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Field Notes - forest threats

Towards Tree Species Preservation: Protecting Ash Amidst the Emerald Ash Borer Invasion in the Northeast

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Abstract

The introduced emerald ash borer (EAB) represents the costliest invasive forest insect in US history, causing significant mortality of ash species across much of eastern North America as well as in Colorado and Oregon. Few surviving overstory ash trees exist in areas first invaded by EAB, such as the Lake States region; however, forests with healthy, mature ash remain in recently invaded regions, such as the northeastern United States. Given the importance of ash to cultural lifeways of Indigenous peoples and the ecology and economies of working forest lands, there is growing interest in applying protection measures to maintain ash in forested settings. We further develop our call for species preservation by presenting Indigenous and Western science case studies of ongoing efforts to mitigate the impacts of EAB, illustrating specific applications of these strategies for meeting different preservation goals in lowland and northern hardwood forests in northeastern North America.

Study Implications: The introduced emerald ash borer (EAB) threatens to functionally eliminate ash species from large portions of the United States. Although the impacts of EAB are now widespread in many areas, portions of the United States, such as the Northeast, still contain forests with healthy, mature ash. This presents a unique opportunity to apply the integrated pest management strategies and knowledge gained from other invaded regions to preserve the cultural and ecological values provided by ash in the forest. Multistakeholder partnerships built around preserving the cultural and ecological values of ash have provided a powerful approach for sustaining ash into the future.

Keywords: emerald ash borer, integrated pest management, adaptive management, cultural values, species preservation

The introduction of nonindigenous insects and pathogens (NIIP) threaten many tree species around the globe (Ramsfield et al. 2016), often resulting in losses of timber, alterations in ecological, biological, and habitat functions, and significant consequences for the important traditional uses and values these trees provide to Indigenous peoples and other cultures (Costanza et al. 2017; Turner et al. 2009). In North America, NIIP have affected dozens of tree species (Lovett et al. 2016); they have led to the functional extirpation of American chestnut (*Castanea dentata*), steep declines in American elm (*Ulmus americana*), American beech (*Fagus grandifolia*), and eastern hemlock (*Tsuga canadensis*), and now threaten all ash (*Fraxinus*) species.

Emerald ash borer (EAB; *Agrilus planipennis*), a nonindigenous insect from Asia capable of killing a healthy ash tree in three to five years (Cappaert et al. 2005), has caused widespread ash mortality in eastern North America in recent years, rapidly becoming the costliest invasive forest insect in US history (Aukema et al. 2011; Herms and McCullough 2014; Kovacs et al. 2010). Initially detected in southeastern lower Michigan in 2002, it was likely introduced on solid wood packing material associated with global trade in the early to mid-1990s (Siegert et al. 2014). Since 2002, established EAB populations have been found across much of eastern North America (CFIA 2023; EAB Info 2023) and geographically isolated infestations have occurred west of the Great Plains, including Colorado (2013) and Oregon (2022). Beyond the commercial value of ash timber, ecological value of ash in forested habitats, and the associated costs of treatment, removal, or replacement of ash in urban and

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residential settings, is the wide array of significant cultural values that ash trees provide to Indigenous cultures as an important cultural keystone species (Benedict and David 2000; Garibaldi and Turner 2004; Siegert et al. 2023). Black ash (*Fraxinus nigra*), also known as brown ash, basket ash, and swamp ash, has a long history of being used in Tribal lifeways, ceremonies, medicines, oral traditions, and legends (Costanza et al. 2017; Diamond and Emery 2011), and is particularly vulnerable to EAB infestation (Siegert et al. 2023) (figure 1).

In the eastern United States, EAB continues to rapidly spread across the landscape but trees and forests with healthy, mature ash remain, particularly in recently invaded regions of the northeastern United States, where EAB impacts are currently less widespread. Given the importance of ash both to cultural lifeways of Indigenous peoples as well as to the ecology and economies of working forest lands, there is growing interest among Tribal Nations, public and private landowners, loggers, foresters, and managers in applying various protection measures to maintain ash in rural forested settings threatened by EAB. Effective insecticide treatments exist for protecting mature ash trees (figure 2); however, these have largely been considered in the context of residential or urban settings, leaving key knowledge gaps in how best to approach long-term preservation of ash in forested contexts. Moreover, preservation of nonliving ash components, such as seeds or wood splints for cultural uses, require coordination and broader community engagement to ensure cultural and ecological values of this species are sustained into the future.

Here, we further develop our call to action (D'Amato et al. first paper in this issue) to protect ash in forested settings by revisiting the primary goals of species preservation in the context of NIIP (figure 3) and associated strategies for meeting these goals. We present Indigenous and Western science case studies of ongoing efforts to mitigate the impacts of EAB, illustrating specific applications of these strategies for meeting different preservation goals in lowland and northern hardwood forest ecosystems in northeastern North America. Although framed around the current threat posed by EAB, our goal with this work is to develop a broad framework for species preservation and generate greater recognition of the importance of these strategies as part of adaptive management to current and future NIIP.

Case Studies of Ash Preservation in Northeastern Forests

Preserving species and their cultural, ecological, and economic values is not a new concept in the fields of forestry

Figure 1 Black ash is a cultural keystone species and (a) an ecologically important component of northern forested wetlands. (b) An emerald ash borer–killed black ash showing larval feeding galleries etched into the wood under the bark. (c) Examples of black ash baskets from Indigenous artisans from New York, Maine, Michigan, and Minnesota. Baskets (left to right) crafted by Angello Johnson (Saint Regis Mohawk Tribe), Kelly Church (Match-E-Be-Nash-She-Wish Tribe), Richard Silliboy (Mi'kmaq Nation), Gerald "Butch" Jacobs (Passamaquoddy Tribe at Pleasant Point Sipayik), Sheila Kanieson Ransom (Saint Regis Mohawk Tribe), and Michael A. Benedict (Saint Regis Mohawk Tribe). Photo credits: N. Siegert.

Figure 2 White ash is the dominant *Fraxinus* spp. in mixed northern hardwoods in the northeastern US. (a) Emerald ash borer readily attacks overstory white ash and is spreading throughout the Northeast, threatening the sustainability of the white ash resource. (b) Several stakeholders, including state agencies and conservation organizations, are treating groups of pole- and sawtimber-sized white ash in forested areas with systemic insecticides to preserve seed-producing trees in areas where they want to keep ash on the landscape. Photo credits: N. Siegert.

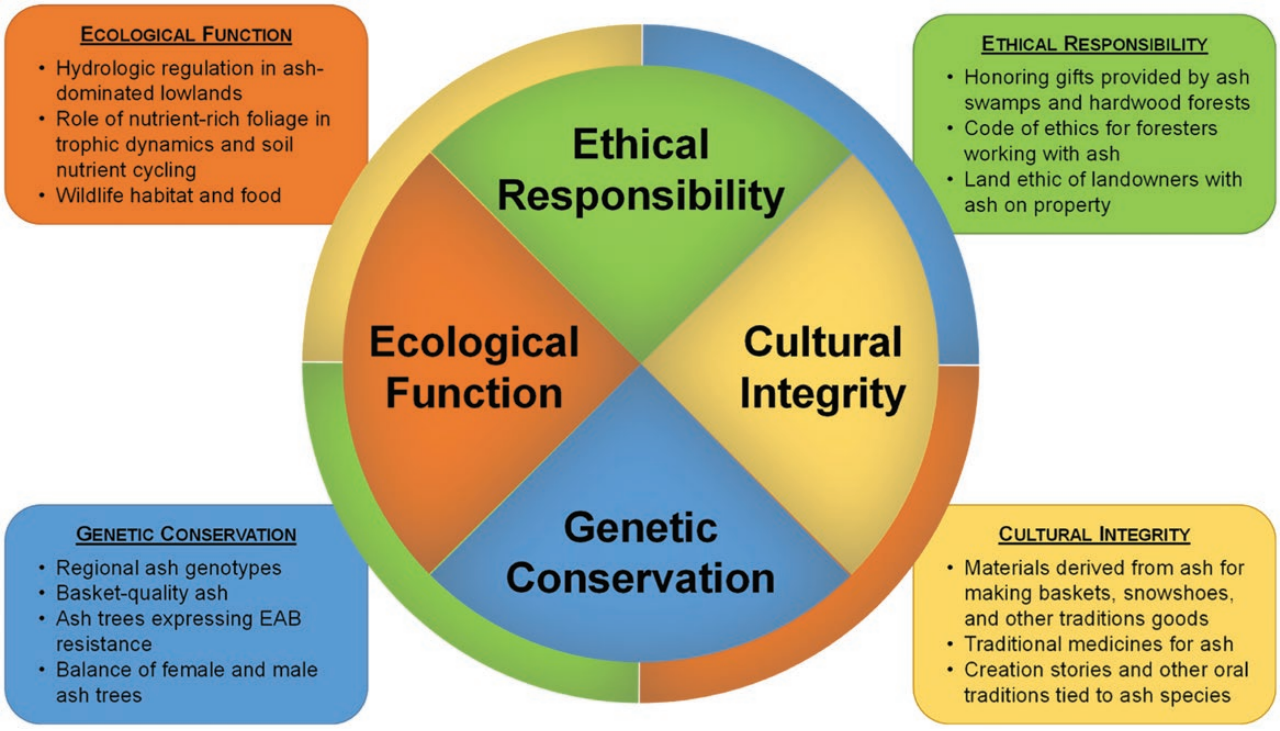

Figure 3 Values guiding preservation efforts related to ash species (*Fraxinus* spp.) in northeastern North America with ethical, cultural, ecological, and genetic considerations specific to these species and the contexts within which they occur.

and biological conservation; however, NIIP create a challenging and uncertain context for how to best sustain a species threatened by pests with no historic or natural analog. The following case studies highlight examples of the partnerships, information exchange, and creativity being leveraged to tackle the novel threat posed by EAB to ash species in the northeastern United States. Our first case summarizes the efforts of several Tribal Nations in preserving black ash, whereas the second case illustrates the landscape and regional-scale ash preservation efforts being led by state forest health specialists

Figure 4 Tribal partnerships have been sustaining ash in northeastern forests for time immemorial. (a) Collection of black ash seeds in Akwesasne, NY. (b) Artisanal ash harvesters visit with private landowners to share site conditions contributing to quality basket grade ash as well as access to sustaining cultural lifeways. (c) Saint Regis Mohawk Tribe natural resource management crew in black ash stand management site. (d) Ash inventory trainings have enabled sharing of knowledge and ideas, relationship building, and development of actionable priorities. Photo credits: a, Akwesasne Task Force on the Environment, b, T. Everett, c, Akwesasne Task Force on the Environment, d, J. Daigle.

and land conservation organizations. Although each case is framed within the context of a primary preservation value (e.g., cultural integrity), each collaterally achieves other values, highlighting the many benefits of active engagement with species preservation (figure 3). For each case, we highlight the crucial role of partnerships and the current and future strategies being used. We conclude with lessons learned to inspire creative action and practical considerations for the preservation of species for different values and various social and ecological landscape contexts.

Case Study 1: Preserving the Cultural Integrity of Black Ash

Across the range of black ash, Tribal Nations in the United States and First Nations in Canada have been working to address the threats posed by EAB to this cultural keystone species. These Nations have set forth management goals consistently focused on protecting the important cultural lifeways and practices historically linked to this species. The management goals associated with the following case study align with the preservation value of "cultural integrity" and will be the lens used to discuss Tribal-led initiatives from the Akwesasne Mohawk Community located in New York and Wabanaki Confederacy located in northern New England and adjacent Canada.

Akwesasne Task Force on the Environment Partnerships

The Akwesasne Task Force on the Environment (ATFE) was developed within the Akwesasne Mohawk Community and has been leading black ash restoration through ash seed collection efforts throughout the region for decades and documenting procedures to propagate and replant black ash (figure 4; Benedict and David 2000). This effort preceded the arrival and establishment of EAB in North America, establishing a network of partners that was in place to respond once EAB was detected, including the strengthening and renewal of inter-Tribal relationships that have existed since time immemorial.

Collaboration among different Indigenous basketmaking communities has been a critical element in responding to the EAB invasion for many Tribal Nations. Through Tribal collaboration and information sharing with federal and state agencies from already invaded midwestern regions of the United States, northeastern Tribal Nations are working to respond

with a sense of urgency to the spread and impact of EAB. Building on concurrent research, historical documents, and community engagement (Tribal elders, leaders, and artisans) for input, the ATFE and its partners developed a comprehensive preparedness and response plan to EAB (ATFE 2015).

Strategies

Ahead of the arrival of EAB in the region, ATFE began contributing to the ever-growing knowledge base of ash management by experimenting with stand density management to enhance forest health by improving stand quality and diversity. Since the arrival of EAB to their forests, ATFE has continued to work to understand the importance of protecting and maintaining different size classes of ash for promoting tolerance to EAB impacts, maximizing ash seed production, and regeneration.

As part of ATFE's EAB response plan, systemic insecticides are being applied to groups of overstory ash trees and releasing biological control agents (i.e., parasitoid wasps). Although biological controls are not likely to save any overstory ash trees, there is hope that establishing them now will contribute to suppressing EAB infestations on ash regeneration at these sites over the long term. Deciding to inject trees with systemic insecticides was a difficult decision due to the Community's sensitivity towards chemicals consequently contaminating Tribal lands by neighboring industries. Ultimately, however, the cultural importance of black ash catalyzed the Tribe to apply insecticides to exemplary black ash overstory trees across the land base.

Maine Indian Basketmakers Alliance and Brown Ash Task Force

Partnerships

Like the ATFE, communities within the Wabanaki Confederacy, including the Cowasuck and Nulhegan Bands of Abenaki, Houlton Band of Maliseet Indians, Mi'kmaq Nation, Passamaquoddy Tribe at Pleasant Point Sipayik, Passamaquoddy Tribe at Indian Township, and Penobscot Nation, were taking steps towards ash preservation that predated the arrival of EAB in North America. In 1993, Wabanaki artisans created the Maine Indian Basketmakers Alliance (MIBA) to foster the preservation of black ash basketry traditions (Daigle 1995; Neptune and Neuman 2015). In the mid- to late 1990s, MIBA partnered with university researchers and state forest health specialists to form the Brown Ash Task Force (BATF) to address concerns about the declining health of ash trees in the region. The research and collaboration of the BATF was one of the first of its kind and shared similar goals to that of the ATFE. Soon after, BATF and ATFE partnered to form a region-wide inter-Tribal contingency.

With the arrival of EAB, the BATF expanded to include federal subject matter experts and regulatory survey specialists. This comprehensive inter-Tribal and multiagency partnership ensured that a Tribal perspective was integrated into Maine's response to EAB. Additionally, the BATF organized meetings with basketmakers and harvesters from Michigan, New York, and Maine to share their experiences and concerns about losing black ash to EAB (Ranco et al. 2010).

Strategies

The BATF, with its growing list of partners, helped to facilitate Maine becoming one of the earliest states to enact an emergency order forcing a regulatory ban on the transport of firewood across state lines and the Canadian border (Daigle et al. 2019; Ranco et al. 2012). These early education and outreach efforts sparked campaigns across the region warning recreationists and the forest industry of the issues surrounding firewood transport, likely contributing to delaying the introduction of EAB to Maine through infested firewood movement.

Since detection of EAB in Maine in 2018, several key next steps are emerging to provide options to inform the decisions of landowners and managers. As partners work collaboratively to share information about these options, it will be critical to incorporate efforts toward facilitating access to ash for Tribal harvesters and basketmakers (figure 4b). Doing so will support efforts to sustain cultural practices and encourage the consideration of management actions and resource inventory in these forests. For instance, protocols have recently been developed for inventorying ash resources across the Wabanaki territories (Everett 2019). Building on the network of communication established since the mid-1990s, the protocols were well informed by efforts of the ATFE and others. The ash inventory protocols have been adopted by Tribal entities across the region and have led to trainings offered to Tribal and non-Tribal foresters alike as they continue to prepare for EAB (figure 4d). Ash inventory trainings have enabled the sharing of knowledge and ideas, relationship building, and development of actionable priorities. Through the guidance of the partners mentioned above, this work is also coinciding with efforts to bolster ash seed collection among public and private landowners with the development of a comprehensive ash seed collection manual.

Case Study 2: Landscape and Regional Preservation of Mature Ash Ecological Functions

Numerous strategies, tactics, and tools to mitigate EAB impacts to our forests have been developed in the 20-plus years since EAB was first detected in North America. The timing of the EAB invasion in the Northeast affords us the opportunity to take advantage of management tools that did not exist for other parts of the country that were infested earlier. In addition, that borrowed time has allowed for the impacts on ash dynamics in post-invasion forests to be more closely studied and better understood; for example, loss of the ash seed bank and overstory seed-producing trees, dominance of non-ash residuals, increased competition with invasive plants affecting ash regeneration, and rapid change in growing conditions following ash overstory losses in some forested wetland habitats. Accordingly, several stakeholders in the Northeast, including state forest health specialists, university land managers, and land conservation organizations have started preemptively treating mature ash with insecticides to keep pockets of seed-producing ash on the landscape. Like the Indigenous case study earlier, the preservation values here include a blend of the four goals outlined in D'Amato et al. (first paper in this issue)—ecological functioning, genetic conservation, cultural integrity, and ethical responsibility.

Partnerships

Landscape and regional-scale ash preservation efforts of state forest health specialists, university land managers, and land conservation organizations are largely supported by federal

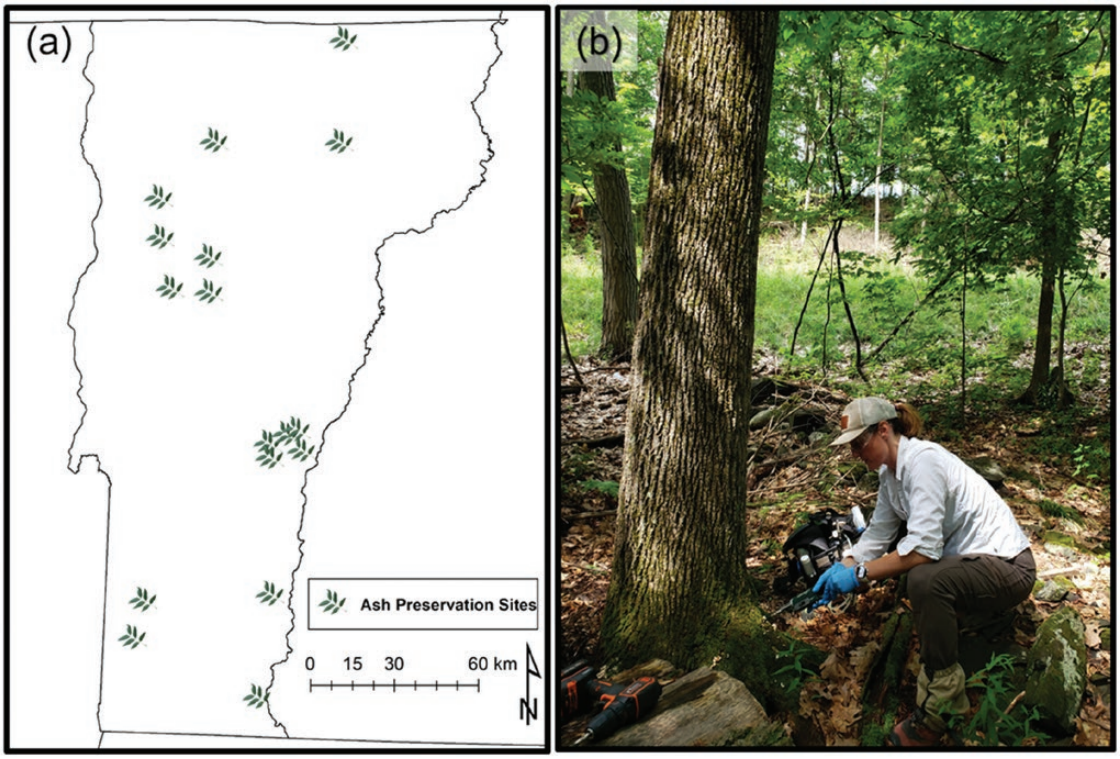

Figure 5 (a) Locations of ash preservation sites for several conservation organizations in Vermont. (b) Sites often include chemical treatment of 12–15 overstory ash trees. Photo credit: C. Cusack.

agencies through technical support, methods development, and funding mechanisms. Regional invasive species management in forests on federal, state, and Tribal lands, including suppression and eradication of damaging forest insects and pathogens, is often coordinated by the USDA Forest Service in association with other federal agencies, state agriculture and forestry agencies, Tribal Nations, conservation organizations, and university partners. Forest health specialists at federal and state levels routinely monitor and manage forest pest conditions and outbreaks, as well as provide management assistance and technical advice to other interested stakeholders. Although a range of EAB management tools are used by these partners, this second case study will focus on recent efforts in the Northeast to use chemical treatment to protect mature overstory ash trees from EAB in forested areas. These efforts have included partnerships across state agencies, such as New Hampshire Forests and Lands and Vermont Forests, Parks and Recreation, conservation organizations, including the Vermont Land Trust and Appalachian Trail Conservancy, and two national forests, the Green and White Mountain National Forests.

Strategies

The northeastern United States continues to be on the leading edge of the EAB invasion in North America and is characterized by a gradient of EAB infestation levels—from heavily infested, to lightly infested but building, to presently uninfested. As a result, management likewise varies considerably based on the phase of the invasion. For instance, management in postinvasion forests may primarily involve restoration activities whereas management in midinvasion forests may focus more on pest suppression activities. Similarly, preinvasion forests that presently remain uninfested rely on preventative measures, such as intensive detection and monitoring surveys, quarantines, and compliance with regulations for early detection of infestations and to reduce human-assisted spread of infested ash firewood and other ash materials to new areas.

Not surprisingly, strategies of participating state agencies, universities, and land conservation organizations to preserve overstory ash through insecticide applications share many similarities. Some variation occurs primarily based on operational considerations and agency objectives, such as the number of sites or trees that can be reasonably treated over time with the funding and staffing resources that are available. The number of sites treated may range from only a few to a hundred or more across an agency's forested lands (e.g., Liu et al. 2018; figure 5). Site selection may involve characteristics such as specific habitats, aspect, elevation, ash density and distribution, and forest composition, depending on an agency's specific objectives. The number of treated trees per site is typically in the 12–15 tree range but may increase upwards of 20 or 30 trees per site as agencies optimize how to achieve preservation goals while maximizing how many sites are manageable to treat. In some unique cases, agencies are planning to protect upwards of 100 trees at a site where there is added value for legacy, ecological function, and visitor interest.

Tree diameter affects how much insecticide is needed per tree (and associated time and cost), so agencies develop tree selection protocols to achieve objectives while balancing operational limitations. Many choose to target pole timber to smaller sawtimber-sized trees in the 8–12 in. diameter class, although sawtimber-sized trees in the 12–20 in. diameter class may occasionally be targeted for chemical treatment. Other common tree selection protocol variables include location

and proximity to other treated trees, tree form and architecture, and tree health and soundness (de Andrade et al. 2021). Because ash are dioecious tree species and the goal is often to protect as many seed-producing trees as possible per site, trees are typically selected with a 3:1 or 4:1 ratio of female to male trees. Ash trees in the Northeast do not necessarily produce seed every year, so identifying seed-producing trees may take multiple site visits over multiple years. Occasionally, agencies may choose to girdle or fell non-ash competitors in close proximity to treated ash trees to potentially increase vigor, improve growing conditions, or gap sizes necessary to recruit ash regeneration.

Lessons Learned

Foresters of all types (public or private, industrial or consultant, Tribal or non-Tribal, federal, state, local, NGO, extension, researcher) are in a critical position to ensure a future that includes ash and all its accompanying values. We have "hard skills" such as intimate knowledge of local forests, an understanding of how forests grow and change, the ability to inventory, monitor, and quantify forest attributes, experience with interventions to help shape forest structure and composition, and the business experience to put projects together that get things done on the ground. All are critical to sustaining ash. The complementary nature of recognizing both the traditional ecological knowledge and the Western science-based knowledge associated with these tree species and EAB as counterparts that are equal in value will be essential in fully understanding and developing solutions.

Across these case studies in the Northeast, a common lesson learned is the importance of multistakeholder partnerships whose constituents are passionate about ash preservation. Beyond the hard skills foresters possess are the many relationships that are acquired through the stewardship of forests, including connections with family forest owners, community leaders, conservation organizations, and other natural resource professionals, including forest health specialists and professional arborists. We must seek out partnerships with all of those who share our goals. These relationships can be foundational to the partnerships necessary to achieve ash preservation at the scales necessary to sustain the species. Partnerships broaden reach across the landscape and increase limited resources through the pooling of assets and expertise. As we continue learning and assessing the efficacy of the latest adaptive management strategies and the latest in genetic research surrounding these tree species, we are hopeful that ash species can remain on the landscape for generations to come, which resonates with the ethical responsibility preservation goal. These relationships do not stop with human interrelations, as the care and reciprocity that Indigenous peoples bring to this realm of ash preservation underscore that we all have relationships with nonhuman beings in these spaces as well and whether it be a cultural obligation or an ethical one, we all have a responsibility to care for these trees.

Perhaps the most important lesson learned through these partnerships is the importance of information sharing. Although many foresters get into the profession to spend time with trees and not people, there is tremendous benefit to sharing knowledge and experience with one another, particularly in the face of these novel threats. Finding ways to keep ash on the landscape (and likely other species in the future as we continue to see more NIIP) will take creative and innovative thinking. We will need to rely on the "art" as much as or more than the "science" of silviculture. That will inevitably result in efforts that succeed and efforts that fail. Sharing our lessons learned from each result will allow foresters to learn from the lessons of others, not making the same mistakes, and advancing success through their replication and evolution.

Conclusion

Our forests are increasingly being recognized for their provision of life-sustaining cultural and ecological benefits. Ironically, our forests have also likely never faced so many novel challenges now threatening these benefits, including NIIP. As such, the forestry profession stands at a watershed moment and must decide how it will respond to these challenges, often in new ways not previously imagined. We argue that the extinction of a species and its cultural and ecological contributions is unacceptable and is counter to the reciprocal relationship of care between humans and land that we need to foster. The case studies we presented reinforce this ethos and highlight that many diverse partnerships are not giving up on meeting the ecological need, ethical responsibility, and crucial cultural imperative to sustain ash into the future.

We find ourselves in uncertain times facing novel conditions, but we are not unarmed. Moreover, as policy and other funding sources continue to realize the uncertainty and challenges posed by NIIP, including EAB, more opportunities for preservation may be realized. The forestry profession is built on the foundation of ecological knowledge and uses this to shape forest species composition, structure, and function. The knowledge and experience of forest stewards, especially that of Indigenous peoples, is an invaluable component in our efforts to conserve ash. However, we must be open to add other components that are not necessarily part of our profession's history, such as the use of chemical treatments once considered only the domain of arboriculture and the evolution of what our ethical responsibilities are in stewarding forests during novel times. We must also see ourselves as a part of a much larger effort, intentionally facilitating the partnerships and information-sharing that are essential to the preservation of a species. If we can blend these traditional and emerging opportunities, we believe that we will find that we are, in fact, not helpless. We can be agents of change, ensuring the continuation of a species and the many benefits it provides. The resilience of Tribal Nations in addressing this threat and their dedication to sustaining these species for future generations should serve as a source of hope and inspiration as we work to honor the many gifts our forests give to us, despite novel and challenging times.

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