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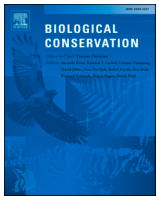

Stealth advocacy in ecology and conservation biology

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ABSTRACT

Ecologists routinely engage directly or indirectly with policy. Long portrayed as a tradeoff between a scientist's societal impact and their credibility, the decision to advocate for specific policies is now widely treated as a matter of personal choice. However, increasing polarization at the science-policy interface has led to a re-examination of the potential pitfalls associated with different policy contexts. We analyze two major biodiversity-related policy issues (non-native species, species at risk) using an existing science-policy framework where policy context is defined by the level of uncertainty and the level of value consensus in society. We argue that ecologists and conservation biologists often find themselves operating in contexts where uncertainty is high and/or value consensus is low. In these conditions, even a common set of facts can generate several legitimate policy alternatives: scientists have the choice to act as issue advocates (narrowing the range of options), or honest brokers (expanding policy options). However, there is also a high risk that scientists might communicate their own policy preferences in a way that is indistinguishable from scientific results: so-called "stealth advocacy". Conflating value-driven positions and scientific advice is not only counterproductive for science, it also hinders the resolution of the environmental challenges we are trying to address, potentially leading to more polarized debates. With four possible roles for scientists at the science-policy interface – pure scientist, science advisor, issue advocate, and honest broker – close attention to their own values and those of others can help scientists more effectively navigate their interactions with broader society.

1. Introduction

Ask a class of incoming undergraduates in ecology why they are choosing this career path, and one recurring answer will be the desire to "make a difference". From climate change to the loss of species and ecosystems and the growing demand for a more equitable distribution of ecosystem services, young people want to effect change. These same students must also prepare to face a world where science and scientists are embroiled in polarized political debates about environmental controversies and other science-based issues (Coffey and Joseph, 2013; Drummond and Fischhoff, 2017). Here, we explore how situations encountered by ecologists and conservation biologists map onto different roles that they can play in informing conservation policies: pure scientist, science advisor, issue advocate, and honest broker (as defined by Pielke, 2012). We are especially interested in potential pitfalls involved in "stealth advocacy" (defined below), which can exacerbate conflicts. We hope that this can help scientists - especially in early career - navigate this landscape and decide which role(s) suit them best.

The role of scientists in engaging with public policy and management has been a source of tension within ecology and conservation for many decades. Bursting onto a scientific landscape that had up to that point put objectivity at the center of the scientific enterprise, the arrival of a "mission-driven" conservation biology (Soulé, 1985) resulted in fierce debates over whether scientists could, should, or even must engage in advocacy (Franz, 2001; Garrard et al., 2016; O'Brien, 1993). Authors opposed to advocacy feared for their credibility as scientific advisors and called for an arm's length relationship between science and politics (Brown and Sax, 2005; Hutchings, 2022; Lackey, 2007). Proponents of advocacy countered that individual objectivity is a myth, and whether implicitly or explicitly, ecology is already value-laden (Franz, 2001). It is not our intention to revisit this debate. We now increasingly understand scientific objectivity as a property that is achieved at the scale of whole scientific communities, where a diversity of viewpoints, opinions and roles contribute to scientific progress (Douglas, 2009; Wallington and Moore, 2005). Having set aside the question of individual objectivity, the question remains as to what might be scientists' role in informing policy, in the broad sense of "a commitment to a particular course of action" (Pielke, 2012).

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The "linear model" of science-policy refers to the idea that scientific knowledge is a necessary and sufficient precursor for policy decisions (Douglas, 2009; Lawton, 2007). It assumes that information about what is (i.e., facts) can answer questions about what ought to be (i.e., normative questions). The linear model works well when values and goals are widely agreed upon and uncertainties are low (Funtowicz and Ravetz, 1993): in this case, difficult policy decisions can be made easier with more information. For instance, with a near-universally shared goal of treating illness and restoring health, medical science has successfully translated knowledge into improved quality of life. However, this model has also met significant criticism both on philosophical grounds, and because the prerequisites for it to work - clear and common goals as well as low uncertainties - do not apply to many real-world problems (Buschke et al., 2019; Funtowicz and Ravetz, 1993; Rose, 2018). From coral reef preservation to biodiversity offsets and invasive species management (Hughes et al., 2013; Maron et al., 2016; Woodford et al., 2016), environmental problems are especially challenging because they often involve high uncertainties or conflicts over values (and often both). When the same set of facts can support multiple legitimate courses of action, science cannot, on its own, tell us what ought to be (Allen et al., 2001).

Disagreement about values or different attitudes toward risk and uncertainty cannot typically be solved with more information. Scientific evidence can be used strategically on both sides of an argument: as a result, more information can actually exacerbate conflict and lead to the polarization of debates. This has played out in debates over climate change, where the more information participants had, the more their positions aligned with their cultural worldviews, political affiliation, or religion (Drummond and Fischhoff, 2017; Kahan et al., 2012). When scientists fail to recognize a policy context where high uncertainty and low value consensus generate several policy alternatives, they run the risk of applying the linear model of science-policy, which can make problems worse (Sarewitz, 2004).

In this paper, we argue that conservation biologists routinely operate in contexts where (i) there are differences in values and (ii) there is high uncertainty, creating room for a range of legitimate policy decisions. We further contend that failure to identify this context can make conservation conflicts worse. By mounting arguments to "follow the science" - invoking the linear model of science and policy - scientists seeking to act as science advisors can inadvertently become issue advocates. Such "stealth advocacy" can lead to more polarized debate, delayed consensus and less stable conservation outcomes. By learning to identify differences in values and risk perception among stakeholders, we hope to foster more transparent and democratic debate surrounding conservation policy alternatives, and more durable conservation outcomes.

2. The many roles of scientists in connecting science and policy

Ecology aims to generate knowledge that can help solve environmental challenges (British Ecological Society, 2022; Ecological Society of America, 2019). Conservation biology goes further in seeking to promote certain values (Franz, 2001; Kareiva and Marvier, 2012; Soulé, 1985). The choice between acting as an advocate or advisor has typically been presented as a matter of personal choice (Brown and Sax, 2005; Franz, 2001; O'Brien, 1993; Sarewitz, 2013). Here, we apply the approach of Pielke (2012) involving not two, but four roles that ecologists and conservation biologists can play in relation to environmental policy. We define "policy" very broadly as any environmental goal or commitment, independent of the actions that are needed to achieve it (management). By presenting scientists' roles as the result of a decision tree based on three fundamental questions (Fig. 1), the framework has two advantages: it broadens the set of roles available to ecologists and conservation biologists, and it emphasizes the importance not just of personal preference, but also of policy context in determining this role. This can be especially helpful for the many ecologists and conservation biologists who find themselves involved in debates that they may not have anticipated.

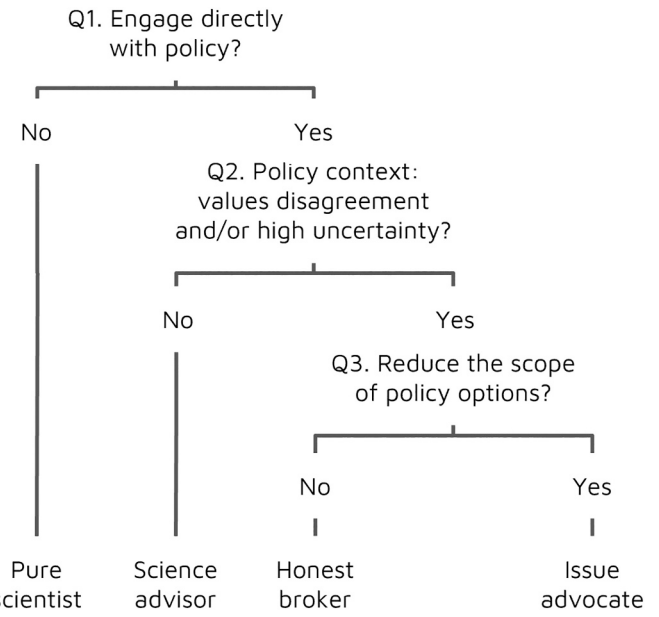

Fig. 1. Four roles that scientists can play in real-world environmental policy and management challenges, as proposed by Pielke (2012). Pure scientists contribute to a general pool of knowledge that is accessible to all, including policy makers, but do not seek to influence policy directly. Science advisors use the best scientific evidence to help achieve goals around which there is agreement and low scientific uncertainty. In situations where there is disagreement on values and/or high uncertainty, honest brokers broaden policy options by noting trade-offs between policy alternatives and issue advocates seek to narrow these options. Misidentification of the policy context (Q2) can lead to scientists to promote value-driven positions (issue advocacy) in a way that is indistinguishable from scientific advice.

When science is unconnected to specific policies, scientists nonetheless contribute to a common pool of knowledge from which policy makers can draw. Most ecological research, including some of our own (e.g., on plant phenology or functional traits), has only minor aspirations of contributing to policy, but it provides critically needed knowledge about how species and ecosystems work and how they might be impacted in the future. In this case, we serve as "pure scientists". In contrast, "scientific advisors" seek to inform policy directly based on scientific evidence, implicitly assuming a single common goal, or explicitly responding to specific questions from policy makers. In Canada, the province of Quebec has determined democratically that forests should be managed at least in part for timber production. In this case, politicians have already weighed various competing values, and what is needed is scientific advice on implementation. This consensus may not be unanimous, but it is the result of a political process of negotiation, bargaining and compromise, which is at least an approximation of values consensus. Given the goal of timber production, science can contribute to its achievement by, for instance, using models to assess how much wood can be harvested in any given period to ensure continued production over time (Girard, 2021).

While engaging with policy is a personal decision (Fig. 1, Q1), the set of possible roles for scientists is not simply a matter of choice: it is also determined in fundamental ways by the social features of the policy context (Fig. 1, Q2). Diverse values frequently create trade-offs and thus multiple policy alternatives. Even when they agree on values, different stakeholders are likely to weigh benefits and risks differently. Where uncertainties are high or where there is low value consensus (or both), scientists have two choices (Fig. 1, Q3): they can either aim to narrow or to broaden the range of policy options. To narrow the options is to serve as an "issue advocate", in effect taking sides in a values trade-off. In contrast, "honest brokers" engage with the full breadth of policy options:

they work to document and communicate trade-offs but stop short of making specific policy recommendations. There are risks associated with failing to recognize a policy context where high uncertainties or low value consensus legitimize a range of policy alternatives (Fig. 1, Q2). If a scientist mis-judges the answer to Q2 in Fig. 1, they risk assuming that it is possible to go from facts to a specific policy choice (i.e., applying the linear model, like a science advisor). In fact, in this situation, any specific policy represents one value-based position among many. Authors have described this role as "inadvertent advocate" (Wilhere, 2012) or "stealth advocate" (Pielke, 2012), denoting different levels of intentionality. In the following sections, we unpack the ideas of uncertainty and values in ecology and conservation, we present evidence of stealth advocacy in the field, and we discuss how ecologists can navigate these complex issues.

2.1. Uncertainty context

Some ecological phenomena are more predictable than others. Conversion of tropical forest to agriculture generally leads to aboveground diversity loss (Newbold et al., 2015). Given enough time and opportunities, bacteria evolve resistance to antibiotics. More often, uncertainties plague pressing societal questions: how much fishing is too much, or how little land protection is too little? Answers to these questions often come down to probabilities, which are themselves difficult to quantify with certainty. Although economists sometimes treat these two phenomena separately, here we address them together. Risk is commonly defined as the product of (i) exposure, or the probability that a harmful event might occur, and (ii) hazard, or how much harm would be associated with that event (lost value). In conservation, "harmful events" can include anything from pathogen outbreaks to the failure of specific conservation policies, and ecologists often advocate for policies that are at one end of the risk spectrum (less fishing, more land protection). This is the precautionary principle. High uncertainty situations generate a range of legitimate policy alternatives, depending on how much risk stakeholders perceive, how much value is ascribed to what is under threat, and personal attitudes to risk in general.

Regulatory agencies routinely report risks associated with different modes of transportation. Although science tells us that there is a much higher risk of death while traveling via motorcycle than any other mode of transportation, many still choose to do so. These motorcyclists are not denying those statistics or failing to "follow the science". General attitudes to risk can vary markedly among individuals and groups, leading to different policy preferences (e.g., Bartke and Schwarze, 2008). For instance, in a study of Australian farmers, Greiner et al. (2009) showed that risk perception was a strong predictor of preferred conservation practices. Prior experiences can also change risk perception, and sometimes trust in institutions. For example, plans by the US Forest Service to control invasive spotted knapweed (*Centaurea stoebe* subsp. *australis*) using herbicides were strongly opposed by local stakeholders because of heightened local risk perceptions based on past exposure to harmful chemicals (Norgaard, 2007). This illustrates the fact that knowledge mediates risk perception, and explains the attitude by many ecologists and conservation biologists that if only people knew what we know, this might increase their willingness to act (e.g., Courchamp et al., 2017).

Level of education is one of the best predictors of climate change awareness (Lee et al., 2015), but climate change is also a cautionary tale for the diminishing returns of "raising awareness". Kahan et al. (2012) showed that more science literacy was actually associated with *less* climate change risk perception, rather than more. Risk perception aligned *most strongly* with cultural worldviews for people with the highest science literacy, a pattern that extends to other environmental risks, such as GMOs (Slimak and Dietz, 2006). In short, while different attitudes to risk may have little influence when uncertainties are low, they are nonetheless pervasive and can legitimate different policy alternatives when uncertainties are high.

2.2. Values context

Values are enduring and stable mental constructs that represent desirable outcomes or modes of conduct (Estévez et al., 2015; Jones et al., 2016). Values disagreements are not new to ecology and conservation biology. From the start, the conservation movement has been divided between protecting nature for nature's sake (intrinsic) or for people (instrumental), and we now additionally recognize "relational values", capturing the breadth of human-nature relationships (Chan et al., 2018; Chan et al., 2016; Kellert, 2012; Smith, 1998). All three types of values can vary markedly among people and groups.

Nowhere has this been more glaring than in the heated debates about whether the economic valuation of natural capital (ecosystem services) helps or harms conservation (Kareiva and Marvier, 2012; Soulé, 2013). While these arguments are usually couched in the language of science, the participants generally do not disagree on basic facts about human impacts on nature. Given these facts however, these conservationists disagree strongly on what the best course of action might be. By recognizing that this debate is rooted in values and not facts (e.g., Tallis and Lubchenco, 2014), conservation science has been able to better grapple with the full breadth of legitimate policy alternatives. As a result, even if the values of conservationists remain split between intrinsic and utilitarian (Sandbrook et al., 2019), extensive literature now documents the trade-offs between nature conservation for its own sake (e.g., a maximum diversity of species) and the preservation of the material benefits derived from nature (e.g., Maes et al., 2012). This opens the door for political solutions to value disagreements that can capture pluralistic outlooks (Tallis and Lubchenco, 2014).

While conservation science includes people with many different values (Sandbrook et al., 2019), there is also reason to suspect that this group represents itself a non-random sample of society (Chaudhury and Colla, 2021; Vellend, 2019). If this sample only captures a small subset of intrinsic, instrumental, and importantly, relational values that people hold with respect to the living world, it is possible that we, as a field, may underestimate the range of potential legitimate policy alternatives. In the Netherlands, Buijs and Elands (2013) found that individual animals and trees as well as aesthetic considerations were valued to a much greater extent by lay people than by conservation professionals. In Germany, Peter et al. (2022) found that scientific researchers valued different bundles of ecosystem services than other groups, aligning with left-leaning political preferences. This is particularly concerning when minority groups that have been historically under-represented and even excluded from ecology and conservation biology hold unique value sets (Buijs and Elands, 2013; Chaudhury and Colla, 2021). A picture emerges in which values consensus is possible but unlikely in many conservation contexts.

2.3. Options for engagement in the face of uncertainty and lack of values consensus

In the face of ubiquitous uncertainty and lack of values consensus, how can scientists engage with policy? One option is to be an issue advocate. For instance, scientists might be the first to discover potential threats to the natural world, and society can benefit when we draw attention to such issues. In this case, there might not be any existing laws or guidelines for a scientific advisor to steer toward. Rachel Carson is the paradigmatic example of the "whistleblower", having painstakingly pieced together evidence for the widespread impacts of pesticides. From her vantage point as an editor and communicator within the U.S. Fish and Wildlife Service, she found herself in a unique position to synthesize a growing body of evidence about novel and unregulated pesticides having pervasive impacts on ecosystems across the country. Although her position against the widespread use of these new compounds was supported by facts, it also rested critically on a value judgment about the relative importance of wildlife vs. goals like economic benefits to farmers. She advocated for specific changes in US policy that culminated

in the creation of the U.S. Environmental Protection Agency (Lear, 1993). However, when specific environmental issues become increasingly well known (e.g., biodiversity loss), it becomes more difficult for scientists to legitimately claim to be whistleblowers.

Once an issue becomes known and addressed formally in legislation, it might be tempting to think that scientists can proceed as if values consensus has been achieved, thus acting in a "science advisory" role (Fig. 1). This is not necessarily the case. Values and knowledge can shift while policy remains unchanged, and laws and regulations can also enshrine and protect many competing objectives, leaving values disagreements to be dealt with at the implementation stage. An example is when natural areas are legally dedicated to multiple uses, leaving the trade-offs and conflicting values to be navigated later (Purdy, 2012). Different environmental laws can also come into conflict if they are based on fundamentally different views of nature, reflecting the time period at which they were drafted (Purdy, 2012). Finally, environmental goals, even when they are formalized into laws or regulations, are usually described in sufficiently ambiguous terms as to leave plenty of leeway in their interpretation. Thus, even existing laws can generate a range of legitimate alternative implementations ("policies" in the broad sense). In this context, issue advocates can engage with policy in several ways: (1) by proposing new laws, (2) proposing changes to existing ones, such as expanding official lists of invasives species or exempting species from endangered species protections, or (3) promoting new ways of applying existing laws or policies. There is great value in continuously questioning whether existing legal frameworks and environmental policies represent values consensus, but continued issue advocacy can lead to scientists being perceived as biased, in which case they might find their role in discussing policy trade-offs diminished (Brown and Sax, 2005; Hutchings, 2022; Redpath et al., 2013; Sarewitz, 2013, 2004).

In the absence of unambiguous laws to guide action, or when laws enshrine more than one competing objective, ecologists and conservation biologists can also engage with policy by acting as honest brokers of policy alternatives (Essl et al., 2017; Redpath et al., 2013). This can take many forms, from documenting trade-offs among ecosystem services all the way to building complete alternative scenarios that will help stakeholders discuss and negotiate solutions. For example, the Montérégie region of Quebec (Canada) is a largely agricultural landscape experiencing rapid development, for which Mitchell et al. (2015) developed four scenarios for landscape planning that captured trade-offs among ecosystem services and biodiversity (as informed by science), as well as stakeholder priorities (values). In cases where value disagreements are common and well known, systematic consideration of policy alternatives can be written into law, as in the case of projects covered by the US National Environmental Policy Act (Smith, 2007), for which government scientists have a duty to act as honest brokers. Importantly, honest brokers themselves need not be any more objective or neutral than anyone else; they need only recognize and accept the legitimacy of policy alternatives, including some they may not personally agree with.

2.4. Stealth advocacy

On the surface, calls for policy to be "evidence-based", and for policy makers to "follow the science", seem beyond reproach. Obviously, policy decisions should be based on sound information. But in situations where diverse values and uncertainty create multiple legitimate policy options, there is no direct link from science to policy. Even with full agreement on the facts, different weighing of pros and cons, based on values, can lead to highly divergent policy options, all of which are "evidence-based". Wilhere (2012, p.40) defines inadvertent or stealth advocacy as "the act of unintentionally expressing personal policy preferences or ethical judgments in a way that is nearly indistinguishable from scientific judgments". When scientists emphasize their own objectivity and suggest that the evidence supports one particular policy option (or a subset), they portray themselves as science advisors and effectively assume that their own values are universally shared (Lackey, 2004; Pielke, 2012; Wilhere, 2012).

This is problematic for at least two reasons. First, it presents value-driven positions under the banner of objective science advice, potentially undermining the good faith position of scientists who engage with policy in general (Lackey, 2004; Pielke, 2012; Wilhere, 2012). Second, it can delay the process of policy making (Sarewitz, 2004). Policy debates that have roots in value disagreements often become framed as debates about facts. Because risk preference and values both influence which fact a person might look for or be more receptive to ("motivated reasoning"; Bardin et al., 2017; Hart et al., 2009), stealth advocacy encourages stakeholders with different policy preferences to also seek out evidence that supports their position. Debates can thus become mired in arguments about the merits of different lines of scientific evidence, obscuring the true source of disagreement: values. Scientists can certainly make important contributions by correcting the record when some stakeholders blatantly misrepresent the evidence, but this will rarely resolve the underlying values conflict. At best, such interventions can help re-focus the discussion on the real point of contention.

There is reason to suspect that stealth advocacy is not rare. The language used in ecology and conservation frequently implies policy preferences linked to particular values, such as a preference for ecosystems with minimal historical change ("ecosystem integrity") or for "native" instead of "invasive" species (Newman et al., 2017). Based on a systematic text analysis, Scott et al. (2007) showed that in the journal *Conservation Biology*, more than half of all *paragraphs* contained normative language, and more than a quarter communicated a preferred policy option. To be clear, there is nothing wrong with expressing and discussing values, as in debates about intrinsic vs. instrumental valuations of nature. However, it is misleading to simultaneously take a value-driven position and to claim to simply be following the science. For example, the editors of *Nature Ecology Evolution* began their inaugural issue (2017, volume 1, issue 1, "Why biodiversity matters", p.1) by saying "we should be protesting bad policy decisions to those in political power". This is a legitimate aim for issue advocates. However, in situations where there is no value consensus or if uncertainties are high, policies considered "bad" according to one set of values might very well be considered "good" according to another. It is therefore misleading to also cast ecologists and evolutionary biologists as science advisors by expressing the hope, in the same editorial, that, as scientists, "we like to think we have the objective neutrality that stops us from crossing the line into activism". In the following sections, we explore in more detail how stealth advocacy can manifest in specific situations. We draw specifically on conservation issues where existing legislation provides room for a range of policy alternatives and values disagreements.

3. Case study: invasive species management

Invasive species management has become a central component of the global conservation agenda (IPBES, 2019). The impact of some invasive species on native species and ecosystems is well documented, with consequences for human health, livestock, agriculture and ecosystems; globally, it is estimated that biological invasions cost 26.8 billion US$ annually (Diagne et al., 2021). The semantics of this field have been the object of protracted debates (Courchamp et al., 2017). The label "invasive species" is a socio-ecological designation that combines an ecological pattern (the success of one species; *sensu* Richardson et al., 2000), and a value judgment about the overall balance of its impacts (*sensu* Blackburn et al., 2014). This value judgment can depend on the characteristics of the species, but it also hinges on the values of the people passing judgment, as well as the socio-cultural context (Shackleton et al., 2019). Humair et al. (2014) found that scientists tend to assume that their own values on these impacts are uncontroversial and widely shared. There is good reason to question this assumption.

It is only recently that the social context of biological invasions has become the subject of scientific inquiry. In a review of 124 publications where the social context was reported, Estévez et al. (2015) found that 1

in 5 described a contentious situation over invasive species management, mostly based on values conflicts. In several cases, values about animal welfare conflicted with management strategies for animals, such as squirrels, wild horses, or cats (Estévez et al., 2015). In other cases, local groups had developed deep relational values toward long-established species despite their "invasive" status (e.g. feral pigs in Hawai'i; Maguire, 2004). Relationships of traditional and indigenous peoples with species labeled "invasive" involve a diversity of outlooks, sometimes emphasizing the establishment of new and valued relationships with these species (Reo and Ogden, 2018; Trigger, 1998). Some species of economic importance, like black locust (*Robinia pseudoacacia*) in Europe, have even been excluded from legally-binding "invasive" labels following political negotiations (Essl et al., 2017). There is clearly a plurality of values surrounding invasive species management.

Scientists may be justified in acting as "scientific advisors" if they can point to policies generated by an accepted political process that signals some level of value consensus (for instance, a formal commitment to eradicate a given species). Reviewing 27 invasive species assessment approaches, Bartz and Kowarik (2019) found that in most cases, scientists did not acknowledge the values underpinning measures of impact, nor did they provide a link to *specific* existing policies (e.g., laws). For non-native species, a plurality of values means that science cannot identify one optimal solution, but it can inform discussion of trade-offs among policy alternatives. Bartz and Kowarik (2019) found that while the vast majority of the approaches they reviewed incorporated species' impacts, only 6 explicitly sought to assess benefits. Assessments that focus solely on one side of the equation cannot hope to capture trade-offs. Under these conditions, there is a high risk that scientist's own values and attitudes toward risk will inadvertently be reflected in invasive species assessment (Essl et al., 2017; Maguire, 2004; Schlaepfer et al., 2011).

To be clear, many scientists engage directly and transparently with values. Conservation biology has historically focused on ensembles of organisms as populations, species, or ecosystems (Soulé, 1985), which has sometimes warranted lethal culls of certain animals such as (non-native) rats, cats, or deer (Estévez et al., 2015). However, values that favor individual animal lives over ecosystems can legitimate a different set of policy alternatives (Ramp and Bekoff, 2015; Wallach et al., 2018). When non-lethal relocation is not possible, "compassionate" conservation can therefore entail accepting higher levels of ecosystem-level impacts. Because "compassionate" conservationists invoke values explicitly, they act as open issue advocates. Many scientists also work with stakeholders as honest brokers, seeking to intentionally explore a variety of policy alternatives (e.g., Potgieter et al., 2019; Woodford et al., 2016). In other cases, scientists have shifted policy work toward issues on which there was broad value consensus, and where they could act as science advisors (Woodford et al., 2016).

More problematically, some authors have attempted to reduce the scope of possible policy alternatives by implicitly casting invasive species management in general as a problem that can be solved by the linear model. For instance, Russell and Blackburn (2017) noted that "Invasion biologists regularly call for increased regulation and restrictions on species transportation, translocation, or trade" (p. 4), but then conclude that "discussions should be evidence based and not disrupted by appeals to values" (p. 5). Ricciardi and Ryan (2018) echoed Russell & Blackburn's concern around "invasive species denialism" (in the sense of a systematic attempt to manufacture uncertainty regarding a set of facts), suggesting that one form of such denialism was value-based disagreement over management alternatives. The implication in both cases is that scientists' calls for stronger regulation and restrictions is based only on science. However, as some authors have pointed out in response, collective resource allocation and assessment of management alternatives cannot even be pondered without consideration of values; disagreement on courses of actions is not denial of science (Crowley et al., 2017; Frank, 2021).

What are the consequences of implicitly or explicitly treating some stakeholder groups as "denialists" or "adversaries" (e.g Courchamp et al., 2017)? It would be naïve to think that this could do anything but hinder the process of negotiation and compromise. For example, stakeholder groups with strong relational values in favor of invasive rainbow trout (*Oncorhynchus mykiss*) went as far as to organize into powerful associations whose specific aim is to oppose management and official "invasive" status of the trout (Ellender et al., 2014; Woodford et al., 2016). By casting their own value-based position as a question of facts ("evidence-based"), stealth advocates can contribute to this stalemate and may well delay the development of pluralistic management plans.

4. Case study: extinction prevention and habitat protection

Species extinction - and its prevention - have always been at the core of conservation biology (Cardinale et al., 2019). The rate of human-caused extinctions of vertebrate animals in recent centuries greatly exceeds the "background" extinction rate and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services estimates that approximately 1 million species are currently at risk of extinction (Barnosky et al., 2011; IPBES, 2019). The inclusion or exclusion of species from official lists of endangered species is (and obviously should be) informed by scientific evidence. However, the notion of "extinction risk" is itself steeped in value judgments and risk perceptions, which make the listing process fundamentally political (Wilhere, 2012). Furthermore, while habitat protection might increase the odds of survival for particular species, it can come with clear trade-offs, including direct costs, economic opportunity costs, or costs to competing environmental goals. The idea that we should act to prevent extinctions is such a deeply felt and widely held value in conservation biology that we might forget that it is, in fact, a *normative* postulate of the discipline (Soulé, 1985), rather than a scientific conclusion. Stakeholders with different values weigh the importance of these benefits and costs in diverse ways.

In the 1970s, a small, endangered fish species, the snail darter (*Percina tanasi*), was found in a Tennessee river slated for damming. Heated debate and legal battles culminated in special legislation exempting the project from the Endangered Species Act, and subsequent building of the dam. Disagreements over what to do (and how far to go) to save species from extinction have continued unabated, whether between stakeholders, as in the notorious case of the spotted owl (Noon and McKelvey, 1996), or within conservation science. "Conservation triage" is the idea (borrowed from emergency medicine) that given finite resources, allocation of resources should recognize that some species have a higher likelihood of recovery than others (Bottrill et al., 2008; Gerber, 2016). For many, this is a defeatist approach that risks normalizing acceptance of extinctions (Pimm, 2000; Wilson and Law, 2016). Proponents argue that a form of triage (prioritization) occurs whether we like it or not, and that formalizing these processes is the only "defensible, rational and repeatable" way to prioritize resources (Bottrill et al., 2008).

At their core, triage methods are intended to increase the efficacy with which value judgments are brought to bear on complex sets of facts. Such methods can help to clearly define the values of issue advocates. For instance, when scientists from The Nature Conservancy sought to prioritize conservation projects in Africa, they expressed their personal beliefs about how different characteristics like habitat connectivity or intactness increase conservation value as explicit mathematical functions (Game et al., 2013). Presented alongside prioritization results, these benefit functions are distinguishable from scientific opinion, and open the door to legitimate value-based debates. However, triage can also become a vehicle for undeclared value judgments if they are described as "objective" or "evidence-based" (e.g., Bottrill et al., 2008; Sutherland et al., 2021). For instance, deciding that all species, beetle or blue whale, are equally worth saving, is a value judgment (on which many would disagree) (Vucetich et al., 2017). The key point is that a

triage model can build in any imaginable value-based weighting, such that emphasizing the objectivity or scientific rigor of any one model is to advocate (stealthily) for a particular value judgment.

Echoing the invasive species debate, authors have begun using the terms "science denial' and "extinction denial" to describe disagreements over endangered species policies. Lees et al. (2020) describe policy disagreements about the potential benefits of economic growth, technological tools, and targeted conservation initiatives as "interpretive denial" and "implicatory denial". A quote from Delingpole (2016), used as an example of implicatory denial, reads: "Actually, though, I'd say it has more to do with the militant left exploiting environmentalism as a fashionable cloak for its ongoing war on liberty, free markets and small government." To our eyes, rather than questioning the science or the need for action, Delingpole is raising the possibility that evidence about species extinction is being marshaled strategically to support political goals (i.e., stealth advocacy). Lees et al. (2020, Supplementary online material) respond with facts: "Many lines of evidence indicate that global business-as-usual economies and operations cause, and are set to continue causing, large negative impacts on biodiversity, implying a need for transformation". It is doubtful that this appeal to evidence will change anyone's view. By tying endangered species protection to a specific worldview, Lees et al. (2020) make conservation contingent on the resolution of left-right political conflicts, and risk making their desired outcomes less rather than more likely. Instead of facts, issue advocates should consider talking about their own values and engaging sincerely with those of they are attempting to convince. Only then is there any possibility to find common ground on which a policy consensus might be built.

5. Discussion

We have argued that consideration and acknowledgement of policy context can help ecologists and conservation biologists navigate the four primary roles of scientists proposed by Pielke (2012) - pure scientist, science advisor, issue advocate, or honest broker - and facilitate interactions with policy and policymakers. Policy context is defined by the degree of scientific (un)certainty and the degree of values consensus among stakeholders. Failure to appreciate the fact that values consensus among scientists (e.g., the normative postulates of conservation biology) does not imply values consensus among the broader set of stakeholders can result in attempts to serve as science advisors when the social context makes this effectively impossible. In such situations, scientists run the risk of stealth advocacy, exacerbating polarization and potentially impeding policy making. We can now turn back to the question that is so prevalent in ecology and conservation lab groups and classrooms: how do we "make a difference", given these potential pitfalls?

Ecologists and conservation biologists have tremendous potential for making positive contributions to society. But from the range of possible roles that young people have in front of them, there is not one that is "easier" than the others. Direct engagement with policy (a right-hand turn at Q1, in Fig. 1) requires skills that are only rarely covered in scientific training: understanding of the values of others, and clarity and transparency about one's own values. For a science advisor, this can entail being knowledgeable of and citing evidence of values consensus relevant to policy advice, for instance in the form of laws or regulations (Bartz and Kowarik, 2019). Honest brokers, even as they put the policy-making process above their own preferences, must remain aware and honest about their own inevitable biases. When asked by editors and reviewers to engage directly with the policy implications of their work, those who choose this path can focus on the trade-offs that exist between policy options. They should also stop short of voicing a preference for one or a subset of alternatives.

How can scientists be open issue advocates? In the words of climatologist and issue advocate Katharine Hayhoe (2019), when facts have nothing left to contribute to a debate, "begin with shared values". In other words, when issue advocates put forward a policy preference, argue for new or modified laws, or in any way seek to narrow the range of policy options, they should begin by recognizing and explaining the ethical positions that support these judgments. Furthermore, when they encounter disagreement about policy alternatives, they should recognize that (when uncertainties are high and value consensus is low) the same set of facts can support a range of policy alternatives. In this case, it is more productive to identify and discuss the core issue of value disagreements. This seems like the most likely way of finding the common ground necessary to build lasting consensus.

Given the importance of considering one's values, we can ask what values might have contributed to our own perspective. First, both of us share the values expressed in Soulé's (1985) normative postulates of conservation biology: "diversity of organisms is good", "ecological complexity is good", "evolution is good", and "biotic diversity has intrinsic value". We support - in spirit and financially - conservation organizations such as the World Wildlife Fund and the Nature Conservancy of Canada. That said, both of us have been confronted with situations that brought into focus the potentially discomfiting mix of values and science in ecology and conservation science. One of us (FC) has worked directly with implementation of a normative concept - ecological integrity - hoping to find out how it was defined by stakeholders, only to be asked by stakeholders to *tell them* what constitutes ecological integrity, on the assumption that this was an answer science could provide (Cardou, 2020). The other one of us (MV) has been concerned about values contributing to bias in scientific studies of biodiversity (including his own; see Vellend, 2017, 2019). He has also advised local conservation organizations who seemed to assume that he would promote certain values (e.g., eradication of non-native species) first and foremost, rather than also discuss potential benefits of other strategies (including doing nothing at all). We are both convinced that these issues, despite having been raised in many previous publications, require ongoing and constant reflection among conservation scientists, as new practitioners enter the field, and find themselves continually faced with new and evolving challenges.

One recent trend presents especially pointed challenges in navigating the interface between science and values. The idea of "compassionate conservation", has generated significant debate in invasive species management literature. Although the core issue is clearly about values, Coghlan and Cardilini (2022) found that over half of papers criticizing compassionate conservation focused on its scientific basis, with some authors going as far as to accuse (once again) its proponents of "science denialism" (Driscoll and Watson, 2019). Such accusations of "denial" are part of a larger and worrisome trend that has manifested in several contexts (Ricciardi and Ryan, 2018; Russell and Blackburn, 2017; Lees et al., 2020). History has indeed revealed clear cases of deliberate "merchants of doubt" motivated by financial or political gain with respect to fossil fuels or tobacco (Oreskes, 2010). We see no evidence of such nefarious motivations or blatant obscuring of facts among practitioners within conservation science. Instead, following some of the responses that these authors have received (Crowley et al., 2017; Frank, 2021), we see disagreement over alternative policy preferences and documentation of trade-offs in a way that can advance policy making in a pluralistic policy context. Given the rise of accusations of "denialism", there is clearly a continuing need to address the respective roles of facts and values in shaping policy, and how this should inform the roles that scientists themselves play in this process.

We believe that society and science itself benefit from having scientists in a diversity of roles, but we also believe that policy context has a major influence on which role(s) are actually possible. As several of our examples illustrate, being "just" a science advisor is near impossible when the political debate is largely about values, because science cannot tell us what is "right". But identifying the context might not always be easy. One might first come into contact with a debate that is, on the surface, about facts (e.g., how many species are threatened with extinction?), when the related political debate is largely about values (e.g., how big an opportunity costs are we willing to pay for nature

conservation?). Many scientists will choose to serve as issue advocates - and be very effective in this role - in which case honesty requires declaring one's values-based position.

Without paying close attention to our own values and those of people around us, it is easy to slip inadvertently into stealth advocacy, which we fear can exacerbate rather than reconcile environmental controversies (Sarewitz, 2004) or lead to conservation outcomes that are, in the words of Redpath et al. (2013, p.100), "less durable". It seems prudent to avoid accusing others of "not listening to science" when what we really mean is that "they're not listening to *me*". In the words of Hutchings and Stenseth (2016, p.9), "the personal value systems of scientists have no intrinsically greater merit than those of the decision-makers whom they advise or the citizenry who might be affected by the advice". To end on a positive note, paying attention not only to how the values of those we disagree with influence their view of the evidence, but also to the influence of our own values, can help ecologists and conservation biologists make more productive, and hopefully more fruitful, contributions to policy and to society.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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References

Allen, T.F.H., Tainter, J.A., Pires, J.C., Hoekstra, T.W., 2001. Dragnet Ecology—"Just the Facts, Ma'am": the privilege of science in a postmodern world: science of intrinsic quality needs narratives with explicit values—not just facts—particularly as it faces multiple-level complexity in advising on environmental policy, such as planning for energy futures. Bioscience 51, 475–485. https://doi.org/10.1641/0006-3568(2001)051[0475:DEJTFM]2.0.CO;2.

Bardin, B., Perrissol, S., Facca, L., Smeding, A., 2017. From risk perception to information selection…and not the other way round: selective exposure mechanisms in the field of genetically modified organisms. Food Qual. Prefer. 58, 10–17. https://doi.org/10.1016/j.foodqual.2016.12.015.

Barnosky, A.D., Matzke, N., Tomiya, S., Wogan, G.O.U., Swartz, B., Quental, T.B., Marshall, C., McGuire, J.L., Lindsey, E.L., Maguire, K.C., Mersey, B., Ferrer, E.A., 2011. Has the Earth's sixth mass extinction already arrived? Nature 471, 51–57. https://doi.org/10.1038/nature09678.

Bartke, S., Schwarze, R., 2008. Risk-averse by Nation Or by Religion? Some Insights on the Determinants of Individual Risk Attitudes (SSRN Scholarly Paper No. ID 1285520). Social Science Research Network, Rochester, NY. https://doi.org/10.2139/ssrn.1285520.

Bartz, R., Kowarik, I., 2019. Assessing the environmental impacts of invasive alien plants: a review of assessment approaches. NeoBiota 43, 69–99. https://doi.org/10.3897/neobiota.43.30122.

Blackburn, T.M., Essl, F., Evans, T., Hulme, P.E., Jeschke, J.M., Kühn, I., Kumschick, S., Marková, Z., Mrugała, A., Nentwig, W., Pergl, J., Pyšek, P., Rabitsch, W., Ricciardi, A., Richardson, D.M., Sendek, A., Vilà, M., Wilson, J.R.U., Winter, M., Genovesi, P., Bacher, S., 2014. A unified classification of alien species based on the magnitude of their environmental impacts. PLoS Biol. 12, e1001850 https://doi.org/10.1371/journal.pbio.1001850.

Bottrill, M.C., Joseph, L.N., Carwardine, J., Bode, M., Cook, C., Game, E.T., Grantham, H., Kark, S., Linke, S., McDonald-Madden, E., Pressey, R.L., Walker, S., Wilson, K.A., Possingham, H.P., 2008. Is conservation triage just smart decision making? Trends Ecol. Evol. 23, 649–654. https://doi.org/10.1016/j.tree.2008.07.007.

British Ecological Society, 2022. British Ecological Society Policy Position [WWW Document]. URL. British Ecological Society (accessed 4.1.22). https://www.britishecologicalsociety.org/policy/our-position/.

Brown, J.H., Sax, D.F., 2005. Biological invasions and scientific objectivity: reply to Cassey et al. (2005). Austral Ecol. 30, 481–483. https://doi.org/10.1111/j.1442-9993.2005.01504.x.

Buijs, A.E., Elands, B.H.M., 2013. Does expertise matter? An in-depth understanding of people's structure of thoughts on nature and its management implications. Biol. Conserv. 168, 184–191. https://doi.org/10.1016/j.biocon.2013.08.020.

Buschke, F.T., Botts, E.A., Sinclair, S.P., 2019. Post-normal conservation science fills the space between research, policy, and implementation. Conserv.Sci.Pract. 1, e73 https://doi.org/10.1111/csp2.73.

Cardinale, B., Primack, R., Murdoch, J., 2019. Conservation Biology. Oxford University Press, Oxford, New York.

Cardou, F., 2020. Développement d'un Indicateur d'intégrité Écologique En Milieux Anthropisés: Application de l'approche Par Traits Fonctionnels. Thesis. Université de Sherbrooke.

Chan, Kai M.A., Balvanera, Patricia, Benessaiah, Karina, Chapman, Mollie, Díaz, Sandra, Gómez-Baggethun, Erik, Gould, Rachelle, et al., 2016. Why protect nature? Rethinking values and the environment. Proc. Natl. Acad. Sci. 113 (6), 1462–1465. https://doi.org/10.1073/pnas.1525002113.

Chan, K.M., Gould, R.K., Pascual, U., 2018. Editorial overview: relational values: what are they, and what's the fuss about?. In: Current Opinion in Environmental Sustainability Sustainability Challenges: Relational Values, 35, pp. A1–A7. https://doi.org/10.1016/j.cosust.2018.11.003.

Chaudhury, A., Colla, S., 2021. Next steps in dismantling discrimination: lessons from ecology and conservation science. Conserv. Lett. 14, e12774 https://doi.org/10.1111/conl.12774.

Coffey, D.J., Joseph, P.H., 2013. A polarized environment: the effect of partisanship and ideological values on individual recycling and conservation behavior. Am. Behav. Sci. 57, 116–139. https://doi.org/10.1177/0002764212463362.

Coghlan, S., Cardilini, A.P.A., 2022. A critical review of the compassionate conservation debate. Conserv. Biol. 36, e13760 https://doi.org/10.1111/cobi.13760.

Courchamp, F., Fournier, A., Bellard, C., Bertelsmeier, C., Bonnaud, E., Jeschke, J.M., Russell, J.C., 2017. Invasion biology: specific problems and possible solutions. Trends Ecol. Evol. 32, 13–22. https://doi.org/10.1016/j.tree.2016.11.001.

Crowley, S.L., Hinchliffe, S., Redpath, S.M., McDonald, R.A., 2017. Disagreement about invasive species does not equate to denialism: a response to Russell and Blackburn. Trends Ecol. Evol. 32, 228–229. https://doi.org/10.1016/j.tree.2017.02.004.

Delingpole, J., 2016. The slow death of environmentalism [WWW Document]. The Spectator Australia (accessed 3.29.22). https://www.spectator.com.au/2016/05/the-slow-death-of-environmentalism/.

Diagne, C., Leroy, B., Vaissière, A.-C., Gozlan, R.E., Roiz, D., Jarić, I., Salles, J.-M., Bradshaw, C.J.A., Courchamp, F., 2021. High and rising economic costs of biological invasions worldwide. Nature 592, 571–576. https://doi.org/10.1038/s41586-021-03405-6.

Douglas, H., 2009. Science, Policy, And the Value-free Ideal. University of Pittsburgh Press, Pittsburgh.

Driscoll, D.A., Watson, M.J., 2019. Science denialism and compassionate conservation: response to Wallach et al. 2018. Conserv. Biol. 33, 777–780. https://doi.org/10.1111/cobi.13273.

Drummond, C., Fischhoff, B., 2017. Individuals with greater science literacy and education have more polarized beliefs on controversial science topics. PNAS 114, 9587–9592. https://doi.org/10.1073/pnas.1704882114.

Ecological Society of America, 2019. ESA Strategic Plan, 2019–2022 [WWW Document]. https://www.esa.org/about/governance/esa-strategic-plan/ accessed 4.1.22.

Ellender, B.R., Woodford, D.J., Weyl, O.L.F., Cowx, I.G., 2014. Managing conflicts arising from fisheries enhancements based on non-native fishes in southern Africa. J. Fish Biol. 85, 1890–1906. https://doi.org/10.1111/jfb.12512.

Essl, F., Hulme, P.E., Jeschke, J.M., Keller, R., Pyšek, P., Richardson, D.M., Saul, W.-C., Bacher, S., Dullinger, S., Estévez, R.A., Kueffer, C., Roy, H.E., Seebens, H., Rabitsch, W., 2017. Scientific and normative foundations for the valuation of alien-species impacts: thirteen core principles. Bioscience 67, 166–178. https://doi.org/10.1093/biosci/biw160.

Estévez, R.A., Anderson, C.B., Pizarro, J.C., Burgman, M.A., 2015. Clarifying values, risk perceptions, and attitudes to resolve or avoid social conflicts in invasive species management. Conserv. Biol. 29, 19–30. https://doi.org/10.1111/cobi.12359.

Frank, D.M., 2021. Disagreement or denialism? "Invasive species denialism" and ethical disagreement in science. Synthese 198, 6085–6113. https://doi.org/10.1007/s11229-019-02259-w.

Franz, E.H., 2001. Ecology, values, and policy: values, whether implicit or explicit, are ineluctably linked to action; in view of the human predicament, the science of ecology brings an essential ethic to policy—vivantary responsibility. Bioscience 51, 469–474. https://doi.org/10.1641/0006-3568(2001)051[0469:EVAP]2.0.CO;2.

Funtowicz, S.O., Ravetz, J.R., 1993. Science for the post-normal age. Futures 25, 739–755. https://doi.org/10.1016/0016-3287(93)90022-L.

Game, Edward T., Kareiva, Peter, Possingham, Hugh P., 2013. Six common mistakes in conservation priority setting. Conserv. Biol. 27 (3), 480–485. https://doi.org/10.1111/cobi.12051.

Garrard, G.E., Fidler, F., Wintle, B.C., Chee, Y.E., Bekessy, S.A., 2016. Beyond advocacy: making space for conservation scientists in public debate. Conserv. Lett. 9, 208–212. https://doi.org/10.1111/conl.12193.

Gerber, L.R., 2016. Conservation triage or injurious neglect in endangered species recovery. Proc. Natl. Acad. Sci. 113, 3563–3566. https://doi.org/10.1073/pnas.1525085113.

Girard, J., 2021. Calcul des possibilités forestières de la période 2018-2023: Synthèse des résultats. Bureau du forestier en chef, Québec, Canada.

Greiner, R., Patterson, L., Miller, O., 2009. Motivations, risk perceptions and adoption of conservation practices by farmers. Agric. Syst. 99, 86–104. https://doi.org/10.1016/j.agsy.2008.10.003.

Hart, W., Albarracín, D., Eagly, A.H., Brechan, I., Lindberg, M.J., Merrill, L., 2009. Feeling validated versus being correct: a meta-analysis of selective exposure to information. Psychol. Bull. 135, 555–588. https://doi.org/10.1037/a0015701.
Hayhoe, Katharine A., 2019. The most important thing you can do to fight climate change: talk about it. available from. TED. consulted 28-10-2022]. https://www.ted.com/talks/katharine_hayhoe_the_most_important_thing_you_can_do_to_fight_climate_change_talk_about_it.
Hughes, T.P., Huang, H., Young, M.a.L., 2013. The wicked problem of China's disappearing coral reefs. Conserv.Biol. 27, 261–269. https://doi.org/10.1111/j.1523-1739.2012.01957.x.
Humair, F., Edwards, P.J., Siegrist, M., Kueffer, C., 2014. Understanding misunderstandings in invasion science: why experts don't agree on common concepts and risk assessments. NeoBiota 20, 1–30. https://doi.org/10.3897/neobiota.20.6043.
Hutchings, J.A., 2022. Tensions in the communication of science advice on fish and fisheries: northern cod, species at risk, sustainable seafood. ICES J. Mar. Sci. 79, 308–318. https://doi.org/10.1093/icesjms/fsab271.
Hutchings, J.A., Stenseth, N., 2016. Communication of science advice to government. Trends Ecol. Evol. 31, 7–11. https://doi.org/10.1016/j.tree.2015.10.008.
IPBES, 2019. Global Assessment Report on Biodiversity and Ecosystem Services [WWW Document]. URL. IPBES secretariat (accessed 3.31.22). https://ipbes.net/global-assessment.
Jones, N.A., Shaw, S., Ross, H., Witt, K., Pinner, B., 2016. The study of human values in understanding and managing social-ecological systems. Ecol. Soc. 21.
Kahan, D.M., Peters, E., Wittlin, M., Slovic, P., Ouellette, L.L., Braman, D., Mandel, G., 2012. The polarizing impact of science literacy and numeracy on perceived climate change risks. Nat.Clim. Chang. 2, 732–735. https://doi.org/10.1038/nclimate1547.
Kareiva, P., Marvier, M., 2012. What is conservation science? Bioscience 62, 962–969. https://doi.org/10.1525/bio.2012.62.11.5.
Kellert, S.R., 2012. Birthright: People And Nature in the Modern World by Stephen R. Kellert. Yale University Press.
Lackey, R.T., 2004. Normative science. Fisheries 29, 38–39.
Lackey, R.T., 2007. Science, scientists, and policy advocacy. Conserv. Biol. 21, 12–17. https://doi.org/10.1111/j.1523-1739.2006.00639.x.
Lawton, J.H., 2007. Ecology, politics and policy. J. Appl. Ecol. 44, 465–474. https://doi.org/10.1111/j.1365-2664.2007.01315.x.
Lear, L.J., 1993. Rachel Carson's silent spring. Environ. Hist. Rev. 17, 23–48. https://doi.org/10.2307/3984849.
Lee, T.M., Markowitz, E.M., Howe, P.D., Ko, C.-Y., Leiserowitz, A.A., 2015. Predictors of public climate change awareness and risk perception around the world. Nat.Clim. Chang. 5, 1014–1020. https://doi.org/10.1038/nclimate2728.
Lees, A.C., Attwood, S., Barlow, J., Phalan, B., 2020. Biodiversity scientists must fight the creeping rise of extinction denial. Nat. Ecol. Evol. 4, 1440–1443. https://doi.org/10.1038/s41559-020-01285-z.
Maes, J., Paracchini, M.L., Zulian, G., Dunbar, M.B., Alkemade, R., 2012. Synergies and trade-offs between ecosystem service supply, biodiversity, and habitat conservation status in Europe. Biol. Conserv. 155, 1–12. https://doi.org/10.1016/j.biocon.2012.06.016.
Maguire, L.A., 2004. What can decision analysis do for invasive species management? Risk Anal. 24, 859–868. https://doi.org/10.1111/j.0272-4332.2004.00484.x.
Maron, M., Ives, C.D., Kujala, H., Bull, J.W., Maseyk, F.J.F., Bekessy, S., Gordon, A., Watson, J.E.M., Lentini, P.E., Gibbons, P., Possingham, H.P., Hobbs, R.J., Keith, D.A., Wintle, B.A., Evans, M.C., 2016. Taming a wicked problem: resolving controversies in biodiversity offsetting. Bioscience 66, 489–498. https://doi.org/10.1093/biosci/biw038.
Mitchell, M.G.E., Bennett, E.M., Gonzalez, A., Lechowicz, M.J., Rhemtulla, J.M., Cardille, J.A., Vanderheyden, K., et al., 2015. The montérégie connection: linking landscapes, biodiversity, and ecosystem services to improve decision making. Ecol. Soc. 20.
Newbold, T., Hudson, L.N., Hill, S.L.L., Contu, S., Lysenko, I., Senior, R.A., Börger, L., Bennett, D.J., Choimes, A., Collen, B., Day, J., De Palma, A., Díaz, S., Echeverria-Londoño, S., Edgar, M.J., Feldman, A., Garon, M., Harrison, M.L.K., Alhusseini, T., Ingram, D.J., Itescu, Y., Kattge, J., Kemp, V., Kirkpatrick, L., Kleyer, M., Correia, D.L. P., Martin, C.D., Meiri, S., Novosolov, M., Pan, Y., Phillips, H.R.P., Purves, D.W., Robinson, A., Simpson, J., Tuck, S.L., Weiher, E., White, H.J., Ewers, R.M., Mace, G. M., Scharlemann, J.P.W., Purvis, A., 2015. Global effects of land use on local terrestrial biodiversity. Nature 520, 45–50. https://doi.org/10.1038/nature14324.
Newman, J.A., Varner, G., Linquist, S., 2017. Defending Biodiversity: Environmental Science And Ethics. Cambridge University Press.
Noon, B.R., McKelvey, K.S., 1996. Management of the spotted owl: a case history in conservation biology. Annu. Rev. Ecol. Syst. 27, 135–162. https://doi.org/10.1146/annurev.ecolsys.27.1.135.
Norgaard, K.M., 2007. The politics of invasive weed management: gender, race, and risk perception in rural California*. Rural. Sociol. 72, 450–477. https://doi.org/10.1526/003601107781799263.
O'Brien, M.H., 1993. Being a scientist means taking sides. Bioscience 43, 706–708. https://doi.org/10.2307/1312342.
Oreskes, N., 2010. Merchants of Doubt. Bloomsbury press.
Peter, S., Le Provost, G., Mehring, M., Müller, T., Manning, P., 2022. Cultural worldviews consistently explain bundles of ecosystem service prioritisation across rural Germany. PeopleNat. 4, 218–230. https://doi.org/10.1002/pan3.10277.
Pielke Jr., R., 2012. The Honest Broker. Cambridge University Press.
Pimm, S.L., 2000. Against triage. Science 289. https://doi.org/10.1126/science.289.5488.2289, 2289-2289.
Potgieter, L.J., Gaertner, M., O'Farrell, P.J., Richardson, D.M., 2019. Perceptions of impact: invasive alien plants in the urban environment. In: Journal of Environmental Management. The Human And Social Dimensions of Invasion Science And Management, 229, pp. 76–87. https://doi.org/10.1016/j.jenvman.2018.05.080.
Purdy, J., 2012. American natures: the shape of conflict in environmental law. Harv. Environ.Law Rev. 36.
Ramp, D., Bekoff, M., 2015. Compassion as a practical and evolved ethic for conservation. Bioscience 65, 323–327. https://doi.org/10.1093/biosci/biu223.
Redpath, S.M., Young, J., Evely, A., Adams, W.M., Sutherland, W.J., Whitehouse, A., Amar, A., Lambert, R.A., Linnell, J.D.C., Watt, A., Gutiérrez, R.J., 2013. Understanding and managing conservation conflicts. Trends Ecol. Evol. 28, 100–109. https://doi.org/10.1016/j.tree.2012.08.021.
Reo, N.J., Ogden, L.A., 2018. Anishnaabe Aki: an indigenous perspective on the global threat of invasive species. Sustain. Sci. 13, 1443–1452. https://doi.org/10.1007/s11625-018-0571-4.
Ricciardi, A., Ryan, R., 2018. The exponential growth of invasive species denialism. Biol. Invasions 20, 549–553. https://doi.org/10.1007/s10530-017-1561-7.
Richardson, D.M., Pyšek, P., Rejmánek, M., Barbour, M.G., Panetta, F.D., West, C.J., 2000. Naturalization and invasion of alien plants: concepts and definitions. Divers. Distrib. 6, 93–107. https://doi.org/10.1046/j.1472-4642.2000.00083.x.
Rose, D.C., 2018. Avoiding a post-truth world: embracing post-normal conservation. Conserv. Soc. 16, 518–524.
Russell, J.C., Blackburn, T.M., 2017. The rise of invasive species denialism. Trends Ecol. Evol. 32, 3–6. https://doi.org/10.1016/j.tree.2016.10.012.
Sandbrook, C., Fisher, J.A., Holmes, G., Luque-Lora, R., Keane, A., 2019. The global conservation movement is diverse but not divided. Nat. Sustain. 2, 316–323. https://doi.org/10.1038/s41893-019-0267-5.
Sarewitz, D., 2004. How science makes environmental controversies worse. In: Environmental Science & Policy. Science, Policy, And Politics: Learning From Controversy Over The Skeptical Environmentalist, 7, pp. 385–403. https://doi.org/10.1016/j.envsci.2004.06.001.
Sarewitz, D., 2013. Science must be seen to bridge the political divide. Nature 493. https://doi.org/10.1038/493007a, 7-7.
Schlaepfer, M.A., Pascal, M., Davis, M.A., 2011. How might science misdirect policy? Insights into the threats and consequences of invasive species. J. Verbr. Lebensm. 6, 27–31. https://doi.org/10.1007/s00003-011-0690-7.
Scott, J.M., Rachlow, J.L., Lackey, R.T., Pidgorna, A.B., Aycrigg, J.L., Feldman, G.R., Svancara, L.K., Rupp, D.A., Stanish, D.I., Steinhorst, R.K., 2007. Policy advocacy in science: prevalence, perspectives, and implications for conservation biologists. Conserv. Biol. 21, 29–35.
Shackleton, R.T., Richardson, D.M., Shackleton, C.M., Bennett, B., Crowley, S.L., Dehnen-Schmutz, K., Estévez, R.A., Fischer, A., Kueffer, C., Kull, C.A., Marchante, E., Novoa, A., Potgieter, L.J., Vaas, J., Vaz, A.S., Larson, B.M.H., 2019. Explaining people's perceptions of invasive alien species: a conceptual framework. In: Journal of Environmental Management. The Human And Social Dimensions of Invasion Science And Management, 229, pp. 10–26. https://doi.org/10.1016/j.jenvman.2018.04.045.
Slimak, M.W., Dietz, T., 2006. Personal values, beliefs, and ecological risk perception. Risk Anal. 26, 1689–1705. https://doi.org/10.1111/j.1539-6924.2006.00832.x.
Smith, M.B., 1998. The value of a tree: public debates of John Muir and Gifford Pinchot. Historian 60, 757–778. https://doi.org/10.1111/j.1540-6563.1998.tb01414.x.
Smith, M.D., 2007. A review of recent NEPA alternatives analysis case law. Environ. Impact Assess. Rev. 27 (2), 126–144. https://doi.org/10.1016/j.eiar.2006.10.001.
Soulé, M.E., 1985. What is conservation biology? Bioscience 35, 727–734. https://doi.org/10.2307/1310054.
Soulé, M., 2013. The "New Conservation". Conserv. Biol. 27, 895–897. https://doi.org/10.1111/cobi.12147.
Sutherland, W.J., Downey, H., Frick, W.F., Tinsley-Marshall, P., McPherson, T., 2021. Planning practical evidence-based decision making in conservation within time constraints: the strategic evidence assessment framework. J. Nat. Conserv. 60, 125975 https://doi.org/10.1016/j.jnc.2021.125975.
Tallis, H., Lubchenco, J., 2014. Working together: a call for inclusive conservation. Nature 515, 27–28. https://doi.org/10.1038/515027a.
Trigger, B.G., 1998. Archaeology and epistemology: dialoguing across the Darwinian chasm. Am. J. Archaeol. 102, 1–34. https://doi.org/10.2307/506135.
Vellend, M., 2017. The biodiversity conservation paradox. Am. Sci. 105 (2), 94. https://doi.org/10.1511/2017.125.94.
Vellend, M., 2019. The behavioral economics of biodiversity conservation scientists. Philos. Top. 47 (1), 219–237. https://doi.org/10.5840/PHILTOPICS201947112.
Vucetich, J.A., Nelson, M.P., Bruskotter, J.T., 2017. Conservation triage falls short because conservation is not like emergency medicine. Front. Ecol. Evol. 5.
Wallach, A.D., Bekoff, M., Batavia, C., Nelson, M.P., Ramp, D., 2018. Summoning compassion to address the challenges of conservation. Conserv. Biol. 32, 1255–1265. https://doi.org/10.1111/cobi.13126.
Wallington, T.J., Moore, S.A., 2005. Ecology, values, and objectivity: advancing the debate. Bioscience 55, 873–878. https://doi.org/10.1641/0006-3568(2005)055[0873:EVAOAT]2.0.CO;2.
Wilhere, G.F., 2012. Inadvertent advocacy. Conserv. Biol. 26, 39–46. https://doi.org/10.1111/j.1523-1739.2011.01805.x.
Wilson, K.A., Law, E.A., 2016. Ethics of conservation triage. Front. Ecol. Evol. 4.
Woodford, D.J., Richardson, D.M., MacIsaac, H.J., Mandrak, N.E., van Wilgen, B.W., Wilson, J.R.U., Weyl, O.L.F., 2016. Confronting the wicked problem of managing biological invasions. NB 31, 63–86. https://doi.org/10.3897/neobiota.31.10038.