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Misrelating values and empirical matters in conservation: A problem and solutions

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A B S T R A C T

We uncover a largely unnoticed and unaddressed problem in conservation research: arguments built within studies are sometimes defective in more fundamental and specific ways than appreciated, because they misrelate values and empirical matters. We call this the *unraveled rope problem* because just as strands of rope must be properly and intricately wound with each other so the rope supports its load, empirical aspects and value aspects of an argument must be related intricately and properly if the argument is to objectively support its conclusion. By characterizing this problem with precision, our study differs from but complements existing studies of value issues in conservation science, in two ways. First, it focuses on key *relationships between* empirical issues and value issues, relations that have sometimes been obscured by focusing on these issues more independently of each other. Second, it focuses on these relationships within arguments and deploys a *method of argument analysis and evaluation* honed in other fields but under-utilized in conservation science. By combining our study's novel features, we detail six families of argument defect that exemplify the unraveled rope problem within existing literature. These defects sometimes manifest within basic research stages, rather than just in more applied downstream stages where roles for values are already obvious to many. As scientific reasoning and communication become increasingly important for addressing society's greatest environmental challenges, overcoming the unraveled rope problem will be essential to the success and integrity of conservation research. Therefore, we also outline potential solutions, preventative measures, and useful further work for conservation researchers.

1. Introduction

This paper uncovers an important but largely unnoticed problem: when studies in **conservation science** build arguments for their conclusions, they are sometimes defective in more fundamental and specific ways than appreciated, because of how they misrelate **values** and **empirical** matters. (Hereafter see the Glossary for definitions of terms highlighted in bold.) We call this the *unraveled rope problem*, because just as strands of rope must be properly and intricately wound with each other so that the rope **supports** its load, empirical aspects and value aspects of an argument must relate intricately and properly if the argument is to support its conclusion.

A combination of two features of our study allow it to differ from, but complement, existing work in this area (see Fig. 1 for related published topics). First, much work has focused on noteworthy roles for values within conservation science; and much has focused on general empirical matters such as making conservation science more empirically rigorous (Fig. 1). But our study is not mainly about matters of value, nor mainly about empirical matters; rather it is about overlooked, intricate, and fine-grained *relations between* these two matters, something we hope the "unraveled rope" metaphor vividly emphasizes. Some authors have flagged or implied the need for studies like this (e.g., Noss, 1996; Robertson and Bruce Hull, 2001; Rykiel, 2001; Failing and Gregory, 2003; Robinson, 2006). But we are aware of only a handful of papers that have focused on such empirical-value relations (see Miller et al., 2011; Brister, 2016; Baumgaertner and Holthuijzen, 2017; Rohwer and Marris, 2019; Yanco et al., 2019; Nelson et al., 2021).

The second distinguishing feature of our paper helps it complement that handful of other studies on empirical-value relations: we focus on such relationships within arguments, understood formally as units of reasoning, and accordingly deploy a *logic-based method of argument analysis and evaluation* developed in other fields but under-utilized in conservation science. Among the few uses of similar methods in conservation science (e.g., Yanco et al., 2019), none prioritize our clarifying use of the argument property of **deductive validity** (e.g., Hurley and Watson, 2018).

Distinguished in those ways, the main goal of this paper is to uncover and characterize the nature of the unraveled rope problem. To do so, we identify and analyze argument defects indicative of the problem. We group these into six families of defect, using the mentioned method. We then outline potential solutions, preventative measures, and useful further work for conservationists.

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Our results include finding that important and influential conservation papers sometimes contain arguments that fail to support their conclusions, or other times arguments that are at risk of such failure, because of how they misrelate or risk misrelating empirical and value-laden aspects of arguments. Since our discussion will show these missteps and risks are actual, the unraveled rope problem is actual rather than merely potential. Although our personal experiences suggest the problem could be widespread enough to be of significant concern, we focus on *characterizing* a varied set of instances of the problem instead of *quantifying* its frequency in conservation science, because the problem must be carefully characterized before it can be accurately quantified. We also emphasize that the unraveled rope problem can manifest within basic research stages themselves rather than just in more applied downstream stages (e.g. an agency's official writing of conservation policy) where important roles for values are already obvious to many. This is important because the success and integrity of conservation research depends essentially on more than just good test designs, quality data, rigorous statistics, effective communication, feasibility of recommendations, and how arguments are perceived. All those things are vital. However, as we will clarify throughout the paper with examples, success and integrity in conservation also depends, fundamentally, on whether the reasoning within arguments is well formed, and the premises well supported—this requires a careful consideration of various specific relations between empirical and value aspects of arguments.

2. Method

2.1. Selecting papers to investigate

If we were attempting to *quantify* the extent of the unraveled rope problem, or exhaustively classify the forms it can take, it would be appropriate to collect a large and randomly generated sample of published articles to investigate. But such quantitative studies cannot yet be accurately conducted because researchers have yet to take the prior step of accurately characterizing the *detailed nature* of the unraveled rope problem by investigating initial examples in detail. Because our study aims to take this prior step, and thus enable future quantitative studies by accurately showing what to look for and count, it is methodologically appropriate to hand-select published articles for their distinct clarity in exemplifying the problem, rather than collecting a large and randomly generated sample of articles. We also wanted to do this in a way that gives readers a first sense that the problem may be important. Therefore we selected papers from within some of the major topics of research and policy in conservation disciplines that had made contributions to our own research or teaching, and/or whose hundreds to thousands of citation counts suggested they were influential papers. As papers were selected, we sought arguments in them and investigated these by applying the method of argument analysis and evaluation described below. We compared instances of defects found, and continued seeking and documenting these, until we had identified six families of defects that were distinct in ways that would give a sufficiently indicative flavour of the nature and importance of the unraveled rope problem.

2.2. Selecting and investigating arguments

The logic-based method adopted for investigating arguments used elements of argument analysis and evaluation that are common in many branches of philosophy and parts of related disciplines such as mathematical logic and computer science (e.g., Hurley and Watson, 2018). The method is particularly well suited for detailing relations between the empirical and value-laden aspects of arguments because of how it separates argument investigation into *analysis* and *evaluation* steps. Analysis clarifies both the logical *form* and the *content* of an argument, as well as how those relate. Evaluation of each can then proceed, informed by how they relate. For readers unfamiliar with such methods, Appendix 1 provides introductory details.

With just one type of exception, we selected arguments that we were able to accurately and charitably model as taking the deductively valid

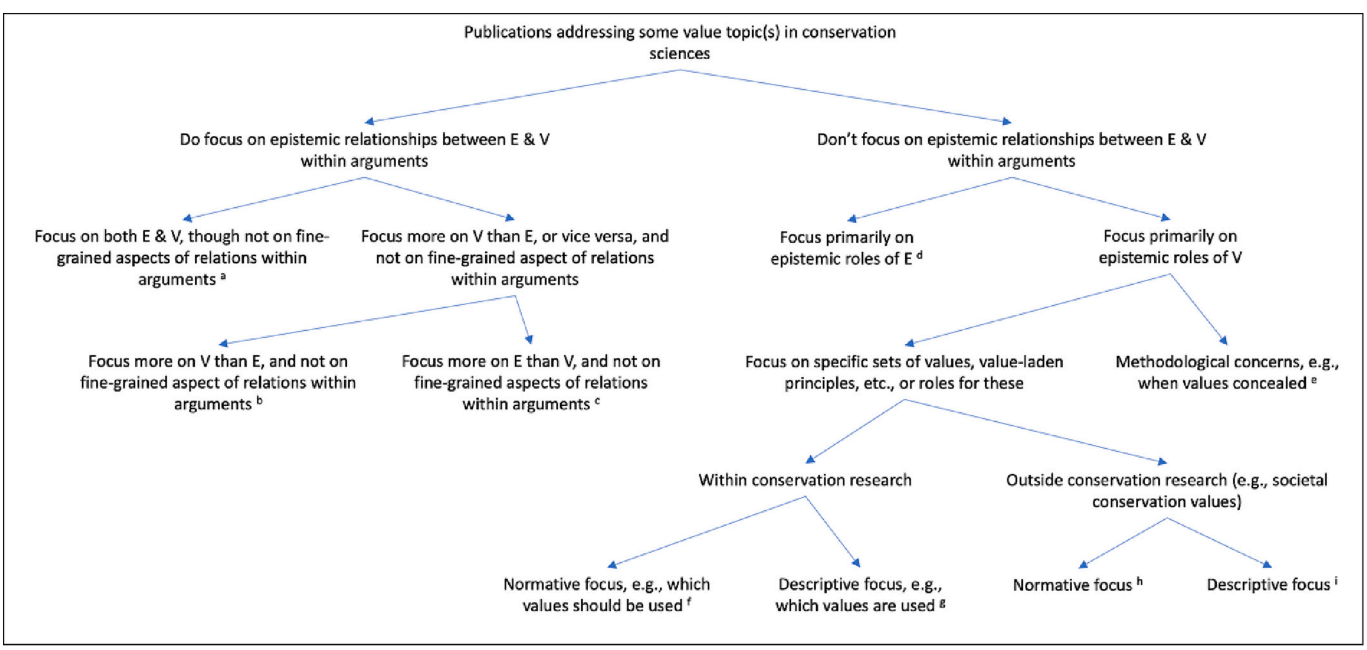

Fig. 1. Distinguishing value topics addressed by conservation publications. The figure uses selected value topics addressed in conservation publication, and how these differ from, while relating to, our fine-grained focus on relations between empirical matters (E) and matters of value (V) within conservation arguments. (We do *not* imply all depicted publications are inferior in focus to ours; many of the topics and publications on them are important and complementary.) Small superscript letters at the bottoms of arrow pathways in the figure correspond to the following sample publications that exemplify the topics identified at those pathway termini: a: (Rozzi, 1999; Sagoff, 2007; Noss, 2007); b: (Robertson and Bruce Hull, 2001; Robinson, 2006); c: (Artelle et al., 2014; Treves, 2009); d: (Drew, 2002; Dayton, 2003); e: (Minteer and Collins, 2005; Varner, 2008; Perry et al., 2012; Boyce et al., 2021); f: (Naess and Mysterud, 1987; Callicott et al., 1999); g: (Perry et al., 2012; Sample, 2018); h: (Jones et al., 2008; Kusmanoff et al., 2020); i: (Seymour et al., 2010; Schuett et al., 2016).

logical form known as *modus ponens*. (The exception is those arguments exemplified in the is-ought **fallacy** section of our Results and Discussion section, which could have more clearly avoided this fallacy by taking *modus ponens* form.) Using conventional notation, here is a general representation of that logical form, where the letters P and Q are variables that can take declarative statements as values, and premises are numbered above a solid line meaning "therefore", which separates them from the conclusion:

1. If P, then Q
2. P.

———

3. Q.

In that representation, premise (1) is "If P, then Q". Premise (2) is "P". And the conclusion (3) is "Q". For an example argument that has that abstract logical form, consider what we call the 'wall and turtle argument', a name we chose because it was inspired by a report of the actual reconfiguring of a retaining wall along a cruise ship dock shoreline within a national park in eastern Canada (Parks Canada Agency and Government of Canada, 2018):

Wall and turtle argument:

1. If reconfiguring the retaining wall would improve the chances of reproduction by endangered turtles, without comparable costs to ecosystems or other organisms, then the retaining wall should be reconfigured.
2. Reconfiguring the retaining wall would improve the chances of reproduction by endangered turtles, without comparable costs to ecosystems or other organisms.

———

3. The retaining wall should be reconfigured.

Analyzed into those components, it is easy to confirm the argument has the *modus ponens* form. Just let:

P = Reconfiguring the retaining wall would improve the chances of reproduction by endangered turtles, without comparable costs to ecosystems or other organisms.
Q = The retaining wall should be reconfigured.

And then compare the argument to the preceding general representation of *modus ponens*.

Compared to the handful of papers that we know have applied methods similar to ours within conservation science (e.g., Yanco et al., 2019), ours is unique in how it uses well documented deductively valid logical forms as a tool for analytically expressing and evaluating arguments. Appendix 1 helps clarify why this approach is effective. One reason is that focusing on arguments accurately expressed as taking the deductively valid *modus ponens* form is especially effective for laying bare key relations between empirical matters and matters of value within conservation arguments, and hence for uncovering related defects that would be indicative of the unraveled rope problem.

For instance, in the wall and turtle argument we see how premise (1) and premise (2) are supposed to work *together*, manifesting a deductively valid logical form that supports the conclusion. It also becomes clear that premise (2) will be more empirical in this partnership of logical structure, while premise (1) is more a matter of value in its contribution. That is, empirical methods will be especially important for determining whether premise (2) is true or well-supported, because it is partly about the probability of biological reproduction under particular conditions; meanwhile, empirical methods will be less central in assessing premise (1) because it is a more value-laden statement about what people *should* do in certain circumstances, regardless of the empirical probability that they will.

The deductively valid form of the argument, and attempts to retain that valid structure when new information arises, also reminds us that the more empirical and more value-laden argument strands cannot be wholly separated if the argument is to be **sound** (Appendix 1). If new information forces us to revise or replace the more empirical premise (2), then we will need to attempt a corresponding revision to or replacement of the more value-laden premise (1), for the argument to maintain a logical form that continues to support its conclusion. Likewise if the revision or replacement begins with premise (1) instead of (2). In sum, expressing an argument in deductively valid form when possible helps clarify how support for a conservation conclusion can depend on relationships *between* empirical and value-laden premises, rather than depend on keeping empirical and value-laden aspects wholly separate. We also use the concept 'prospectively sound'; an argument has this property when and only when it is deductively valid and the truth of all their premises is inconclusive but well-supported (Appendix 1). As shown below, each type of defect we found involved a deductive argument either falling short of deductive validity (a failure of argument form) or failing to be prospectively sound due to having one or more poorly supported premises (a failure of argument content).

3. Results and discussion

Here we integrate our results and discussion to help explain six families of argument defect that indicate the unraveled rope problem.

3.1. The is-ought fallacy

An argument suffers the is-ought fallacy exactly when it includes an inference from *only* **descriptive** content to value-laden **normative** content. These are often said to be *is-ought inferences*, as they are reasoning steps from claims about what *is* or *is not* the case, to claims about what *ought* or *ought not* be the case (or what should or should not be the case) (Pigden, 2010, 2011; see also Callicott, 1982 and Rozzi, 1999 for other conservation-oriented discussion of the is-ought fallacy). Because it is our experience that many (not all) conservation researchers are unaware of the is-ought fallacy, it makes an especially good example of a defect to illustrate.

Consider a non-scientific example, in which someone offers the descriptive statement "the origin of these people *is* such-and-such". Then, from just that statement, they attempt to infer the normative and thus value-laden statement "these people *ought* to be treated in such-and-such a way". Even if the descriptive statement about origins is true, it is impossible for it alone to entail any normative conclusion about how the people ought to be treated. Such inferences violate Hume's Law. This roughly says that no inference from statements featuring only descriptive content to a statement featuring normative content can be formally valid. Recent work has clarified that Hume's Law follows from more general laws of logic (e.g., Russell, 2021; Pigden, 2016, 1989; Schurz, 2010).

Notice the is-ought fallacy is a defect of argument *form*. To avoid it and yet retain a normative conclusion, the argument must be *reformed* by adding one or more related normative premises that work together with the descriptive content to support the normative conclusion. Sometimes this can amount to trading a defect of argument form for a defect of argument content, such as when the added normative premise is itself poorly supported. (See Derelict Normative Premises, below.) But the defects are very different. The is-ought fallacy is a defect of form that is decisive, whereas a poorly supported (or as yet unsupported) premise may eventually be salvageable. The contrast can be seen in Table 1, which takes examples from work by Mittermeier et al. (2003) on the relevance of wilderness areas for conservation. Both arguments depicted there state the same conclusion. Table 1a shows just one premise for that conclusion, a descriptive premise the Mittermeier et al. paper explicitly offers. Without an additional normative premise that can be triggered by that descriptive one, the argument would fail due to the is-ought fallacy, a defect of form. In Table 1b we show how to avoid that result by adding

Table 1
Analytic summary of two different arguments for the same conclusion in Mittermeier et al. (2003).

1a. A biodiversity-over-wilderness argument that fails due to the is-ought fallacy	1b. A biodiversity-over-wilderness argument that avoids the is-ought fallacy with the addition of a normative premise
1. The 5 high-biodiversity wilderness areas identified have significantly greater biodiversity than the other 19 wilderness areas identified.	1. If the 5 high-biodiversity wilderness areas identified have significantly greater biodiversity than the other 19 wilderness areas identified, then conservation should focus significantly more on the 5 high-biodiversity wilderness areas than on the other 19 wilderness areas. 2. The 5 high-biodiversity wilderness areas identified have significantly greater biodiversity than the other 19 wilderness areas identified.
2. Conservation should focus significantly more on the 5 high-biodiversity wilderness areas than on the other 19 wilderness areas.	3. Conservation should focus significantly more on the 5 high-biodiversity wilderness areas than on the other 19 wilderness areas.

an appropriate normative premise.

A general implication of Hume's Law is that no matter how impressive one's empirical premises may be—no matter how sophisticated the study design and methodology on which they are based, how accurate and precise the data, how compelling the interpretation—they cannot on their own *entail* a normative conclusion. This places a heavy burden on conservation sciences because they aim to guide conservation action, policy, intervention, etc., all of which are normative. Such actions, policies, and interventions are about what ought to be done, and so any arguments for them will work *only* if they feature the appropriate value-laden, normative premises in addition to, and working properly together with, empirical ones. In a slogan: *if no carefully argued value-laden premises are put in, no rational guidance of action can come out*.

Upon becoming familiar with the is-ought fallacy, one might suspect it occurs in conservation, and Table 2 gives three candidate examples. But one should be charitable when scrutinizing potential cases of is-ought fallacies, both because many cases are subtler than first seems, and because a verified is-ought fallacy can be perceived as an egregious error. For instance, in Mittermeier et al. (2003) (Table 1b), the authors didn't explicitly provide premise (1), but neither did they explicitly recognize they were committed to that argument's conclusion (see Value Unclarity due to Logic, below). So it could be unfair and misleading to say they committed the is-ought fallacy when they tacitly implied the conclusion. For these reasons, in addition to the unquantitative nature of our current study, we are reluctant to comment on just how prevalent the is-ought fallacy is in conservation science, and more investigation is needed; but it likely arises more often than it should, as cases like those in Table 2 are easily and quickly found.

In summary, when the is-ought fallacy arises it is a specific way in which empirical matters and matters of value are being misrelated (i.e. the unraveled rope problem). Namely, the is-ought fallacy occurs when a descriptive and empirically supportable premise fails to be related to a normative premise in a way that would support the argument's normative conclusion.

3.2. Derelict normative premises

The is-ought fallacy involves the *absence* of normative premises that are required for argument forms to in fact be deductively valid. Conversely, another family of argument defects involves one or more normative premises being provided, but in a way that leaves it/them *derelict*, that is, presented with insufficient elaboration and/or support, especially compared to the empirical premise(s) that it partners with in the argument. In these cases, the impressive work done by the empirical partners can go to waste, as the derelict normative premise(s) prevents the argument from being sound or provisionally sound.

Consider an argument from Mittermeier et al. (2003), which we've analytically summarized in Table 3. It aims to show that despite 25 biodiversity hotspots deserving conservation priority over 24 wilderness areas, the *wilderness areas still have important conservation value*. Both

Table 3
Analytic summary of an explicit value-laden argument in Mittermeier et al. (2003).

Wilderness areas of less-but-important value argument
1. If together the 24 identified wilderness areas (a) hold the bulk of the planet's biomass and last megafaunal assemblages, (b) provide valuable ecosystem services, (c) are destinations for ecotourism and adventure tourism, (d) serve as controls in scientific research, (e) contain strongholds for dying languages, (f) have aesthetic and moral and spiritual value, and (g) are less expensive to conserve than many other areas, then although the 24 identified wilderness areas have less conservation value than the 25 biodiversity hotspots, their conservation value remains important. 2. Statements (a) through (g) are true of the 24 identified wilderness areas.
3. Although the 24 identified wilderness areas have less conservation value than the 25 biodiversity hotspots, their conservation value remains important.

Table 2
Three potential examples of the is-ought fallacy in conservation papers. Italics indicate normative content in conclusions that was not supported by the premises.

	2a. Papaioannou et al., 2019	2b. Pröhl et al., 2021	2c. Wiedenfeld et al., 2021
Quoted passage	"The chamois in Greece harbor an outstanding amount of variability within the species *R. rupicapra* and hence merit the implementation of special conservation measures" (p.939)	"Genetic diversity and genetic connectivity showed a negative relationship with road densities and urban areas surrounding toad occurrences, indicating that these landscape features act as barriers to gene flow. To preserve a maximum of genetic diversity, we recommend considering both genetic clusters as management units, and to increase gene flow among toad occurrences with the aim of restoring and protecting functional meta-populations within each of the clusters." (p.513)	"Extinction is not inevitable, and should not be acceptable. A goal of no human-induced extinctions is imperative given the irreversibility of species loss." (p.1388)
Summary of a possible inference within the passage, committing the is-ought fallacy	1. The *R. rupicapra* chamois in Greece has exceptionally high variability. ——— 2. Special conservation measures *should* be implemented for *R. rupicapra* chamois in Greece.	1. Genetic diversity in the toad clusters was diminished due to roads and urban areas inhibiting gene flow between them. ——— 2. The diminishment of genetic diversity is a bad thing and should be mitigated and reversed by treating the clusters as management units and increasing gene flow.	1. Extinction is not inevitable but is forever once it happens. ——— 2. Conservation *ought* to aim for zero human-induced extinctions.

premises in the argument have value-laden, normative aspects, in addition to empirical aspects. The authors state them with admirable clarity, but devote only about a paragraph to the normative aspects—to the claims about what is valuable and what should be done (p.10312). This pales in comparison to the elaboration and support the authors provide for the related empirical content.

In particular, premise (1) in Table 3 is insufficiently supported as it stands. It lays down conditions, (a) through (g), that would suffice for having important conservation value. But claims to such importance are vacuous unless elaborated through comparison to other things that compete for conservation attention and resources. If the wilderness areas satisfy conditions (a) through (g), would they have more or different conservation value than, say, the planet's estuaries? Its temperate rainforests? It's arable land? Rare populations? Highly productive ecosystems? Especially diverse genera? If so, why? What are the trade-offs, and why trade-off in this or that particular way, in this or that context? And so on. Granted, the authors provide a relatively long list of value considerations. However, devoting the available article space to a long list helps ensure there is little or no space to develop any one consideration in the detail needed for the argument to be provisionally sound.

Unlike the is-ought fallacy, the derelict normative premise defect is context-sensitive. If Mittermeier and colleagues were writing in a different context, where all their value-laden claims had already been established beyond reasonable doubt and this was widely appreciated, then perhaps those claims would also count as sufficiently supported as presented here.

Also note that when an author's normative premises are derelict, this doesn't automatically mean that author is to blame. Indeed there may be many reasons why Mittermeier et al. should *not* be blamed in our example. Perhaps they were adhering to journal requirements on word count, or heeding reviewer suggestions about focus, or did not have the training needed to provide sufficient support for normative premise (1). These points also suggest that the best means for avoiding the derelict normative premise defect—for ensuring normative premises have enough elaboration and support to work together well with their empirical partners in arguments—may be complex, involving, for instance, gradual changes within disciplines and professional organizations more generally.

3.3. Ironic community bias

Another argument defect indicative of the unraveled rope problem involves bias manifesting unintentionally at the level of the research community, rather than at the level of a single stated argument. Single arguments can have roles to play in this manifestation, but they might not support and may even tell *against* the broader community views they inspire or sustain, views that reinforce unintended biases over time.

To begin illustrating, we consider a key aim of biodiversity conservation research: empirical examinations of relationships between species richness and landscape attributes, whether those attributes are generated naturally and/or affected by human activities. Our example is made possible by Vellend humbly casting a critical and insightful eye (2019) upon his own past work with colleagues (2007), about the influences of agriculture on forest biodiversity through history. The authors wanted to know how biodiversity of *primary* forests, of the sort that filled much of Europe and North America prior to agricultural clearing, compares to that in *secondary* forests, i.e., those that now grow in some places where agriculture has been recently abandoned. To help with the comparison, they were fortunate that some ancient pre-agricultural primary forest patches do remain, scattered apart from each other in landscapes where agriculture was practiced then abandoned. Vellend (2019) notes that the 2007 study:

> concluded that agricultural land use "homogenized" forest plant communities based on the result that species composition was more similar among post-agricultural forest patches than among primary forest patches... This is typically considered a "bad" outcome for conservation, but our analysis focused on a contrast between two forest types (post-agricultural vs. primary), rather than the net effect of human activities via creation of a landscape with a mix of habitat types. Specifically, we did not compare the degree of similarity or differentiation among the full set of forest patches (primary + post-agricultural) relative to only primary patches (the assumed historical state of the landscape), so we can't actually say whether the effect of land-use history—at the scale of the whole landscape—was to create a more homogenous or a more heterogeneous set of forest patches. Because species composition varies significantly between primary and post-agricultural forests (Flinn and Vellend 2005), one may well actually expect more heterogeneity rather than less. (Vellend, 2019, p.224).

Thus, the 2007 study design was *small-scale* (about forest patches) in a way that did not support a *large-scale* conclusion (about whole landscapes) that many readers were likely to infer from the paper. We provide Fig. 2 to illustrate the small-scale result that beta diversity was greater at time t3 among primary *forest patches* (Ci – Cv) than among t3 post-agricultural *forest patches* (Ca – Cf). Based on their study design, Vellend et al. (2007) also inferred the causal claim that human agriculture was probably a cause of the lower beta diversity observed among secondary forest patches. Let us grant that the argument for that further *causal* conclusion is good (Table 4a).

But Fig. 2 also shows how the 2007 study details do not support, and may even tell against, the broader, large-scale claim that agriculture probably diminished forest beta diversity across the *whole landscape*. As Vellend (2019) noted, the study may even support the reverse conclusion, i.e., that agriculture increased beta diversity at this larger scale. Thus, if someone explicitly argued that the details of Vellend et al. (2007) support the large-scale conclusion that agriculture diminished landscape beta diversity, they would be offering a bad argument (Table 4b).

Vellend et al. (2007) offered the good argument seen in Table 4a and did not propose the bad one in Table 4b. So if the bad argument wasn't offered, what is the problem? And why is Vellend worried about this sort of thing? Because, as he puts it, "while these studies clearly report their methodology and results, they likely promote collective interpretations that are biased in favor of the 'humans are bad for biodiversity' narrative" (2019, p.224). Notice that Vellend is careful not to locate the bias in that narrative itself. After all, there may well be specifications of "humans are bad for biodiversity" that are true, but we should not take biased routes to it.

We want to draw attention to a broader pattern, then add specificity to it. The pattern consists of *inferences*, from statements supporting only narrow or modest conclusions, to broader statements not established by the narrower ones. An inference that can be modelled as a move from the argument in Table 4a to the one in Table 4b would be an example. That example happens to end in a broad conclusion that jibes with the "humans are bad for nature" view. And that view may indeed be biased in some cases (Vellend, 2019). But any inference of this sort would exemplify a kind of *inferential bias*, and thus a defect, regardless of which specific broader conclusion is found at the end of the inference. In each case, this is because the narrower set of statements don't together sufficiently support the one or more broader ones endorsed.

To add specificity to this general pattern of bias, we first note it can have community-level aspects, something to which Vellend points when speaking of "collective interpretations". Let's suppose his object of concern comes to pass: many of his readers draw the broader landscape conclusion of Table 4b, even though he and colleagues didn't explicitly offer that. Then the type of inferential bias that concerns us would occur, *distributed* across members of a community, rather than isolated in the heads of just this or that person. It would involve work by authors *and* interpretations by readers. It would also be *ironic* because some of the

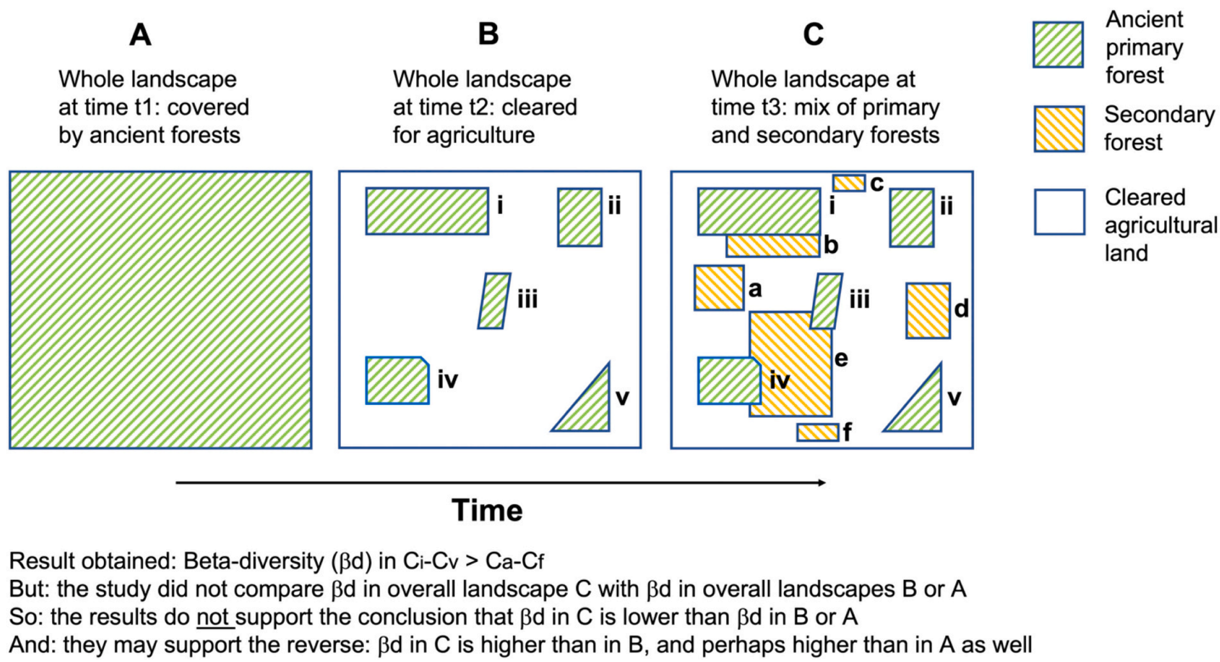

Fig. 2. Forest patch beta diversity vs. whole landscape beta diversity.

Table 4
Analytic summaries of a good small-scale (forest patches) argument made by Vellend et al., 2007, and a bad large-scale (whole landscape) argument they did not explicitly state. The latter is bad because the study did not support premise (1) and instead might suggest that premise is false.

4a. Good *small-scale (forest patch) argument*	4b. Bad *large-scale* (*whole landscape*) *argument*
1. If the study as designed shows lower beta diversity among post-agricultural secondary forest patches than among primary forest patches within the same landscape, then, probably, agriculture helped cause the lower beta diversity among secondary forest patches.	1. If the study as designed shows lower beta diversity among post-agricultural secondary forest patches than among primary forest patches within the same landscape, then, probably, agriculture helped cause forest beta diversity across the whole landscape to diminish.
2. The study as designed shows lower beta diversity among post-agricultural secondary forest patches than among primary forest patches within the same landscape.	2. The study as designed shows lower beta diversity among post-agricultural secondary forest patches than among primary forest patches within the same landscape.
3. Probably, agriculture helped cause the lower beta diversity among secondary *forest patches.*	3. Probably, agriculture helped cause forest beta diversity across the *whole landscape* to diminish.

members involved (Vellend and co-authors) provided premises that favour the *opposite* of the broader landscape conclusion of Table 4b. And the ironic conclusion of Table 4b now threatens to propagate further across the community, even if Vellend and his co-authors didn't intend the conclusion and would have declined to embrace it, were it pointed out to them. Indeed, Vellend notes that this paper and related ones from his group have been cited fairly frequently by the research community (a few hundred to several hundred times). Yet despite receiving such attention, the papers' conclusions have never seriously been challenged (Vellend, 2019), and some of the papers citing Vellend et al. (2007) refer to it as an example of how agriculture homogenizes biological communities at *landscape scales* (e.g., Ponisio et al., 2016; Castilla-Beltrán et al., 2021).

This leads us to next clarify two *risk heightening features*, i.e., features that may increase the risk of ironic community bias from occurring. The first involves the last sentence in Vellend et al. (2007, p.572): "Human land use continues to change the landscape-scale distribution of forest ages, and we can expect such changes to leave an enduring legacy in spatial patterns of biodiversity". After most of the paper carefully constrained its focus and claims to the small patches studied, this last sentence widens out to whole landscapes. The sentence doesn't explicitly say the "enduring legacy" was *homogenization* of the landscape; instead, it refers more vaguely to *change*. However, it would be all-too-easy for readers to infer that homogenization is the issue, as the study found homogenization-by-agriculture in smaller patches. Thereby the paper inadvertently heightens the chance that others will walk away with Table 4b's broader landscape conclusion in mind. We worry this type of risk is significant in conservation science, because articles often end with one or more synoptic birds-eye statements that step away from the careful details of the studies, attempting to lend broader importance and interest to their findings.

A second risk-heightening feature is that, as Vellend (2019) notes, many readers come into articles already embracing views such as "humans are bad for the environment", which may also increase the likelihood that the ironic community bias will occur. Such bias has the hallmarks of a structural or systemic problem that arises and can be sustained because of how a community, institution, or system is structured, not because of the intention or action of any one individual within it. Structural racism is a more familiar example. But in the conservation case, this structural problem involves relations between value-laden views and empirical ones. The "humans are bad for the environment" view is value-laden, and its frequency in the readership heightens the risk that a biased inference from partially empirical information will occur. Subtly then, when ironic community bias occurs it exemplifies the more general unraveled rope problem: mis-relations between empirical matters and matters of value. And as in the case of derelict normative premises, ironic community bias needn't imply that particular authors of arguments are to blame; here that point is especially salient when the bias manifests at the community level. At that level, the bias can also be a reinforcing or self-sustaining one, forming a pernicious feedback loop. When a value-laden view solidifies within a community it can become dogmatic, and the community can become routinely exposed to risk of ironic community bias.

3.4. Action argument conflation

For another family of argument defects indicative of the unraveled rope problem, recall that conservation sciences are inherently "crisis-based disciplines" that, in the face of uncertainties, must decide upon or recommend conservation actions based on incomplete available information about the possible outcomes. Let us call the arguments provided towards this end *action arguments*. These are one of the most important and frequent types of argument that conservation science produces. The identified family of argument defects afflicting these involves conflating the roles played by *probabilities* of the possible outcomes considered, with the *magnitudes of value* those possible outcomes would have.

It is easy to overlook the probability-magnitude distinction, especially in statements of the form "What is the risk of X?" If someone asks, "What is the risk that the fish or wildlife population will decline to unsustainable levels?", they might mean, "What is the *probability* of population decline?"; or instead they might mean "How *bad* would population decline be?" Staying clear on the distinction is important, not so that the two can be kept wholly separate, but rather so that their roles can be *properly integrated* to support the conclusions of action arguments. (If the reader is unfamiliar with the reasons why roles for value magnitudes belong in scientific action arguments to begin with, see Appendix 2 as a starting point.) Several disciplines investigate which ways of integrating probabilities and value magnitudes contribute to the rationality of actions, and which don't (Appendix 2). Complexities abound; nonetheless, some general findings are widely accepted, including that probabilities and value magnitudes can *pick up each other's slack*, so to speak, within action arguments.

In conservation, this is especially salient when complex natural systems are involved and empirical analysis is then affected by scientific uncertainty (as when trends in wild population sizes, age structure, niche resilience, etc., are at issue), and, conversely, when potential objects of conservation have especially significant value (such as local populations threatened by extirpation). For instance, even if empirical work merely suggests rather than confirms that harvesting is causing rapid phenotypic and genetic change in a wild population, the case for new harvesting constraints may remain strong, partly on the precautionary basis of the population's tremendous value (e.g., Pinto-Bazurco, 2020). The Action Argument Conflation defect arises when an action argument fails to achieve such balancing because the respective roles of probabilities and value magnitude are mistakenly conflated rather than properly integrated.

Our research implies that the action argument conflation defect in conservation science can involve empirical probability considerations being forced or presumed to play larger roles than they are able, because authors or readers fail to give value magnitudes the larger roles they can play. Thus, we describe this variation of the defect as one in which *neglect of value magnitudes leads to empirical considerations being overworked*.

To illustrate, consider Table 5 and then a real example. The table shows three models of action arguments. The first two (Table 5a and b) are models of potentially *good* action arguments. In one of them, probability considerations pick up the slack left by value magnitudes; in the other, the opposite relation is depicted. (These are just two among many models of potentially good action arguments that fall along a spectrum, something made most clear, perhaps, in the quantified premises of mathematical decision theory.) The third argument model will instead, in most contexts, be defective when specified because its premise (1) will be false: with neither the probability considerations nor the value magnitudes being clear *and* weighty, the combination of these will not suffice for conservation action as the premise claims.

Table 5
Three models of action arguments. The first two (4a and 4b) are models of potentially good action arguments, the former relying more on probabilities of possible outcomes, and the latter on value magnitudes. The third model (4c) will in most contexts be deficient when specified, as it proposes a combination of insufficient probability and insufficient value magnitude to rely upon.

5a. *Probability model*: A potentially *good* argument model for conservation action, relying more on empirical *probability*.	5b. *Value magnitude model*: A potentially good argument model for conservation action, relying more on value *magnitude*.	5c. *Deficient model*: A bad argument model for conservation action, with insufficient probability and value magnitude to rely upon.
1. If X has *some* conservation value, V, and there is empirically *clear and high* probability that V is in jeopardy, then there is strong reason to consider taking conservation action A. 2. X has some conservation value, V, and there is empirically clear and high probability that V is in jeopardy. ____________ 3. There is strong reason to consider taking conservation action A.	1. If the conservation value, V, of X is of *great magnitude*, and empirical work *suggests but does not confirm* that V is in jeopardy, then there is strong reason to consider taking conservation action A. 2. The conservation value, V, of X is of *great magnitude*, and empirical work suggests but does not confirm that V is in jeopardy. ____________ 3. There is strong reason to consider taking conservation action A.	1. If X has *some* conservation value, V, and empirical work *suggests but does not confirm* that V is in jeopardy, then there is strong reason to consider taking conservation action A. 2. X has *some* conservation value, V, and empirical work *suggests but does not confirm* that V is in jeopardy. ____________ 3. There is strong reason to consider taking conservation action A.

Next is our example, a temporal assessment of population changes in life history, genomics and Indigenous fisher knowledge of walleye populations harvested in northern Canada (Bowles et al., 2020). Paraphrasing here for clarity, one of the conclusions proposed was that when people begin having concerns that harvesting pressure is affecting evolution of a harvested population, conservationists should investigate these concerns much quicker than previously thought. The empirical part of the basis for this conclusion included phenotypic and genetic analyses of populations that experienced substantial harvesting over a 15-year span (1.5–2 generations), compared to those with less harvesting pressure. If accurate, the rate of evolutionary change would be much faster than existing literatures predict for fish populations in general. The study's empirical results, however, were merely suggestive rather than conclusive. One reason for this was that the observed evolutionary changes were just emerging rather than pronounced; another is that authors noted that observed changes, even if accepted, could be explained by things other than harvesting pressure. Consequently, the authors were careful to qualify their empirical findings, e.g., saying the results were "consistent with" (rather than confirming) the hypothesis that genetic changes arising within just 1.5–2 generations were "associated with" (rather than caused by) harvesting.

The empirical limitations of this study suggest that an argument like the Value Magnitude Model depicted in Table 5b will suit the authors much better than the Probability Model shown in Table 5a, when they are proposing their conclusion about acting much quicker than previously thought. But that would require bringing value magnitudes into the open and demonstrating they are weighty enough to pick up the empirical slack left by the study—perhaps, for example, by explicit appeal to a version of the precautionary principle, a topic that now has a large literature to draw from (e.g., Steel, 2014). Unfortunately, the authors did not clearly do this, something they later began to rectify in a follow-up article (Bowles et al., 2021) that responded to critics of the original study (Larson et al., 2021). Perhaps because the original study neglected the value magnitude considerations needed for the conclusion, the critics did not dwell on such value considerations. The critics focused instead on amplifying the empirical limitations of the original study. Thus, we seem to have a case of empirical considerations being presumed to play larger roles than limitations allow, partly because original authors did not start by giving value magnitudes the larger roles they can play. This is a version of Action Argument Conflation in which neglect of value magnitudes leads to empirical considerations being overworked.

Table 5 can help summarize this unproductive state of affairs in a different, more succinct way: the critics presumed the original authors were offering an argument like that in Table 5a, then criticized what would be premise (2). Yet precisely because such a premise would be problematic in the context of the original study, the original authors weren't offering such an argument at all. Instead, they offered one like that shown in Table 5c. But that is not free of problems either, as its premise (1) would fail to demand that value magnitudes pick up the slack left by empirical uncertainty. The fix in this case would be to turn to an argument like the one shown in Table 5b, with correspondingly increased explicit focus on value magnitudes.

The recurring sequence in which this can frequently manifest in conservation science goes like this: a paper proposes empirically careful and cautious claims; but the overall action argument in which these feature isn't fleshed out in sufficient detail, especially the relevant value magnitudes; so some researchers reading the paper interpret the work as though it is overworking its empirical premises when arguing for conservation actions; yet, this conflates the roles for probabilities and value magnitudes that the original authors *should* intend, given that they were up-front about empirical limitations; the fix is to be clearer about those roles, in ways that ensure the value magnitudes do the large work needed for the concluding conservation action. To relate this back to the unraveled rope problem more generally: the defects here involve mis-relating empirical and value-laden premises by failing to have one pick up the slack of the other.

3.5. Value unclarity due to language

Another family of argument defects we found involves unclarity about potential or actual value-laden contents, due to the language (e.g., ambiguous or vague) used to express these. Mere presence of value-laden contents is not necessarily a problem, and is often essential (e.g., Soulé, 1985; Robinson, 2006; Kareiva and Marvier, 2012; Rohwer and Marris, 2019). But unclarities about them due to language can cause or signal problems (Miller et al., 2011; Baumgaertner and Holthuijzen, 2017; Nelson et al., 2021). For instance, the unclarities we'll discuss form one set of largely overlooked mechanisms by which the better-known problem of “stealth advocacy” can occur (Pielke, 2007). Compared to past studies about value unclarities, we focus more on how unclarities can arise in precisely evaluable ways within arguments and signal the unraveled rope problem. These unclarities can seem innocuous—like mere subjective matters of word choice we needn't fuss about. But they can be about whether the arguments objectively provide evidence, strong reasons, or support at all. Rather than choosing an especially clear example, we will choose a subtle one, to help show how value unclarity can be hard to detect but present nonetheless, even in otherwise excellent and highly influential work.

Consider the landmark *Nature* paper “Biodiversity hotspots for conservation priorities” (Myers et al., 2000). Arguing that the “biodiversity hotspots approach” be prioritized as a global conservation strategy, it has been cited over 32,000 times (according to Google Scholar) and continues to be a main scientific source behind the hotspots approach that has attracted “over $1 billion in conservation investment” (Marchese, 2015, 300). The paper, to introduce the approach, defines “biodiversity hotspots” as “areas featuring exceptional concentrations of endemic species and experiencing exceptional loss of habitat” (p.853). Then it says:

> Here we focus on species, rather than populations or other taxa, as the <u>most prominent</u> and readily recognizable form of biodiversity. This is not to suggest that populations and even ecological processes are not important manifestations of biodiversity, but they <u>do not belong</u> in this assessment. There are other types of hotspot[10,11], featuring richness of, for example, rare[12,13] or taxonomically unusual species[14,15]. This article considers only hotspots as defined above. Concentrating a large proportion of conservation support on these areas <u>would go far</u> to stem the mass extinction of species that is now underway. [Superscript numbers in original, designating some of its references.]

We have added the underlining, to indicate three places where language is ambiguous between being merely descriptive, or instead normative and thus value-laden. For example, within the English language it is an objective fact that the term “prominent” is ambiguous, because it has >1 literal meanings; most importantly here, the term can be descriptive (e.g., when one says it is a descriptive fact that the Empire State Building is 119 m more prominent than the Eiffel Tower) or instead normative and value-laden (e.g., when someone claims Picasso's work was more prominent than Dali's, in that it was of more widespread and profound importance).

To see how such ambiguities can signal problems within conservation arguments, Table 6 clarifies three arguments the quoted passage is proposing. Each argument contains one of the ambiguous terms underlined above. And partly via those terms, each argument is concluding with a different consideration in favour of prioritizing biodiversity hotspots and their threatened endemic species, over other conservation foci such as those centred on ecological processes, populations, or other taxa. At this early stage of the Myers et al. paper, it

Table 6
Analytic summaries of small arguments from the second paragraph of Myers et al., 2000.

6a. Prominence argument	6b. Don't belong argument	6c. Go far argument
1. If species are the *most prominent* and recognizable form of biodiversity, then this consideration favours treating species as a greater conservation priority than populations and other taxa. 2. Species are the most prominent and recognizable form of biodiversity. ——— 3. This consideration favours treating species as a greater conservation priority than populations and other taxa.	1. If populations and ecological processes *don't belong* in the paper's assessment, then this consideration favours treating species as a greater conservation priority than populations and ecological processes. 2. Populations and ecological processes don't belong in the paper's assessment. ——— 3. This consideration favours treating species as a greater conservation priority than populations and ecological processes.	1. If concentrating a large proportion of conservation support on biodiversity hotspots defined in terms of endemic and threatened species *would go far* in stemming species mass extinction, then this consideration favours treating biodiversity hotspots as a greater conservation priority than other areas, such as those defined in terms of populations, ecosystem processes, rare species, or unusual species. 2. Concentrating a large proportion of conservation support on biodiversity hotspots defined in terms of endemic and threatened species would go far in stemming species mass extinction. ——— 3. This consideration favours treating biodiversity hotspots as a greater conservation priority than other areas, such as those defined in terms of populations, ecosystem processes, rare species, or unusual species.

would be uncharitable to see the authors as implying these three different considerations are *decisively* in favour of the hotspots approach; rather each argument just proposes some *favourable considerations*. There may be temptation to think Myers et al. do not take themselves even to be offering favourable considerations—that, rather, they are just trying to neutrally clarify the focus of their paper. But our point is not about whether the *motivations* underlying what they do are neutral. It is not about motivations at all. It is about what their study in fact does at this stage, which is proposing value-laden considerations. For even if the authors take themselves to be simply clarifying their focus, this focus is necessarily chosen over other possible foci, and such a choice must involve valuing some goals more than others.

But elsewhere in their paper and in follow-up works, the authors do, themselves, give reason to think the quoted passage is proposing the initial arguments expressed in Table 6. In those other places they explicitly propose such considerations favour their overall "conservation priority thesis" (Myers et al., 2000, 856). That thesis, also conveyed in short in the paper's title, says their "biodiversity hotspots approach" *should* be prioritized *over* other approaches as a global conservation strategy (2000, 853, 856–58). They are also clear that other approaches—e.g., focusing on ecological processes, populations, and other taxa—have important conservation value too. But they see these as, for example, "supplementary" to their greater-priority hotspots approach (Myers et al., 2000, 857), which they deem a "silver-bullet" among approaches (Myers et al., 2000, 853, 858). Perhaps most clearly, Myers says in a follow-up essay that the 2000 paper's thesis, and its focus on threatened endemic species, "implies that other species and other areas should receive lesser priority" (Myers, 2003, 796). The three arguments we express in Table 6 simply identify considerations that are supposed to favour that recurring main idea.

But once it is confirmed that ambiguities reside in each argument, this ensures that empirical and value-laden matters are, as a matter of fact, not yet clearly related in ways needed for those arguments to be sound or prospectively sound. Consider the prominence argument (Table 6a). Its premise (2) comes directly from the passage quoted above. Given the constraints of deductive validity and argument soundness and prospective soundness, how the ambiguity of 'prominent' is resolved in that premise influences how to support and evaluate that premise. It also influences whether and how the premise contributes to argument validity and soundness or prospective soundness. It influences these things for premise (1) too.

For example, suppose 'prominent' is descriptive in premise (2): species are being said to *factually stand out* more than populations and other taxa, in some value-independent way (compared to populations and other taxa, perhaps they are more distant from each other in morphological or phylogenetic space). Then support for that premise will need to be primarily empirical (looking, e.g., at morphological or phylogenetic space measures), and evaluation of the premise will rest heavily on empirical evidence. If the evidence is favourable, this will allow premise (2) to contribute to argument validity and prospective soundness, but *only* if 'prominent' is *also descriptive in premise (1)*. Were it instead normative in premise (1), then the empirical evidence for premise (2) would be inert with respect to argument validity and prospective soundness. This is because the argument would objectively fail to be deductively valid or prospectively sound, due to committing the formal fallacy of equivocation—premises talking about different things, not working together (Hurley and Watson, 2018).

That fallacy could be avoided, and the descriptive (and so empirically tractable) nature of 'prominent' retained in premise (2), by ensuring 'prominent' is *also* descriptive in premise (1). But this would threaten premise (1) itself. Premise (1) would then contain an inference from the descriptive prominence of species, to the normative claim that this favours treating species as having greater conservation priority than other things. As clarified in an earlier section of our paper, premise (1) would then risk committing an is-ought fallacy.

The last option to save the argument from validity failure would be for 'prominent' to be *normative in both* premises. But this poses different challenges to both. Premise (2) would now require more than just empirical evidence in its favour, as it would imply species are the most prominent form of biodiversity in some value-laden sense—that they are of more widespread or profound importance, for instance. Premise (1), on the other hand, would now make an inference from value-laden prominence, to conservation priority for species. And that inference would need to be further articulated and defended in a way that ensures it is not a mere tautology, i.e., that it doesn't amount to saying "if species are more important in terms of conservation, then they are more important in terms of conservation."

Analogous remarks hold for the other two Table 6 arguments extracted from the quoted passage, as they are similarly formed and contain key ambiguous terms. In sum, the ambiguities amount to unclarities that exemplify a family of argument defects. They signal the risk of empirical and value-laden contents of arguments being misrelated in specifiable ways that threaten the actual (not just perceived) support the arguments are able to give. That is a way of exemplifying the unraveled rope problem because that problem is about misrelations between empirical matters and matters of value. It is certainly possible, at least in principle, to rework or clarify the arguments to avoid this; or one might try to show we have misinterpreted them. Regarding the former, the end of our paper discusses concrete ways of avoiding such problems; regarding the latter, even if our case for interpreting the quoted passage as we did were contestable, it seems plain the passage is unclear enough to risk such interpretations by others, and thereby lead to community-level problems of the sort we discussed earlier in our paper.

3.6. Value unclarity via logic

The last family of argument defect we discuss also involves value unclarity, but due to unaddressed logical implication rather than via language. Consider the influential Mittermeier et al. (2003) paper that we referenced when discussing the is-ought fallacy and derelict normative premises. Three of its authors also, earlier, co-wrote the Myers et al., 2000 paper on biodiversity hotspots. In the 2003 paper they continue to prioritize those hotspots. But that later paper additionally emphasizes the conservation value of "wilderness areas" and compares this to the value of the previously identified biodiversity hotspots. After arguing for their criteria adopted to identify wilderness areas, 24 such areas are demarcated on Earth. Moreover, 5 of these wilderness areas had much greater biodiversity than the other 19. These are called "high-biodiversity wilderness areas" (p.10309), even though their biodiversity "pales in comparison" (p.10311) to that in the previously identified 25 biodiversity hotspots. Given all this, Mittermeier and colleagues propose an overall conclusion: "global biodiversity conservation should focus on a two-pronged strategy targeting the 6.1% of the land's surface covered by the five high-biodiversity wilderness areas as well as the 1.4% covered by the hotspots." (p.10312). They are clear that those original hotspots are still to be prioritized: "most conservation should remain concentrated" on them (p.10312). But they urge that the 5 high-biodiversity wilderness areas be a *secondary* area of focus in a two-prong strategy.

That conclusion logically implies this additional conclusion: *conservation should focus significantly more on the 5 high-biodiversity wilderness areas than on the other 19 wilderness areas*. The authors do not pause to state or clarify this additional conclusion, but they logically imply it because of how, in the context of their discussion, they left the 19 wilderness areas of lesser biodiversity *out* of their two-pronged strategy. And this unstated but logically implied conclusion is certainly value-laden. It is thus an example of unclear (in this case, unstated) value-laden content arising via unaddressed logic, rather than via language. It thereby also exemplifies another way the unraveled rope problem can arise, as the paper does not clearly relate empirical and value-laden premises together in ways that explicitly support the unstated but implied conclusion we have identified.

4. Recommendations for resolving the unraveled rope problem in conservation

Across core themes of conservation research studies, we have uncovered and analyzed several ways in which arguments can misrelate empirical matters and matters of value, instead of properly integrating these. In these cases, the arguments become unraveled ropes, not providing the support presumed, envisioned, or needed. This can undermine the support for conclusions, mislead readers, and confound interpretation. It can also misdirect policy and conservation interventions, as well as further work in areas ranging from the formulation of biodiversity hotspots, to quantifying changes in biodiversity in the face of human activities, to harvested species management. What should be done about these defects, about their recurrence, and about the general unraveled rope problem they indicate? Below, we identify general and specific goals for which solutions should aim, then discuss achieving these.

4.1. General goals

- *Make every argument work*. Conservation researchers should try to ensure every argument they produce really does support the conclusion drawn. Minimally this entails ensuring each argument has both good form, and good content. Technically, this means ensuring each premise is true or at least well-supported (good content), and that the logic of each argument is either deductively valid or inductively strong (good form).
- *Express every argument clearly*. This isn't to say authors should express their arguments using the method of argument analysis we have used here (using numbered propositions and logic-identifying lines). That usually won't be suitable for their papers. But authors should express their arguments clearly enough to minimize defective interpretations and some of the community-level aspects of argument defects discussed above, thus helping prevent propagation of bias, misdirection of work, ineffective policies and interventions, and so on.
- *Identify and discuss both implications and limitations of arguments*. This will help avoid some of the defects discussed here, prevent overreaching arguments, and clarify where more work is needed or of interest.

4.2. Specific goals

Conservation researchers should always aim for proper relations between empirical matters and matters of value, to help ensure good form and content of their arguments. Such relations should be clear enough to be readily and accurately analyzed by others; and associated implications and limitations should be identified. In fact, even if exogenous granting agencies, governments, or conservation organizations define the values (e.g. species ‘A’ should be protected), researchers need to be aware of these and frame their conclusions/recommendations within these values (e.g. *if* species ‘A’ should be protect, *then* our empirical results suggest X and Y as interventions). This ensures transparency about conservation values and will help pre-empt conflation (unraveled rope) from occurring. It can also help mitigate the serious problems documented (e.g., Douglas, 2009) to sometimes arise from too much separation between groups defining values and scientists themselves. For the particular argument defects we uncovered and discussed, we recommend:

- *Is-ought fallacy*: always precede any normative conclusion—e.g., any proposal about which conservation actions, strategies, or policies ought to be considered, taken, or deemed important—with appropriate normative, value-laden principles that relate to the empirical parts of the argument in the ways logically required for the conclusion. Avoid leaving such conclusions to be deduced from empirical premises alone.
- *Derelict normative premises*: provide normative premises, e.g., value-laden principles, with enough elaboration and support to help ensure the arguments in which they feature are provisionally sound.
- *Ironic community bias*: Draw attention to what can and cannot be extrapolated or inferred from conservation results; avoid other features of papers that heighten the risk of ironic community bias or related misinterpretations, such as concluding remarks that uncarefully branch out from a study's specific contexts; be mindful of biases through which one's conservation argument may be interpreted.
- *Action argument conflation*: When arguing for or recommending actions based on possible and desired conservation outcomes, ensure that empirical limitations are complemented appropriately by defended claims about the magnitudes of values, and vice versa; don't conflate the distinct but complementary roles that empirical probabilities and value magnitudes must play—instead, properly integrate them.
- *Value unclarity* via *language*: make more explicit the roles that normative, value-laden premises do and should play in conservation arguments, especially by using less ambiguous, vague, obscure, or otherwise unclear language. This is not merely a point about communication, or terminology, or how conservation arguments are “perceived”. It is about whether the arguments in fact work at all, because they can fail when value unclarity via language misrelates empirical matters and matters of value.
- *Value unclarity* via *logic*: check for tacit conclusions or other claims that are logically implied by arguments presented, and ensure that they are supported with arguments in which empirical and value-laden matters are not misrelated.

4.3. Considerations for achieving the goals

Several considerations arise for conservationists when determining how best to meet the goals listed above and solve the unraveled rope problem. Which considerations are most salient, and how best to act on them, will often vary between cases.

Achieving the listed aims will require critical discussion. Not only at the individual study level, such as within research groups working on particular subjects, but also discussion across the entire discipline and between branches of it, to ensure that conservation arguments meet a set of general standards over successive years. This would include that conservation science is honest about the standards of the discipline and how to change them in relation to empirical matters and matters of values.

Conservation research also would benefit from other preventative measures and future *inputs to/outputs of* the discipline. While our paper has taken important early steps of revealing the unraveled rope problem, we need more empirical investigation as to why such conservation argument defects recur. Within conservation-related graduate/undergraduate programs, more training in philosophy of science would be a helpful input—such as a required course in the philosophy of science, and one on environmental ethics or philosophy of the environment. Incorporating a chapter on matters of value and their relations to empirical matters within conservation textbooks would be another. Conventions and frameworks for more explicitly leveraging the integration of empirical and value-laden matters in basic research are needed (e.g., Baumgaertner and Holthuijzen, 2017). More generally, these types of input measures would help conservation scientists to become more familiar with consensus views that other fields have arrived at and which are relevant to their work. For instance, in philosophy of science focused on epistemology, researchers have discovered that roles for values “cannot be escaped by choosing inference guidelines” (Douglas, 2009, 154), and are indeed essential to choice of test design (which helps determine the evidential relevance of data), deciding what kinds and amounts of evidence are sufficient for accepting hypotheses, for selecting which research questions to pursue in the first place, etc. (e.g., Rudner, 1953; Longino, 1990; Harding, 1991;

Douglas, 2000, 2009; Kitcher, 2011; Steele, 2012; Winsberg, 2012; Biddle, 2013; Elliott, 2017). And although some work (e.g., Hausman, 2011) suggests there is an assumption among some scientists that values are not rationally evaluable and require wholly different treatment than empirical claims, there is instead a consensus across several branches of philosophy that complex relations between empirical and value aspects of arguments are critical to the overall rationality of many arguments (e.g., Hausman, 2011; Kolodny and Brunero, 2020; Richardson, 2018). Roles that values and empirical premises play within larger arguments *are* rationally evaluable according to well-established rules of logic and standards of argument evaluation.

Concerning outputs, editorial staff at conservation journals or research grant review committees could include a few members whose focus would be largely on reviewing and/or refining articles through attention to statements of conservation values as well as relations between these and empirical content. Paper review templates often already include questions such as "is the relevant literature adequately cited?" and "are the statistical analyses appropriate for the study design?"; they could also include "are empirical matters and matters of value properly related within arguments?". Similarly, peer-review standards could be refined to allocate more text space for improving arguments as suggested by this paper. Such endeavors could help bridge subdisciplines in conservation research that touch on the social sciences, philosophy, ethics, etc., but also improve the integrity of conservation research.

These strategies and attending challenges could be viewed as beyond the expertise of many scientists. And regularly, conservation research is objective-oriented, with objectives pre-defined by non-scientists. Could, then, some of this be outsourced to some extent? Both pros and cons of similar but more general ideas are already debated (e.g., Douglas, 2009; Kitcher, 2011), and there are a range of possibilities here. For instance, some social scientists have highlighted how their large literatures and sub-fields can be of use to conservation science more generally (e.g., Bennett et al., 2017). Others have, while focusing more on the *ethical* dimensions of conservation science than on the *epistemic* dimensions we have investigated, suggested creating a sister discipline that focuses on "ecological ethics", much in the way the medical research community has the field of bioethics to turn to (Minteer and Collins, 2005). To address epistemic dimensions in addition to ethical ones, perhaps an analogous sister discipline of "conservation epistemology" is possible (there is already a relatively small community of philosophers of conservation biology, e.g., Odenbaugh (2021)). When pursuing such ideas further, it would be important to consider both the strengths and weaknesses already observed in relationships like those between medical research and bioethics communities. For instance, the institutionalization of western bioethics has so far resulted in a research community that is not nearly as diverse and inclusive as it should be (e.g., Fiske et al., 2019), and there is often pressure to codify approaches to highly complex problems that instead require more nuanced case-by-case analysis. This last point is already a topic of discussion in "ecological ethics", not just bioethics (Varner, 2008; Perry et al., 2012).

Here, we started to address the unraveled rope problem by uncovering the different ways it manifests in argument defects in conservation. This has already shown how the problem afflicts the very foundations of scientific reasoning upon which conservation science is built and grows. We contend that further work will enrich these foundations and help secure the discipline's prospects into the future.

Glossary

Here we include terms central to disciplines outside conservation science that study the nature of relations between empirical matters and matter of value. If a term is used in multiple specialized ways in these disciplines, we indicate how we use it in this paper.

Terms	Characterizations	Examples
Conservation science	The interdisciplinary study and protection of Earth's biodiversity, natural environments, and natural resources.	Biological assessments of small, endangered, or harvested populations; biodiversity conservation planning; socio-ecological systems; conservation of natural resources; development of sustainable economies.
Deductive validity	An argument's form is deductively valid exactly when it ensures that the conclusion must be true if all the premises are true. So if it is possible that an argument's conclusion is not true, even when all its premises are true, then the argument is not deductively valid.	The wall and turtle argument (Methods section), and arguments in Tables 1b, 3, 4, 5, and 6 are all examples of arguments expressed in deductively valid forms. The summary inferences in Table 2 are examples of arguments that are not deductively valid.
Descriptive	A descriptive statement, premise, etc., is a factual one that says something is or is not the case, without adding any value-laden claim about whether this should or shouldn't be the case, ought or oughtn't be the case, is important, etc. A descriptive statement may factually be true or instead false.	The population contains <1200 individuals.
Empirical	An empirical statement, premise, etc., is one for which observations or other data or experience must normally play a central role when determining whether it is true or false, or well supported. Typically, descriptive statements are also empirical.	Over time harvesting pressure has correlated with change in number of individuals in the population.
Epistemology	The study of the nature of knowledge and related things, such as evidence, rationality, justification, support, and so on.	The theory that evidence is essentially contrastive, so that an observation can evidentially favour one hypothesis over another, but cannot favour a single hypothesis independently of such comparison, is a view articulated and evaluated in epistemology.
Fallacy	A recurring and deceptive type of error in the form of particular arguments or inferences, one that ensures their form is neither deductively valid nor inductively strong.	The correlation-causation fallacy; the fallacy of equivocation; is-ought fallacy.
Normative	A normative statement, premise, etc., is one that goes beyond mere factual description by adding a claim about whether such-and-such should or shouldn't be the case, ought or oughtn't be the case, is important, etc. Such a claim is explicitly or tacitly value-laden.	We should not have let the population decline to <1200 individuals. (Some value diminished when we did.)
Rationality	There are many conceptions of rationality (e.g., Foley, 2013; Kolodny and Brunero, 2020; Wheeler, 2020). On many of these, rationality can be attributed to multiple types of thing, e.g., to a hypothesis, a set of beliefs, a learning process, an argument, etc. In this paper rationality is about conduciveness to goals, especial epistemic goals such as having	The rationality of the overall argument was improved by adding new data. Our value judgment that it is best to maintain loose harvesting limits is no longer rational because new data has led us to believe the limits threaten something we value more: the fish population.

(*continued on next page*)

(*continued*)

Terms	Characterizations	Examples
	true beliefs, well supported beliefs, consistency between beliefs, well-formed arguments, sound arguments, etc. Rationality can be evaluated by assessing how conducive a belief, process, argument, etc., is to some goal.	
Sound	An argument is sound if and only if it is both deductively valid and all its premises are true.	An example sound argument: *1. If Los Angeles is in California, then Los Angeles is in the USA; 2. Los Angeles is in California; 3. therefore, Los Angeles is in the USA*. An example argument that is unsound because premise 2 is false, even though the argument is deductively valid and premise 1 and the conclusion are true: *1. If Los Angeles is in Florida, then Los Angeles is in the USA; 2. Los Angeles is in Florida; 3. therefore, Los Angeles is in the USA*. An example argument that is unsound because it is not deductively valid, even though both premises are true: *1. If Los Angeles is in Florida, then Los Angeles is in the USA; 2. Los Angeles is in the USA; 3. therefore, Los Angeles is in Florida*.
Support	Talking of an argument supporting its conclusion is to attribute the property of *being supportive* to an argument. As clarified by reading our Methods section and corresponding Appendix 1, sometimes it is a yes-or-no matter whether an argument has this property, and other times it is a matter of degree. In all cases, the property depends on at least two variables: whether its *form* is supportive, and whether its *content* is also supportive (Appendix 1). An argument's form is definitively supportive when it is deductively valid. When it instead has an inductive or abductive form, the supportiveness of its form is proportional to the strength of inductive or abductive logic this form exhibits (not discussed here). An argument's content, on the other hand, is definitively supportive when all its premises are true. When the truth of one or more of the premises is inconclusive, yet there are sub-arguments for each of these premises, then the content of the more general argument is proportional to the supportiveness of the sub-arguments. A deductively valid argument with inconclusively but well-supported premises is said to be prospectively sound (Appendix 1). A deductively valid argument whose premises are indeed all true is, simply, sound (Appendix 1).	The wall and turtle argument supports its conclusion if both its premises are true. And in that case it is a sound argument. The wall and turtle argument offers a high degree of support to its conclusion if each of its premises is in turn well-supported. And in that case it is a prospectively sound argument.
Value	There are many theories of value (Schroeder, 2021). On most, for something to have value is for it to have some goodness. Goodness, and so value, can be attributed in different ways, e.g., implying there is goodness *in* something, or goodness *for* something, or goodness *instrumental* to some further good, or goodness in either some particular or instead all respects when compared to a contrast class, and so on, with each of those exemplified in that order by the examples sentence to the right.	There is value in survival; the population is of value to the ecosystem; genetic diversity is instrumentally valuable to the further good of species longevity; policy A is better than policy B in terms of protecting wilderness, but B is better in terms of conservation on the whole.
Value-laden	Something, e.g., a statement or claim, is value laden when it (perhaps only tacitly) implies or is based upon some value claim.	The black spider monkey ought to be accorded the status of "endangered species".

(*continued on next column*)

Declaration of competing interest

We both *declare no conflicts of interest.*

Data availability

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

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Appendix A. Supplementary data

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