Perception and Conflict in Conservation: The Rashomon Effect

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Conflict is a common feature in conservation and resource management. Environmental conflicts are frequently attributed to differences in values; however, variability in the perception of facts, rooted in social and cultural differences also underlies conflicts. Such differences in perception have been termed the Rashomon effect after the Kurosawa film. In the present article, we explore a conservation Rashomon effect—a phenomenon that results from a combination of differences in perspective, plausible alternative perspectives of a conservation issue, and the absence of evidence to elevate one perspective above others. As a remedy to the Rashomon effect, policy-makers have turned to scientists as honest brokers who share a common environmental reality. We evaluate this supposition and suggest that scientists, themselves, display Rashomon effects. We suggest that Rashomon effects can be reduced by acknowledging the plurality of reality, embracing epistemic pluralism, and prioritizing an inclusive process of resource management.

Keywords: Rashomon effect, risk perception, environmental conflict, conservation

Conflicts in environmental management are ubiquitous, affecting nearly every aspect of conservation (Redpath et al. 2013). Although conflicts can be an important driver of positive environmental change (Barnett 2000), they are frequently costly and damage the goals of conservation (Redpath et al. 2013). Examples include conflicts, rooted in colonialism and slavery, between rural villagers and powerful elites hinder chimpanzee conservation in Western Africa (Dickman 2012); antagonism toward some bird species stems from conflicts between rural and urban dwellers in Pennsylvania (Bronner 2005), and conflicts among actors in European fisheries management can lead to the overharvesting of target species (Hoffmann and Quaas 2016). Conservation and other natural resource conflicts can quickly become pathological, fundamentally undercutting efforts to achieve conservation and, in some extreme instances, lead to violence (Bernauer et al. 2012). Therefore, conflict management is fundamental to conservation success.

Conservation conflicts are embedded in social and cultural history and arise when individuals or groups lack agency or have contrary environmental values (Dietz et al. 2005, Dickman 2010, Redpath et al. 2013). In addition, variability in the perception of facts is a key driver of environmental conflict—a driver that is often unappreciated (Verweij et al. 2010). This perceptual diversity is rooted in social and cultural differences in information capturing and processing, as well as life experience (Atran et al. 2005, Bang et al. 2007). Such differences in perception of an event witnessed by multiple individuals have been termed the Rashomon effect (Heider 1988) after the 1950 film from Akira Kurosawa. The film is set in twelfth century Japan and presents different accounts of the murder of a samurai. Four different tellings of the events are presented from four witnesses, with each version believable but contradictory to the others. The film makes clear that each witness is telling their truth and not simply lying to protect themselves. The movie provides no resolution, and we are left wondering who was telling the truth or even if a single reality exists.

Such a diversity of perceived truths may similarly constrain environmental management and may undermine sustainability. Is it possible that subjectivity in observation and perception generate substantially different but plausible interpretations of the same state of nature? Does the Rashomon effect contribute to conflict in natural resource management? And if so, how can we integrate the existence of subjectivity into conflict resolution?

In the present article, we first develop a definition for a Rashomon effect in conservation and provide evidence for its existence, with a particular focus on the presence and consequence of Rashomon effects in conservation science. Finally, we provide integrative principles to confront the Rashomon effect and generate clarity at the science–policy interface.

Defining a conservation Rashomon effect

Building on work in anthropology, psychology, and political science (e.g., Horowitz 1987, Heider 1988, Roth and Mehta

BioScience XX: 1–9.
doi:10.1093/biosci/biaa117

2002, Moon and Blackman 2014, Kibel 2016), we define the Rashomon effect in conservation as the existence of multiple plausible but conflicting perceptions about the causes and underlying consequences of an urgent conservation challenge.

Building on Kurosawa's epic, a conservation Rashomon effect must be grounded in a compelling experience (Anderson 2015). In the film, it is the presence of a dead body that serves as the shared, exigent reality. In conservation, this shared experience may be the demise of a species, the emergence of threats such as wildfire, invasive species or toxins, or global climate change. A classic example of such an incident is the 1969 burning of Cleveland's Cuyahoga River, which evolved into an iconic episode of the environmental crisis in the late twentieth century (Stradling and Stradling 2008). A recent example of such a compelling event is the 17-day period in August 2018 in which an endangered southern resident killer whale female carried its stillborn calf in Salish Sea of British Columbia and Washington state—a transfixing event that received global attention (e.g., Gathright 2018). Chronic threats such as climate change may also instigate Rashomon effects, even though it is difficult to identify a specific point in time when the threat began. No matter the specific event, resource managers and policy-makers demand answers to the questions accompanying these kinds of environmental episodes. This demand for answers drives an urgent search for explanations and solutions, which naturally vary because of perceptual diversity.

Rashomon effects in conservation are grounded in perceptual differences, but it is not just that parties engaged in conservation issues have different perspectives about an urgent issue: Rashomon effects in conservation occur when alternative perspectives are coherent, plausible, and considered a cogent enough explanation that these arguments are taken up by other members of society. Moreover, Rashomon effects will be strongest when differences develop when evidence is unavailable to falsify one or more versions of the truth (Anderson 2015). Certainly waiting for additional evidence before making conservation decisions is desirable, but the urgency of conservation often precludes delays requiring the use of the best available and often highly uncertain evidence (Charnley et al. 2017). When resource managers and policy-makers are faced with complex situations in which a difference of perspective arises but in which there is an absence of clear scientific evidence, the Rashomon effect enters conservation.

Evidence of Rashomon effects in conservation

Ample evidence exists revealing wide variance in the perception of environmental facts on which stakeholders and other societal actors base their judgments and actions (table 1). The shifting baseline syndrome (Pauly 1995, Dayton et al. 1998) is a case in point in which the context that information is consumed affects conclusions of individuals. Shifting baselines occur when successive generations of people accept the ecosystem state that occurred at the start of their lifetime as the baseline for evaluating the state of a system. In a world suffering losses of species and habitat destruction (IPBES 2019), this creates a sliding and continually reduced expectation of what a desirable, appropriate or natural ecosystem could be. As Dayton mused (Dayton et al. 1998), if one has known only horizon-to-horizon agricultural fields, the concept of a tall-grass prairie is lost. Interviews with resource users in Africa (Bunce et al. 2008), Asia (Ainsworth et al. 2008), Europe (Airoldi and Beck 2007), Central America (Ainsworth 2011) and North America (Beaudreau and Levin 2014) reveal that younger individuals accept lower abundances of exploited species as a baseline from which to evaluate system change—empirical demonstration of the ubiquity of the shifting baseline syndrome. Similarly, psychological research reveals that individuals with remarkably similar moral values across vastly different cultures (Kahn 2002) suffer from an "environmental generational amnesia," in which their perception of environmental information is framed without information about the historical state or states of the system (Kahn and Weiss 2017). Therefore, individuals understand the same observations in very different ways, generating very different expectations of what constitutes a baseline that can be used to evaluate species declines and therefore establish reference points for sustainability. In cases in which historical empirical estimates of population size are lacking, this difference perspective in concert with the absence of evidence to elevate one perspective above another yields a Rashomon effect.

Rashomon effects also manifest in conservation in more nuanced ways. For instance, folk taxonomies—biological classification systems developed outside a Western scientific framework (Raven et al. 1971)—reveal the way in which a culture's environmental context influences perceptions of ecological and biological relationships (Atran 1998), and ultimately inductions about the state of nature (Beaudreau et al. 2011). In a case study on fishes in Puget Sound, Washington, Beaudreau and colleagues (Beaudreau et al. 2011) elicited taxonomies from commercial and recreational fishers, recreational divers, and scientists. Forty percent of respondents did not distinguish between an endangered species (bocaccio, *Sebastes paucispinis*) and its abundant congener (greenstriped rockfish *Sebastes elongatus*). To individuals who did not differentiate between these two species, the imperiled status of bocaccio may be masked by the more abundant greenstriped rockfish (Drake et al. 2010). Because the abundance of both bocaccio and greenstriped rockfish is highly uncertain (Drake et al. 2010, Tolimieri et al. 2017), the structure of people's folk taxonomies can lead to differences in the perception of species extinction risk, and ultimately to conflicts around proposed conservation actions.

Variability in perceptions of risks associated with climate change highlights the second key aspect of conservation Rashomon effects; there must be both a compelling experience and uncertainty. Perceptions of risk associated with climate

Table 1. Examples illustrating the prevalence of Rashomon effects is in conservation and the conflicts to which the Rashomon effects contribute.

Examples of the Rashomon effect in conservation	Conflict caused	Illustrative references
Differences in conservation epistemologies	Conflict over facts, rigor, causal, explanation, and research, goals	Miller et al. 2008, Redpath et al. 2013, Brister 2016
Differences in the perception of the structure of food webs	Conflict over perceptions of how the external ecological "reality" is structured	Halbrendt et al. 2014, Gray et al. 2015a, Bosma et al. 2017, Stier et al. 2017, Levy et al. 2018
Differences in perception of "species"	Conflict over listing of species under the Endangered Species Act	Waples 1991, Crifasi 2007, Carolan 2008, Beaudreau et al. 2011, Allen and Lendemer 2015
Differences in perception of baselines	Conflict over reference points for restoration goals to meet economic and ecological goals	Pauly 1995, Jackson 2001, Kahn 2007, Thurstan et al. 2015
Differences in perception of trends in species abundance	Conflict over degree of harvest regulation required to meet economic or ecological goals	Ainsworth et al. 2008, Verweij et al. 2010, Ainsworth 2011, Bender et al. 2013, Beaudreau and Levin 2014
Differences in perception of social–ecological systems structure and function	Conflict over where to intervene or identify "leverage points" in a resource system	Gray et al. 2012, 2015b, Nyaki et al. 2014
Differences in the meaning of "conservation"	Conflict over the goals of conservation programs	Biggs et al. 2013, Crow and Baysha 2013
Differences in perception of the meaning and goals of building social resilience	Conflict over resilience to what for whom (humans)	Carpenter et al. 2001
Differences in perception of the meaning and goals of building ecological resilience	Conflict over resilience to what for whom (nonhumans)	Carpenter et al. 2001, Levin and Lubchenco 2008
Differences in perception of functional "goals" of conservation	Conflict over what the functional "goal" of what conservation actions are	Shelton et al. 2014, Levin et al. 2015
Differences in risk perception	Conflict over misaligned probabilities and assessment of social or ecological risk	Upreti 2004, Bidwell 2009, Cullen and Anderson 2017
Differences in conservation values	Conflict over what is valued and of highest priority for management	Dietz et al. 2005, Pleasant et al. 2014, Levin and Poe 2017

change are influenced to some degree by general scientific or climate-specific knowledge, as well as demographic (e.g., age, gender) factors. Importantly, however, the values and cultural worldview of people are stronger predictors of climate risk perception than knowledge (Kahan et al. 2012, Shi et al. 2015; see also Dunlap et al. 2001, Feygina et al. 2010 for related discussion on the impacts of political worldviews on the willingness to accept the existence of climate change). This occurs because worldviews and values act as filters on how climate information is interpreted (Corner et al. 2014), which is subsequently manifested as a biased assessment of information (Whitmarsh and Capstick 2018). In particular, several research groups have used the cultural theory of Douglas and Wildavsky (Douglas and Wildavsky 1983) and its derivative, cultural cognition theory (Kahan et al. 2007), to examine climate risk perception (e.g., Kahan et al. 2012, Capstick and Pidgeon 2014, Stevenson et al. 2014, Shi et al. 2015, Xue et al. 2016). In general, this research highlights that individuals with different cultural worldviews can observe the same climate data and reach very different conclusions about the dangers associated with climate change. Although certainty about the existence of climate change is high, perceptual differences about risk in concert with the considerable uncertainty about specific risks, especially at small spatial scales, can generate Rashomon effects.

The notion that stakeholders and conservation managers vary in their perceptions of conservation problems and solutions is, of course, not new. However, by framing this well-known phenomenon in the context of the Rashomon effect, we see that it provides us with an epistemology that applies to a general set of environmental issues. This framework leads us to reflect critically about what participants in natural resource management think they know about the complexity underlying conservation conflicts. Importantly, the Rashomon effect may extend beyond stakeholders and managers to include the scientists supporting conservation decision-making. We explore this below.

The Rashomon effect in conservation science

Frequently, deliberations about environmental issues are based on beliefs about how ecosystems are structured and function (Whitehead et al. 2014). Accordingly, the role of biophysical sciences is clear—ecology, fisheries science, forestry, oceanography, and other related disciplines provide a guide for developing an evidence-based understanding of ecosystems. Therefore, perhaps as a remedy to the Rashomon effect, policy-makers have turned to scientists to provide objective evidence to craft and inform environmental and related policies (Steel et al. 2004). Indeed, the conventional "positivist" (Crotty 1998) perspective of science maintains that knowledge produced by science is generalizable, unbiased and value neutral (Steel et al. 2004). If correct, truth can be acquired through unprejudiced use of the deductive scientific method regardless of the culture or background of those generating the knowledge (Charnley et al. 2017). Scientists, then, are often considered to be honest brokers who share a common environmental reality and are removed from the diverse norms and values that characterize policymaking.

This notion persists despite critical review of the neutrality of science (e.g., Pinch and Bijker 1984, Martinson et al. 2005, Elliott and Nisbet 2018). Indeed, numerous environmental management laws and regulations in the United States direct federal agencies to consult the “best available science” in decision-making. These include the Endangered Species Act (Section 4 [b][1][A]), the Magnuson-Stevens Fishery Conservation and Management Act (Section 301 [a][2]), the Marine Mammal Protection Act (Section 101 (3)(a)), and the Forest Service Planning Rule (36 CFR 219.3). Natural resource legislation in many other countries also contains similar direction (Charnley et al. 2017).

Of course, scientists often disagree, and such scientific disagreement is a major catalyst of scientific progress (Kuhn 1977). Divergence among scientists may simply be the result of someone being wrong. In such cases, a hypothesis is falsified, and science advances. Scientific discord could also be the consequence of two scientists testing different models, investigating slightly different ecosystems or looking at the same ecosystem at different times. In these instances, our hypotheses and theories must evolve to accommodate varying spatial and temporal information. Therefore, science progresses. Alternatively, scientific conclusions may be in conflict because each scientist looks at and experiences the same ecosystem through different eyes. That is, scientists, too, suffer from the Rashomon effect; when differences arise not only in perspective but in the absence of complete information, different interpretations or implications of data may emerge.

Ample evidence exists suggesting that the Rashomon effect in environmental science is possible, if not common. One only need to examine Paine’s iconic work on seastar predation and species diversity (Paine 1966, 1969, 1974) to witness the Rashomon effect. This research on keystone predation along wave-exposed shores is among the best known and most influential work in ecology (Lafferty and Suchanek 2016). In this case, the ochre seastar (*Pisaster ochraceus*) consumes competitively dominant mussels, leading to an increase in the diversity of primary-space-occupying species that would otherwise be outcompeted by mussels. However, the conclusions drawn from this classic ecological work are contingent on one’s perspective. Paine’s focus was on primary space holders, and his work revealed that diversity in this assemblage more than doubled in the presence of *Pisaster*. If, on the other hand, one focuses on community-wide diversity, including small or cryptic species within the mussel bed, the presence of *Pisaster* decreases rather than increases diversity (Lafferty and Suchanek 2016). Because *Pisaster* populations recently suffered unprecedented coast-wide declines as the result of sea star wasting disease (Miner et al. 2018), this seemingly academic difference has increased importance as the conservation implications of this decline are evaluated.

The science examining the efficacy of marine protected areas (MPAs) provides another prime example. No-take MPAs eliminate fishing mortality and protect habitat from destructive fishing practices within the boundaries of protected areas. As a consequence, fish biomass and diversity tend to be higher inside MPAs relative to unprotected areas (e.g., Halpern and Warner 2002, Lester et al. 2009). However, the impacts of MPAs on total fisheries yield and biomass is uncertain and controversial (Pendleton et al. 2017), in part because of uncertainty around larval dispersal, adult movement, and the dynamics of fishing fleets. MPAs are also intensively studied by both marine ecologists and fisheries scientists—disciplines that vary in their histories, epistemologies, cultures, and priorities (Salomon et al. 2011). These differences, together with uncertainties in our understanding of MPA effects, set the stage for Rashomon effects. For example, marine ecologists (Hamilton et al. 2010) revealed higher biomass and densities of fish species targeted by fisheries inside a network of California MPAs relative to outside. The authors portray this as a conservation success (Hamilton et al. 2010). On the other hand, Hilborn, a fisheries scientist, examining the same region suggests that displaced fishing effort led to the decline of the abundance of target species outside of MPAs, yielding no net change in fish densities and therefore no conservation benefit (Hilborn 2014). Hilborn further argues that MPAs will reduce the total sustainable yield of fish stocks, and should this loss in protein be made up with some other form of food production (e.g., beef or pork) there could be negative conservation consequences (Hilborn 2013). Therefore, when considering the conservation impacts of MPAs outside reserves, differences in scientific training and culture lead to different perceptions of the same data (Salomon et al. 2011) and a Rashomon effect emerges.

Disagreement among scientists is the norm and healthy, but a lack of understanding about why disagreement exists is a salient feature of the Rashomon effect in science (Douglas and Wildavsky 1983). Even within conservation science, researchers are enmeshed in varying scientific cultures (Salomon et al. 2011) spanning the social and natural sciences; consequently, scientists emerging from different academic cultures and with distinct training, interests, or experience will be drawn to different questions and form very different conclusions from the same data. Such differences are common and have fueled important inter- and transdisciplinary advances in environmental and conservation science (e.g., Hampton and Parker 2011, Levin and Anderson 2016, Bennett et al. 2017, Francis et al. 2018). However, failure to recognize such fundamental difference in perspectives has led to acrimonious exchanges among researchers that have, perhaps, hindered scientific progress (Paine 1991, Azoulay and Graff-Zivin 2018). Social–ecological systems are complicated; interactions among components of the system rarely have singular outcomes. Conservation scientists can certainly recognize and appreciate complexity and context dependency in order to reconcile divergent observations, but Rashomon effects may thwart this ability.

As policy-makers increasingly turn to science to provide objective, rational, analytical information (Doremus and Tarlock 2005), we scientists ignore the Rashomon effect at our own peril. Rancorous debate regarding environmental issues often focuses on contrasting objectives rooted in divergent beliefs. Do we manage species for maximum productivity or as essential components of ecosystems (Kaplan and Levin 2009, Davies and Baum 2012)? How a scientist answers this question depends on their personal and professional epistemology and culture, which, in turn, influences the questions they ask and the conclusions they reach (Marshall and Levin 2018). When scientists assume that they differ in their values, they confront each other with a level of vitriol that is scientifically unproductive (Cafaro and Primack 2014) and leaves policy-makers wondering what the best available science really is (Marvier et al. 2016). Of course, toxic dialogues in conservation science occur for diverse reasons, but we suggest Rashomon effects are an overlooked source of feckless discourse.

Principles for confronting Rashomon effects in conservation science

A rich literature now exists highlighting structured, decision-support processes in conservation (e.g., Gregory and Long 2009, Gregory et al. 2012b, 2012a, Davies et al. 2013, Estévez et al. 2015). Such processes provide an effective approach for advancing conservation, particularly when stakeholders hold diverse values and objectives. These frameworks may also be usefully applied in cases in which stakeholders vary in their perceptions of nature. Such processes, however, are generally not applied to cases in which conservation science is hindered by Rashomon effects. Therefore, drawing lessons from the social sciences (Heider 1988, Heller et al. 2001, Roth and Mehta 2002, Moon and Blackman 2014, Burton-Jones and Lee 2017), we highlight three integrative principles that acknowledge the Rashomon effect and generate clarity at the science–policy boundary to better manage conservation conflict.

Acknowledging the plurality of reality. There will always be multiple believable, but at times contradictory, interpretations of reality, both formal (i.e., when scientific models predict different outcomes) and informal (i.e., when two individual's mental models are misaligned; Gray 2018). However, similar to critiques of searching for a panacea, or the misguided effort to find a universal solution to problems of overuse or destruction of natural resources (Ostrom et al. 2007), natural resource managers and scientists should embrace and acknowledge that there are multiple perspectives on environmental problems. Indeed, integrating diversity of perspectives has been shown to vastly improve problem-solving across multiple contexts (Page 2007). Similar to the promotion of biodiversity as a way to increase resilience of ecosystems to withstand shocks (Sterling et al. 2017), scientists and managers should cultivate knowledge diversity to improve overreliance on one potentially faulty perspective, scientific or otherwise, in environmental decision-making (Tallis and Lubchenco 2014).

Embracing epistemic pluralism: Not seeking one model. Complementary to embracing the plurality of reality, dealing with the Rashomon effect will also require that different representations, or models, of reality are developed and considered together as a portfolio to understand and react to changing environmental states. Although postnormal approaches to environmental science have been around for some time (Ftowicz and Ravetz 1994), more recently there have been calls to embrace epistemic pluralism in environmental science (Miller et al. 2008), or the notion that there are multiple valuable ways of knowing about the external world that all provide a different dimension of complex environmental problems (Levin et al. 2016). For example, Miller and colleagues (2008) identify different types of knowledge: knowledge as mechanistic believed to be objective (i.e., physics), knowledge as contingent, highlighting the importance of context (i.e., sociology), and knowledge as narrative (i.e., history), showing the importance of personal experience and variation in the norms of scientific training. Although each emerge from different ontologies and produce models through vastly different methodological approaches, thinking of different types of knowledge as complementary forms or views of environmental issues, rather than wrong or right, will provide more comprehensive insight that together can be used to make more robust decisions (Sterling et al. 2017).

Prioritizing the process over the products. Natural resource managers and scientists should embrace the process along with the products when decisions are made (Levin et al. 2018). Integrating multiple perspectives and reviewing multiple representations and interpretations of the same environmental system requires time and other resources. This recommendation follows closely to adaptive management approaches (Walters 1986), where specific, measurable, achievable, relevant, time-bound (SMART; Perrings et al. 2010) objectives are identified, data are collected, and considered decisions are made and evaluated, and the process begins again (Walters 1986). Wicked problems in conservation will never have a stopping point (Batie 2008); rather, they will be continually managed through an active and engaged form of collecting and discussing information. Although scientific and other products produced in this process are important for continued learning (Henly Shepard et al. 2015), it is the learning process and not the models themselves that improve decision-making outcomes (Dietz 2013, Francis et al. 2018).

Results chains are an example of how we can learn from the process. Results chains are a visual representation of the logic and theory by which an intervention leads to positive and negative consequences (Margoluis et al. 2013). Results chains (or similar constructs such as logic models, theories of change, influence diagrams, etc.) have seen increasing use in conservation and environmental planning, and provide a powerful means to lower conflict induced by variable assessments of a system's scale, structure and function (Qiu et al. 2018). Simply creating results chains with multiple viewpoints can help reveal perceptual differences among scientists and reveal differences in perception versus divergence on the basis of data. Although the development of results chains can cause clashes among individuals varying in epistemological orientation, the act of attempting to develop a shared logical framework can serve as part of an antidote for the Rashomon effect (Jeffrey 2003).

Conclusions

Kurosawa's Rashomon challenges us to replace one very simple question (how did the samurai die?) with one that is far more interesting and important: Why do the different witnesses recount different versions of the murder? Rather than only asking which of the testimonies reflects the truth, we might rather ask how each of the accounts achieves its plausibility and how an objective judge or jury could ever decide among them (Tindale 2016).

Importantly, we are not advocating for a postmodernist or constructionist perspective in which objective reality does not exist (cf., Feyerabend 1958, Latour 2004). Rather, we suggest that the Rashomon effect aptly describes a dilemma that arises in conservation when urgent action is needed, knowledge is uncertain, and perceptual differences among conservation actors persist. The Rashomon effect leads to "reality disjunctures" (Pollner 1975), creating conflict that inhibits fruitful environmental management. This phenomenon surfaces in countless conservation settings when contested interpretations of matters exist and where stakeholders express what they know, how they know it, and their confidence in their knowledge.

The brilliance of Kurosawa's Rashomon is not in revealing the prevalence of perceptual differences, but rather in forcing the viewer to question their ability to come to terms with such differences (Anderson 2015). The same holds true for stakeholders, policymakers and scientists engaged in conservation science and management. The film leaves us wondering if we can ever set aside the biases and misjudgments that characterize this effect. But, unlike the fictional world of Rashomon, our world does not give us a choice; overcoming the Rashomon effect is a prerequisite for conservation success.

Acknowledgements

PSL was supported by The David and Lucille Packard Foundation via the Ocean Modeling Forum and the Gordan and Betty Moore Foundation Ocean Tipping Points Project during the formulation of this article. We thank J. Estes, S. Levin and M. Power for critical comments on the manuscript. PSL appreciates the insights of E. Braverman and an unknown dinner guest.

References cited

Ainsworth CH. 2011. Quantifying species abundance trends in the northern gulf of California using local ecological knowledge. Marine and Coastal Fisheries 3: 190–218.

Ainsworth CH, Pitcher TJ, Rotinsulu C. 2008. Evidence of fishery depletions and shifting cognitive baselines in Eastern Indonesia. Biological Conservation 141: 848–859.

Airoldi L, Beck MW. 2007. Loss, status and trends for coastal marine habitats in Europe. Oceanography and Marine Biology 45: 345–405.

Allen J, Lendemer J. 2015. Fungal conservation in the USA. Endangered Species Research 28: 33–42.

Anderson R. 2015. What is the Rashomon effect? Pages 66–85 in Davis B, Anderson R, and Walls J, eds. Rashomon Effects Kurosawa, Rashomon and Their Legacies. Routledge.

Atran S. 1998. Folk biology and the anthropology of science: Cognitive universals and cultural particulars. Behavioral and Brain Sciences 21: 547–609.

Atran S, Medin DL, Ross NO. 2005. The cultural mind: Environmental decision making and cultural modeling within and across populations. Psychological Review 112: 744–76.

Azoulay P, Graff-Zivin J. 2018. One superstar funeral at a time. Science 361: 1194–1195.

Bang M, Medin DL, Atran S. 2007. Cultural mosaics and mental models of nature. Proceedings of the National Academy of Sciences 104: 13868–13874.

Barnett J. 2000. Destabilizing the environment: Conflict thesis. Review of International Studies 26: 271–288.

Batie SS. 2008. Wicked Problems and Applied Economics. American Journal of Agricultural Economics 90: 1176–1191.

Beaudreau AH, Levin PS. 2014. Advancing the use of local ecological knowledge for assessing data-poor species in coastal ecosystems. Ecological Applications 24: 244–56.

Beaudreau AH, Levin PS, Norman KC. 2011. Using folk taxonomies to understand stakeholder perceptions for species conservation. Conservation Letters 4: 451–463.

Bender MG, Floeter SR, Hanazaki N. 2013. Do traditional fishers recognise reef fish species declines? Shifting environmental baselines in Eastern Brazil. Fisheries Management and Ecology 20: 58–67.

Bennett NJ, et al. 2017. Conservation social science: Understanding and integrating human dimensions to improve conservation. Biological Conservation 205: 93–108.

Bernauer T, Böhmelt T, Koubi V. 2012. Environmental changes and violent conflict. Environmental Research Letters 7: 015601.

Bidwell D. 2009. Bison, boundaries, and brucellosis: Risk perception and political ecology at yellowstone. Society and Natural Resources 23: 14–30.

Biggs D, Courchamp F, Martin R, Possingham HP. 2013. Legal trade of Africa's rhino horns. Science 339: 1038–1039.

Bosma C, Glenk K, Novo P. 2017. How do individuals and groups perceive wetland functioning? Fuzzy cognitive mapping of wetland perceptions in Uganda. Land Use Policy 60: 181–196.

Brister E. 2016. Disciplinary capture and epistemological obstacles to interdisciplinary research: Lessons from central African conservation disputes. Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences 56: 82–91.

Bronner SJ. 2005. Contesting tradition: The deep play and protest of pigeon shoots. Journal of American Folklore 118: 409–452.

Bunce M, Rodwell LD, Gibb R, Mee L. 2008. Shifting baselines in fishers' perceptions of island reef fishery degradation. Ocean and Coastal Management 51: 285–302.

Burton-Jones A, Lee AS. 2017. Thinking about measures and measurement in positivist research: A proposal for refocusing on fundamentals. Information Systems Research 28: 451–467.

Cafaro P, Primack R. 2014. Species extinction is a great moral wrong. Biological Conservation 170: 1–2.

Capstick SB, Pidgeon NF. 2014. Public perception of cold weather events as evidence for and against climate change. Climatic Change 122: 695–708.

Carolan MS. 2008. Is it a distinct subspecies? preble's mouse and the "best available science" mandate of the endangered species act. Society and Natural Resources 21: 944–951.

Carpenter S, Walker B, Anderies JM, Abel N. 2001. From metaphor to measurement: Resilience of what to what? Ecosystems 4: 765–781.

Charnley S, et al. 2017. Evaluating the best available social science for natural resource management decision-making. Environmental Science and Policy 73: 80–88.

Corner A, Markowitz E, Pidgeon N. 2014. Public engagement with climate change: The role of human values. Wiley Interdisciplinary Reviews: Climate Change 5: 411–422.

Crifasi RR. 2007. A subspecies no more? A mouse, its unstable taxonomy, and western riparian resource conflict. Cultural Geographies 14: 511–535.

Crotty M. 1998. The foundations of social research. Foundations of Social Research 802: 1–17.

Crow DA, Baysha O. 2013. "Conservation" as a catalyst for conflict: Considering stakeholder understanding in policy making. Review of Policy Research 30: 302–320.

Cullen AC, Anderson CL. 2017. Perception of climate risk among rural farmers in Vietnam: Consistency within households and with the empirical record. Risk Analysis 37: 531–545.

Davies AL, Bryce R, Redpath SM. 2013. Use of multicriteria decision analysis to address conservation conflicts. Conservation Biology 27: 936–944.

Davies TD, Baum JK. 2012. Extinction risk and overfishing: Reconciling conservation and fisheries perspectives on the status of marine fishes. Scientific Reports 2: 561.

Dayton PK, Tegner MJ, Edwards PB, Riser KL. 1998. Sliding baselines, ghosts, and reduced expectations in kelp forest communities. Ecological Applications 8: 309–322.

Dickman AJ. 2010. Complexities of conflict: The importance of considering social factors for effectively resolving human–wildlife conflict. Animal Conservation 13: 458–466.

Dickman AJ. 2012. From cheetahs to chimpanzees: A comparative review of the drivers of human–carnivore conflict and human–primate conflict. Folia Primatologica 83: 377–387.

Dietz T. 2013. Bringing values and deliberation to science communication. Proceedings of the National Academy of Sciences 110: 14081–14087.

Dietz T, Fitzgerald A, Shwom R. 2005. Environmental values. Annual Review of Environmental Resources 30: 335–372.

Doremus H, Tarlock AD. 2005. Science, judgment and controversy in natural resource regulation. Public Land and Resources Law Review 26: 1–37.

Douglas M, Wildavsky A. 1983. Risk and Culture: An Essay on the Selection of Technological and Environmental Dangers. University of California Press.

Drake JS, Berntson EA, Gustafson RG, Holmes EE, Levin PS, Tolimieri N, Waples RS, Sogard SM, Williams GD, Cope JM. 2010. Status review of five rockfish species in Puget Sound, Washington: Bocaccio (*Sebastes paucispinis*), canary rockfish (*S. pinniger*), yelloweye rockfish (*S. ruberrimus*), greenstriped rockfish (*S. elongatus*), and redstripe rockfish (*S. proriger*). National Oceanic and Atmospheric Administration.

Dunlap RE, Xiao C, McCright AM. 2001. Politics and environment in America: Partisan and ideological cleavages in public support for environmentalism. Environmental politics 10: 23–48.

Elliott R, Nisbet MC. 2018. The ethics of framing science. Pages 51–74 in Nerlich B, Elliott R, Larson B, eds. Communicating Biological Sciences: Ethical and Metaphorical Dimensions. Ashgate.

Estévez RA, Anderson CB, Pizarro JC, Burgman MA. 2015. Clarifying values, risk perceptions, and attitudes to resolve or avoid social conflicts in invasive species management. Conservation Biology 29: 19–30.

Feyerabend PK. 1958. An Attempt at a Realistic Interpretation of Experience. Proceedings of the Aristotelian Society 58: 143–170.

Feygina I, Jost JT, Goldsmith RE. 2010. System justification, the denial of global warming, and the possibility of "system-sanctioned change." Personality and Social Psychology Bulletin 36: 326–338.

Francis TB, Levin PS, Punt AE, Kaplan IC, Varney A, Norman KC. 2018. Linking knowledge to action in ocean ecosystem management. Elementa 6: 83.

Ftowicz S, Ravetz JR. 1994. The worth of a songbird: Ecological economics as a post-normal science. Ecological Economics 10: 197–207.

Gathright J. 2018. After 17 days and 1000 miles, a mother orca's "tour of grief" is over. National Public Radio (12 August 2018). www.npr.org/2018/08/12/638047095/after-17-days-and-1-000-miles-a-mother-orcas-tour-of-grief-is-over?t=1554973928523.

Gray S. 2018. Measuring systems thinking. Nature Sustainability 1: 388–389.

Gray S, Chan A, Clark D, Jordan R. 2012. Modeling the integration of stakeholder knowledge in social–ecological decision-making: Benefits and limitations to knowledge diversity. Ecological Modelling 229: 88–96.

Gray S, Hilsberg J, McFall A, Arlinghaus R. 2015a. The structure and function of angler mental models about fish population ecology: The influence of specialization and target species. Journal of Outdoor Recreation and Tourism 12: 1–13.

Gray SA, Gray S, de Kok JL, Helfgott AER, O'Dwyer B, Jordan R, Nyaki A. 2015b. Using fuzzy cognitive mapping as a participatory approach to analyze change, preferred states, and perceived resilience of social–ecological systems. Ecology and Society 20: doi:0.5751/ES-07396–200211.

Gregory R, Long G. 2009. Using structured decision making to help implement a precautionary approach to endangered species management. Risk Analysis 29: 518–532.

Gregory R, Long G, Colligan M, Geiger JG, Laser M. 2012a. When experts disagree (and better science won't help much): Using structured deliberations to support endangered species recovery planning. Journal of Environmental Management 105: 30–43.

Gregory RS, Failing L, Harstone M, Long G, McDaniels T, Ohlson D. 2012b. Structured Decision Making. Wiley.

Halbrendt J, Gray SA, Crow S, Radovich T, Kimura AH, Tamang BB. 2014. Differences in farmer and expert beliefs and the perceived impacts of conservation agriculture. Global Environmental Change 28: 50–62.

Halpern BS, Warner RR. 2002. Marine reserves have rapid and lasting effects. Ecology letters 5: 361–366.

Hamilton SL, Caselle JE, Malone DP, Carr MH. 2010. Incorporating biogeography into evaluations of the Channel Islands marine reserve network. Proceedings of the National Academy of Sciences 107: 18272–18277.

Hampton SE, Parker JN. 2011. Collaboration and productivity in scientific synthesis. Professional Biologist BioScience 61: 900–910.

Heider KG. 1988. When ethnographers disagree. American Anthropologist 90: 73–81.

Heller P, Africa S, Alegre P. 2001. Moving the state: The politics of democratic decentralization in Kerala. Politics and Society 29: 131–163.

Henly Shepard S, Gray SA, Cox LJ. 2015. The use of participatory modeling to promote social learning and facilitate community disaster planning. Environmental Science and Policy 45: 109–122.

Hilborn R. 2013. Environmental cost of conservation victories. Proceedings of the National Academy of Sciences 110: 9187–9187.

Hilborn R. 2014. Protecting marine biodiversity with "new" conservation. Cool Green Science (12 April 2014). https://blog.nature.org/science/2014/04/12/nature-longread-protecting-marine-biodiversity-new-conservation-ray-hilborn.

Hoffmann J, Quaas MF. 2016. Common pool politics and inefficient fishery management. Environmental and resource economics 63: 79–93.

Horowitz IL. 1987. The "Rashomon effect:" Ideological proclivities and political dilemmas of the IMF. Pages 93–109 in Myers RJ, ed. The

Political Morality of the International Monetary Fund. Transaction Books.
[IPBES] Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services. 2019. Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services. IPBES.
Jackson JB. 2001. What was natural in the coastal oceans? Proceedings of the National Academy of Sciences of the United States of America 98: 5411–5418.
Jeffrey P. 2003. Smoothing the waters: Observations of the process of cross-disciplinary research collaboration. Social Studies of Science 33: 539–562.
Kahan DM, Braman D, Gastil J, Slovic P, Mertz CK. 2007. Culture and identity-protective cognition: Explaining the white-male effect in risk perception. Journal of Empirical Legal Studies 4: 465–505.
Kahan DM, Peters E, Wittlin M, Slovic P, Ouellette LL, Braman D, Mandel G. 2012. The polarizing impact of science literacy and numeracy on perceived climate change risks. Nature Climate Change 2: 732–735.
Kahn PH. 2002. Children's affiliations with nature: Structure, development, and the problem of environmental generational amnesia. Pages 93–116 in Kahn PH and Kellert SR, eds. Children and Nature: Psychological, Sociocultural, and Evolutionary Investigations. MIT Press.
Kahn PH. 2007. The child's environmental amnesia: It's ours. Children, Youth, and Environments Children, Youth and Environments 17: 199–207.
Kahn PH, Weiss T. 2017. The importance of children interacting with big nature. Children, Youth, and Environments 27: 7–24.
Kaplan IC, Levin PS. 2009. Ecosystem-based management of what? An emerging approach for balancing conflicting objectives in marine resource management. Pages 77–95 in Beamish RJ, Rothchild BJ, eds. The Future of Fisheries Science in North America. Springer.
Kibel HD. 2016. Rashomon revisited: A re-analysis of the film and implications for mass psychology. International Journal of Group Psychotherapy 66: 75–101.
Kuhn T. 1977. The Essential Tension: Selected Studies in Scientific Tradition and Change. University of Chicago Press.
Lafferty KD, Suchanek TH. 2016. Revisiting Paine's 1966 sea star removal experiment, the most-cited empirical ariticle in the American Naturalist. American Naturalist 188: 365–378.
Latour B. 2004. Why has critique run out of steam? Critical Enquiry 30: 225–248.
Lester SE, Halpern BS, Grorud-Colvert K, Lubchenco J, Ruttenberg BI, Gaines SD, Airamé S, Warner RR. 2009. Biological effects within no-take marine reserves: A global synthesis. Marine Ecology Progress Series 384: 33–46.
Levin PS, Anderson LE. 2016. When good fences make bad neighbors: Overcoming disciplinary barriers to improve natural resource management. Coastal Management 44: 370–379.
Levin PS, Poe MR. 2017. Conservation for the Anthropocene Ocean: Interdisciplinary Science in Support of Nature and People. Academic Press.
Levin PS, Williams GD, Rehr A, Norman KC, Harvey CJ. 2015. Developing conservation targets in social–ecological systems. Ecology and Society 20: doi:10.5751/ES-07866–200406.
Levin PS, Francis TB, Taylor NG. 2016. Thirty-two essential questions for understanding the social–ecological system of forage fish: The case of Pacific Herring. Ecosystem Health and Sustainability 2: doi:10.1002/ehs2.1213.
Levin PS, et al. 2018. Building effective fishery ecosystem plans. Marine Policy 92: 48–57.
Levin SA, Lubchenco J. 2008. Resilience, robustness, and marine ecosystem-based management. BioScience 58: 27–32.
Levy MA, Lubell MN, McRoberts N. 2018. The structure of mental models of sustainable agriculture. Nature Sustainability 1: 413–420.
Margoluis R, Stem C, Swaminathan V, Brown M, Johnson A, Placci G, Salafsky N, Tilders I. 2013. Results chains: A tool for conservation action design, management, and evaluation. Ecology and Society 18: art22.
Marshall KN, Levin PS. 2018. When "sustainable" fishing isn't. Pages 110–115 in Kareiva P, Marvier M, Silliman B, eds. Effective Conservation Science. Oxford University Press.
Martinson BC, Anderson MS, de Vries R. 2005. Scientists behaving badly. Nature 435: 437–438.
Marvier M, Kareiva P, Fuller E. 2016. Mark plummer's legacy: Leave no orthodoxy unquestioned. Coastal Management 44: 380–396.
Miller T, Baird T, Littlefield C, Kofinas G, Chapin III F, Redman C. 2008. Epistemological Pluralism regoranizing interdisciplinary research. Ecology and Society 13: 1–17.
Miner CM, Burnaford JL, Ambrose RF, Antrim L, Bohlmann H, Blanchette CA, Engle JM, Fradkin SC, Gaddam R, Harley CDG. 2018. Large-scale impacts of sea star wasting disease (SSWD) on intertidal sea stars and implications for recovery. PLOS ONE 13: e0192870.
Moon K, Blackman D. 2014. A guide to understanding social science research for natural scientists. Conservation Biology 28: 1167–1177.
Nyaki A, Gray SA, Lepczyk CA, Skibbins JC, Rentsch D. 2014. Local-scale dynamics and local drivers of bushmeat trade. Conservation Biology 28: 1403–1414.
Ostrom E, Janssen MA, Anderies JM. 2007. Going beyond panaceas. Proceedings of the National Academy of Sciences 104: 15176–15178.
Page S. 2007. The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools, and Societies. Princeton University Press.
Paine RT. 1966. Food web complexity and species diversity. American Naturalist 100: 65–75.
Paine RT. 1969. A note on trophic complexity and community stability. American Naturalist 103: 91–93.
Paine RT. 1974. Intertidal community structure: Experimental studies on the relationship between an dominant competitor and its principal predator. Oecologia 15: 93–120.
Paine RT. 1991. Between Scylla and Charybdis: Do some kinds of criticism merit a response? Oikos 62: 90–92.
Pauly D. 1995. Anecdotes and the shifting baseline syndrome of fisheries. Trends in Ecology and Evolution 10: 430.
Pendleton LH, Ahmadia GN, Browman HI, Thurstan RH, Kaplan DM, Bartolino V. 2017. Debating the effectiveness of marine protected areas. ICES Journal of Marine Science 75: 1156–1159.
Perrings C, et al. 2010. Conservation. Ecosystem services for 2020. Science 330: 323–324.
Pinch TJ, Bijker WE. 1984. The social construction of facts and artefacts : Or how the sociology of science and the sociology of technology might benefit each other. Social Studies of Science 14: 399–441.
Pleasant MM, Gray SA, Lepczyk C, Fernandes A, Hunter N, Ford D. 2014. Managing cultural ecosystem services. Ecosystem Services 8: 141–147.
Pollner M. 1975. "The very coinage of your brain": The anatomy of reality disjunctires. Philosophy of the Social Sciences 5: 411–430.
Qiu J, et al. 2018. Evidence-based causal chains for linking health, development, and conservation actions. BioScience 68: 182–193.
Raven PH, Berlin B, Breedlove DE. 1971. The origins of taxonomy. Science 174: 1210–1213.
Redpath SM, et al. 2013. Understanding and managing conservation conflicts. Trends in Ecology and Evolution 28: 100–109.
Roth WD, Mehta JD. 2002. The Rashomon effect combining positivist and interpretivist approaches in the analysis of contested events. Sociological Methods and Research 31: 131–173.
Salomon AK, et al. 2011. Bridging the divide between fisheries and marine conservation science. Bulletin of Marine Science 87: 251–274.
Shelton AO, Samhouri JF, Stier AC, Levin PS. 2014. Assessing trade-offs to inform ecosystem-based fisheries management of forage fish. Scientific Reports 4: doi:10.1038/srep07110.
Shi J, Visschers VHM, Siegrist M. 2015. Public perception of climate change: The importance of knowledge and cultural worldviews. Risk Analysis 35: 2183–2201.

Steel B, List P, Lach D, Shindler B. 2004. The role of scientists in the environmental policy process: A case study from the American west. Environmental Science and Policy 7: 1–13.

Sterling EJ, et al. 2017. Biocultural approaches to well-being and sustainability indicators across scales. Nature Ecology and Evolution 1: 1798–1806.

Stevenson KT, Peterson MN, Bondell HD, Moore SE, Carrier SJ. 2014. Overcoming skepticism with education: Interacting influences of worldview and climate change knowledge on perceived climate change risk among adolescents. Climatic Change 126: 293–304.

Stier AC, Samhouri JF, Gray S, Martone RG, Mach ME, Halpern BS, Kappel CV, Scarborough C, Levin PS. 2017. Integrating expert perceptions into food web conservation and management. Conservation Letters 10: doi:10.1111/conl.12245.

Stradling D, Stradling R. 2008. Perceptions of the burning river: Deindustrialization and Cleveland's Cuyahoga River. Environmental History 13: 515–535.

Tallis H, Lubchenco J. 2014. A call for inclusive conservation. Nature 515: 27–28.

Thurstan RH, McClenachan L, Crowder LB, Drew JA, Kittinger JN, Levin PS, Roberts CM, Pandolfi JM. 2015. Filling historical data gaps to foster solutions in marine conservation. Ocean and Coastal Management 115: 31–40.

Tindale C. 2016. Collateral beliefs and the Rashomon effect. Cogency 8: 125–145.

Tolimieri N, Holmes EE, Williams GD, Pacunski R, Lowry D. 2017. Population assessment using multivariate time-series analysis: A case study of rockfishes in Puget Sound. Ecology and Evolution 7: 2846–2860.

Upreti BR. 2004. Conflict over biomass energy development in the United Kingdom: Some observations and lessons from England and Wales. Energy Policy 32: 785–800.

Verweij MC, van Densen WLT, Mol AJP. 2010. The tower of Babel: Different perceptions and controversies on change and status of North Sea fish stocks in multi-stakeholder settings. Marine Policy 34: 522–533.

Walters CJ. 1986. Adaptive Management of Renewable Resources. MacMillan.

Waples RS. 1991. Pacific salmon, Oncorhynchus spp., and the definition of "species" under the endangered species act. Marine Fisheries Review 53: 11–22.

Whitehead AL, Kujala H, Ives CD, Gordon A, Lentini PE, Wintle BA, Nicholson E, Raymond CM. 2014. Integrating biological and social values when prioritizing places for biodiversity conservation. Conservation Biology 28: 992–1003.

Whitmarsh L, Capstick S. 2018. Perceptions of Climate Change. Elsevier.

Xue W, Hine DW, Marks ADG, Phillips WJ, Zhao S. 2016. Cultural worldviews and climate change: A view from China. Asian Journal of Social Psychology 19: 134–144.

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