RESEARCH ARTICLE

# From anti-science to environmental nihilism: the Fata Morgana of invasive species denialism

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## Abstract

Invasive species denialism (ISD) is a controversial and hitherto underexplored topic, particularly with regard to its potential impacts on stakeholder engagement in support of invasive species management and policy. We examined how ISD is framed within the Great Lakes invasive species community, as well as the impacts of excluding and including those perceived as denialists in engagement efforts. We interviewed key informants in the region to gain an understanding of their framings of ISD, as well as focus groups allowing participants to discuss the impacts of exclusion and inclusion of stakeholders during the engagement process. ISD discussions were organised into three framings: 1) invasive species denialism; 2) invasive species cynicism; 3) invasive species nihilism. Participants raised concerns about outright exclusion of stakeholders and offered recommendations for mitigation of the impacts of inclusion of proponents of ISD in during stakeholder engagement. Our results have shown that a better understanding of the different framings of ISD is crucial to improve communication with stakeholders and to better inform responses and mitigation efforts. The newly defined framings of invasive species cynicism and invasive species nihilism demonstrate that more targeted responses to specific forms of ISD are needed to improve stakeholder engagement outcomes.

## Introduction

Science denialism, while not a new concept, is one which has seen heightened focus in recent years in light of worldwide threats such as climate change or the recent SARS-CoV-2 pandemic. Science denialism is described as an "unwillingness to believe in the existing scientific evidence" (Björnberg et al. 2017) and as a form of pseudoscience in opposition to science (Hansson 2017). Some have employed a more goal-oriented meaning, using the term to describe individuals using rhetoric to give the impression that scientific consensus has not been reached on a topic (Diethelm and McKee 2009), for example claiming that the existence of climate change is still 'up for debate'.

Like climate change and the SARS-CoV-2 pandemic, invasive species are a global threat of great scientific, economic, and social concern and attention. These global threats have also received a lot of attention in the academic literature arising from their mitigation or management efforts further complicated by 'denialism" narratives (Brulle 2020; Taylor 2020). Recently, some invasion ecologists have voiced concerns regarding an increase in vocal opposition toward invasive species management and regulation that they refer to as denialism and which they argue is rooted in a "rejection of undisputed scientific facts" (Russell and Blackburn 2017) and the attempt to cast doubt on science through the use of rhetorical tactics—including misrepresenting or ignoring empirical evidence, cherry-picking data, quote mining, and maligning experts with accusations of bias (Ricciardi and Ryan 2018a, b). These concerns, however, are challenged by other researchers who argue that many disagreements in invasion science stem from different values (Frank 2021) and the choice of language and militaristic metaphors used to describe invasive species (Larson 2005; Janovsky and Larson 2019), rather than a rejection of scientific facts, and that the term 'denialism' is an inappropriate descriptor, particularly given its historical use as a pejorative with a troubled history (Sagoff 2018). These authors have made arguments based on values, environmental ethics, and metaphors, which interpret the significance and management implications of biological and ecological facts differently. Many of these challenges have been responded to in the literature (Ricciardi and Ryan 2018b).

The existence of these alternative views on the nature of disagreements in invasion science or ISD in general suggests that this term may have alternative framings among invasive species practitioners and stakeholders as well, which warrants further exploration. This understanding that multiple perspectives exist should, however, in no way be understood as an equivocation of these positions, or an endorsement of these alternative views by the authors. The controversies present in the literature are outlined here solely to demonstrate the potential variety of responses that one might expect to receive in response to questions relating to invasive species denialism.

The controversy surrounding invasive species denialism (ISD) is worth considering, particularly in the context of invasive species management and policy. Management of invasive species relies not only on researchers and decision-makers, but also the involvement and cooperation of various stakeholders to ensure success (Shackleton et al. 2019). Regardless of whether any of these groups might consider themselves

to be denialists, the fact remains that at least some researchers, decision-makers, and members of the public have been perceived by prominent invasive species researchers as making denialist claims (Russell and Blackburn 2017; Ricciardi and Ryan 2018a). The ongoing arguments about what constitutes 'invasive species denialism' and the motivations behind it seen in the literature (Ricciardi and Ryan 2018a, 2018b; Sagoff 2018, 2020; Munro et al. 2019) demonstrate that this term is not universally understood or defined and may pose a barrier to cooperation between those labelled versus those doing the labelling.

It is therefore reasonable to question whether people who are critical of invasive species management may have reasons for their positions other than denying scientific claims. If such critics hold different values and preferences of where public funding ought to be spent on issues of environmental protection, their views would not be accurately reflected by being labelled as simply science denialism. Engagement of stakeholder groups, each with their own values and preferences, is an integral part of invasive species management used to spread awareness of invasive species to the public (Carter et al. 2021), improve research outcomes and inform ecological models (Samson et al. 2017), and resolve conflicts arising during management efforts (Crowley et al. 2017). It is therefore also reasonable to question whether misunderstandings or differences in framing (Golebie et al. 2022) perspectives on invasive species may limit stakeholder engagement in invasive species management and policy, in turn contributing to reduced ability to achieve those management goals.

Our study, therefore, asked how perceptions of invasive species denialism affect stakeholder engagement with invasive species management. We considered four questions: 1) How is the concept of ISD framed by researchers, decision-makers, and the public?; 2) What are the impacts of excluding those labelled as ISDs, if any?; 3) What are the impacts of including those labelled as denialists, if any?; and, 4) If there are negative impacts, how might these be mitigated?

By examining the ways in which 'denialism' is described by participants, we will determine whether the meanings are as clear cut as a rejection of undisputed scientific facts, or if this label is applied using other framings. By exploring the impacts of excluding and including individuals or groups labelled as denialists, we will explore some of the hurdles to outreach and engagement that different framings can occasion. Finally, our study will outline the impacts on effective communication and outreach arising from the 'denialism' label itself, regardless of the intended or perceived meaning.

## Methods

### Data collection

Within the aquatic invasive species community in the Laurentian Great Lakes basin, key informants were identified by the researchers and invited to participate in semistructured, in-depth interviews [University of Toronto Research Ethics Board Protocol

#40500]. Key informants are those within a particular community who, based on their knowledge, experience, and position in the community, are able and willing to communicate with the researcher about the topic of interest (McKenna and Main 2013). These key informants included individuals with provincial, state, and federal government agencies, those involved in public communication or outreach, and academic researchers. Nine key informants, a sufficient size to reach coding saturation (Hennink and Kaiser 2022), were interviewed between April and August 2021 using the Zoom platform. Each interview took approximately 1–2 hours. Interview participants were asked four questions pertaining to denialism: 1) Does the term 'invasive species denialism' mean anything to you, and, if so, what does it mean?; 2) Are there particular ideas or viewpoints that you would characterise as denialist?; 3) Do you believe that individuals or groups are invasive species denialists?; and, 4) Have you ever had trouble working with an individual or group due to believing that they were an invasive species denialist, or because they believed you were an invasive species denialist?

Following the interviews, participants were invited to participate in a focus group to further discuss as a group the perspectives on ISD previously shared individually during the interviews. Five of the interview participants were willing and able to continue participating further in the focus group. The focus groups were conducted using an asynchronous e-Delphi format over the SurveyMonkey (Momentive Inc. 2018) platform. The e-Delphi is an iterative process, whereby topic experts are asked to discuss conflicting perspectives on a topic and come to a consensus over several rounds of group feedback (Cole et al. 2013). The asynchronous e-Delphi format over SurveyMonkey enabled participants to think over the issues discussed and contribute their ideas at their own pace, and over a time frame convenient for them, to alleviate ongoing online fatigue during the COVID-19 pandemic. The focus group lasted five rounds, sufficient to reach coding saturation (Hennink and Kaiser 2022), with each round lasting one week. Participants were asked about the importance of outreach in invasive species management, and to explore the impacts of both exclusion and inclusion of invasive species denialists on that outreach. The group was also asked for recommendations for how to alleviate some of these impacts, based on their own extensive experience in the Great Lakes aquatic invasive species community.

## Data analysis

Audio recordings of interviews were transcribed verbatim using Zoom software, and then corrected manually to ensure accuracy. Anonymized interview transcripts were uploaded onto the qualitative data analysis software NVivo, Version 12 (QSR International Pty. Ltd. 2018). Focus group responses each week were summarised by the facilitator and participants were asked to indicate whether they agreed with the summary of the group's positions, disagreed, or wished to add additional information or context. The anonymised discussion data were then downloaded from the SurveyMonkey platform into Microsoft Excel.

Analysis of the interview and focus group responses involved a reflexive thematic analysis, using an inductive and semantic approach (Braun and Clarke 2006). A reflexive thematic analysis recognises the importance of the researcher themself as an "analytical resource" by following a six-phase process: 1) familiarising themselves with the data; 2) systematic data coding; 3) using the data to generate themes; 4) reviewing the themes; 5) naming and refining the themes; and, 6) writing the paper (Braun and Clarke 2021). Inductive thematic analysis allows the data to drive framings, rather than solely those within the existing literature. A semantic approach is one in which the data are described based upon what the participants have said, then organised and interpreted by the researcher (Braun and Clarke 2006). We used this approach because it allows for the ways in which participants describe ISD and use those terms to be captured and analysed without presupposing that they will line up with previously published perspectives, or the researchers' expectations.

From the interviews, three framings of invasive species denialism were extracted during the analysis. These framings are "invasive species denialism", "invasive species cynicism", and "invasive species nihilism". In the focus group that followed, three potential impacts emerged as a result of excluding or including individuals or groups believed to be denialists: 1) impacts relating to the accuracy of information; 2) impacts relating to management decisions, goals, and outcomes; and, 3) impacts regarding representation and perceived legitimacy. Finally, the focus group provided recommendations to mitigate some of the impacts discussed, which were to incorporate facilitators into engagement efforts, providing balanced information, and to know when engagement is no longer worth continuing.

## Results

In this section, we begin by describing how interviewees interpreted ISD, which we organised into three framings. Next, we report on the engagement impacts of ISD followed by participant recommendations as they emerged during the focus groups.

### Invasive species framings

Three framings of 'invasive species denialism' emerged from key interviews (Table 1). These framings do not represent a definitive meaning of 'ISD' nor do we propose to set boundaries on its potential meanings and implications. Rather, the emergent framings are intended only to organise the perspectives presented by participants in a way that clarifies different meanings and how they may shape interactions between stakeholder groups.

### Invasive species denialism

"*Does nuance equal denialism? I don't believe so, but others might.*" (Interview participant, environmental author and journalist)

**Table 1.** Framings of invasive species denialism from participant interviews, with paraphrased examples.

| Denialism framings | Forms of the framing | Paraphrased examples |
|---|---|---|
| Invasive species denialism | Lack of understanding of science | Comparison to climate or medical denialism |
| | | Inability to understand science in general |
| | | Used to silence critics, frame arguments as non-scientific |
| | Not believing in the existence of invasive species | Invasive species are not real / are not a problem |
| | | It's just movement from one place to another |
| | | This is natural / inevitable |
| | Lack of understanding of invasive species science | Nature will solve the problem itself |
| | | Refusal to believe in one's role in the spread of invasives |
| | | This species does not require management |
| | | Not believing that management plans could go awry |
| | | Unreasonable expectations for management |
| Invasive species cynicism | Nothing in it for them /Taking action perceived as costly | Action would be inconvenient |
| | Species-centric values | Species they care about have not been impacted |
| | Inaction perceived as beneficial | This species is providing food for other species |
| Invasive species nihilism | Discussing invasive species is pointless | Who cares? / Why bother? |
| | | Invasive species don't matter |
| | | This is not worth talking about / This is a waste of time |
| | Management efforts are futile | This is a waste of money |
| | | This is a losing proposition / This is futile |
| | | We shouldn't be doing anything about them |
| | | Optimism is a form of denialism |
| | Uncertainty leading to inaction | The uncertainty paralyzes us |

This denialism framing reflects the framing commonly discussed in invasion ecology literature (Table 1), and we therefore labelled it as invasive species denialism. This framing includes the description of the opiner as having a limited understanding of invasive species science. The framing also mimics recent discussions about medical denialism during the COVID-19 pandemic. For example, one participant explained: "*I've been saying this, this whole pandemic too. Like not even just in terms of invasive species but like in general. These people. It's just like people that don't believe in doctors or vaccines*" (Interview participant, invasive species public outreach). This framing is generally described as lacking any understanding of science in general, and people perceived this denialism as more generalised, rather than referring to specific people or events. This framing was also described the least, with participants often stating that they had not personally had encounters with anyone holding these views and the majority voicing scepticism that such people really existed. One participant voiced concern that this framing of ISD was used both in the literature and the invasive species community to silence or blunt criticism of the status quo. They said "*[l]argely, my experience with that term was seeing it used by members of the academic community to potentially either discredit or silence or blunt the impact of those outside of the academy who were daring to suggest that it wasn't as black and white as they were suggesting it was*" (Interview participant, environmental author and journalist).

This framing of denialism was also used to describe those who may understand science generally, but who either did not believe in invasive species or did not believe

invasive species were a problem (Table 1). This type of denialism was described far more often by participants, and encounters with individuals expressing these views were often described in terms of frustration or conflict. For example, "*definitely the evolution arguments of, you know, 'it's just how things are and this is a natural progression'. That to me, that's a bit of denialism. And others saying that there are no impacts from invasives in general, 'it's just another fish' or 'it's just another plant, what's the big deal?' I definitely hear that on some occasions, yeah*" (Interview participant, provincial/state government).

This framing also includes those who believed that invasive species were a problem but who lacked an understanding of invasive species science (Table 1). This included people who did not agree that a particular species required management, as well as people who objected to suggestions that they or their industry were responsible for spreading invasive species. For example, "*[The lakers] will tell you that, and quite rightly so, that they don't bring [invasive species] into the system, because it's the ocean-going vessels, the salties, that do. Which is true. But then they'll deny that they really have an effect on it, knowing full well that they're moving them around the system. There's no way under the sun that a Zebra Mussel introduced in Lake St Clair would make it to Lake Superior without it being moved by a ship. Internally, they move this stuff around all the time, but they're in denial about what they should do*" (Interview participant, invasive species communicator).

In addition, this framing also included the view of people who supported management action to prevent or control aquatic invasive species, but who did not understand the potential risks or possibility of failure. Many participants expressed frustration when the public expected management efforts to be wholly without risk of environmental harm, or to be 100% effective, despite the fact that that was not typically possible.

## Invasive species cynicism

"*It's pooh-poohing something that we know is a problem because you don't want to be harmed personally*" (Interview participant, invasive species communicator)

The second framing identified is characterised by a description of someone with a lack of support for invasive species management but, in contrast to the previous framing, this view is not because the person lacked understanding of the science behind it, but because of cynical motivations (Table 1). The key difference was whether the individual voicing the denialist viewpoint was believed to understand invasive species science. Invasive species cynics are people who are not interested in, or outright resisting invasive species management because of perceived costs or benefits to themselves. Participants describing these perspectives often referred to the impacts that these people were potentially having on the environment and society and stated that those folks appeared not to care. "*It's a cynical, 'I'm going to foist my costs off on society' or 'I'm going to profit at the expense of others who are going to be harmed by this'. That's what denialism is all about*" (Interview Participant, invasive species communicator).

Participants also mentioned that some stakeholders were uninterested in invasive species management because the native species they cared about had not been impact-

ed by invasive species, "I think there are some cases where stakeholders do have a single species focus and they are less concerned about the broader benefits of biodiversity and ecosystem function" (Interview participant, federal researcher). Participants also perceived some people as resistant to the idea that species required management because these people had a particular use for them, for example "*you know some of our gardening plants are not native and trying to tell someone that their pretty flower is maybe a problem is actually where I've noticed [denialism] the most*" (Interview participant, federal science advisor). In these cases, this framing of denialism again reflected a position of resistance to invasive species management due to the perceived costs of action or benefits of inaction, and so were also grouped into invasive species cynicism.

## Invasive species nihilism

"*From first-hand experience I would certainly say that there are [denialists] out there. And I think it's not even limited to non-professional stakeholders. I think it goes really across all members of society, including professionals*" (Interview participant, provincial/state government invasive species manager).

The third framing of ISD described a lack of support for invasive species research or management due to the perception that the whole endeavour was ultimately futile (Table 1). This category was described the most often, and descriptions tended to involve first-hand experiences. It included descriptions of denialism that focused on invasive species research, prevention, management, or outreach as ultimately futile, pointless, or without meaning. This was the form of denialism most frequently described by participants, and one that participants most often described having had first-hand, personal experiences of. People with this perspective were described by interview participants as approaching and informing them about the ultimate futility of their management efforts and other invasive species work in a variety of contexts.

Many saw nihilistic denialism posted to them online, saying "*I feel like we get a lot of deniers on social media. Not a ton, but like any time we post things it's like you get people that just say, 'oh just eat them' or 'who cares?', or like 'there are bigger issues out there like water pollution and water quality, why are you wasting your time and money on this?*'" (Interview participant, invasive species outreach). Many participants also described being approached in-person, saying

*I'll be at public events, and you know every once in a while, you'll have one or two people that are like 'why are we spending money on this? This is pointless, there's no point in trying, they're already here'. And so, it's not really disagreeing with the definition of invasive, or early detection rapid response, but more so in the spending of dollars, especially public dollars, on those efforts when to them, it seems futile, it seems pointless* (Interview participant, invasive species public outreach).

Those people expressing these views were described by participants as being particularly concerned with the waste of financial resources on an endeavour that they did not consider to be worthwhile.

Participants also described experiences with these types of nihilistic framings of their work not just in-person, but in professional settings, and even from colleagues. When asked about ISD, one participant responded, sadly, that they believed others perceived them to be the invasive species denialist because they continued to experience hope related to their own work, rather than believing the endeavour was hopeless. They said:

*I suppose my amount of optimism is a form of denial… I've had people approach me being like 'how on earth do you still do this work? Why do you do this? This is ridiculous! It's a waste of your time!'. I've definitely had those people during conferences, and meetings, and presentations confront me about this. And my response is, you know, I'd rather try than not. It's worth the effort. So, I guess I'm sort of a denialist in that way* (Interview participant, provincial/state government invasive species management).

This belief that others may experience them as a denialist during the course of their work in invasive species management was not limited to being told one's work was not worthwhile. Others involved in management decision-making also expressed the possibility that their views may be considered denialist by stakeholders because they did not support prioritising the detection of invasive species that were unlikely to be prevented or controlled. For example, one participant stated:

*I believe that if we don't have the resources to do anything about an invasive species, or we're not willing to do anything about an invasive species, I don't believe in putting resources into early detection. Like why bother spending resources if we're not going to do anything about it? I know that can rub people the wrong way, and I might get labelled a little bit with denialism* (Interview participant, federal government science advisor).

Again, there was a linkage made between a perception of potential waste of resources on management, and denialism. However, when this participant was asked if, resources were unlimited, would they be willing to take action to prevent every invasive species, they said that "*[m]aybe if we had all the money in the world, and we knew that it just doesn't make efficient sense, or effective sense, or it's a good use of the taxpayer dollars, we might still not address something, right?*" (Interview participant, federal science advisor).

## Engagement impacts

Interview participants all agreed that engagement with stakeholders was a priority for invasive species management. Furthermore, they all felt that stakeholder groups should not be excluded on the basis of being perceived to be denialists. However, participants also agreed that inclusion of people with different perceptions or values regarding invasive species management could act as a barrier to communication or action. To address this challenge in more detail, the focus group was asked to discuss these issues as a group. They were asked to describe and come to a consensus regarding some of the impacts of excluding folks believed to be denialists, as well as the impacts of including them in engagement and outreach. They were also asked to come up with some recommendations as a group to prevent or mitigate any of these impacts. The impacts outlined and agreed upon by the focus group can be divided into three

categories: 1) Impacts relating to the accuracy of information; 2) Impacts relating to management decisions, goals, and outcomes; and, 3) Impacts regarding representation and perceived legitimacy.

## Impacts relating to the accuracy of information

Decision-makers engage stakeholder groups in invasive species management to inform, as well as gather input about, invasive species occurrences and management practices. Focus group participants raised concerns about excluding stakeholder groups for two main reasons: that engagement might be biased and therefore lead to less effective outcomes; and second, that unique and important knowledge may be missed if some stakeholder groups are excluded. Focus group participants were particularly concerned that "*exclusion of different stakeholder groups may lead to a biased or limited representation of different values and perceptions*" in the data they gather during engagement efforts for use by decision-makers, making it less accurate and therefore less useful for effective management.

The inclusion of more diverse perspectives was conversely seen as potentially allowing for improvement in the overall information available to researchers and managers. For example, it was noted that some people seen as denialists may still have information on novel invasion pathways that could be of value to managers. Furthermore, engagement with as many people as possible was described as providing greater leverage to promote changes in behaviour and practices.

## Impacts relating to management decisions, goals, and outcomes

Participants often described outreach as potentially the only way to convince those who were opposed to management efforts of its value. Exclusion of individuals or groups without at least an initial attempt at outreach was therefore seen as generally undesirable as it could undermine the ability to meet engagement and management goals. As noted by one participant, "*[e]xcluding engagement is a problem because politicians are not going to regulate a major industry without some justification, and if the industry is not engaged with those working in [aquatic invasive species] policies, they have no incentive at all to cooperate and seek mutually agreeable solutions*".

The primary concern of people in the focus group regarding inclusion of perceived denialists in engagement efforts was that it could lead to delays in decision-making, particularly when urgent decisions and actions are necessary. There were concerns that such inclusion "*may make the process more difficult or lead to decisions that are not supported by some decision-makers*". Their inclusion was also believed to require increased time and effort as "*repeated conversations and outreach will need to take place along with the understanding that some stakeholders will never support the projec*t".

## Impacts regarding representation and perceived legitimacy

Including diverse stakeholders was repeatedly emphasised as a priority, and any exclusion was seen as a potential detriment to that. Exclusion of individuals or groups

believed to be denialists was also described as "*risking public outcry and loss of faith in the process*" of engagement. This was described not as necessarily harmful to a current management project, but potentially harmful for future attempts at engagement if it was perceived that only agreeable perspectives were included.

Because inclusion and representation of diverse stakeholders and values was seen as a priority, the inclusion of denialists was seen as an inherently positive choice, despite the aforementioned drawbacks. Some also noted the ethical importance of including all those who had been, or may be, harmed by the invader to give them the chance to learn more and prevent future harms.

## Participant recommendations

The focus group consensus was that inclusion of diverse perspectives, values, and stakeholders was a priority to them, even if those were believed to be denialists who may impede ongoing management goals. Therefore, the recommendations they provided regarding how to best proceed to mitigate potential impacts focused on those impacts resulting from the denialists' inclusion. Exclusion, at least directly from the outset, was not presented as a viable option.

### Include people trained to engage with stakeholders to facilitate engagement

This guidance was described as being important when engagement may become counterproductive, either because participants are not actually interested in invasive species management, or they are against management entirely. It was emphasised that "*mitigating this type of issue can be helped with a strong chairperson during the engagement process overall. Having participant guiding principles, similar to the Canadian Science Advisory Secretariat, helps the chair point to unproductive conversations*". The use of a facilitator could also potentially ease the emotional burdens placed on the practitioners facing nihilistic comments regarding their careers or values by having a third party take on that responsibility.

### Provide clear, balanced information

This was viewed as particularly important for those considered denialists due to their disbelief in the existence of invasive species, or invasive species science. A scepticism toward invasive species science or researchers was described as stemming from hearing 'one-sided' information from science communicators. As explained by one participant

The best way to engage individuals who do not tend to agree with prevention or other management of aquatic invasive species [AIS] is to show examples of situations where AIS have led to important (i.e., damaging) ecological or social outcomes. To ensure credibility and avoid the 'sky is falling' mentality, these should also be countered with situations where AIS have not led to extreme impacts, which ensures that objectivity is retained.

This was seen as improving credibility of the communicator, and potentially allowing sceptical participants to be convinced.

In addition, this guidance was also viewed as important for those who lacked an understanding of invasive species science, or management limitations or costs. Rather than asking those who may not be informed on this topic, participants noted that "*effective engagement needs to be done with a series of structured management options that clearly lay out potential management targets, their costs (ecological and economic), and related uncertainties, which is a very large undertaking*". This was described as useful for allowing stakeholders to understand the goals and limitations of management, and to make choices that are possible to implement. They also emphasised that communicators "*should also ensure that balanced information makes it clear that invasive species management may fail (i.e., management success is not a certain outcome, and we have to be cognizant of this possibility when committing resources and seeking stakeholder support)*". Ensuring that participants are aware that success is not guaranteed also enables them to be better informed and make realistic decisions.

### Know when to move on

It was noted that breakdowns in communication can occur for a variety of reasons, including resistance due to holding denialist positions. It was therefore noted that "*there are times when you need to accept that, for whatever reason, the stakeholders aren't ready to hear what you have to say or to move forward on a project. Best to reduce engagement and, perhaps, bring in others to try a different strategy*", and that "*the manager might have to accept that he/she can never 'adjust' all stakeholder expectations.*" Focus group participants noted that they had an ethical responsibility to represent all members of the community they were serving, and that if the majority of folks were wishing to proceed with urgent management action, it would not be ethical to prevent that through continued engagement with folks who would not be convinced. Rather, it was recommended to move on without the denialists in the interim and try to reach out to them again at a later date, when urgent action was no longer required.

## Discussion

This study has explored the meanings of ISD and its implications for invasive species engagement and management. ISD has been shown to have a greater variety of meanings and implications than previously explored in the literature. While the research literature has previously discussed the framing of ISD as being a lack of understanding of invasive species science, invasive species cynicism and invasive species nihilism are arguably the most important for practitioners to understand. The latter were reported far more often than views perceived as simply anti-scientific and with more potentially complex impacts on engagement effectiveness and management outcomes. An understanding of these ISD framings, particularly of the importance of cynicism and nihilism in an ISD context, are therefore integral to stakeholder communication and engagement efforts.

## Why is it important how invasive species denialism is framed?

The invasive species literature has mostly focused on discussing the existence and implications of invasive species denialism as a form of science denialism. Our results suggest that this view is an oversimplification with potential negative impacts on stakeholder engagement and invasive species management communication.

General descriptions of denialists as anti-science do not address those people who question invasive species based on public spending or on the likelihood of success/failure of attempts to manage invasive species. All too often, academic technical experts interpret invasive species management as the operationalization of a scientific understanding of the risks and solutions to invasive species. Our results suggest that other views about invasive species are tied to questioning societal prioritisation of environmental protection, spending of public funds, and perceptions of the overall effectiveness of management practices. Such views cannot simply be described as "science denialist" as their objections are not solely about the science of invasive species. Rather, often these views are concerned with policy implications and socio-economic impacts, constituting societal domains of concern which are legitimate grounds for questioning.

Generalisations appear to serve a rhetorical purpose of dismissal of contrarian views, something which was of some concern to at least one interview participant. This dismissal has the potential for biasing engagement efforts, or of omitting important input from the engagement process and resulting decision-making. It is notable that when exploring their understanding of ISD, participant descriptions of a person who lacks understanding of science were generalised and hypothetical, rather than an actual experience. Conversely, discussions of ISD that fit within the cynicism or nihilism frameworks were often of specific people or groups, rooted in first-hand experience. This suggests two things: the idea of the contrarian science denialist appears more widespread than the denialists themselves; and, denialism rooted in cynicism and nihilism appears to be a more immediate concern, particularly given participants' concerns with potential impacts on those forms of ISD for future management and outreach efforts. In both cases, a more nuanced view enables decision-makers and science communicators to better hone their communication strategies and engagement processes.

While the first framing described as invasive species denialism reflects the viewpoints commonly described in the invasion ecology literature of individuals or groups who do not accept invasive species science, the existence of other framings, i.e., cynicism and nihilism in ISD, is an important finding. Previous published work regarding ISD has often framed it as rejecting invasive species science for contrarian reasons (Russell and Blackburn 2017; Ricciardi and Ryan 2018a, 2018b). We have teased apart these as different aspects of ISD to show that these facets are not always seen together, or in every case. Individuals who were described as not believing in invasive species, or believing that we should not intervene because invasive species are natural, were not described in the same way as individuals who did not care about their local ecosystem, or who were perceived to be foisting their costs onto others. Our results also explored a form of ISD rooted in perceptions of futility not captured in descriptions of those who are denialists

to be cynical or contrarian. We have increased the resolution at which we can examine ISD, as described by those involved in invasive species management and engagement.

This will better enable both researchers and practitioners to better understand the potential meanings that these terms may hold to those they communicate with, as well as to consider how the impacts of ISD on their work may differ depending on the framing being employed. For example, outreach devoted to public education must take time to determine precisely whether the community is open to education, and what exactly they need to be educated about. For example, education devoted to defining invasive species will not be as useful for convincing a laker stakeholder who already knows what invasive species are that lakers are partly responsible for the transport and spread of invasive species.

## 'Opening up' and 'closing down': potential responses to cynicism

Cynicism is a broader societal problem and invasive species management must give careful thought on how to handle this issue. On the one hand, there is a need to 'open up' engagement to diverse views, including cynics, because it enables us to produce more accurate science that is seen as legitimate, accountable, and allowing for social empowerment (Stirling 2008). On the other hand, there is a need to 'close-down' engagement with cynics once the basis for their views is understood, discussed, and considered within an expansive view of the values and priorities held by others.

Cynicism or apathy in climate denialism has been previously described not as linked to a lack of scientific understanding, but to a culture of denialism where those who benefit ignore the problem because "we don't really want to know" (Norgaard 2006). Participants in this study also differentiated between those expressing cynicism toward management and those who did not understand or believe the science. Much of invasion science practices and recommendations are rooted not in objective data, but in subjective, normative values (Munro et al. 2019; Latombe et al. 2022). The fact that one's values may lead one to ignore the problem of invasive species for cynical gain means that conventional outreach and engagement, which tend to focus on education about invasive species science, may not be sufficient to change behaviours. Rather, if encountering invasive species cynicism, outreach may need to pivot to focus on the way that invasive species may impact particular values. However, if indeed some people 'don't really want to know', it may be best to 'move on' as recommended by the focus group participants.

## The Janus face of nihilism

Nihilism can lead to reflexivity and empathy for views that question the feasibility of effectively controlling invasive species. Take the example of Sea Lamprey. Management of Sea Lamprey has been touted as "a remarkable success" and "tremendously successful" (GLFC 2014; DFO 2018), yet at the same time eliminating Sea Lamprey is described as "impossible" to the extent that management cannot be relaxed for "even a short time" in the same publications. There is reason to question our ability to fully prevent new invasive species, and what resistance to management really means, not because of a lack of science, but because of limited resources and different perceptions and evaluations of risks and impacts.

On the other hand, nihilism can become debilitating for action when action is needed, feasible and desired. It can also impact managers' ability to do their work. Invasive species nihilism should be particularly concerning to those involved in invasive species work in that it was experienced by participants in their workplaces and was expressed toward them not only from the public, but also from colleagues. Research into workplace wellbeing has shown a connection between perceptions of one's work as meaningless with experiences of alienation, emotional exhaustion, and burnout (Bailey and Madden 2019). While research has been conducted on the impacts of emotional exhaustion in fields such as health care (Meltzer and Huckabay 2004), the emotional labour cost of those in the invasive species community confronted with nihilistic comments on a regular basis about their work remains unexplored. More research is needed to fully measure and comprehend the impacts of invasive species nihilism on invasive species practitioners and their work. This research is needed due to the prevalence of this form of ISD being experienced by participants during the course of their work, and the potential for the impacts of emotional exhaustion or burnout affecting practitioners' ability to manage invasive species or engage with stakeholders.

Nihilism is often expressed as something being a waste; a waste of resources, a waste of effort, a waste of time. Some of our participants expressed that, even were resources unlimited, they would still not support management of every invasive species in the region. This suggests that it is not solely the limited nature of what is being wasted, which is the underpinning concern for this form of denialism, but rather the concept of waste itself; the perception that the effort of management is, at least in some cases, itself wasteful and therefore not worth doing, even if what is being wasted were unlimited. This idea of invasive species research and management being perceived as a type of inherent waste should be examined further, particularly as it may relate to inaction or resistance to other types of environmental research and management.

## Strengths and limitations

This research has delved deeper into the growing and controversial topic of invasive species denialism. To our knowledge, this is the first study to include Great Lakes community members to determine what the term "invasive species denialism" means to them, and how it is being used by decision-makers or practitioners in the field. Our results have shown that ISD is a term with different meanings with different connotations. As a result, we have also shown that the implications of different types of ISD, and the appropriate responses to each, differ as well. This research will contribute to growing efforts to better understand the topic of ISD and provide solid strategies to outreach and engagement professionals encountering different framings of ISD during their work. More in-depth research is needed into how each of these different framings specifically impact management, engagement, and policy in order to craft more finely tuned recommendations for specific situations. We hope that our research has contributed to those future efforts by enabling the identification of these different framings and providing general strategies to build upon.

This research was conducted amongst members of the aquatic invasive species community of the Great Lakes basin. Therefore, it is unclear whether the framings of

ISD employed by participants are due to a unique perspective of people in this region, or whether they can be generalised to the overall invasive species community. More research should be conducted specifically exploring the ways that other communities describe the phenomena of ISD and its impacts to determine how widespread are these framings, particularly that of invasive species nihilism, due to its novelty.

## Conclusions

Familiarity with the framings of ISD are important both to understand the values and motivations that drive those who espouse views perceived as denialist, as well as to clarify how these individuals are either understood or dismissed in the environmental decision-making process. An understanding of these framings is also vital to respond to instances of ISD appropriately. Whether we are being confronted with anti-science contrarianism, environmental cynicism, or outbursts of nihilism, should rightly inform our responses and our strategies to counter these positions.

Future research should examine the topic of invasive species nihilism in greater detail. It is currently unknown how pervasive this phenomenon is in the broader invasive species community and among the public. It is also currently unknown what the impacts of exposure to these nihilistic framings of their work may be on those involved in invasive species research and management. An awareness of those impacts will help us to better understand the role of ISD in invasive species communication and engagement.

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## References

Bailey C, Madden A (2019) "We're not scum, we're human": Agential responses in the face of meaningless work. Scandinavian Journal of Management 35(4): e101064. https://doi.org/10.1016/j.scaman.2019.101064

Björnberg KE, Karlsson M, Gilek M, Hansson SO (2017) Climate and environmental science denial: A review of the scientific literature published in 1990–2015. Journal of Cleaner Production 167: 229–241. https://doi.org/10.1016/j.jclepro.2017.08.066

Braun V, Clarke V (2006) Using thematic analysis in psychology. Qualitative Research in Psychology 3(2): 77–101. https://doi.org/10.1191/1478088706qp063oa

Braun V, Clarke V (2021) One size fits all? What counts as quality practice in (reflexive) thematic analysis? Qualitative Research in Psychology 18(3): 328–352. https://doi.org/10.1080/14780887.2020.1769238

Brulle RJ (2020) Denialism: organized opposition to climate change action in the United States. In: Konisky M (Ed.) Handbook of US Environmental Policy. Edward Elgar Publishing, Cheltenham, 328–341. https://doi.org/10.4337/9781788972840.00033

Carter L, Mankad A, Zhang A, Curnock MI, Pollard CR (2021) A multidimensional framework to inform stakeholder engagement in the science and management of invasive and pest animal species. Biological Invasions 23(2): 625–640. https://doi.org/10.1007/s10530-020-02391-6

Cole ZD, Donohoe HM, Stellefson ML (2013) Internet-based Delphi research: Case based discussion. Environmental Management 51(3): 511–523. https://doi.org/10.1007/s00267-012-0005-5

Crowley SL, Hinchliffe S, McDonald RA (2017) Conflict in invasive species management. Frontiers in Ecology and the Environment 15(3): 133–141. https://doi.org/10.1002/fee.1471

Diethelm P, McKee M (2009) Denialism: What is it and how should scientists respond? European Journal of Public Health 19(1): 2–4. https://doi.org/10.1093/eurpub/ckn139

DFO [Fisheries and Oceans Canada] (2018) Sea Lamprey: The battle continues to protect our Great Lakes fishery. https://www.dfo-mpo.gc.ca/species-especes/publications/ais-eae/lamprey-lamproie/index-eng.html

Frank DM (2021) Disagreement or denialism? "Invasive species denialism" and ethical disagreement in science. Synthese 198(S25): 6085–6113. https://doi.org/10.1007/s11229-019-02259-w

Golebie EJ, van Riper CJ, Arlinghaus R, Gaddy M, Jang S, Kochalski S, Lu Y, Olden JD, Stedman R, Suski C (2022) Words matter: A systematic review of communication in non-native aquatic species literature. NeoBiota 74: 1–28. https://doi.org/10.3897/neobiota.74.79942

GLFC [Great Lakes Fisheries Commission] (2014) Sea Lamprey control in the Great Lakes: A remarkable success!. http://www.glfc.org/pubs/factsheets/FACT%205_all.pdf

Hansson SO (2017) Science denial as a form of pseudoscience. Studies in History and Philosophy of Science 63: 39–47. https://doi.org/10.1016/j.shpsa.2017.05.002

Hennink M, Kaiser BN (2022) Sample sizes for saturation in qualitative research: A systematic review of empirical tests. Social Science & Medicine 292: 114523. https://doi.org/10.1016/j.socscimed.2021.114523

Janovsky RM, Larson ER (2019) Does invasive species research use more militaristic language than other ecology and conservation biology literature? NeoBiota 44: 27–38. https://doi.org/10.3897/neobiota.44.32925

Larson BM (2005) The war of the roses: Demilitarizing invasion biology. Frontiers in Ecology and the Environment 3(9): 495–500. https://doi.org/10.1890/1540-9295(2005)003[0495:TWOTRD]2.0.CO;2

Latombe G, Lenzner B, Schertler A, Dullinger S, Glaser M, Jarić I, Pauchard A, Wilson JRU, Essl F (2022) What is valued in conservation? A framework to compare ethical perspectives. NeoBiota 72: 45–80. https://doi.org/10.3897/neobiota.72.79070

McKenna SA, Main DS (2013) The role and influence of key informants in community-engaged research: A critical perspective. Action Research 11(2): 113–124. https://doi.org/10.1177/1476750312473342

Meltzer LS, Huckabay LM (2004) Critical care nurses' perceptions of futile care and its effect on burnout. American Journal of Critical Care 13(3): 202–208. https://doi.org/10.4037/ajcc2004.13.3.202

Momentive Inc (2018) SurveyMonkey. Mome-ntive Inc., San Mateo, California, USA. https://www.momentive.ai

Munro D, Steer J, Linklater W (2019) On allegations of invasive species denialism. Conservation Biology 33(4): 797–802. https://doi.org/10.1111/cobi.13278

Norgaard KM (2006) "We don't really want to know" environmental justice and socially organized denial of global warming in Norway. Organization & Environment 19(3): 347–370. https://doi.org/10.1177/1086026606292571

QSR International Pty Ltd (2018) NVivo (Version 12). https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home

Ricciardi A, Ryan R (2018a) The exponential growth of invasive species denialism. Biological Invasions 20(3): 549–553. https://doi.org/10.1007/s10530-017-1561-7

Ricciardi A, Ryan R (2018b) Invasive species denialism revisited: Response to Sagoff. Biological Invasions 20(10): 2731–2738. https://doi.org/10.1007/s10530-018-1753-9

Russell JC, Blackburn TM (2017) The rise of invasive species denialism. Trends in Ecology & Evolution 32(1): 3–6. https://doi.org/10.1016/j.tree.2016.10.012

Sagoff M (2018) Invasive species denialism: A reply to Ricciardi and Ryan. Biological Invasions 20(10): 2723–2729. https://doi.org/10.1007/s10530-018-1752-x

Sagoff M (2020) Fact and value in invasion biology. Conservation Biology 34(3): 581–588. https://doi.org/10.1111/cobi.13440

Samson E, Hirsch PE, Palmer SC, Behrens JW, Brodin T, Travis JM (2017) Early engagement of stakeholders with individual-based modelling can inform research for improving invasive species management: The round goby as a case study. Frontiers in Ecology and Evolution 5: 149. https://doi.org/10.3389/fevo.2017.00149

Shackleton RT, Adriaens T, Brundu G, Dehnen-Schmutz K, Estévez RA, Fried J, Larson BMH, Liu S, Marchante E, Marchante H, Moshobane MC, Novoa A, Reed M, Richardson DM (2019) Stakeholder engagement in the study and management of invasive alien species. Journal of Environmental Management 229: 88–101. https://doi.org/10.1016/j.jenvman.2018.04.044

Stirling A (2008) "Opening up" and "closing down" power, participation, and pluralism in the social appraisal of technology. Science, Technology, & Human Values 33(2): 262–294. https://doi.org/10.1177/0162243907311265

Taylor L (2020) Covid-19: How denialism led Mexico's disastrous pandemic control effort. BMJ (Clinical Research Ed.) 371: m4952. https://doi.org/10.1136/bmj.m4952