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Planning for Human-Wildlife Coexistence: Conceptual Framework, Workshop Process, and a Model for Transdisciplinary Collaboration

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Coexistence, as a concept and as a management goal and practice, has attracted increasing attention from researchers, managers and decision-makers dedicated to understanding and improving human-wildlife interactions. Although it still lacks a universally agreed definition, coexistence has increasingly been associated with a broad spectrum of human-wildlife interactions, including positive interactions, transcending a conservation focus on endangered wildlife, and involving explicitly considerations of power, equity and justice. In a growingly complex and interconnected human-dominated world, the key to turning human-wildlife interactions into large-scale coexistence is thorough planning. We present an approach for evidence-based, structured, and participatory decision-making in planning for human-wildlife coexistence. More specifically, we propose (i) a conceptual framework for describing the situation and setting the goals, (ii) a process for examining the causes of the situation and creating a theory of change, and (iii) a model for transdisciplinary research and collaboration integrating researchers, decision-makers and residents along with the interests of wildlife. To illustrate the approach, we report on the workshop considering the *Jaguars of Iguaçu*, a conservation project whose strategy includes the improvement of the relationship between ranchers and jaguars outside Iguaçu National Park, Brazil.

Keywords: collaboration, conservation planning, human-wildlife conflict, stakeholder processes, systems thinking, theory of change, transdisciplinarity

INTRODUCTION

The management of human-wildlife interactions (HWIs), the effects of which include collisions with vehicles, damage to property and agricultural production, zoonotic diseases, and the use of animals as a resource, is becoming more challenging (Broad et al., 2014; Aguirre, 2017; Pooley et al., 2017; IUCN, 2020). Behind this trend are the rapid and profound changes in the physical environment and societal values associated with the Anthropocene and modernization, including factors such as climate change, expanding infrastructure, urbanization, economic globalization, the digital revolution, and the expanding scope of ethical considerations (Vucetich et al., 2021a). One view, that we share, is that in an increasingly complex and interconnected human-dominated world, turning HWI into large-scale coexistence requires thorough planning (Marchini et al., 2019). Nonetheless, goal-setting and decision making in HWI management has been slow to rise to this challenge, perhaps impeded by, amongst other things, the lack of (i) a conceptual framework that integrates wildlife and human goals in order to articulate precisely the desired changes, (ii) a structured, interdisciplinary approach to assess the situation, select actions, and measure their success so as to inform how to cause the changes effectively, and (iii) the proper integration of stakeholders–scientists, decision-makers and residents–to jointly choose the right changes and the means to promote them, and to work together to implement them.

Planning is the process which, when successful, identifies a course of action in a systematic manner to achieve objectives by utilizing the available resources competently in a cost-effective way (Mintzberg and Quinn, 1996; IUCN, 2017). The process starts by addressing the two fundamental questions: where are we and where do we want to get (i.e., what are the current and desired situations, respectively)? The fast-growing scientific literature on HWI provides a clear answer to these questions regarding the general direction to be taken: the aspiration is to transform "human-wildlife conflict" (IUCN, 2020) into "human-wildlife coexistence" (Frank, 2016; Frank et al., 2019). The challenge with this, however, is that "coexistence" is a very vague vision, and can mean many different things to different people in different contexts. The conceptualization and operationalization of solutions to human-wildlife coexistence is still a matter of debate (Carter and Linnell, 2016; Koenig et al., 2020; Glikman et al., 2021; Pooley et al., 2021).

Indeed, "coexistence" is a broad concept and usually too vague to provide a clear functional goal for a conservation initiative. Rather, it needs to be broken down into clear, specific, and achievable envisaged outcome appropriate for the given situation. With a clear objective in hand, the next guiding question to be addressed in the planning process is how to get there? A roadmap to human-wildlife coexistence has to be produced to guide the actions. Nonetheless, despite the wealth of knowledge about HWI generated in the last couple of decades (Nyhus, 2016; Frank et al., 2019; Koenig et al., 2020), and the diversification and dissemination of techniques and tools to enhance decision-making (Schwartz et al., 2018), many projects and programs dedicated to preventing and mitigating human-wildlife conflict (HWC) and/or promoting human-wildlife coexistence still:

(1) lack a clear theory of change informing the linkage between actions and expected effects,
(2) base decisions on unverified, and sometimes flawed, assumptions about those linkages, and
(3) evaluate success based on outputs directly produced by the actions (e.g., number of community workshops conducted) without the proper attention to the indirect, long-term effects (e.g., behavior change among workshop participants).

Evidence-based and structured decision-making in HWC and coexistence requires integration between researchers and decision makers. However, we argue that research in academia has had a strong emphasis on describing and explaining problems instead of testing solutions and measuring the associated direct and indirect changes (but see Van Eeden et al., 2018a,b; Sutherland et al., 2021). Projects and programs, in turn, have not used the scientific evidence available to guide actions and evaluate results to the extent they could. This gap between research and implementation has hindered effective and sustainable solutions (Knight et al., 2008; Toomey et al., 2017; Ferraz et al., 2020). Insufficient engagement of various stakeholders, such as the local residents, can also undermine efforts to improve HWI.

In this paper we present an approach for evidence-based, structured, and participatory decision-making in planning for human-wildlife coexistence. More specifically, we propose:

(i) a conceptual framework for describing the current situation of both wildlife and people in the context of their interaction, and the desired changes i.e. setting the goals,
(ii) a process for examining the causes of such situation and creating a theory of change (ToC), and
(iii) a model for transdisciplinary research and collaboration integrating researchers, decision-makers and residents.

To illustrate the approach, we report on a workshop conducted with Jaguars of Iguaçu, a project the goal of which is the conservation of the jaguar (*Panthera onca*) as a key species for the maintenance of biodiversity inside and outside Iguaçu National Park (Parque Nacional do Iguaçu, PNI), Brazil.

WORKSHOP PROCESS DEVELOPMENT AND CASE STUDY

The workshop process outlined here has been developed by the authors of this paper through its application in partner projects. In the following sections, we illustrate the process with the case of the Jaguars of Iguaçu Project, the first partner project to adopt the approach. The Jaguars of Iguaçu Project[1] was created in 2018 and has subsequently carried out jaguar population surveys and a variety of outreach activities including technical assistance to ranchers, community engagement, education and communication. The project has also conducted a social survey in which 85 ranchers were interviewed. The results from this survey

[1]https://www.oncasdoiguacu.org/

supported some of the assumptions underpinning the theory of change described below.

Our workshop process was first applied in October 2019 in a two-day pilot in-person workshop conducted in the administrative office of PNI. The workshop was facilitated by a representative from the academic sector, and the five project team members and two park staff representatives participated in the workshop. This pilot workshop was also attended by five representatives of the Yaguarete Project (created in 2002). Both Jaguars of Iguaçu and Yaguarete projects are dedicated to the conservation of jaguars, concentrate their actions in complementary, adjacent areas in the Upper Parana Region–PNI in Brazil and Corrientes region in Argentina, respectively–and have continuous collaboration in research. The Upper Parana Region is part of the Atlantic Forest and one of the most critical areas for jaguar conservation. Three key protected areas–Iguaçu National Park and Turvo State Park in Brazil, and Iguazu National Park in Argentina–host an estimated population of 100 jaguars, representing one-third of all jaguars in the Atlantic Forest (Morato et al., 2013).

The goal of the first workshop was to introduce the process to the participants, exposing them to each of the key steps: situation assessment and goal setting, system mapping and identification of leverage points, and production of a ToC and of a framework for monitoring and evaluation (M&E). The outcomes of the pilot workshop, with a focus on the ToC and the M&E framework, were further developed and refined in two follow-up online meetings with the project's team in 2020 and early 2021.

WHERE WE ARE AND WHERE WE WANT TO GET: A CONCEPTUAL FRAMEWORK

Human-wildlife coexistence has drawn increasing attention from researchers (Frank et al., 2019; Koenig et al., 2020; Pooley et al., 2021). Although relatively new to the HWI literature, the concept of coexistence has been addressed from multiple perspectives, with an emphasis on its conceptualization (Carter and Linnell, 2016; Pooley et al., 2021), relationship with similar concepts–tolerance and acceptance–and with HWC (Frank, 2016; Glikman et al., 2021), and scales and levels of analysis (Carter et al., 2019; Koenig et al., 2020; Pooley et al., 2021). The framework described below is intended to contribute to this increasing body of knowledge by providing an approach for placing HWI in the context of planning and management concern.

Expanding from the concept of conflict-to-coexistence continuum (Frank, 2016; Frank et al., 2019), which suggests a one-dimensional graphical representation to depict HWI in its range from mutually negative to mutually positive outcomes, we propose that HWIs be described by their two dimensions–wildlife and human situation–separately (**Figure 1A**). Each situation is typically informed in terms of population-level parameters such as population size or conservation status (e.g., IUCN conservation categories), whereas human situation, in the context of the interaction, has been expressed in terms of both tangible and intangible factors such as financial cost/benefit, attitude (i.e., favor/disfavor), feeling (e.g., like/dislike), and wellbeing. The framework can also accommodate individual-level parameters such as animal welfare, which are increasingly considered in wildlife conservation and management (Sekar and Shiller, 2020). In the context of planning, the choice of the parameter is based on feasibility besides relevance. For instance, individual human wellbeing is arguably what ultimately matters, but its measurement can be challenging, so decision makers may select another parameter that, while also relevant, can be objectively assessed (e.g., attitude) so that management results can be tracked and demonstrated. For decision-making purposes, each axis can inform a single parameter or a set of parameters, one at a time or combined (e.g., in an index).

The wildlife and human axis combined define four archetypical representations (Fischer et al., 2017; Hartel et al., 2018) that cover all possible HWIs: (i) negative for both wildlife and people (left lower quadrant), like when endangered wildlife causes damage to people and preventive or retaliatory killing or harassment ensues (e.g., Das and Jana, 2018; LaDue et al., 2021; Simpfendorfer et al., 2021); (ii) negative for wildlife and positive for (some) people (left upper quadrant), as in overharvest associated with poaching or wildlife trade (e.g., Shepherd et al., 2017; Gomez et al., 2020); (iii) positive for wildlife (at the population level) and negative for people (right lower quadrant), as when abundant wildlife is a nuisance (e.g., Gamalo et al., 2019; Carpio et al., 2021); vehicle collisions and zoonotic diseases produce negative outcomes to people and are associated with both endangered and abundant wildlife (e.g., Pagany, 2020; Namusisi et al., 2021), therefore they belong in the two lower quadrants; and (iv) positive for both wildlife and people (right upper quadrant), like when abundant, native or exotic wildlife, is used in tourism (e.g., Macdonald et al., 2017) or sustainable harvest (e.g., Campos-Silva et al., 2017) (both, but most obviously the latter, may only apply to population-level parameters and not to individual-level).

In Latin America, where the approach described in this paper has been developed and applied, the Spanish and Portuguese word used to illustrate the condition in the right upper quadrant of the framework is *convivencia/convivência* which means, literally, to live together. *Convivencia* has a positive connotation. It is not only about sharing the space (as in co-occurrence or cohabitation), but also mutually benefiting from the interaction, even if the benefit is intangible (e.g., enjoying the presence of each other). The goal of HWC management is to "shift" situations in the left and lower half of the framework to the right and up, respectively, toward *convivencia*. Yet generally desirable, the win-win condition implied by *convivencia* is seldom realistic (Vucetich et al., 2018) and not ultimately necessary for conservation. Instead, in many instances it may be good enough to achieve *a condition whereby none of the parties involved–wildlife and human–receives a significant negative impact from the other, so that their "existing together" can be sustained* (**Figure 1A**). This is the operational definition of coexistence adopted in this approach, and the ultimate goal of planning for human-wildlife coexistence would be to move HWIs in the left and bottom halves to the right and upwards until coexistence is reached. As a note, *convivencia* implies coexistence (a mutually beneficial interaction can only occur when the parties

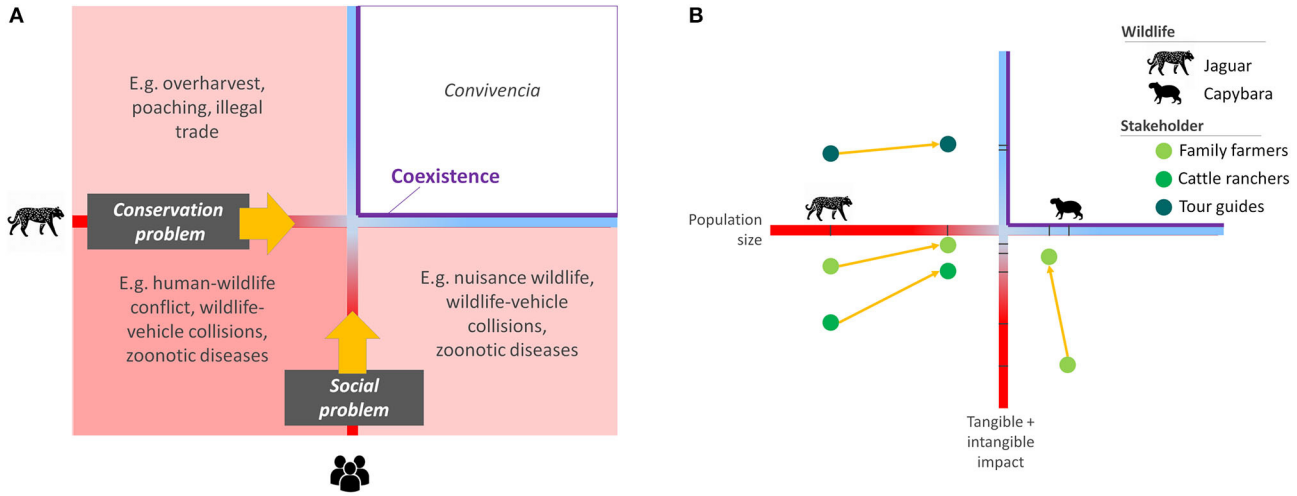

FIGURE 1 | Conceptual framework for describing human-wildlife interactions based on wildlife and human situations separately. **(A)** Situation ranges from poor (red) to good (blue). Parameters for wildlife and human situation are chosen according to relevance and accessibility (e.g., species population size and perceived impact, respectively). Arrows inform the direction of desired change from the conservation and social perspectives. Coexistence is defined as the condition whereby none of the parties involved–wildlife and humans–receives a significant negative impact from the other (purple line), so that their "existing together" can be sustained; **(B)** Hypothetical use of the framework to set goals and communicate current and desired situation in planning for multi-species (e.g., jaguar and capybara) and multi-stakeholder (e.g., family farmers, cattle ranchers and tour guides) coexistence. In this hypothetical but realistic example, the objective is to improve the situation of the parties involved toward coexistence, while recognizing that coexistence will not be fully achieved with available resources (e.g., time).

involved exist together) but not necessarily the other way around, as two parties can coexist without a win-win interaction (they can coexist even with some degree of conflict!).

This two-dimensional framework for describing HWI can be used to "map" any HWIs of management interest (**Figure 1B**), also allowing for multiple stakeholders and species. In the context of planning, the framework is used to visually inform both the current situation and desired changes within a specific timeframe (**Figure 1B**). When multiple stakeholders are portrayed, their current and desired situation can reveal actual and potential common ground and conflict. Such graphical representation can be a particularly useful tool for goal-setting and of communication in stakeholder engagement processes.

The framework also provides objective criteria for clarifying confusing terminology such as coexistence and *convivencia* (or equivalent). More than just a matter of semantics, these two terms refer to fundamentally different goals in HWI management. Other terms that have been used interchangeably with coexistence and *convivencia* are co-occurrence and cohabitation. Co-occurrence and cohabitation refer to the necessary ecological condition for any HWI to happen: the two species coincide in space and time, regardless of the outcome from their interaction (Waldron et al., 2013). In all HWIs depicted in the four quadrants of the framework humans and wildlife co-occur or cohabitate (the later term arguably connoting greater proximity between the parties).

Furthermore, the graphic representation makes a clear distinction between the conservation and social dimensions of a HWI problem (left and lower halves of the figure, respectively), encouraging decision-makers and managers to explicitly address each of them. When an endangered species does not cause any significant perceived impact on people, i.e., the interaction does not have an important social dimension, the situation and desired change can be properly expressed unidimensionally along the wildlife situation axis: it is about conservation only. But whenever HWIs have social implications, either negative or positive, situation assessment, and therefore planning, will benefit from such a framework that integrates the ecological and social dimensions.

In the workshop, participants were asked the following questions (Q1–Q6), whose answers (A1–A6) served to populate the framework: Q1. *What changes are intended to be caused?* A1. To improve the situation of both sides of the human-jaguar relationships; Q2. *What parameters are used to describe this change?* A2. Jaguar population size and local attitude toward jaguar conservation (other parameters were used but for the sake of illustration, we focus on attitude in this paper); Q3. *What are the target social groups?* A3. Family farmers; Q4. *What is the magnitude of the change?* A4. From the current 28 to 50 jaguars, and from 75 to 95% of the farmers favorable (as opposed to unfavorable) to jaguar conservation; Q5. *Where is the change expected to happen?* A5. In the 14 municipalities adjacent to Iguaçu National Park, home to approximately 500,000 people; and Q6. *When is the change expected to happen?* A6. Within 5 years.

These questions were not resolved sequentially but iteratively. The answer to one question can affect the answer to other questions. For example, the lack of a proper baseline (Q4) may result in the need to revisit the proposed parameters (Q2), and the magnitude of the desired change (Q4) may determine the expected timeframe (Q6). A cornerstone of planning for human-wildlife coexistence is that a project must be able to demonstrate

its success, hence the importance of selecting the right (i.e., relevant and viable) parameters, indicators, and timeframe. The exercise is useful for getting all participants on the same page regarding the issue they are addressing and the changes they want to cause. The resulting graphic display describes in a nutshell the *what, who, how much, where*, and *when* of their particular project. The next question to be addressed is, then, *how* to cause the desired change.

HOW TO GET THERE–AND SHOW THAT YOU DID IT: SYSTEMS THINKING AND THEORY OF CHANGE

A key assumption in the proposed change-focused approach is that HWIs are embedded in a system (i.e., "a group of interacting or interrelated elements that act according to a set of rules to form a unified whole", Merriam-Webster, 2019). Actually, HWI issues typically involve interacting ecological, economic, and sociopolitical elements, with complex and adaptive dynamic relationships driven by the thoughts, feelings, and power of the associated actors (Bunnefeld et al., 2017). Therefore, systems thinking, defined as "a set of synergistic analytic skills used to improve the capability of identifying and understanding systems, predicting their behaviors, and devising modifications to them in order to produce desired effects" (Arnold and Wade, 2015), can be useful for examining HWIs. Systems approaches emphasize the need to understand dynamic interrelations between various components (Von Bertalanffy, 1993), shifting the emphasis from isolating the causal effect of a single factor to comprehending the functioning of the system as a whole. Feedback loops and unintended effects, in addition to linear chains of causality, are central to systems thinking. In application, systems thinking has been defined as both a skill and an awareness (Sanko et al., 2021).

In the workshop, systems thinking is used to develop a system map depicting in terms of "nodes and connections" the factors that determine the change. The emphasis is on whether the boundaries and interrelationships of the proposed system accurately reflect the story the group is trying to depict. System maps are shorthand descriptions of what we perceive as current reality. If they reflect that perspective, they are "right enough." Proper facilitation techniques are used to help participants analyze the map and draw conclusions on potential leverage points i.e., where interventions could bring about the desired changes in a more cost-effective way (Meadows, 1999; Abson et al., 2017). If all the causes cannot be overcome by the project, it is important to prioritize the pathways to intervene. The participants then select one or more solution pathways to form their strategy, based on explicit criteria such as project's objectives and priorities, preferences of key stakeholders, cost-effectiveness and technical feasibility.

Once the system is understood and the leverage points for each selected causal pathway are identified, the next step in the workshop process is to describe in detail how the change is expected to happen. In other words, it is time to create a Theory of Change (ToC). A ToC is a decision support tool that illustrates the causal links and sequences of events needed for an activity or intervention to lead to a desired outcome or impact (Center for Theory of Change, 2013). It is both a process and a product (Vogel, 2012). Fundamentally, the participants describe the causal pathways in terms of inputs, activities, outputs (products), short- to long-term outcomes (effects) and desired final impact, choose indicators for each product and effect and, in doing so, generate a framework for monitoring and evaluating results. Intermediate outcomes must be clearly articulated within the ToC. This is perhaps the most important part of the process: too often project teams jump from their activities to their final goals without thinking through the changes that need to happen in between. Indeed, the process of creating a ToC enables a better understanding of the underlying assumptions and questioning of the assumptions that are often side-lined, in the specific context where activities and interventions take place (e.g., electric fences cause less livestock depredation, which causes higher tolerance, which causes less persecution). This can help to identify knowledge gaps and guide research, as an additional benefit from producing a ToC.

A major advantage of this approach–systems thinking followed by ToC–is that the context analysis and decision-making are integrated. Traditional ToC diagrams usually depict only the actions that a particular organization or program plans to implement, together with the related changes they anticipate through the implementation of those actions. Organizations imply that positive change (e.g., increased wildlife population) results directly and solely from their actions, rather than from a range of interrelated contextual factors, of which their program is part. Starting with a system map and integrating a ToC can be an effective way to address this issue.

As a conservation-oriented project, Jaguars of Iguaçu ultimately aims at increasing jaguar population size up to a viable and sustainable level, while improving the actual and perceived impact of jaguars and of the INP on local communities. In order to encourage the workshop participants to consider from local to distant causes, the systems approach to examine the factors that determine change in jaguar population size was structured in different levels of analysis: ecological, (human) behavioral, personal, social/institutional, and societal (**Figure 2**). System mapping started with the ecological factors that directly determine jaguar population size: mortality, natality, immigration and emigration. These in turn are affected by changes in habitat quality and prey base besides human behavior: intentional and unintentional killing of jaguars, intentional and unintentional killing of prey, changes in land use and habitat management. Participants were then briefed on some of the main conceptual frameworks that have been used to explain and predict human behavior such as the Theory of Planned Behavior (Fishbein and Ajzen, 2010) and Hazard Acceptance Model (Bruskotter and Wilson, 2014). The explanatory variables include attitudes, perceived social norms, and perceived behavioral control regarding jaguar killing; tolerance to jaguars, which in turn is determined by perceived costs and benefits, affect toward the species, and trust in the management agency; motivations vs. perceived barriers; and level of awareness, knowledge and skills. Factors at the social and institutional level include the level of engagement, the magnitude of economic incentives, technical

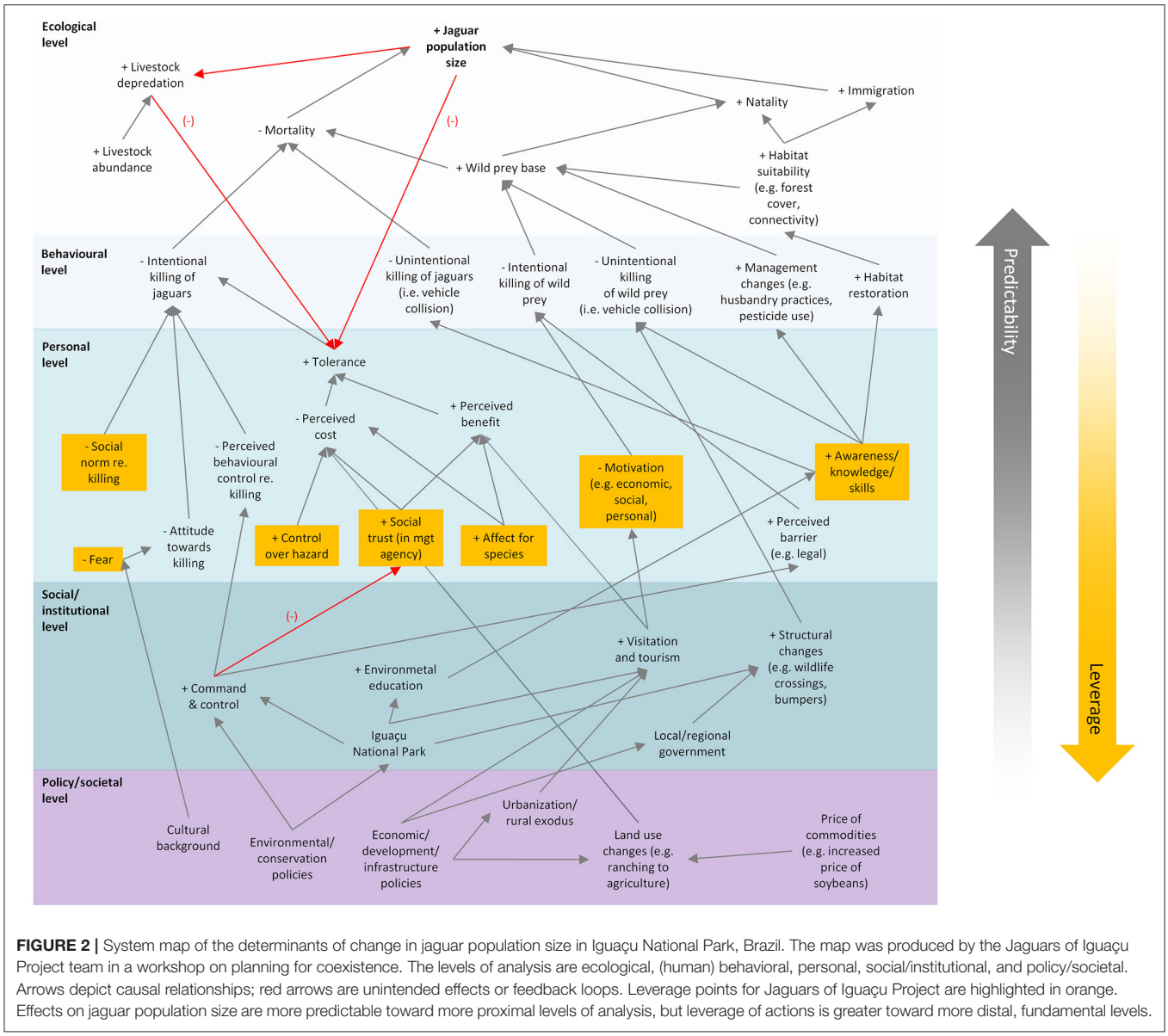

FIGURE 2 | System map of the determinants of change in jaguar population size in Iguaçu National Park, Brazil. The map was produced by the Jaguars of Iguaçu Project team in a workshop on planning for coexistence. The levels of analysis are ecological, (human) behavioral, personal, social/institutional, and policy/societal. Arrows depict causal relationships; red arrows are unintended effects or feedback loops. Leverage points for Jaguars of Iguaçu Project are highlighted in orange. Effects on jaguar population size are more predictable toward more proximal levels of analysis, but leverage of actions is greater toward more distal, fundamental levels.

assistance in agriculture, and of command and control, and the role of protected areas, all determined by institutional capacity and financial resources. At the societal level, urbanization, changes in land use, the growth of tourism, and the national action plan for the conservation of large felids were added to the map.

Throughout the analysis, systems thinking allows participants to see previously hidden linkages, including unanticipated side effects—e.g. the negative impact of protection on people's trust in the park authority—and feedback loops, like the negative effect of more jaguars on people's tolerance to jaguars. In the HWI literature, the factors that more proximally and directly determine the situation, at the upper levels of analysis in **Figure 2**, have received more attention. However, the large-scale and sustained condition implied by coexistence–as opposed to a temporary truce–requires a more in depth understanding of the system, which is achieved by addressing the factors at the social, institutional and societal levels of analysis (Massarella et al., 2021). Besides, while it is generally easier to detect the effects of actions implemented at the ecological, behavioral and personal factors, the more fundamental the level of intervention, the higher the leverage.

For the development of a ToC for Jaguars of Iguaçu Project, specific pathways were selected, taking into account the desired impact of the project, the activities already underway, the databases available, and the feasibility of collecting additional data to serve as indicators of intermediate outcomes. For each pathway, a detailed results chain was articulated connecting activity to outputs to outcomes to impact. This information was organized in a logical framework, informing also the respective

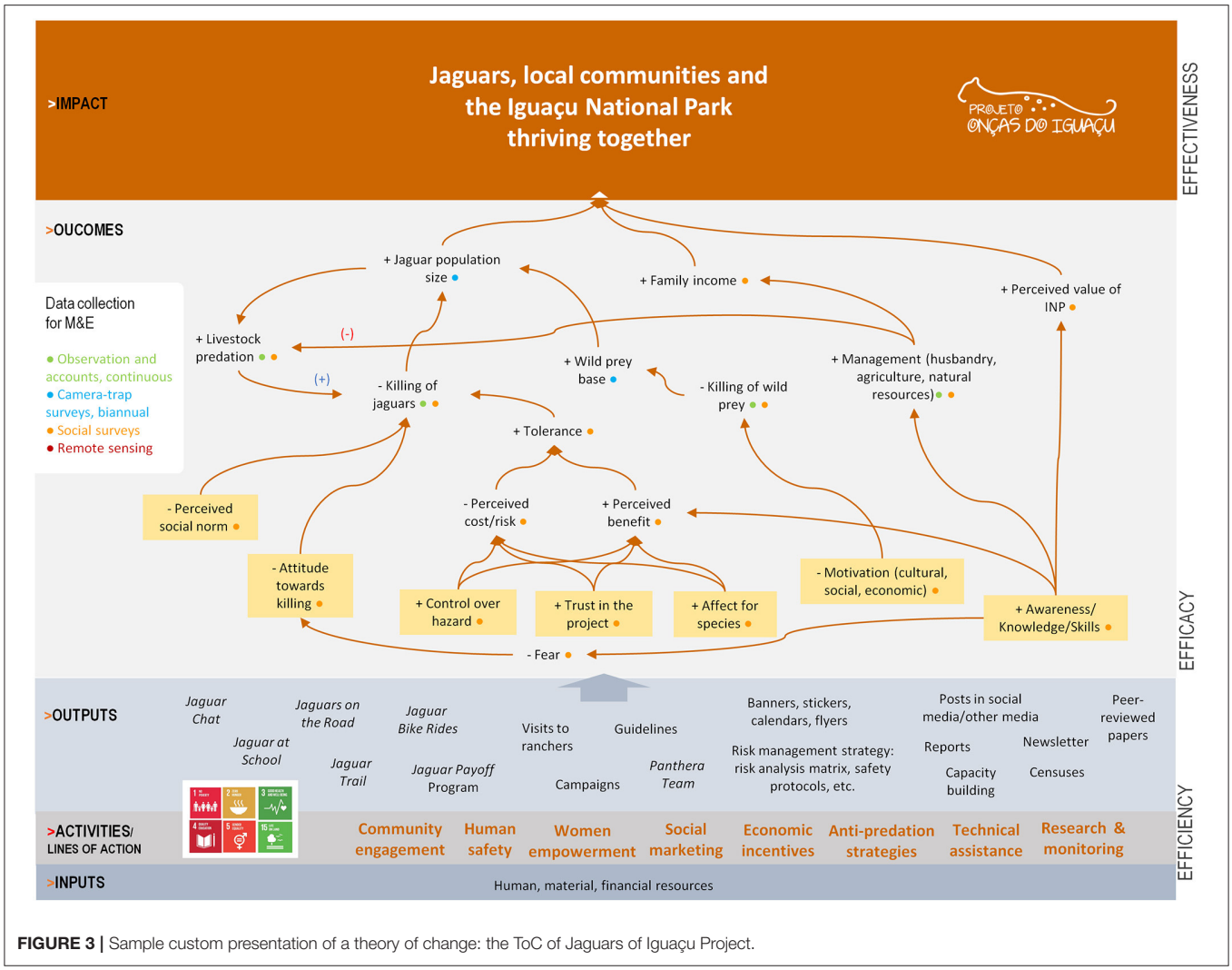

FIGURE 3 | Sample custom presentation of a theory of change: the ToC of Jaguars of Iguaçu Project.

indicators, means of verification, and assumptions behind each causal link. Next, the project team informed baseline values and agreed upon target values for each outcome, the timeframe to achieve the target values, and the estimated budget to do it. Altogether, this dataset is a framework for evaluating the effectiveness of the project (i.e., extent to which the desired impact is caused), the efficacy of the actions (i.e., extent to which planned short- and long-term outcomes are achieved), and the efficiency of the project and each action (i.e., the ratio of outputs to inputs in terms of time, energy, and money). Custom decorations were used to make the project's ToC look attractive (**Figure 3**). While this sounds superficial, it can be useful to make those all-important presentations to donors, board members and key stakeholders.

In addition to the product summarized in a logic model or results chain, the ToC is a process that gives organization and program teams the opportunity to think, discuss, learn from each other, collaborate, and develop a sense of ownership of the process. It strengthens projects through more considered decision-making and stronger teams as people are brought together. It also enables projects to identify knowledge or capacity gaps as they appear and facilitates projects to evolve and become refined over time through adaptive management.

Future Directions: Advancing a Transdisciplinary Model for Planning

The planning and managerial perspective in which human-wildlife interactions is discussed above has an explicit emphasis on change. More specifically, it is about changing HWI toward the benefit of both wildlife and people. Accordingly, delivering change should be the primary focus of research for human-wildlife coexistence. The evidence on which decision-making is based must come not only from research on wildlife and on people, but preferably also from research on how the system changes in response to management actions. Such changes obligatorily affect people, and the associated costs and benefits are not always distributed equally among interest groups or over time (e.g., for some groups the long-term benefit may imply short-term costs). Therefore, creating the conditions for these groups to participate in decision-making is a moral imperative and

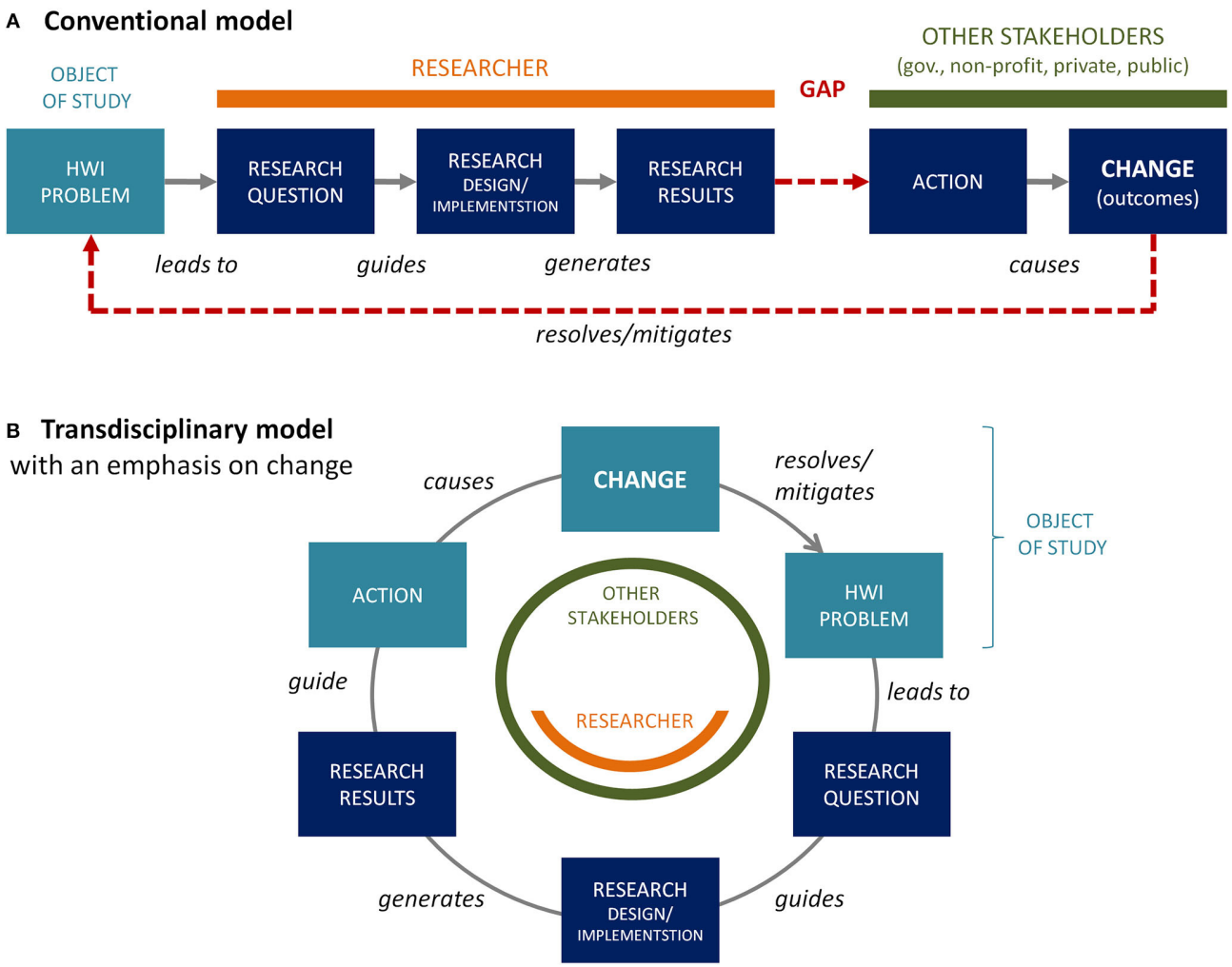

FIGURE 4 | Conventional **(A)** and alternative **(B)** models for the role of researchers and other stakeholders in tackling HWI problems. Dashed arrows represent the links that are typically weak or missing: the use of research results by decision makers and practitioners, and the monitoring and evaluation of the ultimate effects of actions on the HWI problem.

also more promising, complementing top-down approaches that might, on their own, result in lack of buy-in and implementation (Treves et al., 2009; Dietsch et al., 2021; Salvatori et al., 2021; Vucetich et al., 2021b).

The proposed process of planning for human-wildlife coexistence favors an alternative to the conventional model of research-implementation in HWI in which a gap can too often separate academia from decision-makers and other stakeholders (**Figure 4A**). Actually, the science-policy gap is not just a concern in conservation practice, but an urgent challenge to be addressed in many fields (e.g., climate change). Most academic research in HWI has focused on describing and explaining HWC-related problems. Levels of livestock loss to predators and of retaliatory killing, and the factors determining these phenomena, are examples of objects of such research (e.g., Bruskotter et al., 2017; Chaka et al., 2021, respectively). Research objects are chosen according to academic and scientific criteria, including the adequacy and feasibility of the research within the norms and timeframes imposed by graduate programs and funding bodies. Researchers' personal interests and preferences, and scholarly originality, also play a role in the selection of research topics. In this model, the contribution of academia can end with the publication of research results in scientific journals, typically in academic language and in English, regardless of the language spoken by the stakeholders–decision-makers, managers, and residents–of the study site/system. These actors, in turn, have made limited use, if any, of the results of scientific research, whether because of difficulties in understanding them, limitations in accessing them, or being overwhelmed with information and studies, some of which contradict each other (Wesselink and Hoppe, 2020). Without a robust evidence base, teams in charge of projects and programs measure the success of their activities based on outputs and short-term outcomes, at best, but the connection between

their results and the impact on the HWI problem at hand is often not demonstrated.

Planning for coexistence will benefit from a process that differs from the conventional model in three major points (**Figure 4B**): (i) research objectives go beyond describing and explaining the problem to address also how the problem is resolved or mitigated by management actions and their outcomes, (ii) decision-makers, managers and residents participate in all stages of the process: research questions, for example, are not chosen only for their academic and scientific merit, but mainly for their relevance to these stakeholders, i.e., the contribution of academia is directly guided by concrete demands of specific stakeholders; and (iii) the process is explicitly cyclical and iterative, and the emphasis is not on a definitive solution–which in fact rarely exists–but on adaptation and resilience.

This transdisciplinary model with a focus on adaptive change constitutes an approach for creating the knowledge, skills, and collaborations necessary among researchers, practitioners and stakeholders for furthering human-wildlife coexistence. The transdisciplinary approach, by definition, integrates fields beyond academia with academic research, and engages stakeholders in knowledge co-production, through processes of collective inquiry and reflection with relevant stakeholders (Lang et al., 2012) that foster ownership and full participation. Transdisciplinarity has indeed been increasingly mentioned as a promising way of producing knowledge and decision-making in the context of the world's most pressing issues (Macdonald, 2019; Rigolot, 2020). Nonetheless, despite the growing interest in transdisciplinary approaches among sustainability scientists and practitioners (Sharpe et al., 2016; Rocha et al., 2020), their use in the field of HWI is still in its infancy (Hartel et al., 2019; Jiren et al., 2021).

The planning for coexistence workshop with Jaguars of Iguaçu Project integrated academia (University of São Paulo) with the government (Iguaçu National Park) and non-profit (the project itself) sectors as the starting point of a continued and adaptive process. Local stakeholders' needs have guided scientific research, and research results have subsidized the design and implementation of interventions. The mapping of the stakeholders of jaguar conservation, both in the Iguaçu region specifically and in the Atlantic Forest as a whole, was done in a separate workshop, as part of a partner project of the Jaguars of Iguaçu project. Stakeholder analyses were used to identify the stakeholders and group them according to their levels of participation, interest, and influence in the project, and to determine how best to involve and communicate each of these stakeholder groups throughout (Sandroni et al., submitted). Local stakeholders, however, have not participated in-person in the planning workshop. Their needs and aspirations have been assessed through surveys and taken into account in the process. A challenge ahead facing planning for coexistence will be to implement and refine mechanisms for greater stakeholder participation (Vucetich et al., 2021b)—local farmers and ranchers, in the case of jaguar conservation—ensuring that the transdisciplinary model proposed here is fully implemented.

CONCLUSIONS

The process outlined here provides a generally usable template for how to conduct evidence-based, structured, and participatory planning for human-wildlife coexistence. We hope it can help to overcome a major stumbling block in the transformation of problematic HWI into coexistence i.e., the vagueness of goal and pathway. While we are still far from generating a predictive theory of coexistence, current efforts to improve HWI can benefit from more systematic and inclusive ways of making decisions. Naturally, as research findings reveal the high degree of complexity and local specificity of human-wildlife and human-human interactions (Zimmermann et al., 2021), the specific methodological steps of the proposed approach need to be adjusted according to the study area, stakeholders involved, and resources available. Ready-made and one-size-fits-all solutions for HWI problems are scarce, hence the potential benefit of our planning approach.

The process of planning for coexistence as proposed here can complement current approaches such as threats analyses and action plans which, as the names suggest, place relatively more emphasis on threats and actions than on results i.e., change. In addition, it can expand the reach of workshop processes, analytical tools, and monitoring and evaluation frameworks currently in use (e.g., Open Standards, the tools of the IUCN SSC Conservation Planning Specialist Group) and especially the scope of HWI management and policies, traditionally concentrated on negative interactions involving threatened species.

Given the growing importance of coexistence and the associated more holistic, fairer ways of addressing HWIs, the approach outlined here has great potential for tackling current and future pressing HWI issues. The realization of this potential, however, will depend on a greater support from funding bodies for long-term, interdisciplinary, collaborative research focusing on change and on ways to monitor and evaluate results. It is important to make training in decision-making and solutions-oriented, actionable science more accessible in academic and informal learning environments. Also, mechanisms for data sharing and collaboration involving researchers, government agencies, non-profit organizations, and the private sector will need to be improved.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

SM wrote the first draft. KF, AZ, and DM contributed to the conception of the study and contributed revisions. VF and YB contributed revisions and together with AK and TR collected data in the planning workshop.

All authors contributed to the article and approved the submitted version.

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