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PERSPECTIVE

Bridging the research-implementation gap in avian conservation with translational ecology

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ABSTRACT

The recognized gap between research and implementation in avian conservation can be overcome with translational ecology, an intentional approach in which science producers and users from multiple disciplines work collaboratively to co-develop and deliver ecological research that addresses management and conservation issues. Avian conservation naturally lends itself to translational ecology because birds are well studied, typically widespread, often exhibit migratory behaviors transcending geopolitical boundaries, and necessitate coordinated conservation efforts to accommodate resource and habitat needs across the full annual cycle. In this perspective, we highlight several case studies from bird conservation practitioners and the ornithological and conservation social sciences exemplifying the 6 core translational ecology principles introduced in previous studies: collaboration, engagement, commitment, communication, process, and decision-framing. We demonstrate that following translational approaches can lead to improved conservation decision-making and delivery of outcomes via co-development of research and products that are accessible to broader audiences and applicable to specific management decisions (e.g., policy briefs and decision-support tools). We also identify key challenges faced during scientific producer–user engagement, potential tactics for overcoming these challenges, and lessons learned for overcoming the research-implementation gap. Finally, we recommend strategies for building a stronger translational ecology culture to further improve the integration of these principles into avian conservation decisions. By embracing translational ecology, avian conservationists and ornithologists can be well positioned to ensure that future management decisions are scientifically informed and that scientific research is sufficiently relevant to managers. Ultimately, such teamwork can help close the research-implementation gap in the conservation sciences during a time when environmental issues are threatening avian communities and their habitats at exceptional rates and at broadening spatial scales worldwide.

Keywords: co-production, knowing-doing gap, ornithology, science producer, science user

LAY SUMMARY

- Translational ecology is an intentional approach in which science producers and science users work collaboratively to define objectives and desired outcomes to co-produce research that, ideally, results in improved environmental decision-making.
- Avian conservation naturally lends itself to translational ecology because birds require coordinated conservation efforts across extensive, human-dominated geographies and the full annual cycle.
- Using the 6 principles of translational ecology (collaboration, engagement, commitment, communication, process, and decision-framing), we provide several examples that successfully bridge the research-implementation gap in avian conservation.
- We recommend strategies for overcoming science producer–user conflicts and for building a stronger translational ecology culture within ornithology and avian conservation.
- Translational teams will only become more vital as anthropogenic global change continues to threaten avian communities at exceptional rates and with ever-increasing complexities around the world.

Reduciendo la brecha entre investigación e implementación en la conservación de las aves con la ecología traslacional

RESUMEN

La brecha existente entre investigación e implementación en la conservación de las aves puede ser superada con la ecología traslacional, un enfoque guiado en el cual los hacedores y los usuarios de ciencia de múltiples disciplinas trabajan de manera colaborativa para desarrollar en conjunto y ofrecer investigación ecológica que aborde temas de gestión y conservación. La conservación de las aves se presta naturalmente a la ecología traslacional debido a que las aves están bien estudiadas, típicamente están ampliamente distribuidas, usualmente muestran comportamientos migratorios que trascienden las barreras geopolíticas, y necesitan esfuerzos de conservación coordinados para integrar los recursos y las necesidades de hábitat a través de todo el ciclo anual. Desde esta perspectiva, destacamos varios estudios de caso provenientes de gestores de la conservación de las aves y de las ciencias sociales ornitológicas y de la conservación que ejemplifican los seis principios fundamentales de la ecología traslacional introducidos en estudios previos: colaboración, compromiso, entrega, comunicación, proceso y encuadre de decisiones. Demostramos que el seguimiento de los enfoques traslacionales puede llevar a mejorar el proceso de toma de decisiones en conservación y la entrega de resultados a través del desarrollo conjunto de la investigación y de los productos que son accesibles a audiencias más amplias y aplicables a decisiones de manejo especificas (e.g., resúmenes de políticas, herramientas de apoyo a la toma de decisiones). También identificamos los desafíos claves que se enfrentan durante la vinculación entre los hacedores y los usuarios de ciencia, las tácticas potenciales para superar estos desafíos, y las lecciones aprendidas para superar la brecha entre investigación e implementación. Finalmente, recomendamos estrategias para construir una cultura de ecología traslacional más fuerte que mejore aún más la integración de estos principios en las decisiones de conservación de las aves. Adoptando la ecología traslacional, los conservacionistas de aves y los ornitólogos pueden estar mejor preparados para asegurar que las futuras decisiones de manejo estén basadas en información científica y que las investigaciones científicas sean relevantes para los gestores. En definitiva, este trabajo en equipo puede ayudar a cerrar la brecha entre investigación e implementación en el ámbito de las ciencias de la conservación durante un período en el que los temas ambientales están amenazando las comunidades de aves y sus hábitats a tasas excepcionales y a escalas espaciales cada vez mayores en todo el mundo.

Palabras clave: brecha entre conocimiento y acción, hacedor de ciencia, ornitología, producción conjunta, usuario de ciencia

INTRODUCTION

In an era of pressing environmental challenges coupled with limited public funding for scientific investigation, there is a vital need for science producers (e.g., researchers and community scientists) and users (e.g., managers and decision-makers) to effectively collaborate to achieve optimized conservation outcomes. The research-implementation gap (also called the knowing-doing or science-policy gap) is the accumulation of scientific information without incorporation into management decisions (see Table 1 for a glossary of terms), and its persistence has led to questions about whether the broader field of conservation science is failing to accomplish its mission (e.g., Matzek et al. 2014, Toomey et al. 2017, Dubois et al. 2019). Translational ecology approaches represent one of the proposed solutions for overcoming this divide through the creation of integrated partnerships between resource managers and scientists from multiple disciplines, including the social sciences (Dayer et al. 2020a). The concept of translational ecology was first proposed by Schlesinger (2010) and Brunson and Baker (2016), and the framework has recently gained

TABLE 1. Glossary of terms, synonyms (if applicable), and references relevant to the application of translational ecology to avian conservation.

Term	Definition	Synonym(s)	Citation(s)
Adaptive management	Structured, cyclical process for decision-making with the goals of reducing uncertainty over time while improving resource management through information feedback via monitoring and ongoing learning from statistical analyses		Holling (1978), Walters (1986), Nichols et al. (2007), and Williams et al. (2009)
Boundary spanner	Institution, group, or individual that works at and/or manages the boundary between science users and producers, produces boundary products or tools that enable communication between these 2 groups, and is accountable to both groups	Knowledge broker and boundary organization/consortium	Guston (2001), Cash et al. (2006), and Safford et al. (2017)
Collaboration	Co-production of knowledge and co-development of shared objectives through the application of an interdisciplinary approach incorporating all points of view to answer relevant research, policy, and management questions	Partnership and teamwork	Enquist et al. (2017) and Lawson et al. (2017)
Commitment	Participation, accountability, and openness to learning that is necessary to establish joint goals and achieve results	Dedication	Enquist et al. (2017) and Lawson et al. (2017)
Communication	Clear and regular interactions with project team members that promote a fuller understanding and integration of new information for co-development of decisions and outcomes	Knowledge exchange and knowledge mobilization	Enquist et al. (2017) and Lawson et al. (2017)
Decision-framing	Identification of the context of the problem (users' needs, values, and timeframe) to achieve decision-relevant outcomes		Enquist et al. (2017) and Lawson et al. (2017)
Engagement	Relationship-building and deep dialoging between team members to promote mutual understanding and high levels of trust	Active participation	Enquist et al. (2017) and Lawson et al. (2017)
Process	Participatory method for guiding interactions that are transparent, holistic (encompassing various perspectives and information needs), and lead to a sense of ownership among participants	Process-focused interactions	Enquist et al. (2017) and Lawson et al. (2017)
Research-implementation gap	Accumulation of scientific information without incorporation into management actions or policy decision-making	Knowing-doing gap, science-policy gap, and decision-implementation gap	Toomey et al. (2017) and Evans and Cvitanovic (2018)
Science producer	Individual or organization that conducts research or otherwise contributes to knowledge and information generation for scientific purposes	Scientist and researcher	Safford et al. (2017)
Science user	Individual or organization requiring scientific information for decision- or policy-making	Non-scientist, manager, and policy-maker	Safford et al. (2017)
Stakeholder	Person or organization with an interest in an environmental decision or outcome		Enquist et al. (2017)
Structured decision-making	The use of decision analysis to think through multidimensional choices characterized by uncertain science, diverse stakeholders, and difficult tradeoffs	Decision analysis	Gregory and Failing (2012) and Runge et al. (2020)
Translational ecology	Decision-making approach that embodies intentional processes in which ecologists, stakeholders, and decision-makers work collaboratively to develop ecological research via joint consideration of the sociological, ecological, and political contexts of an environmental problem	Science co-production, joint production, and cooperative production	Lemos and Morehouse (2005), Hegger et al. (2012), and Podestá et al. (2013)

momentum because of the implementation guidance provided by Enquist et al. (2017) and others (e.g., Hallett et al. 2017, Lawson et al. 2017, Safford et al. 2017, Schwartz et al. 2017). Translational ecology calls for ongoing engagement between scientists and stakeholders to understand, address, and communicate multi-faceted decision contexts (Schlesinger 2010).

Avian conservation naturally lends itself to translational ecology approaches given that birds are well studied, typically widespread, often exhibit migratory behaviors transcending boundaries, and necessitate coordinated conservation efforts to accommodate resource needs across human-dominated landscapes and throughout the full annual cycle. Birds are also excellent indicator species whose populations can be monitored efficiently and cost-effectively to assess the overall health of wildlife communities (Kati and Şekercioğlu 2006). Moreover, many state and federal wildlife agencies are tasked with conserving avian populations and their habitats via rigorous evidence-based approaches, necessitating partnerships with researchers who have crucial analytical resources. Thus, science producers and users who work together to achieve shared avian conservation goals often exemplify effective translational research teams. We define science producers as individuals or organizations that conduct research or otherwise contribute to knowledge and information generation for scientific purposes (Table 1). Within the context of avian conservation, producers may include, but are not limited to, scientists (e.g., ornithologists, ecologists, conservation biologists, and social scientists) at academic research institutions, research-focused agencies (e.g., United States Geological Survey), or other science-based organizations (e.g., private firms and research-oriented non-governmental organizations [NGOs]), as well as community scientists (also called "citizen scientists"), who participate in data collection for programs, such as eBird, the North American Breeding Bird Survey, and the Christmas Bird Count (Figure 1).

Science users are individuals or organizations requiring scientific information for decision-making, such as conservation planning or policy enactment (Table 1). Users within avian conservation may include resource managers in local, state, and federal regulatory agencies (e.g., National Park Service and state fish and wildlife departments), conservationists in public facilities (e.g., zoos, aquariums, and botanical gardens), as well as legislators and media outlets interpreting scientific outputs for public consumption (Figure 1). Yet the roles of science producer and user are not always mutually exclusive. Intermediaries, or boundary spanners, traditionally work at and/or manage the interface between producers and users of research and may be individuals or organizations with dual missions of information generation and utilization (Table 1). A variety

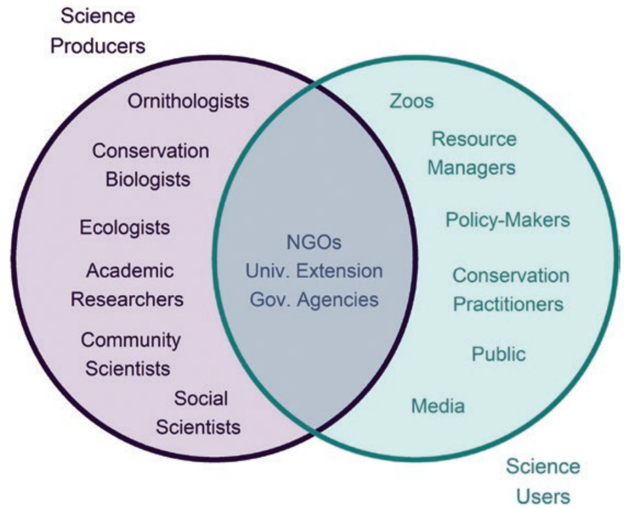

FIGURE 1. Typical science producers (purple circle), science users (blue circle), and boundary-spanning entities (gray intersection) that are involved in avian conservation efforts. Science producers are defined as individuals or organizations that conduct research or otherwise contribute to knowledge/information generation for scientific purposes. Science users are individuals or organizations that require scientific information for decision-making, such as for conservation planning or policy enactment. Boundary spanners (or knowledge brokers) typically work at and/or manage the interface between producers and users of research and may be individuals or organizations with dual missions of information generation and utilization. While Indigenous peoples and other traditional communities and stakeholder groups are important boundary-spanning entities who collect and apply traditional ecological knowledge and/or science, our review focuses on Western science and lacks coverage of these groups. The science producers and users shown here do not represent an exhaustive list but are intended to capture the breadth of entities that often participate in avian conservation work.

of entities may operate as boundary spanners in avian conservation projects, including NGOs and nonprofit organizations (e.g., National Audubon Society and The Wildlife Society), government agencies (e.g., United States Forest Service), university extension programs, and public–private partnerships for bird conservation (e.g., Migratory Bird Joint Ventures), among others (Safford et al. 2017; Figure 1). Indigenous peoples are also important boundary spanners by collecting and applying traditional ecological knowledge (Wilder et al. 2016).

Translational ecology is a purposeful approach in which science producers and users work collaboratively to define research questions and decisions arising from on-the-ground management issues (i.e. actionable science; Beier et al. 2017) and conduct and deliver ecological research that, ideally, results in improved, real-world outcomes. Elsewhere, this approach is referred to as science co-production (Lemos and Morehouse 2005), joint production (Hegger et al. 2012), or cooperative production

(Podestá et al. 2013; see Table 1). Elements of translational ecology are critical to both structured decision-making and adaptive management (Table 1) and aim to establish strong collaborations through social science-derived techniques (e.g., establishing or rebuilding trust) that foster meaningful 2-way dialogue with the goal of co-producing science. Translational practitioners use an adaptive and iterative mode of inquiry to cultivate mutual learning as contexts and questions shift, a strategy based on ideas from translational medicine (Schlesinger 2010). Successful translational ecology is measured by partnership-building that results in decision-relevant research and management that is understandable and beneficial to all stakeholders (Enquist et al. 2017).

Previous work (Enquist et al. 2017, Lawson et al. 2017) has identified 6 foundational principles of translational ecology: collaboration, engagement, commitment, communication, process, and decision-framing (Table 1). Of the 6 principles, *collaboration* among teams of science producers and users is the foundation of effective translation; among these participants, shared knowledge is developed and decisions to be made are defined by all parties. To support these collaborative efforts, continued *engagement* is essential to foster relationship-building and open dialogues among participants for tackling complex ecological issues (Jacobs et al. 2005). Because of the collective, multidisciplinary nature of translational work, project timelines may be prolonged, which entails long-term *commitments* by all participants for achieving the required level of trust and accountability. Straightforward and frequent *communication* is critical to such long-term interactions, which includes active listening techniques for eliciting diverse perspectives. *Process*-focused interactions (e.g., relationship-building; Ferguson et al. 2014), which lead to a sense of ownership or buy-in for the project, provide a framework for applying the results of translational ecology to a problem by facilitating trust-building and continued learning exchange. Finally, conducting the project within a shared *decision-framing* context enables the achievement of decision-relevant outcomes through an improved understanding of the users' needs, values, resources, and timeframe. Taken together, these principles provide a decision-making framework for addressing complex ecological issues and co-developing products that are accessible to broader audiences and stakeholder communities.

Here, we present successful applications of the principles of translational ecology that are paving the way for overcoming the research-implementation gap within avian conservation science. The majority of our examples take place in North America, given the composition of our team, and illustrate how shared decision-making has resulted in creative problem-solving and, ultimately, improved bird conservation and management outcomes that directly serve the needs of science users. Tools, programs, and research teams exist that join science and practice to achieve ecological outcomes ranging from climate change adaptation and natural resource management to environmental policy impacts (e.g., Beier et al. 2017, Evans and Cvitanovic 2018, Dayer et al. 2020a, Runge et al. 2020, Westwood et al. 2020). Our perspective builds upon this work by highlighting several case studies at the intersection of ornithology and bird conservation that show how both science users and producers contribute to translational processes. Our examples are not exhaustive, and we encourage readers to refer to, for instance, Drum et al. (2015), Runge et al. (2020), and Westwood et al. (2020) for further avian-related examples of co-produced research or decisions for improving conservation outcomes. We also note that our paper lacks coverage of the role of Indigenous peoples and other traditional community and stakeholder groups, and we encourage future translational work to consider additional sociocultural contexts in which research and conservation results are produced. Although each of these case studies incorporates elements of multiple translational ecology principles, we attribute cases to the principle they most effectively demonstrate for ease of interpretation. To illustrate the complete translational process, we present a comprehensive example of the 6-pronged translational approach being used to guide the management of free-roaming cats in Canadian cities. Through the case studies, we identify some of the core challenges faced during scientific producer–user engagement, potential tactics for overcoming these challenges, and lessons learned. We conclude with strategies for building a stronger translational science culture within ornithology and avian conservation as well as tangible recommendations for integrating these principles into decision-making more explicitly. By embracing translational ecology, bird conservationists and scientists can continue to close the research-implementation gap through simultaneous enrichment of the scientific process with practitioners' context-specific knowledge and development of relevant, scientifically informed management recommendations.

FOSTERING COLLABORATION WITHIN AND OUTSIDE OF RESEARCH TEAMS

The unidirectional and passive transfer of knowledge (e.g., via articles in scientific journals) has traditionally characterized the science producer–user relationship (Cash et al. 2006). However, the process to bridge the science-implementation gap is not linear, but complex and multidimensional (Stokes 2011, Westwood et al. 2020), often beginning with a problem or question that can be addressed through collaborative learning, knowledge sharing, understanding mutual goals, or a combination of all 3 techniques. For example, early collaboration with stakeholders outside the academic realm can establish a foundation for innovative conservation-oriented solutions. In one community science program, the Smithsonian Migratory Bird Center's Neighborhood Nestwatch (nationalzoo.si.edu/migratory-birds/neighborhood-nestwatch), a scientist visits participating yards annually to capture and color-band birds, measures habitat features, and monitors yards and the surrounding neighborhood for previously banded birds and nests. The one-on-one exchanges between the scientist and the participant regarding the backyard habitat provide a strong platform for shared stewardship of both the land and the birds. Such partnerships have resulted in a robust cohort of conservation advocates from within the general public, with over 80% of participants reporting increased awareness of their local environment (Evans et al. 2005). Concurrently, this collaboration has generated a rich dataset for understanding species–habitat relationships across urban gradients (e.g., Evans et al. 2015, Narango et al. 2017), enabling researchers to provide robust habitat recommendations to landowners, of which >50% have made habitat improvements in their yards (Evans et al. 2005).

PROMOTING ACTIVE AND CONTINUED ENGAGEMENT

Active engagement requires continued discussions of the complexities of current environmental problems and the efficacy of potential solutions. One of the most beneficial ways to foster the co-production of bird conservation knowledge by science users and producers, as well as encourage ongoing dialogue and action, is via individuals or organizations working at boundary-spanning organizations (Figure 1). The Great Lakes regional office of the National Audubon Society (a nonprofit organization with a dual mission of science generation and utilization) leads the Calumet Wetland Conservation Working Group, a team of science producers (Audubon scientists) and users (private landowners and coastal communities) who have been working to restore hydrological connectivity, natural water level management, and marshbird and native plant communities to wetlands along the southern shore of Lake Michigan since 2015. Audubon Great Lakes regularly engages with Calumet partners at every stage of restoration rollout, from goal formulation to restoration to joint data collection and reporting. Audubon's Government Affairs Team also supports on-the-ground restoration efforts by advancing conservation policy and building community connections with local Audubon chapters—assets that are not always available to other local agencies or institutions. In addition, Audubon Great Lakes' Wild Indigo Nature Explorations engagement program (gl.audubon.org/wild-indigo-nature-explorations) activates communities of color and often works in areas affected most by environmental injustice, thus bringing underserved voices to the conservation table. Through this multi-pronged engagement to provide science, social justice, and policy capacity, Audubon Great Lakes has launched other collaborative restoration projects at wetlands throughout the Great Lakes region.

ACHIEVING BUY-IN THROUGH DEMONSTRATED COMMITMENT

One way to generate shared commitment is by bringing scientists, managers, and other stakeholders together to jointly articulate the problems as decisions (Gregory and Failing 2012, Beier et al. 2017) and co-create conservation or management solutions. KuzeyDoğa, a community-based conservation organization focused on northeastern Turkey's highly biodiverse and threatened ecosystems (Akküçük and Şekercioğlu 2016), helped declare Lake Kuyucuk as eastern Turkey's first Ramsar wetland of international importance (i.e. wetland of ecological, botanical, zoological, limnological, or hydrological importance) and first European Destination of Excellence (EDEN) site for sustainable tourism in 2009. Since 2004, thousands of birds have been banded at the lake and multiple documentaries featured the site. As a result, press coverage increased exponentially, which spurred both local and national visibility and interest, and culminated in the Kars governor's and mayor's first visits to the lake in 2009 (Figure 2). Their interest in bird conservation following these visits resulted in their advocating for Ramsar and EDEN status. Following Ramsar and EDEN declarations, the government declared Kuyucuk an official "Bird Paradise" and demonstrated commitment to the local community by funding an upgrade to the village road and sewage systems and construction of a guesthouse and community center. Though the locals were initially hesitant to support the project, the combination of the income from tourism, government investments in infrastructure, and pride from receiving extensive media coverage generated enthusiasm and a sense of ownership.

STIMULATING KNOWLEDGE EXCHANGE VIA COMMUNICATION

The use of communication strategies (e.g., active listening and perspective elicitation) that promote the exchange and integration of knowledge into decision-making is a critical component of the translational process. Ideally, participants have regular opportunities to share feedback throughout the project's duration to maximize the value of the tailored end products for all parties. In one project team, the Intermountain West Joint Venture (iwjv.org) partnered with social scientists at Virginia Polytechnic

FIGURE 2. The Kars governor's and mayor's first visit to Turkey's Lake Kuyucuk to observe bird banding, which led to extensive media coverage, local pride, national awareness, and critical support for Lake Kuyucuk being declared eastern Turkey's first Ramsar wetland of international importance and EDEN site.

Institute and State University and University of Montana to conduct day-long landowner-listening workshops (Sketch et al. 2019) with the goal of integrating landowners' perspectives into wet meadow conservation plans. Wet meadows of the Intermountain West are critical for migratory and breeding waterbirds as well as brood-rearing greater sage-grouse (Donnelly et al. 2016). Analysis of the workshop dialogue within a sociological framework revealed that landowners face an array of natural, cultural, human, social, and political capital considerations in maintaining the viability of their ranches and feel that they are not adequately acknowledged for the societal and ecological benefits of their land management efforts (Sketch et al. 2020). Based on these findings, the Intermountain West Joint Venture and partners are now discussing the social–ecological complexity of landowners' decisions with a full-time communications specialist on staff. As a result, recent media (e.g., iwjv.org/beyond-the-banks) reveal an accurate story of ranchers, who are balancing multiple considerations in their ranching operations while simultaneously benefiting wildlife habitat.

BUILDING RELATIONSHIPS THROUGH PROCESS-DRIVEN INTERACTIONS

Desired outcomes, knowledge, and alternative actions are co-produced by users, local communities, and scientists through process-driven interactions. Relationship-building, however, is often time-consuming and met with reluctance from scientists, who are not trained in community engagement, as well as managers who hesitate to consider input from the public. Motivating local communities to invest in or support biodiversity conservation has been shown in many cases to yield stronger outcomes (Şekercioğlu 2012, Ortega-Álvarez et al. 2016). In Puget Sound, Washington, USA, a complex conservation issue concerns the relationship between marine fisheries recovery efforts and bird conservation. Puget Sound supports hemispherically important concentrations of shorebirds and waterfowl, but birds receive little consideration under state- and federal-funded ecosystem recovery efforts, which are largely driven by salmon recovery needs (Governor's Salmon Recovery Office 2018). Recognizing that information-implementation gaps (e.g., lack of bird monitoring data) may be preventing the integration of bird conservation into management frameworks, Audubon Washington led a collaborative team from the Puget Sound Ecosystem Monitoring Program (PSEMP) Marine Birds Work Group that hosted 2 regional workshops with robust participation across state and federal agencies, conservation NGOs, Indigenous communities (Quinalt Indian Nation, Skokomish Indian Tribe, Samish Indian Nation, Shoalwater Bay Indian Tribe, Stillaguamish Tribe of Indians, and Tulalip Tribes), and partners in Canada. Workshop participants revealed that institutional capacity and social support are critical for enabling a successful transformation of the current ad hoc approach to avian monitoring (Bayard et al. 2019). The project team continues to pursue the development of a regional monitoring framework for Puget Sound that addresses the spectrum of science, technical, and social needs voiced by stakeholders and instills a sense of a shared vision for bird and landscape protection in the region.

DEVELOPING A DECISION-FRAMING CONTEXT FOR COLLABORATION

Finally, co-development of a framework to facilitate decision-making and goal-setting across team members (e.g., establishing priorities and allocating funding) allows for adaptive actions and mutual learning. A useful decision-support framework incorporates information from diverse stakeholders and is transparent, actionable, and adaptable. The Gulf of Mexico Avian Monitoring Network (GoMAMN; gomamn.org), formed after the Deepwater Horizon oil spill in 2010, created a structured decision-making framework with stakeholders to help funding agencies and researchers better understand and incorporate the values of the bird conservation community into proposed Gulf of Mexico bird monitoring projects. The bird monitoring portfolio selection tool (Fournier et al. in press) synthesizes the values of regional stakeholders identified by GoMAMN, which are represented by 27 individual performance metrics that can be quantitatively evaluated. Potential monitoring projects are scored across all metrics, which are then summed to create a project-specific benefit score that can be used, along with other variables about the project (e.g., cost), to find an optimal solution to the conservation issue of interest. Because post-spill funding will continue to be released for the next 2 decades, decision-makers can use this support tool recurrently to evaluate possible bird monitoring projects and incorporate the values of the bird conservation community into their decision-making processes over time.

APPLYING TRANSLATIONAL ECOLOGY IN PRACTICE: MANAGEMENT OF FREE-ROAMING CATS IN CANADA

Domestic cat (*Felis catus*) predation is one of the most significant human-induced causes of bird mortality in North America (Calvert et al. 2013, Loss et al. 2015). The growing conflict over cat management strategies is often framed as an impasse between wildlife enthusiasts—who recognize cats as a threat to wild birds, mammals, and reptiles—and free-roaming cat enthusiasts, who believe that cats benefit from being allowed to roam at will outdoors (Crowley et al. 2020, Wald and Peterson 2020). For free-roaming cat management to be effective, all stakeholder groups benefit from a sense of empowerment and motivation to accept and implement management actions (Wald et al. 2013). However, the majority of research and reporting on this issue has occurred with little input, collaboration, and conversations among science producers (e.g., ornithologists and conservationists) and users (e.g., shelter workers and cat owners; Marra and Santella 2016, Loss and Marra 2018, Lynn et al. 2019, Wald and Peterson 2020). This lack of communication has often led to significant conflicts between these stakeholders. Below, we detail how the principles of translational ecology (Figure 3) have been used in several communities across Canada to overcome user-producer conflicts and enable the enactment of policies for managing free-roaming cats.

Guelph, Ontario, has emerged as a model city for *collaboration* because many Guelph-based research initiatives (e.g., web surveys and city-wide education campaigns) have incorporated diverse perspectives (e.g., Van Patter et al. 2019). These voices include humane society staff, trap-neuter-release organizations, veterinarians, leaders of education campaigns, community science and stewardship initiative representatives, government workers within the Canadian Wildlife Service, ornithologists, and social scientists studying the perception of cats in Canada. The desire for collaboration spurred the creation of the Guelph Cat Population Task Force in the early 2010s, a translational team that includes the above stakeholders. Following the first population assessment of cats in a Canadian urban area (Flockhart et al. 2016), task force members worked

FIGURE 3. Translational ecology principles and related goals for managing free-roaming cats in cities across Canada. See Table 1 for detailed definitions of each principle.

together to co-develop a white paper in 2018 summarizing relevant cat and bird research conducted within the city. These collaborative initiatives (Figure 3) helped form a national committee to tackle human–bird–cat conflicts across the country: The Cats and Birds National Advisory Committee, created by Nature Canada as part of their "Keep Cats Safe and Save Bird Lives" campaign (Nature Canada 2020; catsandbirds.ca). This committee aims to reduce conflict through the development of a cultural fluency that identifies commonalities among stakeholders and promotes the understanding of stakeholder values and goals within communities. Concurrently, at a local level in Vancouver, British Columbia, a boundary-spanning subcommittee of the Vancouver Bird Advisory Committee (VBAC) was created, the Cats and Birds Committee (CBC), to develop and implement a VBAC Cats and Birds Strategy (VBAC 2015) that includes a detailed outreach and education campaign encouraging safe and healthy habitats/homes for birds and cats in Vancouver.

Members of these collaborative teams regularly *engage* with each other (from monthly to biannually) to encourage relationship-building among stakeholders, develop trust, and foster understanding of diverse perspectives (Figure 3). Further, all teams have open invitations to new stakeholders who are willing to engage in constructive and respectful dialogue as well as to interested participants from under-represented parties. Group participants are aware that forming mutual respect and accountability takes time; long-term *commitments* are often necessary. Hence, many members have been involved since the committees' inceptions (Figure 3). Given the scale and complexity of the cat management issue, extended commitments can build capacity, identify common goals, and frame decisions appropriately. Each of these advisory committees fosters *communication* by creating agendas where each stakeholder group has scheduled opportunities to speak, and members are encouraged to share their perspectives and desires (Figure 3). This standardized communication approach helps members recognize collective aims, while also developing an understanding of where and why there may be potential conflicts.

Once the different needs and goals of each stakeholder group are understood and acknowledged, translational teams can begin to shift their work to be *process-driven* or focused on the achievement of specific initiatives or goals (Figure 3). As an example, the CBC collectively decided that scientific research was needed to estimate the number of free-roaming cats specifically within the city of Vancouver. To do this, the Stewardship Centre for British Columbia, with support from Environment and Climate Change Canada and expertise from researchers at the University of Guelph and the University of British Columbia, began a large-scale project to monitor and quantify the number of cats and birds within Vancouver city limits (SCBC 2020). For members of the CBC, this project led to a sense of ownership and strong buy-in and also generated interest and support from the municipal government and general public. The findings of this co-produced work are being incorporated by the CBC to develop a "Statement of Collaboration" that can act as a guideline for cat management and communication for all participating organizations in Vancouver (Figure 3). This statement (still in development at the time of writing) will provide the *decision-framing context* for conducting future research, developing educational programs and additional policy recommendations, and improving free-roaming cat management programs. Importantly, following a translational approach to produce this statement of collaboration has built trust, created a foundation of commitment, and set a precedent for continued engagement that will be critical for implementing mutually designed actions to manage free-roaming cats.

RECOMMENDATIONS FOR ENHANCING THE TRANSLATIONAL CULTURE IN ORNITHOLOGY AND AVIAN CONSERVATION

Translational ecology is, of course, not without its challenges (Table 2), some of which critically preclude its application in specific projects. While we promote the extension of translational ecology to include the implementation of co-produced decisions and subsequent monitoring and evaluation, we recognize that co-production of actionable science requires additional time and adequate funding resources that are not always available. To generate institutional solutions to broad-scale conservation issues, it is important to begin with fostering cultural norms that support translational ecology across organizations. Many of the practices we outline below (e.g., training and incentives) are already in use within environmental management programs and other disciplines (e.g., medicine and social policy; Mâsse et al. 2008, Hegger et al. 2012); here, we are advocating for their increased adoption in the fields of ornithology and avian conservation.

Building awareness of a translational ecology culture is most effective when introduced early in an undergraduate academic career and explicitly integrated into graduate training and during postdoctoral experiences (Fernández 2016). Translational ecology principles can be instilled in coursework (e.g., in structured decision-making courses), incorporated by individual advisors via curricula and laboratory policies, and conveyed via workshops held during professional society meetings and international ornithological conferences. In academic institutions where ornithology and/or conservation biology is taught at the undergraduate level, instructors have the opportunity to increase students' awareness by incorporating translational ecology concepts into discussions on conservation decision-making. For example, designing role-playing group assignments with one or more members representing the interests of the science producers (e.g., ornithologists), other members representing the interests of the science users (e.g., natural resource managers), and member(s) representing a boundary-spanning organization or social scientist would ensure that students learn the value of thinking creatively to balance science with real-world management constraints (Chapman et al. 2015). Inclusion of both avian conservation practitioners and ornithologists on graduate committees can also expose graduate students to the broader issues within their study systems and encourage the development of transdisciplinary vocabulary (Courter 2012, Cooke et al. 2020).

Previous work has identified the need for enhanced translational training for future scientists (e.g., Brunson and Baker 2016, Schwartz et al. 2017). Here, we further emphasize that an ideological shift can incentivize science-based conservation outcomes and create reward structures inside and outside the research arena that value translational science (in addition to basic or theoretical research). This reward structure could take several forms, including at the level of the funding agencies (e.g., Huutoniemi et al. 2010). Requiring identification of science users and their involvement on project teams as part of the grant criteria and allowing for timelines that are appropriate for such collaborative work—in addition to providing funds for team meetings, stakeholder engagement approaches, and development of science outputs that are structured to address user needs—are all potential strategies for promoting

TABLE 2. A synthesis of challenges faced, techniques for overcoming each challenge, and lessons learned when incorporating translational ecology principles into avian conservation work.

Challenge	Potential solution(s)	Lessons learned
Building, or rebuilding, trust among partners	Meet with partners individually first, then bring everyone together for decision-making; grant equal time and weight to all participants' ideas/ concerns	Trust should be built from the outset and actively maintained—if needed, steps should be taken to rebuild trust as soon as possible
Maintaining sustained engagement over long time periods	Plan for an iterative scoping process; create time "buffers" for unexpected changes and circumstances; establish teams that provide continuity over time	Plan for the long-term, realizing implementation will take sustained attention. Extensions of the scope are likely to contribute to a more successful end product
Democratizing decision-making	Develop transdisciplinary teams early to promote co-ownership of objectives/ goals and facilitate an openness to altering management strategies if the science indicates	Managers may be reluctant to share in decision-making with scientists and vice-versa but having both groups fully buy into the conservation process will facilitate shared knowledge exchange
Building mechanisms for ongoing communications between science producers and users	Develop dialogue models to promote 2-way knowledge exchange and achieve reciprocal understanding	Creating deliberate forums and modes of discourse will set the foundation for sustained communications after project completion
Sociopolitical constraints to management action and decision-making	Hold in-person workshops with small group activities designed to build trust and relationships, which can help elicit forthright input on barriers and constraints	Research/monitoring takes place within unique sociopolitical contexts; researchers must be cognizant of the real-world challenges that managers face in decision-making
Incorporating Indigenous peoples and/or traditional communities and stakeholders into the decision-making process	Engage and collaborate with Indigenous and/or traditional communities early and meaningfully to incorporate their perspectives; provide support, compensation, and/or acknowledgment for their contributions, as stipulated by the community	Trust-building is a critical first step, and team members should recognize that knowledge comes in many forms, including traditional ecological knowledge; participants should be mindful that conservation actions do not further gentrify or oppress marginalized communities
Developing research that is user-friendly, actionable, and timely	Invest in boundary spanners and/or social scientists who can provide the linkages across stakeholder groups to enable efficient co-production of relevant research	Decision-making timelines are usually fast-paced and demanding; thus, actionable, decision-relevant information should be anticipated and produced ahead of time

translational communities of practice. Such strategies would be particularly valuable for prioritizing funding allocations for migratory bird research by urging the creation of cross-hemispheric partnerships to achieve full-annual-cycle conservation outcomes (Drum et al. 2015).

Within academic institutions, the reward structure built into the promotion and tenure processes for faculty members can be flexible, accommodating individuals who excel at different aspects of ornithological research, including those whose work is truly collaborative and follows translational policies (e.g., Parsons and Cigliano 2020). Developing standardized metrics for translational outcomes can be challenging, but tenure packet templates could include such sections that encourage committees to evaluate these activities explicitly (e.g., Mâsse et al. 2008). Further, along with identifying student coauthors on academics' publications, coauthors who are science users could be highlighted (i.e. representing full involvement in science co-production). Reports and other products for science users (e.g., management agencies and news outlets) could also be listed alongside or after peer-reviewed publications as salient work.

Similarly, outside academia, conservation- or management-oriented organizations can reward and promote staff who cultivate collaborations that allow for the rigorous and sustainable use of the best available science in decision-making. With funding being reduced or eliminated for many conservation entities and staff positions, it is critical to continue investment in boundary-spanning organizations and teams, such as the National Audubon Society, Migratory Bird Joint Ventures, Birds Canada, American Bird Conservancy, and the North American Bird Conservation Initiative. Such boundary-spanning consortiums provide linkages across groups of stakeholders attempting to solve location-specific problems (Lawson et al. 2017) and promote the translational process by ensuring

2-way flows of communication that often extend beyond the original grant or project timelines (Westwood et al. 2020).

CONCLUSIONS

Although some of these recommendations entail a shift in the conservation culture, the development and support of transdisciplinary skills and relationships within avian conservation are a necessity for enacting effective management actions that satisfy both science producers and users. However, we recognize that using a translational framework for decision-making does not necessarily guarantee the successful implementation of conservation actions. Further, we acknowledge that our paper does not adequately cover the inclusion of traditionally marginalized communities within translational teams. Engaging with Indigenous peoples and/or traditional communities and stakeholders can be a critical step toward meaningful reconciliation and transformative justice, particularly in the context of Indigenous sovereign land management, where traditional ecological knowledge was used long before colonial Western knowledge (Renwick et al. 2017). While we do not discuss the roles and perspectives of Indigenous peoples and other traditional communities in ornithology here, we point the reader to other sources for further reading (e.g., Naves et al. 2019, Dayer et al. 2020b, Rayne et al. 2020, Wong et al. 2020). By working in a decision-framing context, science users and producers can achieve decision-relevant outcomes through their improved understanding of each other's values, needs, constraints, and timeframe. These translational conservation teams will only become more vital as global change continues to threaten human and avian communities at unprecedented rates with ever-increasing complexities and spatial scales around the world.

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