



# Defending the scientific integrity of conservation-policy processes

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**Abstract:** *Government agencies faced with politically controversial decisions often discount or ignore scientific information, whether from agency staff or nongovernmental scientists. Recent developments in scientific integrity (the ability to perform, use, communicate, and publish science free from censorship or political interference) in Canada, Australia, and the United States demonstrate a similar trajectory. A perceived increase in scientific-integrity abuses provokes concerted pressure by the scientific community, leading to efforts to improve scientific-integrity protections under a new administration. However, protections are often inconsistently applied and are at risk of reversal under administrations publicly hostile to evidence-based policy. We compared recent challenges to scientific integrity to determine what aspects of scientific input into conservation policy are most at risk of political distortion and what can be done to strengthen safeguards against such abuses. To ensure the integrity of outbound communications from government scientists to the public, we suggest governments strengthen scientific integrity policies, include scientists' right to speak freely in collective-bargaining agreements, guarantee public access to scientific information, and strengthen agency culture supporting scientific integrity. To ensure the transparency and integrity with which information from nongovernmental scientists (e.g., submitted comments or formal policy reviews) informs the policy process, we suggest governments broaden the scope of independent reviews, ensure greater diversity of expert input and transparency regarding conflicts of interest, require a substantive response to input from agencies, and engage proactively with scientific societies. For their part, scientists and scientific societies have a responsibility to engage with the public to affirm that science is a crucial resource for developing evidence-based policy and regulations in the public interest.*

**Keywords:** endangered species act, external peer review, science communication, scientific advocacy

En Defensa de la Integridad Científica de los Procesos de Política de Conservación

**Resumen:** *Las agencias del gobierno que enfrentan decisiones políticas controversiales comúnmente rebajan o ignoran la información científica, ya sea de empleados de la agencia o científicos no-gubernamentales. Los desarrollos recientes en la integridad científica (la capacidad de desempeñar, usar, comunicar, y publicar*

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*ciencia libre de censura o interferencia política) en Canadá, Australia y en los Estados Unidos demuestran una trayectoria similar. Un incremento percibido en los abusos a la integridad científica provoca presiones conjuntas por la comunidad científica, lo que lleva a esfuerzos por mejorar las protecciones de la integridad científica bajo una nueva administración. Sin embargo, las protecciones se aplican continuamente sin consistencia y están en riesgo de una regresión bajo administraciones públicamente hostiles a la política basada en evidencias. Comparamos los retos recientes para la integridad científica para determinar cuáles aspectos de la contribución científica a la política de conservación están en mayor riesgo de una distorsión política y qué puede hacerse para fortalecer los salvoconductos contra dichos abusos. Para asegurar la integridad de las comunicaciones salientes de los científicos del gobierno al público sugerimos que los gobiernos fortalezcan las políticas de integridad científica, incluyan el derecho a hablar libremente de los científicos en los acuerdos de negociaciones colectivas, garanticen el acceso del público a la información científica, y que fortalezcan la cultura de la agencia apoyando a la integridad científica. Para asegurar la transparencia y la integridad con la cual la información de los científicos no-gubernamentales (por ejemplo, los comentarios entregados o las revisiones de política formal) informa los procesos políticos sugerimos que los gobiernos amplíen el enfoque de las revisiones independientes, aseguren una mayor diversidad de contribuciones de expertos y transparencia con respecto a los conflictos de interés, requieran una respuesta sustanciosa a la contribución de las agencias, y que participen de manera proactiva con las sociedades científicas. Por su parte, los científicos y las sociedades científicas tienen la responsabilidad de comprometerse con el público para afirmar que la ciencia es un recurso crucial para desarrollar las políticas basadas en evidencias y las regulaciones en el interés público.*

**Palabras Clave:** ciencia, comunicación, defensa científica, ley de especies en peligro, revisión de colegas externos

## Introduction

Effective conservation outcomes depend in part on the degree to which policy and management strategies are supported by scientific evidence (Sutherland et al. 2004). However, government agencies faced with politically controversial decisions often discount or ignore scientific information received from agency staff or nongovernmental scientists. We compared recent challenges to scientific integrity in conservation policy making in Canada, Australia, and the United States to determine what aspects of scientific input into policy are most at risk of political distortion and what can be done to strengthen safeguards against such abuses.

We defined *scientific integrity* as the ability to perform, use, communicate, and publish science free from censorship or political interference (Goldman et al. 2017). This definition encompasses the ability of government scientists to speak freely about their research and the transparency and integrity with which information from nongovernmental scientists (e.g., consultations, submitted comments, or formal policy reviews) informs the policy process.

Although scientific integrity abuses arise under all political parties, they are accentuated under administrations that publicly question the value of science and the validity of widely accepted scientific knowledge (Goldman et al. 2017). The 2016 election of Donald Trump as U.S. president alarmed much of the scientific community given his administration's attempts to silence government scientists from speaking with the media and his rhetoric disparaging accepted scientific concepts, including climate change (Ritchie et al 2017).

Recent developments in the United States are reminiscent of issues that arose when political appointees of George W. Bush (2001–2009) prevented federal scientists from publicly sharing their research and manipulated scientific reports to justify policy decisions (Doremus 2008). Similar violations occurred in Canada in the latter years of the Harper administration (2011–2015), when federal scientists were systematically prevented from communicating their work to the public (Noël 2016). Scientific integrity became a key issue in Canada's 2015 election and contributed to the election of a prime minister publicly committed to strengthening scientific integrity. In Australia, scientific-integrity violations became a prominent political issue under the Howard administration (1996–2007) (Khan 2017). When the opposition Labor party took power in 2007, it publicly endorsed the right of government scientists to speak freely about their work (Price 2009).

Canada, Australia, and the United States are all examples of developed economies with common-law systems. Although this is only one of many socioeconomic contexts for conservation, comparison of these 3 nations illustrates the challenges to scientific integrity that arise when a longstanding legal and societal commitment to conservation confronts a perceived tension between conservation and economic activities. The 3 nations demonstrate a similar trajectory concerning scientific integrity: a perceived increase in abuses precipitates concerted pressure by the scientific community followed by efforts to improve institutionalization of scientific-integrity protections under a new administration. However, continued violations and inconsistent application of new policies remain even as those administrations publicly endorsed

**Table 1.** Types of policy reform discussed in this review for strengthening the scientific integrity of 2 categories of scientific communication.

<i>Communication type</i>	<i>Suggested reform</i>
Outbound communication from government scientists to public	<ol style="list-style-type: none"> <li>1. Strengthen scientific integrity policies</li> <li>2. Include scientists' right to speak freely in collective bargaining agreements</li> <li>3. Guarantee public access to scientific information</li> <li>4. Strengthen agency culture supporting scientific integrity</li> </ol>
Inbound communication from independent scientists to government policy processes	<ol style="list-style-type: none"> <li>5. Broaden the scope of independent reviews</li> <li>6. Ensure greater diversity of input with transparency regarding conflicts of interest</li> <li>7. Require substantive response to input by agencies</li> <li>8. Engage proactively with scientific societies and organizations</li> </ol>

reforms (Goldman et al. 2015; Ritchie et al. 2017). With the recent advent of a U.S. administration more publicly hostile to science than previous administrations, even inconsistently applied reforms appear vulnerable to abrogation through regulatory changes designed to undermine the role of science in policy (Goldman et al. 2017).

We took a step back from recent crises to identify problems that transcend administrations and geography and examined how institutional safeguards of scientific integrity can be made more robust. Although it may seem impractical to propose strengthening scientific-integrity policies under unsympathetic administrations, we believe a defense of existing protections must be coupled with a focus on necessary improvements to ensure long-term success in institutionalizing a culture of scientific integrity in conservation-policy processes.

We built on other recent reviews of emerging scientific-integrity issues (e.g., Goldman et al. 2017) by focusing specifically on how science informs conservation policy. We examined commonalities and contrasts across the 3 nations to determine which reforms are limited to specific contexts and which are broadly relevant. We considered reforms that address distinct threats to 2 types of communication related to scientific integrity (Table 1). First, outbound scientific communications from government scientists to the public and media are threatened by restrictive policies that limit scientists' latitude to publish or publicize their research findings. Public access to websites or other sources of government scientific data have also been curtailed in some instances. These limitations on the free flow of information from government scientists to the public undermine the ability of citizens to be informed about and involved in debate on science-based policy questions.

Second, politicians have sought to restrict or ignore inbound scientific communication through which nongovernmental scientists inform policy. Although science is only one source of influence on policy, democratic processes are undermined when policy makers conceal how and to what extent decisions are based on science. Lawmakers in the United States have included in environmental statutes formal opportunities for nongovernmental scientists to inform the policy-making process via peer review of draft decisions. In Australia, such opportu-

nities arise primarily via informal consultation or material submitted during the public-comment period.

### **Censorship in Communication between Government Scientists and the Public**

When government scientists conduct research, the policy implications of their results are often unpredictable. Scientific integrity requires not only a rigorous and unbiased research process, but also the ability of scientists to speak openly about their findings. In surveys of scientists across 8 U.S. federal agencies in 2005–2007, 60% of respondents reported incidents of political interference in their work, and 7% reported they had been directed to “provide incomplete, inaccurate, or misleading information” to the public (Goldman et al. 2017).

In a 2013 survey of Canadian government scientists, 25% reported being asked to exclude or alter information for nonscientific reasons (Professional Institute of the Public Service of Canada 2013). Under the Harper administration, government scientists communicating their work through the media faced lengthy approval processes. Media minders often sat in on scientist's interviews and even followed scientists at conferences to discourage spontaneous commentary. These restrictions stimulated sustained public protests by Canadian scientists (Noël 2016).

In Australia, even after the advent in 2007 of a new administration's public commitment to scientific integrity, authorization was still often required (and sometimes denied) before government researchers could speak publicly about their research (Ritchie et al. 2017). Commissioned research was routinely subject to contractual clauses allowing governments to prohibit publication of research or modify language in scientific papers (Kyprri 2015). Recently, news of the rediscovery of a plant species thought to be extinct for 200 years (*Hibbertia fumana*) was reportedly suppressed by the New South Wales Office of Environment and Heritage until after a development at the site where the plants were found was approved (Hannam 2017) (Fig. 1). At the federal level, the Australian government successfully requested that the UN Educational, Scientific and Cultural Organization remove mention of the climate-change threats



*Figure 1. Species that provide examples of challenges to the scientific integrity of conservation-policy processes. Political considerations delayed protection of the wolverine (upper left) in the United States (photo by U.S. National and Park Service) and the shortnose sturgeon (lower right) in Canada (photo by U.S. Fish and Wildlife Service [USFWS]). The U.S. recovery plan for the Northern Spotted Owl (upper right) (photo by USFWS) was revised to correct deficiencies identified in a review by 3 scientific societies. News of the rediscovery of the shrub *Hibbertia fumana* (lower left) (photo by A. Orme) in Australia was delayed until a development at the site of rediscovery had been permitted.*

to Australian World Heritage areas in their 2016 report on at-risk sites (Markham et al. 2016). Climate scientists were also recently restricted from submitting comments based on their results during public processes (Salleh & Borschmann 2017).

## **Reforms to Safeguard the Scientific Integrity of Outbound Communications**

### **Institutionalize Protections via Scientific Integrity Policies**

Publicity surrounding scientific integrity violations in the United States led the Obama administration to issue a Memorandum on Scientific Integrity that directed federal

agencies to develop policies that would strengthen safeguards on the integrity of the scientific process (Holdren 2010). Twenty-seven executive branch departments and agencies developed policies to guide and protect the process by which agencies use and publicly communicate science, including use of nongovernmental scientists for peer review and federal advisory committees. Many agencies also put in place officials to oversee enforcement of the policies. This system appears to work best when a full-time scientific-integrity official reports to the highest ranking civil servant in the agency and the person is close to agency science activities and removed from political appointees. These new policies and continuing pressure from the scientific community have resulted in a

reduction in reported cases of inappropriate interference in government decision-making processes (Goldman et al. 2015).

In Canada, the incoming Trudeau administration declared that federal researchers could speak publicly about research within their area of expertise without prior approval in most cases (Government of Canada 2016). The government also established the new position of chief science advisor, whose mandate includes safeguarding scientific integrity and accelerating shifts toward more transparent communication of federal scientific research to the public.

To date, institutionalization of scientific integrity reforms in Australia has been more limited than in Canada and the United States. Although several federal and state institutions have issued statements committing the organizations to a rigorous unbiased research process (ARC 2015), their policies do not generally encompass transparency in communication between agencies and the public. In many agencies scientists still need approval before they can speak publicly about their research.

### **Strengthen Collective Bargaining Agreements**

Although the adoption of the 2016 directive increased public engagement by Canadian government scientists, the new open-communication policies were not uniformly applied. Government scientists are employed under different contracts, and protections varied widely among agencies. In response, the union representing government scientists successfully negotiated for the contractual right of scientists to speak publicly about their research. Protections under this agreement will be difficult to reverse even if a future administration decides to modify the communications directive. Although collective bargaining agreements are an effective means of insulating government scientists against loss of the right to communicate their work, alternative methods exist that strengthen such protections where such agreements are not feasible.

When the Australian Labor party took power in 2007, it promulgated charters for some public research organizations that sought to protect the right of scientists to speak out and to ensure scientific publications presented information free from political interference (Price 2009). To address perceived shortcomings of the new policy, Australia's Community and Public Sector Union, which represents staff at government research organizations, campaigned for a stronger Science Integrity Charter based on several principles: open communication, dissemination, and internal and external debate of scientific work; acknowledgment of the contestability of uncertain science; and independence of public-sector institutions and their staff (CSIRO Staff Association 2012). To our

knowledge, the proposed charter has not been implemented to date.

### **Safeguard Public Access to Scientific Information**

Open access to scientific information allows the public to have confidence in conclusions from scientific research and to engage as informed citizens in policy debates. Administrations vary in their commitment to public access to scientific information produced by government agencies. During the Obama administration, public access to scientific information was expanded via new scientific-integrity policies and new statutes. The FOIA (Freedom of Information Act) Improvement Act of 2016 increased public access to government scientific documents and communications, and the Whistleblower Protection Enhancement Act (WPEA) of 2012 increased protections for federal scientists who expose censorship of scientific and technical information. Similarly, the 2016 Directive on the Management of Communications committed the Canadian Government to principles of open government including access to data. In Australia, some state governments (e.g., New South Wales) have publicly committed to transparency and open access to data (NSW OEH 2016).

Despite new protections enacted in the United States, dismissal of the scientific underpinnings regarding climate change by Donald Trump has raised fears that public access to government climate data and other scientific data will be curtailed. In response, scientists at several major universities developed tools and organized data-rescue events to rapidly archive government scientific data on nongovernmental servers to ensure continued public access (Holthaus 2016). Although efforts such as DataRefuge (<http://www.ppehlab.org/>) provide a defense against loss of public access to government data, they are not a substitute for stronger institutional safeguards that would mandate continued access and collection of new data.

### **Bias and Lack of Transparency in Considering Input from Nongovernmental Scientists**

Informed debate and provision of robust scientific evidence for decision making requires comprehensive access to available science, much of which is not done by government scientists. The extent to which and ways in which science produced by nongovernmental scientists informs conservation policy decisions differs among the 3 nations. Consequently, reforms necessary to ensure that independent scientific input is solicited and considered without political bias also differ. Environmental statutes in the United States contain extensive requirements for science-based decisions. For example, the U.S. Endangered Species Act (ESA) (16 U.S.C. §1532 4(a)(1)) requires listing and delisting decisions for certain species

be based solely on scientific data (Doremus 2004), and agency policy requires external scientific peer review of draft decisions to ensure scientific integrity. The U.S. courts play a prominent role in adjudicating policy disputes, and litigation often hinges on whether an administrative agency's decision follows from the available science.

In Canada and Australia, few statutes require independent scientific input into conservation policy, aside from the public-comment period. However, the Canadian Species at Risk Act formalizes the role of an independent scientific advisory body (Committee on the Status of Endangered Wildlife [COSEWIC]) to assess species at risk. The committee conducts independent scientific reviews on the status of species at risk and makes the results publicly available, whether decisions support or reject listing (Hutchings et al. 2017).

Much authority for conservation policy, especially in Canada and Australia, resides at the state and provincial rather than the federal level, and the role of science in policy often differs between the 2 levels. For example, in New South Wales, Australia, listing of threatened species and ecosystems is decided by an independent scientific committee, whereas at the federal level, although an analogous committee exists, its recommendations must be approved by the minister for the environment (Nicholson et al. 2015).

To illustrate key reforms to protect the integrity of independent scientific input into policy, we examined several recent agency decisions related to the ESA, the main statute designed to protect biodiversity in the United States (Fig. 1). We considered the ESA because it contains clear requirements that policy makers incorporate independent scientific input, yet 73% of staff survey respondents at the U.S. Fish and Wildlife Service (FWS), one of 2 agencies that implement the ESA, thought improper political pressure remained too high despite the ESA's science mandates (Goldman et al. 2015). We linked our suggested reforms to examples from Canada and Australia where possible.

## Reforms to Safeguard the Scientific Integrity of Inbound Communications

### Broaden the Scope of Information Solicited from Independent Scientists

Agencies are constantly faced with the policy question, should we act? This initial decision is often heavily influenced by an agency's scientific evaluation of the facts. However, in many agencies only the decision to take proactive action is subject to peer review. For example, the ESA requires 2 federal agencies (FWS and the National Marine Fisheries Service) to make determinations about adding or removing species from the law's lists of protected species. Currently, external peer review of

decisions to list a species as endangered or threatened is required but external review is not required for decisions not to list a species.

The wolverine (*Gulo gulo*), a mid-sized carnivore, is threatened by loss of snow-covered denning habitat (Fig. 1). Although FWS scientists concluded that threats to the wolverine from climate change qualified the species for listing as threatened, FWS leadership overruled these conclusions and declined to list the wolverine. A federal court subsequently concluded that the decision to deny protections was not consistent with the best available science and was likely due to "immense political pressure" by states that opposed listing (*Defenders of Wildlife v. Jewell*, U.S. District Court for the District of Montana, CV 14-246-M-DLC. 2016). If regulations had required the decision not to list to be subject to review by nongovernmental experts, litigation might not have been necessary. Although increasing the number of decisions requiring outside peer review will result in increased time and costs for the agency, these may be offset by more robust conservation outcomes and less litigation. However, previous informal peer reviews of the FWS scientists' conclusion in favor of listing showed that their conclusion was scientifically sound, but these reviews were ignored by agency leadership. When the political and economic stakes are high concerning listing of a species, litigation may be difficult to avoid, at least in the United States.

Even in Canada, where scientific advice is required to inform both positive and negative listing decisions, political actions can constrain the role of scientific advice in the process. Although COSEWIC assessments are based solely on evidence, species receive no formal protection until the relevant minister submits the species-at-risk files to the prime minister's cabinet for final approval and the consultation process concludes (Hutchings et al. 2017). This legislative loophole allows for politically motivated delays. Under the Harper administration, the minister of the environment ceased transmitting COSEWIC advice to the cabinet to delay protection of as many as 198 species, subspecies, and distinct populations in Canada, including the shortnose sturgeon (*Acipenser brevirostrum*) (Noël 2016) (Fig. 1).

Agencies also often seek to narrowly define the scientific questions presented to peer reviewers to insulate controversial scientific determinations from review. For example, the scope of peer review of Klamath Basin (U.S.A.) water policies by the National Academy of Sciences and National Research Council was manipulated by direction from Vice President Cheney (Fein 2011). Another example is the review of the proposed delisting determination for the gray wolf (*Canis lupus*), for which reviewers were directed to focus solely on taxonomic issues, rather than consider the full spectrum of scientific questions on available habitat and other topics relevant to the analysis required under the ESA (FWS 2013).

### Ensure a Diversity of Independent Scientific Input with Transparency Regarding Conflicts of Interest

Selection of peer reviewers by agencies and contractors remains vulnerable to political interference. The FWS often specifies in the statement of work for peer review that prior “advocacy” disqualifies scientists from serving as peer reviewers (FWS 2013). This clause has been used to exclude scientists who interpret their science for the broader public or comment during a regulatory comment period. Because scientists who have taken positions supportive of agency policy are typically not considered advocates, this screening process may lend bias to reviews.

Political screening processes may subvert the effectiveness of legislation intended to protect declining species. Prior to 2009, COSEWIC recommendations to the Ministry of the Environment for expert appointments were routinely accepted. Under the Harper administration, there were concerns over potential political interference after scientists who had publicly commented on conservation issues were denied renewal of their COSEWIC appointments (Noël 2016). In 2013, negative coverage of the exclusion of key experts from the peer review of national wolf delisting forced the FWS to suspend the initial contractor-led scientific peer review and commission a more independent review by the National Center for Ecological Analysis and Synthesis (Morell 2014). The review by a panel of experts (which included scientists previously excluded from the review) concluded that the proposal was not based on the best available evidence (Morell 2014).

No-advocate reviewer selection policies, where they still exist, should be reformed to reflect peer review policies that explicitly value a diversity of independent and qualified scientific perspectives. The U.S. Office of Management and Budget has such a policy stating that “[o]n most controversial issues, there exists a range of respected scientific viewpoints regarding interpretation of the available literature. Inviting reviewers with competing views on the science may lead to a sharper, more focused peer review. Indeed, as a final layer of review, some organizations (e.g., the US National Academy of Sciences [NAS]) specifically recruit reviewers with strong opinions to test the scientific strength and balance of their reports” (OMB 2002).

Another problematic aspect of current U.S. agency peer-review policies involves undisclosed conflicts of interest by the large corporate contractors frequently used to manage the peer-review process. Although this approach gives the appearance of providing an arms-length separation between the agency and peer reviewers, the reality is often different. Conflict of interest may result in biased selection of peer reviewers and a biased summary of peer reviews being provided by the contractor. Conflicts of interest may arise when the same corporation also

performs services for entities that have a vested interest in the policy under review (Goldman et al. 2015). For example, a consulting firm that has managed hundreds of government peer reviews for toxicological assessments of chemicals also frequently conducts reviews for the chemical industry and has been criticized for relying on a small circle of experts with industry ties as reviewers (Adams & Song 2014). Although the FWS has recently taken steps to document conflicts of interest by individual peer reviewers (FWS 2016), the new policy does not ensure transparency concerning conflict of interest by the contractors themselves.

A key difference between scientific-journals peer review and scientific review that occurs as part of regulatory decision making is the absence in the latter of an independent editor or arbiter who decides whether the agency has adequately addressed shortcomings identified by reviewers (Greenwald et al. 2012). Agency peer review, especially for highly controversial decisions, could benefit from an additional round in which an arbiter or the peer reviewers themselves evaluate the adequacy of the agency’s response to reviewer concerns. Without this process, the only recourse to address an improper decision is a legal challenge. At a minimum, agencies should be required to produce a detailed statement resembling the response to reviewers required by scientific journals, rather than a general response to public comments as required under current policies.

### Strengthening Societal Support for Scientific Integrity

Although the reforms we suggest provide procedural safeguards, the most important factor in protecting scientific integrity may be consistent support from agency leaders and other political appointees. A key lesson from the Canadian experience is that undermining scientific integrity creates a cultural change in public service that is only slowly undone, even after formal policy reform. To institutionalize a culture of scientific integrity, agency leaders should be appointed who have solid track records of supporting determinations made by scientists in the face of political pressure. Policies designed to ensure agency scientists are insulated from political pressure should be compared among agencies and best practices adopted more uniformly across agencies in order to implement a structure and culture that supports independent science (Lowell & Kelly 2016). Agency culture should encourage and reward government scientists when they publish policy-relevant research in peer-reviewed science journals, speak publicly about scientific findings, present at scientific conferences, and participate in professional scientific societies. Finally, those holding key leadership positions in agencies making regulatory policy based in significant part on science should

be required to have a minimum background in a relevant scientific discipline.

Scientific societies can play a valuable public service by performing independent scientific reviews of draft agency decisions. For example, 3 U.S. scientific societies reviewed the recovery plan for the Northern Spotted Owl (*Strix occidentalis caurina*) and identified major deficiencies. Their conclusions led the subsequent administration to substantially revise the recovery plan (SCB 2008) (Fig. 1). Agencies should engage independent nonprofit scientific organizations to oversee the peer review process to increase the independence of the process from political pressure. Such organizations include academic institutes, universities, and scientific societies in the relevant fields. Agencies should invite reviews from scientific societies even in cases where the primary review is done elsewhere, rather than simply passively accepting such input as part of the public-comment process. Agencies should also consider soliciting advice from nongovernmental scientists in cooperation with relevant scientific societies to help strengthen scientific integrity policies.

In turn, scientific societies should work to increase engagement in the policy process by the scientific community. For example, scientific societies should encourage their members to contribute their expertise during public-comment periods required for agency rule making. Such public participation by scientists, if properly framed, does not negatively affect their credibility (Kotcher et al. 2017). There are complementary roles for scientific societies, public-sector unions, and other nongovernmental organizations (e.g., the Union of Concerned Scientists and Evidence for Democracy in the United States and Canada, respectively), and some roles will be more appropriately filled by the latter groups than by scientific societies. Establishing mechanisms through which government scientists can securely share information with NGOs and journalists can help the latter organizations publicize and contest integrity abuses.

Scientific societies can also assist in building public support for the use of evidence in decision making, via coalitions between scientific societies in many disciplines and other nongovernmental organizations. The most prominent recent example is the global March for Science, which involved over 100 scientific organizations in over 600 events designed to defend scientific integrity and increase awareness of positive role of science in society (Wessel 2017). Given recent trends toward politicization of science around issues such as climate change, scientists have a civic responsibility to engage with the wider public to affirm that science is a crucial resource for developing evidence-based policy and regulations that are in the public interest (McCright & Dunlap 2011; Garrard et al. 2016).

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## Literature Cited

- Adams R, Song L. 2014. One-stop science shop has become a favorite of industry—and Texas. Inside Climate News 19 December. Available from <https://insideclimatenews.org/news/20141219/one-stop-science-shop-has-become-favorite-industry%E2%80%94and-texas> (accessed May 2017).
- ARC (Australian Research Council). 2015. Research integrity and research misconduct policy. ARC, Canberra. Available from [http://www.arc.gov.au/sites/default/files/filedepot/Public/ARC/Feedback%20and%20Complaints/ARC\\_Research\\_Integrity\\_and\\_Misconduct\\_Policy\\_Arp15.pdf](http://www.arc.gov.au/sites/default/files/filedepot/Public/ARC/Feedback%20and%20Complaints/ARC_Research_Integrity_and_Misconduct_Policy_Arp15.pdf) (accessed May 2017).
- CSIRO Staff Association. 2012. Integrity test for public sector science. Wavelength: Spring 2012. CSIRO Staff Association, Melbourne. Available from [https://csirostaffassociation.files.wordpress.com/2011/07/wavelength\\_spring2012.pdf](https://csirostaffassociation.files.wordpress.com/2011/07/wavelength_spring2012.pdf) (accessed May 2017).
- Doremus H. 2004. The purposes, effects, and future of the Endangered Species Act's best available science mandate. *Environmental Law* 34:397–450.
- Doremus H. 2008. Scientific and political integrity in environmental policy. *Texas Law Review* 86:1601–1653.
- Fein I. 2011. Reassessing the role of the National Research Council: Peer review, political tool, or science court? *California Law Review* 99:465–555.
- FWS (US Fish and Wildlife Service). 2013. Order statement of work peer review of the scientific findings in the proposed rule: removing the gray wolf (*Canis lupus*) from the list of endangered and threatened wildlife and maintaining protections for the Mexican Wolf (*Canis lupus baileyi*) by listing it as endangered. US Fish and Wildlife Service, Washington, D.C.
- FWS (US Fish and Wildlife Service). 2016. Memorandum on peer review process, FWS/AES/DCC/061995. US Fish and Wildlife Service, Washington, D.C. Available from [https://www.fws.gov/endangered/improving\\_ESA/pdf/Final%20peer%20review%20policy%20061995%20Signed.pdf](https://www.fws.gov/endangered/improving_ESA/pdf/Final%20peer%20review%20policy%20061995%20Signed.pdf) (accessed May 2017).
- Garrard GE, Fidler F, Wintle BC, Chee YE, Bekessy SA. 2016. Beyond advocacy: making space for conservation scientists in public debate. *Conservation Letters* 9:208–212.
- Goldman GT, Berman E, Halpern M, Johnson C, Kothari Y, Reed G, Rosenberg AA. 2017. Ensuring scientific integrity in the Age of Trump. *Science* 355:696–698.
- Goldman GT, Halpern M, Bailin D, Olali A, Johnson C, Donaghy T. 2015. Progress and problems: government scientists report on scientific integrity at four agencies. Union of Concerned Scientists, Cambridge, Massachusetts.
- Government of Canada. 2016. Directive on the management of communications. Available from <http://www.tbs-sct.gc.ca/pol/doc-eng.aspx?id=30682> (accessed May 2017).
- Greenwald DN, Suckling KF, Pimm SL. 2012. Critical habitat and the role of peer review in government decisions. *BioScience* 62:686–690.
- Hannam P. 2017. 'Don't rock the boat': Rediscovery of plant kept under wraps as project approved. *Sydney Morning Herald*, January 28. Available from <http://www.smh.com.au/environment/dont-rock-the-boat-rediscovery-of-plant-kept-under-wraps-as-project-approved-20170127-gtzrf3.html> (accessed May 2017).
- Holdren JP. 2010. Memorandum for the heads of executive departments and agencies, 17 December. Office of Science and Technology Policy, Washington, D.C.

- Holthaus E. 2016. Why I'm trying to preserve federal climate data before Trump takes office. *Washington Post*, 13 December. Available from <https://www.washingtonpost.com/posteverything/wp/2016/12/13/why-im-trying-to-preserve-federal-climate-data-before-trump-takes-office> (accessed May 2017).
- Hutchings JA, Otto SP, Whitton J, Kerr JT, Mooers A, Findlay SF. 2017. Recovering the species at Risk Act. Policy options, February 2017. Institute for Research on Public Policy, Montreal. Available from <http://policyoptions.irpp.org/magazines/february-2017/recovering-the-species-at-risk-act/> (accessed May 2017).
- Khan S. 2017. Why we're marching for science in Australia. *The Conversation*, 7 March. Available from <http://theconversation.com/why-were-marching-for-science-in-australia-73907> (accessed May 2017).
- Kotcher JE, Myers TA, Vraga EK, Stenhouse N, Maibach EW. 2017. Does engagement in advocacy hurt the credibility of scientists? Results from a randomized National Survey Experiment. *Environmental Communication* **11**:1-15.
- Kypri K. 2015. Suppression clauses in university health research: case study of an Australian government contract negotiation. *The Medical Journal of Australia* **203**:72-74.
- Lowell N, Kelly RP. 2016. Evaluating agency use of "best available science" under the United States Endangered Species Act. *Biological Conservation* **196**:53-59.
- Markham A, Osipova E, Lafrenz-Samuels K, Caldas A. 2016. World heritage and tourism in a changing climate. UN Environment Programme, Nairobi.
- McCright AM, Dunlap RE. 2011. The politicization of climate change and polarization in the American public's views of global warming, 2001-2010. *Sociological Quarterly* **52**:155-194.
- Morell V. 2014. Science behind plan to ease wolf protection is flawed, panel says. *Science* **343**:719.
- Nicholson E, Regan TJ, Auld TD, Burns EL, Chisholm LA, English V, Harris S, Harrison P, Kingsford RT, Leishman MR. 2015. Towards consistency, rigour and compatibility of risk assessments for ecosystems and ecological communities. *Austral Ecology* **40**:347-363.
- Noël B. 2016. How Stephen Harper's government screwed over Canadian wildlife. *Vice News*, 4 January. Available from [https://www.vice.com/en\\_us/article/there-was-a-dramatic-drop-in-wildlife-protection-under-stephen-harpers-majority-government](https://www.vice.com/en_us/article/there-was-a-dramatic-drop-in-wildlife-protection-under-stephen-harpers-majority-government) (accessed May 2017).
- NSW OEH (New South Wales Office of Environment and Heritage). 2016. An open, transparent and accessible OEH. NSW Office of Environment and Heritage, Sydney South. Available from <http://www.environment.nsw.gov.au/resources/whoware/Openoeh-case-studies-160445.pdf>.
- OMB (Office of Management and Budget). 2002. Guidelines for ensuring and maximizing the quality, objectivity, utility, and integrity of information disseminated by federal agencies. *Federal Register* **67**:8452-8460.
- Price T. 2009. Scientific freedom of speech: the changing tide. *Optics and Photonics News* **20**:12-13. Available from <http://www.osa-opn.org/Content/ViewFile.aspx?id=11162> (accessed May 2017).
- Professional Institute of the Public Service of Canada (PIPSC). 2013. The big chill, silencing public interest science: a survey. PIPSC, Ottawa. Available from <http://www.pipsc.ca/portal/page/portal/website/issues/science/bigchill> (accessed May 2017).
- Ritchie EG, Driscoll DA, Maron M. 2017. Communication: science censorship is a global issue. *Nature* **542**:165-165.
- Salleh A, Borschmann G. 2017. CSIRO: leaked emails reveal claims organization 'missing in action' on climate advice. *ABC Science*, 1 May. Available from <http://www.abc.net.au/news/science/2017-05-02/csiro-missing-in-action-on-climate-advice/8479568> (accessed May 2017).
- SCB (Society for Conservation Biology). 2008. Review of the final recovery plan for the Northern Spotted Owl. SCB, Washington, D.C. Available from [http://conbio.org/images/content\\_policy/SCB-AOU\\_Review\\_%E2%80%93\\_Northern\\_Spotted\\_Owl\\_Final\\_Recovery\\_Plan.pdf](http://conbio.org/images/content_policy/SCB-AOU_Review_%E2%80%93_Northern_Spotted_Owl_Final_Recovery_Plan.pdf) (accessed May 2017).
- Sutherland WJ, Pullin AS, Dolman PM, Knight TM. 2004. The need for evidence-based conservation. *Trends in Ecology & Evolution* **19**:305-308.
- Wessel L. 2017. From a tweet, a march for science is born. *Science* **355**:556-557.