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Invasive Species, Indigenous Stewards, and Vulnerability Discourse

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North American Indigenous nations are confronting various forms of rapid environmental change, ranging from climate-induced sea-level rise on the Gulf Coast, to melting permafrost and shifting sea ice patterns in the Arctic, to invasive species-induced trophic cascades in the Great Lakes.¹ These changes are all evidence used to justify calling our current geologic era the “Anthropocene,” viewed as the period during which human activity has been the dominant influence on climate and the environment.²

Invasive species can cause dramatic changes to ecosystems, including shifts in species composition, species mortality, biodiversity, disturbance regimes, and ecosystem-level nutrient dynamics. Globally, the impacts of invasive species cost billions of dollars annually.³ Land managers and policy makers in the United States and Canada try to minimize these ecological and economic impacts through a range of management strategies, including prediction, prevention, preparedness, education, eradication, containment, monitoring, and research/development (figure 1).

Indigenous peoples in the United States and Canada have a long history of dealing with environmental changes. They are acutely aware of invasive species in their territories and are actively responding in various ways as well. Indigenous nations’ invasive species work is generally underreported in the literature but includes communication and education initiatives, scientific research that tests new stewardship strategies, ecosystem restoration through Indigenous knowledge, and adaptation of cultural practices to account for changing conditions, including incorporating introduced species into Indigenous food systems.⁴ Thus, Indigenous nations’ responses to invasive species include all of the gener-

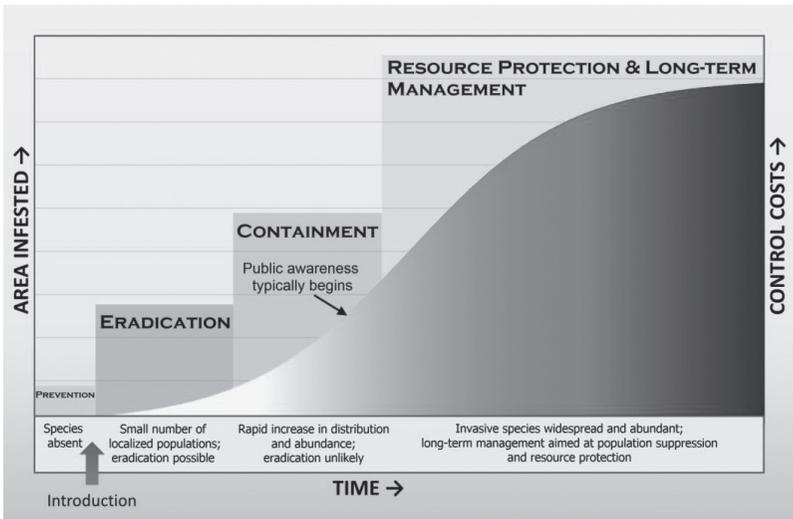


FIG. 1. Generalized invasive species “invasion curve” showing appropriate steps and scale of economic costs at different stages of invasion. From Rebecca Harvey and Frank Mazzotti, *The Invasion Curve: A Tool for Understanding Invasive Species Management in South Florida*, publication no. WEC-347, December 2014, University of Florida Institute of Food and Agricultural Sciences. Based on an original figure by Natural Resource Management Ministerial Council, “Australian Weeds Strategy: A National Strategy for Weed Management in Australia,” 2006, Australian Government Department of the Environment and Water Resources, Canberra.

alized steps taken by settler governments and NGOs plus some unique, culturally informed strategies reported in the literature; we describe these below.

Despite this range of activities, Indigenous peoples are rarely mentioned in the literature on human dimensions of invasive species, and most of the publications that do discuss Indigenous peoples’ experiences with invasive species focus on sociocultural impacts. For example, Jeanine Pfeiffer and Elizabeth Huerta Ortiz document the effects of invasive species on culturally important plants, landscapes, livelihoods, and traditions.⁵ In their case study of sudden oak death on the Hoopa and Yurok reservations in California, Janice Alexander and Christopher Lee note the cultural significance of the affected tanoak trees and reference the deep personal connections that frame tribal involvement in tanoak mortality and efforts to combat it.⁶ Importantly, these and related

papers highlight the unique cultural dimensions of Indigenous peoples' experiences with invasive species.⁷

The key messages in these and related papers are about cultural impacts and Indigenous peoples' vulnerability to invasive species. Native American and Indigenous studies scholars have increasingly problematized the vulnerability narratives used to characterize Indigenous peoples' experiences with rapid environmental change.⁸ One reason is that vulnerability narratives obscure the actions, strategies, resources, and knowledge that Indigenous groups mobilize to navigate environmental change. Vulnerability narratives are criticized for portraying Indigenous groups as passive or helpless, hiding the agency of very active Indigenous groups. Vulnerability narratives can portray Indigenous nations as dependent on settler colonial nation-states and other non-Indigenous parties for relief from environmental problems, which could lead to policymakers drafting climate change or invasive species policies that interfere with Indigenous nations' aspirations of self-determination.⁹

Benedict Colombi's studies about the Nez Perce (Niimiipu) are noteworthy because they show dimensions of the tribe's response to the degradation of salmon habitat that do not arise out of a vulnerability or help narrative.¹⁰ His studies reconceptualize the current habitat issues the tribe faces from the tribe's own history of having to adapt to multiple habitat changes before and after US colonization. Colombi found that the Nez Perce developed important strategies for adaptation, or adaptive capacities, that included proactive approaches to strengthening and continuing Nez Perce leadership models and knowledge systems. Far from being passive recipients of salmon habitat degradation, the Nez Perce draw on their own history and culture to develop strategies that are both innovative and ancient for exercising self-determination in the face of risky changes. Colombi's work highlights how, for the Nez Perce, culture is not a passive victim to the degradation of salmon habitat; instead, culture itself is an essential adaptive capacity that supports Indigenous self-determination.

In the same spirit as Colombi and others, our article seeks to contribute to a shift toward recognizing Indigenous agency in environmental change research. We contribute to this transition through our exploratory research, which characterizes the range of ways Indigenous natural resource managers and practitioners are responding to invasive species. We ask how and why Indigenous people in the United States and Canada are

preparing for, responding to, and adapting to invasive species in their respective territories. This investigation will lead to a better understanding of (1) how Indigenous knowledge, perspectives, and values guide Indigenous nations' environmental governance in relation to invasive species; (2) the motivations and goals behind Indigenous peoples' approaches to invasive species; and (3) the tools and methods Indigenous people use to carry out planning, adaptation, and mitigation measures.

METHODS

We collected data on Indigenous peoples' responses to invasive species through an online survey of staff from natural resource, environmental, and cultural departments from Indigenous nations across the United States and Canada.¹¹ We used a combination of purposive and snowball sampling to identify hard-to-find respondents with expert knowledge.¹² We chose a nonprobabilistic (i.e., nonrandom) sampling strategy, which means that we cannot quantitatively estimate the odds that we have represented the population well. This approach was appropriate given the dearth of published information about Indigenous peoples' approach to invasive species management in the United States and Canada. Given the exploratory nature of this research, our goal was to cast as wide a net as possible. The survey was sent via email to contacts within our professional networks; these contacts then forwarded the survey to Indigenous nations' staff from the contacts' own networks and to staff identified through publicly available contact lists for Indigenous nations. We sent one follow-up email to each potential respondent to increase our response rate. We informed respondents that their participation was voluntary, that they could skip any of the questions, and that they could exit the survey at any time. The survey was posted from July 2013 through June 2014.

The survey consisted of fourteen questions, including multiple-choice, open-ended, and Likert scale questions. Survey questions were structured based on findings and questions posed in the literature and our own experiences working with Indigenous nations in and outside of research settings. The survey instrument was designed following Jelke Bethlehem and Silvia Biffignandi. A draft of the survey instrument was pretested with representatives from one tribe in the United States and one First Nation in Canada and modified based on their feedback.¹³

Once data collection was complete, we used the survey software (SurveyMonkey Gold) to remove forty-five respondents who exited the survey before reaching the end. Descriptive statistics were calculated primarily as percentages to identify notable trends and anomalies. Open-ended questions/comments were qualitatively analyzed through an iterative coding process to further understand the context and nuances of invasive species management by Indigenous peoples.

Respondent concerns, rated from 0 to 5 on a Likert scale, were quantitatively analyzed with Cronbach's α , which allows multiple questions to be combined into an indirect measure of an underlying concept. Cronbach's α scores range from 0 to 1, with 0 indicating a set of questions that measure unrelated concepts and 1 indicating a set of questions that measure the same concept. Therefore, any particular response to one question perfectly predicts a particular response to another question in the set. An α score of 0.7 or higher is considered sufficient to group questions together as an aggregate measure of an underlying concept. When an α score greater than 0.7 was found for a group of specific concerns, a mean score is reported for the whole category of concern in addition to the mean score for each specific concern. Cronbach's α scores were calculated with the "lrm" package in R (version 3.2.2).

RESULTS

Demographic Summary

We numerically analyzed the data from all complete responses to the survey ($n = 107$, table 1). Sixty-three percent of respondents identified as citizens or descendants of Indigenous nations, and 94 percent were employed by an Indigenous nation. The largest majority (88 percent) of Indigenous nation employees described natural resource and environmental management as their primary work roles.

In total, through enrollment, descent, and employment, respondents represent 144 unique Indigenous nations in 17 U.S. states and 4 Canadian provinces (figure 2). The final number of respondents is higher than our sample size of 106 because several respondents were citizens of one Indigenous nation and worked for a separate nation.

Table 1. Demographics of survey respondents and summary of responses

<i>Variables</i>	<i>All respondents (n = 106) %^a</i>
Female	50
Age in years (mean \pm SD)	45 \pm 12
Indigenous nation citizen	63
Harvester	79
Employed by Indigenous nation ^b	88
<i>Position within nation</i>	
Natural resources	88
Research and education	16
Cultural resources	13
Planning	6
Official	2
Health services	2
Other	15
<i>Prevention</i>	
Increasing resilience	82
Cooperating with non-Indigenous government agencies	81
Creating education programs	70
Cooperating with an NGO	58
Cooperating with other Indigenous nations	55
Cooperating with a university	50
Developing policies with non-Indigenous entities	44
Developing emergency response	25
Creating Indigenous nation policies	24
<i>Mitigation</i>	
Hand pulling	83
Educational programs	76
Mechanical removal	64
Chemical application	50
Fire	37
Hunting	36
Biocontrol	36
Ceremony	21
Grazing	20

<i>Variables</i>	<i>All respondents (n = 106) %^a</i>
<i>Adaptation</i>	
Documenting traditional ecological knowledge	53
Saving native seed	47
Sharing strategies with other Indigenous nations	47
Traveling farther to harvest native species	46
Ceremony	38
Transplanting native species	27
Shifting from native to introduced species	16
Using alternative materials	14

^a Percent of respondents who are employed by an Indigenous nation ($n = 94$); multiple responses permitted per individual.

^b Except where noted.

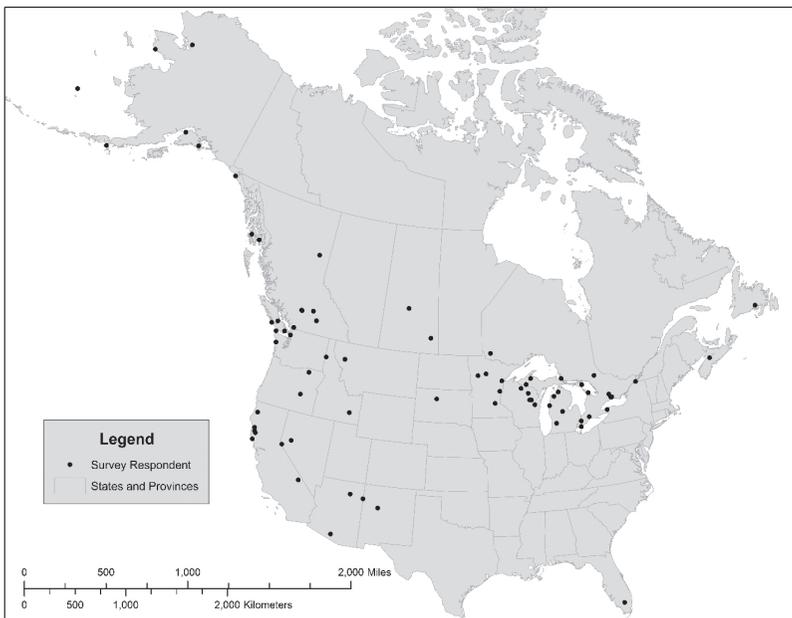


FIG. 2. Map of survey respondents.

Prevention

Indigenous nations commonly draw on partnerships in their work to prevent invasive species on their lands. Most (81 percent) respondents indicated that their communities have worked with non-Indigenous governments, including local, state, provincial, and federal government bodies and agencies, to prevent new invasive species. Indigenous nations have also partnered with nongovernmental or nonprofit organizations, including lake associations, numerous intertribal councils, and conservation organizations. Despite all the partnerships that Indigenous groups appear to be participating in, they can be left out of the loop or informed too late about new invasive species populations, compromising early response strategies. As a representative from the Caldwell First Nation in Ontario indicated, “We are [often] not informed that a new species has taken root until it is already too late and then we are dealing with damage control.”

Efforts directed at educating the public and increasing the resiliency of lands and waters are important components of invasive species prevention. Seventy percent of respondents’ Indigenous nations have given or currently give education programs to recruit public participation in prevention efforts. Tribal nations in the Great Lakes region, including the Lac Vieux Desert Band of Lake Superior Chippewa, Fond du Lac Band of Lake Superior Chippewa, and Little Traverse Bay Bands of Odawa, give harvesters maps of areas with invasive species and instructions on how to prevent spreading, and they have established prevention services such as free boat washes.

Nearly a quarter (24 percent) of respondents noted having established code or formal Indigenous governmental policies intended to prevent the spread of invasive species. In several cases, Indigenous nation policies that formally target invasive species include protocols for nation citizens and employees who work regularly in the field and may encounter invasive species, as well as broader protocols governing community responses to invasive species.

Mitigation

Hand pulling is the most commonly used means of invasive species removal; 83 percent of respondents indicated that their nation had re-

moved invasive species by hand. Mowing is the second most commonly used means (64 percent). Other possible methods, including chemical treatments (50 percent), fire (37 percent), hunting (36 percent), biological controls (36 percent), ceremonies to support native species (21 percent), and grazing (20 percent), were less common.

While the Stockbridge-Munsee Band of Mohican Indians and other nations treat up to several hundred acres a year with chemicals and other controls, many other Indigenous nations lack the funding to use many mitigation methods and the knowledge of how to implement removal methods. For instance, a representative from the Menominee Nation considered using fire but was unsure “whether it would help reduce the invasive, or prepare the area to be invaded.” This response and others show a wariness over potential negative outcomes, and these concerns are warranted. The Nanwalek IRA Council in Alaska used bacterial treatments designed to control geometrid moths on berry bushes, but this action wound up negatively affecting berry harvest for their communities. Concern for the cultural impacts of removal treatments has also halted potential action.

Education remains a primary tool in combating unwanted invasive species. Seventy-six percent of respondents and their communities have used education programs, including brochures, public service announcements, and public presentations, to limit the spread of established invasive species. Indigenous nations are also actively engaged in improving their own understanding of invasive species and how to treat them. Several Indigenous nations have looked to Western science to mitigate the impact of invasive species. The Walpole Island First Nation noted that their community had conducted a small trial of comparative methods in controlling invasive *Phragmites australis* (common reed). Chugachmiut, a Native organization that serves the seven tribes in the Chugach region of Alaska, is modeling areas where berry bushes will be most resistant to moth defoliation and plans to use the data to “implement silvicultural berry improvement treatment in areas most likely to resist future defoliation.”

Adaptation

Data suggest that no single adaptation measure is more commonly used than others. More than half (53 percent) of respondents have doc-

umented traditional knowledge and practices about threatened native species. Almost half have shared adaptive strategies with other Indigenous nations (47 percent), saved seeds from threatened native species (47 percent), and/or traveled farther than normal for harvest (46 percent). Twenty-seven percent have transplanted plants or animals to new locations to protect them from invasive species.

Even though, broadly, respondents tended to be very concerned about the sociocultural impacts of invasive species and less so about cultural adaptations, their responses to the latter are noteworthy. Following impacts by invasive species, 16 percent have shifted their reliance to alternative species. This includes forgoing more traditional foods that are less abundant or more at risk, as well as harvesting edible invasive plants. Fifteen percent have maintained skills or expertise following invasive species impacts by using alternative materials (e.g., basket makers using alternative materials). A representative from the Hiawatha First Nation noted, "We frequently harvest European Purging Buckthorn instead of native varieties of Dogwood and willow for basketmaking. We've begun to harvest Garlic Mustard as a food source, while leaving [culturally valued] wild leeks and wild ginger alone." An Aleut community from the Pribilof Islands of Alaska employed a more symbolic measure by renaming an island after invasive species were removed.

Traditional Ecological Knowledge

Survey responses provided some insights into the ways traditional ecological knowledge (TEK) factors into Indigenous groups' interactions with invasive species. For instance, 54 percent of respondents indicated that their nation is actively documenting their community's TEK about native plants and animals (or human-animal and human-plant relationships) threatened by invasive species. For example, in the northeastern United States, Indigenous nations reported documenting their knowledge about ash trees given the likely arrival of the emerald ash borer in the future. In this case, documentation would include knowledge concerning the role of ash in creation stories as well as use-specific or artisan-specific knowledge and skills like those held by ash basket makers.

Documenting TEK often means documenting the knowledge held by a community's elders. The Nanwalek IRA Council in Alaska indi-

cated that they are gathering information from their elders about ways to enhance berry populations impacted by invasive species. In Maine and Michigan, ash tree gathering methods are being documented to show not only methods of locating and harvesting appropriate trees but also family and tribal stories associated with traditional gathering areas. For the Wabanaki Nations of Maine, the urgency of this documentation ties back to their creation story of Gluskabe shooting an arrow into the ash tree, the spot from which all Wabanaki people emerge, singing and dancing.

Traditional ceremonies are one form of TEK. Thirty-nine percent of respondents use ceremonies to honor Indigenous plant and animal population, and 21 percent of respondents said their Indigenous nation has used ceremonies specifically to help native species impacted by introduced species. Some of these same respondents indicated that they factor in elders' perspectives and TEK when determining their invasive species response strategies, like the Sokaogon or Mole Lake Band of the Lake Superior Chippewa: "We have to be real careful how we combat the invasives because our elders won't allow us to use herbicides in some areas so we have to hand pull those protected areas. Which is fine with us because we respect their wishes."

Indigenous Concerns

Though it was not the focus of our survey, we also asked respondents about their concerns over invasive species. We distinguish concerns from goals and motivations in the following way: goals are aspirational statements for desired future conditions or actions; motivations are underlying reasons or inspirations behind a group's actions or decisions; concerns are the current phenomena or future conditions groups are worried about. In this way, "concerns" are often about impacts. Emphasizing goals and motivations over concerns was our way of acting as a counterbalance to the large body of work on Indigenous experiences with global change emphasizing impacts.

Respondents were most concerned about environmental impacts, then cultural impacts, then economic impacts (table 2). A substantive majority (83 percent) of respondents reported that they were "very concerned" about the impacts to overall health of ecosystems, while 76 percent were "very concerned" about impacts to specific populations of in-

Table 2. Mean ratings and Cronbach's alpha scores for invasive species concerns

<i>Concern</i>	<i>A</i>	<i>Mean</i>
Ecological	0.754	3.68
Overall ecosystem		3.73
Indigenous species		3.64
Cultural	0.824	3.32
Communal TEK		3.41
Tribal food systems		3.37
Cultural identity		3.19
Economic	0.855	2.79
Regional economy		2.94
Respondent's finances		2.77
Tribal economy		2.63

Note: Mean scores are based on responses to a Likert scale question indicating 1, not concerned; 2, neutral or unsure; 3, somewhat concerned; or 4, very concerned.

digenous plants and animals. Respondents noted that invasive species reduce the overall availability of essential resources, including water in semiarid environments and flora and fauna populations that have traditionally been staples in food and material cultures. One person from the Hopi Tribe explained their concerns over impacts to water availability, describing how reduced water availability affects plants, animals, and humans alike: “In a semi-arid environment, water is of the utmost concern, with invasive species such as salt-cedar and Russian olive overtaking drainage systems/ecosystems that were havens for water, plant and animal species utilized by our people devastated, the ecosystems have been drastically altered with no means of controlling or stabilizing the situation.”

A representative from the Quinault Indian Nation described how invasive species are impacting the habitat of cultural keystone species: “The large river floodplains are severely degraded due to dense populations of invasive species. Riparian Habitat for native salmon is threatened by extensive knotweed infestations which will negatively impact Quinault salmon fisheries and elk populations.”

These concerns are intimately related to concerns about the impacts on culture and traditions. Sixty-two percent of respondents were “very concerned” about the impacts of invasive species on both local food systems and communal traditional ecological knowledge, and 53 percent were “very concerned” about impacts on cultural identity. A representative from the Ketchikan Indian Community commented that “hardly anyone collects our [medicinal plants] for medication and that knowledge is being lost.” One Akwesasne Mohawk respondent noted that the loss of native species and subsequent decreased use has resulted in loss of their native language associated with those species.

Overall, respondents were less worried about the potential economic consequences of invasive species. Responses averaged just below “somewhat concerned” (2.74) on a four-point Likert scale. The impact on an Indigenous nation business’s ability to generate revenue was of least concern. However, individuals still do have their livelihoods on the line. One Mississauga respondent worried, “If emerald ash borer gets in here, we’ll lose good basket and bow wood. I depend on bow making and basketry to make an income.”

DISCUSSION

Indeed, invasive species are an important type of environmental change, but to suggest that such change is unprecedented, as is implied with the idea of the Anthropocene, is problematic for several reasons. First, the concept of the Anthropocene assumes that invasive species are a “problem” for Indigenous peoples. Whatever Indigenous peoples are doing today to approach invasive species flows out of their own histories with environmental change and how these histories shape their assumptions today about the meaning or significance of their current interactions with novel species. These histories and assumptions—which do not flow out of nonindigenous frameworks such as “the Anthropocene”—shape what Indigenous peoples view as appropriate approaches to invasive species. Without losing sight of the reality of Indigenous vulnerabilities and Indigenous suffering, our focus is on what Indigenous peoples’ agency will hopefully disclose about Indigenous strategies, knowledge, and capacities for stewardship and policy responses to invasive species. Such a focus is committed to how Indigenous peoples exercise self-determination (a term that itself is nuanced and culturally and politi-

cally specific) and recognizes Indigenous creativity, which tends to get marginalized or washed out by the concept of the Anthropocene, too often defined by what others assume about Indigenous peoples.¹⁴

Climate change literatures and media coverage of Indigenous peoples' experiences with environmental change are dominated by characterizations of Native peoples as vulnerable, "endangered others."¹⁵ This rhetorical trend has potentially serious implications for Indigenous nations and their citizens. Our primary concerns about this trend are the power dynamics at play and the political implications of these power dynamics. Focusing on an Indigenous group's impacts or vulnerability obscures and glosses over the relationship between Indigenous nations and settler colonial governments that seek to balance Indigenous autonomy and the responsibilities settler states have to address underlying territorial rights and land claims issues; assure Indigenous free, prior, and informed consent; respect Indigenous knowledges; and work to ensure that Indigenous groups have the freedom to build their own self-determining governance capacities to address environmental issues.

For instance, existing scholarship details the ways that pervasive vulnerability messaging is influencing policy and directing, if not limiting, options for Indigenous nations without their full participation in policy-making processes. In locations where Indigenous homelands are threatened by rising sea levels and coastal erosion, community relocation planning has become a disenfranchising process for Indigenous nations in instances where they have not been centrally involved in planning or determining appropriate new locations for their own communities.¹⁶ Such disenfranchisement is occurring in the case of small Pacific Island nations, where climate change discourse focuses on ecological impacts of climate change, often ignoring the presence of islanders altogether and very rarely seeing the relevancy of Indigenous knowledge systems and adaptive capacities of Indigenous Pacific Islander societies for understanding and responding to climatic change.¹⁷

From an ethical or human rights perspective, Indigenous nations need to be directly involved in developing any environmental change policies that aim to generate, or happen to constrain, future options for their societies. As legal scholar Sarah Krakoff says concerning the disenfranchisement of Indigenous peoples in climate change adaptation initiatives, "We should support governance structures that will allow in-

Indigenous peoples to chart their own path in a world that has no precedents.¹⁸ Our results indicate that Indigenous nations in the United States and Canada have ample experience with different forms of environmental change policy making, including drafting invasive species policies within their nations and partnering with non-Indigenous governments from local to federal levels to codetermine invasive species policy. Considering these results alongside the various U.S. and Canadian laws that require meaningful consultation with Indigenous nations, it is difficult to imagine a convincing rationale for *not* involving Indigenous nations in environmental change policy making.¹⁹

As Bethany Haalboom and David Natcher point out, these vulnerability-focused characterizations also have the potential to shape the ways Indigenous peoples view themselves. As Native peoples continually shape their own identities, pervasive endangerment messages could prompt feelings of vulnerability among Indigenous community members, interfering with their goals of autonomy and self-determination.²⁰ This outcome is of concern to Indigenous leaders. For example, in a recent lecture, Indigenous leader and author Sheila Watt-Cloutier explained why she wrote her book *The Right to Be Cold*: “Inuit are not victims of globalization. . . . [W]e have a powerful history of strength, of wisdom, that can be offered back by integrating that kind of wisdom into the new institutions. But what’s happened is that these institutions have taken over the role of parents, the role of the provider, and have even helped to make it worse in many cases.”²¹ Thus, she wrote this book specifically to help empower Inuit youth and to intervene against any tendencies to see themselves as victims.

Elizabeth Hall and Todd Sanders refer to what they call the “endangered other” trope, which leads to fear for loss of tradition: “Faced with rapid climate change, [the endangered other’s] traditional survival strategies are in peril, and likely at any moment to collapse.”²² James Ford posits that the climate change impacts facing Inuit peoples occur within a backdrop of “acculturative stress” following recent and historic socioeconomic shifts in Inuit communities.²³ Henning Pedersen describes increased access to Western pop culture as a form of cultural pollution that, with the added stress of climate change, puts “Arctic cultures and societies . . . at major risk of extinction.”²⁴ These contentions expose authors’ assumptions about what constitutes “culture” and “tradition”

vis-à-vis Indigenous peoples and exemplify the ways many social scientist and humanities scholars who work on climate change are thinking about Indigenous experiences.

While our results confirm that Indigenous nation citizens are concerned about the cultural impacts of invasive species (table 2), open-ended responses to our survey indicate that Indigenous citizens regard their cultures as more or less resilient to environmental change. For instance, one Anishinaabe respondent stated, "At this point the problem isn't so bad as to affect tribal identity or traditional knowledge." We certainly recognize the potential impacts climate change and invasive species could have on Indigenous sociocultural and economic systems. The strong linkages between land/environment and Indigenous ways of knowing and being are undoubtedly affected by rapid environmental or biological changes.²⁵ But there are important elements of Indigenous cultures and traditions that are understudied and often ignored by researchers and journalists. For instance, traditional values, morality, and spirituality, important elements of Indigenous knowledge and lifeways, are woven into subsistence systems in complex and subtle ways.²⁶ And these elements of Indigenous sociocultural systems are more persistent, or change very slowly, even while outward expressions of culture undergo rapid evolution. Thus, in our view the threats to Indigenous peoples and their cultures posed by invasive species and other forms of rapid environmental change are not as dire as they are often made out to be.

Furthermore, regardless of the extent of cultural impacts, our study supports the idea that Indigenous nations and their citizens are focused on active response strategies, deemphasizing impacts and emphasizing actionable responses. Our results show that Indigenous groups in the United States and Canada are actively preparing for and responding to introduced species using a wide range of practices and leveraging both Indigenous knowledge systems and Western science and resource management tools. Respondents removed invasive species by hand and via other mechanical measures and used chemical responses, fire, grazing, and biocontrols. In addition to all these approaches used by their non-Indigenous counterparts, more than half of respondents reported using Indigenous knowledge directly in their invasive species work. For instance, Indigenous nations are documenting traditional knowledge and practices about threatened native species and using ceremonies to care

for lands, plants, and animals. In response to introduced species, Indigenous peoples also use ceremonies that honor and enact reciprocal moral responsibilities between humans and nonhumans.

North American Indigenous nations have embraced Western science not as a new worldview that supplants their preexisting ways of knowing and being but as a tool useful in meeting community objectives and priorities. Just as Indigenous peoples have adopted new technologies and enfolded them into their subsistence and socioeconomic systems, they are using Western science to support important community activities, including traditional land- and marine-based activities.²⁷ Our study indicates that invasive species management is one area where Indigenous groups are utilizing Western science alongside Indigenous knowledge approaches to protect culturally significant Indigenous plants and animals as well as places. This approach to using non-Indigenous tools is also reflected in the creative ways in which Indigenous nations are building resilient systems of governance. The high percentage of Indigenous nations partnering with other sovereign and nongovernmental entities (81 percent) in managing invasive species shows a strategic use of Western modes of governance, as well as reinscription of Indigenous modes of governance.²⁸ For the Wabanaki Nations in Maine, the cooperative governance issues for detection and response to the anticipated arrival of the emerald ash borer, present in multiple Memoranda of Understanding with USDA-APHIS, reflect communication processes and respect for different forms of knowledge reflective of multinational partnership principles in the Wabanaki Confederacy.²⁹

Our results indicate that Indigenous groups in the United States and Canada clearly see the value of partnering with Indigenous and non-Indigenous neighbors in preparation for and response to invasive species. Two obvious rationales for partnering in these contexts are that (1) invasive species pay no attention to property lines or treaty boundaries and therefore require cross-boundary coordination, and (2) sharing equipment, human resources, knowledge, and data tends to increase the effectiveness and longevity of partnerships.³⁰ However, not all partnerships achieve their potential or even get off the ground. One reason is that misperceptions and stereotypes can create obstacles to cross-cultural partnerships.³¹ We hope that by providing a more accurate picture of the various ways Indigenous nations and organizations are thinking about, preparing for, and responding to invasive species, this

article can help set the stage for more land management and community research partnerships in the future.

For many of the Indigenous groups whose staff or members responded to the survey, their approaches to invasive species are perceived as opportunities to exercise self-determination in several respects. First, they are building relationships with non-Indigenous parties, which can strengthen the diplomatic and cooperative potential of Indigenous peoples to negotiate invasive species and other changes. Second, they are finding ways to build self-determining capacities by harnessing Western science, connecting this form of science to Indigenous knowledge and including Indigenous forms of science where appropriate. Third, Indigenous responses to and interactions with invasive species provide opportunities to renew and expand Indigenous knowledges, including determining the nature of novel relationships between Indigenous peoples and invasive species.

Responses to our survey question about the impacts of invasive species raise important follow-up questions. Because our study was intended to assess the current response to invasive species, and the survey tool was advertised as such, it may have biased participation from people who are already aware of and concerned about invasive species. We also purposively sampled natural resource and cultural agency staff from Indigenous nations along with subsistence practitioners and artisans such as basket makers. What remains unexplored is whether other Indigenous North Americans who are less involved in subsistence activities, as well as staff from departments in Indigenous nations other than environmental and cultural programs, care one way or another about invasive species. Our survey was not set up to address this question, and future research is necessary to understand perceptions of invasive species in Indigenous communities more generally. Another critical area for future work includes studies that help us see how introduced species fit into Indigenous cosmologies. In Indigenous communities where local plants and animals are thought of as part of your extended family, how do you respond to newly introduced species, especially if they somewhat aggressively take over habitat of the long-standing plant and animal members of your community? In other words, to borrow a term from Rarámuri (Tarahumara) scholar Enrique Salmón, what does a “kincentric ecology” of invasive species look like, or if none exists, how could such an understanding be cultivated?³²

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NOTES

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