Science, Policy, and Species at Risk in Canada

Author(s): Arne O. Mooers, Dan F. Doak, C. Scott Findlay, David M. Green, Chris Grouios, Lisa L. Manne, Azadeh Rashvand, Murray A. Rudd and Jeannette Whitton,
Source: BioScience, 60(11):843-849. 2010.
Published By: American Institute of Biological Sciences
URL: http://www.bioone.org/doi/full/10.1525/bio.2010.60.10.11

Science, Policy, and Species at Risk in Canada

ARNE O. MOOERS, DAN F. DOAK, C. SCOTT FINDLAY, DAVID M. GREEN, CHRIS GROUIOS, LISA L. MANNE, AZADEH RASHVAND, MURRAY A. RUDD, AND JEANNETTE WHITTON

The meaningful incorporation of independent scientific advice into effective public policy is a hurdle for any conservation legislation. Canada's Species at Risk Act (SARA; 2002) was designed to separate the science-based determination of a species' risk status from the decision to award it legal protection. However, thereafter, the input of independent science into policy has not been clearly identifiable. Audits of SARA have identified clear deficiencies in the protection and recovery of listed species; for example, of the 176 species legally protected in 2003, only one has a legal implementation plan for its recovery. We argue that clearly distinguishing science from policy at all relevant stages would improve the scientific integrity, transparency, accountability, and public acceptance of the legal listing and recovery implementation processes in SARA. Such delineation would also clarify exactly what trade-offs are being made between at-risk species recovery and competing policy objectives.

Keywords: endangered species, critical habitat, listing, recovery, transparency

For many aspects of policymaking, especially regarding environmental issues such as endangered species conservation, the use of sound and reliable scientific knowledge is required (Dybas 2006, Bean 2009). In practice, the translation of scientific information into policy is difficult (Hunt and Shackley 1999). Scientific evidence may be called mere scientific "claims" in a complex argument among people with different worldviews. However, it is necessary to understand and delineate the essential role of science in the policymaking realm to foster a constructive dialogue between competing interests and agendas (Sarewitz and Pielke 2007) and to form effective environmental policy (Martín-López et al. 2009).

Endangered species legislation is a major framework for the delivery of science advice to conservation policy. Much has been written of the 35-year-old US Endangered Species Act (ESA; see, e.g., Schwartz 2008), but Canada's much more recent Species at Risk Act (SARA; 2002) is only now undergoing its first statutory review by the Canadian federal government. This review offers opportunities to draw lessons for creating or improving legal frameworks to protect biodiversity, particularly with regard to the role of independent scientific advice in the policymaking process.

Here, we evaluate the key elements of SARA; outline an important strength and several of its critical shortcomings, both in terms of the statute's design and implementation; and offer suggestions for addressing these shortcomings. Our main conclusion is that the implementation of environmental legislation such as SARA requires a very clear delineation between all natural and social-scientific inputs and the relevant political trade-offs.

The current process: Design and intent

The SARA process is outlined in figure 1a. It begins (box A) with assessment of species by the independent Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Assessment of species. The committee uses biological criteria, aboriginal and traditional knowledge, and input from many stakeholders to assess Canadian wildlife species as extirpated, endangered, threatened, of special concern, or not at risk. The criteria for status assessment are patterned after the International Union for Conservation of Nature's (IUCN) scheme (Mace et al. 2008), and delineate legally defined "wildlife species" using the concept of a "designatable unit" (Green 2005). These designatable units meet similar criteria of discreteness and evolutionary significance to those used to identify distinct population segments in the United States (Hutchings and Festa-Bianchet 2009).

COSEWIC identifies wildlife species suspected of being at risk and commissions status reports for those given highest priority. Relevant jurisdictions (i.e., federal agencies or provinces and territories) review draft reports first; the reports are then reviewed by scientists in the relevant species specialist subcommittees of COSEWIC and holders of traditional aboriginal knowledge. The subcommittees' final draft recommendations are then discussed by all COSEWIC members before the committee makes a status recommendation for the species to the federal government. The government ultimately decides whether to add the species in question to the SARA registry. The classification

BioScience 60: 843–849. ISSN 0006-3568, electronic ISSN 1525-3244. doi:10.1525/bio.2010.60.10.11

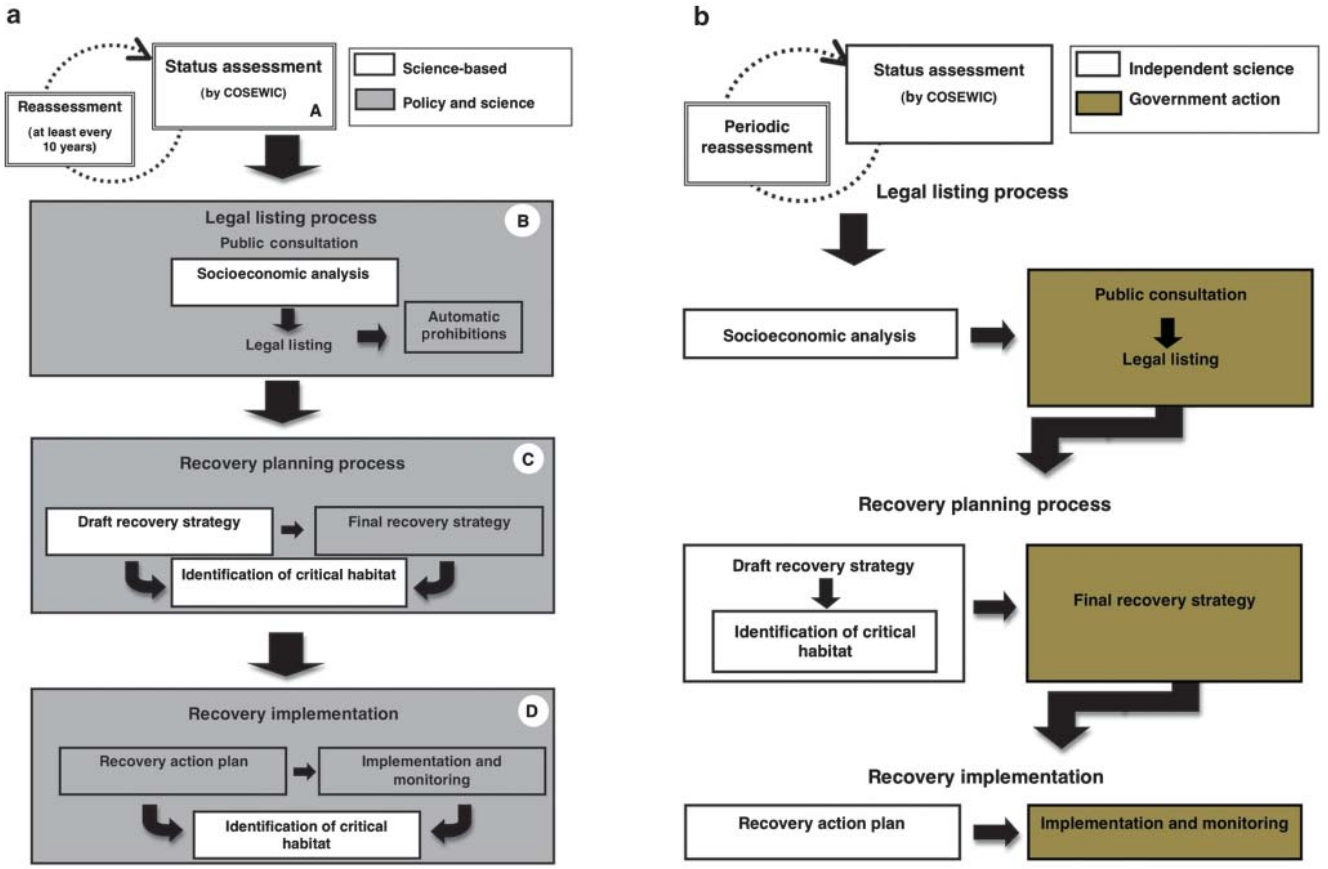

Figure 1. Schematics of the Canadian Species at Risk Act. (a) Current structure, highlighting independent science activities (in white) and activities that are a mix of policy and science (in gray). (b) Potential modification highlighting enhanced separation of science activities (in white) from government action (ochre). In this scheme, independent, peer-reviewed science offers transparent input to government decisionmaking. COSEWIC, Committee on the Status of Endangered Wildlife in Canada.

process thus draws on broad input, with more than 100 people generally commenting on any one report. COSEWIC status assignments are made public on its Web site following wildlife species assessment meetings. Thus, SARA incorporates a science-based prioritization and assessment of wildlife species independent of legal listing decisions. It is important to note that COSEWIC considers neither the feasibility nor the cost of recovery, nor the social or political ramifications of its assessment decisions. At the time of this article's writing, 598 wildlife species were on COSEWIC's list of wildlife species at risk. Although COSEWIC's list of wildlife species at risk has grown steadily (figure 2), the rate of growth is primarily a reflection of the rate at which COSEWIC can assess wildlife species requiring examination.

Under SARA, COSEWIC's recommendations impose no federal duty to list a wildlife species. The Canadian government has three options: It can (1) accept COSEWIC's recommendation to legally list a wildlife species; (2) decline the recommendation, in which case the responsible minister must provide reasons for such action; or (3) return the issue to COSEWIC for further clarification. In making listing decisions, the federal government considers input from public consultations and internal economic assessments, in addition to COSEWIC's scientific assessment (figure 1a, box B).

After listing. As soon as a wildlife species is listed as endangered or threatened, individuals of that species and their dwellings are automatically protected on federal land. SARA typically applies only to federally managed lands, waters, and species; the responsibility for protecting wildlife species on lands managed by provinces and territories usually falls to the province or territory, although aquatic species and migratory birds are managed by the federal government under preexisting statutes.

Listing also initiates a two-step recovery planning process. The first step is the development of a recovery strategy (figure 1a, box C). The recovery strategy identifies the needs of and threats to the wildlife species, as well as objectives for population and distribution recovery. Recovery strategies can be contentious because of their socioeconomic implications. The next step is development of a recovery action plan (figure 1a, box D). These plans put the strategy into action

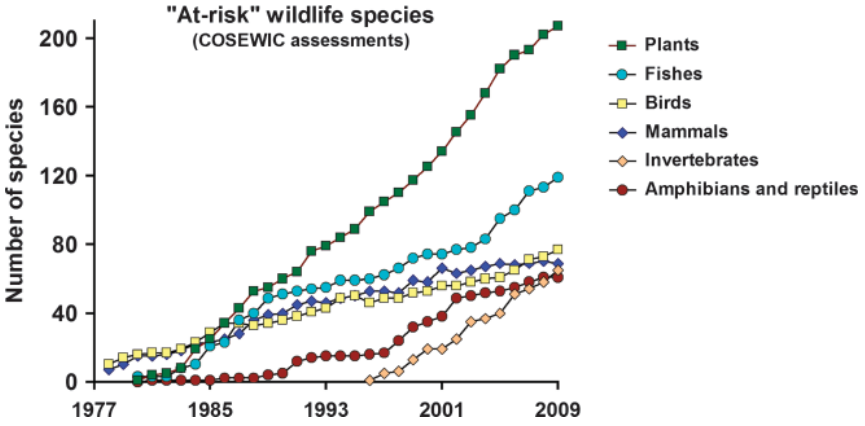

Figure 2. Assessment of imperiled wildlife species in Canada. Numbers of species designated by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in the "at-risk" categories of extirpated, endangered, threatened, and special concern according to taxonomic group from 1977 to the present (updating Shank 1999). Data are from published COSEWIC reports (http://cosewic.gc.ca).

by specifying concrete recovery measures and evaluating potential socioeconomic impacts of these actions. Both the recovery strategy and the recovery action plan must identify critical habitat—the habitat necessary for a listed species' survival or recovery (SARA, s.2.1)—to the extent possible. Once defined, the federal government must protect critical habitat on federal land (which constitutes 4% of Canada's 10 southern provinces as well as most of the three northern territories), and SARA is clear that the government may move to protect critical habitat outside of federal lands should it so choose (though, notably, it has never done so). The government must report on recovery progress for each species every five years.

There is no separate process for delisting wildlife species under SARA; in Canada, wildlife species at risk are simply reassessed by COSEWIC at least every 10 years. Such reassessments offer one window into the trajectory of Canada's imperiled wildlife: Since the inception of COSEWIC in 1977 (predating SARA), wildlife species that have been assessed more than once have moved to a more imperiled status nearly twice as often as they have moved to a less imperiled status (52 versus 27, $p < 0.01$, sign test; table 1). Although in some cases a deteriorating status could be the result of changes in available information, the pattern is consistent with a need for concerted action.

Listing issues

Here we outline several potential issues relating to current listing procedures under SARA.

Independent assessment and legal listing. There are limits to administrative capacity, and SARA instructs that priority for assessment should be given to species that are more likely to go extinct. Candidate species for assessment are themselves prioritized by COSEWIC according to a combination of probable threat, taxonomic distinctiveness, geographic extent, and endemism; data are required for each criterion. However, a "data deficient" assessment ruling triggers neither more research under SARA nor automatic reassessment. Such designations may be more common for taxa for which there is less taxonomic expertise, and this taxonomic deficit may become a more acute problem in the future as attention turns to invertebrates.

The separation of assessment from legal listing has its own implications: It can give the government an opportunity to avoid or delay the costs and consequences of protecting imperiled wildlife species. As of December 2007, the Canadian federal government has chosen not to list a taxonomically and geographically nonrandom 23% (60 of 252) of wildlife species recommended by COSEWIC since SARA's enactment in 2002 (Findlay et al. 2009). However, the framework also allows a time window for stakeholders and civil society to become more involved in the legal listing process at the consultation stage. Most important, the framework allows for a transparent separation of science and policy, providing the opportunity for accurate and science-based assessments as well as an unequivocal government response. We see this as the primary strength of SARA. We describe significant weaknesses in later stages of listing and recovery below.

Table 1. Matrix of changes in risk status accorded by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Rows indicate initial status and columns represent the relisted risk status.

	Extirpated	Endangered	Threatened	Special concern	Not at risk
Extirpated	27 (4)	1			
Endangered	2	98 (24)	5 (1)	1	1
Threatened		29 (7)	43 (15)	7	3 (1)
Special concern		3	12 (2)	28 (10)	9 (1)
Not at risk	1	2	1 (1)	2 (2)	14 (2)

Note: Entries below the diagonal represent deterioration, and entries above the diagonal represent improvement in cases where COSEWIC has assessed species more than once. Numbers in brackets refer to the subset of wildlife species that have been reassessed since legal listing under Canada's Species at Risk Act. Listings to more imperiled status predominate over listings to less imperiled status. *Source: http://coswic.gc.ca.*

Incomplete economic considerations in listing decisions. Although SARA makes no mention of economic analyses at the listing stage, it is the Canadian government's policy to review the economic implications of any regulatory change (such as a listing; Government of Canada 2007). A key component of reviews under Canadian legislation is the regulatory impact assessment statement (RIAS). When developing a RIAS before making a listing decision, government policy analysts are directed to work with scientists and resource managers to develop plausible scenarios for economic costs and benefits and impact analyses on the basis of the best available information. The depth of analysis is dictated by the potential economic consequences of regulatory change. Government guidelines recognize the need to account for the economic value of public environmental goods (Government of Canada 2007). Economic impact analyses, which address short-term distributional issues regarding jobs and regional economic effects, may also be conducted when sufficient data are available. Thus there is a framework for making evidence-based, informed economic SARA decisions, and such economic concerns have been given as an explicit reason in 50% of the cases (10 out of 20) in which listing has been denied outright (Findlay et al. 2009).

Despite the clear RIAS framework, there are several challenges to informed decisionmaking, all compounded by the nine-month legally mandated timeline for making a listing decision (SARA s.27.3; note that this time line is often extended through an apparent loophole in the legislation; see Mooers 2004). The initial choice of plausible scenarios to analyze is unclear. There is also substantial uncertainty about the potential impacts of listing or not listing under any scenario, as well as significant technical challenges with economic cost-benefit analyses for RIASs.

For species listings with potential impacts on industry or economic interests, there has been an emphasis on short-term, regional economic impacts (e.g., local jobs, effects on local businesses). As is typical in policy analyses focused on regional impacts, attention is diverted from long-term, national benefits to Canadian society as a whole (Vining and Boardman 2007).

This focus is evident in SARA listing decisions. In one egregious example, listing was denied for the porbeagle shark (*Lamna nasus*) in part because of (a) the costs to a single community that derived 2% of its total landings' value, and (b) the costs to two fishers who earned less than 25% of their gross revenue from the porbeagle shark fishery (DFO 2006). Preliminary data available at the time of the nonlisting decision estimated the porbeagle shark's nonuse value to Canadian society at tens of millions of dollars annually (Rudd 2009).

Although we see the explicit incorporation of economic analysis as a reasonable part of the SARA process, this approach has often failed to live up to its potential. This is perhaps because it comes too early (Findlay et al. 2009), because of a lack of general policy analysis capacity within government (Lindquist and Desveaux 2007), or perhaps because economic analysis is not supplied as independent science advice but rather is embedded in a nonscientific policy-based framework (figure 2a, box B).

Recovery strategies: Ineffective meshing of science and policy. The production of recovery strategies has been slow (figure 3) and problematic. Issues may result from having science input that is too deeply embedded in a policy framework (figure 1a, box C). Although a choice of minimal conservation goals may be a legitimate societal decision, there should be clarity about whether the goals are selected on the basis of scientific or socioeconomic considerations.

As mandated under SARA, population and distribution objectives are crucial goalposts for species recovery and must be specified in recovery strategies (SARA s.41.1.[d]). Transparent conservation decisions depend on the clarification of the biological meanings of key terms that are not

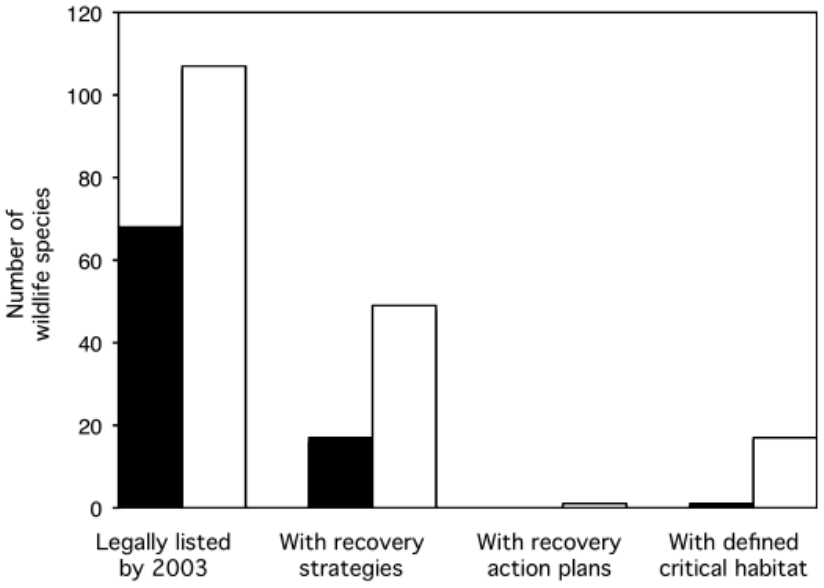

Figure 3. Listing and protection of imperiled wildlife species in Canada. For the cohort of 176 wildlife species legally listed as threatened (black bars) or endangered (white bars) in the Species at Risk Act (SARA) upon its full inception 5 June 2003, the numbers of species that have accepted recovery strategies, that have accepted recovery action plans, and for which critical habitat is at least partially identified, all as of 3 March 2009, are shown. Under the law, all 176 recovery strategies were to be finalized by 5 June 2007 at the latest. There are a further 20 recovery action plans that are now overdue according to the deadlines set in their respective recovery strategies. Source: Data were compiled from the SARA Public Registry (www.sararegistry.gc.ca).

defined in SARA, such as survival and recovery. Because critical habitat is defined as the habitat "necessary for the survival or recovery" of a listed wildlife species (SARA, s.2.1), the quantity and location of critical habitat (and associated socioeconomic impacts) and permitting will be sensitive to the biological interpretation of survival and of recovery. Permitting for activities that affect listed species is allowed when regulators believe that such activities will not "jeopardize the survival or recovery of the species" (SARA, s.73.3.[c]). A standard interpretation of survival from the scientific literature using minimum viable populations (which are widely viewed as the minimum unit for species conservation; see, e.g., Traill et al. 2007) would, following IUCN criteria, characterize survival as a greater than 90% chance of species persistence for at least 100 years. A species not meeting the definition of the minimum viable population for survival would trigger a listing of "at risk" in Canada, in the United States, and internationally (Doremus 1997, COSEWIC 2006, Mace et al. 2008). The Canadian federal government has suggested policy whereby survival would mean maintaining the current population in the "short term" (DFO 2005). It is therefore important to ask whether a benchmark of 100 years is considered "short term" in Canadian policy: For a species already listed as at risk of extinction, merely maintaining its current population size for some limited time (e.g., until the next COSEWIC reassessment in 10 or fewer years) would provide little assurance of continued survival.

Recovery has been defined in Canadian policy as "long-term persistence" (DFO 2005) or simply where decline is "arrested or reversed" (NRWG 2005). The definition of "long term" must be clarified here. The "or" in the second definition is also potentially important, as the easier goal (arresting decline) could become the default policy. Arresting decline may be enough action for the few species with large population sizes that are still widely distributed but nonetheless considered imperiled. However, recovery as restoration, rather than merely an arrested decline, implies higher benchmarks with respect to population size and distribution.

Critical habitat designation has been hampered for several reasons. First, although the law is clear that the precautionary approach must be followed (SARA, s.38), and that critical habitat must be identified to the extent possible using the best available information (SARA, s.41.1[c]), such habitat has been identified for just 23 of the 104 species with finalized recovery strategies (see also figure 3), and thus for only 23 of 447 (roughly 5%) of listed species.

Two species' recovery strategies (the greater sage grouse and the Nooksack dace) that omitted known critical habitat were successfully challenged in court in 2009 (*Alberta Wilderness Association v. Minister of the Environment*, 2009 FC 710; *Environmental Defense Canada v. Minister of Fisheries and Oceans*, 2009 FC 878). Although these precedent-setting lawsuits may lead to the official identification of some critical habitat in other recovery strategies, we wonder whether litigation or fear of it is the most efficient approach for identifying the critical habitat needed to achieve species recovery.

Currently, the government oversees the preparation of recovery strategies, though it usually seeks outside scientific advice. However, the government ministries involved may have conflicting interests that could affect the final scientific content of these strategies. We suggest that the process of writing an official recovery strategy could benefit from something similar to the two-step listing process, using unbiased scientific proposals that meet clear goals that are followed by clear government responses.

Recovery action plans: Lost in the fog. Recovery action plans detail the specific projects and activities that must be implemented to enable species recovery, in addition to analyzing potential costs and benefits. They are supposed to be developed and implemented by biologists, managers, economists, and stakeholders using scientific guidance from the recovery strategy. Although voluntary recovery activities have been initiated for many species (OAG 2008), only a single wildlife species, the Banff Springs snail (*Physella johnsoni*), whose entire range is in a national park, has a legally accepted recovery action plan (figure 3). It is important to note that if critical habitat is not described in the initial recovery strategy, there are no legal time lines for identifying and thus protecting such habitat because the recovery plans themselves have no legal time lines for completion. A lack of definition means that much effort can be expended in a legal process of identifying, listing, and strategizing for the eventual recovery of a species with no certainty that the process will ever lead to action on the ground.

Conclusions

To ensure accountability, environmental legislation must clearly delineate the role of independent science in the implementation of recovery actions. SARA is one of a widening net of endangered species protection laws that have slowly emerged around the world: By our count, at least 36 countries now have legislation to identify and protect species threatened with extirpation or extinction. To its credit, SARA was written to explicitly incorporate both scientific and economic concerns, and in a few places the law seems to limit consideration to purely scientific concerns when appropriate (e.g., listing assessments, critical habitat identification, and the determination of the feasibility of recovery). In many other cases SARA also allows for the quantification of economic costs and benefits. This emphasis on economic analysis and planning is arguably better embodied in SARA than in, for example, the US ESA (Illical and Harrison 2007). In theory, more explicit and transparent consideration of competing governmental priorities might avoid the distorted implementations sometimes seen in environmental laws that are less realistic about competing agendas (Carroll et al. 1996).

Though the assessment process itself might be improved (see, e.g., Lukey and Crawford 2009), it does offer a clear delineation between independent science and policy. Following COSEWIC's recommendations, however, the legal listing, recovery planning, and implementation phases of SARA do not offer this delineation. These phases have been identified as problematic, such that hard choices are simply being postponed indefinitely (OAG 2008).

In particular, we suggest that both social and natural sciences must better inform independent social and economic analyses that are necessary to decide whether a wildlife species is listed. One simple improvement would be to subject the scenario choices and the resulting evaluations to independent, nongovernmental peer review (Mooers et al. 2007). It is worth considering whether extra emphasis on this important stage would require longer mandated time lines in conjunction with interim legal protection, as is how these evaluations would flow into the recovery phase. In the same vein, we recommend timely independent peer review and oversight of both recovery strategies and recovery action plans, as is policy under, for example, the ESA (Carden 2006).

In general, a structural separation of information gathering and interpretation (i.e., scientific advice) from strategic planning and action (i.e., policy and implementation) seems an excellent basis on which to proceed (Hutchings et al. 1997). This aim would be best served by extracting all of the science-based aspects of the conservation process—assessments of biological status, of critical habitat and threats, population and distribution objectives, and economic analysis—as discrete modules that would produce independent and transparent scientific advice to feed back into a political process (figure 1b), with attendant hard deadlines. The need for a mandated framework for the delivery of such independent scientific advice into subsequent political processes is a significant hurdle to improving SARA, and may be also be an important component for environmental legislation elsewhere.

Acknowledgments

This article is publication 001 from the Canadian Institute of Ecology of Evolution and the Scientific Committee on Species at Risk. We thank Art Weiss and the Canadian Society for Ecology and Evolution, Mart Gross, and Locke Rowe for support, and Jordan Rosenfeld and several anonymous reviewers for critical technical input and advice. AOM, DMG, SCF, LMM, and JW were each supported by NSERC Discovery Grants, and MAR by the Canada Research Chairs program.

References cited

Bean MJ. 2009. The Endangered Species Act: Science, policy, and politics. Annals of the New York Academy of Sciences 1162: 369–391.

Carden K. 2006. Bridging the divide: The role of science in species conservation law. Harvard Environmental Law Review 30: 165–259.

Carroll R, Augspurger C, Dobson A, Franklin J, Orians G, Reid W, Tracy R, Wilcove D, Wilson J. 1996. Strengthening the use of science in achieving the goals of the Endangered Species Act: An assessment by the Ecological Society of America. Ecological Applications 6: 1–11.

[COSEWIC] Committee on the Status of Endangered Wildlife in Canada. 2006. COSEWIC's Assessment Process and Criteria. COSEWIC. (25 August 2010; *www.cosewic.gc.ca/pdf/assessment_process_e.pdf*)

[DFO] Department of Fisheries and Oceans. 2005. A Framework for Developing Science Advice on Recovery Targets for Aquatic Species in the Context of the Species at Risk Act. CSAS Science Advisory Report. Government of Canada.

———. 2006. Potential Socio-economic Implications of Adding Porbeagle Shark to the List of Wildlife Species at Risk in the Species at Risk Act (SARA). Fisheries and Oceans Canada.

Doremus H. 1997. Listing decisions under the Endangered Species Act: Why better science isn't always better policy. Washington University Law Quarterly 75: 1029–1153.

Dybas CL. 2006. Biodiversity: The interplay of science, valuation, and policy. BioScience 56: 792–798.

Findlay CS, Elgie S, Giles B, Burr L. 2009. Species listing under Canada's Species at Risk Act. Conservation Biology 23: 1609–1617.

Green DM. 2005. Designatable units for status assessment of endangered species. Conservation Biology 19: 1813–1820.

Government of Canada. 2007. Canadian Cost-benefit Analysis Guide: Regulatory Proposals. Treasury Board Secretariat. Catalogue no. BT58-5/2007.

Hunt J, Shackley S. 1999. Reconceiving science and policy: Academic, fiducial and bureaucratic knowledge. Minerva 37: 141–164.

Hutchings JA, Festa-Bianchet M. 2009. Canadian species at risk (2006–2008), with particular emphasis on fishes. Environmental Review 17: 53–65.

Hutchings JA, Walter CJ, Haedrich RL. 1997. Is scientific inquiry incompatible with government information control? Canadian Journal Fisheries and Aquatic Sciences 54: 1198–1210.

Illical M, Harrison, K. 2007. Protecting endangered species in the US and Canada: The role of negative lesson drawing. Canadian Journal Political Science 40: 367–394.

Lindquist E, Desveaux J. 2007. Policy analysis and bureaucratic capacity: Context, competencies, and strategies. Pages 116–142 in Dobuzinskis L, Howlett M, Laycock D, eds. Policy Analysis in Canada: The State of the Art. University of Toronto Press.

Lukey JR, Crawford SS. 2009. Consistency of COSEWIC species at risk designations: Freshwater fish as a case study. Canadian Journal of Fisheries and Aquatic Sciences 66: 959–971.

Mace GM, Collar NJ, Gaston KJ, Hilton-Taylor C, Akçakaya HR, Leader-Williams N, Milner-Gulland EJ, Stuart SN. 2008. Quantification of extinction risk: IUCN's system for classifying threatened species. Conservation Biology 22: 1424–1442.

Martín-López B, Montes C, Ramírez L, Benayas J. 2009. What drives policy decision-making related to species conservation? Biological Conservation 142: 1370–1380.

Mooers AO. 2004. Why did the fish miss the boat? The Globe and Mail. 30 April, A21.

Mooers AO, Prugh LR, Festa-Bianchet M, Hutchings JA. 2007. Biases in legal listing under Canadian endangered species legislation. Conservation Biology 21: 572–575.

[NRWG] National Recovery Working Group. 2005. Recovery Handbook (ROMAN) 2005–2006 Edition, October 2005. Recovery of Nationally Endangered Wildlife.

[OAG] Office of the Auditor General of Canada. 2008. March 2008 Status Report of the Commissioner of the Environment and Sustainable Development. OAG.

Rudd MA. 2009. National values for regional aquatic species at risk in Canada. Endangered Species Research 6: 239–249.

[SARA] Species at Risk Act. 2002. Bill C-5, An act respecting the protection of wildlife species at risk in Canada. (25 August 2010; *http://laws.justice.gc.ca/PDF/Statute/S/S-15.3.pdf*)

Sarewitz D, Pielke RA. 2007. The neglected heart of science policy: Reconciling supply of and demand for science. Environmental Science and Policy 10: 5–16.

Schwartz MW. 2008. The performance of the Endangered Species Act. Annual Review of Ecology, Evolution and Systematics 39: 279–299.

Shank CC. 1999. The committee on the status of endangered wildlife in Canada (COSEWIC): A 21-year retrospective. Canadian Field-Naturalist 113: 318–341.

Traill LW, Bradshaw CJA, Brook BW. 2007. Minimum viable population size: A meta-analysis of 30 years of published estimates. Biological Conservation 139: 159–166.

Vining AR, Boardman AE. 2007. The choice of formal policy analysis methods in Canada. Pages 48–85 in Dobuzinskis L, Howlett M, Laycock D, eds. Policy Analysis in Canada: The State of the Art. University of Toronto Press.

Arne O. Mooers (amooers@sfu.ca) is with the Biosciences Department at Simon Fraser University, in Canada. Dan F. Doak is with the Zoology Department at the University of Wyoming, in Laramie. C. Scott Findlay is with the Institute of the Environment, University of Ottawa, in Canada. David M. Green is with the Redpath Museum at McGill University, in Canada. Lisa L. Manne is with the Department of Biological Sciences at the City University of New York. She was previously with the University of Toronto at Scarborough. Chris Grouios and Azadeh Rashvand are with the Zoology Department at the University of Toronto at Scarborough, in Canada. Murray A. Rudd is with the Environment Department at the University of York, in the United Kingdom. He was previously with Sir Wilfred Grenfell College, Memorial University of Newfoundland, in Canada. Jeannette Whitton is with the Department of Botany, University of British Columbia, in Canada.