to embrace social sciences to better understand the human dimensions of the conservation of biodiversity (Madden & McQuinn 2014; Bennett et al. 2017). 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; Madden & McQuinn 2014; Redpath et al. 2017; Hovardas 2018). However, based on a review of articles indexed by the Web of Science (January 2019), we identified that transdisciplinary approaches are still rare in the large carnivore literature and other aspects, such as leadership and institutions, are

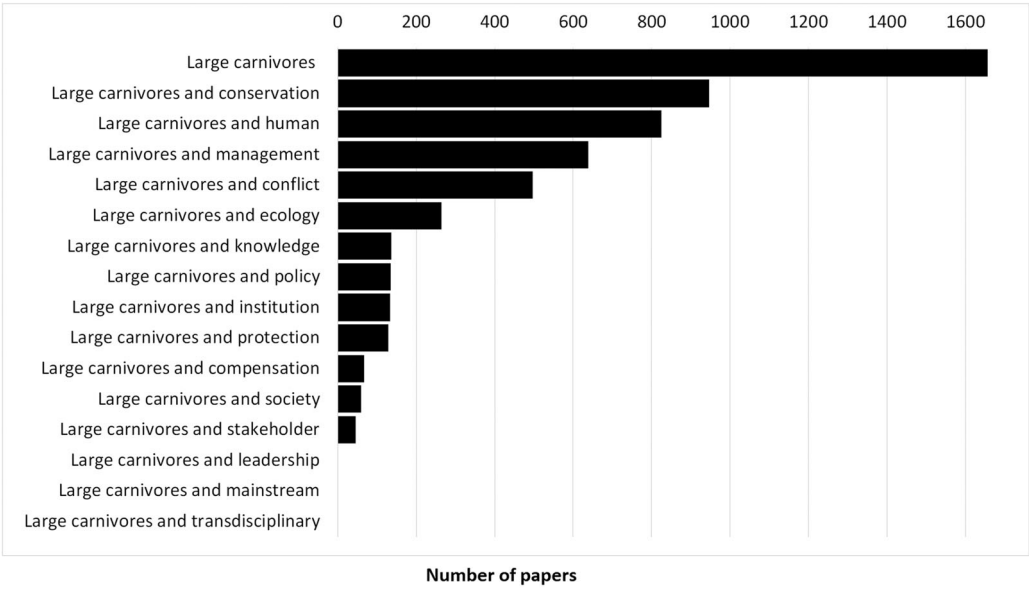

Figure 1. Number of scientific articles returned with search terms (y-axis) related to large carnivores (Web of Science Core Collection 1975–2018, accessed 19 January 2019).

poorly represented relative to other dimensions of large carnivore research (Fig. 1).

Although it is widely recognized that academia should have a key role in triggering and guiding societal transformations toward 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 2007). 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 coproduction of actionable knowledge to address real-world problems (Lang et al. 2012).

The consideration of leverage points—a hierarchy of system levels that have different potentials to leverage transformational changes in the system (Meadows 1999)—has great relevance 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 and result in improved outcomes (Abson et al. 2016; Fischer & Riechers 2019).

Our central goal was 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 favorable to human–large carnivore coexistence in HDLs. Although we focused 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).

We sought to provide a brief overview of the conventional institutional approaches to manage large carnivores and achieve human–large carnivore coexistence in HDLs; present real-world examples of the institutional challenges associated with attempting to mainstream human–large carnivore coexistence based on 3 case studies from areas where densities of large carnivores are substantial; and present key lessons that emerge for academic institutions wanting to increase their capacity to foster institutional collaboration and mainstream human–large carnivore coexistence in HDLs.

Conventional Approaches to Human–Large Carnivore Coexistence

Conventionally, institutional approaches to the management of HDLs 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

Table 1. System characteristics and leverage points within which interventions can be made in a system to mainstream human–large carnivore coexistence in human-dominated landscapes (HDLs).

Leverage realms[a]	*Leverage points*[b]	*Examples of factors determining human–large carnivore coexistence*
Parameters (mechanistic characteristics, typically targeted by policy makers)	constants, parameters, numbers	legal protection of large carnivores payment schemes to compensate damage caused by large carnivores, to prevent further losses, or both culling quotas
	sizes of buffers and other stabilizing stocks	population size of the target large carnivore species amount and diversity of interest groups around large carnivores degree of urbanization within the HDL area 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 system elements that drive internal dynamics)	length of delays relative to rate of system changes	delays in institutional responses to mitigate human–large carnivore conflicts, despite existence of knowledge of how to achieve it and demand for implementation persistence of negative attitudes toward large carnivores in the society, even when damages caused by large carnivores are substantially reduced persistence of tensions between institutions responsible for managing HDL
	strength of negative feedback loops	extent to which society will tolerate large carnivores and their damages vulnerability of large carnivore population to human-caused loss
	gain in driving positive feedback loops	point at which specific ways of protecting large carnivores contribute to human–wildlife conflicts, induce negative perceptions of large carnivores, or increase conflicts between institutions
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 society transparency around knowledge generation and management interventions related to large carnivores
	rules of the system	establishment of new formal and informal rules that govern people's activity in HDL relevant to large carnivores, which may substantially affect peaceful coexistence
	power to add, change, evolve, or self-organize system structure	capacity of stakeholders and institutions to self-organize and create new types of institutional forms to mainstream human–large carnivore coexistence and possibly to mitigate higher-level policy weaknesses
Intent (underpinning values, goals, and worldviews of actors that shape the orientation of the system)	the goals of the system	goals of central governing system (i.e., government) and funding schemes regarding large carnivore conservation management goals of various institutions relevant to HDL management where large carnivores occur
	mindsets and paradigms underpinning the system	paradigms underpinning institutions and sectors relevant to the governance of HDL and large carnivores within them (these typically represent barriers for cross-sectoral collaborations and partnerships for achieving human–large carnivore coexistence) individual and collective values, norms, identities, and sociocultural factors related to large carnivores
	power to transcend paradigms	capacity to critically evaluate paradigms and even shift from them to gather a better, more holistic picture about the role of large carnivores in HDL and to form cross-sectoral collaborations to coproduce knowledge and cocreate human–large carnivore coexistence

[a]*The 4 leverage realms proposed by Abson et al. (2016). The first 2 are considered shallow leverages and the last 2 deep leverages.*
[b]*Leverage points as proposed by Meadows (1999).*

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 to agricultural production (i.e., trees, wetlands) were largely neglected by agricultural policies (e.g., the European Union's Common Agricultural Policy; Beaufoy et al. 2015). The approach of academia to the management of HDLs is also largely sectoral, either through teaching and training (e.g., in agronomy, forestry, biology, wildlife management, ecology, nature conservation) or implementation of unidisciplinary research programs to understand the various aspects of HDLs. This sectoral approach to manage and understand HDLs implies these landscapes or their components (e.g., species) are compartmentalized based on their uses, and management decisions are made by private and public bodies with different, but not necessarily, compatible and complementary objectives or shared goals. Conflicts and mismatches among institutions managing HDLs often exist because of the differences in priorities and paradigms underlying their actions and policies (Abson et al. 2016). A notable case of conflict and lack of genuine collaboration between different sectors is represented by the tensions among agriculture, forestry, nature conservation, and urban development sectors in many parts of the world (Scheele et al. 2018). Furthermore, some institutions operating in HDLs have limited interest in carnivore conservation or are hostile to carnivore conservation. This compartmentalized and often conflicted institutional environment of HDL governance is poorly suited for effective conservation of biodiversity and maintenance of HDLs with high natural and cultural values (Hossu et al. 2017).

To illustrate the need for a better understanding of the underlying institutional factors and mechanisms for managing human–wildlife coexistence, we examined 3 case studies from HDLs with large carnivore populations and human–large carnivore conflicts: Romania, India, and Brazil.

Human–Large Carnivore Conflict in Romania after a Hunting Ban

In Romania, failure to engage all stakeholders in large carnivore management and conservation in HDLs led to reactive policy decisions and fueled conflict. In 2016, hunting of brown bears (*Ursus arctos*) (Romania harbors the largest number of brown bears in the European Union; approximately 6000 individuals; Zedrosser et al. 2001) and other large carnivores (lynx [*Lynx lynx*], wolf [*Canis lupus*]) was banned by the Ministry of Environment in part because of the weak scientific basis for setting bear hunting quotas (Popescu et al. 2016), the perceived influence of certain economic interests in determining annual quotas (i.e., trophy hunting in the case of bears), and intense public campaigns seeking a ban on hunting of protected large carnivores (WWF 2017). Because 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 quotas. The Ministry of Environment (2018) then endorsed a new brown bear conservation action plan clearing the way for higher quotas.

In parallel and in sharp contrast to the national approach, at a local scale, the Council of Harghita county, in collaboration with the Pogány-Havas Association, initiated the Working Group for the Sustainable Management of the Cultural Landscapes in response to human–bear conflicts and 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 HDLs and large carnivores, including civil society, academia, wildlife management, hunting, forestry, environmental protection, tourism, rural development, agriculture, and media institutions. The media were allowed access to the working group's meetings to provide open, factual information for the general public, and to raise public awareness of issues related to large carnivore conservation and management. Although the working group realized that harmonizing human–large carnivore coexistence without genuine governmental support and financial investment would be difficult, it also recognized that proactive steps to tackle this issue were paramount for success at the community level.

Carnivore Relocation in India

In India, the world's second-most populous country, large carnivores such as tigers (*Panthera tigris*), leopards (*Panthera pardus*), wolves, and bears (brown [*Ursus arctos*], black [*Ursus thibetanus*], and sloth bear [*Melursus ursinus*]) 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 so-called problem individuals from HDLs into regions 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 a more natural forested landscape in the mistaken belief that they had strayed from these forested areas and that nonlethal removal benefitted both animals and people (Athreya et al. 2011). This resulted in a spike in human casualties at the site of the release and 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 preempt the occurrence of leopard conflicts in one of the world's most populous cities, Mumbai, is an excellent example of interinstitutional 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 (Athreya et al. 2016; Landy et al. 2018). However, state wildlife authorities, nongovernmental organizations, researchers, city officials, and the media worked together with the public to generate awareness, change attitudes, and respond quickly to conflict-creating situations to change the nature of human–large carnivore relationships in the city (Bhatia et al. 2013; Athreya et al. 2016). This initiative, called the Mumbaikars for SGNP (https://sgnp.maharashtra.gov.in/1221/Living-with-Leopards), offers a useful template for intersectoral collaboration in managing relationships between large carnivores and humans, even in the most heavily HDLs 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 (*Panthera onca*) in Brazil (modified from Bredin et al. 2015, 2018).

A stakeholder analysis requires considering those who influence jaguar conservation, those who are influenced by jaguar conservation, and those who fall into both categories. Key stakeholders, in this case, were cattle ranchers, crop farmers, foresters and forest management agencies, fishers, tourism operators, hydropower and mining developers, financial institutions, transport agencies, indigenous people, landless-movement participants, environmental and animal-welfare groups, and law enforcement. Cattle ranchers who are affected by predation could potentially engage in illegal killing of carnivores. Crop farmers who use large areas of land are required by law to maintain a certain proportion of forest, including along watercourses. These areas can provide substantial habitat and corridors for jaguars and their prey. Crop farmers are also responsible for clearing primary forest, which provides jaguar habitat. Decisions by foresters and forestry management agencies directly affect jaguar habitats. Fishers frequently come into contact with jaguars in the gallery forests that line riverbanks. Tourism operators may make a living by promoting ecotourism in general and by promoting jaguar tourism specifically. Activities of hydropower and mining developers 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. Financial institutions (in Brazil and overseas) finance major development activities. Transport agencies allow the building of roads that open up areas for development, fragment habitats, and can cause substantial mortality through collisions. Indigenous people share with jaguars most of the forests jaguars inhabit. The landless movement represents thousands of people who seek farmland of their own. Environmental and animal welfare groups seek to promote wildlife conservation and a change in human–animal relationships, respectively. Law enforcement agencies potentially enforce jaguar protection laws and forest conservation laws and prevent cross-border smuggling of jaguar body parts for the Chinese market. 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 (Bredin et al. 2015).

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, to national, to international. Coordinating large carnivore recovery automatically requires interacting with all these stakeholders and sectors to ensure that conflicts are minimized and that carnivore habitat quality and connectivity is maintained. 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 HDLs

Although our 3 case studies differ due to their 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 cases also highlight that innovative institutional partnerships can arise 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 and paradigms such as those highlighted by the Brazilian case). While acknowledging that academia is just one of the several important sectors relevant to human–large carnivore coexistence in HDLs, we suggest 3 ways to foster cross-sectoral collaborations to mainstream human–large carnivore coexistence in HDLs.

Creating Institutional Capacity for Transdisciplinary Research within Academic Institutions

We see 3 interlinked levels at which academia can meet the transdisciplinary 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). Although similar initiatives are on the rise (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 HDLs. Second, academic institutions should create an atmosphere conducive to transdisciplinary research. Transdisciplinarity requires genuine engagement with nonacademic actors, and this typically requires constant preparation and presence to monitor the process of engagement. Unplanned emergencies that require a reactive and quick mobilization of the researcher (emotional, physical, and intellectual) can be common, especially in conflict-laden institutional, social, and environmental contexts. Examples of such activities are mass media interventions to clarify various aspects of human–large carnivore coexistence, meeting the demands of stakeholders and society, and conflict resolution. Third, incentives and reward systems should be developed for scientists implementing transdisciplinary work. Research incentives and quality indicators for researchers should account for the obstacles and challenges imposed by the real-world complexities of transdisciplinary research so that their dedication and efforts to advance sustainability are fully recognized by academia (Sharachchandra & Norgaard 2005). Narrow measures of researcher impact (e.g., number of articles published in high-impact journals) should be relaxed and complemented with other indicators, such as number and quality of workshops, policy briefs, policy seminars, and other types of community engagement.

Considering Research Approaches and System Leverage Points to Assess the Significance of Research Results

When setting research goals to advance human–large carnivore coexistence in HDLs, we suggest reflecting on 2 interlinked realms. First, decide on the research approach (i.e., disciplinary, interdisciplinary, or transdisciplinary) to be used to address human–large carnivore coexistence (Fig. 2). Second, consider a systems perspective for how research results could leverage change toward harmonizing human–large carnivore coexistence (Fig. 2 & Table 1).

Disciplinary and interdisciplinary approaches can provide important knowledge for understanding several aspects and challenges of human–large carnivore coexistence (column 1 in Fig. 2), but they may have limited power to leverage the deeper system changes needed to mainstream coexistence (column 4 in Fig. 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 (e.g., wildlife management, as happened in Romania; T.H. & L.R., personal observation). Furthermore, social sciences can improve understanding of the various types of stakeholders, their interests and values, and the relationships between them (e.g., Jacobsen & Linnell 2016; Brazilian case study). However, on their own, these research approaches and results have limited power to leverage mechanisms that may ultimately bring stakeholders together to form a common vision (deep leverage points) (Fig. 2 & Table 1). Transdisciplinary approaches can complement the limitations of disciplinary approaches because they are built on strong cooperation with real-world nonacademic actors in codesigning the research project, coproducing knowledge, and cocreating solutions (Fig. 2). By incorporating the intent (i.e., norms, values, and goals embodied in the system and the paradigms underpinning them (Abson et al. 2016) (Table 1), transdisciplinary approaches can address deep leverage points that, although they require more time to provide tangible change, offer robust grounds for sustainability transformations and their long-term viability. For example, participatory scenario planning can incorporate diverse quantitative and qualitative information and different perspectives, values, and goals into the decision-making process in a systemic way (Peterson et al. 2003). Coproduced scenarios can represent a shared understanding and provide a common base for discussions and negotiations about the future of carnivores in HDLs (Hovardas 2018). Participatory scenario planning can therefore simultaneously address several system levels, including deep and shallow leverage points (Table 1 & Fig. 2), and thus can advance human–large carnivore coexistence in HDLs.

Being Present in or Contributing to Development of Cross-Sectoral Collaborative Institutional Structures

There is value in collaborative-governance structures for addressing regional and local challenges of human–large carnivore coexistence (Redpath et al. 2017) and for

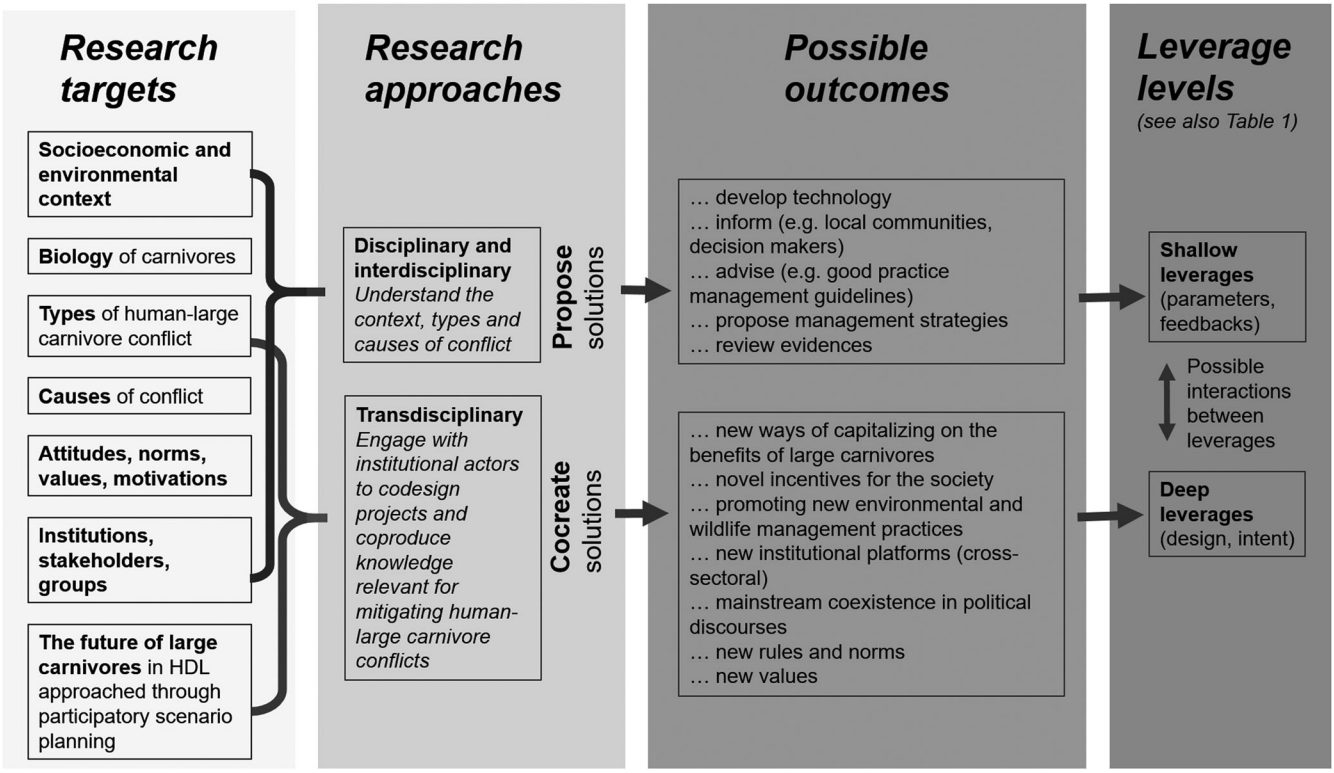

Figure 2. Schematic representation of the research targets, research approaches, possible outcomes, and leverage levels for advancing human–large carnivore coexistence in human-dominated landscapes (HDLs).

managing protected areas (Rozylowicz et al. 2017). Research institutions are typically partners in such initiatives, either as consultants or for implementing specific research objectives. Novel institutions can emerge from the initiatives of one or more institutions. Academia does not always have a direct and facilitative role in their formation, but it can contribute to their functioning through training, knowledge sharing, critical thinking and analysis, and innovation and monitoring (e.g., Nita et al. 2016; Rozylowicz et al. 2017). One form of cross-sectoral governance structure that represents a promising way to address human–large carnivore coexistence is the community of practice (CofP) (Watkins et al. 2018). The CofP represents structured interaction spaces for representatives of different stakeholders and sectors to facilitate knowledge flow, learning, and sharing of skills and experiences and ultimately to come to innovative solutions for complex societal problems (Wenger-Trayner & Wenger-Trayner 2015). As shown by the Romanian and Indian study cases, CofP-like governance structures can emerge in response 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 United States (Kretser et al. 2014; Redpath et al. 2017). Several community initiatives to facilitate human–large carnivore coexistence could represent "seeds of a good Anthropocene" (Bennett et al. 2016).

A prominent example of this is the 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, among others things, to identify good practices in the management of large carnivores in Europe. Hovardas and Marsden (2018) highlight 10 good-practice cases within the platform. They included awareness raising, innovative financing, and involving stakeholders in monitoring and bridging various stakeholder groups. Although the formation and functioning of such cross-sectoral platforms are not free of conflicts and challenges (Redpath et al. 2017), they represent optimistic examples of multiple sectors embracing a common problem and engaging in commonly shared solutions and therefore engages deep leverage realms (Table 1) in the search for sustainable solutions to human–bear coexistence.

Conclusions

There is an urgent need to align key stakeholders and sectors responsible for HDLs and large carnivore management, so that human–large carnivore coexistence can be mainstreamed. Spatial planning (e.g., the establishment of protected areas, buffer zones, and ecological corridors, i.e., "shallow leverage realms"; Table 1) is a powerful tool for safeguarding biodiversity worldwide. However, safeguarding large carnivores in HDLs generally requires consideration of land within and outside protected areas. Such mainstreaming is a major challenge for institutions and society, and we argue that academia needs to take a more proactive, ambitious role in efforts to mainstream human–large carnivore coexistence in HDLs (i.e., addressing "deep leverages," Table 1). Urgent steps are needed to embrace the principles and methods of sustainability sciences and create institutional spaces for the implementation of transdisciplinary projects; to determine the research approaches needed and how research can leverage institutional transformations for mainstreaming human–large carnivore coexistence in HDLs; and to engage with various institutions and stakeholder groups for create novel institutional structures that can respond to the multiple challenges of human–large carnivore coexistence. Realizing complex conservation goals, such as human–large carnivore coexistence, will have far-reaching benefits for people and biodiversity alike.

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