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Ten bridges on the road to recovering Canada's endangered species

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Abstract

Wildlife is declining around the world. Many developed nations have enacted legislation on endangered species protection and provide funding for wildlife recovery. Protecting endangered species is also supported by the public and judiciary. Yet, despite what appear as enabling conditions, wild species continue to decline. Our paper explores pathways to endangered species recovery by analyzing the barriers that have been identified in Canada, the United States, and Australia. We summarize these findings based on Canada's Species at Risk Conservation Cycle (assessment, protection, recovery planning, implementation, and monitoring and evaluation) and then identify 10 "bridges" that could help overcome these barriers and bend our current trajectory of wildlife loss to recovery. These bridges include ecosystem approaches to recovery, building capacity for community co-governance, linking wildlife recovery to ecosystem services, and improving our storytelling about the loss and recovery of wildlife. The focus of our conclusions is the Canadian setting, but our findings can be applied in other national and subnational settings to reverse the decline of wildlife and halt extinction.

Key words: *Species at Risk Act*, biodiversity, Aichi Target 12, extinction

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1. Introduction

The loss of wild species is a global issue (Barnosky et al. 2011; Pimm et al. 2014; Ceballos et al. 2015). Around the world many wild species that were once common are now declining (WWF 2020). Current extinction rates are up to one thousand times greater than natural historical levels (May and Lawton 1995; De Vos et al. 2015), and future rates are projected to increase. Globally, over 32 000 species are now assessed as threatened (IUCN 2020a), and up to one million species are at risk of extinction in the coming decades (Díaz et al. 2019; Tollefson 2019).

For over half a century there have been global efforts to list and recover endangered wildlife. The first International Union for Conservation of Nature (IUCN) list of endangered species was published in the 1960s (Scott 1965). Conserving endangered species is now a target of global conservation efforts including the *Convention of Biological Diversity* (CBD) (Aichi Biodiversity Target 12) (UN 1992) and the *United Nations Sustainable Development Goals* (Target 15.5) (UN 2018).

Over 35 countries have national legislation to prevent the extinction of wild species (Mooers et al. 2010). These laws are generally supported by the courts (e.g., Langlois 2019) and by the public. Four in five Americans support the *Endangered Species Act* (ESA) (Bruskotter et al. 2018) and almost

90% of Canadians agree that it is important to prevent extinctions (McCune et al. 2017). Legislation and action to recover endangered wildlife can be effective. In the United States (US), 39 species listed under the ESA have fully recovered (Greenwald et al. 2019). Globally, conservation actions have prevented 21–32 bird and 7–16 mammal extinctions since 1993 (Bolam et al. 2021).

Despite some promising conditions, we may currently be witnessing the "sixth extinction" (Pimm and Brooks 2000; Kolbert 2014; Ceballos et al. 2015, 2017). Wild species continue to be lost, including in jurisdictions with strong endangered species legislation.

Our paper explores pathways to reimagine and improve endangered species recovery in Canada. We start by reviewing the approaches and effectiveness of endangered species conservation in Canada, Australia, and the US. We then summarize the barriers to endangered species conservation that have been identified from these countries. The final section of our paper presents 10 "bridges" (Gunderson et al. 1995) that can support the transformation of endangered species management and change our current trajectory towards recovery.

2. Three countries, three Endangered Species Acts, same results

We reviewed and compared the approaches, effectiveness, and barriers of endangered species conservation of Canada with Australia and the US. We chose to review Australia and the US to find common issues and solutions that can be applied to endangered species conservation in Canada. These nations differ widely in their ecological setting, but share similar political and economic systems, histories of colonization, and national legislation to protect endangered species (**Table 1**). While the general framework of species assessment, listing, and recovery is similar, there are unique approaches in each country.

2.1. Canada

Canada has 80 000 known species and approximately 30 000 of those species have been assigned conservation status ranks by NatureServe (CESCC 2016). Due to its biogeography, Canada has fewer species than countries nearer the equator. This latitudinal gradient of species richness (Gaston 2000) also occurs within Canada, with more species occupying southern regions (Cameron and Hargreaves 2020). Most of Canada's endangered species are found along the southern border (Coristine et al. 2018). These southern regions are also where most Canadians live and the natural systems have been heavily altered (Venter et al. 2016).

The *Species at Risk Act* (SARA) is part of Canada's Biodiversity Strategy (Environment Canada 1995); the federal response after ratifying the United Nations *Convention on Biological Diversity* (CBA) in 1993. This international treaty made biodiversity a national interest. In Canada this federal interest in biodiversity protection is restricted by the constitutional division of powers (Campbell and Thomas 2002). The federal government has very limited jurisdiction in the provinces, and can only protect migratory birds, aquatic species, and species found on federal lands (e.g., national parks, national wildlife areas). All other species and geographies fall under the jurisdiction of the provinces. Federal responsibilities of SARA lie within three different departments. The Ministry of Environment and Climate Change (ECCC) is responsible for the overall coordination of the federal species at risk strategy and the protection and recovery of migratory birds. The Department of Fisheries and Oceans (DFO) is responsible for the protection and recovery of aquatic species at risk under federal jurisdiction. Parks Canada Agency is responsible for the development of recovery strategies for those species that occur in Canada primarily in national parks, national historic sites, and other federal protected heritage areas.

Table 1. Summary of species diversity and endangered species legislation in Canada, Australia, and the United States.

Attribute	Canada	Australia	United States
Number of listed species[a]	688	1890	2532
Number of globally imperiled species[b]	1616	Undetermined	17 634
Percent of listed species that are globally imperiled[c]	Approx. 10% (Raymond et al. 2018)	Estimated 80%	<99%
Number of nationally endemic mammals and birds[d]	5	611[e]	180
Number of Extinctions[f]	10	41 (territories not included)	285 (territories not included)
Legislation, year	*Species at Risk Act* (SARA), 2002	*Environmental Protection and Biodiversity Conservation Act* (EPBC Act), 1999	*Endangered Species Act* (ESA), 1973
Assessment categories	Extinct, Extirpated, Endangered, Threatened, Special Concern, Not at Risk, Data Deficient, Non-active[g]	Extinct, Extinct in the Wild, Critically Endangered, Vulnerable, Conservation Dependent	Extinct, Endangered, Threatened, Warranted but precluded, Endangered or Threatened due to similarity of appearance, Candidate[h]
Taxonomical units	Species, infraspecies, designatable units	Species, infraspecies + ecological communities and threatening processes	Species, infraspecies, distinct population segments
Assessment criteria	Based on IUCN Red List	Based on IUCN Red List	ESA Assessment Criteria
Private/federal land (%)	11%/41% (Neimanis 2013)	63%/<10% (Australian Bureau of Statistics 2020)	57%/28% (Hardy Vincent et al. 2017)
Annual Spending on Endangered Species ($US)	$60M (Smart Prosperity Institute 2018)	$92M (Wintle et al. 2019)	$1.478B (USFWS 2016a)

Note: IUCN, International Union for Conservation of Nature.

[a]Canada—Species at Risk Public Registry: Extirpated, Endangered, Threatened, Special Concern; US—Environmental Conservation Online System: Endangered, Threatened, Emergency Listing, Endangered, Emergency Listing, Threatened, Experimental Population, Essential, Experimental Population, Non-Essential, Similarity of Appearance (Endangered), Similarity of Appearance (Threatened); Australia—EPBC Act List of Threatened Fauna + Flora, includes Extinct species.

[b]Search of NatureServe: country + G1, G2, G3, GH, GX (Canada and US only). No sources found for Australia. Given the high number of endemic species the number of species of global conservation concern is likely in the tens of thousands.

[c]US number based on NatureServe Explorer search for ESA Endangered and Threatened species + global rank. Six species of 1538 are globally secure (G4, T4). Austrailian number from Species Profile and Threats Database query. Based on listed species that have been assessed as threatened on the IUCN Red List (290/362).

[d]Full species only (IUCN 2019a).

[e]Approximately 40% of Australian vertebrates and 84% of plants are endemic (Chapman 2009).

[f]IUCN Red List, "Extinct" and "Extinct in the Wild" categories. Over 50% of US extinctions are from Hawaii.

[g]COSEWIC (Committee on the Status of Endangered Wildlife in Canada) also maintains a candidate list of species for assessment.

[h]Populations can also be designated as "experimental" or "non-essential". "Partial status" applied when status only applied to a portion of the species range.

Canada's *Species at Risk Act* maintains a separation between species assessments and listing. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species (including subspecies, varieties, or other designatable units) that are suspected of being at risk of extinction or extirpation. The government then decides if species assessed as at risk will be listed under SARA in a schedule. Once listed, the species receives legal protection afforded and mandatory recovery planning required under SARA.

There are 810 species that COSEWIC has assessed in risk categories and 688 species are listed under the *Species at Risk Act*. Canada currently has 41 species that have been assessed as extinct or extirpated (Government of Canada 2020). This does not include all species assessed as extinct on the IUCN Red List (e.g., Rocky Mountain Locust (*Melanoplus spretus*)) or extirpated by NatureServe (e.g., Pale Avens (*Geum virginianum*)) and the actual number is higher. Regardless of the number of species lost from Canada, species continue to disappear, such as the recent extinction of the Hadley Lake Stickleback (*Gasterosteus aculeatus*) pairs (Taylor and Piercey 2018).

Key threats to species at risk include habitat loss (agriculture and urban expansion), over-exploitation, invasive species, and interactions with native species (Venter et al. 2006; Prugh et al. 2010; Woo-Durand et al. 2020). Human disturbance and invasive species are the most frequently listed threats in species recovery strategies (McCune et al. 2013). The threat of climate change and pollution are increasingly identified as threats to species at risk (Woo-Durand et al. 2020).

Federal, provincial, and territorial ministers are responsible for implementing SARA and, with the exception of the province of Quebec, signed the non-binding *Accord for the Protection of Species at Risk* in 1996. The federal government can enforce SARA through emergency orders and the "safety net" provision, but these are rarely invoked. As such, a patchwork of protection measures exist for most species through differing provincial and territorial interpretations and implementation of SARA (Olive 2015). For example, many species listed under SARA are not included in provincial or territorial legislation (e.g., BC, see Westwood et al. 2019), which can limit recovery efforts. The incongruency is most pronounced in the six jurisdictions (Nunavut, Yukon, British Columbia, Alberta, Saskatchewan, and Prince Edward Island) that do not have specific provincial or territorial endangered species legislation and manage species at risk under existing provincial acts (primarily wildlife acts).

There are several aspects of endangered species listing and recovery that are unique to Canada. SARA was influenced by the experiences of endangered species legislation in the US, and focuses on stewardship rather than regulation (Illical and Harrison 2007). Unlike the US and Australia, most endangered species in Canada are range-edge species that are of national, but not necessarily global, conservation concern (Raymond et al. 2018). Canada also prioritizes and assesses species through taxa-based Species Specialist Subcommittees within COSEWIC and assesses more wildlife below the species level (i.e., ecologically and evolutionarily distinct sub-species or populations) as designatable units than Australia and the US. Currently 27% of the species assessed as at risk or extinct by COSEWIC are below the species level, including 25 designatable units of Sockeye Salmon (*Oncorhynchus nerka*) and 11 designatable units of Caribou (*Rangifer tarandus*).

Recovery planning in Canada is also unique. While in the US and Australia the scientific bodies that assess risk are involved in the approval of recovery plans, COSEWIC does not have this role in Canada (although individual COSEWIC members may provide input to recovery strategies).

In Canada, most species do not change risk status categories (Favaro et al. 2014). An almost equal percent have moved to a higher (17%; uplisting) or lower (18%; down-listing or delisting) category (ECCC 2020a) when reassessed (usually every 10 years). However, there are issues in this

classification approach since most of the down-listings are the result of the discovery of new populations or changes in criteria and species classification, rather than genuine recovery that result from increased populations or threat mitigation.

2.2. Australia

Australia has been identified as a "mega-diverse country" (Mittermeier et al. 1997) with two global biodiversity hotspots along its eastern and southwestern coasts (Myers et al. 2000). Over 147 000 species have been documented, but the actual number is estimated to be over 566 000 (Chapman 2009). Because of Australia's continental isolation, most species are nationally endemic. Invasive species, habitat loss and modification, altered fire regimes, and agricultural activities are impacting the greatest number of endangered species (Evans et al. 2011; Kearney et al. 2019). Unlike Canada and the continental US, the main contributing factor to extinction in Australia is predators introduced to islands (Woinarski et al. 2015).

In Australia, the *Environment Protection and Biodiversity Conservation Act* (EPBC Act) is the main federal legislation to protect endangered species and, like Canada, was developed in response to the *Convention on Biological Diversity*. Species are prioritized and assessed by the Threatened Species Scientific Committee (TSSC). The TSSC reviews a nomination list annually and provides independent scientific advice to the Minister for the Environment on the proposed listing status and on the approval of recovery plans.

The EPBC Act has much broader scope than SARA and covers several matters of national environmental significance including threatened ecological communities (Government of Australia 2019). As with species, recovery plans are prepared for listed communities. In addition, key threatening processes can also be assessed and listed. Key threatening processes are those that are endangering, or could endanger, threatened species and communities. There are currently 21 key threatening processes that are listed, which include predation by feral cats, land clearance, and incidental catch of seabirds. However, the government has recently stopped listing threats under the EPBC Act (Cox 2020). Changes to endangered species legislation to reduce protection under the auspices of efficiency and removal of "red tape" is a common and reoccurring event that has also recently occurred in the US (Lambert 2019) and Ontario, Canada (Bergman et al. 2020).

In 2015, the federal government released the *Threatened Species Strategy* to accelerate the recovery of wild species (Government of Australia 2015). The strategy prioritized efforts and partnerships with local communities and state/ territory governments over a five-year period and set specific recovery targets.

Australia has experienced the largest documented decline in biodiversity of any continent over the past 200 years (Australian Bureau of Statistics 2020). It has one of the highest human-driven extinction rates of land mammals (Woinarski et al. 2015), with continued loss of potential critical habitat for threatened species and communities (Ward et al. 2019). Recovery plans do not have a significant effect on species conservation status (Bottrill et al. 2011). A recent study concluded that since Australia's EPBC Act was enacted, four times as many vulnerable species have declined in their threat status than have improved (Simmonds et al. 2019). This is likely the result of both delayed ecological responses to conservation actions (Watts et al. 2020) and ineffective approaches.

2.3. United States

The US has also been identified as a "mega-diverse country" (Mittermeier et al. 1997) with a high richness of endemic freshwater fishes and mussels, turtles, and salamanders (Stein et al. 2000). The California Floristic Province, Polynesia-Micronesia (including Hawaii), and the North American

Coastal Plain have been identified as biodiversity hotspots (Myers et al. 2000; Noss et al. 2015), and most endangered species occur in these regions (Dobson et al. 1997). There are an estimated 200 000 species in the US and one-third of these are of conservation concern (Stein et al. 2000). Primary threats to endangered species are habitat loss, invasive species, and pollution (Wilcove et al. 1998; Evans et al. 2016). These threats, along with climate change, have generally been increasing over time (Leu et al. 2019).

The ESA (1973) is among the world's first national endangered species legislation. The US Fish and Wildlife Service leads the process of species nomination, assessment, listing, and recovery planning. The most important factors for listing species under the ESA are the magnitude and immediacy of threats and taxonomic distinctiveness (USFWS 2016b). Although there is coordination between the federal and state governments through *State Wildlife Action Plans*, most states have not enacted complementary legislation and provide little funding to the management and recovery of endangered species (Camacho et al. 2017).

There are notable differences between the US and Canadian approaches to listing and recovery (Olive 2014a, 2014b, 2016; Pawluk et al. 2019). ESA assessment criteria focus on threats and the effectiveness of existing protections, but do not include intrinsic factors that increase extinction risk (e.g., small populations) (USFWS 2016b). In the US "distinct population segments" can only be applied to vertebrates such as Grizzly Bear (*Ursus arctos*) in the Lower 48 states (Rosen 2007), whereas in Canada designatable units have been also applied to vascular plants, lichens, mussels, and insects.

The ESA has a long history of negotiating and implementing conservation on private lands (Davis et al. 2005), including many legal challenges (Simberloff 1987; Plater 2004). In 1982, the ESA was amended to introduce *Habitat Conservation Plans* to provide private landowners with long-term assurances about land use restrictions in exchange for conservation measures. While these agreements can result in loss of habitat for the endangered species, there is general consensus that endangered species benefit (Langpap and Kerkvliet 2012). In addition to supporting regulatory compliance, these agreements foster cooperation between governments, landowners, and interest groups. Despite a focus on federal regulation, the US has overcome many stewardship challenges and other issues related to endangered species conservation on private lands.

The ESA has prevented the extinction of roughly 291 species, and more than 99% of species under its protection remain extant (Greenwald et al. 2019). It has been particularly effective for marine mammals and turtles that were threatened with over-exploitation (Valdivia et al. 2019). There is also evidence that recovery plans and critical habitat are effective because they spark conservation action (Taylor et al. 2005). However, 52% of listed species are continuing to decline and few species are down-listed or delisted (Evans et al. 2016). Since being enacted, four species listed under ESA have become extinct and 22 are possibly extinct (Greenwald et al. 2019). As with Canada and Australia, there are many other species that have not been listed by national endangered species legislation and have continued to decline.

2.4. The same results

Among the three case study jurisdictions, there is over 85 years of experience in implementing contemporary national endangered species legislation. While there is evidence that endangered species listing and recovery have slowed species declines and there have been notable recoveries, the results have been the same: none of the approaches have been fully effective in preventing the decline and loss of endangered species. In the next section we explore some of the barriers that are preventing more effective recovery.

3. A review of barriers to endangered species recovery

Several recent studies have examined the effectiveness of the IUCN Red List (Betts et al. 2020), ESA (Evans et al. 2016), and EPBC (Scheele et al. 2018) (**Table 2**). In addition to reviewing these benchmark studies, we conducted a literature search in the Web of Science on national endangered species legislation from the three case study countries. We searched by country/national legislation name, and by the name of the county and the nomenclature commonly used to describe threatened species (e.g., "Canada" + "Species at Risk Act"; "Canada" + "species at risk"; "United States" + "Endangered Species Act"; "United States" + "endangered species"; "Australia" + "Environment Protection and Biodiversity Conservation Act"; "Australia" + "threatened species". We screened our results to focus on papers from the last decade that identified issues with current approaches and proposed opportunities to overcome these issues. We also searched Google News for these terms to identify current events related to changes in endangered species legislation.

We reviewed these papers through a Canadian lens and organized the barriers they identified based on the components of Canada's Species at Risk Conservation Cycle: assessment, protection, recovery planning, implementation, and monitoring and evaluation (ECCC 2018b) (**Table 3**). The results of our review are not intended to catalogue criticisms of current approaches but to identify key issues that may be limiting our current response to wildlife decline.

The barriers we identified are diverse but also interrelated. They include the economic barriers of perverse incentives (Langpap and Wu 2017), political barriers such as delays in government listing (Ferreira et al. 2019), structural barriers that discourage qualitative measures (Doak et al. 2015) and reporting (Bottrill et al. 2011), and social barriers that range from our bias towards certain species (Bellon 2019) to the traditional paucity of social sciences in conservation (Bennett et al. 2017a).

Table 2. Summary of recommendations by recent reviews of International Union for Conservation of Nature (IUCN) Red List, and *Environmental Protection and Biodiversity Conservation Act*.

IUCN Red List	United States	Australia
Betts et al. (2020)	Evans et al. (2016)	Scheele et al. (2018)
1. Improve scientific knowledge.	1. Establish and consistently apply a system for prioritizing recovery funding.	1. Stakeholder engagement and communication.
2. Raise awareness of conservation issues.	2. Strengthen partnerships for species recovery by expanding collaboration and by developing incentives for private landowners.	2. Foster strong leadership and the development of achievable long-term goals.
3. Better understand conservation priorities and planning.	3. Promote more monitoring and adaptive management for species recovery.	3. Knowledge of target species' biology and threats, particularly focusing on filling knowledge gaps that impede management, while noting that in many cases there will be a need for conservation management to proceed initially despite knowledge gaps.
4. More or better targeted funding and resource allocation.	4. Refine methods to develop more objective, measurable recovery criteria.	4. Setting objectives with measurable outcomes.
5. Legal and policy development or change.	5. Use well-established climate-smart conservation strategies.	5. Strategic monitoring to evaluate management effectiveness.
6. More or better targeted conservation action.	6. Evaluate ecosystem-based approaches such as surrogate species and coarse ecological filters to develop methods that increase the efficiency of managing for recovery.	6. Greater accountability for species declines and failure to recover species to ensure timely action and guard against complacency.

Table 3. Barriers and opportunities for endangered species recovery.

Barriers	Description of barrier	Proposed opportunities
Assessment The missed opportunity of prelisting conservation	Few programs support conservation of species before they are listed. Canada's Habitat Stewardship Program (HSP) only funds recovery actions for listed species. HSP did incorporate a "prevention stream" funding program starting in 2014–2015, but it has been discontinued, and is not included in the new Pan-Canadian Approach. Wildlife recovery can be less expensive and more effective when deployed before species populations reach crisis levels (Li and Male 2015).	There are hundreds of species that could be eligible for SARA listing. Canada's Habitat Stewardship Prevention Stream could be reintroduced, or a COSEWIC candidate species incorporated into assessments and recovery strategies. Prelisting conservation of candidate species has successful prevented candidate species from being listed in the US (Donlan 2015). Tools ranging from RAMAS software to machine-learning (Pelletier et al. 2018) can rapidly assess species that are likely to be assessed as at risk so that early conservation interventions can be supported.
Assessment/ protection Unmanageable backlog of species to assess and list	Many threatened species are not listed. For example of 22 species of fishes identified as highly threatened by experts in Australia, 19 are unlisted (Lintermans et al. 2020). COSEWIC has a backlog of species that may warrant listing. There are currently over 500 vascular plants on the COSEWIC candidate list. While the full costs for SARA listing have not been determined, in 2021 the average contract value to prepare a new assessment for vascular plants was $11 200. Many species that are critically imperiled in Canada, such as Cleland's Evening-primrose (*Oenothera clelandii*) have been on the COSEWIC candidate list for years while their status has likely deteriorated.	Many species that are assessed and listed could serve as umbrella species (Simberloff 1998) for candidate species. Assessment and recovery planning can also be done for higher taxonomic groups (e.g., dragonflies) or indicator species (Braby 2018). While Australia lists threatened ecological communities, this could be complimented by identifying and listing faunal communities (Fraser et al. 2019). Canadian examples of faunal communities would include grassland birds or Great Lakes coast wetland fishes. This could be a gateway to ecosystem approaches to listing and recovery, or bundling species assessments. Species that are assessed as at risk, and then down-listed based on non-genuine status changes, such as the discovery of additional populations (IUCN 2020b) also add to the backlog (e.g., Pygmy Pocket Moss (*Fissidens exilis*)). More surveys before listing and the use of species distribution models are needed (McCune 2019).
Assessment/ protection Too much focus on range edge species	Many species at risk in Canada reach their northern range limit in southern Canada (Glass et al. 2017). A study on vascular plants found that almost 80% of listed species at "edge" species (Klemet-N'Guessan et al. 2019). While nationally imperiled, they are often globally common. Canada's conservation of these species does not support global conservation efforts. Edge of range species are prioritized over global status (Raymond et al. 2018).	The purpose of SARA protected all wild species. While some edge of range species that are globally secure may be a lower priority for conservation in Canada, species redistribution science (Bonebrake et al. 2018) is providing new approaches to assess which edge of range species may be critical to support climate change driven range shifts, and that "leading edges" should be targeted for conservation (Gilbert et al. 2019). For example the range of American Chestnut (*Castanea dentata*) is projected to shift northward (Barnes and Delborne 2019) and the Canadian "edge" could play an important role in its conservation. The significance of Canadian edge populations in global conservation could be used to prioritize edge species.
Assessment/ protection Biases of charismatic species	Charismatic species are more likely to be listed as threatened and receive funding for conservation actions leading to the neglect of other taxonomic groups (Mooers et al. 2007; Walsh et al. 2013; Bellon 2019; Creighton and Bennett 2019; Mammides 2019). Charismatic species are also more likely to have specific recovery strategy targets (Théberge and Nocera 2014). Birds and mammals generally require more resources to recover resulting in unequal resource allocation among taxonomic groups (Gordon et al. 2019).	The public is attracted to charismatic species, and these can be used as flagships to leverage conservation (Thompson and Rog 2019; McGowan et al. 2020). Scientists that prioritize species and prepare assessments and recovery plans can unconsciously commit "stealth policy advocacy" (Wilhere 2017). This can be reduced by training and awareness of motivational and other sources of bias (Burgman 2004). Priority lists should be prepared that are focused on extinction risk. In Canada vertebrate experts may now become focused on reassessments rather than new assessments since there has been a bias on assessing these taxa.

(*continued*)

Table 3. (*continued*)

Barriers	Description of barrier	Proposed opportunities
Protection Delayed listing	Delays in listing species after they are assessed has been identified as a key issue in Canada (Ferreira et al. 2019) and the US (Puckett et al. 2016; Walls et al. 2017; Malcom and Li 2018).	Listing delays in Canada tend to be for widespread but declining species that intersect with major land uses. For these species initial listing could be limited to Special Concern which will not trigger critical habitat designations. This would allow government and user groups to develop and implement conservation strategies to prevent future listing as Threatened or Endangered.
Recovery planning Delayed recovery plans	Delays in developing recovery plans is a significant barrier in endangered species conservation (Mooers et al. 2007, 2010). In the US, one-fourth of listed species lack final recovery plans and half of recovery plans are more than 20 years old. There is also significant variation in planning between agencies, and among regions and taxonomic groups (Malcom and Li 2018).	Recovery plans may not actually impact the status of species (Bottrill et al. 2011), and just assessment should trigger conservation actions. Recovery planning could also be streamlined in Canada by not repeating detailed information that is previously covered in assessments including biology of the species and threats. Involving COSEWIC in recovery planning, or at least setting thresholds for recovery during species assessments would be consistent with approaches in Australia and the US and could help improve and streamline the process.
Recovery planning Delayed identification of critical habitat	The protection of critical habitat is one of the most contentious decisions of environmental agencies (Martin et al. 2017). In Canada 62.9% of listed species lack critical habitat designation (Bird and Hodges 2017). The US. Fish and Wildlife Service often has not designated critical habitat, based on the legal exceptions in the ESA of "not prudent" or "not determinable" (Hagen and Hodges 2006).	Critical habitat may not actually be effective for species conservation. In the US critical habitat designation did not have a significant impact on land use change, especially when compared to other factors such as land prices (Nelson et al. 2017). However, in Australia species with critical habitat were more likely to be improving (Taylor et al. 2005). In Canada, most critical habitat is primarily designated on federal lands that are already protected. Fear of lawsuits and backlash makes governments hesitant to introduce critical habitat. Critical habitat is probably not the best term to market conservation to private landowners. Introduction of Habitat Conservation Plans (used in the US), greater public awareness and locally led implementation (Jones et al. 2019) could reduce the opposition.
Recovery planning Climate change not considered in recovery	An estimated that 15%–37% of species may be "committed to extinction" as a result of climate change (Thomas et al. 2004), although there are knowledge gaps regarding adaptation, microhabitat buffering, accuracy of models and tipping points (Moritz and Agudo 2013). Threatened and endangered species are likely to be disproportionately affected by climate change because they are often habitat specialists and rare. In the US agencies consider climate change as a threat to 64% of species but plan management actions for only 18% (Delach et al. 2019). In Australia, just under 60% of the sampled recovery plans listed climate change as threat and only 22%, identified specific actions (Hoeppner and Hughes 2019).	There are tools that can model future habitat (e.g., Maxent and bioclimatic modeling) and this information can be incorporated into recovery actions, refine climate change threat and prioritize species (Stewart et al. 2018; Wilkening et al. 2019). Practitioners may need to re-consider the concept of native range (Pereyra 2020) and be prepared for assisted migration. Conservation banking or other offsets could be targeted at areas where species are likely to occur in the future (i.e., climate banking) (Whipps 2015). Approaches to climate banking include future habitats, ark easements and stepping stones (Kimbrell 2010).

(*continued*)

Table 3. (*continued*)

Barriers	Description of barrier	Proposed opportunities
Recovery planning Inconsistent or ineffective threat assessment and recovery criteria	Recovery plans have diverse authors and approaches can be inconsistent, particularly in how threats are assessed and recovery criteria developed (Brigham et al. 2002; Ortega-Argueta et al. 2017; Scheele et al. 2018). Recovery objectives often lack qualitative measures to assesses recovery progress (Doak et al. 2015) or don't incorporate the full suite of criteria needed to assess success (Wolf et al. 2015).	Expert judgements in assessing status and threats are subject to heuristics that can bias judgements (Heeren et al. 2017). Providing tools to avoid these will improve consistency. In Canada, the adoption of the IUCN threats calculator has improved consistency in threats assessment, although there is no requirement to justify decisions with data. Using climate vulnerability assessment tools would improve predictions for the threat of climate change (Young et al. 2010). Authors need guidance on developing recovery criteria and thresholds (Ortega-Argueta and Contreras-Hernández 2013; Che-Castaldo and Neel 2016). An analysis of past recoveries and a database on recovery objectives, thresholds and actions would support greater consistency. Metrics of threats progress would also support comparisons (Garnett et al. 2019)
Implementation Lack of engagement and use of social sciences	While conservation may be about the state of biodiversity, implementation requires changes in social systems including values, beliefs and norms. Although there is an on-going shift in conservation towards social and political factors (Hintzen et al. 2020), traditionally conservation has not fully incorporated social sciences due to ideological, institutional, knowledge, and capacity barriers (Bennett et al. 2017b).	Broader engagement informs management and outreach decisions and enhances collaborative decision-making, which results in improved conservation outcomes (Sawchuk et al. 2015; Rodgers et al. 2017). While species assessments are beginning to incorporate Indigenous traditional knowledge (Hill et al. 2019), they do not address the social landscapes where species live (other than threats). Adding community knowledge and values to assessments, engaging social scientists in recovery actions and including a communications and marketing plans in recovery strategies could improve their effectiveness.
Implementation Failure to protect critical habitat	Often critical habitat protection is not enforced. In Australia over 7.7 million ha of potential threatened species habitat and threatened communities were cleared in the period 2000–2017 (Ward et al. 2019). In Canada, critical habitat is lost through exemptions to user groups including agriculture and forestry.	Offsetting and habitat banks based on the principle of "net positive gain" (Bull et al. 2020) could support a more flexible approach to critical habitat protection. Flexible market-based approaches to implementing SARA would increase support, reduce conflicts and, if properly implemented, lead to better conservation outcomes (Smart Prosperity Institute 2018).
Implementation Insufficient critical habitat	Critical habitat is often not based on the needs of the species to persist because of data limitations or a desire to limit conflicts with resource users and potential legal challenges (Camaclang et al. 2015).	Evidence on the effectiveness of critical habitat in supporting species recovery is mixed, but it appears to be less important than a recovery plan (Langpap et al. 2018). For some species, critical habitat designation should be more flexible, including non-regulatory designations.
Implementation Perverse incentives	Regulations and habitat designations, both enacted and pending, can create the incentive for landowners to remove habitat to avoid regulation (Langpap and Wu 2017; Ward et al. 2019).	Enhance initiatives on private land by making government-funded stewardship programs more directed, flexible, and incentive-based (Smart Prosperity Institute 2018)Local implementation can reduce perceived threats of regulation (Jones et al. 2019). Incentive programs such as cost sharing and compensation can increase adoption of species stewardship activities (Pittman 2019) and help overcome perverse incentives created by regulation (Langpap et al. 2018).
Implementation Key and cumulative threats not effectively managed	Recovery strategies may not address key threats. Prioritizing strategies based on the prevalence of threats may have a low probability of success and not be cost-effective (Butt et al. 2020).	In addition to IUCN threats categorization and calculation and prioritizing threats based on impact, threats need to be prioritized by management effectiveness (Carwardine et al. 2019) and probability of success (Prugh et al. 2010) Place-based approaches in endangered species hot-spots may be better positioned to understand and mitigate cumulative threats than actions based on individual species.

(*continued*)

Table 3. (*concluded*)

Barriers	Description of barrier	Proposed opportunities
Implementation Protected areas not effectively identified, created or managed	There is often a mismatch between protected areas and key areas for endangered species (Rodrigues et al. 2004). This pattern is well known from Canada (Deguise and Kerr 2006) where the Mixedwood Plains Ecozone has one of the country's highest numbers of endangered species and only 1.9% is protected (ECCC 2020c). Protected areas can give a false sense of conservation if they are unable to manage continued threats (Kearney et al. 2020). In Canada the primary threat to species with recovery plans was recreation, primarily within protected areas (McCune et al. 2013).	Protected areas can be very effective. Endangered species with most of their range in protected areas are more likely to have stable or increasing populations (Taylor et al. 2011). Biodiversity is higher in protected areas than the surrounding landscape (Gray et al. 2016). Protected areas may also provide important climate change buffers where species can persist as broader landscape strategies are developed (Lehikoinen et al. 2019). Systematic conservation planning (Margules and Pressey 2000) has been effective in Australia to align new protected areas with key areas for threatened species (Barr et al. 2016). Conservation planning tools can also incorporate costs in setting spatial priorities (Carwardine et al. 2008). The Key Biodiversity Area initiative will support the identification of critical areas (IUCN 2016).
Monitoring and evaluation Lack of accounting and reporting	The lack of basic accounting in recovery strategies makes it difficult to assess their effectiveness (Bottrill et al. 2011). In Canada species recovery is most often reported as case studies and examples rather than a systematic account and analysis of results and factors of success.	Better accounting of recovery plans promotes transparency, improves future actions and investments (Bottrill et al. 2011) and can be enhanced by regular monitoring and reporting (Ortega-Argueta 2020). Canada's reporting once done by the Recovery of Nationally Endangered Wildlife program should be reinvigorated to consolidate and share lessons of recovery.

Note: SARA, Species at Risk Act; COSEWIC, Committee on the Status of Endangered Wildlife in Canada.

Some of the barriers are deeply rooted in constitutional frameworks and the division of powers including Indigenous rights, treaties, and land claims.

Funding is certainly a key issue for species recovery (Gerber 2016; Luther et al. 2016; Wintle et al. 2019) and will be important to help overcome some of these barriers (Langpap et al. 2018). Change in political leadership has also been shown to influence endangered species policy and implementation (Lambert 2019; Bergman et al. 2020). However, we have chosen to focus on new approaches and not directly include funding or political change in the bridges we identified to overcome these barriers.

4. Ten bridges on the road to recovery

We developed our 10 bridges to help span the gap from our current state of wildlife loss to a future state of recovery (**Box 1**). We recognize that building and crossing many of these bridges will require transformative change. Fortunately, calls for transformation in the conservation of wild species are being made. For example, the recent global assessment by the *Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services* has called for "transformative changes" across social, political, and technological dimensions of society (Bridgewater et al. 2019; Díaz et al. 2019). The new *Pan-Canadian Approach to Species at Risk Conservation* calls for a "transformative approach to operationalizing species at risk conservation" (ECCC 2018a). As part of this transformation the pan-Canadian approach has also identified priority places, priority species, and priority threats and sectors, and the goals include better outcomes for species at risk and increased co-benefits for biodiversity and ecosystems.

Box 1. Ten bridges to support transformation of endangered species recovery in Canada.

1. National action for global priorities
2. Place-based and threat-based recovery
3. Clearer recovery targets
4. Species recovery through ecosystems approaches
5. Building capacity for community co-governance
6. Significant net gain
7. Document the full benefits of recovery
8. Ambitious and future-forward translocations
9. Species need stories
10. Share success (and failure)

Our definition of this transformation is a change in trajectory of widespread biodiversity loss to that of recovery and, ultimately, zero extinction. A global vision of this transformation has recently been expressed in the *Abu Dhabi Call for Global Species Conservation Action* to prevent human-driven extinctions by 2030 (IUCN 2019b). Achieving this vision will require a rethinking of our current conservation practices and, ultimately, our relationship with nature.

Based on the barriers we summarized in our synthesis of the literature (**Table 3**) we identified 10 bridges that could provide solutions (**Table 4**) (Gunderson et al. 1995). These 10 bridges are intended to support the direction of the *Pan-Canadian Approach* and the transformation of endangered species recovery, with a goal of halting extinctions and extirpations from Canada.

Bridge 1: National action for global priorities

More focus on globally imperiled and endemic species will support endangered species conservation in Canada and is our most important contribution to stopping extinction.

Canada has not prioritized globally at-risk and nationally endemic species for conservation (Raymond et al. 2018). Of the 381 species and 188 infraspecies that are globally imperiled based on NatureServe conservation status ranks (Rainer et al. 2017, Appendix B) only 34% have been assessed by COSEWIC, and COSEWIC has assessed less than 20% of Canada's 308 nationally endemic species and infraspecies (Enns et al. 2020). This is in sharp contrast to Australia and the US where most nationally listed species are also globally imperiled (**Table 1**). SARA does not prioritize, but COSEWIC has latitude to refocus on species of global conservation concern. Prioritization of candidate species already includes global status and Canadian responsibility, including endemism (COSEWIC 2019). COSEWIC could expand on existing taxon-based candidate lists to create a master list of Canadian species of global conservation concern based on NatureServe conservation status ranks and the IUCN Red List of Threatened Species to prioritize future assessments that are based on endemism and global rank. Ensuring that all species of global conservation concern are priority candidates for assessment and subjected to the prioritization exercise will support both the purpose of SARA and Canada's commitments to protect global biodiversity under the CBD.

Table 4. Summary of barriers and bridges for endangered species recovery.

Barriers	Key bridges
Assessment The missed opportunity of prelisting conservation	Place-based and threat-based recovery Species recovery through ecosystems approaches Building capacity for community co-governance
Assessment/protection Unmanageable backlog of species to assess and list	Place-based and threat-based recovery Species recovery through ecosystems approaches
Assessment/protection Too much focus on range edge species	National action for global priorities Species recovery through ecosystems approaches
Assessment/protection Biases of charismatic species	National action for global priorities Species recovery through ecosystems approaches
Protection Delayed listing	Place-based and threat-based recovery Species recovery through ecosystems approaches
Recovery planning Delayed recovery plans	Species recovery through ecosystems approaches Building capacity for community co-governance
Recovery planning Delayed identification of critical habitat	Species recovery through ecosystems approaches
Recovery planning Climate change not considered in recovery	Place-based and threat-based recovery Ambitious and future-forward translocations
Recovery planning Inconsistent or ineffective threat assessment and recovery criteria	Clearer recovery targets Ambitious and future-forward translocations
Implementation Lack of engagement and use of social sciences	Building capacity for community co-governance Significant net gain Document the full benefits of recovery Species need stories
Implementation Failure to protect critical habitat	Significant net gain Document the full benefits of recovery
Implementation Insufficient critical habitat	Significant net gain
Implementation Perverse incentives	Significant net gain Document the full benefits of recovery Building capacity for community co-governance
Implementation Key and cumulative threats not effectively managed	Place-based and threat-based recovery Significant net gain
Implementation Protected areas not effectively identified, created or managed	Place-based and threat-based recovery Species recovery through ecosystems approaches Building capacity for community co-governance
Monitoring and evaluation Lack of accounting and reporting	Clearer recovery targets Species need stories Share success (and failure)

Unless additional resources are provided to COSEWIC, expanded global prioritization may result in a conservation trade-off between assessing globally imperiled species and species at the northern edge of their range or designatable units. The reassessment of globally secure species that are listed under SARA could be deferred unless there is a high probability of a status change to create additional capacity to assess globally imperiled and endemic species. These trade-offs are not ideal. The purpose of SARA is to provide for the recovery of all wildlife that is at risk, and designatable units and species at the northern edge of their range can have important evolutionary significance (Glass et al. 2017). But trade-offs are already being made in current approaches in deciding which species to assess. Our future conservation prioritization should be deliberate and deliberated in consideration of global status, genetic distinctiveness, significance as leading-edge populations (Carvalho et al. 2019), and potential for future reintroduction.

Bridge 2: Place-based and threat-based recovery

Clearly grouping species that can best be protected through place-based actions and species that need threat mitigation would support and accelerate conservation efforts.

How species are protected should depend on intrinsic extinction risks and threats. Very different approaches are needed to conserve "declining populations", "small populations" (Caughley 1994), and "recovering populations" (Hutchings 2015). Species that have small ranges, low numbers, and narrow habitat specificity are the most vulnerable to changes in land use (Sykes et al. 2020), stochastic events (Smith and Almeida 2019), and ultimately to extinction (Staude et al. 2020). These species should be the focus of the most urgent conservation actions including habitat protection and translocations, particularly when they are endemic or of global conservation concern.

Many "small population" species can be directly conserved through place-based actions. A comprehensive national strategy to include these in Canada's new protected areas would support their conservation. Over 60% of Canada's species at risk occur in nine "crisis ecoregions" that cover just 5% of Canada's lands and inland waters (Kraus and Hebb 2020) and many, "small population" endangered species co-occur in remnant habitats. New protected areas and habitat restoration in these areas can support the conservation of small population endangered species. The spatial extent of these areas need to be clearly identified and prioritized beyond the current number and spatial scale of "Priority Places" (ECCC 2018a). Many of the areas that support a high richness of species at risk are known and could be refined by combining existing data sets and through species distribution models (Rosner-Katz et al. 2020). Multiple species that are spatially restricted can often be effectively conserved through ecosystem approaches (see Bridge 4).

Although wildlife recovery in Canada was founded on the protection of common species that had become scarce (e.g., Plains Bison (*Bison bison bison*), Pronghorn (*Antilocapra americana*)), proactive protection of common but declining species to prevent future endangerment is relatively new to conservation. For the first 21 years of COSEWIC qualitative criteria that focused on species with small ranges and populations were applied to assess risk (Shank 1999). Adoption of the IUCN criteria (IUCN Standards and Petitions Subcommittee 2017), and in particular criterion A (declining populations), has resulted in the listing of species that are still common and widespread but rapidly declining such as Barn Swallow (*Hirundo rustica*) and Snapping Turtle (*Chelydra serpentine*). These species often occur in regions dominated by farms, cities, and forestry and have been the source of much of the conflict and criticism around SARA (e.g., Boan et al. 2018).

Conservation of these species will often require changes in socio-economic systems. Depending on the rate of decline there may be more time to formulate and implement recovery strategies for this

group than for species with small populations or ranges. In the case of common but declining species, delayed listing could be beneficial if that time is used to constructively build alliances and support for recovery. Preemptive and cooperative conservation actions that could reduce future regulation can be used as an incentive to spark and implement threat mitigation strategies. Current initiatives of the federal government to engage priority sectors (forestry, agriculture, urban) in species at risk recovery and priority threat management approaches (Carwardine et al. 2019) may lead to new models of co-governance (see Bridge 5).

Categorizing species during the assessment process into clear "risk/recovery groups" based on their needs for place-based or threat-based recovery could help to accelerate and coordinate conservation actions by grouping species that can be conserved at common locations or by managing common threats. These categories could be based on existing assessment criteria (e.g., declining or small population) and other factors such as habitat, highest threats, and location). This approach would provide direction to recovery strategy authors, highlight existing species in the same risk/recovery group so that current actions can be incorporated into new recovery plans, facilitate the coordination of actions, and encourage actions prior to a final recovery strategy. A simple one-page addendum to existing COSEWIC assessments the provides the committee's perspectives on general recovery needs would help to jump-start both recovery planning and actions.

Bridge 3: Clearer recovery targets

Recovery goals with clear benchmarks make it easier to measure progress and are more likely to be achieved.

Canadian recovery strategies lack consistency in applying measurable and timebound objectives and thresholds. These are precisely the types of conservation targets that are more likely to be achieved (Green et al. 2019). Quantitative metrics allow practitioners to focus on goals and report on the recovery of endangered species (Gerber and Hatch 2002). Quantifiable and ambitious goals are more prevalent under the ESA than SARA (Pawluk et al. 2019). Clearer recovery targets would also allow progress across taxa and jurisdictions to be better tracked, support the identification of best practices, and help practitioners focus on actions that have the highest probability of moving a species towards a defined threshold.

SARA requires the development of one or more action plans based on the recovery strategy for species listed as extirpated, endangered, or threatened. These action plans often contain more detail on timelines and quantifiable measures. There may be both planning efficiencies and opportunities to improve recovery effectiveness if the quantitative information in action plans was not delayed and completed during the recovery planning process.

Clear recovery goals are not consistently defined. Charismatic species have more specific recovery goals (Théberge and Nocera 2014) and fishes have a higher proportion of quantitative and ambitious goals compared to other taxa (Pawluk et al. 2019). For fishes, this may be the result of *Recovery Potential Assessments* (RPA) (DFO 2007) that are often prepared by Department of Fisheries and Oceans scientists following the COSEWIC assessment.

Many recovery strategies in Canada are also not ambitious. They not only lack clear targets but they do not aim to change species status For example, Drooping Trillium (*Trillium flexipes*) could potentially be reassessed from Endangered to Threatened if the number of locations was increased from two (the current number) to greater than five (the threshold for Endangered under assessment criteria B). This threshold to nudge the species to a lower status category and associated actions are not included in its recovery strategy (Environment Canada 2016). However, some recent recovery

strategies, such as Sharp-tailed Snake (*Contia tenuis*) (ECCC 2020b), very clearly discuss the links between assessment categories and criteria to recovery potential and could serve as a model.

While change in status is not necessarily the same as full recovery (Akcakaya et al. 2018), clearer recovery targets that strive for status improvements would encourage actions that reduce extinction risk. A guide to identifying targets and thresholds would support recovery efforts and could be modeled on the primer to evaluate restoration success (Prach et al. 2019). Recovery strategies could incorporate long- and short-term objectives with indicators of success that are leading (inform preventative actions), coincident (measure current state), and lagging (change as a result of actions) (Stevenson et al. 2020). The current approaches used in RPAs for aquatic species (DFO 2007) could also be incorporated into recovery strategies for all taxa. The new global standard on the Green List of Species may also provide a tool for recovery strategy authors to identify strategies to both reduce extinction risk (i.e., change assessment category) but also to quantify species recovery and measure progress (Grace et al. 2021)

Bridge 4: Species recovery through ecosystem approaches

Managing multiple species through ecosystem approaches improves efficiency and can help conserve other species of conservation concern before they are listed.

Traditional single-species approaches to recovery have been very successful for some wildlife, but as the list of species at risk grows many endangered species can no longer be effectively managed individually. Although multi-species recovery plans may be less effective for individual species (Greenwald et al. 2019), ecosystem-based approaches increase efficiency and provide protection to other species of conservation concern. These approaches can also reduce potential management conflicts. For example, on Pelee Island in Lake Erie prescribed fires maintain habitat for the Endangered Blue Racer (*Coluber constrictor foxii*), but they can also eliminate habitat for the Endangered Yellow-breasted Chat virens subspecies (*Icteria virens virens*) (ECCC 2019). Ecosystem approaches can help managers to identify these species interactions and conflicts and develop actions that coordinate and maximize conservation outcomes.

Multi-species and ecosystem-based planning in species-rich focal areas would have similarities to the Australian approach of listing threatened ecological communities and could prioritize actions to reduce threats in that specific area. Developing, implementing, and reporting on ecosystem-based plans that integrate terrestrial and aquatic species (which would require cooperative planning and recovery between ECCC and DFO) and include candidate and other species of conservation concern would support multi-species ecosystem planning and recovery.

Multi-species or ecosystem approaches are permissible under SARA (Section 41 (3)) but have not yet widely been implemented as policy. With only a few exceptions, COSEWIC assessments and recovery strategies and management plans are based on single-species approaches. Multi-species and ecosystem-based approaches are more prevalent in action plans, with 67 final action plans that address more than on species at risk. However, almost two-thirds of these are for aquatic species and multi-species plans for species at risk found in national parks.

Ecosystem approaches will require flexibility, and even experimentation on how SARA is implemented. Although the diversity of provincial and territorial approaches to implementing the federal *Species at Risk Act* may seem like a policy patchwork, the science of endangered species protection and recovery is still emerging. Organization and innovation at sub-national levels may be necessary to drive change, and to provide sustainability experimentation (Leach et al. 2012) that is

needed to find practical solutions at larger scales. However, this must be supported by rigorous monitoring and sharing of innovation and best practices (see Bridge 10).

Bridge 5: Building capacity for co-governance

Engaging local communities and stakeholders in decision-making and implementation can be complex, but it will improve wildlife recovery outcomes.

Building on the theory and experience of ecosystem-based management that calls for participatory, consultative approaches (Slocombe 1993), co-management or co-governance approaches are showing promise for wildlife conservation since they encourage learning among practitioners and adaptive decision-making (Decker et al. 2016). The recent *Edinburgh Declaration on post-2020 global biodiversity framework* also calls for the increase participation of local government and groups in implementation of the Aichi targets.

There have been some promising recent trends towards co-governance models for the management of endangered species in Canada. The *Species at Risk Partnerships on Agricultural Lands* program in western Canada is implemented by Rancher's Stewardship Alliance and incorporates ranchers' contributions into stewardship (Pittman 2019). One of the challenges of these incentive-based programs are that landowners that have previously adopted practices to protect wildlife habitat may not be rewarded. However, they have been shown to build trust and increase cooperation (Jones et al. 2019). These programs can also provide a buffer to changing government priorities if local groups that are implementing recovery action have access to multiple streams of funding.

Incorporating social and behavioral sciences into conservation results in better conservation outcomes (Cinner 2018). However, recovery strategies do not always identify objectives and actions that integrate participation by communities, community-based organizations, or local authorities. Building social-science capacity within governmental organizations that are responsible for wildlife recovery, providing policy-based training to recovery strategy authors on approaches that engage communities, and systematic sharing of successful examples that link co-governance with improved species outcomes would support their integration. The template for recovery strategies could also be updated to include sections on community participation, such as the core principles of community-centered conservation governance that involves building multi-level collaborative networks, empowering local institutions, and responding meaningfully to emerging political, economic, and justice claims (e.g., from Indigenous Peoples) that result from historical or future land enclosures in the name of conservation or wildlife management (Armitage et al. 2020). In particular Indigenous Peoples have rights over many areas that are critical for wildlife (Schuster et al. 2019) and need to be more fully engaged in endangered species recovery (Hill et al. 2019).

Bridge 6: Significant net gain

If done properly, development can be used to leverage improvements in species status and turn traditional adversaries into future allies.

Species conservation is a complex social–ecological issue that will require many solutions. If done correctly, identifying, regulating, and protecting critical habitat can be complemented by biodiversity offsets and habitat banking (Dupont 2019). These must be supported by rigorous guidelines that follow the mitigation hierarchy and include avoidance (e.g., critical habitat) and limits to offsets (i.e., not all species or subpopulations can be offset) (BBOP 2012; Arlidge 2018).

Past biodiversity offset approaches of "no net loss" have generally resulted in habitat loss (Turner et al. 2001; Quigley and Harper 2006). Going forward, offsets must use targets that unequivocally result in a

significant net gain for impacted endangered species with the state and trajectory of the population clearly improved (Bull et al. 2020). In some cases, offsetting the loss of lower quality habitat for endangered species can be used to support recovery efforts. In Ontario, overall benefit permits issued under the provincial *Endangered Species Act* for construction of the Herb Gray Parkway in the City of Windsor significantly increased the habitat and numbers of the Endangered Colicroot (*Aletris farinosa*) (COSEWIC 2015). Offsets and habitat banking may require managers of endangered species to develop population and habitat targets that go beyond existing sites, but these can incorporate the thresholds that are needed to improve conservation status. Offsetting also provides an opportunity to implement climate change adaptation strategies through restoration and translocation in future habitat areas (see Bridge 8) and can generate funding for research. It can also create new relationships as diverse stakeholders cooperatively engage to find solutions.

Bridge 7: Document the full benefits of recovery

Documenting the important benefits that habitat conservation and restoration provides to people can increase support and funding for wildlife recovery.

Wildlife recovery provides benefits beyond biodiversity. The current biodiversity crisis is interrelated and mutually enforcing of other crises including climate change (Gardner et al. 2020), the loss of ecosystem services (Díaz et al. 2019), and our current global pandemic (Kavousi et al. 2020). Evidence is mounting that human interaction with nature supports health and well-being (Maller et al. 2006) and provides critical benefits to our cultures and societies (Díaz et al. 2018).

The interest, urgency, and potential funding associated with maintaining and restoring ecological services (Cohen-Shacham et al. 2019; Seddon et al. 2020) is an opportunity to link wildlife recovery with the benefits that nature provides to people. Habitats that support ecological services and endangered species often overlap. The analysis of green infrastructure and biodiversity benefits from urban areas (Filazzola et al. 2019) could be applied to endangered species habitats allowing practitioners to target areas for ecological restoration that will also deliver a suite of wider social and economic benefits (Gilby et al. 2020). Ecosystems services and their valuation have been applied to protected areas in Canada, such as Rouge Urban National Park (Wilson 2012), but not to habitat protection and restoration for species at risk.

Recovery strategies could project the value of the ecological services that species protection and restoration could provide. In particular linkages between habitat conservation and "nature-based solutions" for climate change (Griscom et al. 2017) may broaden new partners and funding (Echols et al. 2019). For example, the restoration of riparian habitat is a recovery objective for the Endangered Lake Chubsucker (*Erimyzon sucetta*) (Staton et al. 2010). Riparian habitats and forested headwaters provide habitat for the Lake Chubsucker but these same habitats also provide other important benefits such as water quality improvement and carbon sequestration (Hanna et al. 2019). The value of the services provided by forests in regions where the Lake Chubsucker lives in southern Ontario are over $19 000/year/ha (TD Bank Group and Nature Conservancy of Canada 2017). Protecting and restoring this habitat would also create jobs and support Canada's transition to a "restoration economy" (BenDor et al. 2017) and a post-COVID "green recovery" (Mansuy 2020). Describing and quantifying the potential ecological services and annual economic benefits of restoring riparian habitats and forested headwaters in the critical habitat of the Lake Chubsucker would support the case for implementation that complements the needs of the species and links recovery to broader societal values.

This information could be incorporated into the existing section in COSEWIC assessments on "Special Significance of the Species" so it can be considered in the socioeconomic analysis of the listing

process. Greater detail on the social and economic benefits could then be detailed in recovery strategies. This may require training for assessment and recovery strategy authors, or the engagement of other experts in developing this information.

By incorporating the ecological services that are associated with endangered species conservation, the economic and social values of conservation can be communicated with a message that may resonate with a broader suite of actors (see Bridge 9). The integration of social and ecological targets make the interdependences between biodiversity and ecological services more explicit (Reyers and Selig 2020). The need to use socio-ecological indicators in ecological restoration has been recently highlighted (see Evju et al. 2020) but they have not been included in wildlife recovery strategies (with the exception of the social benefits of game species). Identifying and demonstrating the benefits of endangered wildlife recovery and habitat restoration to the public and policy-makers may be essential to ensure that funding remains available (Kavousi et al. 2020).

Bridge 8: Ambitious and future-forward translocations

Reintroductions are essential for the recovery of many species and are becoming more critical in a rapidly changing world.

Many of Canada's most successful species recoveries have involved translocations such as Sea Otter (*Enhydra lutris*) (Fisheries and Oceans Canada 2014) and Trumpeter Swan (*Cygnus buccinator*) (Lumsden and Drever 2002). Future species recovery in Canada will require conservation translocations to augment populations, increase locations, or reintroduce species that have been extirpated.

While translocations are not a panacea for extinction, they have been essential for the recovery of many species around the world (Bolam et al. 2021) and are necessary to increase the number of locations and range for some species. Conservation translocations may also be required to maintain species diversity as climate change rapidly alters the environment (Lee-Yaw et al. 2019). In Australia, climate change is often identified as a threat, but rarely integrated into recovery strategies (Hoeppner and Hughes 2019). The inclusion of climate change as a threat in species assessments is increasing in Canada (Woo-Durand et al. 2020), but direct conservation actions in response to climate change also do not appear in many recovery strategies. Assisted migration to facilitate range shifts and increase locations of species that are vulnerable to the impacts of climate change and other pervasive threats may be necessary for some species to persist. Some species may need to be relocated to novel ecosystems, including urban areas, to maintain populations. Species redistribution science (Bonebrake et al. 2018) is providing new approaches to assess which edge of range species may be critical to support climate change driven range shifts and which "leading edges" should be targeted for conservation (Gilbert et al. 2019). Maintaining ex situ populations of highly threatened species as a component of translocation projects would also provide insurance against loss (Farhadinia et al. 2020).

Despite notable successes, translocations for conservation purposes have not been common in Canada compared to Australia and the US (Dalrymple et al. 2012; Silcock et al. 2019), but are projected to increase (Swan et al. 2018). Low ambition in recovery strategies to implement translocations may also reflect a lack of institutional experience and resources from agencies, a traditional focus on research and monitoring (Buxton et al. 2020), and fear of conservation failure (Meek et al. 2015). In addition, regulators may lack enthusiasm for translocations because of a lack of supportive policies and the potential conflicts with private landowners.

Translocations have resulted in the delisting or down-listing of approximately eight birds, mammals and fishes in Canada. This low number may be a result of agencies first researching threats and

habitat needs to inform future translocations, such as current efforts with fishes in the Great Lakes region (Lamothe and Drake 2019; Lamothe et al. 2019).

Bridge 9: Species need stories

By telling the right stories we can engage more people in species recovery and accelerate our efforts.

Most people have a natural attraction to wild species (Wilson 1984), but it is also a learned characteristic (Simaika and Samways 2010). In Canada, and around the world, an increasing number of people are living in urban areas and creating stories that connect people with endangered species conservation is critical. To date there has been a paucity of these stories. Media coverage on climate change are up to eight times higher compared to biodiversity issues (Legagneux et al. 2018).

Our understanding of effective conservation messaging is growing (Kidd et al. 2019) and this supports the emerging field of "translational ecology" (Schlesinger 2010) that seeks to better convey scientific knowledge to the public and policy-makers. Traditional conservation messages may not resonate with people, either because they do not reflect their moral foundation or the jargon muddles their understanding. Our new "biodiversity narratives" (Louder and Wyborn 2020) need to have a diverse and flexible message toolbox, and that message should change with the audience (Saul 2018). "Boundary objects" (Brand and Jax 2007), such as ecological services (see Bridge 7), can be used to connect with different groups and bridge moral foundations and interests. Our current storytelling about charismatic species does not need to be replaced but needs an infusion of new stories that reflect the full range and richness of biodiversity. Flagship and endemic species (Meuser et al. 2009; McGowan et al. 2020) can be leveraged to increase public awareness and support, and the "iconization" of poorly known species can also be used to increase public awareness and their willingness to pay for conservation (Rudd 2009).

Personal stories about conservation may be more effective with conservative audiences than scientific facts (Stein et al. 2020). Surveys in Canada and the US show that farmers and rural land owners respond to messages about moral responsibility, stewardship, and benefitting future generations (Bonnie 1999; Sherren et al. 2020). Wildlife conservation messages cannot just be based on scientific facts and must be expanded to include compassion, emotion, nostalgia, and ecocentric values (Lumber et al. 2017; Willson et al. 2019; Taylor et al. 2020).

Bridge 10: Share success (and failure)

Canada needs a species recovery forum to share best practices and celebrate our progress.

Despite our current extinction crisis, Canada has a long history of recovering wildlife species. It is critical to build public awareness about extinction, but it is also important to build awareness about species recovery within the public, scientific, and conservation communities. An evidence repository of the factors of success (and failure) in recovery could inspire and inform practitioners and ensure we are building on our collective knowledge of best practices (Sutherland et al. 2020).

Today, recovery stories are most often shared as scattered case studies rather than a regular comprehensive review. Reporting on recovery is outside of the mandate of COSEWIC and will need to be coordinated by the Canadian Endangered Species Conservation Council. The annual reporting previously done by the Recovery of Nationally Endangered Wildlife program should be reinvigorated to fill this role and support periodic implementation reviews completed by agencies (e.g., ECCC 2018b). Reporting on the patterns and processes of wildlife recovery across taxa and jurisdictions would be a key source of information to inform new recovery strategies and identify factors of success. Systematic reviews and evidence reporting are widely used in the medical field and could help to

reduce the science–practice divide in conservation (Walsh et al. 2019). Such a review has recently been prepared on the effectiveness of captive breeding for freshwater fishes and mussels (Lamothe and Drake 2019; Lamothe et al. 2019) and could serve as a model for approaching other technical barriers to recovery.

Although change in the status of a species is a measure of extinction risk and is not necessarily the equivalent of recovery (Akcakaya et al. 2018), it can be a useful measure towards the ultimate benchmark of delisting. In the US, 47 species have recovered sufficiently to be delisted (Langpap et al. 2018). In Canada, 59 species have been delisted by COSEWIC, although only 15 of these (primarily birds) are for genuine reasons (i.e., threat reduction or conservation measures have successfully improved the status of the species) (IUCN 2020b). Reporting and analyzing these recoveries could be a useful tool to help understand the anatomy of successful species recovery and barriers to progress. As in the US (Greenwald et al. 2019), Canada has many species that have been recovered because of endangered species laws and actions. These conservation bright spots (Bennett et al. 2016), individually and in aggregate, provide an opportunity to build on best practices, inspire action, and showcase the benefits of recovery actions. Our ability to recover species needs to be shared and celebrated. The loss of biodiversity is a significant issue that the public and politicians need to understand. But just as importantly, we need to demonstrate solutions.

5. Conclusion

The loss of biodiversity is one of the most critical issues facing our planet. Canada has not been immune to the global trend of biodiversity loss. Despite a foundation of good science, supportive legislation, positive public opinion, and many examples of wildlife recovery, we are not bending the curve of extinction.

There certainly are knowledge gaps that we need to address. Every recovery plan has a list of additional research that is needed. There are also important knowledge gaps that we have identified in our bridges. These include refinement in the identification of priority areas, linking ecosystem services to critical habitat and prioritizing edge of range species. But the main limitation of endangered species recovery is not a question of what to do, but how to do—how can we mainstream and accelerate current efforts to a pace and scale that matches, and then exceeds, the rate of biodiversity loss? Our current state of extinction and the rapid pace of ecological change necessitate both rethinking our traditional strategies to conservation and testing new transformative strategies.

The 10 bridges we propose here can help to improve the effectiveness of recovery and bend our trajectory of wildlife extinction to recovery. Our focus of these bridges is on Canada, but the ideas and solutions we identify can be adapted to a wide range of other contexts and countries. These bridges are intended to support efforts that span the "knowing-doing" gap (Pfeffer and Sutton 1999). Some bridges require only modification to current practices, while others need major changes in approaches and institutions. This transformation requires an extension beyond traditional practices and must integrate and normalize nature conservation into our society and culture.

Ecosystem approaches can shift our thinking from species recovery to ecosystem recovery. Ecological services can help society to better understand the full value of nature's services. Community governance and flexible implementation can engage diverse actors in recovery. Sharing past success can help to inspire more ambitious conservation efforts. Species conservation that meets a broad array of interests and values will lead to more enduring outcomes. Calibrating and communicating our wins and losses is important for assessing the effectiveness of actions and building support from the public and decision-makers.

Canada has many examples of successful wildlife recovery; from the reintroduction of the Swift Fox (Herrero et al. 1986) to the recent delisting of the Peregrine Falcon (anatum/tundrius subspecies) after 39 years on the endangered species list (COSEWIC 2017). An understanding of wildlife biology and thoughtful application of conservation science were needed for this work. But the essential component of these successes has been the result of small groups of people that were impassioned and empowered to act. The recovery or extinction of species in Canada has foundations in biology and threats, but the fate of a species may ultimately be decided not by more science or government policies, but by transforming our values about wildlife, our perceptions about conservation, and inspiring a new generation to act.

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Author contributions

DK and SM conceived and designed the study. DK performed the experiments/collected the data. DK and SM analyzed and interpreted the data. DK, SM, and DA contributed resources. DK, SM, and DA drafted or revised the manuscript.

Data availability statement

All relevant data are within the paper.

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