POLICY PERSPECTIVE

Preserving environmental health and scientific credibility: a practical guide to reducing conflicts of interest

Jason R. Rohr & Krista A. McCoy

Integrative Biology Department, University of South Florida, SCA 110, 4202 East Fowler Avenue, Tampa, FL 33620, USA

Keywords
Atrazine; biodiversity; chemical registration; ecotoxicology; junk science; manufacturing uncertainty; peer-review process.

Correspondence
Jason R. Rohr, Integrative Biology Department, University of South Florida, SCA 110, 4202 East Fowler Avenue, Tampa, FL 33620, USA. Tel: 813-974-0156, fax: 813-974-3263. E-mail: jasonrohr@gmail.com

Received
5 December 2009
Accepted
9 March 2010

Editor
Richard Krannich

doi: 10.1111/j.1755-263X.2010.00114.x

Abstract

Conflicts of interest, situations where personal or organizational considerations have compromised or biased professional judgment and objectivity, can weaken scientific credibility, pose threats to biodiversity and ecosystem services, and are often precursors to corruption. Here, we review historical and international examples of conflicts of interest and their impacts on global biodiversity. We present a contemporary example of a conflict of interest that might have implications for the U.S. Environmental Protection Agency's reevaluation of the safety of the herbicide atrazine. To help scientists, natural resource managers, policy makers, and judicial officials identify and thwart conflicts of interest, we review strategies used by individuals and organizations with conflicts of interest to evade environmental and public health decisions, discuss the role of the scientific and governmental review processes in maintaining scientific integrity, and offer recommendations to reduce bias and facilitate sound and swift decision making for enhanced environmental health.

Introduction

Although all researchers are influenced by their own ideas and perspectives, biases driven by conflicts of interest can be particularly harmful to biodiversity and the goods and services it provides. We define conflicts of interest as circumstances where it can be reasonably perceived that financial or other personal or organizational considerations have compromised or biased professional judgment and objectivity. A conflict of interest is a prerequisite, and can be a precursor, to outright corruption, where an individual or organization unlawfully exploits a professional capacity for private gain (Laurance 2004; Smith & Walpole 2005).

Conflicts of interest have encouraged individuals and organizations with personal agendas to distort, misrepresent, and suppress scientific research and foster skepticism in science as a strategy to evade unwanted political or judicial decisions (Michaels & Monforton 2005). This strategy can progressively deteriorate trust in science (Mooney 2005), making it difficult for policy makers, regulators, and managers to remediate the loss of goods and services associated with our biodiversity crisis because they are left wondering what science to believe (Michaels & Monforton 2005). Indeed, conflicts of interest are implicated in the international loss of forest ecosystem services and declines of threatened and endangered species (Robertson & van Schaik 2001; Gross 2005; Bradshaw *et al.* 2009). Here, we discuss and review the consequences of conflicts of interest in conservation science and provide knowledge and recommendations to reduce conflicts of interest.

Why conflicts of interests and conservation science?

There is a long tradition of science being influenced and co-opted as a result of pressures from governmental agencies, corporate interests, and environmental advocacy groups (Mercer 2000). Formal discussion of cooptation and its impacts on natural resources date back to at least the 1940s (Selznick 1949). Indeed, there is a long history of conservation-related conflicts over forest products and mining, energy, and water rights (e.g., Mercer 2000). Conflicts of interest are at the root of many of these conflicts, as well as several contentious topics in conservation science, such as advocacy (Lackey 2007) and corruption (Laurance 2004; Smith & Walpole 2005). Hence, conflicts of interest represent an important unifying theme for these historically controversial conservation issues.

Additionally, there is considerable evidence that biodiversity offers economically important services to humans including stabilizing ecosystems and the services they provide (Hooper *et al.* 2005; Dobson *et al.* 2006; Rohr *et al.* 2007; Bradshaw *et al.* 2009). Therefore, based both on economic and human health grounds, there is a reasonable argument for general biodiversity conservation. Thus, conflicts of interest that impede conservation likely have detrimental effects on the human condition.

Strategies used to evade undesired decisions

To reduce the adverse effects of conflicts of interest, scientists, natural resource managers, policy makers, and judicial officials must be able to identify its many guises. Perhaps the most commonly used strategy to avert undesired environmental and public health decisions is to manufacture uncertainty (Michaels & Monforton 2005). By making any decision seem premature, uncertainty forestalls, sometimes for decades, and can even prevent, decision making (Michaels & Monforton 2005). Opponents of environmental and public health regulations and judicial decisions have generated uncertainty by ridiculing, distorting, and misrepresenting scientific research that threatens their interests, by releasing competing or misleading science, and by intentionally suppressing undesired information (Herrick & Jamieson 2001). The act of individuals or organizations disparaging science that opposes their interests so that it appears as nonsense, regardless of its quality, has been labeled the "junk science" movement (Herrick & Jamieson 2001). In fact, the junk science movement has even generated a lucrative "science for hire" industry, where scientists are employed to dispute data and argue that undesired evidence is inconclusive (Michaels & Monforton 2005). Sometimes focusing on conflicts of interest themselves can be a strategy, misdirecting people toward each other's credibility rather than examining the data or policy at stake (Campbell 2007).

Although individuals and organizations have the right to defend their science, products, and actions, disingenuous defense often serves to obfuscate the issues, sway public opinion, and delay regulations that might be necessary to protect environmental health. Misleading the public to believe that an organization's products or actions are environmentally safe has been referred to as "greenwashing" (Koh *et al.* 2010). Greenwashing seems to have facilitated tropical forest conversion to oil palm plantations in South East Asia (Koh & Wilcove 2009) that has reduced biodiversity and ecosystem services (Sodhi *et al.* 2004; Brook *et al.* 2006). Alternatively, "blackwashing" occurs when environmental groups mislead the public by suggesting that a corporation's actions will result in extreme environmental degradation (Koh *et al.* 2010). Blackwashing or sensationalizing environmental issues can diminish trust in environmental groups and conservation scientists and undermine public support for conservation (Bradshaw *et al.* 2007; Koh *et al.* 2010). Some authors have even argued that conservation science, with its mission of advancing the science and practice of conserving the Earth's biological diversity, is normative and biased and thus can be perceived as having a conflict of interest (Lackey 2007). However, evidence that biodiversity, in general, offers important services to humans offers a defensible argument for general biodiversity conservation.

Governments, individual researchers, animal rights and environmental groups, and corporations can all be guilty of taking advantage of uncertainty and suppressing undesired information. Many activist groups have fervently applied the "precautionary principle," demanding certainty that no harm will be done by a particular act. This is contrary to the probabilistic nature of science and can have adverse consequences for the human condition and biodiversity (Cooney 2004). For example, it has been proposed that the precautionary principle increased starvation risk in the famished countries of Zambia and Zimbabwe, where governments rejected food aid because it could not be guaranteed that it was free of genetically modified corn (Sunstein 2005). Similarly, animal activist groups in Europe, that categorically oppose killing animals, have made it difficult to eradicate invasive gray squirrels, *Sciurus carolinensis*, that are displacing native red squirrels, *S. vulgaris* (Perry & Perry 2008). Hence, uncertainty can be magnified and the precautionary principle exploited by many groups, delaying or preventing advances that could benefit the "public good" and biodiversity.

Examples of conflict of interest and their impacts on biodiversity

Examples of conflicts of interest with consequences for environmental health are numerous. For instance, there are many convincing examples of the consequences of modern climate change on biological systems (Parmesan & Yohe 2003; Rohr *et al.* 2008a), and these consequences could have only been exacerbated by well-documented conflicts of interest in the United States and Australia. For instance, in an effort to prevent global warming regulation, the Bush administration of the United States and associated political consultants apparently muzzled governmental climate scientists, suppressed climate findings, and highlighted uncertainty and scientific disagreements on the subject, despite a great deal of scientific consensus (Mooney 2005; Anonymous 2006). Similar tactics were employed in Australia. The Australian Bureau of Agricultural and Resource Economics (ABARE) released reports suggesting that curbing greenhouse gas emissions would financially devastate Australians (Mercer 2000). ABARE is carefully monitored by a steering committee consisting largely of representatives from the country's major energy corporations, a committee that denied conservation groups membership. The ABARE reports on climate change are in contrast to reports offered by the independent Intergovernmental Panel on Climate Change, which suggested that it would be more financially devastating to Australians not to curb greenhouse gas emissions (Mercer 2000).

Conflicts of interest also occur in science dealing with endangered species and habitat loss. The Florida panther is considered endangered (under U.S. Endangered Species Act of 1973) and, at one point, there were as few as 30–50 adults in the wild (Gross 2005). The U.S. Fish and Wildlife Service is the agency responsible for protecting the panther. In 1998, it was determined that a Lee County, Florida Department of Transportation project would degrade panther habitat and that the county must mitigate by preserving habitat elsewhere (Gross 2005). In the end, the Fish and Wildlife Service used the Panther Habitat Evaluation Model that required the county to mitigate only 60% of what was originally recommended. This model was developed by a paid consultant for Lee County and a senior advisor to the lobbying firm hired by Lee County and is generally considered to be based on faulty science (Gross 2005). After some pressure, the agency later admitted to the long-term use of faulty science, and its long-standing conflicts of interest are believed to have adversely affected populations of the Florida panther (Gross 2005).

Politicians driven by conflicts of interest can also have important adverse effects on scientific integrity and ecosystem services. For example, countries rich in species and priority areas for conservation have greater perceived levels of conflicts of interest than other nations and it has been suggested that these conflicts of interests and ensuing corruption can be major impediments to conservation and sustainable resource use (Smith *et al.* 2003). In fact, the level of perceived conflicts of interest in national governments was the best predictor for declines of endangered African elephants and black rhinoceroses (Smith *et al.* 2003).

Conflicts of interest that develop into corruption are particularly pronounced in Southeast Asia, a hotspot for biodiversity (Robertson & van Schaik 2001; Sodhi *et al.* 2004). For example, corruption appears to have allowed logging to outstrip sustainable timber supplies in both "protected" and unprotected areas of Indonesia (Laurance 2004; Smith *et al.* 2003), and in Singapore, similar deforestation was associated with widespread local extinctions (Brook *et al.* 2003). Corruption and considerable greenwashing seem to have facilitated forest conversion to oil palm plantations in Southeast Asia (Koh & Wilcove 2009; Koh *et al.* 2010), which caused declines of Sumatran orangutans (Robertson & van Schaik 2001). This deforestation is predicted to extirpate 13–42% of the wildlife populations in the region, at least half of which would represent global species extinctions (Brook *et al.* 2003; Sodhi *et al.* 2004; Brook *et al.* 2006). If present rates of oil palm-driven deforestation continue unabated, Southeast Asia could lose up to three-quarters of its original forest by 2100 (Koh & Wilcove 2009).

Corruption is also a major conservation impediment in other parts of the world (Bradshaw *et al.* 2009). Corruption appears to be driving losses of Amazon rainforests, but the establishment of good governance by 2050 might eradicate deforestation from protected areas (Soares *et al.* 2006). Corruption might also affect biodiversity losses in marine systems, such as off the Galapagos Islands (Shepherd *et al.* 2004). Some researchers have gone as far as stating that reducing corruption and improving governance in tropical countries will offer the greatest long-term improvement to biodiversity conservation (Bradshaw *et al.* 2009).

Conflicts of interest and pollution: a case study with potential policy ramifications

Given that the global production of pharmaceuticals and industrial chemicals is an international industry worth billions of U.S. dollars, it is perhaps not surprising that conflicts of interest are possibly most prominent when it comes to evaluating the biological effects of these chemicals. For example, of 115 studies, 94% of those that were publicly funded found harmful effects of the plastics additive bisphenol A, whereas 0% of industry studies found evidence of harm (vom Saal & Hughes 2005). In 1983, the environmental safety of 15% of the pesticides approved for use in the United States was brought into question by the fraudulent practices of a subsidiary laboratory of Nalco Chemical Company (Markowitz & Rosner 2002; Myers *et al.* 2009).

Despite pollution being the second greatest threat to aquatic and amphibious species in the United States and perhaps the world (behind habitat loss; Wilcove & Master 2005), it is considered one of the most understudied stressors in conservation science (see Lawler *et al.* 2006). Furthermore, in the European Union, the safety of pesticides developed before 1981 does not appear to have been thoroughly or systematically evaluated; this includes 97% of the major pesticides in use and more than 99% of pesticides produced by volume (Hartung 2009). As conservation science redresses the gap between the threat of pollution and research efforts, it will inevitably increase encounters with the many guises of conflicts of interest.

An important, contemporary example of a conflict of interest resulting in a potential illusion of environmental safety that could influence a current regulatory decision is a recent, peer-reviewed paper on the effects of the herbicide atrazine on freshwater amphibians, reptiles, and fish (Solomon *et al.* 2008). This review and the research of many of its authors were indirectly or directly funded by the company that produces the herbicide, Syngenta Crop Protection, Inc. Atrazine is one of the most widely used pesticides in the world (Kiely *et al.* 2004). The safety of atrazine is presently being re-evaluated by the U.S. Environmental Protection Agency (USEPA 2009), and the U.S. Congress appears to be investigating policies regarding atrazine (Ivory 2009). For amphibians and fish, authors have reported that atrazine affects behavior and physiology (Larson *et al.* 1998; Rohr *et al.* 2003 2004; Rohr & Palmer 2005), elevates mortality (Storrs & Kiesecker 2004; Rohr *et al.* 2006; Rohr *et al.* 2008c), suppresses immunity and increases infections (Fatima *et al.* 2007; Rohr *et al.* 2008b, c), disrupts the endocrine system (Hayes *et al.* 2002, 2003), causes gonadal abnormalities (Hayes *et al.* 2002; Carr *et al.* 2003), and induces community-wide, indirect effects (Boone & James 2003; Rohr & Crumrine 2005). Therefore, there is potential that atrazine is having grave consequences for aquatic biodiversity and associated environmental services worldwide. However, there are many studies that have not detected effects of atrazine on amphibians or fish and many atrazine studies might be flawed (reviewed in Hayes 2004; Solomon *et al.* 2008). Consequently, many of the biological effects of atrazine are controversial (Hayes 2004; Renner 2008), making a critical and credible synthesis of the literature crucial for a re-registration decision.

Table 1 Number of studies Solomon *et al.* (2008) criticized and whether or not those studies found adverse effects of atrazine at ecologically relevant concentrations

Solomon *et al.* (2008) describe adverse effects of atrazine at ecologically relevant concentrations	Solomon *et al.* (2008) criticize, or cast doubts on the validity of, the study		
	No	Yes	Total
No	68	2	70
Yes	4	59	63
Total	72	61	133

See Table S2 for details on all 133 studies.

However, this most recent industry-funded review (Solomon *et al.* 2008) on the biological effects of atrazine arguably misrepresented over 50 studies and had 122 inaccurate and 22 misleading statements (Table S1; see Supplementary Materials for methods used to quantify these errors). Of these 144 seemingly inaccurate or misleading statements, 96.5% appeared to be beneficial for Syngenta Crop Protection, Inc., in that they supported the safety of the chemical, whereas only 3.5% appeared to be neutral or detrimental to the company (Table S1). In addition to inaccuracies, criticisms were more often cast at studies that found adverse effects of atrazine (Table S2). The authors (Solomon *et al.* 2008) cast doubts on the validity of 94% of the 63 presented cases where atrazine had adverse effects, whereas they only weakly criticized 2.8% of the 70 cases where there were no effects of atrazine at environmentally relevant concentrations (Table 1, Table S2). We found no evidence that the criticized studies were more poorly conceived or conducted than those that were not criticized (Supplemental Methods; see also Rohr & McCoy 2010). Furthermore, in contrast to the conclusions of this industry-funded review, a recent meta-analysis revealed consistent effects of atrazine on many traits of aquatic and amphibious vertebrates, suggesting that it might have important effects on biodiversity (Rohr & McCoy 2010). Although atrazine is banned in Europe, it is still being detected in groundwater in parts of the European Union (Gutierrez & Baran 2009), it continues to be used around the world, and is found in precipitation hundreds of kilometers away from its source (van Dijk & Guicherit 1999); thus there could be international consequences to these conflicts of interest. We, of course, do not know the intent of any of the authors of this industry-funded review (Solomon *et al.* 2008), but the errors and patterns of criticism provide a reminder that conflicts of interest can challenge scientific credibility, policy, and conservation.

Role of the review process

In our examples of conflict of interest, fault does not lie solely with companies or researchers misrepresenting science. Appreciable damage also comes from the failure of the scientific and governmental review processes to prevent such biases from being publicly released, regardless of whether the research was funded by an entity that would benefit from the result. Fortunately, misconceptions and biases of the magnitude presented here are relatively rare in peer-reviewed literature, and we stress that although the peer review system is not infallible, there is no indication that it is widely corrupted either. Indeed, in most cases, it minimizes misinformation and promotes credibility. When, on occasion, papers are published that propagate important errors or misconceptions, the system usually ensures that they are quickly revealed and resolved.

Steps toward an improved future

Given that many entities are culpable, there is no single panacea to prevent the adverse effect of conflicts of interest. A series of improvements, outlined below (also see the last chapter of Michaels 2008), should ideally occur to preserve scientific integrity and ecosystem services. These include education, enhancements to the scientific and governmental review processes, and changes to national and international policies.

Education

(1) The adverse consequences of conflicts of interest cannot be addressed until we know how to recognize its subtleties. Hence, educating the public on environmental ethics and conflicts of interest will be vital to reducing the impacts of conflicts of interest on societies and biodiversity (Shrader-Frechette & McCoy 1999); (2) Ecologists and conservation scientists should enhance campaigns to educate the public on the value of ecosystem goods and services to humans so that the public has a more personal understanding of the potential consequences of conflicts of interests (Kareiva & Marvier 2007).

The review process

(1) All journals and regulatory agencies should require and publish information on funding sources and potential conflicts of interest of authors, editors, and reviewers. We must also remember, however, that disclosing a conflict of interest does not remove it (Campbell 2007); (2) The review process is set up to prevent biases and misinformation from being publicly released. Hence, appreciable effort should be given to finding appropriate reviewers and excluding authors' recent colleagues; (3) Given that conflicts of interest can transpire at any step of conservation planning, governments should encourage independent scientific review at several stages of the planning process (Gross 2005).

National and international policies

(1) Governmental agencies and judicial systems should have the authority to mandate information on who paid for scientific research and whether the sponsors controlled or influenced what research was publicly released. Research conducted by governments should be held to the same level of transparency; (2) No chemical should be approved for sale or use without toxicity testing and federal approval to sell a product should not be based on product safety research conducted by the producing or affiliated companies. Companies should be required to provide funds to the regulatory agency to study the safety of its product. The regulatory agency should release a request for proposals to study the product, and the agency should ensure that the funds are provided to qualified, impartial laboratories that remain anonymous until the research is completed; (3) Action should be taken to limit the abuse of national policies to forestall or prevent potentially important regulatory or judicial decisions. These policies can, at times, occur subtly. More subtle examples include the U.S. Data Quality Act (enacted in 2001), which is widely reported to have been slipped into legislation to obviate science that can lead to "costly" environmental regulations (Michaels & Monforton 2005), and the Daubert rule, which allows judicial officials in the United States to set admissibility standards for scientific research that exceed realistic certainty, excluding credible science from the courts (Michaels & Monforton 2005). Governments must prevent parties with a vested interest in scientific, judicial, or regulatory outcomes from using uncertainty as a tool to stonewall judicial and regulatory decisions or to fulfill personal agendas, (4) Given that the source of governmental corruption is conflict of interest, an important step at the national level will be to ratify international anticorruption agreements, such as the Organization of Economic Cooperation and Development's Anti-Bribery Convention and the Criminal Law Convention Against Corruption (Laurance 2004). Additionally, these agreements must be enforced; (5) We must employ, but not abuse, the precautionary principle and avoid supporting political agendas that are overly optimistic about biodiversity and ecosystem services in developing countries. Supporting this level of optimism will likely only

result in further declines of biodiversity and ecosystem services (Bradshaw *et al.* 2009).

Conclusion

Honest mistakes and spurious results are not uncommon in science, but we assert that they are not as damaging to scientific credibility as systematic bias created by conflicts of interest. We hope that this article provides readers with an understanding of the potential consequences conflicts of interest can have for science, humanity, biodiversity, and ecosystem services. But most importantly, we hope that this article arms readers with the knowledge necessary to identify and minimize the adverse effects of conflicts of interest. We all have a responsibility and role to reduce the adverse effects of conflicts of interest and to preserve the credibility and integrity of science—the health of our families and ecosystems might depend on it.

Acknowledgments

We thank M. Martin, E. McCoy, M. McCoy, C. Osenberg, the Rohr lab, and anonymous reviewers for comments on this work and David Michaels for writing an enlightening paper and book. Funds were provided by National Science Foundation (NSF: DEB 0516227), U.S. Department of Agriculture (USDA: NRI 2006-01370, 2009-35102-0543), and U.S. Environmental Protection Agency STAR (R833835) grants to J.R.R. As a PhD student, K.A.M temporarily worked for an advisor that was indirectly funded by Syngenta Crop Protection, Inc. She terminated her affiliation with this laboratory, did not publish any work conducted there, and relinquished all data upon leaving.

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1: Inaccurate or misleading quotes from Solomon *et al*. (2008), the presumed effect the quote would have for Syngenta, the company who makes atrazine and funded the Solomon *et al.* (2008) review, and an explanation for why the quote is either inaccurate or misleading.

Table S2: List of studies discussed by Solomon *et al.* (2008), whether Solomon *et al.* (2008) describe adverse effects of atrazine at ecologically relevant concentrations from these studies, and whether Solomon *et al.* (2008) criticize, or cast doubts on the validity of, these studies.

Please note: Wiley-Blackwell is not responsible for the content or functionality of any supporting materials supplied by the authors. Any queries (other than missing material) should be directed to the corresponding author for the article.

References

Anonymous. (2006) Science under attack. *Nature* **439**, 891–891.

Boone, M.D., James S.M. (2003) Interactions of an insecticide, herbicide, and natural stressors in amphibian community mesocosms. *Ecol Appl* **13**, 829–841.

Bradshaw, C.J.A., Brook B.W., McMahon C.R. (2007) Dangers of sensationalizing conservation biology. *Conserv Biol* **21**, 570–571.

Bradshaw, C.J.A., Sodhi N.S., Brook B.W. (2009) Tropical turmoil: a biodiversity tragedy in progress. *Front Ecol Environ* **7**, 79–87.

Brook, B.W., Bradshaw C.J.A., Koh L.P., Sodhi N.S. (2006) Momentum drives the crash: mass extinction in the tropics. *Biotropica* **38**, 302–305.

Brook, B.W., Sodhi N.S., Ng P.K.L. (2003) Catastrophic extinctions follow deforestation in Singapore. *Nature* **424**, 420–423.

Campbell, L.M. (2007) Conservation conflicts, conflicts of interest, and conflict resolution: what hopes for marine turtle conservation? *Mar Turtle Newsletter* **118**, 1–2.

Carr, J.A., Gentles A., Smith E.E. *et al*. (2003) Response of larval *Xenopus laevis* to atrazine: assessment of growth, metamorphosis, and gonadal and laryngeal morphology. *Environ Toxicol Chem* **22**, 396–405.

Cooney, R. (2004) Better safe than sorry? The precautionary principle and biodiversity conservation. *Oryx* **38**, 357–358.

Dobson, A., Cattadori I., Holt R.D. *et al*. (2006) Sacred cows and sympathetic squirrels: the importance of biological diversity to human health. *PLoS Med* **3**, 714–718.

Fatima, M., Mandiki S.N.M., Douxfils J., Silvestre F., Coppe P., Kestemont P. (2007) Combined effects of herbicides on biomarkers reflecting immune-endocrine interactions in goldfish immune and antioxidant effects. *Aquat Toxicol* **81**, 159–167.

Gross, L. (2005) Why not the best? How science failed the Florida panther. *PLoS Biol* **3**, 1525–1531.

Gutierrez, A., Baran N. (2009) Long-term transfer of diffuse pollution at catchment scale: respective roles of soil, and the unsaturated and saturated zones (Brevilles, France). *J Hydrol* **369**, 381–391.

Hartung, T. (2009) Toxicology for the twenty-first century. *Nature* **460**, 208–212.

Hayes, T., Haston K., Tsui M., Hoang A., Haeffele C., Vonk A. (2003) Atrazine-induced hermaphroditism at 0.1 ppb in American leopard frogs (*Rana pipiens*): laboratory and field evidence. *Environ Health Persp* **111**, 568–575.

Hayes, T.B. (2004) There is no denying this: defusing the confusion about atrazine. *Bioscience* **54**, 1138–1149.

Hayes, T.B., Collins A., Lee M. et al. (2002) Hermaphroditic, demasculinized frogs after exposure to the herbicide atrazine at low ecologically relevant doses. *P Natl Acad Sci USA* **99**, 5476–5480.

Herrick, C.N., Jamieson D. (2001) Junk science and environmental policy: obscuring public debate with misleading discourse. *Philos Public Policy Q* **21**, 11–16.

Hooper, D.U., Chapin F.S., Ewel J.J. *et al*. (2005) Effects of biodiversity on ecosystem functioning: a consensus of current knowledge. *Ecol Monogr* **75**, 3–35.

Ivory, D. (2009) EPA's failure to publicize drinking water data prompts rethinking in Agency, Congress. The Huffington Post Investigative Fund, http://huffpostfund.org/blog/2009/09/04/epas-failure-publicize-drinking-water-data-prompts-rethinking-agency-congress.

Kareiva, P., Marvier M. (2007) Conversation for the people – pitting nature and biodiversity against people makes little sense. Many conservationists now argue that human health and well-being should be central to conservation efforts. *Sci Am* **297**, 50–57.

Kiely, T., Donaldson D., Grube A. (2004) *Pesticide industry sales and usage: 2000 and 2001 market estimates*. U.S. Environmental Protection Agency, Washington, D.C.

Koh, L.P., Ghazoul J., Butler R.A. *et al*. (2010) Wash and spin cycle threats to tropical biodiversity. *Biotropica* **42**, 67–71.

Koh, L.P., Wilcove D.S. (2009) Oil palm: disinformation enables deforestation. *Trends Ecol Evol* **24**, 67–68.

Lackey, R.T. (2007) Science, scientists, and policy advocacy. *Conserv Biol* **21**, 12–17.

Larson, D.L., McDonald S., Fivizzani A.J., Newton W.E., Hamilton S.J. (1998) Effects of the herbicide atrazine on *Ambystoma tigrinum* metamorphosis: duration, larval growth, and hormonal response. *Phys Zool* **71**, 671–679.

Laurance, W.F. (2004) The perils of payoff: corruption as a threat to global biodiversity. *Trends Ecol Evol* **19**, 399–401.

Lawler, J.J., Aukema J.E., Grant J.B. *et al*. (2006) Conservation science: a 20-year report card. Front. *Ecol Environ* **4**, 473–480.

Markowitz, G.E., Rosner D. (2002) *Deceit and denial: the deadly politics of industrial revolution*. University of California Press, Berkeley, CA.

Mercer, D. (2000) *A question of balance: natural resources conflict issues in Australia*. The Federation Press, Sydney, Australia.

Michaels, D. (2008) *Doubt is their product: how industry's assault on science threatens your health*. Oxford University Press, New York.

Michaels, D., Monforton C. (2005) Manufacturing uncertainty: contested science and the protection of the public's health and environment. *Am J Public Health* **95**, S39–S48.

Mooney, C. (2005) *The republican war on science*. Basic Books, New York.

Myers, J.P., vom Saal F.S., Akingbemi B.T. *et al*. (2009) Why public health agencies cannot depend on good laboratory practices as a criterion for selecting data: the case of bisphenol A. *Environ Health Persp* **117**, 309–315.

Parmesan, C., Yohe G. (2003) A globally coherent fingerprint of climate change impacts across natural systems. *Nature* **421**, 37–42.

Perry, D., Perry G. (2008). Improving interactions between animal rights groups and conservation biologists. *Conserv Biol* **22**, 27–35.

Renner, R. (2008) Atrazine effects in *Xenopus* aren't reproducible. *Environ Sci Tech* **42**, 3491–3493.

Robertson, J.M.Y., van Schaik C.P. (2001) Causal factors underlying the dramatic decline of the Sumatran orang-utan. *Oryx* **35**, 26–38.

Rohr, J.R., Crumrine P.W. (2005) Effects of an herbicide and an insecticide on pond community structure and processes. *Ecol Appl* **15**, 1135–1147.

Rohr, J.R., Elskus A.A., Shepherd B.S. *et al*. (2003) Lethal and sublethal effects of atrazine, carbaryl, endosulfan, and octylphenol on the streamside salamander, *Ambystoma barbouri*. *Environ Toxicol Chem* **22**, 2385–2392.

Rohr, J.R., Elskus A.A., Shepherd B.S. *et al*. (2004) Multiple stressors and salamanders: effects of an herbicide, food limitation, and hydroperiod. *Ecol Appl* **14**, 1028–1040.

Rohr, J.R., Mahan C.G., Kim K. (2007) Developing a monitoring program for invertebrates: guidelines and a case study. *Conserv Biol* **21**, 422–433.

Rohr, J.R., McCoy K.A. (2010) A qualitative meta-analysis reveals consistent effects of atrazine on freshwater fish and amphibians. *Environ Health Persp* **118**, 20–32.

Rohr, J.R., Palmer B.D. (2005) Aquatic herbicide exposure increases salamander desiccation risk eight months later in a terrestrial environment. *Environ Toxicol Chem* **24**, 1253–1258.

Rohr, J.R., Raffel T.R., Romansic J.M., McCallum H., Hudson P.J. (2008a) Evaluating the links between climate, disease spread, and amphibian declines. *Proc Natl Acad Sci USA* **105**, 17436–17441.

Rohr, J.R., Raffel T.R., Sessions S.K., Hudson P.J. (2008b) Understanding the net effects of pesticides on amphibian trematode infections. *Ecol Appl* **18**, 1743–1753.

Rohr, J.R., Sager T., Sesterhenn T.M., Palmer B.D. (2006) Exposure, postexposure, and density-mediated effects of atrazine on amphibians: breaking down net effects into their parts. *Environ Health Persp* **114**, 46–50.

Rohr, J.R., Schotthoefer A.M., Raffel T.R. *et al*. (2008c) Agrochemicals increase trematode infections in a declining amphibian species. *Nature* **455**, 1235–1239.

Selznick, P. (1949) *TVA and the grass roots: a study in the sociology of formal organization*. University of California Press, Berkeley, CA.

Shepherd, S.A., Martinez P., Toral-Granda M.V., Edgar G.J. (2004). The Galapagos sea cucumber fishery: management improves as stocks decline. *Environ Conserv* **31**, 102–110.

Shrader-Frechette, K., McCoy E.D. (1999) Molecular systematics, ethics, and biological decision making under uncertainty. *Conserv Biol* **13**, 1008–1012.

Smith, R.J., Muir R.D.J., Walpole M.J., Balmford A., Leader-Williams N. (2003) Governance and the loss of biodiversity. *Nature* **426**, 67–70.

Smith, R.J., Walpole M.J. (2005) Should conservationists pay more attention to corruption? *Oryx* **39**, 251–256.

Soares, B.S., Nepstad D.C., Curran L.M. *et al*. (2006) Modelling conservation in the Amazon basin. *Nature* **440**, 520–523.

Sodhi, N.S., Koh L.P., Brook B.W., Ng P.K.L. (2004) Southeast Asian biodiversity: an impending disaster. *Trends Ecol Evol* **19**, 654–660.

Solomon, K.R., Carr J.A., Du Preez L.H. *et al*. (2008) Effects of atrazine on fish, amphibians, and aquatic reptiles: a critical review. *Crit Rev Toxicol* **38**, 721–772.

Storrs, S.I., Kiesecker, J.M. (2004) Survivorship patterns of larval amphibians exposed to low concentrations of atrazine. *Environ Health Persp* **112**, 1054–1057.

Sunstein, C. (2005) *Law of fear: beyond the precautionary principle*. Cambridge University Press, Cambridge.

USEPA. (2009) FIFRA Scientific Advisory panel: notice of public meeting, EPA–HQ-OPP-2009-0104, FRL-8403-1. *Fed Regist* **74**, 7891–7893.

van Dijk, H.F.G., Guicherit, R. (1999) Atmospheric dispersion of current-use pesticides: A review of the evidence from monitoring studies. *Water Air Soil Pollut* **115**, 21–70.

vom Saal, F.S., Hughes C. (2005) An extensive new literature concerning low-dose effects of bisphenol A shows the need for a new risk assessment. *Environ Health Persp* **113**, 926–933.

Wilcove, D.S., Master L.L. (2005) How many endangered species are there in the United States? *Front Ecol Environ* **3**, 414–420.

