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Shifting the language of ‘invasion’ ecology: two-eyed seeing as a framework for discourse regarding introduced species

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PERSPECTIVE ESSAY

Shifting the language of 'invasion' ecology: two-eyed seeing as a framework for discourse regarding introduced species

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Abstract
Discourse used in the field of invasion ecology has significant impacts on society's perception, yet communication related to "invasives" is rife with problematic, exclusionary language. We provide potential solutions, including a repositioned perspective that may facilitate better relationships with the natural world by applying the two-eyed seeing framework. Our discussion calls for a paradigm shift for deeper understandings of human and more-than-human relationships. Ultimately, we advocate for respectful, considerate, and intentional language and stewardship.

Keywords Indigenous knowledge · Invasive species · Science–society discourse · Two-eyed seeing

1 Introduction

Human activity across our planet has led to the introduction and spread of innumerable species beyond their historical ranges. Both directly and indirectly, introduced species have resulted in significant ecosystem change and devastating ecological (and economic) loss in North America and globally (Reo et al. 2017). For reference, an article by Angulo et al. (2021, pp. 3, 5) gives an estimate of the global economic impact of introduced species totaling in the trillions of dollars (USD). As the Anthropocene continues, repercussions become ever more apparent (Larson et al. 2005). Anthropogenic impacts, such as climate change and globalization of trade, are influencing species range shifts in ways not yet fully understood, which makes the study and management of introduced species challenging and uncertain (Inglis 2020). Moreover, there is often a disconnect between scientific and public discourse concerning environmental issues. Effective management of problematic species is dependent on both environmental and social factors (Lakoff 2010; Schüttler et al. 2011). We assert that with time-sensitive issues that require urgent action, such as introduced species and their related discourse, building effective communication is key to engaging the public, creating diverse, multi-scaled resolution options, and motivating effective action (Lakoff 2010).

The language used to describe introduced species can have significant impacts on public perception and often does little to bridge the gap between academic and public spheres (e.g. Cameron et al. 2013; Cheng et al. 2023; Reid et al. 2021). As in many scientific fields, discussion of introduced species in natural resource management, and the literature used to inform it, is shaped by Western colonial ideology and dominated by aggressive, militaristic, and xenophobic language that implies intent on the part of the organisms (e.g. Carson 1962; Elton 1958). This language shifts responsibility away from humans and enforces a negative relationship with these species that become the "enemy" (Inglis 2020; Reo and Ogden 2018). This mindset, which is normalized in Western scientific ideology, degrades our relationship with the natural world and our more-than-human kin (Gibbs et al. 2015; Larson et al. 2005). Although out of place, these organisms are themselves living beings. Humans hold primary responsibility for displacing them and it is important to remember that we are environmental

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stewards and acknowledge their impacts within new environments by being conscientious and informed in creating solutions that are both respectful and effective in monitoring, mitigating, and minimizing impacts (Bach and Larson 2017; Inglis 2020).

In this article, we, from the perspectives of an applied ecologist, an environmental policy scholar, and a forest health management scholar, deconstruct the language used in scientific discourse to discuss introduced organisms. In particular, we focus on organisms considered ecologically problematic and examine how language regarding these species impacts scientific communication, public perception, management practices, and the way we interact with and relate to the natural world. Then, we explore potential solutions that can allow us to build better relationships with and within the ecosystems of which we are a part (Fig. 1). Two-eyed seeing is one way of knowing and understanding that we explore to begin to reframe this narrative. This is the conceptual framework through which we will be exploring and proposing alternative ways of approaching invasion

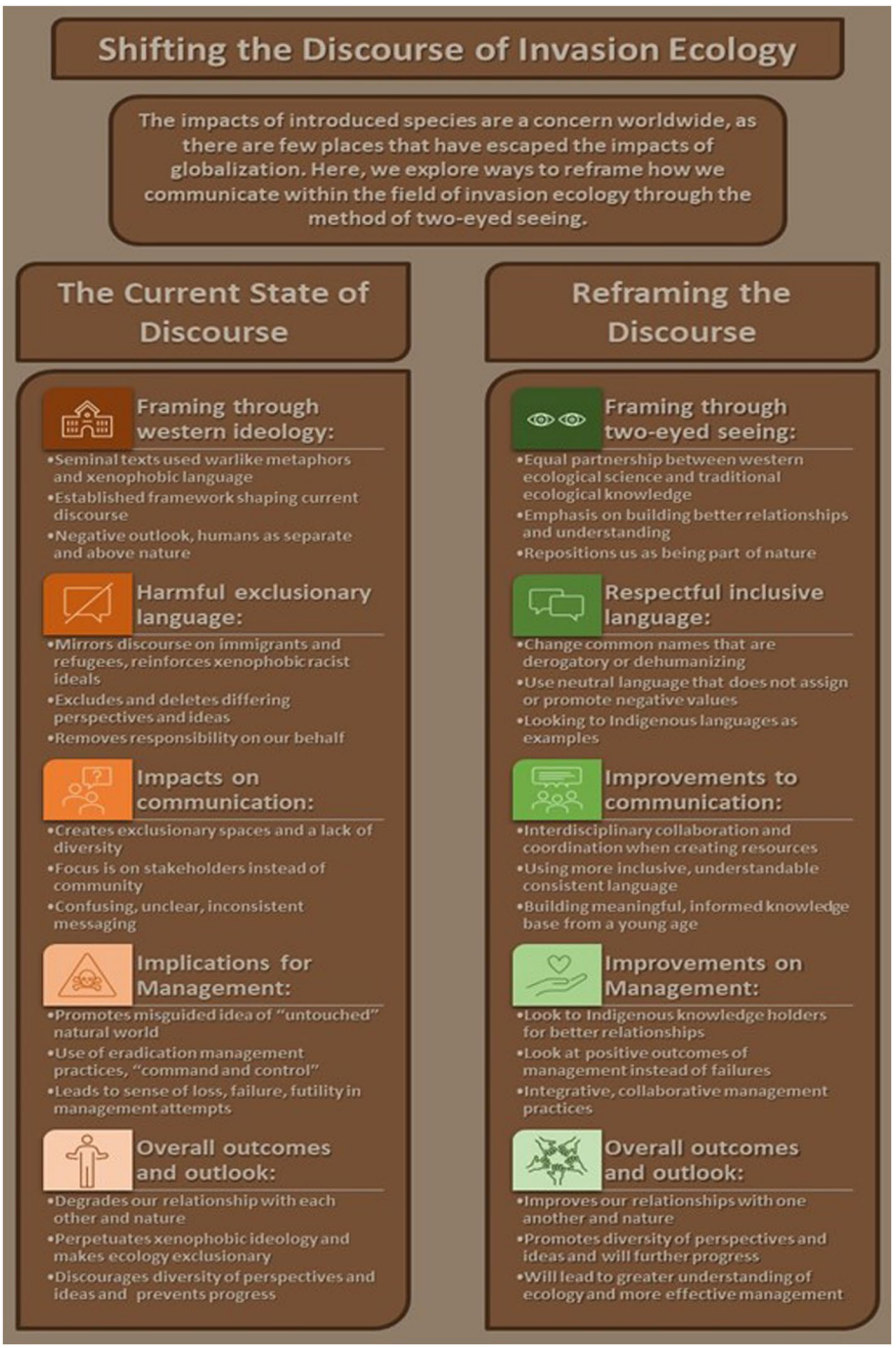

Fig. 1 An infographic summary of the comparison between the current state of discourse regarding the field of invasion ecology and recommended reframing of perspectives and discourse through two-eyed seeing

ecology discourse. Ultimately, we are not arguing for less research, management, mitigation, or restoration regarding introduced species. Rather, we call for a perspective shift that leads to deeper understanding so humans may act more effectively and use messaging that resonates with a wider audience, with the goal of improving management and the related discourse on introduced species to allow for more respectful, considerate, and intentional stewardship.

2 The current framing of discourse in the field of invasion ecology

To understand the current state of discourse on invasive species management, we need to acknowledge the existing framing around it, both in public and academic spheres (Larson et al. 2005). When we say the word "invasive," we incite a framework of ideas and concepts that has been constructed over the course of decades. Repeated exposure to language and ideology strengthens associations and framing, causing the dominant discourse to become reified in our neural systems (Lakoff 2010). From the very beginning, the field of invasion ecology was established through the use of militaristic language and metaphor (Inglis 2020; Larson et al. 2005). Use of war metaphors can be traced back to the foundational book on invasion ecology, *The Ecology of Invasions by Animals and Plants* by Charles S. Elton in 1958, which is considered a seminal work in the field and led to invasive species garnering more attention from the scientific community (Elton 1958; Lowry et al. 2013). The field of invasion ecology has been growing since, experiencing a surge in published literature in the late 1990s and continuing strong today (Lowry et al. 2013). Even Rachel Carson's famous book *Silent Spring* (Carson 1962), a formative text for many ecologists, uses militaristic language, further cementing this framing of discourse on the topic of environmental issues like introduced species (Larson et al. 2005). This language now permeates all levels of invasive species discourse, from scientific literature and communication, to policy and legislation, to public forums, and so forth. Subsequently, introduced species have become synonymous with negative language (Greenhalgh-Spencer 2019; Inglis 2020).

2.1 Consequences of harmful, exclusionary language

The words and phrases used in the field of invasion ecology perhaps communicate more about humans than about the organisms we discuss. Language used to discuss introduced species often mirrors language that has been used throughout history in discussions about topics like immigration and racism to refer to people that are considered undesirable, alien, or otherwise other (Anderson 2017; Cheng et al. 2023; Lancette 2021). For example, immigrants and refugees are regularly equated with organisms we consider pests using metaphorical language in an attempt to create fear and animosity; this draws on the Western idea that non-human beings are lesser and must be controlled or even exterminated, reinforcing the narrative that immigrants and refugees should be treated in the same way (e.g., consider the use of pesticides and herbicides, such as Zyklon B and Agent Orange, on both human and non-human beings) (Anderson 2017; Inglis 2020; Lancette 2021; Shinozuka 2013). Additionally, the xenophobic, militaristic language used in invasion ecology saw a similar exacerbation as the discourse regarding immigrants after 9/11, as invasive species began to be referred to as "terrorists" as well (Druschke et al. 2016, p. 2740; Larson et al. 2005, p. 248).

The perceived value of a species, or lack thereof, shapes and informs management actions and reflects the biases and expectations of those in charge of making management decisions (Bhattacharyya and Larson 2014; Inglis 2020). Economic impact is at the forefront of both arguments, with significant attention given to the threat of financial loss and the rhetoric that immigrants and introduced species both take and use up resources that are considered entitled to the existing occupants of a place (Anderson 2017). This ideology creates an "us vs. them" mentality, where the lives of "our own" (local or familiar species) are given more value than the lives of the "invaders," thus justifying violence and taking of life to preserve life we deem more valuable (Anderson 2017; Greenhalgh-Spencer 2019; Inglis 2020; Larson et al. 2005). This creates a harmful dichotomy of who belongs and who does not, as opposed to a conversation of how to better understand the complex issues at hand and work to remedy them in a respectful, equitable, effective way (Cheng et al. 2023; Gibbs et al. 2015).

This is further exemplified in the use of place-based common names when referring to introduced species. While it is true that common names serve an important purpose, especially when it comes to communication and education, associating an organism with a place of origin, especially when the species is considered invasive, incites xenophobic and racist sentiments (Lancette 2021). Members of marginalized groups, particularly BIPOC individuals, have expressed that the language used in the field of invasion ecology is reminiscent of the "go back to where you came from" mentality with which they themselves have been treated (Cheng et al. 2023). For example, jumping worms in the genus *Amynthas* (specifically the species *Amynthas agrestis*) are commonly referred to as Asian jumping worms. Much like what happened in previous decades with the discourse surrounding the commonly named Japanese beetle (*Popillia japonica*), when these worms are regularly associated with the words "invasive," "threat," "destructive,"

and so on, the moniker of "Asian" draws on xenophobic and racist stereotypes and ideals regarding Asian people that have existed for well over a century within Western society (Shinozuka 2013). The word "exotic" also poses issues, as it is associated with the dehumanization and commodification of BIPOC communities (Cheng et al. 2023). Ultimately, the process of dehumanization, separation, and othering serves to detach us from the repercussions of injustices, atrocities, and violence committed against living beings, both human and more-than-human (Anderson 2017; Lancette 2021).

2.2 Implications for education and outreach communication

The language of invasion ecology is not conducive to creating an inclusive environment for marginalized groups, and may actually ostracize them by using xenophobic and racist language that they may have experienced used against them (Cheng et al. 2023). This can act as a deterrent to diversity, restricting who has access to scientific spaces and excluding differing perspectives and ideas (Lancette 2021; Schüttler et al. 2011). Terminology used within the field is also messy; many terms have vague and ambiguous definitions and may incorrectly be used interchangeably, which leads to unclear, confusing messaging (Cheng et al. 2023; Iannone et al. 2020; Inglis 2020). Some terms are specific to legislation, such as the term "noxious weed," while others are frequently used in outreach but are incorrect or misleading, such as "native invasive" (Iannone et al. 2020, p. 9). There is also often a lack of coordination between educators, academics, policy-makers, and industry professionals on what terminology to use (Verbrugge et al. 2021). Overall, education and outreach have fallen short in effectively reaching the public sphere, which has contributed to the importance of media in filling that role.

Mass media plays a crucial role in bridging the gap between academic and public spheres when it comes to communicating scientific issues (Larson et al. 2005). This comes at the cost of neutrality, however, as there is pressure for media industries to garner attention through views, clicks, and engagement that leads to the messages being sensationalized for attention (Anderson 2017). This is especially evident when it comes to reporting on introduced species. Using emotional, fear-inducing language is an effective way to grab viewers' attention (Inglis 2020; Larson et al. 2005). This is also true on the part of the scientists and organizations that are communicating information to the public, as those that act as mouthpieces in a scientific story need to provide newsworthy material that will benefit media partners (Bach and Larson 2017). To get public stakeholders involved in management, it is necessary to not only have their attention and interest, but also to spur action (Iannone et al. 2020; Verbrugge et al. 2021).

Education and outreach are essential when it comes to crisis disciplines like climate change and the management of introduced species, as humans are at the core of the issue and changes in our behavior are the basis of the solution (Bach and Larson 2017; Verbrugge et al. 2021). While education-based communication would be the most effective long-term and highly beneficial for building an environmentally conscious society, using sensationalism and fearmongering is often the most effective way to motivate immediate action (Druschke et al. 2016). Ultimately, the language used by those within the scientific sphere shapes and informs policy, management, future research, and scientific communication, which in turn shapes public opinion, creating a self-perpetuating feedback loop (Druschke et al. 2016; Larson et al. 2005).

2.3 Implications for science, policy, and management

Reflecting the mindset that humans are above and separate from the rest of the natural world, people are sometimes excluded from the narrative of invasion ecology, ignoring or even omitting human involvement in the movement of organisms, despite being at the core of the process (Gibbs et al. 2015; Inglis 2020; Reid et al. 2021). Subsequently, the current state of invasive species discourse in Western science is intrinsically anthropocentric and prevents us from seeing beyond the immediate negative impacts of introduced species, particularly when we only focus on the implications for human interests (e.g. economy, human health, etc.) (Anderson 2017; Gibbs et al. 2015; Inglis 2020). This disconnect between humans and the environment can stifle the responsibility to care for and live in cooperation with the natural world. It can also lead to the idea that people have power over the environment and can, or should, manage it for our benefit, contributing to "command and control" management regimes (Inglis 2020; Lakoff 2010; Reo and Ogden 2018).

These attitudes impact management and policy and can be seen in the way we perceive and manage introduced species. People often place responsibility on the organism, implying malicious intent on their part, despite being the force that acted to displace them (Bach and Larson 2017; Gibbs et al. 2015; Inglis 2020). Additionally, Western science often views nature as fragile and static, espousing an impression of helpless victimhood, and subsequently treats and manages it as such, holding onto a notion of "untouched nature" and the "wild" (Larson et al. 2005; Reid et al. 2021). This idea that people are detached saviors that must maintain nature as a pre-human condition, while well-intentioned, is unrealistic and problematic. This also relates back to the idea of ecosystems that we view as "our own" being under attack from "foreign invaders" discussed earlier (Anderson 2017; Inglis 2020). As a result, this leads to invasive species

management regimes focused on eradication, evoking the mindset of "waging war" that pervades invasion ecology (Inglis 2020; Larson et al. 2005).

Novel ecosystems, and the transitional processes within them, have come to represent human failure, where the perception is that native ecosystems have been lost due to the inability of humans to save them (Gibbs et al. 2015). There is an inherent sense of futility and failure when "fighting a losing battle" against an introduced species (Bach and Larson 2017). Unfortunately, invasive species management is resource-intensive and expensive, and funding typically hinges on the establishment of an economic impact; i.e., resources are only allotted to management of introduced species when there is a proven economic benefit, or a threat of significant loss. Because of this, the focus for much of education and outreach in the field is communicating with stakeholders (Iannone et al. 2020).

These factors contribute to the degradation of human relationships with each other and with the natural world. The ideology that humans are separate from and above all other beings in the natural world has become normalized and embedded in the way Western society thinks and behaves, and it is difficult for many to consider that alternative ways of relating to nature even exist (Greenhalgh-Spencer 2019; Reo and Ogden 2018). Challenging the dominant dialogue and attempting to deconstruct and reconstruct the framing surrounding a topic is not an easy task, especially when presenting new information and new issues, but it is not impossible (Lakoff 2010), a fact often overlooked. In the final section, we will explore new ways to approach the discussion and management of introduced species using more respectful, considerate, and intentional practices.

3 Reframing discourse on introduced species through two-eyed seeing

To reframe discourse associated with introduced species, we suggest transitioning to multi-perspective approaches for communication and management that also seek to build better relationships with the natural world (Gibbs et al. 2015). Changes in the way we perceive and discuss introduced species requires a shift to a holistic, integrative mindset that prioritizes collaboration and communication between disciplines, knowledge systems, and communities. We believe such changes have potential to contribute to the creation of novel policies that result in improved management strategies (Druschke et al. 2016). In what follows, our discussion is framed through the two-eyed seeing approach, with the goal of proposing an alternative framework for the study, teaching, communication, and management of introduced species that will ultimately facilitate discourse that is inclusive of diverse ways of knowing and communities, as well as support beneficial ecosystem management across disciplines (Reid et al. 2021).

Importantly, a multi-perspective shift would promote equitable additions of traditional Indigenous knowledge systems alongside Western scientific knowledge in the discourse regarding introduced species (Table 1 and Fig. 1). This would serve to address long-standing power dynamics that prioritize Western science above alternative bodies of knowledge (Bartlett et al. 2012). We acknowledge the plurality of knowing and understanding the world and recognize that a practice of knowledge coexistence and complementarity supersedes one of integration or incorporation (Reid et al. 2021). There is a growing body of literature discussing the concept of two-eyed seeing and other ways of knowing related to traditional ecological knowledge (e.g. Broadhead and Howard 2021). For example, further descriptions of commonalities and differences and how Indigenous worldviews offer a shift in perspectives for ecological discourse can be found in Chapin et al (2013), regarding traditional knowledge in Alaskan ecosystems. Indigenous worldviews are not monolithic and should be respected with individual integrity (e.g. Kimmerer 2013; Waasegiizhig Price 2023, pp. 2, 18). There are, however, shared common traits, values, and processes that occur widely across Indigenous knowledge systems, such as interconnectedness, reciprocity, and relationship-building (Reid et al. 2021; Shaw et al. 2023). Thus, we propose two-eyed seeing as a good framework to benefit the study, management, and discourse associated with introduced species.

Two-eyed seeing is an illustrative way to describe an approach that metaphorically uses one eye to view the world through an Indigenous knowledge system approach while using the other eye to view through the Western knowledge system (Reid et al. 2021). In the case of introduced species, Western and Indigenous sciences are not mutually exclusive. Both sciences are valuable, neither are superior, and each has unique strengths to contribute to the other (Shaw et al. 2023). In partnership, each supports and strengthens a holistic approach so that collaborative, novel solutions can be applied to contemporary ecological challenges (Reo et al. 2017). For Indigenous communities, traditional knowledge systems include ways of knowing and being as everyday relations and seasonal practices with lands, waters, foods, medicines, and much more (Salmon 2000).

In contrast to Western ideals, Indigenous ways of knowing acknowledge human positionality as part of the natural world. As part of natural systems, humans seek to sustain honorable relationships, live in kinship with the more-than-human beings with which we share environs, and work in partnership with others to maintain healthy ecosystems for future generations (Bhattacharyya and Larson 2014; Horn et al. 2021; Reid et al. 2021). Two-eyed seeing implores action, inspiring applications of new knowledge

Table 1 Example comparisons of the discourse between the ways two knowledge systems, Western Ecological Knowledge and Traditional Ecological Knowledge, often approach the subject of introduced species and invasion ecology

	Western Ecological Knowledge (WEK)	Traditional Ecological Knowledge (TEK)
Framing	Seminal texts often use war-like metaphors and xenophobic language Established framework shaping current discourse Negative outlook, humans as separate and above nature	Equal partnership between WEK and TEK Emphasis on building better relationships and understanding Repositions humans as being part of nature
Language	Uses more harmful, exclusionary language Mirrors discourse on immigrants and refuges Excludes and deletes differing perspectives and ideas Removes responsibility on our behalf	Uses more respectful inclusive language Promotes change of common names that are derogatory or dehumanizing Use neutral language that does not assign or promote negative value Looking to Indigenous languages as examples
Communication	Creates exclusionary spaces and a lack of diversity Focus is often on stakeholders instead of community Confusing, unclear, inconsistent messaging	Interdisciplinary collaboration and coordination when creating resources Using more inclusive, understandable consistent language Building meaningful, informed knowledge base from a young age
Management	Promotes misguided idea of "untouched" natural world Use of eradication management practices, "command and control" Leads to sense of loss, failure, futility in management attempts	Look to Indigenous knowledge holders for better relationships Look at positive outcomes of management instead of failures Integrative, collaborative management practices
Overall Outlook	Degrades our relationship with each other and nature Perpetuates xenophobic ideology and makes ecology exclusionary Discourages diversity of perspectives and ideas and prevents progress	Improves our relationship with one another and nature Promotes diversity of perspectives and ideas to further progress Will lead to greater understanding of ecology and more effective management

in ways that value diversity and equity while upholding connection and relationship (Reid et al. 2021). Such values prioritize respectful, inclusive language to inform enhanced practices in education, communication, and management of ecosystems where introduced species reside.

3.1 Transitioning to respectful, inclusive language

Criticism of the language used for introduced species in the field of invasion ecology is not new, tracing origins to the 1990s. Early arguments challenged the use of negative language that assigned xenophobic, war-like attributes to these organisms (Druschke et al. 2016; Larson et al. 2005). Although acknowledged as exclusionary and discriminatory, little progress has been made on the transition to unbiased language across disciplines in the sciences (Cheng et al. 2023). Despite an expansion and evolution in our knowledge and understanding of the processes involved in the ecology of introduced species, the language used within the field of invasion ecology has remained largely the same, oversimplifying what is, in actuality, a complex, complicated web of biological interactions and relationships that are not yet fully understood, and stagnating progress in the way we approach, conduct, and communicate research regarding this topic (Inglis 2020).

In the ecological sciences, positive efforts are being made. For example, The Better Common Names Project, initiated in 2021 through the Entomological Society of America (ESA), aims to transform the field of entomology to be more respectful by changing common names that may cause harm due to their derogatory or dehumanizing nature (Cheng et al. 2023; Lancette 2021). Notably, the campaign recently changed the common name of the moth *Lymantria dispar* from one that contained a racial slur to spongy moth (Lancette 2021). Additionally, the Just Language in Ecology Education initiative works to challenge xenophobic, warlike terms, and shift to neutral language that does not assign negative values to organisms (Cheng et al. 2023). Some groups are currently compiling resources to make them more accessible to educators and communicators, such as The Ecology and Evolutionary Biology (EEB) Language Project, with the goal of making systemic change more effective and successful (Cheng et al. 2023).

Although genuine change begins with an individual, interdisciplinary collaboration will be necessary to create the collective change needed for real impact (Cheng et al. 2023; Lancette 2021). An important first step is to stay current with the ongoing changes to common names. Up-to-date educators can make conscientious choices to use updated nomenclature in new outreach materials, as well as update existing resources (Lancette 2021). These terms incite a xenophobic

mindset of "otherness." Transitioning to alternative terminology may include "introduced," "novel," "neophyte," and "peregrine" which maintains descriptiveness and denotes the species' range has been impacted by human-activity without specifically assigning negative values to particular organisms (Table 2) (e.g. Anderson 2017; Bhattacharyya and Larson 2014; Hendrix et al. 2008). Many authors have been promoting the shift to alternative language away from the more harmful 'invasive' and 'alien' connotations, suggesting words based on time since introduction (e.g. 27 alternatives are provided in Colautti and MacIsaac 2004) or damage criterion (e.g. Warren 2007), though there is still much promotion and use of the native/alien, positive/negative construct that can promote harmful discourse. To support the use of respectful, inclusive language, we encourage using and/or creating common names and descriptors that assign value and define organisms based on what an organism is, in contrast to what the organism is not as much as possible (Gagnon et al. 2022). Transitioning away from using the prefix "non" in descriptive names better draws attention away from how organisms are lacking or that the difference is a negative attribute (Gagnon et al. 2022). Neutral terms such as "adventive," "naturalized," or "short-term residents" are good alternatives, in addition to others that are based more on the stage of an introduction (Colautti and MacIsaac 2004). In Ojibwe Anishinaabemowin, the phrase "bakaan ingoji ga-ondaadag" was coined by Ojibwe author Lee Obizaan Staples to refer to introduced species, and roughly translates to "that which comes from somewhere else and now resides here" (Tribal Adaptation Menu Team 2019, p. 49; Waasegiizhig Price 2023, pp. 2, 18). Similarly, the Kimberly Aboriginal people of Australia use "kartiya," which denotes that a being is from or associated with a place other than where it is presently (Bach and Larson 2017, p. 571).

Shifts in introduced species language are taking place, but challenging the dominant discourse will require a continuous dialogue on neutral naming. Neutral naming is not only respectful to species but can also enhance the inclusivity and accessibility of the study of introduced species, which in turn has positive synergies for education and communication, and thus the next generation of policy and management practitioners (Cheng et al. 2023; Lancette 2021). Using respectful language does not diminish the effectiveness of management actions that take place to mitigate impacts from introduced species.

3.2 Improving outcomes for education and outreach communication

It is essential to begin unbiased language transitions in early education, building base knowledge and constructing the framework needed for lifelong awareness and more holistic understandings of social and environmental issues (Lakoff 2010; Verbrugge et al. 2021). Investing the time and effort needed to build educational foundations is invaluable though rarely the approach taken, particularly for pressing ecological issues (Fischer et al. 2014; Verbrugge et al. 2021). These frames also inform the foundation for beliefs, and subsequently attitudes and behaviors, and therefore become deeply ingrained in one's neural network; once intact, it is difficult to alter, even when new and accurate information is provided, and the typical response is to take the path of least resistance, relying on the dominant discourse already in place (Bhattacharyya and Larson 2014; Fischer et al. 2014; Lakoff 2010). Moreover, public audiences may not possess the necessary background knowledge about issues within the field of invasion ecology. Thus, one's reliance on frames and beliefs, accurate or not, will be the rational default.

Building on foundations provided in education, outreach communication efforts can strengthen more accurate, holistic framings. Effectively engaging the public is essential in addressing contemporary environmental issues, but often there is a lack of coordination or inconsistency in messaging between educational organizations that contributes to ineffective communication (Iannone et al. 2020; Verbrugge et al. 2021). Adjusting outreach approaches

Table 2 Examples of alternative descriptive language that supports a more respectful, inclusive dialogue when considering introduced species or invasion ecology. This is not an exhaustive list, nor does it go beyond the English or Ojibwe languages which the authors are familiar with; however, the alternatives offered may help with dialogue regarding introduced species that has less negative connotation

Introduced	Inserted or brought into a place
Endemic	Something found in an area naturally
Novel	Something new
Neophyte	A newcomer or new beginner at something
Peregrine	Wide ranging, likely used in context to something moved about by humans (e.g. Hendrix et al. 2008)
Adventive	Not from a location though still in early stages of establishment (e.g. Colautti and MacIsaac 2004)
Naturalized	Not from a location though has more fully established or been there longer (e.g. Colautti and MacIsaac 2004)
Transplanted	Something moved from one location to another
"Bakaan ingoji ga-ondaadag"	"That which comes from somewhere else and now resides here" (Tribal Adaptation Menu Team 2019, p. 49)

and adapting specific content, delivery, and messaging are vital steps when applying ongoing scientific research and other expertise within a diverse public sphere (Verbrugge et al. 2021). For example, involving trusted local community leaders as ambassadors has been shown to have positive outcomes in outreach efforts (Cameron et al. 2013). Additionally, voices of local knowledge-holders need to be uplifted and empowered, as they retain extensive knowledge and expertise gained through on the ground experience instead of formal education (Fischer et al. 2014). With growing acceptance, local Indigenous knowledge-holders are receiving timely recognition for valuable contributions, and we are seeing potential benefits for public relations, policy, and management (Drumond et al. 2015).

In outreach education, communication efforts are increasing emphasis on the benefits of interdisciplinary collaboration; for example, partnering with psychologists to create more effective materials (Cameron et al. 2013; Verbrugge et al. 2021). Consistently using unbiased language across and between communication efforts creates clear, unified messages on introduced species, their impacts, and how to respond, which will enhance overall communication efficacy more broadly (Cheng et al. 2023; Iannone et al. 2020). Additionally, as the topic of introduced species in of international concern, there is a large wealth of knowledge and information regarding the ecology and impacts of introduced species that is held by non-English speakers and in non-English literature, which is often not included in overall consideration of this topic (Angulo et al. 2021). Inclusion of non-English sources reduces the number of gaps in knowledge and understanding, and therefore it is beneficial to also consider a multilingual approach to communication regarding introduced species (Angulo et al. 2021). In short, regardless of age, language, knowledge level, ethnicity, etc., outreach must communicate accessible, adaptable information from trusted sources, including local knowledge-holders.

3.3 Improving outcomes for science, policy and management

Two-eyed seeing is an important, powerful method for enacting discourse transitions in science, policy, and management (Nonkes et al. 2023; Stirling et al. 2023). Indigenous peoples and their existing work on introduced species can provide culturally informed, integrative management strategies, as they approach environmental issues in adaptive ways that consider community and society holistically in management (Bhattacharyya and Larson 2014; Reo et al. 2017; Shaw et al. 2023). Long-held records of traditional and cultural practices and knowledge provide invaluable information and act as a resource that allow Indigenous nations to better understand ecological relationships and how they change over time, which helps inform decisions about how to build relationship and interact with the environment (Bach and Larson 2017; Drumond et al. 2015; Shaw et al. 2023). Western scientific practices are not designed to build intimate, long-term relationships with individual organisms, and may be unable to parse out fine details about ecology that traditional scientific practices can (Drumond et al. 2015). Local knowledge systems can help fill gaps in Western scientific knowledge, adding new perspectives that can strengthen and fortify policy and management (Bach and Larson 2017; Drumond et al. 2015; Schüttler et al. 2011).

In the case of introduced species, knowledge holders within the original-natural range can be a resource for others. Importantly, existing traditional and cultural relations with these organisms have the potential to provide insights and inform socio-ecological relationships elsewhere. Understanding long-term organism characteristics, behavior, and interactions within their endemic or original range has the potential to support management efforts, including forecasting outcomes associated with their introduction elsewhere (Reo and Ogden 2018; Shaw et al. 2023; Tribal Adaptation Menu Team 2019). Overall drawing on Indigenous and Western knowledge systems exemplifies a two-eyed seeing approach and its potential effectiveness for others (Reid et al. 2021).

In many Indigenous knowledge systems, all living beings (introduced or otherwise) are considered to be persons living in kinship with all others and all have a right to exist (Horn et al. 2021; Waasegiizhig Price 2023, pp. 2, 18). As persons, we all live to share our gifts with others, which may be interpreted as serving a specific purpose within a specific ecosystem (Horn et al. 2021; Reo and Ogden 2018). It has been articulated that the human duty is to "learn from," in contrast to solely "learning about," more-than-human beings (Kimmerer 2021). As such, the human obligation is to learn why a particular more-than-human species has migrated to another region, as well as how we, as humans, can develop new relations (Kimmerer 2021; Reo and Ogden 2018; Waasegiizhig Price 2023, pp. 2, 18).

Humans are responsible for relocating innumerable species worldwide, and subsequently, are responsible for acknowledging fault and taking accountability for the myriad of unforeseen impacts (Waasegiizhig Price 2023, pp. 2, 18). It is becoming more necessary to shift our perception of ourselves as human from being apart from and above nature to being a part of and within nature (Bhattacharyya and Larson 2014). As a result, humans are obligated to create informed solutions that are both respectful and effective for life more broadly (Bach and Larson 2017). Instead of a crisis-management or eradication approach to invasive species management, Indigenous land managers take time to observe and learn before proceeding

to management decisions and actions (Bach and Larson 2017; Tribal Adaptation Menu Team 2019). The emphasis is understanding how the environment is responding and how we can act in partnership with our more-than-human kin to enact management strategies that reflect ecological relationships and maintain healthy systems for generations to come (Bhattacharyya and Larson 2014; Reid et al. 2021).

While it is our responsibility as stewards to monitor, minimize, and mitigate the harm that we cause, it is more beneficial to redefine success by focusing on the positive outcomes of a healthier, more resilient ecosystem (Bach and Larson 2017). Managing ecosystems so they are resilient will make it so they are less susceptible to the detrimental impacts of introduced species (Tribal Adaptation Menu Team 2019). Bach and Larson (2017) provide an example of how this change in perspective on introduced species can change attitudes, perceptions, and behaviors in teams of Aboriginal weed management rangers in Australia. When the rangers focused and relied on language taught to them in professional training, their outlook was narrow, negative, and made them feel like their work was futile. However, when they switched to using language traditionally used by Aboriginal elders, they were able to think more broadly about the implications and purpose of their work and how it was helping to improve the overall health of the land, finding more success in their work.

Dynamic pragmatism can be valuable to the education, communication, and institutional practices concerning introduced species (Drumond et al. 2015; Druschke et al. 2016; Gibbs et al. 2015). For established introduced species, it would be wise to move beyond a sole focus on negative impacts; instead, it may be more productive to accept altered ecosystems and the particular set of gifts provided in expanded ranges. In contrast to abrasive management, scientists, educators, and practitioners may desire to provide information on ways introduced species can be managed to minimize harm and mitigate impacts to others (Druschke et al. 2016). By drawing on positive effects and interactions, management regimes could better work towards repairing ecological relationships (Bach and Larson 2017). Conducted in a thoughtful, careful manner, reframed discourse can discourage the spread of problematic species while also avoiding the promotion of an apathy for land stewardship. Acknowledging positive and negative consequences can support better human relationships within ecosystems and with more-than-humans (Verbrugge et al. 2021).

Species impacts are not homogenous or isolated, and managing them under that assumption leads to ineffective practices and poor results (Bhattacharyya and Larson 2014). Effective management should look at the big picture, considering the network of interactions and relationships an organism, introduced or not, has within its environment (Bach and Larson 2017; Gibbs et al. 2015; Shaw et al. 2023). In some cases, managers are opting to shift away from trying to totally eradicate problematic species when it becomes clear that eradication is not feasible. Instead of funneling resources and effort into trying to remove these species entirely, the focus could be shifted to helping ecosystems adapt and become more resilient (Druschke et al. 2016). Since many introduced species are associated with human activity, the best thing we can do is to promote realistic, accessible ways that the public, organizations, and corporations can get involved and help.

Discourse transitions serve to improve human relationships with each other and the natural world, and especially, the more-than-human beings with which we share environs. By approaching introduced species with two-eyed seeing, we seek to gain an enhanced understanding of ecosystem relations (Table 1 and Fig. 1). Further, this knowledge can be applied to intentionally engage with diverse knowledge systems, and transition to be more respectful and inclusive in science, policy, and management discourse. As a result, discourse transitions have the potential to simultaneously facilitate the general public's framing and everyday discourse. Reframing for the transition to unbiased discourse on introductory species has the potential for synergistic efforts across scientific communication, education, outreach, policy, and management practices and relations more broadly.

4 Conclusion

Introduced species are a concern and have detrimental impacts, but the current ways we discuss them are undoubtedly problematic and impede, rather than facilitate, effective communication and serve to harm our relationship with each other and with the natural world. We have not provided an exhaustive list of strategies in which we can work to improve the way we discuss, study, and manage introduced species, but rather, we have started an illustrated framework of doing so through the method of two-eyed seeing The goal of this article is to further an ongoing conversation about the impacts of language within the field of invasion ecology, as attempting to declare definitive solutions and strategies as three non-Indigenous authors from one university would directly oppose the message of prioritizing inclusive, collaborative, interdisciplinary work on this subject through the frame of two-eyed seeing. Although there are many leading efforts for meaningful change to improve our relationships with introduced species and management outcomes, there is still much work to be done. Reframing the discourse moving forward will allow for diverse and novel perspectives and approaches that would otherwise not be possible with the current state of discourse.

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Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest with respect to the research, authorship, and/or publication of this article. This manuscript is developed from the thesis of Shelby Lane-Clark, titled "Impacts of Introduced Earthworms on Sugar Maple Sap Chemistry and the Discourse of Invasion Ecology," that was submitted to the Graduate School at Michigan Technological University in partial fulfillment of the requirements for the degree of Master of Science with a Major in Forest Ecology and Management from Michigan Technological University on August 7th, 2023. Bal and Gagnon served as advisors.

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