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Understanding Private Landowners Involvement, Knowledge Sharing, and Social Networks in Conservation of Brown Ash in the Face of Emerald Ash Borer

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UNDERSTANDING PRIVATE LANDOWNERS INVOLVEMENT, KNOWLEDGE SHARING, AND SOCIAL NETWORKS IN CONSERVATION OF BROWN ASH IN THE FACE OF EMERALD ASH BORER

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A DISSERTATION

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UNIVERSITY OF MAINE GRADUATE SCHOOL LAND ACKNOWLEDGEMENT

The University of Maine recognizes that it is located on Marsh Island in the homeland of Penobscot people, where issues of water and territorial rights, and encroachment upon sacred sites, are ongoing. Penobscot homeland is connected to the other Wabanaki Tribal Nations— the Passamaquoddy, Maliseet, and Micmac—through kinship, alliances, and diplomacy. The University also recognizes that the Penobscot Nation and the other Wabanaki Tribal Nations are distinct, sovereign, legal and political entities with their own powers of self-governance and self-determination.

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By Emily T. Francis

Dissertation Advisor: Dr. John Daigle

An Abstract of the Dissertation Presented
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North America is facing a deadly invasive forest pest: the emerald ash borer (EAB, *Agrilus planipennis* Marsh.), which has the ability to eliminate brown ash trees (*Fraxinus nigra*). The geopolitical boundary for Maine is the unceded territory of the Wabanaki People, and the final northeastern US state for EAB to infest. EAB threatens brown ash which holds importance environmentally, economically, culturally, and intrinsically to the Wabanaki People and the state of Maine. This dissertation aims to determine the direction of outreach and research to sustain brown ash trees for the future through an important stakeholder group, private landowners, to explore how the network of those protecting against EAB has developed and the future for this as a long-term conservation problem. Objectives of this study include: determining private landowner understanding and intentions for managing ash against EAB, developing a community-focused ash seed collection manual, and analyzing the network of relationships of the parties involved with brown ash conservation and protection against EAB in Maine. Private landowners of forested land in Maine were surveyed using Involvement Theory to gain understanding of the knowledge of brown ash and EAB and the management intentions for protecting ash in Maine. An ash seed collection manual was developed with input and review by various research partners and ash experts to create a 'living document' to be updated in perpetuity as the ash seed research needs develop. The network of those protecting ash against EAB in Maine was analyzed for connectedness using Social Networking Analysis. The outcomes of this research will: increase protection of ash as an ecological and cultural resource providing insight into the plans of management by private landowners, increase the ability for ash to be protected and researched with community efforts in seed collection, and an understanding of the social network that

works together to slow the spread of EAB and respond to the aftermath of EAB to sustain brown ash on the land.

DEDICATION

Barbara and Myron Francis

You have been with me every step of the way.

This is for you.

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LIST OF ABBREVIATIONS

APCAW: Ash Protection Collaboration Across Wabanakik

APHIS: Animal and Plant Health Inspection Service

ARS: Agricultural Research Service

BATF: Brown Ash Task Force

ME DACF: Maine Department of Agriculture, Conservation and Forestry

EAB: Emerald Ash Borer

FFO: Family Forest Owner

MIBA: Maine Indian Basketmakers Alliance

MFS: Maine Forest Service

NGO: Non-governmental organization

NSL: National Seed Laboratory

NPGF: National Plant Germplasm Facility

NWOS: National Woodland Owners Survey

SNA: Social Networking Analysis

USDA: United States Department of Agriculture

WSP: Wild Seed Project

CHAPTER 1
INTRODUCTION TO DISSERTATION

1.1 Introduction of EAB to North America

The United States and Canada are currently facing an invasive species with the ability to eliminate ash trees, and there is specific concern for the brown ash, genus *Fraxinus*, which is referred to as black ash outside of Maine (Maliseet/Passmaquoddy: wikp, Penobscot: wíkəpəyak Mi'kmaq: wiskoq, *Fraxinus nigra*) (Baumflek, Emery, & Ginger, 2010). Emerald ash borer (*Agrilus planipennis*, EAB), a threat to native ash species, has spread outward from its first detection in Detroit, MI (USA) and Ontario, Canada in 2002, reaching Maine in 2018 (Haack et al., 2002; Kovacs et al., 2010; Maine Department of Agriculture, Conservation, Forestry (DACF), n.d.). Mortality of infected brown ash trees has, so far, been almost 100%. As Herms et al. stated, "in terms of invasive forest pests, EAB may well represent a worst-case scenario" (p. 23, 2010). Brown ash is essential to the culture and tradition of the Tribal Nations in the Dawnland, those in the Wabanaki Confederacy, the unceded territory that is geopolitically called Maine (Costanza et al., 2017). EAB's impending spread across Maine and the assumed effect on brown ash as an environmental and cultural asset, creates a dire concern for the health of brown ash habitat and culture intrinsically tied to this tree species.

1.2 EAB: An economic and environmental threat in Maine

There are three species of ash trees found in Maine: brown, green (*Fraxinus pennsylvanica*) and white (*Fraxinus americana*). In a decadal economic projection spanning 2009 to 2019, Kovacs et al. (2010), estimated that the cost to remove EAB infested in residential and municipal green and white ash trees in the state of Maine would be between $255 million and $381 million. As EAB was only detected in Maine in 2018, this projection has not come to fruition, yet. The sheer economic risk associated with removing all municipal and residential ash still remains and does not minimize future costs that treatment and removal of dead or infected trees will incur to municipalities and landowners.

Ash is commonly used as a source of firewood for both camping and home heating purposes, as well as nursery stock and landscaping. In the forest, ash is an important species for the timber industry;

eventual loss of white ash, a species used for wood veneer, baseball bats, building materials, among other items, will be a significant loss to forestry in Maine and the industries that depend on it.

Brown ash is sometimes called a “trash tree”, as it is considered by some a non-timber forest product (Baumflek, Emery, & Ginger, p. 14, 2010). However, this species still drives the Wabanaki basketmaking economy, which is directly tied to the Wabanaki People in Maine. Ash is depended upon by multiple industries and EAB is a direct threat to the livelihoods of many Maine and Wabanaki businesses and artisans.

The US Department of Agriculture (USDA) implemented an inter-county to interstate quarantine in 2003 that limited businesses and citizens movement of ash and ash products across set boundaries (Emerald Ash Borer; Quarantine and Regulations, 2003). The USDA quarantine was lifted in 2021, but the Maine Forest Service continues to enforce and update a state quarantine as EAB continues to spread to new areas. It is necessary to limit the spread of EAB because it continues to impact businesses and culture that depend on ash. EAB’s impending spread to the entire state will also heavily impact municipalities and private landowners who will have to remove ash trees that have died because of this forest pest. Ash also has inherent environmental benefits that are not economically quantifiable but need to be reviewed (Grinde, et al., 2022b).

Beyond the economic benefits of the three ash species, there are numerous environmental benefits, which each species provides to the landscape. All ash support specific environmental niches that they thrive in, although mixed stands of ash are not uncommon on the landscape in the Northeast. White ash is typically found in upland areas of low hills, whereas green ash is found in low hills with moist soil, for example, on riverbanks (Maine Forest Service, 2008). Brown ash is found where ‘it can keep its feet wet’ in swampy areas with a high water table, but not submerged year round. Brown ash is particularly important for the nutrients it provides to its local surroundings in the form of leaves. These trees are typically the last to leaf out in the spring and one of the first to lose their leaves in the fall. This layer of ash leaves is very important to the whole ecosystem, breaking down and supplying nitrogen to the surrounding habitat. Ash leaf litter is generally preferred by many invertebrate species in riparian forests, and lack of ash leaves has a significantly slower decomposition rate compared to other species (Kreutzweiser, et al., 2019).

Losing brown ash trees changes the forest by opening the canopy, loss of yearly nitrogen to the soil by fallen leaves, and loss of hydrologic management from the brown ash root system (Davis, et al., 2019).

Findings from Grinde, et al. (2022a) indicate that, loss of brown ash in the Great Lakes region, where there are pure brown ash stands, "increased ponding extent and longer hydroperiods [which] may be beneficial for some amphibian species, the loss of the forest canopy will result in an overall decrease in bird diversity and reduce forest connectivity for all species," (p. 1). With EAB a direct threat to all ash species, brown ash habitat is in danger for not only the loss of the trees themselves, but the ecosystem as a whole.

While not all brown ash habitat is in its own species dominant stands, as is the case in the Great Lakes region, there will be significant changes to the mixed forests in Maine, changing the hydrology, forest makeup, nutrients of the soil and potentially, the connectivity of bird habitats and diversity, as well as loss of invertebrate species dependent on brown ash (Grinde, et al., 2022a; Kolka, et al, 2018; Wagner & Todd, 2016; Youngquist et al., 2020). As Maine is the last New England state to be infested by EAB, the greater part of the state with EAB-free forests is the last in the Northeast to exist without guaranteed high mortality of this very important species of tree. As EAB will continue to spread throughout the state, research on ash, management and protection is key.

1.3 Brown ash: Cultural keystone species in the Dawnland

Basketmaking or weaving is an art form and livelihood of the Wabanaki Confederacy (in alphabetical order: Houlton Band of Maliseet Indians, Mi'kmaq Nation, Passamaquoddy Tribe at Motahkomikuk, Passamaquoddy Tribe at Sipayik, and Penobscot Nations) which has survived centuries and uses principally brown ash (Frey, Emery & Greenlaw, 2019; Hardy, 2009; Neptune & Neuman, 2014). Methods for harvesting, processing, and making ash baskets are traditions passed down between Tribal artisans that is tied to the way of life people have followed since time immemorial in the Dawnland, the geopolitical region of Maine and beyond. EAB is a threat to generations of art, traditional knowledge and way of life that no other species of tree can replace, even playing an essential role in one of the Wabanaki creation stories (Costanza et al., 2017). According to this story, brown ash takes the role of where people emerged from, when one such tree was struck by an arrow by Glooskap, an important cultural figure in Wabanaki storytelling (Frey, Emery & Greenlaw, 2019).

The economics of this basket making industry is also incredibly important to the rural communities where many artists live and often depend on baskets for income, and baskets from notable artisans can sell for thousands of dollars (Daigle & Putnam, 2009; Neuman, 2010; Neptune & Neuman, 2014; Voggesser et

al., 2013). Figure 1.1 provides an example of a brown ash pack basket that is popular for hunting and fishing in New England by Mi'kmaq artisan Richard Silliboy, and an intricate brown ash basket with leather lid and clasp by Passamaquoddy artisan Gabriel Frey. Both of these artisans come from generations of Wabanaki basketmakers and the art form has been passed down for centuries. For example, Frey is a thirteenth generation basketmaker (Frey, Emery & Greenlaw 2019). With the loss of brown ash as a material for traditional basket making, EAB will be detrimental to the Wabanaki basketmakers, as it has already affected other Algonquian-related Tribal Nations across the northeastern US and southeastern Canada, (Costanza et al., 2017; Neptune & Neuman, 2014).

Figure 1.1. Examples of Wabanaki-made brown ash baskets. Left: Brown ash pack basket by Mi'kmaq basketmaker Richard Silliboy ([Photography of ash basket by Richard Silliboy] (n.d.)). Right: Ash basket and workshop of Passamaquoddy basketmaker Gabriel Frey (Bullock, 2021).

Ash that is currently healthy on the landscape is a finite resource with multiple factors limiting traditional stewardship and use. As of now, is it unknown if using brown ash that has been treated with insecticides against EAB is possible or safe to be handled in basketmaking, although this is being currently researched at the University of New Hampshire. Ash splints used for weaving can be pounded, split and saved for later use, if stored properly, but for how long is also unknown. Availability of basket quality brown ash varies from each stand. However, only between 1% and 10% of brown ash is basket quality, and that quality is specific to each basketmaker's standards, preferences and design choices (Silliboy, Frey & Newall, personal communication, 2023). This limits the source material for brown ash baskets before EAB is even present. While brown ash stands are traditionally curated and cared for by Wabanaki People, settler- to

modern-day land theft excludes this environmental caretaking, as 93% of land in Maine is privately owned (McCaskill et al., 2016). Therefore, access to brown ash is limited to agreements by individual landowners to individual basketmakers, which is a further strain on access before EAB is present. EAB further compounds access challenges, endangering this culturally important art form.

1.4 Federal and state changes to EAB regulation and management

The first quarantine against the movement of ash over political boundaries took place in Michigan in 2002 as researchers and entomologists were first learning about EAB and recognizing the damage the species had caused (Haack et al., 2002). After EAB was detected in Ontario, the Canadian government attempted to create an "ash-free zone" near the town of Chatham, removing swathes of ash trees in an effort to stop the spread of EAB further into Canada (Mackenzie & Larson, 2010; Marchant, 2007). Unfortunately, these measures of removing the host species for EAB did not stop the insect from spreading, and it is now recognized that removing all ash, whether or not EAB is present, does not slow, but increases the spread of EAB (Mackenzie & Larson, 2010). By February of 2024, 36 US states had counties with detections of EAB, which had now spread west to Portland, Oregon, as seen in Figure 1.2. A federal quarantine by the U.S. Department of Agriculture restricted the movement of ash and untreated ash materials across the over 1,200 infested counties, but was lifted in January 2021 due to the extent EAB was detected in the U.S. and the acknowledged unlikelihood of removal of the invasive pest (Animal and Plant Inspection Service, 2020). As of February 2024, there were five Canadian provinces with EAB regulated areas, all of which confirmed infestations (Canadian Food Inspection Agency, 2021; Emerald Ash Borer Network, 2018).

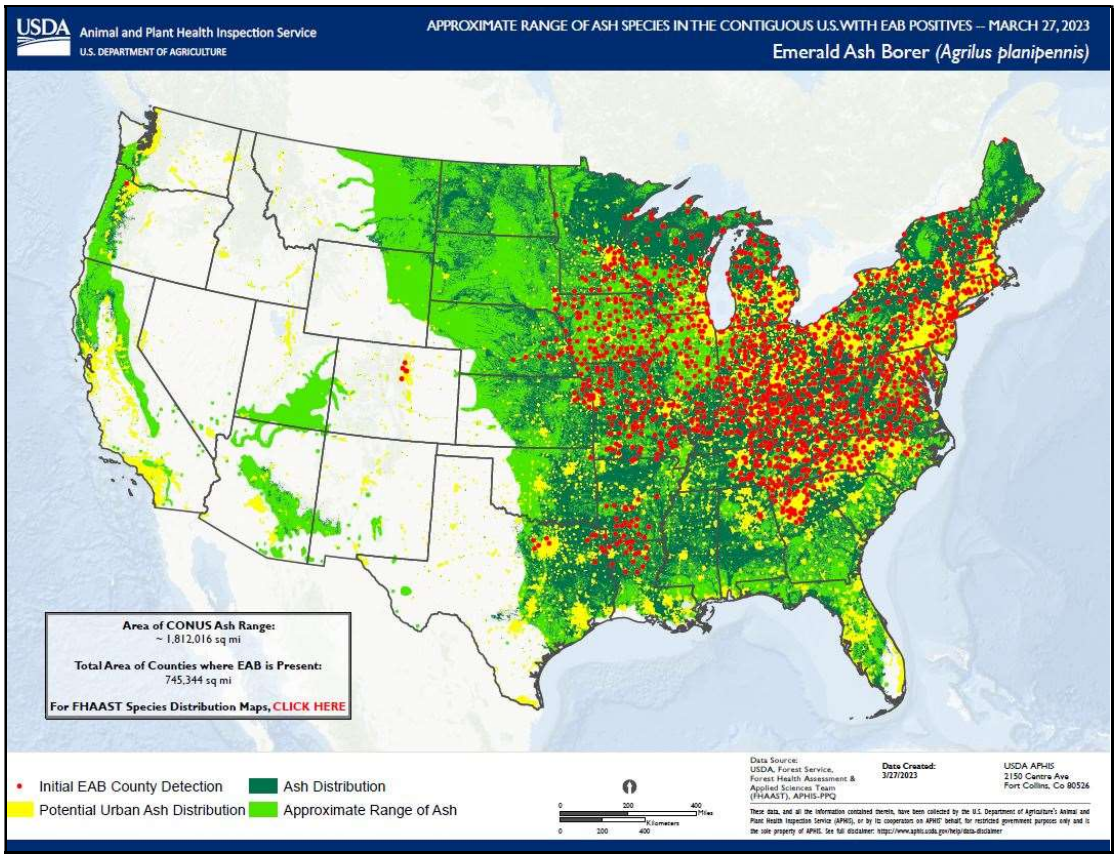

Figure 1.2. USDA map highlighting initial county detection of EAB within the United States (US Department of Agriculture [online], 2024).

With the lifting of the U.S. federal quarantine, efforts shifted to combating EAB with biological controls (biocontrols). Focus turned to a program started in 2007, led by the USDA Animal and Plant Health Inspection Service (APHIS), which is also operated in partnership with the Agricultural Research Service and US Forest Service (USDA–APHIS/ARS/FS, 2021). This biocontrol program selected four parasitic wasp species (*Oobius agrili*, *Spathius agrili*, *Spathius galinae*, and *Tetrastichus planipennisi*) from the native range of EAB, which had been tested extensively for release in the U.S. (US Department of Agriculture, 2020; USDA–APHIS/ARS/FS, 2021). In concert with state agriculture agencies and forestry departments, requests for these wasps have been made to the USDA for locations where EAB has become established. If approved, appropriate and available wasp species are be shipped to a release site from the Biological Control Production Facility in Brighton, MI (USDA–APHIS/ARS/FS, 2021). APHIS conducts long term monitoring if release takes place to determine if the wasp species has established in the area. In Maine, the Department of Agriculture, Conservation and Forestry (DACF) has 7 active release sites, as of

2024 (C. Teerling, personal communication, March 4, 2024). It is hoped that long term release and monitoring of these biocontrols will effectively combat the EAB population and create a defense against this invasive species alongside native predators, like woodpeckers and other insectivorous birds (Koenig & Liebhold, 2017; Lindell et al., 2008)

In January 2021, federal EAB quarantine was lifted though the state of Maine decided to uphold the quarantine boundaries and continue implementing them as EAB spreads across the state. This effort is managed by the Maine DACF, the same department that works with USDA APHIS for release of biocontrols. State forestry professionals including horticulturists and entomologists have worked to prepare Maine for the infestation of EAB and have continued this effort to slow the spread.

Two efforts, beyond biocontrols, have been crucial: state-wide monitoring of EAB spread and public outreach and education. The monitoring of EAB is state wide and has included trap programs, which use different types of tree hanging devices to lure EAB to a location to be caught and identified, and tree girdling, where landowners create a sink to attract EAB by girdling a tree on their property. An infested tree is then cut down after a period of time and debarked to assess the presence of EAB. There are other management strategies that landowners can take, which are suggested by DACF and researchers, including: harvesting merchantable ash ahead of EAB, identifying different size classes of brown ash to keep on the landscape, allowing seed collectors access to brown ash, and using chemical insecticide treatments. These management strategies will be discussed in Chapter 2.

Public outreach and education has been extensive, starting with the DACF website, which provides a plethora of information for Maine citizens and beyond on EAB, the spread within the state, how to identity and report, as well as how to prepare ash for EAB. DACF creates and supplies publications for homeowners, municipal managers, forest managers and solid waste handers on recommendations for caring for ash trees, rather than targeting the pest. This includes D'Amato et al.'s (2020) "Ten Recommendations for Managing Ash". Noticeable outreach can be seen on almost every road on the borders of the state with signs warning about moving firewood and the dangers of invasive species, which can also be seen at visitor centers along Interstate 95. The DACF holds forums for municipalities and private citizens to be updated on quarantine zones and the spread of EAB quarterly. It is also common to see DACF EAB and invasive education tabling at events like the annual Vacationland RV & Camping Show, State of Maine Sportsman's Show, the Common Ground Country Fair, and many others, which gather very large numbers of Maine residents and

vacationers. The current marketing of Maine to tourists identifies the state as "Vacationland". It is essential that both those living in Maine and visitors understand the dangers of moving wood materials that could hold invasive species. This is why public outreach and education is important to the DACF. However, due to funding and all of the other invasive species, the USDA and DACF cannot be the only organizations working against EAB in Maine.

1.5 Development of the Brown Ash Task Force and focus on seed collection

While federal and state efforts may be the most visible or publicized, other entities have also been preparing for EAB in Maine. These organizations include Tribal Nations, academic researchers, and non-governmental organizations. Researchers at the University of Maine, John Daigle, PhD and Darren Ranco, PhD, both of the Penobscot Nation, became concerned with the health of ash trees in the early 2000s and approached the Maine Indian Basketmakers Alliance (MIBA) to discuss the future of brown ash. MIBA expressed concern about an invasive species recently found in the Great Lakes region, which had been brought to their attention by Tribal Nations experiencing the loss of their brown ash stands in Michigan. This call to research came directly from the MIBA, which requested that information be gathered to understand what was going on in the Great Lakes region and what needed to be done in Maine to prepare. The result was the creation of the Brown Ash Task Force (BATF), a group of interested parties to learn and update the broader community about EAB and the threat it posed to Maine. For over a decade this group has kept in touch, communicating and visiting Tribal Nations and basket harvesters in Michigan and New York. EAB reached Maine in 2018, and since then the BATF's focus has shifted from fact finding and preparing for detection, to monitoring the spread and researching options for protection of ash.

One priority that has come out of BATF is the need for proactive ash seed collection. At the time of EAB's first detection in 2002, there was very little stock of ash seeds held by major seed banks (Knight, Karrfalt, & Mason, 2010; Widrlechner, 2010). As EAB has spread, ash seed collection for genetic research and conservation has become a priority for researchers at both US and Canada government seed centers (Benson et al., 2012; Hausman et al., 2014; Hendrickson, 2012; Karrfalt, 2013; Simpson, 2010). The US has data held at the US National Center for Biotechnology Information and US Department of Agriculture germplasm facilities. However, a majority of the research has focused on brown stands in the Great Lakes. The Northeast, including Maine, has not seen the same research efforts or seed collection taken place

(D'Amato, et al., 2018; Klooster, et al., 2014; Kolka, et al., 2018; Siegert, Engelken & McCullough, 2021). A clear purpose exists for more genetic data and seed storage, essential for both research and future rematriation efforts.

Private landowners play an enormous role in land management in Maine, with less than 7% of land owned by federal, state or municipal governments (McCaskill et al., 2016). Another interest of the BATF is to understand what private landowners know about EAB, what they plan to do and if they understand the importance of brown ash to the Wabanaki People. Much of Maine is rural with family owned forests, camps, and farms, as well as large tracts of forest for timber products. In 2014, acreage of commercially owned forests almost doubled family owned forests with over 10 million acres (McCaskill, 2015). Understanding what landowners are planning to do with their ash as EAB bears down on Maine is essential to planning a future for the species. Members of the BATF recognize a need for research on private landowner plans for the future, and a need for building capacity for protection efforts.

1.6 Ash Protection Collaboration Across Wabanakik and understanding a network

Due to increased funding for brown ash protection against EAB, there has been an influx of graduate students at the University of Maine, Orono interested in this issue, and opportunity developed for research to take place with a focus on the interest of the BATF. This places an emphasis on Tribal interests including basketmakers and harvesters in the direction of research, as well as human dimensions focused research needs. This has allowed a new entity to be created, the Ash Protection Collaboration Across Wabanakik (APCAW), which is the research laboratory based at the University of Maine. This group acts as a hub for the collaboration and network of organizations and people interested in ash protection against EAB. By highlighting interdisciplinary research skills of students and faculty at the University of Maine, as well as the central geographic location of the university in the state, APCAW is well positioned to build on the interests of the BATF. Recognizing the existing network of interested parties, APCAW has worked to invite these groups together in moving forward the research and collaboration on ash protection, while identifying new groups to assist in this work.

APCAW has identified five groups of organizations and individuals who are in the network: federal and state agencies, Tribal Nation governments, universities, non-governmental organizations and private citizens (Figure 1.3). Understanding how this network functions will reveal dynamics of long-term

conservation problems and has implications for how they can be addressed in the future. The partnerships between these entities working to prepare and limit the effects of EAB in Maine provide an opportunity to study how groups come together to address long-term conservation issues. Understanding how these partnerships formed and are working together, or do not work together, could lend insight into future conservation issues and how best to approach them. Ranco et al. (2012) discusses how there needs to be an effort to "study how a group of [conservation partners] develops and interacts over time with a particular emphasis on how different power positions and knowledge intersect to create barriers and opportunities for sustained collaboration," (p. 82, 2012). While there has been energy spent on collaborations involving EAB and Maine, there is still research to be advanced and questions to answer (Costanza et al., 2017; Ranco et al., 2012; Voggesser et al., 2013). APCAW provides the platform to address this network and understand how it functions to protect a vulnerable species against a deadly invasive.

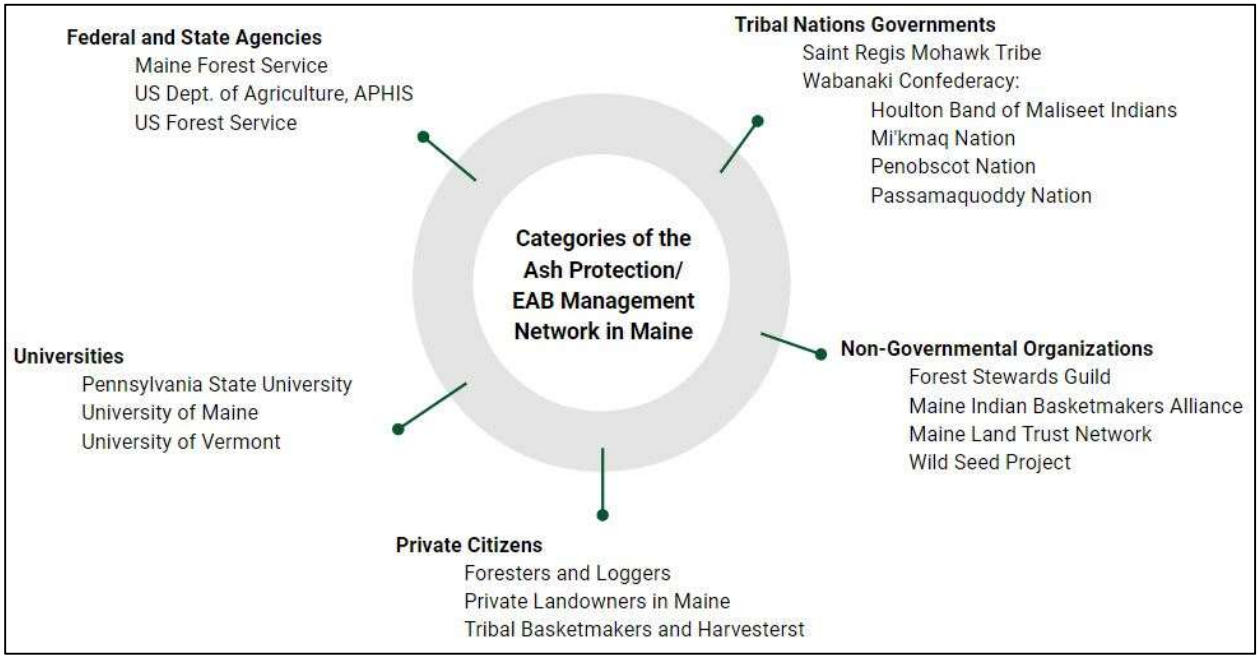

Figure 1.3. Organization and individual members of ash protection/EAB management network in Maine. The pool is divided into five categories: federal and state agencies, private citizens, university researchers, Tribal Nation governments and non-governmental organizations.

One such way to discover how the relationships between entities who have been and are involved with the EAB and ash issue in Maine have developed and work together is using a Social Network Analysis (SNA). This method of research is used to address connections between nodes and ties, people or organizations and their relationships (Curran & Curran, 2014). SNA allows researchers to understand a

network and how each part relates to one another, and the analysis provides insight into identifying key participants, outliers, and areas that are missing potential connections (Cheuk, 2007; Corlew et al., 2015; Farr, Reed & Pejchar, 2018; Hauck, Schmidt & Werner, 2016). For a network that has existed and evolved with the Tribal values and research needs of brown ash for almost two decades, this is a network to investigate. Not only is this important for the research focus at hand, but also to increase knowledge about what works for invasive species management networks. SNA has been used across various fields, as well as in mixed-method research (Christensen & O'Sullivan, 2015; Froehlich, Van Waes & Schäfer 2020; Rienties & Nolan, 2014). There are a number of studies that identify SNA as a useful tool for addressing partnerships and governance issues in conservation and natural resource management (Fliervoet et al., 2016; Guerrero et al., 2020; Paletto, Hamunen, & De Meo, 2015; Yamaki, 2017). At this time there is no evidence in the scholarly literature of this tool being used to address EAB and ash.

1.7 Decolonizing approach to Western Research methodologies

The above methodologies are legitimate methods of research within the constructs of Western Science. However, other ways of thinking and knowing, like Indigenous Knowledge are equally important and should be considered, especially this is issue with an invasive species threatening a cultural keystone species to a Tribal Nation and way of living (Kovach, 2009). As the researcher of this dissertation is not Indigenous, it should be noted that interest in incorporating these non-Western methods are from the perspective of ally-ship and need to broaden the scope of solutions to difficult environmental problems. The proposal for this dissertation included Indigenous Research Methodologies, specifically, Two-Eyed Seeing (Bartlett, Marshall & Marshall, 2012; Hatcher et al., 2009). For a number of reasons these methods were unable to be included in chapters. Decolonizing Western Science is of enormous importance to the author, as well as the APCAW lab at the University of Maine, and the greater ash protection network. While the direct Indigenous Research Methodologies were unable to be included, the perspective of the work places significance on inclusion of Indigenous values and needs, which is illustrated in the

ash seed collection manual. This document was created by request of the Maine Indian Basketmakers Alliance and the Brown Ash Task Force, which will be discussed further in Chapter 4, and was written for the non-researcher's use, like basketmakers and harvesters. Therefore, great care and purpose was taken to include and promote the needs to Tribal partners and their deep care to keep ash on the landscape in the Dawnland.

1.8 Goals and objectives

The goals of this research is (1) to inform the direction of outreach and education for interested parties, including private landowners, to sustain brown ash trees for the future, and (2) to explore the network of those protecting ash against EAB in Maine and how it can direct the future for this as a long-term conservation problem.

Objective 1 – Determine private landowner's of Maine understanding the importance of ash and their intentions in managing ash against EAB.

Objective 2 – Development of a community-focused ash seed collection manual in collaboration with the network of those interested in protection of ash trees against EAB.

Objective 3 – Create a framework for the network of relationships of those involved with brown ash protection against EAB in Maine, and to address how knowledge is shared by this group, and directions of future efforts.

1.9 Rationale and significance

The cultural significance of brown ash and the risk of its loss by invasion of EAB enhances the importance of this research. The role of brown ash in Wabanaki culture and the broader Algonquin tribes of the Northeast highlights the important difference that brown ash has which other ash species do not. There is no replacement for brown ash in Wabanaki culture or traditional basketmaking. Because of this, EAB is a danger to thousands of years of traditional ways of knowing, which exist presently in each Wabanaki basketmaker. As a Land Grant university which resides on unceded Wabanaki land, supporting this research is the duty of those at the University of Maine. EAB has not yet spread throughout the state of Maine, and any knowledge that can be shared appropriately to preserve and extend the existence of brown

ash on the landscape must be done as quickly as possible. Therefore, this research is of great and immediate importance.

The outcomes of this research will provide insight to improving long-term networks tackling conservation issues with partnerships from federal and state agencies, private citizens, Tribal Nations, non-governmental organizations and other universities. There will also be understanding of private landowners' future plans for ash on their land as EAB spreads, and a community-driven manual for collecting ash seeds by non-researchers. It is assumed that communication between those involved with this research is a crux to the success and longevity of this work through sharing new research and methods, like seed collecting, and tailoring communication to specific groups. The three stated objectives together synthesize how EAB as an invasive species has been handled in Maine, what plans members of the largest group of landowners in the state have for the host species, and how to conserve future ash for research and rematriation to the forest. From the results of this research, researchers leading future studies will potentially be able to work with landowners as EAB reaches their land, increase the amount of ash seed in seed banks for genetic research, and implement frameworks created from this work on other invasive species issues in Maine and other regions. This research is key to protecting the future of the brown ash tree throughout the rest of its region and preparing for EAB spreading throughout Maine.

1.10 Description of dissertation chapters

This dissertation is split into five chapters. The first chapter is the introduction to the EAB, its threat to Maine and the Tribal Nations in the Dawnland, monitoring and defenses against EAB on a federal and state level, the development of a protection network in Maine, as well as, the goal and objectives of the dissertation, the rationale, significance and the broader impacts of this research. Chapter 2 uses Involvement Theory as a method to identify private landowners in Maine who are interested in using proposed management strategies to protect ash on their landscape (Zaichkowsky, 1986). The survey for this work was administered in 2022, after being approved by the University of Maine's Institutional Review Board in the fall of 2021. The outcomes of this research will guide the direction of public outreach and education for private landowners in Maine and increased protection and the future of ash. Chapter 3 is a modified version of the APCAW "Brown Ash Seed Collection Manual". This document was created to be updated as research and methods evolve, as such, what is found in this dissertation is only a current

snapshot of what the methodology may be in the future. The most current version of this manual will be found at the University of Maine's APCAW website: https://umaine.edu/apcaw/. This chapter goes into detail about all aspects of seed collecting: identifying ash, its sex, when it has seed, how to collect, sort and store the seed, and where to send seed and the variety of purposes of saving seed. There are webinar videos that complement this document on ACPAW's YouTube channel (@ashprotection). Chapter 4 explores the ash protection network originally developed by the BATF, and more formally organized by APCAW using SNA. An SNA survey was developed and approved by the University of Maine's Institutional Review Board in the fall of 2023. The outcomes of the research will provide an understanding of the APCAW network and identify strengths, weaknesses and key members who are conduits of knowledge transfer. The final chapter represents the culmination of the previous four chapters. Here, the results of the dissertation as a whole are reviewed and synthesized. Future directions of this research are suggested and a reflection of the work as a whole is discussed.

CHAPTER 2

EVALUATING PRIVATE LANDOWNER INTEREST IN IMPLEMENTING ADAPTIVE MANAGEMENT STRATEGIES FOR ASH (*FRAXINUS* spp.) PROTECTION AGAINST EMERALD ASH BORER IN MAINE

2.1 Abstract

The emerald ash borer (*Agrilus planipennis*, EAB) is one of the most destructive invasive species in North America (Aukema et al., 2011; Herms & McCullough, 2014). It was first detected in Maine in 2018 in the most northern and southern counties. By 2022, the US Department of Agriculture's federal quarantine was lifted, and Maine's Department of Agricultural, Conservation and Forestry took over managing a quarantine to restrict the movement of ash between zones of detected EAB and to non-infested areas. As the state of Maine is 94% privately owned, it requires landowner's buy-in and public outreach and education to protect ash on the landscape against EAB. There are six adaptive management strategies that are proposed here: EAB monitoring programs, harvesting merchantable ash ahead of EAB, reserving trees of specific size classes, seed collection, using pesticides or insecticides on ash trees, and participating in biological control programs (D'Amato et al., 2020). This study surveyed private landowners owning land in Maine in 2022 to gain an understanding of their knowledge of ash, EAB, their level of involvement using the Involvement Theory (Zaichkowsky, 1986), and their interest in the six adaptive management strategies. Out of the 601 respondents sampled, 362 qualified for inclusion in analysis by owning 10 or more acres of partly or fully wooded land. Among them, over 98% were familiar with EAB, while just 5.9% reported experiencing EAB effects on their forest property in Maine. Of the four involvement levels, methodology adapted from Zaichkowsky (1986) by Daigle et al. (2019), 28.8% of respondents were in high involvement, Level 4, with 18.4% in low involvement, Level 1. The overall results indicated a proportion of private landowners who are interested in protecting ash against EAB on their forest properties in Maine. Of the six adaptive management strategies, the highest interest was participation in seed collection and allowing for seed collection on their properties. This is an avenue that outreach, education and policy makers should focus on to increase the protection of ash.

2.2 Introduction

Emerald ash borer (*Agrilus planipennis*, EAB) is an invasive forest pest in North America, first detected in 2002 at the United States and the Canadian border near Detroit, Michigan (Haack et al., 2002). Native to Russia and China, it has spread by human transportation to over 36 U.S. states and 5 Canadian provinces within 20 years, killing millions of ash trees. It is estimated that by 2035, EAB will be present in 87% of the brown ash (*Fraxinus nigra*) range in North America, with at least 75% mortality of the species (Siegert et al., 2023). Given the likely scenario of EAB being present, one would think nothing can be done to address the threat of EAB. However, research efforts since the arrival of EAB now focus on optimizing forest conditions for ash species to coexist with the insect, and timing is a critical component of different EAB management strategies. A growing collaboration of Tribal communities, universities, conservation and non-profit native seed organizations, state and federal natural resource agencies, and private landowners are attempting to build engagement in saving the ash species in the Northeast where there is still time to be proactive against EAB's arrival. A concept of overlapping goals has been identified as guiding reasons for the preservation of ash species and consequent adaptive management strategies to be implemented by landowners (D'Amato et al., 2023a and 2023b). A critical piece to ash preservation efforts is an awareness and willingness for landowners to take action if there is any hope of retaining ash as a component of our future forests.

Almost 94% of the total land in Maine is privately owned, making it a management mosaic of corporations, family forest owners (FFOs), land trusts, Tribal Nations government, among others (Maine Department of Inland Fisheries and Wildlife, n.d.; Epanchin-Niell et al., 2010). Maine is known for being heavily forested but lacking the large tracts of public land that are common in the Western United States (McCaskill et al., 2016). Of the 84% of land in Maine that is forestland, 9 out of 10 acres is privately owned (McCaskill et al., 2016; Woodall et al., 2022). With such a small amount of public land, the patchwork of privately owned land means that statewide conservation efforts must have buy-in from a diverse group of stakeholders. Private forest landowners vary from large companies to FFOs and the purpose or goals of ownership also vary within ownership type.

The National Woodland Owners Survey analyzes ownership objectives in the following categories: ownership for beauty or scenery, nature or biological diversity, water resources, wildlife, land investment, privacy, raising a family, passing land to children, firewood, timber products, non-timber forest products,

hunting and recreation (Caputo & Butler, 2021). The owners and their purpose for managing forest land are diverse. Beyond the purpose of managing land, it is also important to understand owner demographics, as it has been documented that female and male forest owners have differences in management goals and objectives; for example, timber harvesting is typically found to be a focus commonly held by men (Butler et al., 2018; Lidestav & Ekstrom, 2000; Schelhas et al., 2012). Understanding what private landowners know about invasive forest pests, as well as knowledge of their land, interests, and intentions in protecting trees on that land, is essential to outreach and education efforts regarding EAB and brown ash trees.

EAB was discovered in Maine in 2018, in both the northernmost and southernmost counties: Aroostook and York. Since then, the invasion has spread toward the center of the state, moving faster from the south than the north. In 2022, EAB was present in five counties: Androscoggin, Aroostook, Cumberland, Oxford, and York. By early 2024, EAB had been detected in 14 of the 16 counties in Maine, the five previously mentioned, as well as, Franklin, Kennebec, Knox, Lincoln, Penobscot, Piscataquis, Sagadahoc, Somerset, and Waldo counties.

The United States Department of Agriculture (USDA) implemented an inter-county to interstate quarantine in 2003 to limit the movement of ash and unprocessed ash materials across geopolitical boundaries (Emerald Ash Borer; Quarantine and Regulations, 2003). However, the federal effort ended in 2021, leaving states to decide how they would monitor and manage forests for EAB. The Maine Forest Service's ash quarantine restricts the movement of ash and raw ash products across county and municipal lines, which has effects on a number of industries, including tourism. As of 2024, the Maine State Forest Service continues to enforce and update a state quarantine with various programs, including those designed to encourage landowners of all kinds to be aware of EAB and take part in the monitoring effort as the invasive species continues to spread. For example, Trap Tree Network, is an organization that designs programs encouraging landowners to become aware of EAB and take part in monitoring efforts. Another program focuses on releasing and monitoring parasitic wasps as part of a USDA biological control program. It takes multiple methods to monitor and combat the spread of EAB.

Three species of ash occur naturally in Maine: white (*F. americana)*, green (*F. americana)*, and black (*F. nigra)*, or as it is commonly referred to in Maine, brown. While white and green ash are important to the timber industry in Maine, green is also a common municipal street tree. Brown ash is typically difficult to access due to its habitat occurring in marshes or very wet areas of the forest. Brown ash leaf litter

is nutrient rich and generally preferred by many invertebrate species in riparian forests, and lack of ash leaves has a significantly slower decomposition rate (Kreutzweiser et al., 2019 & Youngquist et al., 2020).

Loss of brown ash trees changes the forest by opening the canopy, causing loss of yearly nitrogen to the soil by fallen leaves, and loss of hydrologic management from the brown ash root system (Davis et al., 2019). An example of a changing forest is a finding from Grinde et al. (2022a), which demonstrated that in the Great Lakes region, where there are pure black ash stands, "the loss of the forest canopy will result in an overall decrease in bird diversity and reduce forest connectivity for all species," (p. 1). With EAB a direct threat to all ash species, brown ash habitat is in danger for not only the loss of the trees themselves but the habitat as a whole.

In the Northeast US it is unusual to find brown ash habitat in pure stands. Loss of brown ash will create pockets of significant changes to the mixed forests in Maine, affecting the hydrology, forest makeup, nutrients of the soil, and potentially, the connectivity of bird habitats and diversity (Grinde et al., 2022; Kolka et al., 2018; Wagner & Todd, 2016). While ash is established throughout the state of Maine, it is important to note that it is only around 2 percent of the total forest composition (DeSantis et al., 2013). It is incredibly important in its ecological niche, which are smaller areas spread across the entire state. This makes the management of brown ash habitat disjointed, difficult to manage on a landscape scale and important for those with brown ash on their land to understand the threat facing them.

Maine is the last state in New England to experience an infestation of EAB. The majority of the state still has forests unaffected by EAB, making it the last region in the northeastern U.S. without the guaranteed high mortality of this crucial tree species. However, time is becoming short, and the need for buying into management strategies by private landowners is now to keep healthy ash on the landscape for as long as possible.

2.2.1 Adaptive management strategies to protect ash from EAB

There are five adaptive management strategies that show promise to protect ash against EAB: EAB monitoring programs, seed collection, using pesticides or insecticides on ash trees, reserving trees of specific size classes, and participating in biological control programs. There is another strategy that is discussed, but is not positive for keeping the genetic diversity of ash on the landscape: harvesting

merchantable ash ahead of EAB. This option is included to understand how interested landowners are in this strategy. Each of these strategies has been tested in Maine and other states, but expanding these efforts to a greater audience and network of landowners will increase the protection of ash on the landscape.

As land ownership in Maine is almost entirely privately owned, this group needs to be introduced to these management strategies. However, prior to any management strategy being implemented, it is important that forests are inventoried for ash (Everett, 2019). This ensures that the extent of ash has been identified and can be included in planned management.

EAB monitoring programs take place at the state level in Maine and are managed by the Maine Department of Agriculture, Conservation and Forestry, DCAF. These programs, which include the Trap Tree Network, where trees are girdled to attract EAB into an ecological sink, and purple trap survey, are vital to monitoring levels of EAB in areas where there is an established presence and to detect new infestations (Marshall et al., 2009; Mercader et al., 2011; Sun et al., 2023). It is key that monitoring takes part across the state, and that is where private landowners can take part. These programs require minimal cost by landowners. This monitoring strategy is potentially a long-term commitment for access to the land, permission to place and check traps, time and effort to girdle and harvest a trap tree, and monitor for lingering ash once EAB becomes present. Not all of these methods are required, so the level of commitment is up to the landowner, but it should be noted that this can be long-term.

Seed collection is an essential part of the long term efforts to protect ash against EAB (Knight, Karrfalt & Mason, 2010). Seeds can be used for a variety of purposes, including: seed banking, genetic research, and growing common gardens. Collecting seed captures the genetic diversity and potential resistance to EAB. Ash species have different timescales in which they produce seeds. The brown ash will produce seed every 5 to 7 years (Benedict & David, 2003). This limits seed collectability and natural regeneration from the forest floor (Siegert, Engelken & McCullough, 2021). The most recent mast year for brown ash in the Northeast was 2022, meaning it could be 2028 before another mast year. At that point, EAB will have been detected in Maine for 10 years, and the spread may be seriously detrimental. This requires people to take part in seed collecting and monitoring their ash every year, in case trees do produce seed. Private landowners are key to collecting seed and protecting the species' longevity. The cost of seed collecting to private landowners is not necessarily high, as equipment for collecting are common garage or household items, like tree pruners, paper bags, and clipboards. However, to allow access for seed collectors

to collect on their land is a no cost effort. Time is the main cost associated with seed collecting for landowners. The University of Maine's APCAW has a detailed list and instruction for ash seed collection: https://umaine.edu/apcaw/seed-collection-and-ash-regeneration/.

Another adaptive management strategy is to utilize pesticides or insecticides to protect individual ash trees. Injection of emamectin benzoate and azadirachtin are two insecticides developed specifically for EAB. Once injected the chemical is drawn up through the tree into leaves where EAB in the larval stage eats the leaves and dies. The chemical is present in the tree for 3 to 5 years, when it is recommended that treatment be injected again. Results illustrate that this strategy is keeping seed bearing trees on the landscape, even while EAB is present (Mwangola et al., 2022). Research is also testing the effectiveness of treating trees in the forest, rather than only municipal or residential trees, and has shown to protect neighboring trees as well (de Andrade et al., 2021; Flower et al., 2018). This overall strategy allows ash to remain on the landscape (Duan et al., 2023a). This is especially important for seed production and keeping seed bearing trees present, which allows researchers to continue to collect seed, even with EAB on the landscape. However, there are factors to consider. There is a financial cost associated with treating trees for landowners, as a licensed professional is required to inject trees, as well as a cost for the chemical and injection equipment. This cost will need to be repeated every 3 to 5 years while EAB is present. The purpose of the tree should also be considered: is this an ornamental/residential tree? The sex of trees should also be considered to further the species on the landscape. The tree's health must be evaluated so that the effort of this process is used for vigorous trees, which will further the genetic diversity and health of the species. U.S. Forest Service funded ash specific Landscape Scale Restoration grant has established demonstration plots for multiple adaptive management strategies, specifically insecticide treatments alongside biocontrols. Results of this work should provide insight into the ability to continue seed collection once EAB is present.

The next two adaptive management strategies are both silviculture-based. The first is to harvest merchantable ash ahead of EAB and the second is to identify and reserve ash of different size classes in the stand. The former is not a positive strategy because it removes healthy ash from the landscape as genetic diversity and seed sources. However, harvesting merchantable ash ahead of EAB is an opportunity for landowners to protect timber investments. However, it has been shown that clearing a forest of ash does not deter EAB (Liu, 2018). The insect will fly to access ash, this can speed the process of infestation (McCullough, 2020). EAB is drawn to the chemical pheromones produced by low vigor or sick ash, and it

can draw insects to a stand. Removing some merchantable and low vigor ash can protect the larger stand by requiring EAB to attack healthy trees, which have higher defenses against attack, prolonging the health of the stand (D'Amato et al., 2020; Kenefic & Nyland, 2005). The knowledge gained by being aware of the ash on their property will allow landowners to monitor for lingering ash, another outcome of this strategy.

Similar to harvesting merchantable ash, assessing the ash stand for size classes is another silvicultural-based management strategy (Kenefic & Nyland, 2005). This allows for the health of the ash stand to be assessed and decisions made on which trees to keep based on their size and vigor. Keeping a range of size classes on the landscape ensures there will be age differences, allowing ash to continue growing when EAB becomes present (Catanzaro et al., 2023). A range of size classes in the forest will hopefully bolster protection for the stand and promote regeneration (D'Amato et al., 2020). Bringing in a licensed professional will incur costs on the landowner but these strategies are highly beneficial for long term health and monitoring of the forest. As with other strategies, keeping the healthy ash on the landscape increases the chances of seed production, as well as the possibility of lingering ash being identified. It is particularly important to assess forests for a mixture of ages and sexes for genetic and seed production purposes.

The final adaptive management strategy is the implementation of biological controls. These are nonnative non-stinging wasp species that are proven to be host specific to EAB, and exist as predators to EAB in their native range. These species, *Tetrastichus planipennisi*, *Spathius galinae*, and *Oobius agrili*, are all reared by the US Department of Agriculture (USDA). The Maine Forest Service works closely with the USDA in a program to identify appropriate EAB infested areas, release, and monitor the health and presence of biological control insects. Due to the nature of land ownership in Maine, it is important for the state to partner with landowners to take part in releasing these biological controls. These biological controls are effectively establishing populations across the US and Canada (Aker et al., 2022; Butler et al., 2022; Duan et al., 2022; Duan et al., 2023b). However, these biological control species are only released after EAB is present, as they predate EAB exclusively (USDA-APHIS/ARS/FS, 2021). Due to the nature of releasing a new nonnative species, landowners may have these insects on their land without their consent because of the natural spread once species have established. As of 2024, there are a number of locations in the northern and southern infestations where this program is present. The cost to landowners is similar to taking part in EAB monitoring programs, which allow state entomologists access to release and monitor for biological controls. A key note regarding this management strategy is that once EAB is present and ash succumbs,

having biological control present on the landscape will hopefully limit the EAB population. By taking part in this management strategy, there is a hope that lingering ash will be apparent for landowners monitoring their ash health and locations. Biological controls will hopefully assist in keeping ash on the landscape as long as possible.

These positive strategies play a key role in protecting the current and future of ash on the landscape. Each of these strategies has the opportunity for direct involvement by the largest group of landowners in the state of Maine: private landowners. However, as ash is not a large component of the Maine forest landscape, not every landowner will have ash or be able, or interested, to participate in any or all ways to protect these species against EAB. It is up to each landowner to evaluate what is on their property and choose what works for their situation. Therefore, understanding what landowners know about EAB, ash, and their interest in taking part in management strategies is key to engaging landowners in outreach efforts.

2.2.2 Conceptual framework

Understanding and predicting the behavior of forest landowners to protect ash trees are critical in assessing the likely effectiveness of proposed adaptive management strategies. For this reason, Involvement Theory and the Expectancy Value Model was used in constructing a context and assessing the strength of beliefs about the relationship between EAB and the adaptive management strategies, as these variable ultimately influence attitudes and behaviors, as well as assessing the intentions and understanding of private landowners in regard to ash management and protection as their decisions affect the landscape and spread of EAB (Ajzen & Fishbein 2000; Bewsell, Bigsby and Cullen, 2012; Holt et al., 2022). Involvement Theory utilizes a person's negative or positive reaction to a statement regarding a specific issue, like EAB, and how it affects their property. It creates an index, which allows researchers to gauge their attitudes and beliefs toward actions they may take. These potential actions highlight the involvement or likelihood of taking action on a specific issue. The Expectancy Value Model identifies antecedents to levels of involvement (Daigle et al., 2019). To assess forest owners perspectives using these two frames a survey was created to solicit the level of interest those owning forest land have on protecting ash against EAB, and what management strategies are most favorable. Examining the perspectives of private landowners in Maine regarding forest management with EAB necessitates a theoretical framework that enables researchers to comprehend the extent of their engagement with their land.

Involvement Theory methods discussed here stem from Zaichkowsky (1986), which outlines a framework containing the Antecedents of Involvement, the Involvement, and the Possible Results of Involvement. The key to this theory is that the more effort, time spent, caretaking, and other behaviors a person, object, or situation might have, the more likely there is a high involvement (Daigle et al., 2019). An individual's "personal factors," their needs, importance, interests, and values, along with "object or stimulus factors" and "situational factors," all will interact with an involvement with an issue or an object for an outcome of a possible result of the involvement (Zaichkowsky, 1986). This theory was developed in marketing and advertising, where researchers focused on consumers becoming involved with a product or service and the likelihood of spending time and money. It has also been utilized through artificial intelligence, where consumers shop through smart speakers (Klaus & Zaichkowsky, 2022), strategies and development for branding (Zaichkowsky, 2010), advertising in travel blogs (Huang, Chou & Lin, 2010), biosecurity at national borders (Bewsell, Bigsby & Cullen, 2012), and firewood movement of forest pests by campers (Daigle et al., 2019). This last study, Daigle et al., is crucial in the methods employed in the current study.

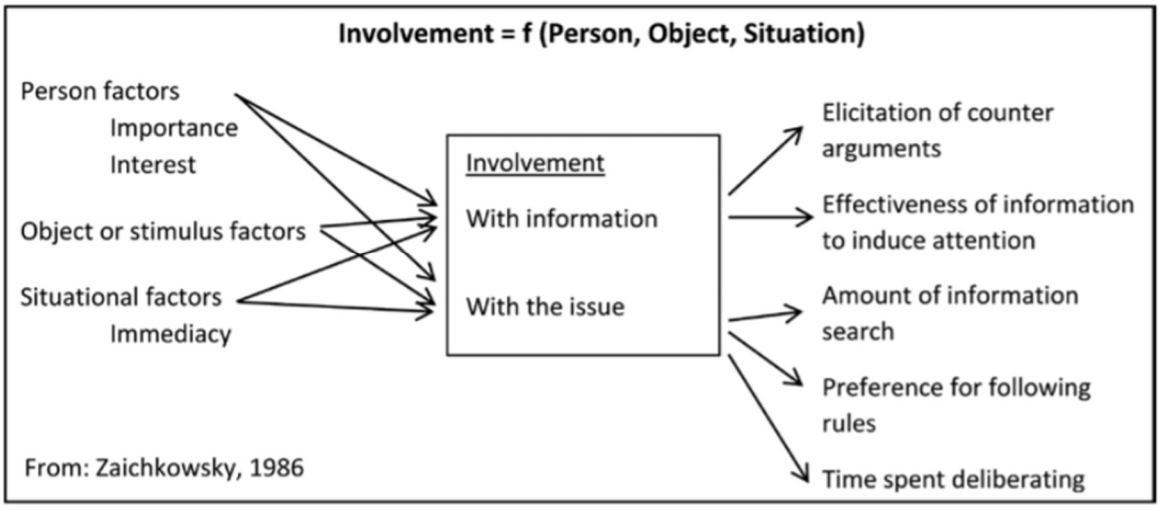

Figure 2.1 Involvement Theory framework from Daigle et al. 2019, original framework from Zaichkowsky, 1986.

While Involvement Theory has been utilized in many fields and systems, it has been underutilized in conservation, except for Daigle et al. (2019). This private landowner issue with EAB is an opportunity to

extend the use of this theory to ascertain Maine forest landowner's level of involvement in managing their ash trees regarding EAB.

2.3 Methods

2.3.1 Survey IRB, design, and dissemination

The survey was developed using the Involvement Theory (Zaichkowsky, 1986) and sent to the sample population following Dillman's Tailored Design Method (Dillman et al. 2014). The survey was created with input from the Ash Protection Collaboration Across Wabanakik, APCAW, research team and reviewed by the Forest Stewards Guild, the US Forest Service, and the Maine Forest Service. The final version of the survey was approved by the University of Maine's Institutional Review Board under the name "Building Stewardship Capacity: Protecting the Brown Ash of the Northern Forest - *Understanding Forester, Logger, and Landowner involvement and behavior in the management of the emerald ash borer*." It was submitted by Emily Francis, Tyler Everett, and co-PI Dr. John Daigle and approved by December 2021, Application # 2021_11_15. The survey was administered via the University of Maine's Qualtrics account and sent to respondents through a network of Maine landowner and forest owner organizations.

Eleven organizations agreed to participate by sharing the survey with their networks through an email listserv, a digital newsletter, and/or media blurb, see Table 2.1. Seven of the organizations were specific to forestry: the Cooperative Forestry Research Unit at the University of Maine, the Forest Products Council, Maine Forest Service, Maine Forest Service Plant Health and Monitoring Division, MOFGA Low Impact Forestry, Maine TREE Foundation, and Maine Woodland Owners. All of these organizations work with landowners in Maine who either have forests that they manage or are interested in the health of forests. The Maine Land Trust Network and the Southern Maine Conservation Collaborative are both land trust based networks that distribute the survey to land trust managers, rather than family forest landowners. The Maine Bureau of Parks and Lands approached the research team to take part after hearing about the survey. This was the largest network made available to the research and was utilized for its reach beyond forest landowners and those who live in Maine, but might own land in Maine. Finally, First Light Learning Journey focuses on the needs of the Wabanaki community and returning land to the Wabanaki Tribal Nations. The cultural aspect of protecting brown ash was important for them to share this survey with their

network. Due to the methods of survey distribution, it is impossible to know how many people came in contact with the survey recruitment materials. With one news media blurb from the Maine Bureau of Parks and Lands, the survey announcement was sent to over 25,000 email addresses. Therefore, it is not possible to quantify the response rate.

Table 2.1 List of organizations who agreed to distribute recruitment content for the private landowner survey.

Organization	**Type of media release**	**Approx. # of people sent to**	**Following Dillman et al. (2014)**
Cooperative Forestry Research Unit - University of Maine	Email (listserv)	600	Yes, all three reminders
First Light Learning Journey	Email (newsletter)	150	Yes, one reminder
Forest Products Council	Media blurb	517	No
Maine Bureau of Parks and Lands	Media blurb (newsletter)	25,000	No
Maine Forest Service	Email (listserv)	5,927	Yes, all three
Maine Forest Service - Plant Health and Monitoring Division	Media blurb	25,000	No
Maine Land Trust Network	Email (listserv) and media blurb	2,000	Yes, one reminder
MOFGA Low Impact Forestry	Email (listserv and newsletter)	1,000	Yes, one reminder
Maine TREE Foundation (Tree Farmers list)	Email (listserv)	903	Yes, two reminders
Maine Woodland Owners	Email (newsletter and direct to listserv)	Listserv: 2,000 Newsletter: 3,000 - 3,500	No
Southern Maine Conservation Collaborative	Email (listserv)	500	Yes, one reminder

The Dillman et al. (2014) was utilized to engage with the potential participants. Survey invitations sent by email followed a modified Dillman et al. (2014) method that provided options to the listserv and network managers on how many emails they would send to their networks. Organizations were given the option to distribute information written by the research team in three ways: to follow the Dillman Method,

a modified Dillman Method (where they could choose how many follow-up notifications to send), or a media blurb. Recruitment emails and messages were sent in January and February, 2022. Of the 11 organizations, two chose the complete Dillman method; four chose a modified version. The survey was open to the public on Qualtrics from January 10th, 2022, and the final response was recorded on March 17th, 2022.

The survey was broken into five sections. The first section focused on gathering information on what kind of land they owned, the type of ownership, their reasoning for owning land in Maine, how many years they had owned land in Maine, and the amount of acreage they owned, as well as their knowledge of ash and if it was present on property they owned in Maine. The second section posed questions about EAB awareness, including if they knew about EAB and if their property had been affected by EAB, selecting their agreement regarding statements involving EAB, and belief statements. This section use Involvement Theory with the belief statements regarding landowner's views about EAB and the future of ash. The third section were questions regarding knowledge of brown ash and Wabanaki cultural uses of the species. The fourth section's questions were related to adaptive management strategies. The final section contained the demographic questions, including questions on residence, what states respondents owned property in, their gender identity, race, and what type of forest management plan they might have.

2.3.2 Measurement of involvement with emerald ash borer

Private landowner's involvement with EAB was assessed using a 5-point scale for 5 statements, listed in Table 2.2. The value selected by the participant indicates their agreement with the positivity or negativity of each statement. This model was adapted from Mittal's (1995) Personal Involvement Inventory (PII), similarly used in Daigle et al.'s (2019) camper beliefs study. These statements began with a definition of invasive species, and each statement followed the same scale with 1 being the most negative and 5 being the most positive. The value for each response was totaled for an overall number between 5, the lowest involvement, and 25, the highest involvement. In testing for reliability, Cronbach's Alpha was used to indicate the internal consistency for the levels of involvement (Nunnally, 1978). The Cronbach's Alpha was 0.78, an acceptable magnitude for internal reliability. Similar to the methodology used by Zaichkowsky (1985), Beswell et al. (2012), and Daigle et al. (2019), the categories were determined by exploring the distribution of involvement scores and assessing the ratings needed to obtain those scores. Respondents were divided into the following categories: Level 1 (low involvement) scored a value between 5 to 17, Level

2 (medium low involvement) scored between 18 and 20, Level 3 (medium involvement) scored between 21 and 23, and Level 4 (high involvement) scored between 24 and 25.

Table 2.2 Landowner belief statements for assessing involvement levels.

On a scale of 1 to 5, would you say that EAB:						
Negative Statement	**Numerical Value**					**Positive Statement**
Is of no concern to me	1	2	3	4	5	Is of serious concern to me
Does not matter to me	1	2	3	4	5	Matters to me
Does not impact what I do with the land that I own	1	2	3	4	5	Impacts what I do with the land that I own
Does not impact others nearby me	1	2	3	4	5	Impacts others nearby me
Does not have an impact to others in Maine	1	2	3	4	5	Impacts others in Maine

2.3.3 Measurement of beliefs about emerald ash borer and value of ash trees

Seven statements were presented to assess the private landowner's views about EAB. Those statements were: “There is not much a landowner can do to prepare for the impacts of EAB,” “As long as EAB continues to spread throughout my state, my efforts to sustain ash are useless,” “In the long run, things will balance out with EAB,” “The EAB threat is exaggerated,” “EAB has the ability to kill all or nearly all native ash species,” “Other tree species can fulfill environmental roles of ash trees,” and “Other tree species can grow in the place of ash trees and provide the same or increased value”. Participants ranked their agreement or disagreement on a 5-point Likert scale, with 1 being “strongly agree,” 2 “agree,” 3 “neither agree or disagree,” 4 “disagree” and 5 “strongly disagree.” An important reason for utilizing the 5-point Likert scale was to gauge the relative strength in belief or, conversely, the level of uncertainty with private landowners' views about EAB.

2.3.4 Measurement of involvement and interest in adaptive management strategies

All survey respondents were asked about specific strategies and practices related to ash protection they would consider implementing on their properties, seen in Table 2.3. Since some of the strategies

involve pre- and post-stages of EAB presence and proximity, five responses were available. Each of these questions had the same five options to choose from: "I have done this," "I plan to do this," "I am interested in doing this," "I might consider doing this," and "I have no interest in doing this." Landowners who indicated they are currently doing or expressed a level of interest in doing an adaptive management strategy were also asked reasons for why they do or why they might do each of each of the selected strategies. Some of these reasons were: "to maintain existing forest conditions, to restore to past forest conditions," "to change forest conditions to allow other trees to replace ash," "I don't know," or "other" where they could write a response.

Table 2.3 Adaptive management strategies and practices.

a. Participate in a monitoring program to assist efforts with detection of EAB
b. Plan to harvest all or majority of merchantable ash trees ahead of EAB
c. Identify sites to reserve ash trees with different size classes ahead of EAB in efforts to save resistant ash or restore ash
d. Allow for the collection of ash seeds by seed collectors to support potential future replanting for ash
e. Consider practices for protecting certain ash trees for scenic, economic, and/or seed source values using chemical treatment (pesticides)
f. Consider practices to cooperate with the state in efforts of introduction and monitoring of biological control agents, such as insects, that kill EAB

2.3.5 Measurement of social and economic factors influencing participation in adaptive management strategies

A question posed the following: "How influential would the following social or economic factors be for you to participate in your ash management decisions in general?" Nine statements were provided with five possible responses for each, valuing as follows: extremely influential (1), very influential (2), somewhat influential (3), slightly influential (4), and not at all influential (5). These statements were: "Fits with the long-term management goals of the land," "You think the practice is likely to succeed," "Other landowners have successfully implemented the practice," "Public perception of the practice," "Other landowner's perception of the practice," "The practice will serve as a demonstration," "Economic returns of the practice," "Cost of the practice," and "Cost-share funding available for the practice". This question was provided to each respondent of the survey, but analyzed for only respondents who answered the question: "Do you know

if you have the following ash trees [species] on lands you own or manage?" with: yes, "I have ash," or I don't know, "Unsure of ash on my property." Those who answered: no, "I do not have ash," were excluded from the analysis.

2.3.6 Data analysis

The analyses focused on the involvement levels of private landowners, and their awareness and beliefs regarding ash and the EAB invasion in Maine. Cross-tabulation was used to assess the abundance of ash on a landowner's property by the three types of ash in Maine, as well as each involvement level by frequency within the sample. It was also used to test each adaptive management strategy response by each involvement level. One-way ANOVA testing with a post-hoc Tukey HSD was used to assess the Involvement Theory belief statements by the involvement level means to compare the significance between involvement levels. Chi-squared analysis was used to test the involvement levels of male and female respondents for significance. Depending on the analysis, only certain categories of respondents were used. When analyzing the adaptive management strategies, only respondents with ash on their properties, or those who were unsure or didn't know if they had ash were included. Results were analyzed using IBM's Statistical Package for Social Sciences (SPSS) software and Microsoft Excel.

2.4 Results

There were 602 survey responses recorded. Respondents were only included if they could describe their land as having an intact forest of at least 10 acres. As the analysis of this work is specific to the Involvement Theory, respondents who did not answer the questions required for this analysis were removed, as discussed in section 2.4.3 Landowners Involvement Theory Analysis. The analysis represented in this section included 362 respondents. Of the excluded respondents, they either had less than 10 acres of forest land, owned residential property or agricultural land that was not forested. These excluded respondents were mostly family forest owners, although there were 13 who owned land in a trust, 4 who owned their land through a company, at least one Tribal trust land owner and a small number of municipalities. While they did not qualify for further analysis, they are still important in protecting ash and should be considered for future research and outreach efforts.

2.4.1 Survey respondent demographics and land characteristics of those who own more than 10 acres of forest land in Maine

Of the 362 respondents, the mode age of the respondents was 72 years old (n=18), with a minimum age of 26 and a maximum age of 88 years old. Male respondents accounted for 62.2% (n=225), and female respondents 21.5% (n=78). Racially, 80.1% (n=290) of the respondents identified as white, with 1.7% (n=6) identifying as American Indian or Native Alaskan. This is reflective of Maine forest landowner's demographics from the National Woodland Owners Survey (NWOS), where 52% of owners are between the ages of 65-74 years old, 58% identify as male, and 100% identified as white for their race (Caputo & Butler, 2021). According to the most recent US Census data, 96% of Mainers identified as a single race, and 92.3% identified as White (U.S. Census Bureau, 2022). Males are approximately 49.4% of the population. The largest age group is 65-74 at 13.4% of the population, with the median age being 45 (U.S. Census Bureau, 2022). In addition, of the 323 participants who provided their state of residence, 92.6% (n=299) responded as Maine residents and 7.4% as out-of-state residents, including Colorado, Connecticut, Florida, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, New York, Oregon, Rhode Island, Tennessee, and Virginia.

Family forest owners (FFOs) were categorized as either individual, family or joint ownership and represented 88.7% (n=321) of private landowners. The mean number of years owning land in Maine was 30.64 years for this owner category. Table 2.4 represents the acreage for the total respondents owning over 10 acres, and almost 50% of FFOs owned land between 25 and 49 years. The NWOS reports that 92% of Maine woodland owners have joint ownership between spouses or owned by an individual (Caputo & Butler, 2021). The highest percentage of ownership by land tenure was between 25 and 49 years at 53%. Of the FFOs, 39.9% own between 100 and 999 acres, the highest percentage. The next highest percentage is 30.5% for owning between 10 and 49 acres. This is similar to the NWOS, in which landowners who owned more than 10 acres had the largest percentage of ownership, between 20 and 49 acres, at 36%. The second largest percentage of respondents is between 10 to 19 acres, with 33% (Caputo & Butler, 2021). The second largest ownership category was trust owners, which were defined as those owning land held in trust, land trust or real estate investment trust. This was 9.94% of the total sample of those owning over 10 acres of land. Of trust owners, 30.6% own between 100 and 999 acres, and 68.8% owned land between 20 and 50 years. The

next largest category of ownership was companies, of which there were 4 respondents. These owners ranged in years owning land from 6 to 65 years, and owned acreage between 100 to over 10,000 acres.

Table 2.4. Frequency for landowner's total number of acres owned.

Approximately how many acres do you own/manage in Maine?	Frequency	Percent
10-49 acres	103	28.5%
50-99 acres	88	24.3%
100-999 acres	142	39.2%
1,000-9,999 acres	17	4.7%
10,000 or more acres	12	3.3%
Total:	362	100%

2.4.2 Landowner's knowledge of ash species on their property and awareness of EAB

While ash is only a fraction of the Maine forest, it is an important species widespread across the state. Of the 318 respondents to these questions, 77.4% reported having at least one species of the three native ash on their property. When asked if landowners have ash on their property, 71.5% responded they have white ash, which is the most common ash species on the landscape in Maine. Whereas 38.7% reported to have brown ash, which is the second most common ash on the landscape, and 14.9% reported to have green, the least abundant. These responses reflected the presence of each species of ash across the forests in Maine. Only 2.8% (n=10) of respondents reported to have no ash of any kind on their properties. A large percentage of respondents reported that they were "unsure of ash on my property" for each species: 53% (n=192) for green ash, 39.2% (n=142) for brown ash, and 22.7% (n=82) for white ash.

Table 2.5. Response frequencies: Awareness of ash tree presence on owned or managed lands.

Species	Yes: "I have ash"	No: "I do not have ash"	I don't know: "Unsure of ash on my property"	Missing	Total (n=362)
Brown	140 (38.7%)	55 (15.2%)	142 (39.2%)	25 (6.9%)	337 (93.6%)
Green	54 (14.9%)	75 (20.7 %)	192 (53%)	41 (11.3%)	321 (88.7%)
White	259 (71.5%)	16 (4.4%)	82 (22.7%)	5 (1.4%)	357 (98.6%)

The question, "How abundant is the ash on your property?" posed a Likert scale for participants with "very little ash on my property" as 1 and "most of my property is ash" as a 7. No one responded with "most of my property is ash," and 78.9% (n=224) responded between 1 and 3, meaning there is little to less than a mid-range abundance of ash. Almost a quarter of participants did not respond to the question, which could indicate that they do not know. When asked if owners have a forest management plan for their property, 72.5% (n=240) of those responding to the question said "yes." Of those who said they have a forest management plan, 23.5% (n=57) said that they have specific reference to ash in their management plan. However, 21.8% (n=53) said they were unsure or did not know if they had ash specified in their management plan, and 26.4% (n=14) of that sample did not respond to how abundant ash was on their property.

In 2022, there were five counties with EAB presence: Androscoggin, Aroostook, Cumberland, Oxford, and York: however, only a portion of Aroostook and Oxford counties were under quarantine at the time, see Figure 2.2. The portion of Oxford County in quarantine was under an Emergency Order. Of the 20 landowners who said their properties had been affected by EAB, 1 claimed to own land in Androscoggin County, 2 in Cumberland County, 1 in Oxford, and 7 in York County. Aroostook was the only county with EAB presence where landowners did not report that EAB had affected their property. The survey did not ask landowners what county they reside in for Maine, therefore, it is unknown if landowners who own land within the quarantine zone or not actually live there, and if this could have affected their responses.

An important note is that 36.2% of respondents did not know or were unsure if EAB affected their property, see Table 2.6. Of these landowners, 4 claimed property in Androscoggin, 8 in Aroostook, 13 in Cumberland, 13 in Oxford, and 11 in York County. Of all of the landowners, 81.5% claimed property ownership in a single county, whereas 67 (18.5%) respondents claimed property in multiple counties. This is typical of Maine forest landowners, who mostly own small family properties, although there are large-scale industrial forest landowners. Therefore, while ownership was claimed for every county in Maine, it is important to note that a much larger percentage of owners could not say if they had been affected by EAB. However, it should be noted that 36.5% did not know or were unsure if they had been affected.

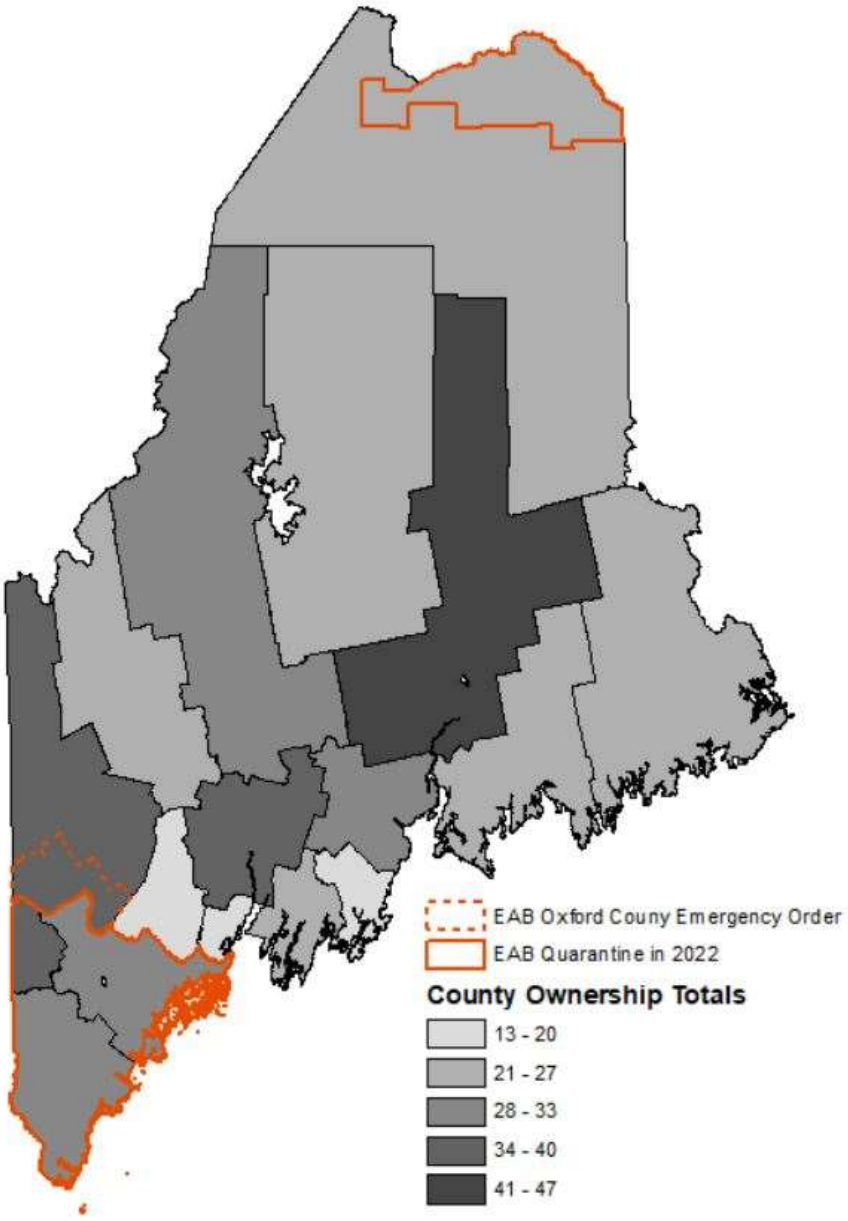

Figure 2.2. EAB Quarantine and Emergency Order Areas in 2022: County ownership totals for landowners. Map by author.

Table 2.6. Frequencies of awareness and impact of Emerald Ash Borer (EAB) in Maine.

	Have you heard of EAB?		Has your property been affected by EAB?	
Responses	**Frequency**	**Percent**	**Frequency**	**Percent**
Yes	356	98.3%	20	5.5%
No	3	0.8%	210	58%
I don't know / I am not sure	2	0.6%	131	36.2%
Did not respond	1	0.3%	1	.3%
Totals	362	100%	362	100%

2.4.3 Landowners Involvement Theory analysis

In an effort to explore differences between landowners who owned land within counties under quarantine, the overall mean for each statement was calculated, see Table 2.7. While there were no significant differences between the means of those within the quarantine counties, each of the statements had different means. The first three statements, "Of concern to me," "Matters to me," and "Impacts what I do with the land I own," each had a higher mean between 0.10 and 0.02. The fourth statement, "Impacts others nearby me," had a 0.01 difference, and the final statement, "Impacts to others in Maine," had a 0.10 difference with counties outside the quarantine with a higher mean. Landowners who own land within the quarantine were, therefore, more marginally concerned about EAB and the impacts of their actions on their land. Those owning land outside of counties in the quarantine were still highly concerned, but had the higher mean for "Impacts to others in Maine." This suggests that landowners not currently affected by EAB are cognizant of those experiencing its effects.

Table 2.7. Comparison of landowner involvement averages between properties within and outside EAB Quarantine Areas.

Statement	**Means**	
	Counties in quarantine	Counties outside quarantine
Of concern to me	4.36	4.26
Matters to me	4.58	4.52
Impacts what I do with the land that I own	3.68	3.66
Impacts others nearby me	3.78	3.79
Impacts to others in Maine	4.47	4.56
Note: means closer to 1 = low involvement, and those closer to 5 = very high involvement.		

Based on the compiled measures of involvement, 28.7% (n=104) of landowners were in the very high category, high was 27.1% (n=98), medium was 25.1%, and low was 19.2% of the survey takers, as seen in Table 2.8. While gender was presented with the demographic of respondents, the involvement levels for gender were the following: 225 respondents identified themselves as male, 78 as female. For females, 11.5% (n=9) were categorized as low, and 32% (n=25) were very high. For male respondents, 20% (n=45) were low, and 27.9% (n=63) were very high. Interestingly, the second highest category for males was medium, with 26.7% (n=60). The Pearson chi-squared test showed no significance (p=.291) between male and female identifying respondents. However, landowners exhibited a broad range of overall levels of involvement with EAB. As a result, we hypothesized that differences may exist among landowners given involvement being an important precursor of beliefs (Kaine et al. 2010) and further explored their beliefs associated with EAB and the environmental role and value of ash trees.

Table 2.8. Level of Involvement and respondents' engagement with EAB.

Involvement Level	Frequency	Percent of valid survey respondents
Low (5-17)	69	19.1%
Medium (18-20)	91	25.1%
High (21-23)	98	27.1%
Very High (24-25)	104	28.7%
Total:	362	100%

2.4.4 Landowner involvement levels and belief statements

Respondents rated their agreement with seven statements regarding the perceived threat and severity of EAB, as well as ash replacement in forests, and these ratings were analyzed alongside their involvement level. Generally, respondents with low involvement scores had significantly different perceptions of belief statements than their counterparts with higher levels of involvement, as seen in Table 2.9. Respondents with very high involvement were most likely strongly agree with statements where there is a possibility to protect ash and work against EAB. Whereas those with low involvement scores were more likely to strongly disagree with statements regarding the future of ash against EAB. Of the seven statements, three proved to be statistically significant. Landowners with very high levels of involvement had much stronger disagreement with the statement that "In the long run, things will balance out with EAB" than landowners with low involvement. Finally, landowners with high involvement levels more strongly disagreed that "the EAB threat is exaggerated" than those with low involvement scores. The following statements, "The EAB threat is exaggerated" and "Other tree species can grow in the place of ash trees and provide the same or increased value," have similar significance where low involvement respondents have more agreement to the statements than other respondents. Those in the higher levels disagree with EAB being exaggerated and then other species can replace ash for the same or increased value. These results, the differences of means between levels, were expected, specifically that the higher levels of involvement would align with the following responses: that the threat of EAB is not exaggerated, and no tree species can fulfill the same environmental roles as ash.

Table 2.9. Average strength of beliefs regarding EAB outcomes across varying levels of Involvement.

Belief Statements:	**Involvement Level Means**			
	Low	**Medium**	**High**	**Very High**
a. There is not much a landowner can do to prepare for the impacts of EAB	3.02	3.13	3.30	3.35
b. As long as EAB continues to spread throughout my state, my efforts to sustain ash are useless	3.21	3.41	3.48	3.52
c. In the long run, things will balance out with EAB	3.30[a]	3.43	3.58	3.70[b]
d. The EAB threat is exaggerated	3.83[a]	4.10[c]	4.41[b,d]	4.48[b,d]
e. EAB has the ability to kill all or nearly all native ash species	2.12	2.15	2.23	2.31
f. Other tree species can fulfill environmental roles of ash trees	3.50	3.66	3.72	3.74
g. Other tree species can grow in the place of ash trees and provide the same or increased value	3.17[a]	3.51	3.54[b]	3.70[b]
Superscripts indicate between-group differences significant at $P < .05$. Note: 1 =strongly agree, 2= agree, 3= neither agree nor disagree, 4 = disagree, 5 =strongly disagree				

2.4.5 Landowners and adaptive management strategies

All survey respondents were asked about specific strategies and practices related to ash protection, adaptation, and re-establishment and if they would consider implementing them on their properties. Respondents who had already taken part in a monitoring program were 11.1% (n=344); see Table 2.10. The strategy with the highest interest of respondents was regarding ash seed collection on their property(ies) with 70.8% (n=243). Only 0.9% (n=343) of respondents said they had no interest in allowing seed collection on their property, and no respondents claimed to have taken part in allowing it. The strategy with the lowest interest was harvesting all or the majority of merchantable ash, with 14.2% (n=344) saying they were interested, and 26.5% responding they had no interest in that activity. However, 47.1% of respondents said they might consider harvesting all or the majority of merchantable ash.

Table 2.10. Responses to the six adaptive management strategies and the reasons for selecting those strategies.

Adaptive Management Strategies		I have done this.	I plan to do this.	I am interested in doing this.	I might consider doing this.	**Top reason for selecting this strategy:**				
						Respondents	To maintain existing forest conditions	To restore to past forest conditions	To change forest conditions to allow other trees to replace ash	Other
Participate in a monitoring program (n=344)	Yes 96.2% (n=331)	38 (11.1%)	12 (3.5%)	168 (48.8%)	113 (32.8%)	311	219 (70.4%)	29 (9.3%)	13 (4.2%)	50 (16.1%)
	I am not interested 3.8% (n=13)									
Plan to harvest all or majority of merchantable ash (n=344)	Yes 73.5% (n=253)	15 (4.4%)	27 (7.8%)	49 (14.2%)	162 (47.1%)	222	77 (34.7%)	15 (6.8%)	29 (13.1%)	101 (45.5%)
	I am not interested 26.5% (n=91)									
Identify sites to reserve ash trees with different size classes (n=342)	Yes 96.8% (n=331)	16 (4.7%)	13 (3.8%)	171 (50%)	131 (38.3%)	316	221 (69.9%)	44 (13.9%)	8 (2.5%)	43 (13.6%)
	I am not interested 3.2% (n=11)									

Table 2.10. Continued.

Allow for the collection of ash seed (n=343)	Yes 99.1% (n=340)	0 (0.0%)	5 (1.5%)	243 (70.8%)	92 (26.8%)	322	150 (46.6%)	123 (38.2%)	2 (0.6%)	47 (14.6%)
	I am not interested 0.9% (n=3)									
Consider use of chemical treatments (n=341)	Yes 75.7% (n=258)	4 (1.2%)	9 (2.6%)	95 (27.9%)	150 (44%)	243	170 (70%)	31 (12.8%)	2 (0.8%)	40 (16.5%)
	I am not interested 24.3% (n=83)									
Consider practices for biological control agents (n=344)	Yes 93.6% (n=322)	3 (0.9%)	4 (1.2%)	177 (51.4%)	138 (40.1%)	306	233 (76.1%)	31 (10.1%)	1 (0.3%)	41 (13.4%)
	I am not interested 6.4% (n=22)									

Participants who responded positively to taking part in an adaptive management strategy were posed with a follow-up question to select the top reason why they had positively responded to that strategy. There were three reasons provided, as well as "Other," where a respondent could include a reason not listed. The management strategy with the highest percentage, "to maintain existing forest conditions," was for considering the use of biological controls, at 76.1% of respondents. For a reason "to restore to past forest conditions," the highest percentage was 38.2% for allowing for ash seed collection on a participant's property. The third reason, "to change forest conditions to allow other trees to replace ash," had the highest percentage of harvesting all or the majority of merchantable ash with 13.1%. The final reason "Other," had at least 13.4% or larger for each management strategy, but the responses varied or were left blank. 45.5% of respondents for the strategy of harvesting all or the majority of merchantable ash chose "Other." Of the 90 written responses, one of the major concerns was the monetary or utility value of the ash being lost with EAB infesting their property. These values include using ash for firewood or timber sales, but there is concern about the loss of value if EAB has access to the trees first. Participants also used the opportunity to harvest ash to slow or stop EAB spread. Removing ash from the landscape is not a method to slow or stop the spread of EAB. However, from the responses by participants, it is still believed by landowners that this is a viable strategy. It is important to note that a number of participants were interested in leaving selected trees of different size classes, which relates to those who also want to keep the current species present in the forest. Therefore, there are people who want to ensure ash and the current ecological niches remain. The strategies of use of chemical treatments and biological controls had concerns from respondents about the use of chemicals in the environment, as well as introducing a new species to combat EAB. Although, a number of respondents said they would rather have biological controls than using chemicals. The overall response from respondents who selected "Other" was a general desire to help ash against EAB, whether that is collecting ash seeds for research or supporting the desires of the Wabanaki community, among other wishes.

Respondents indicated what may influence their decision to take part in ash management, as seen in Table 2.11. Of the nine social and economic factors, two had high percentages of Very Influential responses: "You think the practice is likely to succeed" with 44.5%, and "Fits with the long-term management goals of the land" with 41.6%. The third highest percentage was "Cost of the practice" as

Somewhat Influential at 38.3%. The factor with the highest percentage in the Not at all Influential category was "Public perception of the practice," with 33.2%.

Table 2.11. Frequency and influences of social and economic factors in landowner participation.

	Extremely Influential	Very Influential	Somewhat Influential	Slightly Influential	Not at all Influential
Fits with the long-term management goals of the land (n=281)	78 (27.8%)	117 (41.6%)	57 (20.3%)	20 (7.1%)	9 (3.2%)
You think the practice is likely to succeed (n=281)	40 (14.2%)	125 (44.5%)	92 (32.7%)	19 (6.8%)	5 (1.8%)
Other landowners have successfully implemented the practice (n=279)	35 (12.5%)	96 (34.4%)	82 (29.4%)	44 (15.8%)	22 (7.9%)
Public perception of the practice (n=280)	5 (1.8%)	33 (11.8%)	77 (27.5%)	72 (25.7%)	93 (33.2%)
Other landowner's perception of the practice (n=278)	7 (2.5%)	40 (14.4%)	83 (29.9%)	79 (28.4%)	69 (24.8%)
The practice will serve as a demonstration (n=280)	35 (12.5%)	81 (28.9%)	96 (34.3%)	38 (13.6%)	30 (10.7%)
Economic returns of the practice (n=277)	21 (7.6%)	51 (18.4%)	66 (23.8%)	66 (23.8%)	73 (26.4%)
Cost of the practice (n=277)	33 (11.9%)	86 (31%)	106 (38.3%)	30 (10.8%)	22 (7.9%)
Cost-share funding available for the practice (n=279)	64 (22.9%)	85 (30.5%)	86 (30.8%)	22 (7.9%)	22 (7.9%)

2.5 Discussion and conclusion

Given the high interest and involvement of private landowners in Maine, landscape-level coordination for EAB management could be feasible, with statewide participation aimed at ash protection (Niemiec et al., 2017). Private landowners who have over 10 acres of forest land are a population that could participate in many of the adaptive management strategies. Of the 601 respondents to this survey, some owned more than 10 acres, not of forestland, but residential or agricultural. While ash in these locations is still important, the focus on the majority of the strategies requires the location to be in the forest. It is important to mention that anyone interested in protecting ash can take part, even if they have a single ash tree or no property at all, they can get involved with their municipality or local land trust. Interestingly, of

the 362 landowners who fit the criteria for the analysis, only a portion were within the Maine quarantine boundaries. Meaning that whether or not landowners had experienced or were aware of EAB, they were still interested in participating in this research about protecting ash. This is noteworthy because it illustrates landowners in Maine are interested in taking part in this effort by simply taking a survey. Overall, the interest in this invasive species issue is high, however addressing factors of landowner involvement is the next step.

A similar study of FFOs in western New England found invasive forest pests could influence changes in timber harvest plans, depending on each pest's threat (Markowski-Lindsay et al., 2020). Specifically, "the harvest intention estimates in the study area [...] exceed the USDA National Woodland Owner Survey's harvesting estimate of similar FFOs for the larger, four-state region" (Markowski-Lindsay et al., 2020, p. 167; Butler and Miles, 2016). Therefore, the landscape may be poised to undergo a significant transformation at a greater rate than previously understood due to invasive forest pest management by private forest landowners. MacLean et al. (2020) concluded that EAB's presence in this watershed "could dramatically alter timber harvest regimes," as private forest owners remove ash.

Maine's landowners' levels of involvement varied, but regardless of this there were positive responses to potential engagement with each adaptive management strategy. However, not all landowners had the same management objectives nor reasons for being interested in those strategies. Mostly, landowners want to keep the tree species that are present on their land, but a small portion prefer to change the species composition. Overall, the mean of respondents neither agree nor disagree with two belief statements, "There is not much a landowner can do to prepare for the impacts of EAB," and "As long as EAB continues to spread throughout my state, my efforts to sustain ash are useless." This uncertainty of beliefs by landowners indicates that, while there are positive responses for potential engagement in adaptive management strategies, landowners are unsure if their efforts can make a difference. The previous studies indicate a lack of explanation in proper adaptive management of ash forests can greatly affect the larger forest system. Looking closer at the adaptive management strategies alongside the involvement levels may provide a deeper understanding of how to influence landowners.

Results of the involvement levels provided insight into the interest and possibility of action for the landowners. Overall, there was a high level of positive response for all of the adaptive management strategies; however, providing access for ash seed collection had the highest level. This is a key strategy for

a few reasons. Firstly, ash seeds are a finite resource, and once the source is no longer available, the genetic material and the ability to plant new trees are gone. Secondly, this is a relatively inexpensive strategy, particularly if landowners are opening their property for a trained seed collector to access the seed. Therefore, the associated financial and time costs are low. Whereas, strategies involving chemical treatments or silviculture would require hiring professionals or becoming licensed to administer tree injections could be very costly. Of all of the strategies, seed collecting may be the most time sensitive, as seed is produced so infrequently. As EAB spreads, seed production and collecting is essential at every opportunity. While the positive responses to the other adaptive management strategies are encouraging and provide important information for education and outreach efforts, seed collecting needs to be focused on for the future of ash genetics. Concern over EAB's impact on Maine residents transcends county boundaries, evident in the involvement levels of landowners inside and outside the quarantine zone. Landowners in Maine care about their state and the ash on the landscape beyond their own property. Landowners are interested in taking the steps necessary to protect ash trees and, in turn, help their fellow landowners protect their ash. Increased engagement among landowners with adaptive management strategies might help reverse disinterest in certain approaches and foster stronger enthusiasm for action.

It is known that landowners discussing invasive species management with their neighbors is an important factor for participation, and can be a driver in collective action (Clarke et al., 2021). The social and economic factors responses provide valuable insight into what may influence action among landowners. It is also important for those implementing outreach and education to address more than just financial incentives; they should also address the beliefs of social and ecological contexts of the invasive species (Niemiec et al., 2017). In this survey, the most influential social and economic factors in landowner participation were economic and support focused. It is documented that simply providing information to landowners will not influence their behaviors (McLeod et al., 2015). While the landowners in Maine are interested and aware of EAB, understanding what factors will influence their action is paramount to designing strategies that increase those implementing management practices. Two key factors emerged as most influential: financial considerations, where landowners require cost-sharing and clarity on the costs involved, and confidence in the practice, demonstrated through examples from their peers. Landowners want to see that this is a successful strategy, that it fits with the goals of their management, and that they can be a demonstration for others (Niemiec et al., 2017). This highlights two relationships, the landowner

to an agency or organization for financial partnership, and landowners with their network of peers across the state with whom they can connect on these practices (Langer, 2008; Ma, Clarke, & Church, 2018; Niemiec et al., 2016). Landowner-peer interactions as "microinterventions" to increase private land conservation have already been shown to be a promising method (Niemiec et al., 2019). For future outreach and education efforts, honing in on these influences for landowners should be central. However, landowners must first have an inventory of the ash on their land to understand possible practices, if any.

While there were relatively high numbers of positive responses to the adaptive management strategies, not all of the strategies are available to each landowner, nor are they appropriate for each property. Each strategy requires ash to be present on the property; 16.9% (n=61) were unsure, and 2.8% (n=10) responded to having no ash species on their property. Landowners need an inventory of their ash to evaluate which strategy is possible for them to implement. Looking at which species landowners were unsure of, green ash had the highest percentage, with 53% unsure or did not know if it was on their land. While green ash is the least common species in Maine, landowners' lack of awareness is important to note. For the other two species, brown ash had 39.2%, and white ash had 22.7% of landowners unsure or did not know if they had these species on their land. An important step in long-term care and protection for ash starts with becoming familiar with the trees that people have. When asked about forest management plans, 66.3% of landowners said they had a plan for their land, and 23.3% specifically referenced ash in those plans. However, the species specified in those plans were not asked. Although there were positive responses from landowners in this survey for interest in adaptive management strategies, this does not equate to their ability to participate in a strategy, nor does it equal behavior to act on those interests. Therefore, landowners inventorying their properties is the first crucial step in discovering if they can take part in strategies.

While there were relatively high positive responses for all of the adaptive management strategies, which potentially correlates to actions by landowners, strategies require specific conditions to be appropriate. For example, biological controls can only be released in areas with confirmed EAB. This limits the availability and ability of interested landowners as EAB is not present across the state. This education and outreach to discuss options with landowners need buy-in from the forestry community who interact with landowners, like foresters and loggers. These are the industry professionals who can make an impact by communicating the need to protect ash and the options to be a part of the effort. While landowners are

the access point to forests, it is the recommendation of strategies, and the selection of trees to harvest that foresters and loggers are responsible for. The presence of EAB affects the management and tree selection of foresters and loggers in New England (Markowski-Lindsey et al., 2023). Foresters and loggers have been found to increase the intensity of management for ash and harvest larger areas to manage the ecological impacts of EAB (Holt et al., 2022). Therefore, it is suggested that foresters and loggers educate themselves on these adaptive management strategies to advise their clients best to protect ash on their land. Understanding what foresters and loggers actions and recommendations to landowners in Maine is an important next step in the research. This will provide insight into the state of ash management in Maine, and where it should be adjusted to increase the needs of ash.

The results illustrate the overall interest, attitudes, and involvement of landowners who own over 10 acres of forest in Maine in participating in adaptive management strategies to protect ash trees against EAB. However, interest does not always correlate with action. Understanding the decision making of landowners to take part in these strategies is the direction that research should move. The Theory of Planned Behavior, which addresses intentions and implementation of actions, is well suited for this analysis (Ajzen, 1991). There are sufficient examples in the literature where this theory has been applied to forest landowner decision making, even focusing on EAB and invasive species management (Holt et al., 2021; Adhikari et al., 2023a; Adhikari et al., 2023b). The social and economic factors that will influence private landowner involvement with adaptive management strategies should be addressed in the future and will provide insight into the needs of landowners to take part. One such example of a visualization that may be of use in explaining participation by landowners in this effort is the Tarnside Curve, which is used in philanthropic fundraising and highlights involvement versus giving (Boggen, n.d.). In this case, the giving could be the actions by landowners to take part. For example, from low involvement individuals characterized by awareness and subsequent increased in the levels of involvement that include interest, engagement, commitment, ownership and lastly, taking personal responsibility. The importance of understanding landowner action for protecting ash cannot be overstated. It is only by influencing landowners to put adaptive management strategies into widespread action that the best protection for ash to take place.

2.5.1 Research limitations and future directions

A limitation of this research that must be noted is the organizations with which the sample size was captured. As seen in Table 2.1, many of the organizations focus on conservation or environmental purposes, meaning those who are a part of their network or receive their newsletters and communications are most likely pro-conservation and environmental issues. While the results of this research are encouragingly positive, that private landowners are interested in protecting ash from EAB mortality, the sample was gained partially from a pro-conservation/environmental pool. Efforts to find participants by other means were explored, like encouraging participants to share the survey with their neighbors, fellow landowners and families. However, the bulk of the effort by researchers was to request that partnering organizations would assist their efforts by sharing the survey amongst their networks. A future direction of this research could be to investigate other avenues of gaining access to private landowners outside these networks. One suggestion would be to advertise the survey at outdoor recreation shows, which are popular in Maine. These attract private landowners who may not be a part of forestry or land conservation organizations but may know their property enough and have an interest in protecting ash from EAB.

Another direction to focus on would be highlighting the Indigenous culture tied to brown ash, specifically with Wabanaki basketmaking. Brown ash is a cultural keystone species for the four Nations of the Wabanaki Confederacy: Maliseet, Mi'kmaq, Passamoquoddy, and Penobscot, (Costanza et al., 2017). Traditional basketmaking or weaving is an art form and livelihood of the Wabanaki people, which has survived centuries and uses exclusively brown ash (Frey, Emery & Greenlaw, 2019; Hardy, 2009; Neptune & Neuman, 2014). A section of the private landowner survey was not analyzed, which asked participants about their knowledge of brown ash and its importance to the Wabanaki People. This cultural piece would be important for understanding what is needed to expand education regarding brown ash uses and access to the trees for Wabanaki harvesters and basketmakers. This is an important key to telling the entire story of brown ash and its importance, beyond the economic and environmental reasons focused on in this research.

Finally, lingering ash, or ash that has not yet succumbed to EAB after all the surrounding ash has died, is one of the most important factors in the future of ash and has been found in the Lake states of the US (Knight et al., 2012). As the EAB invasion is more recently detected in New England, lingering ash has not had the time or opportunity to yet be found. However, efforts are underway to prepare the public to be

aware of these trees and to alert researchers when they are found (APCAW, 2023). Where Maine is almost 94% privately owned, it is up to the landowners and caretakers to monitor for EAB spread and post-invasion lingering ash. The genetic material from these trees will be collected for research to potentially cross with other ash to increase the resistance of the trees in the hope of creating a species that can coexist with EAB. EAB is not leaving North America, as there is no way to eradicate the spread. The only solution for researchers is to find a solution for both trees and insects to live together, which native ash does with many native wood-boring insects. The buy-in from private landowners will increase the discovery of lingering ash and the possibility of future ash that can withstand the predation of EAB. Where the data presented here illustrates private landowner interest in seed collection, it seems a natural step for landowners to become aware of the ash they have and monitor their forests. In the future, this is a key area to focus on: identifying ash on the landscape before EAB spreads so that ash can be monitored during and post-invasion for lingering ash. Private landowners will be a key part of this effort in Maine.

2.6 Funding

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CHAPTER 3

BROWN ASH SEED COLLECTION MANUAL: PRESERVING BROWN ASH (*FRAXINUS NIGRA*, WIKP/WISKOQ) THROUGH THE ASH PROTECTION COLLABORATION ACROSS WABANAKIK, APCAW

Notes and acknowledgments

The Brown Ash Seed Collection Manual was created with the goal of providing guidance for non-researchers to take part in efforts to protect the cultural, ecological and economic resource of the brown ash tree. It was designed as a "living document" to be updated by the APCAW lab and greater ash protection network in Maine as new information is learned regarding seed collection and storage. The version of the document found here has been formatted for the purpose of fulfilling a dissertation requirement. The most updated version of the seed manual can be found on the University of Maine's APCAW website, umaine.edu/apcaw.

APCAW and the authors acknowledge the many people and organizations who contributed to this manual. We thank: Nate Siegert, entomologist at the US Forest Service, for his work in the field collecting ash seed with us, as well as developing and reviewing drafts of this manual. Les Benedict, Assistant Director of the Environment Division for the Saint Regis Mohawk Tribal Nation, for his decades of experience working to protect brown ash, the support he provided to us through all stages of this document, and hosting us in Akwesasne, NY. Andrea Berry, Anna Fialkoff, Emily Baisden and colleagues at Wild Seed Project for their knowledge and support as we worked to develop seed processing protocol. To the USDA ARS employees who we have communicated with through this process, including Jeffrey Carstens and Stephanie Greene. Finally, the development of this manual was also **supported by the USDA National Institute of Food and Agriculture, McIntire-Stennis project** 1019853 Socio-ecological Model (SEM) as a Conceptual Framework for Improving Forest Planning and Management.

The document is divided into four sections. The first introduces emerald ash borer and the need to protect ash species in Maine. The second provides direction on how to use the document, as well as step-by-step instructions preparing for seed collection, identifying ash on the landscape, what documentation is required to collect and submit seed for storage, methods of collecting seed, and post-harvest handling and

processing. The last two sections cover future uses of seed and a conclusion. All necessary forms and equipment check list can be found in the appendices.

3.1 Introduction

3.1.1 EAB invasion threatens ash resource

Discovered in 2002 in North America, the emerald ash borer (*Agrilus planipennis,* EAB, Figure 3.1), has spread across much of the eastern United States and southeastern Canada to the detriment of all native species of ash trees, EAB's primary host species. The damage this invasive forest pest has caused across the continent is undeniable. The insect eats the phloem, a layer under the bark that transports food and nutrients to all parts of the tree. If enough EAB attack the tree it cannot survive and will die. Between 2002 and 2006, it is estimated EAB had killed 15 million ash trees in the United States, and as of 2023, many more millions of ash trees have died; EAB has now been detected in 36 states and five Canadian provinces (Emerald Ash Borer Network, 2023; Poland & McCullough, 2006). Established populations of EAB were first detected in Maine in 2018 in York and Aroostook counties, the southernmost and northernmost in the state, respectively, and the infestation is now spreading toward the center of the state (Siegert, 2019).

Figure 3.1. Example of an EAB feeding gallery on an ash tree. Examples of adult and larval EAB specimens (Siegert, 2023).

3.1.2 Loss of culturally significant brown ash

There are three species of naturally occurring native ash found in Maine: green ash (*Fraxinus pennsylvanica*), black ash or brown ash (*Fraxinus nigra*), and white ash (*Fraxinus americana*). Non-native, ornamental ash are also susceptible to EAB. While all native ash trees are important and worth saving, the brown ash tree is a cultural keystone species to the Wabanaki people who are deeply tied to the tree species and use it almost exclusively for the art of basketmaking (Costanza et al., 2017). Brown ash is significant in multiple creation stories between the Tribes of the Wabanaki Confederacy. There is no replacement for brown ash in Wabanaki culture. Brown ash is important to all Tribal Nations throughout the species range including but not limited to: the Wabanaki Confederacy, the Haudenosaunee Confederacy and the Anishinaabe Peoples' on both sides of the political boundary between Canada and the United States. Seed collecting is a long-term strategy for protecting ash. Collected seeds may be used for research and conservation of the species. Partnerships are in place with the Tribal Nations of the Wabanaki Confederacy, the University of Maine: School of Forest Resources, natural resources agencies for the state of Maine, United States Forest Service, land trusts and private landowners.

3.1.3 Preserving brown ash through seed collection

Why harvest seeds? This is an excellent question. There are several research directions and conservation methods with which ash seeds can be used: genetic studies, future plantings and possible regeneration of trees in seed banks, to name a few. Looking to the Great Lakes region, there are numerous concerns on what the Wabanaki refer to as the Dawnland, present-day Maine, will look like after EAB has spread through the entire state. In many states ash trees have been used for municipal and residential street trees and with the infestation of EAB, these trees must be removed which has changed the landscape of many cities and towns across the country. Maine is covered in mixed forest and white ash is typically a timber tree. Therefore, loss of ash in Maine will change not only what many of the towns will look like, but forests too. Maine's total forest is only a small percentage of ash, but brown ash is highly important to localized ecology of wetter areas within the forest. While all ash contribute important functions to their environment, brown ash is often essential to the water table in the areas it is found and there has not been a species of tree identified to regulate water in the same way. Brown ash leaves are to last the come out in

the spring and some of the first to fall in autumn, making its leaf litter on the forest floor very important to many animals and plants.

Maine is the last state to be impacted in the Northeast for brown ash. Therefore, the time is now to collect seed before overstory seed trees are lost. EAB is not going to go away, even after it has covered the ash range, so it is highly important to collect seed while the forest still has naturally occurring brown ash. A further discussion of research possibilities is presented later in this document in the section titled, "Future Uses of Seeds".

3.2 How to use this document

This document is to be used as a guideline for collecting ash seed on potentially an annual basis. Ash trees do not produce seed every year, so it is important to at least scout for seed each year, so if trees are producing seed can be collected in the fall. The goal of this document is to provide those interested in protecting brown ash a way to be involved with the effort, regardless of experience or skill in forestry or research. We will be walking through the methods for how to prepare for seed collecting, identifying ash trees, returning to collect seed, and the post-collection processing. The future uses of seed and an example of a well-stocked seed collection kit developed by APCAW is also included. The final section of this document outlines the collection of ash leaves for a research project that we have partnered with Dr. Jill Hamilton at Pennsylvania State University. Please consider this opportunity to assist fellow ash researchers in collecting these materials.

3.2.1 Steps for seed collection

3.2.1.1 Where to start? Prioritizing areas for collection

While all ash is important, the genetic diversity of wild ash or non-nursery ash is of utmost importance to those wishing to protect the species for the future. That is why this document is meant to focus on collecting ash in the forest, rather than ornamental or street trees, like what someone might plant in their front yard. For this reason, we recommend reading and practicing the methods outlined in "An Ash Resources Inventory Field Manual" (Everett, 2019), a guide for finding ash stands for potential seed collection. The inventory field manual is highly technical and has helpful information regarding the background of ash, EAB, treatments to protect against EAB, and how to find ash stands on your property.

While green ash and white ash may be mentioned in comparison, the focus of this manual is on brown ash seed identification, collection, and storage options.

3.2.1.2 Identification of ash trees and seasonal observations

A helpful guide for all trees in Maine is the "Forest Trees of Maine: Centennial Edition 1908 – 2008" produced by the Maine Forest Service, which provides excellent information on identifying ash. The "Ash Identification Table" in the appendix comes from the "Forest Trees of Maine" text and will be referenced throughout this seed collection manual. We will now highlight the differences between the three species of ash that you can find in the Northeast: brown ash, green ash, and white ash.

Ash trees are deciduous, meaning that leaves grown in the spring will mature and die in the fall. Generally, the three ash species in Maine will grow between 50-70 feet in height, but are often found in different areas of the forest. In the Northeast, mixed ash stands are not uncommon, but knowing where ash species are typically found is helpful in identifying individual trees. White ash is typically in upland areas, whereas green ash is found in low hills with moist soil, but brown ash is found where 'it can keep its feet wet'. Brown ash is often in swamps and along riverbanks where the water table is higher, making it less desirable for timber harvesting, along with it generally not being valued as a timber species. White ash is first and foremost an important timber species, as well as used in residential areas for ornamental or street trees. Green ash is least commonly seen in the wild, mostly found in central Maine. It is however a very common street tree.

Distinguishing between species of ash is not always easy and can be challenging even for those used to working with trees. Please view the appendix section titled, "Ash Identification Table" for a complete description, as well as Figure 3.2. It is suggested to have a field guide that highlights all three species when in the field to help properly identify trees. Brown ash has yellow-green leaflets, brighter than other species, and are long and thin with 7 to 11 on one leaf. The leaflets are no more than 5 inches long and are "lance-shaped," (Maine Forest Service, 2008, p. 133). Green and white ash will generally have fewer leaflets, between 7 and 9, and 5 and 9, respectively. White ash is the only one whose leaves will turn purple in the fall, green ash and brown ash will turn yellow.

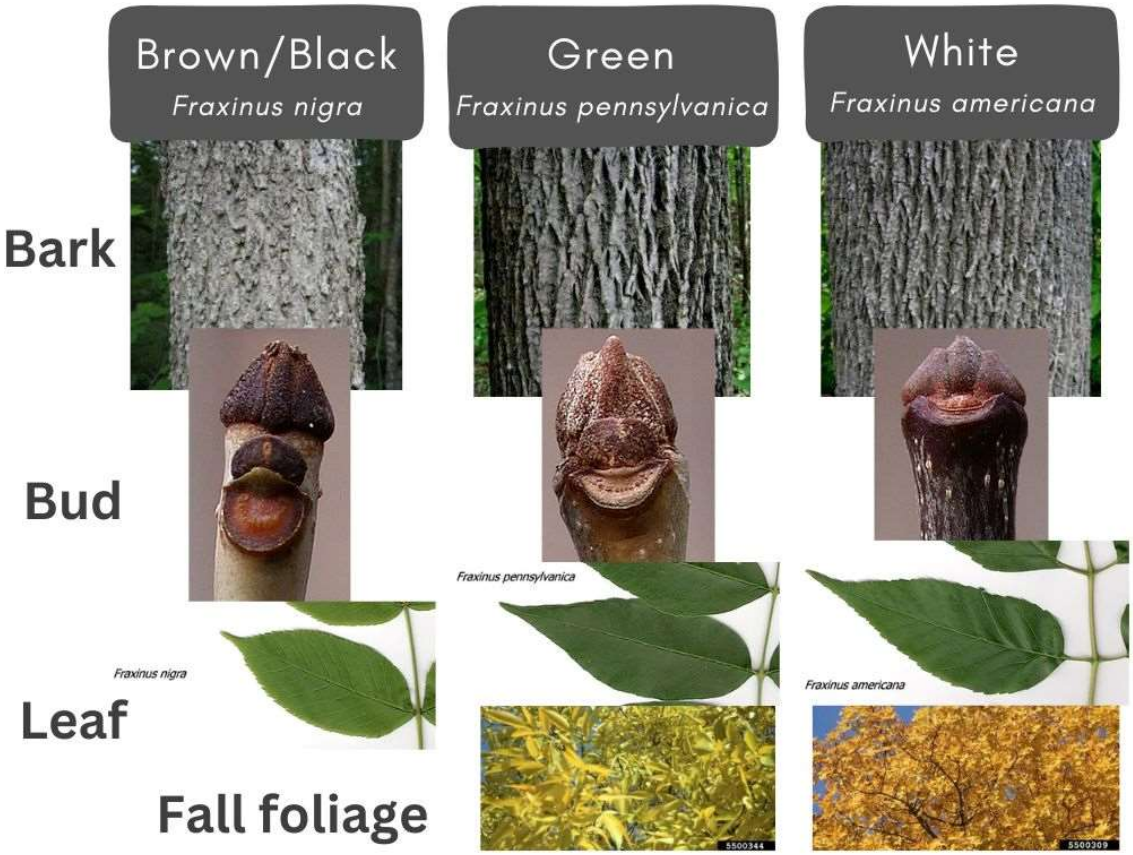


Figure 3.2. Photo representation of the bark, buds and leaves of each ash species in Maine. Bark photos (Maine Forest Service, 2020), bud photos (Dzuik, 2014), leaf photos (Chayka, 2014), and fall foliage (Syndor, 2013a & 2013b).

The bark of the trees is another indicator to identify species. Brown ash is known for its spongy bark, which is corky, scaly, flakey or furrowed. The outer layer of bark can sometimes rub off easily when touched and is often gray to dark gray in color. Green ash should feel firmer, gray to brown in color, and often with deep channels in the bark. White ash, as described by the "Forest Trees of Maine", "resembles a woven basket," (2008, p.128) which is confusing language because this tree is not used as splint material in traditional Wabanaki basketmaking. This texture comes from a description of the ridges in the bark. White ash is usually a dark gray or brown color.

The buds of the trees are another way to differentiate ash species, if you are able to reach the limbs. The three species buds are all ¼ of an inch or less in size. Brown ash buds are dark in color and "sharply-pointed", green ash are brown and "cone-shaped" and white ash are brown and "blunt-pointed" (Maine Forest Service, 2008, p. 127). Being able to tell the difference between buds is important depending on the

time of the year you are surveying ash trees. Surveying before the leaves are present in the spring means you must be able to tell the difference in the trees with the bark and maybe buds.

Finally, the differences between the fruit of the ash trees. The fruit is the container in which the seeds are kept. The fruit of the ash tree is called a samara, and each of the ash trees have similarly sized and shaped samaras. Brown ash samara wings are the long almost oval-shaped housing, like a canoe paddle blade, which contains the flat seed. When it is growing on the tree, they are green in color and yellow when dried. These are what are often seen on the ground under a brown ash tree after the growing season. Green ash has similar samaras, although they are described as "funnel-shaped" (Maine Forest Service, 2008, p. 131), and white ash samaras as, "cigar-shaped" (p. 128). Figure 3.3 shows the seeds of the three ash species next to each other for comparison.

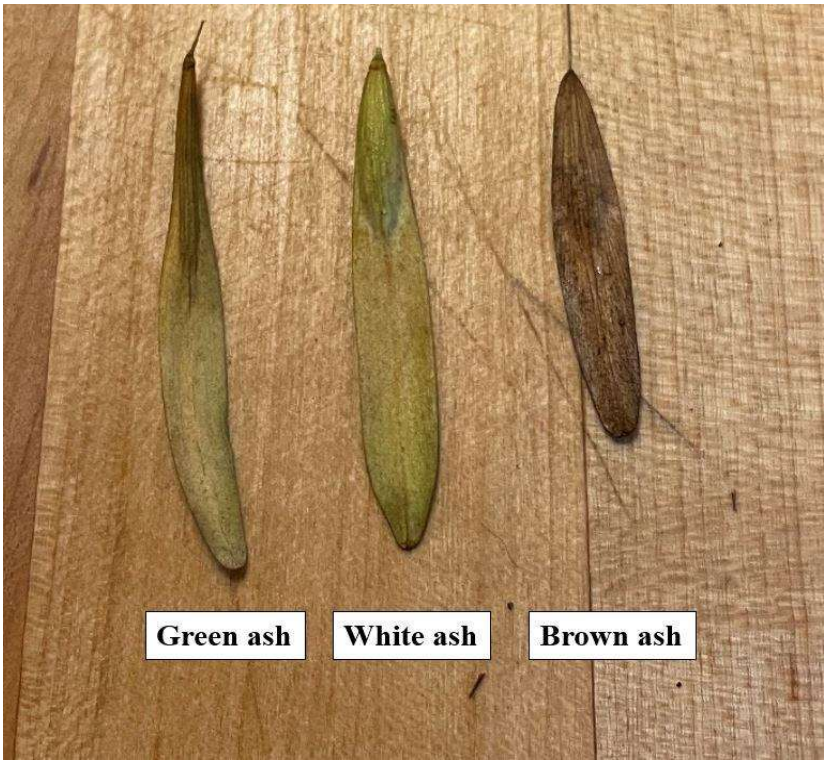


Figure 3.3. An example of samaras from each type of ash species found in Maine: green ash, white ash, and brown ash. Photograph by Emily Francis.

3.2.1.3 Identifying the sex of a brown ash tree

Brown ash trees have three possible sexes: female, male or polygamous, meaning that the tree can produce both female and male flowers. Identifying the sex of a tree is important as it will indicate which trees can produce seeds. Finding the female trees is essential to seed collection and a very important reason

for scouting your ash stand in spring, which will be reviewed in the next section. The female trees are often described as wispy or "feathery, yellow panicles, 1 to 2 inches long," as seen in Figure 3.4a and 3.4c (MinnesotaWildflowers.info, n.d.). Male flowers are rounded or globular, and dark in color (Figure 3.4b). These can often be seen after spring and into the summer for a very short window of time, and can be hard to distinguish on particularly tall trees if still visible after the trees have bud out. Remnants of the flowers can sometimes be seen throughout the rest of the year from the ground with binoculars. Male flowers often remain on the tree throughout the year due to the stocky stature. They are most visually recognizable when they have been impacted by the ash flower gall mite. This causes the male ash flowers to have very dark growths that can be seen across the trees canopy well into the fall and winter months. The female flowers leave behind the stems, making them look like long bristles at the end of the tree branches, and male flowers are dark blobs in the same place, but on male trees. Polygamous trees can be difficult to distinguish unless both parts of flowers are left behind. The female and male flowers bloom at different times to prevent self-pollination, and therefore it is possible to mark a tree as one sex and later see it present as another. It is important to keep records of the trees you collect from over time and can consult which trees did produce seed. It is also important to remember that all seed producing trees are important to collect from, as many factors go into seed production. As ash trees do not produce seed every year, it is essential to collect from as many seed producers as possible to collect the broadest range of genetic variation.

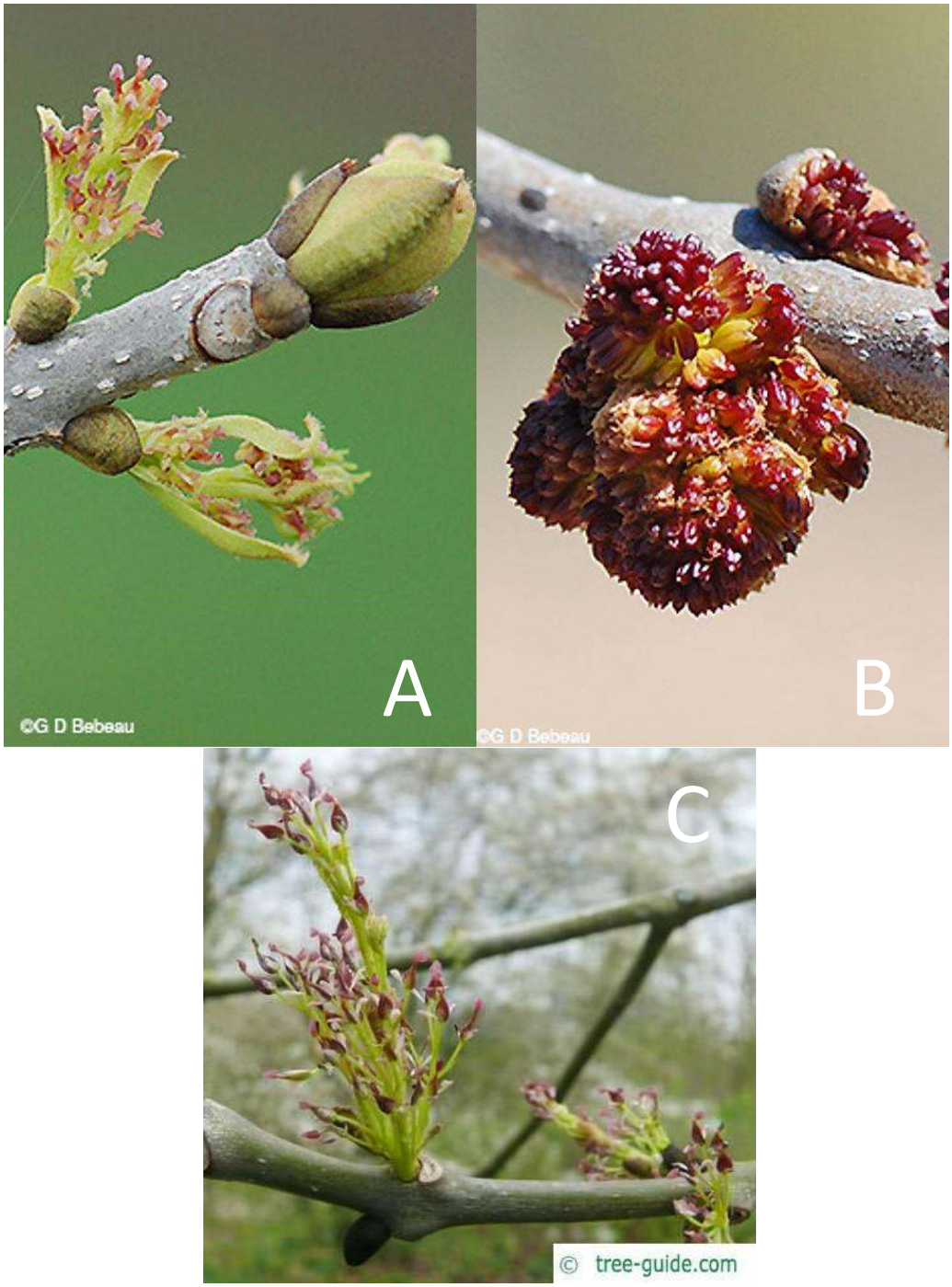


Figure 3.4. Male and female ash brown ash flowers. Image A represents developing female brown ash flowers (Bebeau, 2013a). Image B represents a male brown ash flower (Bebeau, 2013b). Image C represents female brown ash flowers (Benning, n.d.).

3.2.1.4 Timing of seed collection

Ash has a broad range in North America, and different species vary in when they have harvestable seeds. According to partners and seed collection experts with the Akwesasne Saint Regis Mohawk Tribe, as

well as basketmakers, ash harvesters, and foresters in Maine, it is suggested to begin scouting trees in early spring. Brown ash trees will start producing flowers slightly before they "leaf out" in the spring. Scouting is recommended to occur in early to late spring, between April and May, see Table 3.1. If seed is detected in the spring, you may want to monitor the trees during the summer months of June, July and August. Seed collecting takes place between September and the first week of October with the processing and storage immediately after collection. The end of October through December is time to evaluate the collection cycle, complete records, and share outcomes with partners. Late winter, January to March, can be a time for resupplying and updating protocol for the next round of spring tree scouting, and the whole cycle starts again.

Table 3.1. Annual seed collection activities divided by month.

ACTIVITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Evaluate previous year protocol and update, if needed. Resupply seed collection kits.	■	■	■									
Spring tree scouting: identifying trees, sex, evidence of EAB activity, and marking for potential collection.				■	■							
Monitoring of seed growth and development. Leaf collection research – see Ash Foliage Collection section.						■	■	■				
Seed collection time. Sort, clean and dry seeds. Must be packaged and stored very soon after collection.									■	■		
Evaluate completeness of collections and make plans for the next collection cycle. Complete records of collection, and share outcomes with seed collection partners.										■	■	■

3.2.1.5 Things to consider before collecting

The recommended items for ash seed scouting and collecting can be found in the "Ash Seed Collection Kit: Recommended Checklist" in Appendix A. This list of items was curated by discussing seed collecting with experts with the Akwesasne Saint Regis Mohawk Tribe's Akwesasne Task Force on the Environment, forestry professionals, as well as harvesters, to find what works best for collecting ash seed with the pruning pole method in mind. The "Seed Collection Techniques" section will provide other options for collecting seed, but the list provided here highlights what is recommended when using pruning poles to

cut branches for ash seed. The scouting trees section of the checklist should be universal to all seed collecting methods. Having the proper items for ash seed scouting and collecting is very important.

Brown ash can be difficult to access due to the wet areas in which it grows and may not be located close to roadways. Ash trees can also have hard to reach branches, depending on where a tree is located and its height. This is something to consider when looking for ash trees to collect from: can you safely reach the branches that have seed? If not, look for roadside or forest edge trees that may be more accessible, rather than the taller canopy trees or trees inaccessible to reach. It is important to have everything you might need before heading into the field, so you will be prepared during both scouting and collecting trips. While it is not listed in the checklist, there are other items you might want to bring anytime you are heading into the woods in Maine: a good pair of boots, bug spray and/or tick spray, sunscreen, a hat, a cell phone with full power, a camera (if your phone does not have one) and drinking water. We also suggest working in 2 or 3 person teams for safety and always letting someone know your plans before heading out.

3.2.1.6 Documentation of trees and seeds

Documentation of trees and seeds collected from these trees are an essential part of the seed collection process. Without it, there will be no data to locate trees, their geographic location, and all the information associated with the collection. Depending on where you will be sending your seed will depend on which of two data collection sheets you will need to fill out. We have included two forms and how to fill them out in this document. It is important to decide where you plan to send your seeds for storage prior to collection so you can follow the correct guidelines and requirements for each location.

The three locations described in this manual include:

- United States Department of Agriculture (USDA) Agricultural Research Service National Plant Germplasm Facility in Ames, Iowa;
- USDA Agricultural Research Service's National Plant Germplasm Facility in Fort Collins, Colorado, and
- University of Maine's Ash Protection Collaboration across Wabanakik (APCAW) in Orono, Maine.

The distinction between the two National Plant Germplasm Facilities will be discussed in the "Post-harvest Seed Handling and Processing" section of this document. We refer to the National Seed Laboratory as NSL and the National Plant Germplasm Facilities as NPGF while the forms for each are overviewed.

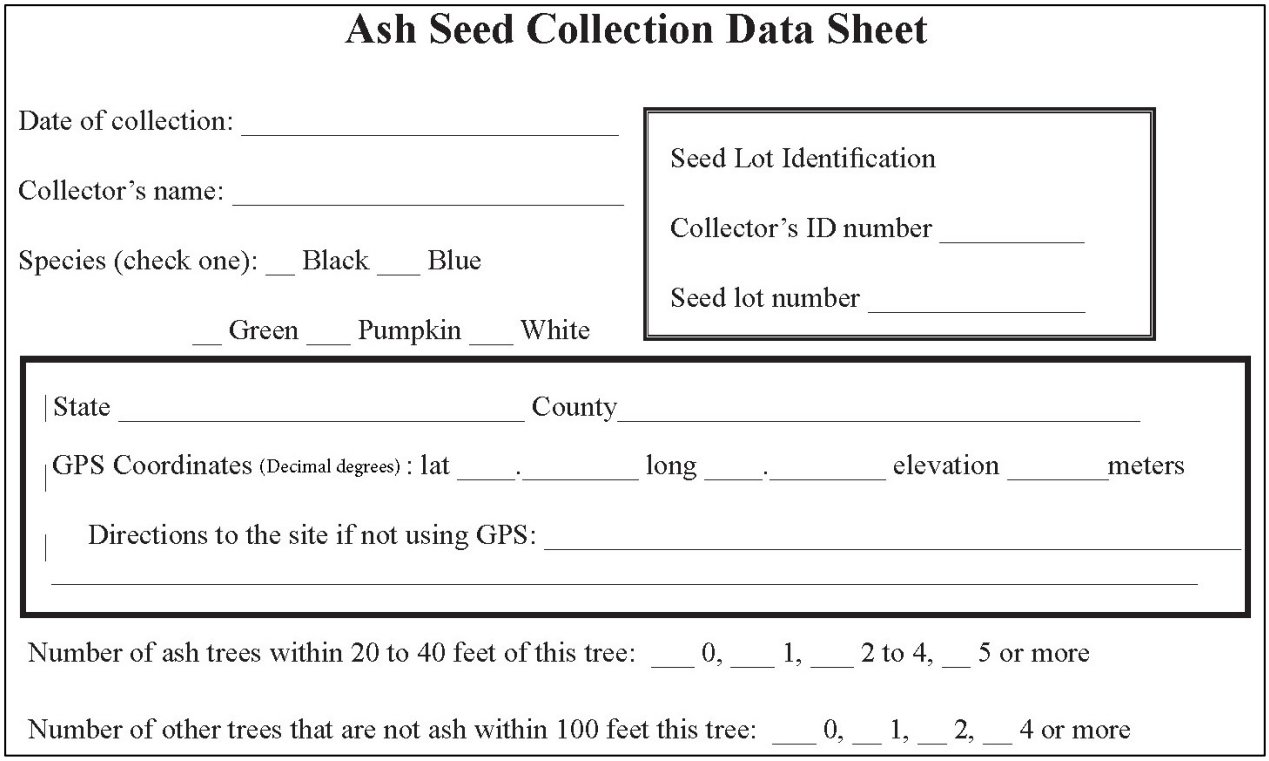
If you are collecting for one of the Wabanaki Tribal Nations, please use the address of the Nation's headquarters (Table 3.2) and share the longitude and latitude of the collection location separately with the Tribe. This can also be shared with APCAW and the information can be forwarded to the respective Nation. This allows the location of the ash seed trees to be protected by the Nation.

Table 3.2. Addresses for Wabanaki Tribal headquarters to be used when submitting for seed collection.

Houlton Band of Maliseet Indians	**Mi'kmaq Nation**	**Penobscot Nation**	**Passamaquoddy Tribe – Indian Township**	**Passamaquoddy Tribe – Sipayik**
88 Bell Rd, Littleton, ME 04730	7 Northern Road Presque Isle, Maine 04736	27 Wabanaki Way, Indian Island, ME, 04468	8 Kennebasis Rd, Indian Twp, ME 04668	9 Sakom Drive, Perry, ME 04667

3.2.1.6.1 National Seed Laboratory Data Sheet

Please use the USDA Ash Seed Collection Data Sheet as a reference, found in Appendix B, as we walk through the steps to filling it out. One sheet should be completed for each tree sampled, each time it is sampled and will correspond with one bag a seed. You will need a clipboard, datasheets, and a pen or pencil. Starting at the top of the sheet, make sure to document the date of collection and the name of the collector, or team of collectors. As this effort is focusing on brown ash, once the species is identified, this should be marked. If working in a seed lot, you may have a Collector's ID and seed lot information and can be applied to the sheet, see Figure 3.5. Please work with whoever is leading your collection to identify Collector's ID numbers or codes, as well as identifying the seed lot numerical identification you will be using. If you are working as an individual, your initials can be used for a Collector's ID with a number corresponding with a sample number for your own records. This information will be written on the seed collection paper bags, so it is essential these numbers be correctly documented on the corresponding data sheet. The large, black outlined box in the next section, contains the geospatial information for the state, county and GPS, Geospatial Positioning System coordinates in decimal degrees. The latitude, longitude, elevation, and meters should be included there. If a GPS unit is not being used for this collection, directions of how to relocate the tree should be noted.



Ash Seed Collection Data Sheet

Date of collection: _____

Collector's name: _____

Species (check one): __ Black ___ Blue

__ Green ___ Pumpkin ___ White

Seed Lot Identification

Collector's ID number _____

Seed lot number _____

State _____ County_____

GPS Coordinates (Decimal degrees) : lat ____._____ long ____._____ elevation _____meters

Directions to the site if not using GPS: _____

_____

Number of ash trees within 20 to 40 feet of this tree: ___ 0, ___ 1, ___ 2 to 4, __ 5 or more

Number of other trees that are not ash within 100 feet this tree: ___ 0, __ 1, __ 2, __ 4 or more

Figure 3.5. Top half of the NSL Ash Seed Collection Data Sheet.

Beneath the GPS box, the following questions to be answered include: the number of ash trees within 20 to 40 feet of the tree being sampled, number of other trees- not ash- within 100 feet of the tree, and distance between the tree and other ash trees that have been or will be collected from. Note that these questions are referring to brown ash trees as the species in question, as this is a brown ash seed collection project. The National Seed Lab, requests a "minimum of 100 feet between trees… so that related mother trees are not collected. This [is] especially important for … ash which can root sucker, [that is] put up sprouts from the roots. Several trees growing close to each other might in fact even be the same tree or clone" (Karrfalt 2011, slide 67).

The next two questions (Figure 3.6) involve EAB evidence and activity: Is it [EAB] present surrounding the tree(s); and are there signs of EAB activity on the sampled tree? There is a list of the four terms: epicormic sprouting, canopy thinning, blonding, and 'D' shaped exit holes. Epicormic sprouting are branches that come out of the main stem of the tree in unusual places. Canopy thinning is when the canopy, the highest branches of the tree, are missing leaves. Blonding is when the bark of the tree is a lighter color than it should be because the top layer of bark has been removed due to woodpecker activity. Finally, 'D'

shaped exit holes are what EAB makes when they bore out of the tree as an adult, as seen in Figure 3.1. Examples of these holes can be found on the Maine Department of Agriculture, Conservation and Forestry web page titled, "Signs and Symptoms of Emerald Ash Borer Infestation" at https://www.maine.gov /dacf/php/caps/EAB/EABsigns.shtml, as well as the reporting web page highlighted in Figure 3.7.

*****If there is suspected activity from an Emerald Ash Borer in the State of Maine, it must be reported at the following website: https://www.maine.gov/dacf/php/caps/EAB/EABreportFORM.shtml Or search online for "Maine Emerald Ash Borer (EAB) Report Form"*****

Distance between this tree and nearest other ash tree from which seeds were collected.

____ 100 feet (minimum), ___ 200 feet, ___ more than 200 feet

Emerald ash borer (EAB) present in surrounding area: Yes_____ No _____

Signs of EAB present on collection tree (check all that apply):

_____ epicormic sprouting _____ canopy thinning _____ blonding _____ 'D' shaped exit holes

Soil: ___ Rocky ___ Gravel ___ Sand ___ Loam ___ Clay

Site type: ___ upland __ wetland __aquatic.

Complete only for upland sites Topography: ___ Flat ___ Slope (Aspect: ___ N ___ S ___ E ___ W)

Twig sample has been put in bag ___ Trunk and whole tree photos have been taken _____

Figure 3.6. Bottom half of the NSL Ash Seed Collection Data Sheet.

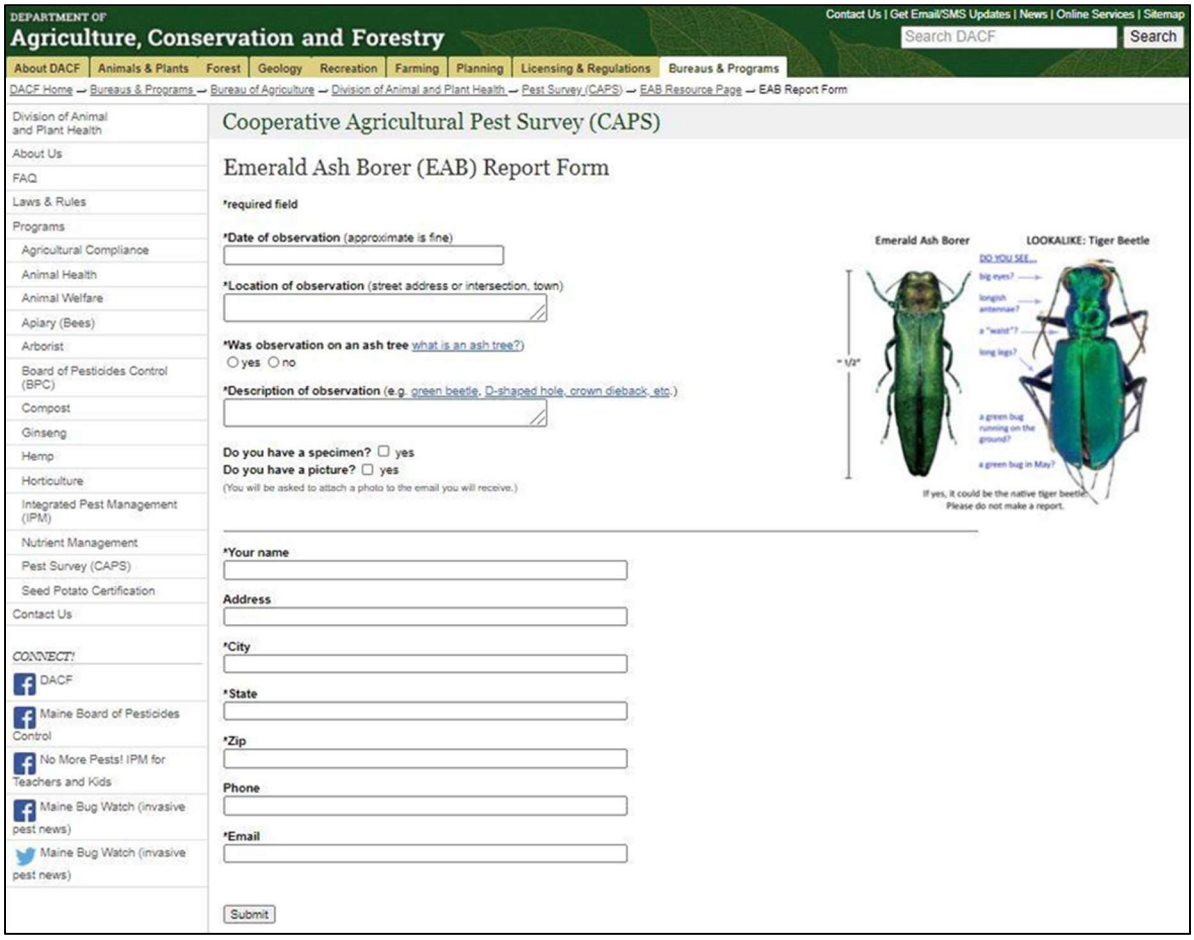


Figure 3.7. Maine DACF Cooperative Agricultural Pest Survey website for reporting suspected EAB (Maine Department of Agriculture, Conservation and Forestry, 2020).

The next three questions on the sheet involve the soil, site type, and topography around the sample tree. Is the soil around the tree: rocky, gravel, sand, loam, or clay? Is the site surrounding the tree: upland, wetland, or aquatic? If the site is upland, is the tree on flat ground or on a slope, and what is the cardinal direction aspect of the slope (North, South, East or West)?

Before leaving the site, make sure to take photographs of the sample tree, including identification in the image that corresponds with the seed sample and collection data sheet. Photographs should include images of the tree, pictures of the crown (the top of the tree), bark, seeds, and leaves. A voucher specimen (e.g., leaf or twig) should be documented in a photograph, if possible. A 6-to-9-inch twig should be included in the collection bag, as well for further tree identification. Mark the data sheet that photographs have been taken and a twig sample has been included in the collection bag.

3.2.1.6.2 National Plant Germplasm Facility Data Sheet

Please use the National Plant Germplasm Facility data sheet and Definition sheet, both found in the Appendix B, as a reference while reading this section. **The main difference in the collection sheets is that the NPFG sheet can be used for multiple tree samples, whereas the National Seed Lab sheet must be filled out for each individual sample.** The NPFG data sheet is also less specific to collecting ash, but it is equally important to put as much information as you can. Starting at the top with Site # (Figure 3.8), this is assigned by yourself as the collector. It is important to have some code that you understand to differentiate where you collect. The date of collection is required in the format of DD/MM/YY.

DATA COLLECTION FORM

Site # _____ Date Harvested (DD/MM/YY)_____

Genus_____ Species _____

Location Name _____

Directions_____

Lat/Long source: ☐GPS ☐Map Map Datum: _____

Plant Description _____

_____

_____

_____

Collector(s) Contact Information:

Name(s)_____Institution_____

Distance to planted/cultivated ash trees (miles): _____

No. plants found _____ No. plants sampled _____ Site size (m^2) _____

Herbarium specimen: ☐ yes ☐ no Herbarium Specimen # :_____

Pop. abundance: ☐ abundant ☐ frequent ☐ occasional ☐ rare

Figure 3.8. Top half of the NPGF Data Collection Form.

As you are collecting ash the genus will be *Fraxinus* and the species will be *nigra*, if collecting brown ash, *pennsylvanica*, for green ash, and *americana*, for white ash. Location name is where you are collecting

from. If it is from your woodlot, you can label this as “private woodlot in (Town name)”. Directions can be an address and description of the location, for example, the address to your woodlot and its distance from a landmark like a town or body of water. The seed collection kits recommend a GPS unit to collect the latitude and longitude, but if you are using a map, you will mark the appropriate answer in the Lat/Long Source section. The Map Datum can be found in your GPS unit. If you are using a map, this does not apply. The Plant Description section is used to describe the tree that you have collected from. Are there any characteristics worth noting? Is there visual dieback in the canopy? Blonding in the bark? This is a place to make notes on the specific tree you are collecting from.

The next section is where you identify yourself as the collection in Collector(s) Contact Information. Please include the names of those collecting and the institution you are associated with. If you do not have an institution, you can list yourself as a private landowner, or whatever applies to you. The “Distance to planted/cultivated ash trees (miles)” is asking how far your sample is to ash trees that are planted or cultivated. As we are looking for wild ash trees, rather than planted trees from nursery, if you know how far your sample is from a planted or cultivated ash tree, please include that information. Number of plants (ash trees) found and number sampled is asking how many ash trees are in the general location you are sampling in and how many did you sample. The site size in meters squared is requested, which can be calculated using your GPS unit. Herbarium specimens are not necessary for collecting, but this would include leaf samples with the seed samples. Population abundance is asking how many ash are in the area. Are they abundant (do you see a lot of them?), frequent (do you see some of them?), occasional (do you have to seek them out?), rare (are they hard to find?).

The *Site Description* section allows you to provide information about the area that you have sampled ash trees (Figure 3.9). Exposure is asking if the ash trees are in full sun or shade during the day, whereas *Slope* is the percentage referring to the grade of slope where the tree being collected from is located. The *Aspect* is the direction that the slope is facing in: north, south, east or west. The *Site Physical* is a description of the surroundings to the site you are collecting from. This can be the type of habitat the sample is in, like a wetland or an open field. The *Site Vegetation* is requesting you to list what other plants are growing in the immediate area of the site. If you can, identify species of trees, shrubs or grasses around the site. *Soil Type* is also asking for a description of the soil around the sampled tree.

SITE DESCRIPTION:
Exposure _____ Slope _____ Aspect _____

Site Physical _____

_____

Site Vegetative _____

_____

_____

Soil Type _____

GPS COORDINATES FOR SAMPLES:

Tree: _____Lat: _____ N S Long: _____ E W
Tree: _____Lat: _____ N S Long: _____ E W
Tree: _____Lat: _____ N S Long: _____ E W
Tree: _____Lat: _____ N S Long: _____ E W
Tree: _____Lat: _____ N S Long: _____ E W
Tree: _____Lat: _____ N S Long: _____ E W
Tree: _____Lat: _____ N S Long: _____ E W
Tree: _____Lat: _____ N S Long: _____ E W
Tree: _____Lat: _____ N S Long: _____ E W
Tree: _____Lat: _____ N S Long: _____ E W
Tree: _____Lat: _____ N S Long: _____ E W

Figure 3.9. Bottom half of the NPGF Data Collection Form.

The last section on the NPGF data sheet is the GPS Coordinates for Samples. This is where your number or code is the individual tree that you have collected from is entered. These numbers are very important because they will be written on the corresponding seed bag in black permanent marker for storage. The latitude and longitude that you have taken from your GPS for each sampled tree must be listed with the tree number or code.

3.2.1.7 Seed collection techniques

Ash trees can vary in height, branch distance from the ground, and surrounding environment, which can cause different options for collection to be preferable to others. Some ash trees may not be reachable with a pruning pole, the preferred method in this case is explained in next section or may require more pruning pole extensions than what we have suggested in the Ash Seed Collection Kit found in Appendix A. This is important when scouting for ash to consider how you plan to reach seed to harvest and plan accordingly. Anecdotally, trees on roadsides and fields may be easier to reach with pruning poles, than those located in the interior of the forest. This is because trees growing in the interior of the forest structure must compete with adjacent trees for sunlight, which places their crown high above the forest floor. Making

notes in the scouting stage may make it simpler in the collection stage and ensure you have the proper equipment on hand for collections at certain sites.

3.2.1.7.1 Pole pruners

Pole pruners are useful for seeded branches up to 30 feet from the ground, see Figure 3.10 (Knight, 2010). Caution should be taken for using pole pruners, as they can be unwieldy when extended from the operator, and cut branches can be dangerous falling to the ground. Safety precautions should be taken including the use of safety glasses and hardhats. It is recommended that those using the pole pruners protect themselves and their heads while collecting. Never use pole pruners near power lines.

Figure 3.10. Saint Regis Mohawk Tribal Nation foresters using pruning poles to collect brown ash seeds. Photograph by Emily Francis.

Becoming familiar with individual pole pruners before use is important, as each type of pole pruner has specifications of maximum branch diameter it can cut, maximum height it can reach, etc. Knowledge

of these specifications will indicate what is appropriate for cutting. When a branch has been chosen for pruning, a tarp should be placed under where the branch will fall. This is to collect seeds falling during the pruning process and for cleaner sorting after the branch has fallen. It will also collect seeds that may fall from other branches during cutting.

There are different kinds of pruning heads available, and it is important that you are familiar with and understand how your pruning head works. We suggest searching the type of pruning head you have on YouTube for videos providing directions on your specific equipment. Essentially, with the pruning head suggested in our collecting kit, see Figure 3.11, the cutting head of the pole pruner should be rested on a cross branch while preparing to cut. The rope should be clear of other branches, so as not to get caught. Depending on the height of the pole pruner, it may be easiest to place the end of the pole in the instep of the operator's boot to guide the cutting without holding the pole above the ground. Cutting may be a two-person job, depending on the height of the branch and the length of the pruning pole. If using two people, one person should focus on holding the pole and another on using the rope to cut the branch. Care must be taken when the branch dislodges from the tree, as the branch is going to fall straight to the ground, depending on wind, most likely at those operating the pole pruners. Some pole pruners have hooks under the cutting head that will attach and lower the cut branch to the ground. This can be useful to ensure the least number of seeds become loose from the branch, and a greater collection can be made.

Figure 3.11. Example of the Jameson PH-11 Tree Trimmer Head (Jameson, n.d.)

Loppers or handheld branch cutters may be helpful to clear the area around an ash tree for collection, as some areas can be thick with foliage and brush around a tree. It is important to be able to have space for the seeds and branches to fall onto the tarp, which may require clearing up to 8 or more feet around a particular tree. Permission from landowners to harvest is especially important if brush needs to be cleared before cutting branches for seed.

3.2.1.7.2 Rope and weight - "Tarp shaking"

This method uses ropes and weights to bend branches within reach of a pole pruner or to break a branch. Knight (2010) notes that, "in our experience, black [brown] ash branches are easiest to break," of all the ash tree species (pg. 7). This method may be used for branch breaking, rather than to lower a branch for pole pruning.

The rope and weight method uses a large tarp, rope, pole pruner (if the branch does not break), and a lightweight throw bag and throw rope. These weights are usually between 12 to 16 ounces. The US Forest Service suggests the Big Shot® slingshot made by Sherrilltree (Knight, 2010, pg. 7). This device can throw a 14 ounce throw bag over 80 foot high branches and does require some practice before use. The US Forest Service has provided a video showing the use of this equipment, titled "Ash Collection Video (action of using the big shot sling shot and more)" at the following web address: https://www.fs.usda.gov/nsl/Genetic Conservation_Ash.html.

It is possible to use this method without breaking or cutting a branch, but rather shaking a branch to dislodge seeds. That is why this method is also called the "tarp shaking" method. Throwing or shooting a weight over a branch and shaking for seeds can be difficult, especially on a windy day when the seeds may not fall directly beneath the branch and onto the tarp. Caution must be exercised for this method to avoid trees near power lines and for the operators to wear glasses and hard hats. As Knight mentions, "a 400-g (14oz) throw bag shot at 24 m (80ft) into the air will hit the ground with a velocity of 22 m/s (49 mph)", therefore, it is important for all involved to pay attention (p. 9).

3.2.1.7.3 Pocket rope saw

This method is particularly useful for smaller branches under ¾ of an inch in diameter (Knight 2010). Like other methods, a tarp should be placed under the chosen branch and a rope with weight or shot with a slingshot is sent over the branch. Once the pocket rope saw, see Figure 3.12, is positioned over the

branch, both sides of the rope are pulled back and forth to cut through the chosen branch. Knight states that, “some ash trees have flexible limbs, [therefore] it is necessary to cut larger branches on these trees. One or two people can operate the saw… Steeply angled branches should be avoided because the saw will slide down the branch. Sharp crotches should also be avoided because the saw or knots can become stuck on them” (pg. 10). The US Forest Service suggests the Pocket Chainsaw® by Supreme Products. Once again, trees and branches near power lines should be avoided. Hard hats and safety glasses should be worn by all participants in the seed collection process in the field. Falling branches are unpredictable and dangerous.

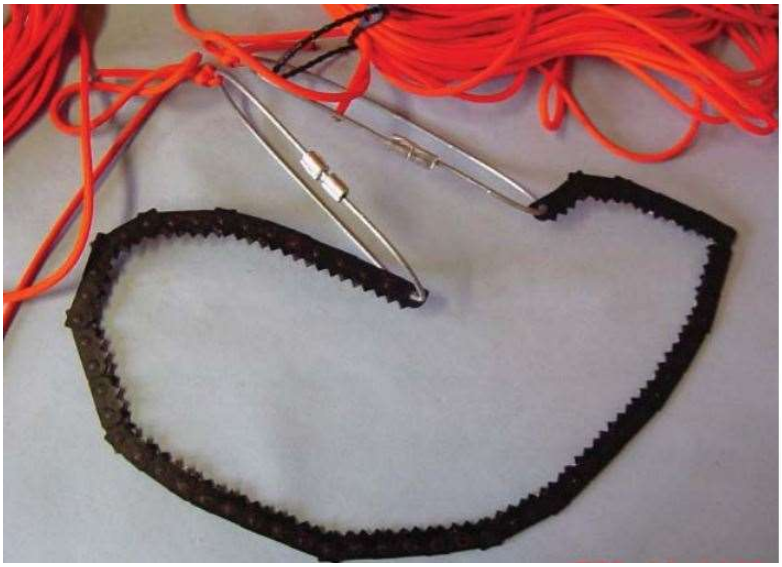


Figure 3.12. Example of a rope saw provided by US Forest Service (Mason, 2010).

3.2.1.7.4 Hand or tarp basket method

Depending on the height of the branches, it may be possible to collect seeds by hand. A sample from one tree should equate to filling the bottom of a paper bag at least 3 inches. This is just a suggestion, as the amount required for submitting seed will depend on where you are sending seeds, see section Post-harvest Seed Handling and Processing for more information. This method can be used to supplement other methods, or by itself, however, it should result in a full sample. A tarp should be placed under the tree to collect the maximum number of seeds, which may fall while seeds are being collected. Pruning clippers can be used to cut the lower branches within reach. Depending on the size of the tree, it may also be shaken to dislodge seeds.

It is also possible to take a canvas tarp, making sure it has a drainage hole, and tying the four corners beneath an ash tree. The tarp must not be in the way of someone walking into it, animals getting caught in it, or rainwater to pool in the tarp. Make sure to choose a "good seed-bearing tree", which will drop seeds into the tarp basket. This should be checked daily to make sure that other kinds of seed are not mixing with the ash seeds (Benedict & David, 2003). This is a passive way to collect seeds, but not wholly recommended, as seed can be lost with winds.

3.2.1.8 Post-harvest seed handling and processing

There are different locations to send seed after processing it, and how much the seed will be processed will affect where it can be sent for storage. Each storage facility also has different potential uses for seed, like who can request it for research or how it is used. Depending on how much seed you collect will narrow down where you can send seed. For that reason, the three locations we suggest seed to be sent will be overviewed according to their processing requirements. From there, the requirements for shipping to seed storage facilities will be reviewed. Online locations for access to documents in the appendices can be found in Appendix D.

The type of data collected will be dictated by where the seeds will be sent. The flowchart, "Deciding where to send ash seed", (Figure 3.13), breaks down each section in the decision-making process: level of sorting, locations for storage, data sheet type, and required seed quantities. First on the flowchart, level of cleaning, highlights two options: simple cleaning of seeds, and complete sorting and cleaning of seeds. Each of these processes will be reviewed in the next section. The simple cleaning of seeds can be submitted to the University of Maine and the USDA Agricultural Research Station (ARS) in Iowa. A complete sorting and cleaning of seeds is required to submit seed to the USDA ARS facility in Colorado, which is also called the "Black Box". The University of Maine and the USDA ARS Colorado accept either the NSL or NGFP data sheet, and the USDA ARS Iowa requires the NGFP data sheet. These data sheets are overviewed in the "Documentation for trees and seed" section above, and copies of them can be found in the appendices. USDA ARS Colorado also requires the Black Box Template, which is a Microsoft Excel form to be discussed in the "Shipping for seed storage" section below. The University of Maine requests at least 1,000 seeds per mother tree (Figure 3.13). The USDA ARS "Black Box" does not have a required number of seeds as it is specific to the sender and project submitting seed to the facility. The USDA ARS in Iowa requires at least

1,000 seeds but recommends 3,000 to 5,000 seeds per mother tree (Figure 3.13). Each seed storage facility has different focuses for storage and abilities for seed removal, or the ability for someone to request seeds from the facility, for research or propagation. Figure 3.14 highlights the differences between the locations for more information on deciding where to send seed.

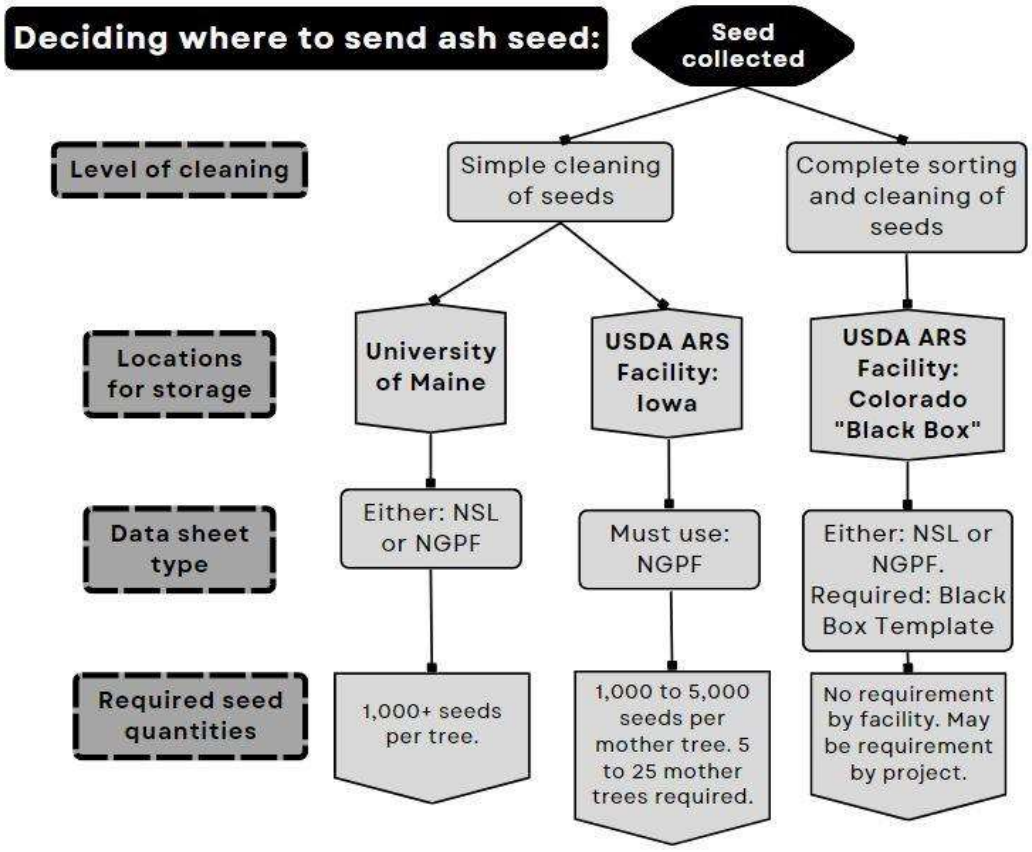


Figure 3.13. "Deciding where to send ash seed flowchart" identifies the aspects of seed preparation for each facility.

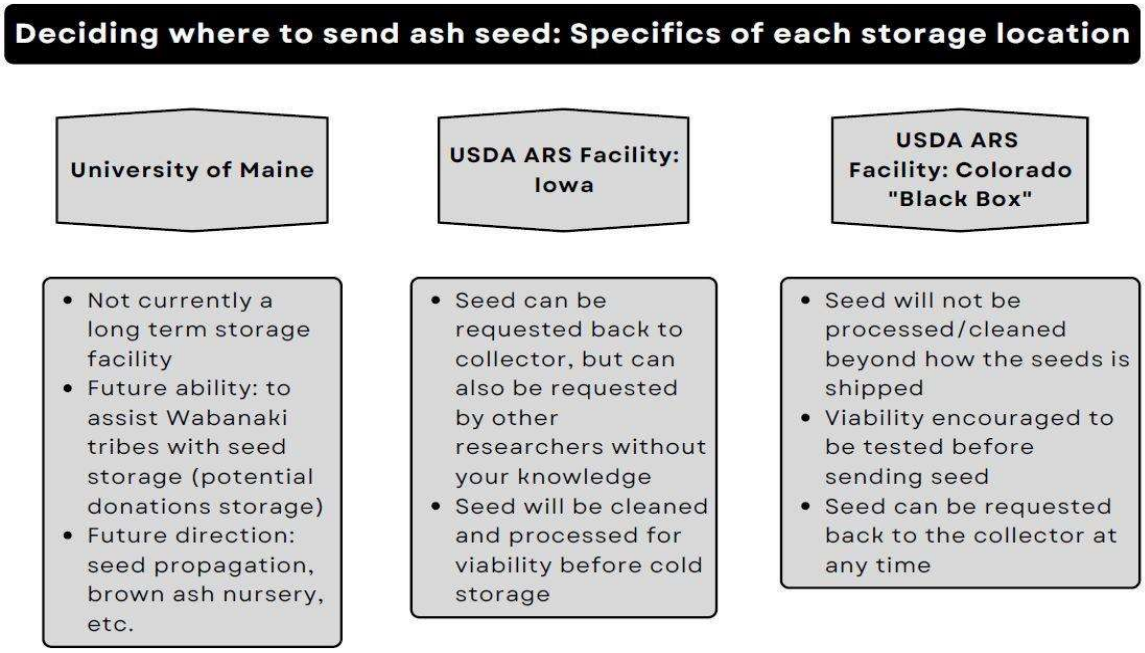


Figure 3.14. Highlights for each of the recommended ash seed storage locations.

3.2.1.8.1 Storage facility: University of Maine, APCAW

The University of Maine and the APCAW lab, is just starting a seed program and currently is not a long-term storage facility (as of early 2024). There are plans to create a network with the Wabanaki Tribal Nations in present day Maine to store seed and partner together for research and grow ash. Seed donation to APCAW will allow seed to be used for Tribal Nation use or research and seed may be sent to another seed facility after cleaning for long term storage. The capacity for storage is small currently, but scaling up to larger storage is the goal, as well as a potential brown ash tree nursery for all of our Tribal Nation partners, and to propagate trees for other planting purposes. Therefore, the quantity required, see Figure 3.14, is set at least 1,000 seeds per mother tree, which is around 1.5 liters of seed. This is not a strict requirement, but enough seed is required to provide sufficient seed for testing viability before storage. Lesser amount of seed will still be accepted by the APCAW.

3.2.1.8.2 Storage facility: USDA ARS - Iowa

The USDA ARS Iowa facility is where the National Plant Germplasm Ash Conservation Project is located, and any seed sent here will be housed under this research group. Seed sent here must be “simple cleaned”, as the researchers will sort and store the seeds thoroughly, checking for viability for future growth

and the overall health and quality of the seed. This facility requires as much seed as you can collect, at least 1,000 seeds per mother tree, but preferably 3,000 to 5,000 seeds, see Figure 3.13. This is almost 2 liters of seed for brown ash (USDA: Agricultural Research Service, 2018a). It is possible this facility may choose to store high quality seeds at the Black Box, as well at their own facility, but the final storage location of seed will be recorded on the Germplasm Resources Information Network, GRINs (USDA: Agricultural Research Service, 2018b). Although this public information may be negotiable for Tribal Nation member's privacy of brown ash stand locations for basket harvesting. The Black Box is a federal facility in Colorado, which will be discussed below. Seed stored in or by USDA ARS Iowa can be requested back by the collector, however, any researcher can request seed from here and your seed may be provided to another requestor without your knowledge or permission.

3.2.1.8.3 Storage facility: USDA ARS - Colorado

The final location is the USDA ARS Colorado Black Box, which is the Agricultural Genetic Resources Preservation Research center. At this location seed is submitted to be held in deep freeze for long-term storage. The formal name for the Black Box is the Deposit for Security Duplicate Collections. This depository receives a box of seed that must be completely sorted and cleaned for long-term storage. The box received by the facility is simply placed in cold storage without any further action. Therefore, seed must be completely ready for long-term storage when shipped and the box must be prepared for cold storage. The sender of the seeds may request only their box back at any time, which will be removed from storage and mailed back. This is a great resource for researchers without the capacity to store seeds themselves and would like to take advantage of the security of a USDA cold storage facility. There is no requirement for the number of seeds to be stored, due to the seed being unopened and kept until it is requested back by the sender. It is up to the sender to decide what the purpose of the storage is, what type of research, and the needs for that in the long-term, see Figure 3.14.

3.2.1.9 Seed cleaning and sorting

Two types of seed cleaning that we have distinguished in this document for ease of explanation and for final storage options: simple cleaning of seeds and complete sorting and cleaning of seeds. Figure 3.13 dictates which facilities will accept which level of sorting and cleaning: the University of Maine will accept

limited and simple cleaning of seeds; USDA ARS Iowa accepts simple cleaning and USDA ARS Colorado accepts complete sorting and cleaning.

Simple cleaning: this has been partially modified but is what is recommended by the USDA ARS Iowa facility for submission. It is very important to limit the amount of moisture that the seeds encounter during collection, post-harvest handling, and final deposition of seeds in storage or for research, as seeds can rot and be ruined. During the entire time that seed is collected, all of the bags that contain seed need to be kept between 65- and 70-degrees F, this includes the vehicle that the seed is being transported in (USDA: Agricultural Research Service, 2018b). It is extremely important not to overheat the collection before it has been fully processed for storage. It is best to find an area to work in with good ventilation and where insects, which may be in or among the samaras, can get out, like a garage. Hotel rooms and the backs of cars are not good places for this work. It is best to secure a workspace where the samaras can be spread out on a table or in a tub. Each bag needs to be opened, but not ripped, will need to be stapled shut again, and the seed spread to where it can be looked over. The samara needs to be removed from the twig that it is attached to and placed back into the paper bag. When looking over the samaras on the table, please remove any woody debris, like larger sticks, twigs, leaves, grass, or anything other than samaras that may have gotten into the bag in the field. Leaving leaves in the bag can increase the moisture content of the samaras while the seeds are being transported and must be removed. If the samaras are wet, like if they were collected in the early morning, they must be left out to be completely dry before putting them back into the paper bags and sending them to the facility. This may take 24 hours or more depending on how green the seeds are when collected (USDA: Agricultural Research Service, 2018b). If samaras look like they might have insect damage or mold, they must not be submitted to a facility. Remove the samaras and dispose with the rest of the non-samara material. Once all the woody debris has been removed, the samaras must be placed back in their original bags with corresponding datasheets, with the bags stapled closed. Then the bags need to be prepared for packaging and shipping to the storage facility. Bags going to the University of Maine, APCAW, may be dropped off at the facility and instructions for this can be found in the next section.

Complete sorting and cleaning of seeds: this is what is required to send seed to the USDA ARS Colorado facility. This location requires the seed to be ready for cold storage upon arrival, and therefore must be completely prepared by the sender beforehand. The instructions provided for the submission of seed to the USDA ARS Colorado facility can be found in Appendix C, “Recommendations for the collections,

storage, and germination of ash (*Fraxinus spp.*) seed" (Ellis, 2006). This document outlines how to collect, sort and test seed for viability before sending to the facility and should be followed as closely as possible for the best results. Please focus on section "Collecting seeds (samaras)" starting at number 12, through to "Testing ash seed (samara) viability" section 1.

3.2.1.10 Packaging and shipping seeds for storage at chosen facility

As for packaging collected seeds, each facility has specific criteria for shipping seeds. Seeds can be brought to the University of Maine in-person to Nutting Hall and the School of Forest Resources administrative office, or to the drop-off bin outside of Room 118 on the first floor. Materials must be in paper bags with a completed datasheet stapled to each bag with information regarding who collected the seed, who dropped off the seed, a phone number and email address to get in contact with the collector for questions, and to what level the seed was sorted. Please contact John Daigle, PhD via email, jdaigle@maine.edu, to let the team know you have left seed. If you are dropping off many bags of seed, please contact John Daigle before arrival, so someone can meet you and receive the bags. To ship seeds to the University of Maine, please use the address found in Table 3.15. Seed must be placed in a cardboard box that will fit all of the paper bags and shipped with the proper datasheets and paperwork as recommended for dropping off in person. Ground transportation shipping is recommended, as shipping via airline can affect the moisture content of the seeds.

To send seed to the USDA ARS facility in Iowa, you will need to get in touch with Jeff Carstens, PhD, (jeffrey.carstens@usda.gov) the contact at the facility. It is recommended to ship via FedEx, which the USDA ARS will be able to cover the cost of, otherwise, you can ship via the US Postal Service. Please choose ground transportation shipping to prevent changes in moisture content of your package, which can happen with airline shipping. Seeds must be placed in properly marked paper bags with corresponding datasheets and securely stapled shut to prevent seeds from coming out of the bags and mixing in the box. Please see Table 3.3 for addresses for shipping, which depend on which carrier you are choosing to use.

The USDA ARS Colorado "Black Box" facility does not open the box that seed is shipped in and has a different shipping procedure. The contact for this facility is NLGRP-Blackbox@usda.gov, and you will need to notify this email address before shipping that you intend to send seed. You will need to fill out, sign and submit a Material Transfer Agreement (MTA), which can be found in Appendix C. By filling out the

MTA, you will be provided with a Black Box MTA#, which will be required on your documents going forward. The MTA requires a Microsoft Excel spreadsheet to be included, which is called the NLGRP Black Box Deposit Template, also in the Appendix C. This spreadsheet will identify the taxon, Inventory Identifier, cultivar of the species, along with other information that gives the facility the information of what is being shipped to them. The Instructions tab of the worksheet explains what each of the fields mean and how to fill out the worksheet on the Blackbox Shipment tab. The Blackbox Shipment tab must be filled out and included within each box for each shipment, as well as the MTA and submitted to the facility before shipment. After sending your first shipment, all other shipments must include the Letter of Transmittal, see Appendix C. Your MTA# covers subsequent future shipments, so this entire document only needs to be filled out the first time, the Letter of Transmittal and the Black Box Deposit Template must be included in every shipment. Packages must be sent under expedited shipping services.

As it has been mentioned, seeds submitted to the Black Box must be completely sorted, dried and ready for cold storage. The boxes shipped cannot be larger than 86 cm wide by 75 cm deep by 55 cm high, as this is the size of the space they will be held in. Each bag of seed must be in “moisture proof packaging such a heat-sealed foil laminate pouches" and labeled with the sender's information, MTA# and name of the species within. Boxes must be labeled according to the number total boxes shipped, example: Box 1 of 3, etc. Finally, the shipment information must be emailed to the contact email: NLGRP-Blackbox@usda.gov. Further questions regarding this process may be answered on the website of the USDA ARS Colorado, along with access to all documents mentioned: https://www.ars.usda.gov/plains-area/fort-collins-co/center-for-agricultural-resources-research/paagrpru/docs/plants/pages/deposit-germplasm/, under “Deposit of Security Duplicate Collections (Black Box Storage)”.

Table 3.3. Addresses of seed storage locations for shipping of seed.

Addresses for shipping seed to each location:		
University of Maine	**USDA ARS: Iowa**	**USDA ARS: Colorado**
School of Forest Resources Attn: Ash Protection Collaboration Across Wabanakik (APCAW) 5755 Nutting Hall, Room 118 Orono, ME 04469-5755	*FedEX (contact Jeff first):* USDA-ARS North Central Regional Plant Introduction Station Attn: Jeff Carstens 1305 State Avenue Ames, IA 50014 *USPS:* USDA-ARS North Central Regional Plant Introduction Station Attn: Jeff Carstens Iowa State University G212 Agronomy Hall Ames, IA 50011-1170	USDA, ARS, NLGRP Attn: Black Box Storage 1111 South Mason Street Fort Collins, CO 80521

3.3 Future uses of seeds

There are many uses for ash seed and there are many organizations getting involved with this effort. To briefly discuss the three main options of seed usage, we will overview the following: conservation of seed for storage (both long and short term), collecting seed for propagation, and collecting seed for scientific research. In one event of seed collecting, there could be multiple uses, and often this is the case with research. All the reasons discussed here for collecting ash seed are important, and there are more beyond these. For the brevity of this document, this is just a few reasons or projects.

3.3.1 Seed storage, propagation, and scientific research

Conservation of seed can happen for several reasons. Short term storage of seed may be for holding seed until a research project is ready to use the seed, or for the season to be right to plant the seed, or for a project that might not yet be decided upon. We would categorize short term storage as: months to a few years. Most seed is stored in cold storage, and smaller facilities even use home refrigerators. The health and viability, or ability for the seed to be successfully stored for future planting, depends on how the seed was prepared for storage and the temperature settings of the refrigerator or freezer used to store the seed. We hope to provide more information on this type of storage process in the future. Long-term storage is another option to hold seed in freezers under specific conditions for an extended period. This storage could be for years with the correct conditions. This kind of storage can be used to hold genetic material for long periods

of time to protect against threats, like EAB, with the hope that there may be a more favorable time to repopulate the species.

Collecting seed for propagation means the seed is intended to produce seedling stock that can then be planted in the forest at suitable sites. There are many preservation goals that drive these efforts; brown ash is culturally significant, has ecological values, and economic values to Tribal Nation artisans. Because of these values there has been a continued interest in ensuring that there will be brown ash on the landscape for generations to come. Growing ash to plant in these forests is ensuring the critical continued recruitment of brown ash in the overstory of these forests. The propagation and development of seedling stock can be achieved in the following ways: individuals can grow their own seedling stock at home; if your community has one established, a Tribal Nation nursery can grow this seedling stock for their community and forests; nonprofits and environmental groups can grow seedling stock for reforestation efforts; and the research community can produce seedling stock for use in management trials to improve our knowledge base on this strategy in the face of EAB. There are even situations where a suitable site is not in the forest but in a controlled environment for ease of access for seed collection. These orchard-like settings serve the purpose of a living seed bank, and this is something already being practiced by the Akwesasne Saint Regis Mohawk Tribal Nation. There are many reasons for propagating and growing ash trees from seed and it is all made possible with collection of seed right now.

Finally, collecting brown ash seed can benefit scientific research. All the above strategies could combine with research regarding brown ash seeds, however, there are those who collect solely for research purposes. Two scientific projects will be overviewed to provide insight into the type of research that utilizes ash seeds. The first examined the effect of insecticides used on ash trees to prevent EAB and what happens to the native weevils who use ash seeds to lay their eggs (Mwangola et al., 2022). Ash seeds were collected from trees that were treated with insecticides for EAB and compared with trees that were not treated to see which trees had fewer weevils in their seeds. It should be noted that according to this study, trees that were treated had fewer weevils, meaning that more seed was available to potentially produce new ash trees (Mwangola et al., 2022). This is a rare positive outcome of non-target impacts from insecticide treatments.

A second research project that focuses on ash seed collection, looked specifically at collections from lingering ash trees, or trees that have survived the initial wave of EAB. The researchers state on their website that they are "targeting seed collections from areas in which the emerald ash borer was detected in 2010 or

earlier, since those areas have likely already seen widespread tree death," (Holden Forest & Garden, 2022). Ash trees that are still producing seed in the Great Lakes region survived the initial wave of EAB and have been living with the insect present since. It is essential to collect seed anytime trees produce them in this area, as any genetic information can greatly inform science on what might be the key to EAB resistance for this species. This is an excellent example of collecting seed for genetic research. More information about this research can be found at: https://holdenfg.org/news/ash-trees-are-exploding-with-seeds-researchers-are-capitalizing-on-it/.

For more information regarding the collection and storing of ash seed, we encourage you to visit the USDA Ash Conservation Research webpage (https://www.ars.usda.gov/midwest -area/ames/plant-introduction- research/home/npgs-ash-conservation-project), hosted by the Plant Introduction Research program in Ames, Iowa. This is a great location for more information on the National Plant Germplasm System and introduces the Germplasm Resources Information Network, or GRINS, which is the federal database that holds information on seed stored at federal facilities.

3.3.2 Ash Foliage Collection: Pennsylvania State University partnered research

To assist other research projects involving the protection of ash trees in the Northeast, our team at the University of Maine, APCAW, has partnered with Dr. Jill Hamilton's collection of ash leaves at Pennsylvania State University. The goal of this research is to collect leaves from ash trees across Maine, to capture a wide range of genetic variation, of which the Penn State research team can explore key genomic differences. The protocol that Dr. Hamilton has provided for this collection can be found in Appendix E. If you are interested in collecting ash foliage, please use the contact information in that section to receive the materials needed to harvest and ship samples.

3.4 Conclusion

This document was created to assist in the collection of brown ash seed against the threat of EAB, which is spreading throughout the state of Maine and beyond. Efforts to save this great tree species need to be made by all of those interested in its survival. A call for direction on how to collect brown ash seed was made by that community, specifically the Tribal Nation artisan community, enabling this document to be written. This document is meant to be a living one where it can be updated as new information regarding seed collection, storage, and uses for seed development. At the time of its first publicly released version, it

has been written and reviewed by the University of Maine APCAW team in the School of Forest Resources, as well as key partners in the US Forest Service, Wabanaki Tribal Nation, researchers at the University of Vermont, non-profit partners at Wild Seed Project, Akwesasne Saint Regis Mohawk Tribal Nation, and others. Great effort has been made to include those interested and invested in protecting ash, on the landscape and its deep cultural importance, in the creation of this document. All reviews and input by our network have been taken into consideration to ensure the information provided here is accurate, useful, and done with care and dedication to the task of protecting ash for the future. Updates to this document and inquiries regarding this project can be found at **www.umaine/apcaw/**. Thank you for your time and interest in this very important project.

If you are interested in allowing access for seed collection on your property, please contact APCAW (jdaigle@maine.edu). We are interested in connecting those interested in seed collecting with places to access ash to increase the availability of genetic material being harvested. We are greatly appreciative of those willing to allow for seed collection for the many reasons that have been mentioned above.

CHAPTER 4

NETWORK CONNECTIVITY AND KNOWLEDGE TRANSFER IN THE ASH (*FRAXINUS* spp.) PROTECTION NETWORK IN MAINE

4.1 Introduction

The protection against and management of invasive species is a constant challenge that increases in severity as new species are brought into forested environments through trade and travel. These novel species can be detrimental to the health of an ecosystem and destabilize essential ecosystem services, examples of which can be found worldwide (Charles & Dukes, 2007; Panzavolta et al., 2021). Different frameworks in natural resource governance and agencies are used to protect a nation or state against the negative effects of invasive species. Generally, once invasive species are present, the framework must include containment, particularly if eradication is not possible. These are sometimes called "wicked problems," and creative solutions are needed to tackle these issues (Lönngren & Van Poeck, 2021; Woodford et al., 2016). While there is no singular agreed upon definition to this term, Rittel stated in 1967 "wicked problems" are, "that class of social system problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing. … Where proposed 'solutions' often turn out to be worse than the symptoms," (Churchman, 1967; Lönngren & Van Poeck, 2021, p. 481). Ranco, in his TedxDirigo talk, discusses how these issues, "force us to confront our social, cultural, and experiential differences because they require many points of view to solve" (Tedx Talks, 2017, 4:46). In the case of invasive species, these "wicked problems" illustrate the complex issues that arise with the introduction of nonnative species: how these species can impact human lives, businesses, agriculture, and environmental processes, to name a few, and there is no silver bullet to solve these issues.

In North America, the accidental introduction of the emerald ash borer (*Agrilus planipennis*, or EAB), is an example of a "wicked problem". This species of wood-boring beetle is one of the most destructive invasive species in the U.S. (Aukema et al., 2011; Herms & McCullough, 2014). Since 2002, when it was first detected, it has spread to 36 states and 5 Canadian provinces (Figure 4.1). EAB reached the final New England state, Maine, in 2018. Maine, however, had been planning for EAB's arrival since the early 2000s. This advanced preparation is largely thanks to connections made by Indigenous ash basketmakers in

Michigan to Wabanaki basketmakers in Maine. Brown ash (*Fraxinus nigra*), also referred to as black ash, is the main basket building material for Algonquin Tribes, which include the Tribal Nations in Michigan and the Wabanaki Confederacy in Maine (Costanza et al., 2017; Poland et al., 2017). Sharing knowledge about EAB and how it affected ecosystems that included species of cultural and spiritual significance facilitated the development of a grassroots network. This network helped Maine to prepare for EAB.

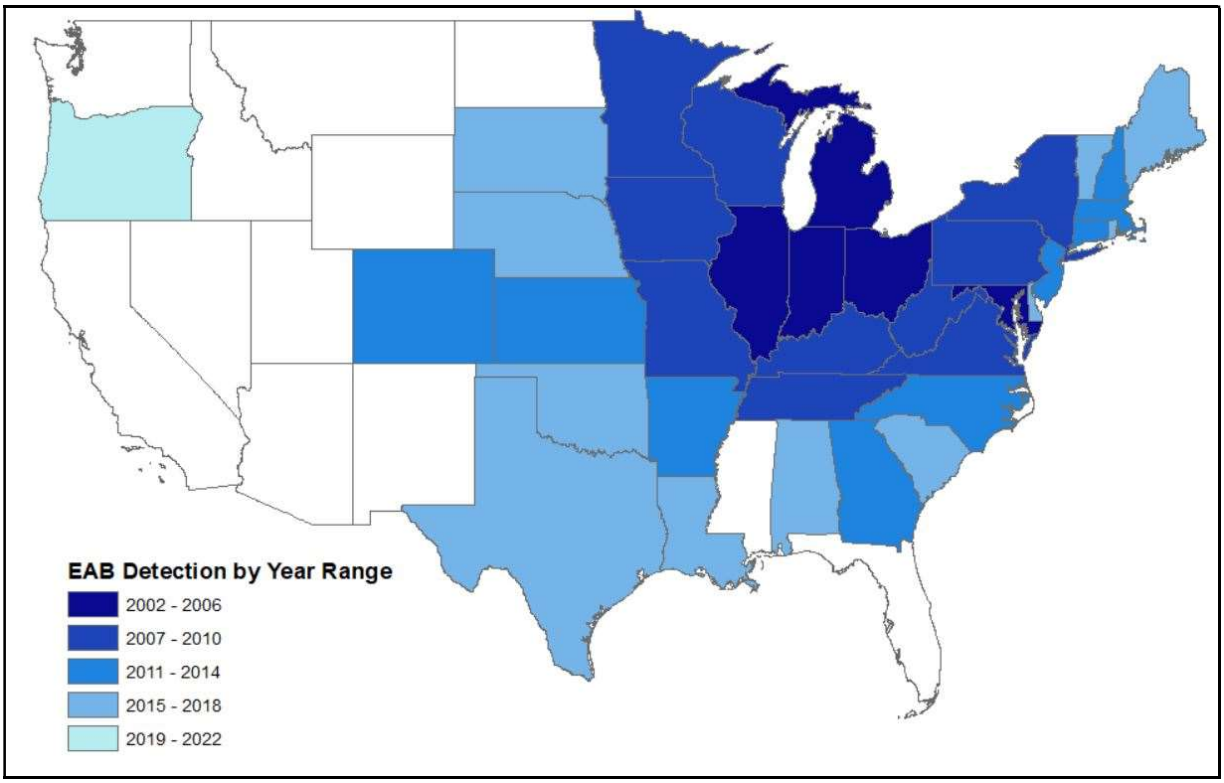


Figure 4.1 Detection of emerald ash borer (EAB) by U.S. State, 2002-2024 (Author's Map, 2024; Emerald Ash Borer Network, n.d.).

Grassroots networks are non-formal, voluntary, and collaborative efforts, often created by entities outside of established governing bodies, like within local communities (Morris et al., 2013). Grassroots networks can also interact with ecosystem management, and when they do are sometimes considered environmental movements. In contrast, formal natural resource governance is developed by structured agencies and entities responsible for managing resources within geopolitical areas (Yeboah-Assiamah, Muller & Domfeh, 2017). For example, federal and state environmental and conservation agencies manage publicly owned forests and rangelands and regulate environmental stewardship on private lands. Grassroots networks provide an avenue outside of the established governmental system for individuals to take part in conservation efforts, like combating climate change by limiting food waste (Mariam et al.,

2020), protecting biodiversity in freshwater ecosystems (Koning et al., 2020), and increasing access to local food through agrobiodiversity conservation strategies (Campbell & Veteto, 2015).

This study examines the connections within one such grassroots network, the ash protection network, which was born from the interest and necessity to protect a culturally important species from certain mortality, and without intervention, is likely to be completely removed from the landscape. The ash protection network in Maine was created through relationships between Indigenous artisans and harvesters who value brown ash, a cultural keystone species in peril (Costanza et al., 2017). While both federal and state agencies are a part of the ash protection network, they are not responsible for creating or maintaining the network. By being created outside the formal management space, it developed without the rigidity that formal networks must follow. This network was able to be centered differently, specifically aligned with Tribal involvement and values.

4.2 Background

4.2.1 The story of the ash network in Maine

Efforts for an ash protection network in Maine were born from a grassroots action to gather information about the EAB infestation in the early 2000s. The initial contact between individuals who would become network members occurred when Tribal basketmakers from Michigan contacted Wabanaki basketmakers in Maine, alerting them of a new invasive threat killing brown ash trees (McGreavy et al., 2021). At the time EAB had been detected on both sides of the U.S. and Canadian border, the speed at which the mortality of ash was dying was staggering. As Herms, Stone, and Chatfield (2004) stated, "the threat cannot be over-estimated" (p. 62). Between 2002 and 2004, the area of detection had spread to 2 to 3 thousand square miles in Michigan and Ontario, and was detected in Ohio, Indiana and Maryland (Herms, Stone & Chatfield, 2004; Emerald Ash Borer Network, n.d.). Wabanaki basketmakers realized they needed the support of researchers to gather more information on this threat, and they contacted professors at the University of Maine.

This call to action was initiated by the Brown Ash Task Force (BATF). This group had formed in the 1990s when the Maine Indian Basketmakers Alliance sought information regarding ash dieback that had been seen in the region prior to EAB's first detection. After they were notified by basketmakers outside of Maine, BATF came together once again to address the new threat that was EAB, to share research, stories,

information and hold meetings. An important part of this effort was centralizing Tribal values and interests. The BATF called on the most recent science from universities, state, and federal agencies to inform their discussions, and to place the importance of brown ash as a central focus. Wabanaki faculty at the University of Maine were key to creating a space focused on Tribal values and interests and connecting research with Tribal Nations and basketmakers. This new effort to build the work around Tribal values and interests has occurred for over a decade in their dialogues. The length of time this group has been active is important considering that funding cycles and research interests change frequently, especially in academia and state and federal agencies.

Over several years, the threat of EAB continued to grow, steadily moving outward across the US and Canada from the point of initial detection. While it had been estimated that EAB could reach Maine as early as 2013, it was not until 2018 that EAB was detected by the Maine Forest Service for the first time (Kovacs et al., 2010). It is possible that Maine experienced the EAB invasion later than other New England states due to Maine's state efforts in planning and strategic defense programs, such as public service announcements and notices on state border crossings that barred movement of firewood across the state border. Research, publications and outreach by researchers at the University of Maine played a role as well (Daigle et al., 2019). Letters by Tribal basketmakers, specifically Richard Silliboy of the Micmac Nation, to USDA APHIS were also important in raising awareness of this impending invasive species and the need for quarantines. It is important to mention that during this time there was a federal quarantine for the movement of ash products by the US Department of Agriculture. However, the state of Maine also worked to notify the public and placed internal quarantines for the movement of ash products. State action continued even after the federal quarantine was lifted in 2021. Once EAB was detected in the state, efforts shifted from prevention to monitoring and slowing the spread.

During this period, members of the BATF also attempted to develop alternatives for protecting ash in new ways. One early idea was seed collecting, which would provide direction for short to long term preservation of brown ash genetic resources. Early efforts of Tribal seed collection took place, but the seed was reportedly lost in the system once it was sent away to a federal facility, creating distrust and confusion for Tribal Nations. 21111111The group reached out to members at the University of Maine to create a manual on ash seed collecting and storage. In addition, a by-product network was formed, called the Ash Protection Collaboration Across Wabanakik (ACPAW) in 2022 (Table 4.1). APCAW became the research and funding

center of ash protection in Maine. It is currently housed at the University of Maine, where graduate students and faculty can devote time and effort to this work. The BATF remains active as an informal advisory council to APCAW. The organizations share members, and APCAW extends the reach to include a broader range of partnerships, specifically with nongovernmental organizations (NGOs), like The Nature Conservancy and land trusts in Maine. Some of these partnerships share funding applications, and members serve as advisors on committees between organizations, among other relations.

Table 4.1. Key years and events in the ash protection network development in Maine.

Year	Event
1990s	Maine Indian Basketmakers Alliance formed the BATF
2002	EAB detected in North America. Michigan basketmakers contact Wabanaki basketmakers.
2003	USDA implements federal quarantine for ash materials for EAB detected counties
2009	University researchers helped refocus the BATF with focus groups during the summer. BATF Protecting the Ash for Future Generations I (Maine) in October.
2010	BATF Protecting the Ash for Future Generations II (Maine)
2011	BATF Protecting the Ash for Future Generations III, Emergency Response Planning (Maine)
2012	BATF Protecting the Ash for Future Generations IV, Emergency Response Scenarios (Maine). EAB first detected in New England: Massachusetts and Connecticut
2013	BATF Protecting the Ash for Future Generations V (Maine)
2014	University of Maine's Black Ash Symposium (Maine), Costanza et al., 2017 was an outcome
2018	EAB detected in Maine, internal state quarantine implemented
2019	Regional EAB meeting, Towards Preservation of a Cultural Keystone Species (Vermont)
2021	USDA Federal quarantine removed. Maine DACF continues state quarantine.
2022	Creation of APCAW at UMaine
2023	APCAW training and webinar series, seed collection manual produced. Akwesasne Basket Maker Gathering, invitational meeting (New York)
2024	APCAW Brown ash meeting at UMaine

One of APCAW's primary objectives is to increase public knowledge about the importance of ash protection. In 2023, APCAW launched its website (https://umaine.edu/apcaw/) and a virtual and in-person workshop series. The website provides written information on the relationship between the

Wabanaki People and brown ash, ash and EAB specific research, steps for seed collection and growing ash, and tools for monitoring and managing ash. Both the ash seed collection and an ash inventory manuals are available on the website (APCAW, 2023). The 2023 workshop series included seven focus areas, (Table 4.1). These topics included: (1) an introduction to the APCAW training series; (2) the cultural importance of brown ash, as told by Wabanaki basketmakers, harvesters and Knowledge Keepers; (3) identification and inventorying of brown ash; (4) EAB and ash resilience research; (5) exploring the need for ash seed collection; (6) training for ash seed collection; and (7) a workshop series wrap-up. These events were attended by people and organizations from throughout Maine, neighboring states, and Canada. The workshop series was a preamble to a brown ash colloquium set to take place in the Fall of 2024 and a continuation of previous research summits hosted by or otherwise connected to the BATF. The formal creation of APCAW in 2022 and the development of a workshop series in 2023 allowed the network to be clearly defined for a social network analysis at the end of 2023.

4.2.2 Social networking analysis

Social networking analysis (SNA) has developed as a convergence of disciplines from multiple fields, specifically social psychology, social anthropology, and sociology, whose roots date back to the early Twentieth Century (Prell, 2012). It is a highly flexible approach used for identifying, understanding, and evaluating social networks, defined as, “a set of nodes (or network members) that are tied by one or more types of relations”(Marin & Wellman, 2011, p. 11; Wasserman & Faust, 1994). SNA has provided researchers an opportunity to explore how different communities tackle environmental issues, for example: stakeholder analysis and participatory natural resource management (Paletto, Hamunen, & De Meo, 2015; Prell, Hubacek & Reed, 2009), diffusion of knowledge within farming communities (Wood et al., 2014), how multiple stakeholders work across borders to protect biodiversity (Gogaladze et al., 2020), and to manage invasive species (Omondiagbe et al., 2017). SNA has also been employed to explore networks that govern key resources, such as water (Fliervoet et al., 2016; Holt, Moug, & Lerner, 2012; Nabiafjadi, Sharifzadeh & Ahmadvand, 2021), and greenspace (Jazayeri, Poursaeed, & Najafabadi, 2023). SNA provides a framework to identify actors within a community, and study the relationships between. Considering contemporary complex environmental and natural resource issues sometimes labeled as “wicked problems”, SNA is an invaluable toolset to explore relationships that might be otherwise hidden from researchers and

policymakers. By analyzing networks, a better understanding of the processes, like knowledge transfer and actor connectedness, can be explored. For grassroots networks, like the ash protection network in Maine, this is an opportunity to explore how well connected the network is and future directions for efforts.

4.2.3. Membership categories of the APCAW network

The APCAW network, which includes members from Wabanaki Tribal communities and the homelands of the Saint Regis Mohawk people, is composed of members from five categories: Tribal Nation governments, universities, federal and state agencies, non-governmental organizations (NGOs), and private citizens (Figure 4.2). Members from Tribal Nation governments are often professionals employed by Wabanaki or Saint Regis Mohawk Tribal Nations, mostly in the forestry or natural resources departments. University-based members include students and faculty who work on ash- or EAB-specific research. Network members based within federal and state agencies are scientists and policy officials involved in research on ash health, EAB monitoring and spread, and ash quarantine. Network partners based at NGOs include those who work for land trusts and natural resources and conservation focused organizations in Maine. The final group, private citizens, are individuals interested in and involved in ash protection. These individuals are often Tribal basketmakers, harvesters and artisans, private landowners, foresters, and loggers. It's worth noting that members of the network are often affiliated with multiple categories of the aforementioned groups.

The membership of APCAW consists of those actively part of research at the University of Maine, Pennsylvania State University, and the University of Vermont; along with partners in policy, state and federal government, education and outreach, basketmakers, and harvesters, among others. Those interested in the work of APCAW who have taken part in events and follow the email newsletters are considered part of the network, but as passive participants. This group consists of over 600 contacts, whereas those who are part of the APCAW research team and involved partners are the focus of this research.

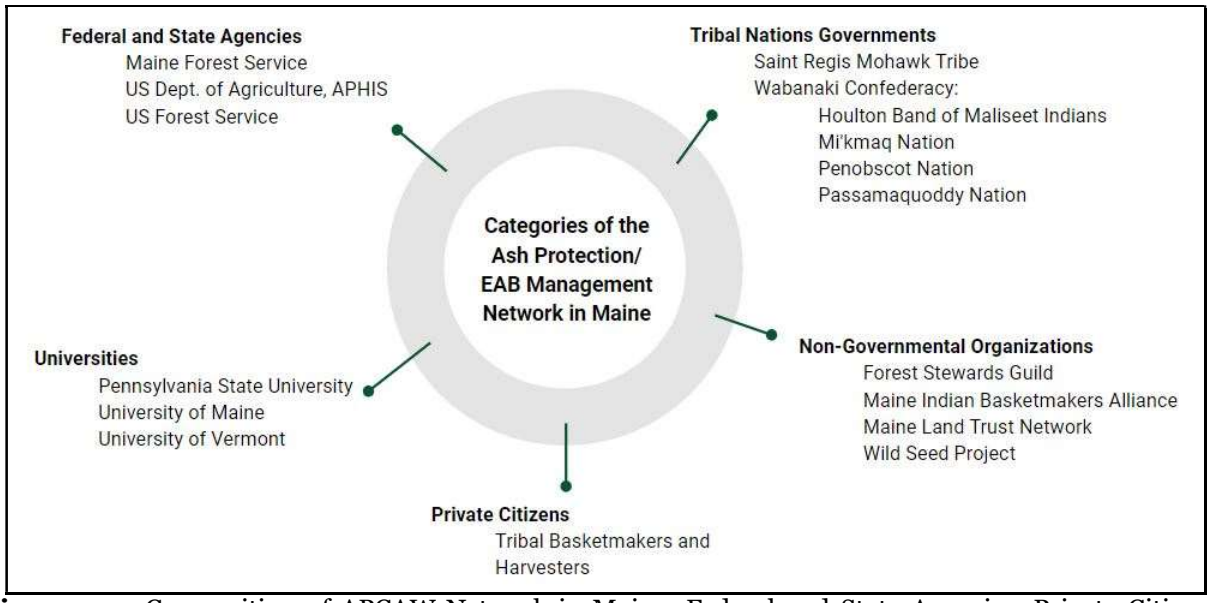


Figure 4.2. Composition of APCAW Network in Maine: Federal and State Agencies, Private Citizens, University Researchers, Tribal Nation Governments, and NGOs

Understanding the network can elucidate the future direction of collaborative efforts. This analysis can also serve as an example for other networks that protect culturally and environmentally important species against invasive pests, specifically for grassroots efforts. The objective of this study is to create a framework for the network of relationships involved with brown ash protection against EAB in Maine, to address how knowledge is shared by this group and provide direction for future ash preservation efforts. This timely effort is essential as EAB spreads across the state of Maine. The research questions are:

1. How is knowledge shared within a discrete natural resources network, specifically one initiated in response to an invasive species?
2. How do central actors' connectivity in the network relate to knowledge transfer between the other categories?
3. What is the outlook and effectiveness of the future of ash and the efforts taking place by the APCAW network?

4.3 Methods

This study focuses specifically on the core group of individuals who are a part of the APCAW network, those involved in the planning and development of some of the APCAW 2023 events. The broader ACPAW network, and those who joined during the workshop series, are important to the work being accomplished on a large scale. However, this study focuses on a target sample of the APCAW network, those

focused on the mission to protect ash from EAB as a large part of their work life and personal life. Some of these individuals have a history of being a part of this work from before EAB's original detection in 2002 when ash was showing dieback in the mid-1990s. These are the key participants who have been identified for this study. This group is key to understanding how a network of this type operates, how knowledge is shared between categories and who the gate keepers of information are.

4.3.1 SNA survey description and network recruitment

A survey targeting APCAW members was developed in the fall of 2023 and approved by the University of Maine's Institutional Review Board. The survey was split into three sections (the full survey can be found in Appendix 11). Following the approach established by Prell (2012), the first section of the SNA survey prompted participants to review a list of 33 names and answer follow-up questions regarding each individual (Table 4.2). These questions are essential to the SNA measurements of centrality, specifically the four questions or statements posed in Section 1 (Table 4.2). The second section of the survey asked respondents for their opinions of specific ash and EAB topics, and questions about the ACPAW network. The final section of the survey collected demographic information, including age, state of residence, county of residence if living in Maine, and what sector they were employed in.

Table 4.2 SNA survey questions from Section 1 following methods from Prell (2012).

Question/statement	Response values
Do you know the following names as part of the Ash Protection Collaboration Across Wabanakik (APCAW) events or because of their work related to ash or EAB in Maine?	1 = Yes 2 = No 3 = Unsure 4 = This is me
How long have you known them to be involved with ash protection or EAB management?	1 = Less than 1 year 2 = 1 to 4 years 3 = 5 to 10 years 4 = Over 10 years 5 = Unsure
How often do you communicate with this person on topics of ash protection or EAB management?	1 = Daily 2 = Weekly 3 = Monthly 4 = Yearly 5 = Never
Do you communicate with this person because of their:	– knowledge or expertise of natural resource policy – expertise on research funding – knowledge on forest management/silviculture – knowledge on Tribal government – access to university resources and research – knowledge or experience on seed collecting – cultural background as a basketmaker or ash harvester – expertise as a researcher/scientist – expertise on a subject related to ash or EAB

The survey instrument followed the methodology of Dillman, et al. (2014) for contact and recruitment, all of which was through email, which was obtained internally through the APCAW email list. This methodology included an initial email, informing the potential participant of the study that they would be receiving the survey link in a certain number of days, an email with the survey link, and a follow up email to remind the potential participant of the survey (Dillman, et al., 2014). The survey was hosted on the University of Maine's Qualtrics account.

4.3.2 SNA measurements and SPSS analysis of network

Social networking analysis was performed using UCINET 6 for Windows and NetDraw for network visualization (Borgatti, Everett & Freeman, 2002). Data was downloaded from Qualtrics, organized in Microsoft Excel, and then imported into UCINET. Specifically, UCINET was utilized to analyze centrality measures (Table 4.3), including, degree, in- and out-degrees, betweenness, degree of centralization, as well

as tie reciprocity, directionality, and density for the overall network and individual actors (Prell, 2012). Actors were identified for their centrality values to highlight *brokers*, or key participants in the network who facilitate movement of information between categories (Currie et al., 2014; Scott, 2000). These analyses inform research questions 1 and 2, identifying centrality measures of the overall network and specific actors who are highly connected.

Table 4.3 Definitions of SNA centrality measures (Prell, 2012).

Measure	**Definition**
Betweenness	A measure for the connection between a single actor and two or more actors, like a bridge. It is measured by the shortest distances a specific actor sits between connecting actors.
Degree	The number of connections a single actor (node) has to other actors in the network.
Degree of centralization	The mean degree across all actors represented as a proportion, (Du, 2022).
Density	How connected a network is, or the proportion of the number of possible connections between all of the actors.
Directionality	The direction that a relationship or connection can take between actors in a network, see in-degree and out-degree.
Eigenvector	An actor-level measure taking an individual's degree and weighing it by the degree of centrality.
Flow betweenness	An actor-level measure that takes into account all options of connections in the network between two actors, (Hanneman & Riddle, 2005).
Geodesic distance	The shortest measurable length between two actors.
In-degree	The number of connections an actor has that is directed to them from other actors: who knows them?
Out-degree	The number of connections an actor has that is directed away from them: who they know.
Tie reciprocity	Ties that are undirected, or two actors who both select each other as a connection.

Using the demographic questions (Appendix 11) in Section 3, frequencies were calculated using IBM's SPSS. This was analyzed for questions: what sector are you employed with, what year were you born, what state do you have residence in, and if in Maine, what county do you live in? Mode was calculated for: what year were you born, and question from Section 2, what year (approximately) did you first hear about emerald ash borer? Means of Section 2 of the survey were calculated for statements regarding the outlook

for the future of brown ash, ash seed collection, genetic research and basketmaking, and the effectiveness of forest management and biological controls. These questions were posed with 7-point bipolar scale responses (Table 4.4). This analysis relates to research question three, discussing the participants' outlook for the future and their centrality to the network.

Table 4.4 The 7-point bipolar values of Section 2 used in measuring means for outlook and effectiveness of the future and current efforts in ash protection

Question	**7-Point Scale**	
What is your outlook for the following statements?	- The existence of brown ash on the landscape in the next 50 years in Maine: - The use of seed collecting to protect brown ash for the future: - The use of genetic research for brown ash in the future: - The future of Wabanaki basket making in Maine:	Extremely negative (1) Fairly negative (2) Somewhat negative (3) Neutral (4) Somewhat positive (5) Fairly positive (6) Extremely positive (7)
How effective do you think are the following efforts?	- Forest management techniques or silviculture - Biological control agents, such as insects	Extremely ineffective (1) Fairly ineffective (2) Somewhat ineffective (3) Neutral (4) Somewhat effective (5) Fairly effective (6) Extremely effective (7)

4.4 Results

The researchers of this study identified between 6 and 8 individuals from each of the five categories in the network for a total of 33 individuals (Table 4.5). These individuals range from being members associated with the BATF to those who have become partners with APCAW within the last few years. Each person has been involved with meetings, workshops, research, or have professional relationships involving the network. Members of APCAW can be part of multiple categories within the network represented in Table 4.1. For example, someone can be a basketmaker but also a part of the university research team. For the purpose of this analysis, individuals were placed into the category they are most associated with in their relationship to APCAW. In SNA literature, network members are referred to as actors, or nodes, when referencing a network graph, so the terms “members” and “individuals” will be used interchangeably with “actors” (Prell, 2012).

Table 4.5 APCAW member categories and participant numbers for SNA

Category	**Number of participants**
Federal or state agencies	6
Tribal Nations governments	6
University research	8
Non-governmental organizations	7
Private citizens (basketmakers and harvesters)	6
Total participants:	**33**

4.4.1 Demographics and network description

All 33 participants responded to the SNA portion of the survey, a 100% response rate. Geographically, most participants were residents of Maine (78.8%, n=26), with one participant in each of the following states: Vermont, New Hampshire, New York, and Pennsylvania (Table 4.6). Three participants did not respond to this question. Of the 26 participants in Maine, Penobscot County had the highest number of residents with 11 (33.3%), and Aroostook, Cumberland, and Kennebec Counties each at 4 residents (12.1% each). Sagadahoc and Washington Counties each at 1 (3%) participants respond as residents. Therefore, of the 16 counties in Maine, 7 were represented. Ages of participants ranged from 27 to 77 (n=29, 87.9%). Four (12.1%) participants did not respond. These responses are similar to the APCAW member categories and participant numbers for SNA in Table 4.5, which were identified by the researchers.

Table 4.6 SNA survey questions and associated value for demographic data

Question/statement	**Results**
What sector are you employed with?	Federal and state agency: 6 (18.2%) Private citizen: 3 (9.1%) University researcher: 7 (21.2%) Tribal Nation government: 7 (21.2%) NGOs: 6 (18.2%) Missing: 3 (9.1%)
What year were you born?	Range: 1947-1997 Mean: 1977
What state do you have residence in?	Maine: 26 (78.8%) New Hampshire: 1 (3%) New York: 1 (3%) Pennsylvania: 1 (3%) Vermont: 1 (3%) Missing: 3 (9.1%)
If Maine is selected, the following question is prompted What county do you live in?	Aroostook: 4 (12.1%) Cumberland: 4 (12.1%) Hancock: 1 (3%) Kennebec: 4 (12.1%) Penobscot: 11 (33.3%) Sagadahoc: 1 (3%) Washington: 1 (3%) Missing: 7 (21.2%)

The network described through SNA analysis has a total of 33 actors and 673 ties between those actors (Table 4.7). The whole network density was 0.673, which means 63.7% of the potential ties, or connections between actors, were met. The average degree, or average number of ties per actor, were 19. With 32 potential ties total, the average actor was directly connected to over half of the members of the total network. Ties between actors had reciprocity value of 0.826, meaning that 82% of ties were positively responded to by other actors. The average betweenness was 11.606, with a range of 0.00 to 55.261. Betweenness is important as it indicates those with the power to connect actors to others, like an intermediary (Hanneman & Riddle, 2005). Finally, the average geodesic distance between actors was 1.363. This indicates that actors' optimal distance between each other was on average direct from one actor to another, however, as not all actors were connected, the average was over 1 (Hanneman & Riddle, 2005). Overall, these measures suggest a highly connected network.

Table 4.7 Overall whole network statistics for APCAW network, modeled from table by Gogaladze et al. (2020).

Network data	**Values**
Total number of actors	33
Total number of ties	673
Average degree (ties per actor)	20
Density	0.637
Degree of centralization	0.2698
Betweenness	11.606
Tie (Arc) reciprocity	0.826
Average geodesic distance	1.363

A network graph, represented in Figure 4.3, visualizes all 33 actors and their ties for a positive response (i.e., "Yes" to knowing each individual actor). Those who are most connected and central to the network are in the middle of the network. It should be noted that the red circles, representing University Research actors, dominate the center of the network graph. Yellow circles represent NGO actors, which along with Tribal government actors, are found mostly on the periphery of the network graph. Federal and State Agency actors, in green, as well as Private Citizens, in blue, are mixed between the center and to the edges of the graph. Notably, there are two actors, a Private Citizen and a University Researcher who are set apart from the center of the graph, as seen on the right side of Figure 4.3. These represent actors with lower degrees of centrality and number of ties.

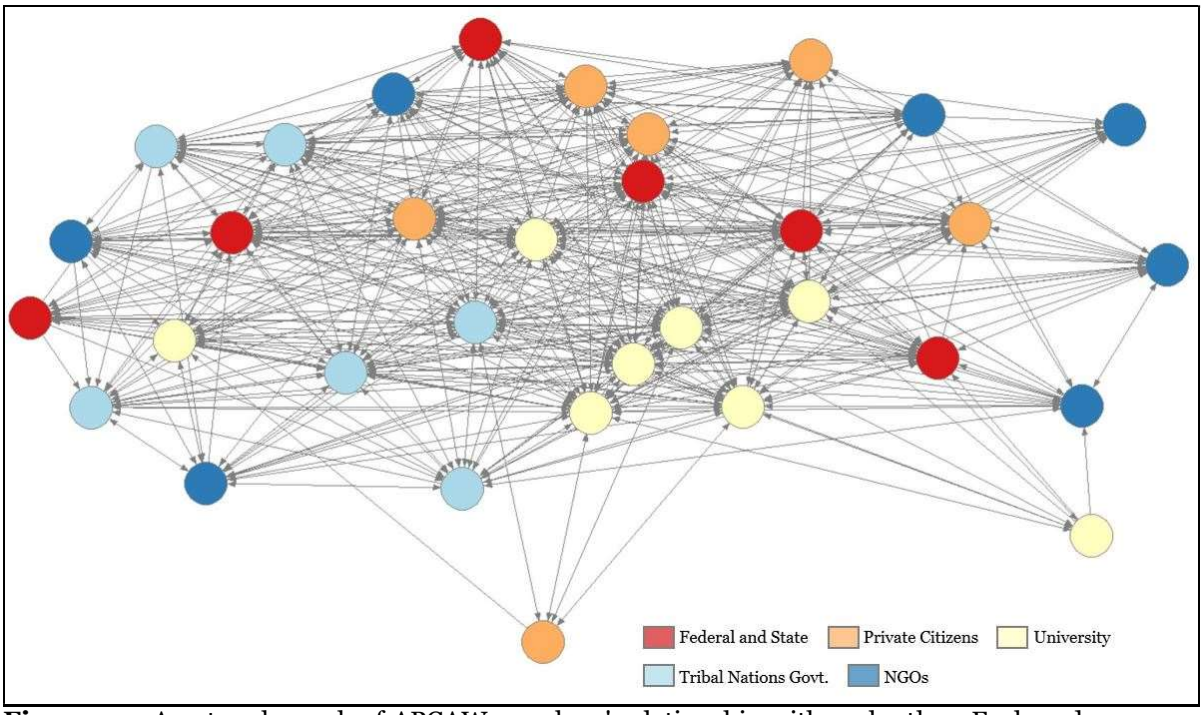


Figure 4.3 A network graph of APCAW members' relationship with each other. Each node represents a member and the color of the node represents the category they belong to. Lines between actors represent an actor responding that they know another actor. Arrows represent the direction of the connections between actors. Distance represents the strength of relationships between actors.

4.4.2 How is knowledge shared within a discrete natural resources network, specifically one initiated in response to an invasive species?

In SNA, one measure that is used to discuss how knowledge is shared is *directionality*, discussed in terms of out-degree and in-degree. These measures record the number of actors who interact with a specific individual. As seen in Figure 4.3, there are some actors with many arrows pointing toward their node, and some who have very few arrows. This indicates the actors who have lower in-degrees, which is considered to be "receiving" less connections, whereas, those with higher in-degrees have "prestige or popularity" within the network (Prell, 2012, p. 99). Conversely, those with higher values for out-degree are "giving" information and connections, and have the ability to increase the "expansiveness" of the network (Prell, 2012, p. 99).

For the APCAW network there were specific members with very high out-degree and in-degree values; these individuals are key members who can introduce information and make connections to a large part of the network. The top four members with the highest rates for out-degree are all in the University Researchers category, and the fifth highest is in the Federal and State Agency category (Table 4.5). The top

four highest values for in-degree values are in the University Researchers category and the fifth is a member of the Private Citizens category. This suggests that these University Researchers are conduits for getting information to the largest number of network members, with an individual in the Federal and State Agencies, also a key. On the other hand, these University Researchers are also the ones most likely being communicated too, along with a Private Citizen.

Table 4.8. Members of the APCAW network with the highest out-degree and in-degree measures and the category they are in.

APCAW Member/ Category	Out-degree	ACPAW Member/ Category	In-degree
Actor 20 / University Researcher	32	Actor 20 / University Researcher	32
Actor 11 / University Researcher	31	Actor 33 / University Researcher	31
Actor 12 / University Researcher	31	Actor 11 / University Researcher	30
Actor 33 / University Researcher	31	Actor 12 / University Researcher	30
Actor 26 / Federal and State Agencies	29	Actor 28 / Private Citizen	29

Analyzing how often members of the APCAW network communicate with each other was divided into the following responses in the SNA survey: “daily” = 1, “weekly” = 2, “monthly” = 3, “yearly” = 4, and “never” = 5. “Never” is an important response which indicates that while someone is aware of another person, they may not actually communicate with them on a regular basis or at all. The regularity of the communication present in the network with the top 4 members of in the University Researcher category, highlighted in Table 4.5, averages the following: Actor 20 with 3 (n=29), Actor 11 with 3.04 (n=26), Actor 12 with 3.24 (n=25), and Actor 33 with 2.97 (n=29). This means that the average contact that a member of the network has with the most connected individuals in the network is “monthly”, with Actor 22 as the exception with 2.97 or “weekly” interactions (connected with 29 individuals). Actor 26, with the Federal and State Agencies, has an average communication value of 3.66 (connected with 24 individuals), and Actor 28 with Private Citizens category with a value of 4 (connected with 28 individuals). Therefore, the average communication that members of the network interact with the most connected members is in the range of “weekly” to “yearly”, but mostly “monthly”.

To understand how knowledge is shared within the network, the actors with the knowledge and expertise need to be identified. When participants of the survey were asked if they knew specific members,

they were also asked the topics they communicated within the scope of ash protection with each person (listed in Table 4.2). Counting the frequency of responses for each actor provided the ability to assign each a rank, demonstrating who is most regarded as the go-to person for each topic. The top 5 individuals are listed in Table 4.6. Overall, Actor 20, who has the highest out-degree and in-degree scores, has knowledge or expertise in five topics: knowledge or expertise of natural resources policy, knowledge on Tribal government, expertise on research funding, access to university resources and research, and expertise as a researcher or scientist, The last two topic areas make logical sense as the actor is in the University Researcher category. However, this individual is perceived to have also knowledge or expertise of natural resources policy with Actor 26, (a Federal or State Agencies actor), for knowledge of Tribal government with Actor 33, (a University Researcher), and Actor 23, (a Tribal Nations Government actor). Of the five categories of actors in APCAW, the only one missing from this list of most knowledgeable individuals is the NGO category.

Table 4.9. APCAW members with the highest frequency of knowledge, expertise or access on a specific topic, and the network range for each for the SNA network from the survey.

Topic	Network range	Actor(s) with highest value	Category(s)
Knowledge or expertise of natural resources policy	0 to 14	Actor 20 (n=14) Actor 26 (n=14)	University Researcher Federal and State Agencies
Expertise on research funding	0 to 18	Actor 20 (n=18)	University Researcher
Knowledge on forest management and silviculture	0 to 23	Actor 33 (n=23)	University Researcher
Knowledge on Tribal government	0 to 19	Actor 33 (n=19) Actor 23 (n=19) Actor 20 (n=19)	University Researcher Tribal Nations Government University Researcher
Access to university resources and research	0 to 23	Actor 20 (n=23)	University Researcher
Knowledge or experience on seed collecting	0 to 20	Actor 23 (n=20)	Tribal Nations Government
Cultural background as a basketmaker or ash harvester	0 to 21	Actor 23 (n=21) Actor 28 (n=21)	Tribal Nations Government Private Citizen
Expertise as a researcher or scientist	0 to 21	Actor 33 (n=21) Actor 20 (n=21)	University Researcher University Researcher
Expertise on a subject related to ash or EAB	0 to 24	Actor 26 (n=24)	Federal and State Agencies
Other (Text response)	0 to 7	Actor 11 (n=7)	University Researcher

4.4.3 How do central actors' connectivity in the network relate to knowledge transfer between the other categories?

Using centrality measures, individual actors can be identified as being key members of the network. These actors represent those who have access to knowledge and can move information through the network. Table 4.7 shows the measures of centrality used to rank each of the 33 members of the APCAW network. From each analysis, the actor with the highest score was selected from each category. This is to identify who the key central actors are for each category and how connected these categories are within the whole network. Each category had a single actor who held the highest rank within each measure, with the following exceptions: for degree centrality and Eigenvector, three actors tied, as well as the top out-degree for Tribal Nations Government, who is a different Actor 23, who has the top scores for the other measures (Table 4.7).

Table 4.10. Categories of APCAW members and the highest value for each of the following centrality measures: degree, in-degree, out-degree, Eigenvector, betweenness, and flow betweenness. The actor with the majority of the highest values for each measure is named under each category title.

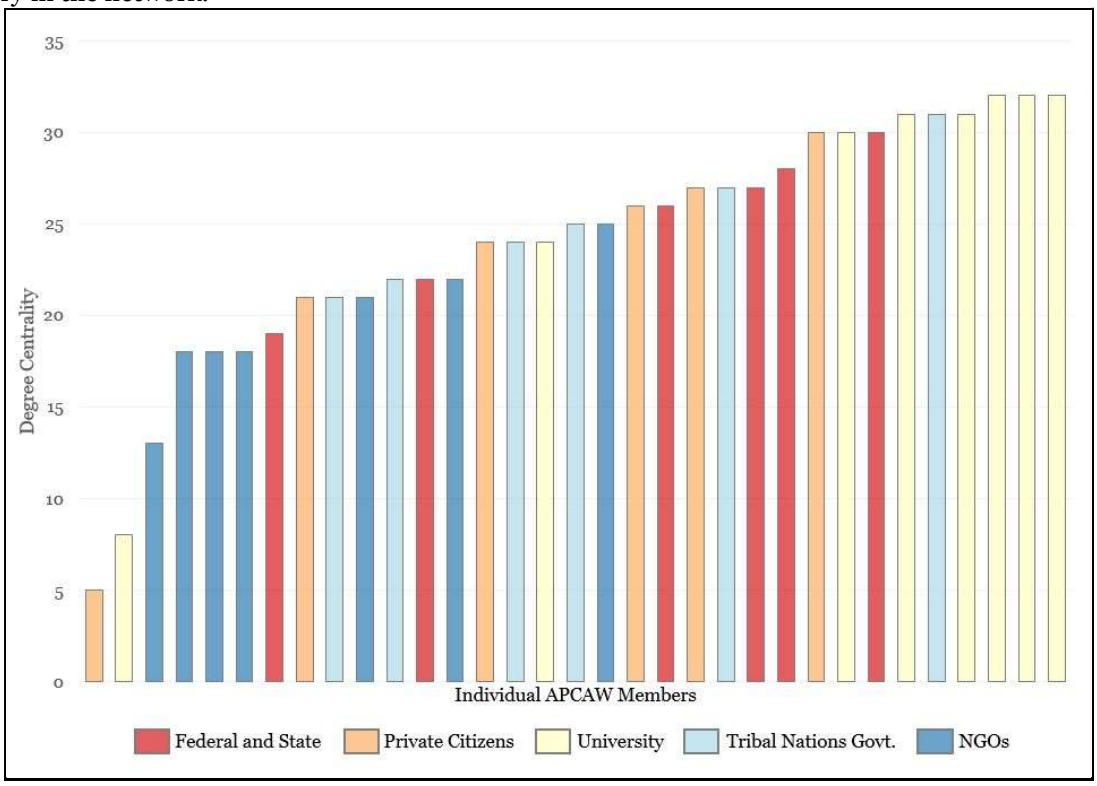
Measure	**University Researcher:** Actor 20	**Federal/State Agency:** Actor 26	**Tribal Nations Government:** Actor 23	**Private Citizen:** Actor 28	**NGOs:** Actor 5
	Values				
Degree centrality	32 (3 actors)	30	31	30	25
Out-degree	32	29	24*	23	24
In-degree	32	27	29	30	16
Eigenvector	0.211 (3 actors)	0.204	0.208	0.207	0.180
Betweenness	55.261	26.561	20.692	15.818	5.739
Flow betweenness	79.093	54.342	47.958	41.747	26.591
*The measure for out-degree was a different actor than the other values for this category.					

Eigenvector measures use an individual's degree and weigh it by the degree of centrality. This means that Actor 20 has the highest measure, therefore the most central with a value of 0.211 (Hanneman & Riddle, 2005). The differences in values with both betweenness and flow betweenness measures for Actor 20 and the other most central actors for each category illustrate the centrality of this one member. Actor 20 having the highest values for both betweenness measures means that they have great power and control of connectivity between other ACPAW members. Actor 20 is the most connected actor in the network. The top actors for Federal and State Agencies, Tribal Nations Government, and Private Citizens have similar values for each of the measures. The least connected of the top actors for each category is an individual who is associated with a NGOs, Actor 5. While Actor 5 has the highest values within that category, they are ranked overall 16th of all the members in the network for connectivity.

Figure 4.4 provides further visualization of centrality measures for the members within the APCAW network differently than the network graph in Figure 4.3. The representation of the actors on an axis visualizes a linear ranking of the connectedness that is not as easily readable in the network graph. This is important because the dominance of the University Researcher category versus the lower values of the NGO category tells a story of the lack of integration in the network between those two categories. Whereas, the Private Citizen, Tribal Nations Government and Federal and State Agencies are integrated within the center

of the axis. The outcome of this representation is that while the centrality measures of the whole network indicate this is a highly connected network, there is an outlier of a category that is visible when the actor's centrality measures are ranked. Overall, there are clear differences between the connectedness of University Researchers and NGOs, but there are actors with high connectivity within each category.

Figure 4.4 APCAW members degree centrality represented by their rank and color coded by their assigned category in the network.



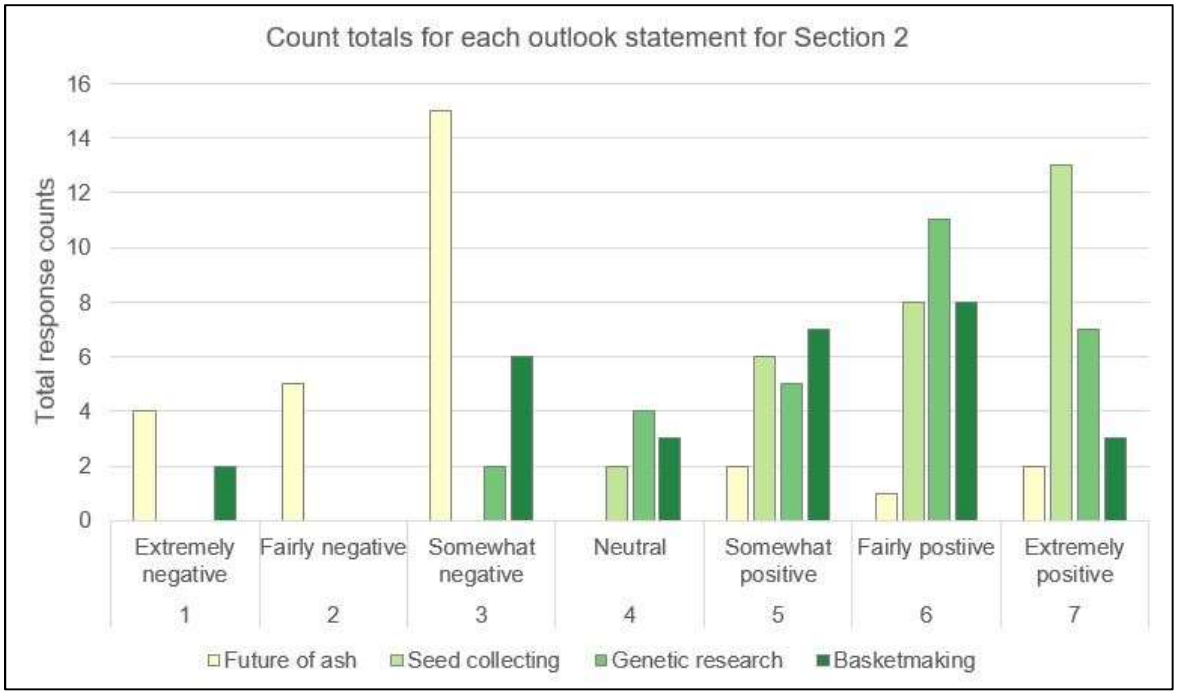
4.4.4 What is the outlook and effectiveness of the future of ash and the efforts taking place by the APCAW network?

Respondents were asked to select their belief on the outlook of the future of ash, and the efforts of the APCAW network by a series of statements (Table 4.8), which together illustrate their outlook on these matters. The outlook statements have the following mean values: the existence of brown ash on the landscape in the next 50 years in Maine, 3.07 ("somewhat negative"), the use of seed collecting to protect brown ash for the future, 6.10 ("fairly positive"), the use of genetic research for brown ash in the future, 5.59 ("somewhat positive"), and the future of Wabanaki basketmaking in Maine, 4.69 ("neutral"), seen in Table 4.8. The effectiveness statements have the following mean values: forest management techniques or

silviculture, 4.38 (“neutral”), and biological control agents, such as insects, 4.69 (“neutral”). These means for each statement are visually represented in Figure 4.6, with outlook statements in the top bar chart and effectiveness statements on the bottom. There it is easy to visualize the means for each statement compared to the other statements at the same time, particularly the difference between the future of ash and seed collecting, which are skewed to opposite ends of the axis.

Table 4.11. SNA survey questions from Sections 1 and 2: Actors in the network, EAB awareness, management and methods, and quantitative measures.

Question/statement	**Response values**	**Results**
What year (approximately) did you first hear about emerald ash borer?	Drop-down menu with options of “Unsure” and each year from 2002 to 2023	Range: 2002 to 2021 = 23 (69.7%) Mean: 2009 “Unsure”: 3 (9%) Missing: 7 (21.2%)
What is your outlook for the following statements?	Seven Point Scale (1 = Extremely negative, 7 = Extremely positive)	
- The existence of brown ash on the landscape in the next 50 years in Maine:		Mean: 3.07 (n=29) Standard deviation: 1.580
- The use of seed collecting to protect brown ash for the future:		Mean: 6.10 (n=29) Standard deviation: 0.976
- The use of genetic research for brown ash in the future:		Mean: 5.59 (n=29) Standard deviation: 1.211
- The future of Wabanaki basket making in Maine:		Mean: 4.69 (n=29) Standard deviation: 1.650
How effective do you think are the following efforts?	Seven Point Scale (1 = Extremely ineffective, 7 = Extremely effective)	
- Forest management techniques or silviculture		Mean: 4.38 (n=29) Standard deviation: 1.656
- Biological control agents, such as insects		Mean: 4.69 (n=29) Standard deviation: 1.466



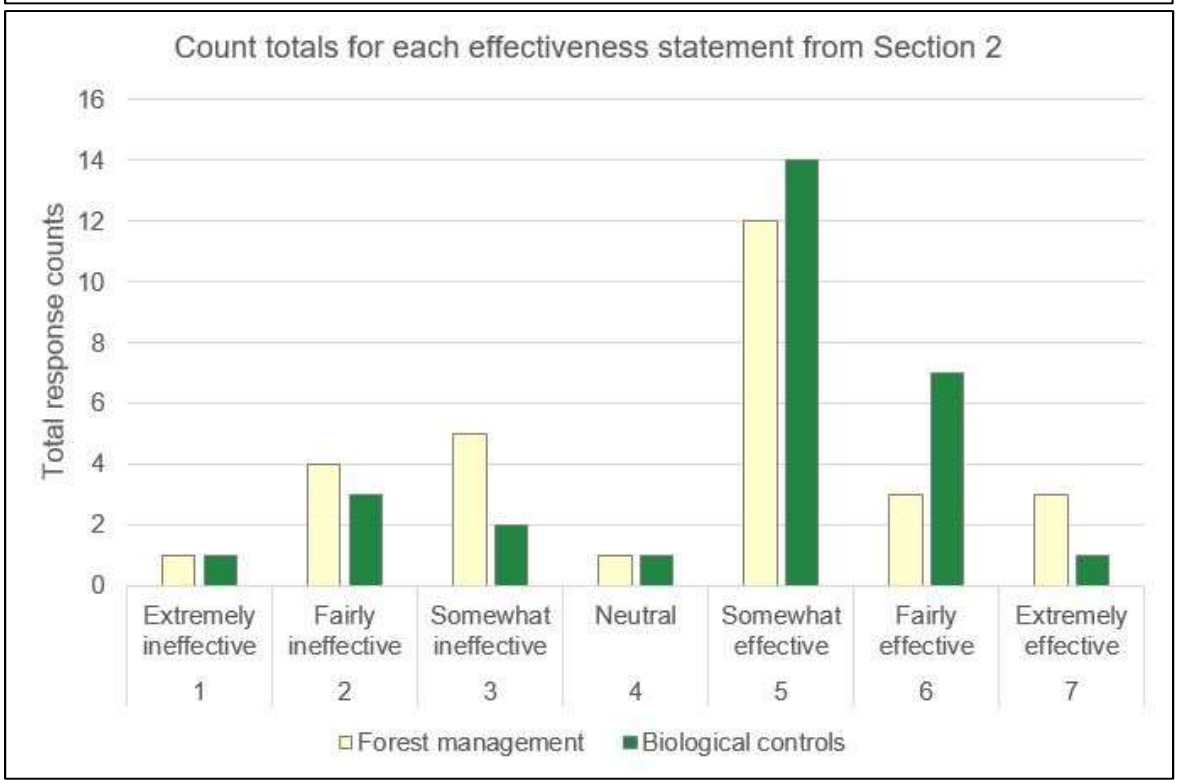


Figure 4.5. Top: count totals for each outlook statement from Section 2. Bottom: count totals for each effectiveness statement from Section 2.

To obtain a deeper understanding of the outlook and perceived effectiveness of ash protection efforts in the APCAW network, the averages of the statements presented in Table 4.8 were divided by the categories of the network, seen in Table 4.9. What this illustrates is how the outlooks and perceived

effectiveness are represented by category, providing insight into the potential positive and negative beliefs of those categories on specific topics. Something that could be inferred from these means are how categories beliefs could affect their actions or interest in supporting efforts, like seed collection or forest management/silviculture. As established from the overall means for each statement, "future of ash on the landscape" was "somewhat negative", but the range of means from each group, 1.75 to 4, shows that there is a difference by category. There is a clear difference between the mean of Private Citizens, who are basketmakers, harvesters and Knowledge Holders, who's outlook is collectively "extremely negative" versus Tribal Nations Governments, who had the highest mean, with "neutral." There is also a difference in the mean outlook for the "future of Wabanaki basketmaking", where Private Citizens are once again have the lowest mean, "somewhat negative", and the University Researchers, who have the highest mean, "somewhat positive." With these effectiveness statements, the overall means were "neutral", but separated by category, Private Citizens had a mean of "somewhat ineffective" for "biological control agents, such as insects," whereas Tribal Nations Government's mean was the highest with "somewhat effective." Overall, Private Citizens had the lowest means for each statement. The Tribal Nations Government had the highest means for each outlook and effectiveness statement, except for the "future of Wabanaki basketmaking," where University Researchers had the highest mean.

Table 4.12. The means for outlook and effectiveness statements averaged, and the range of the means by APCAW category (n=29).

Categories	**Outlook for the following topics:**				**Effectiveness of the following efforts:**	
	Future of ash on the landscape	Use of seed collecting to protect ash	Use of genetic research for brown ash	Future of Wabanaki basket-making	Forest management techniques or silviculture	Biological control agents, such as insects
Range	*1.75 to 4*	*5 to 6.8*	*5 to 6.2*	*3 to 5.14*	*3 to 5*	*3.25 to 5.8*
Federal and State Agencies (n=6)	2.83 Fairly negative	5.67 Somewhat positive	5.33 Somewhat positive	4.83 Neutral	4 Neutral	4.5 Neutral
Private Citizens (n=4)	1.75 Extremely negative	5 Somewhat positive	5 Somewhat positive	3 Somewhat negative	3 Somewhat ineffective	3.25 Somewhat ineffective
University Researchers (n=7)	3.86 Somewhat negative	6.14 Fairly positive	5.29 Somewhat positive	5.14 Somewhat positive	4.57 Neutral	4.86 Neutral
Tribal Nations Governments (n=5)	4 Neutral	6.8 Fairly positive	6.2 Fairly positive	4.8 Neutral	4.8 Neutral	5.8 Somewhat effective
NGOs (n=7)	2.57 Fairly negative	6.67 Fairly positive	6 Fairly positive	5 Somewhat positive	5 Somewhat effective	4.86 Neutral

4.5 Discussion

The APCAW network is a grassroots effort by motivated individuals and organizations across the state of Maine, and has continued even with the understanding that EAB eradication is not possible. The SNA results reported here provide insights into how the network communicates, who the experts are and how they are situated to share information across the network. The current efforts and outlooks within the protection of ash against EAB illustrate the concerns and hope for the future. Of these outcomes, two points have surfaced which highlight actions and issues that the APCAW network should consider as the community of interested people and organizations continues this work. They include holding space in the

network for all categories of participants, and focusing on the future with the current outlooks of members, as well as planning for member changes.

4.5.1 Centrality and power

A key outcome of the SNA analysis for the APCAW network is the evidence for the centrality of the University Researcher category. Not only does this category have the greatest number of central actors, it has the top actor for many of the centrality scores, equating to social power (Hanneman & Riddle, 2005). This power comes in the form of movement of communication and introduction of knowledge into the network. While other categories of actors with included individual's high centrality measures and are well connected in the network, the University Researcher category is by far the most connected and contains a number of the top experts and knowledge holders. In the development of the APCAW network, this makes sense: university researchers were requested by the BATF to research ash and EAB, which in turn requires sourcing funds for this work, and therefore, the University of Maine holds an important role for the network. There are institutional requirements for applying and using money for research that is not a capacity that just any organization can produce. The location of researchers at the institution where the funding has been awarded logically streamlines the production of research, creating a seemingly efficient system. However, what does this mean for one category to apparently take up central space in the network? It is suggested that networks with too much centralization can limit the ability of long-term success and that networks require a greater mix of tie strength (Crona & Bodin, 2006; Prell, Hubacek & Reed, 2009). While this does not seem to be the case of the ash protection network in Maine, which has lasted over a decade, it is something to consider for this network planning team.

Though the University Researcher category dominates the connectedness and power, other metrics should also be considered to evaluate the currently hidden attributes of other categories. Prell et al. (2008) suggests reevaluating the commonly used SNA analysis methodology that depends on centrality measures, and uses structural equivalence instead. This would focus on, "seeing the need to balance marginal actors with central ones, and the need to optimise [sic] diversity in stakeholder categories, … Rather than focus on centrality, … we focused on locating stakeholders' structural positions, and then selecting stakeholders who held dissimilar positions," (Prell et al., 2008; p. 452). It is possible that the outcome centrality measures, highlighting power, overshadows what are considered marginal actors and their contributions to the

network. While acknowledging centrality and identifying those who have the ability to connect disparate actors is important, it ignores the importance of other actors and categories. A future iteration of SNA could address analysis in structure equivalence to better understand the attributes of other categories and actors outside of centrality.

4.5.2 Looking to the future of ash protection in Maine with APCAW

While the outlook is certainly grim for the future of ash in light of EAB, there is hope. The overall network's outlook statement means are pessimistic regarding the future of ash on the landscape and Wabanaki basketmaking, but potentially hopeful for efforts regarding ash seed collecting and genetic research. In the written responses to questions, one actor stated strengths to this network has been a, "diversity of participants and their expertise, level of passion for ash trees and Wabanaki basketmaking, [and] collaborative activities with other First Nations." On the other hand, one participant commented, "After the last 20 years of fighting this insect, with little to no success. [sic] I am surprised you still think something can be done. it [sic] seems to me like just another way to spend grant money. This bug is here to stay and unless the tree evolves a natural defense, there is nothing you or I can do." Though there was certainly a mix of opinions, the overall consensus focused on the efforts taking place, and suggestions for future research needs.

Seed collecting is an action that a broad scope of people can participate in and is seen as having a positive outlook by the internal members of APCAW. The publication of an ash seed collection manual and the focus of efforts on training the public by ACPAW in 2023 may be the reason that this effort is positive to people. However, the variability of seed production by ash, brown ash may not produce seed for 5 to 7 years, could create uncertainty of production each year deterring people in the future from taking part in this effort. Given the interest and positive outlook on seed collection this is an angle that the network should focus on in keeping the larger population engaged in ash protection. With this internal positivity, there is an opportunity to keep membership involved, as well as grow public interest and awareness through collective action, education and outreach. Graham et al. (2019) specifically refers to organizational coalition collective action in invasive species management which references studies similar to the APCAW efforts. While some organizational coalitions are large, formal networks, there are grassroots networks that also

employ this type of action. It may be prudent for the APCAW planning network to explore other examples of this type of collection to address future efforts.

A second point to consider in the future of the APCAW network are changes in staffing and participation. APCAW itself is a young network, with BATF being much older. The University Researcher category, in particular, depends heavily on graduate students and research funding to function. Without these, the network does not work the same way. Both of these commodities exist on cycles: by degree programs and funding. Outside of the University Researcher category there is always a potential for members to change jobs or for their jobs to change responsibilities which may impact their ability to take part in the network's effort. There is also the possibility of interest waning for the negativity of ash as a lost cause as EAB mortality becomes visible in Maine. One member mentioned in the written responses, "it is unclear to me how long this initiative will last." In 2021, the USDA ended the federal quarantine regarding EAB, and at least one state, Illinois, has deregulated movement of ash internally (Frequently asked questions. Illinois Department of Agriculture. (n.d.). As EAB damage and ash mortality becomes more evident in Maine, it is unknown how public perception of continued ash protection will fare. This includes the perceptions of APCAW members. Regardless of the future, the current network for ash protection against EAB in Maine is connected and hopeful for the efforts to collect seed and support genetic research, which is promising to give ash a chance to exist on the landscape in the future.

4.6 Conclusion

The ash protection network in Maine is an example of a grassroots effort to tackle a "wicked problem". This effort includes a range of stakeholders, but it is focused on Tribal Nations needs and values. While the results point to centrality and power being held mostly by a single category, University Researcher, this is logical for building capacity of the APCAW team and its efforts. As newer partners to the network increase their involvement, and employment changes are made within the established connections, relationships may change over time. As EAB continues to spread and funding for this work continues, APCAW has a future in guiding the greater ash protection network toward managing a landscape where EAB and ash can exist.

4.7 Limitations and future directions

A main limitation of this research is the lack of qualitative data. A mixed method approach to an SNA, which contains data collection from a quantitative source, SNA, and a qualitative source, interviews, could have provided a deeper understanding of the network (Luxton & Sbicca, 2021). SNA studies with both components can illustrate and investigate the network in ways that a survey cannot. Any research going forward with this network should have a qualitative component. There is also information missing by the researcher identifying the network and the boundaries. Rather than using snowball sampling or a different method to allow the actors to identify who is in the network, the researchers set the boundaries. While the researchers feel the network was appropriately and reasonably defined, there could have been actors left out that would have changed how the data was analyzed and interpreted. In a future iteration, it would be interesting to develop the list of participants differently and compare the results. Due to the timing of this research and its relation to the end of a graduate degree for the main researcher, the methodology was developed with specific constraints that would hopefully not be present in the future for this research.

CHAPTER 5

CONCLUSION AND RELFECTION

5.1 Revisiting dissertation goals and objectives

I focused this dissertation on the social aspects of managing an invasive forest pest, EAB, to protect a culturally important species, brown ash, in Maine. I wanted to inform the direction of outreach and education for the state agencies dealing with ash protection and managing EAB invasion, as well as exploring the network of those working toward that purpose. Each chapter of this dissertation highlighted one of the objectives stated in Chapter 1. In Chapter 2, I was able to determine private landowner involvement with potential adaptive management strategies, as well as factors that may influence their ability to participate in those strategies. Chapter 3 produced the ash seed collection manual, which provided step by step instructions in non-technical language for how to identify, collect, ship and store ash seed for short and long term storage. This document was the focus of numerous seed collection trainings by ACPAW and other organizations in 2023 and continues to be used in classrooms in Southern Maine under the direction of APCAW partners. Chapter 4 identified and analyzed the core group of participants in the APCAW network from five different categories, highlighting those who are conduits of information transfer, and addressing needs for future directions for this network. Combined these chapters develop an example of broad participation in native species protection against invasive forest pests and how a dedicated planning network can increase the ability for protection and create a model for future protection of native species against invasive species.

5.2 Collaboration with partners: Discussion with Wild Seed Project

One of the most important parts of the APCAW efforts has been the partnerships. A specific partnership that I enjoyed developing a relationship with is Wild Seed Project (WSP), an NGO based in North Yarmouth, Maine. Their mission is, “to inspire people to take action and join us in increasing the presence of native plants grown from wild seed” (About Our Work, n.d.). This perfectly aligns with APCAW and the focus on ash seed collection. WSP has been excited and generous in their resources to take part in APCAW events and utilize the seed collection manual, going beyond reviewing the seed collection document. WSP has taken the ash seed collection into classrooms in southern Maine, working with school

aged children to inventory ash stands and collect ash seed. In talking with Nell Houde, Manager of Educational Programs for WSP, in early 2024, she shared ash-specific efforts that WSP accomplished in 2023 and plans for 2024. WSP subsequently worked with the Gulf of Maine Research Institute to work with 12 middle school classrooms in southern Maine, bringing students to two different land trusts, where they identified, inventoried, collected, and sowed ash seeds. The ash that was identified were affected by EAB, and the students wanted to know how they could help the trees. In 2024, more classrooms are interested in joining the cohort, gathering new students to be exposed to ash protection and invasive species education. In thoughts for the future, Nell is curious of devising ways to connect schools directly with land trusts, finding how to center Wabanaki voices in telling the story of ash in science communication for education, and what it means to focus on a species that will have large scale mortality across the landscape. These are timely and important questions that should be considered beyond ash and EAB. How can schools connect with local land trusts for educational purposes? How can Indigenous voices be centered on culturally relevant topics in schools in a way that is not extractive or exhausting on the Indigenous communities? How does education tackle teaching about loss and mortality of species? These questions deserve time and thought to explore solutions, and WSP is a great partner to bring these to the attention of APCAW and our network. Partnerships like this one give hope for positive outcomes and interesting directions for the protection of ash in the future.

5.3 Future directions for research

There are many directions this work can take, especially from the three very different chapters presented here. Starting with Chapter 2, a continuation of analysis for the remaining data would be the next step for research. Specifically, analyzing the section which asked private landowners questions about ash as a cultural resource and their knowledge of and interest in allowing for ash to be harvested on their properties. As this survey focused on the Involvement Theory, which analyzes interest and potential involvement, a next step would be to apply the Theory of Planned Behavior to the same population. The goal would be to gain understanding on what adaptive management strategies private landowners are willing to take part in by providing more information about each strategy. Another avenue of inquiry would be to focus on a larger population of adults who are interested in protecting ash, but do not have property over 10 acres, pursuing the question of how to get more people involved in ash protection? One final thought

would be to focus on landowners with 10,000 acres or more. How can we get the largest landowners thinking about ash protection and taking part in this effort?

While Chapter 3, the ash seed collection manual, is a standalone chapter, there are still future directions to focus future efforts. While not ash specific, it would be interesting to create a larger manual for seed collection of other culturally relevant and threatened species in Maine that people could collect seed for. This would provide a greater opportunity for seed collection and growing of plants to a larger audience. Care would need to be taken for manuals to be created for appropriate species and Tribal consultation would be suggested to take place before choosing other species. Another direction would be to continue to develop opportunities for seed collection instruction to take place in educational settings, like what is being done by WSP and the Gulf of Maine Research Institute. Introducing seed collecting and the importance of protecting plants is a way to get students interested in nature and connected to the land they live in.

Finally, Chapter 4 and the APCAW network, my interest for future research would be to dive deeper into the needs of the network through interviews and focus groups with participants. This was part of my original plan for this chapter, but with time constraints and availability of participants, it did not come to fruition. Centering the values and needs of the Wabanaki people needs to be the focus of the next steps with the network. This is particularly important as Western Science solutions, like biological controls, genetic research and insecticide treatments are the focus for large scale protection. As ash is a building material that is utilized by hand and in close proximity to the basketmakers face, long term effects of insecticide are crucially important. Thankfully, this research is being explored by researchers at the University of New Hampshire. Similarly, community meetings with each Wabanaki Tribal community to discuss these protection options are also underway by graduate student Tyler Everett at the University of Maine. Therefore, some of the future directions for this work are already in place. However, for the long term health and longevity of the network, a coming together of core participants to devise an agreed upon direction for future work, centering Wabanaki needs and values, will be the key for the future of the network and ash health in Maine.

5.4 Return to decolonizing approach to Western Research methodologies

I wanted to include Indigenous Research Methodologies, Indigenous Knowledge and Ways of Knowing into this work because of the knowledge and importance that ash has to the Wabanaki People. Wabanaki knowledge of ash has been honed and collected for millennia and should be at the forefront of solving this "wicked problem." Unfortunately, a number of road blocks occurred in the process of research and the initial plans for including Two-Eyed Seeing and sharing circles did not come to fruition. While the IRB for the Two-Eyed Seeing had been approved, getting the community of basketmakers to take part proved difficult. It is possible that the basketmaker community has been oversaturated with requests for input by the research community. It is possible that my need to follow university protocol was off-putting, and basketmakers did not want to participate in my research. As a non-Indigenous person, I may not have explained in writing the purpose and needs of the study to make it seem worthwhile. All of these are understandable reasons. These methodologies were also taking place near the end of my degree and there was no opportunity to reschedule what I had planned when the lack of interest became apparent. For these reasons, the proposed research had to pivot and focus on the SNA survey entirely, rather than compliment it with basketmaker sharing circle story telling about the emerald ash borer issue. I hope that there is an avenue in the future for a student to incorporate these ideas, as I did have support from Wabanaki faculty and some basketmakers. I hope future students will be able to appropriately incorporate other ways of knowing into finding solutions for "wicked problems."

5.5 Personal reflections

I started this degree program in January of 2020, and spent the next four years experiencing the rollercoaster of the global COVID pandemic as a graduate student. This definitely colored my experience and created many unknowns to an already intense road that is graduate school. Opportunities changed from in-person to online, spending hours upon hours in virtual classes, meetings, conferences, and hangouts. This time created a cohort of students thrust into solitude in an already isolating environment. As restrictions lifted and in-person events were held again, it was never the same, and some things changed permanently. Within all of that, I was able to meet the ash protection network in Maine and beyond, travel to Akwesasne, NY multiple times, help make a basket with Richard Silliboy, watch brown ash be harvested by basketmakers, and present about and teach ash seed collection for a large variety of audiences. What

started as a bleak and sad affair, the loss of ash trees and the looming spread of EAB, turned into a glimmer of hope as the years progressed. Biological controls, silvicultural trials, insecticide treatments, genetic research, and seed collection all became possibilities to keep ash on the landscape. The development of APCAW and the outpouring of interest, particularly from land trusts and NGOs, was inspiring and awesome. As my time at the University of Maine comes to a close, I appreciate the hard work that has been accomplished, and continues to move forward, by all of those involved in this deeply meaningful service to the ash tree which has brought all of us together.

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APPENDICES

APPENDIX 1: Private Landowner Survey, 2022

A. First, please tell us some background information about your property.

2) Which of the following best describes your property? Please indicate one of the listed items. (1 choice)

a. Large intact forest area – at least 10 acres of forest cover
b. Agricultural area – mix of farm land with wood patches
c. Residential area – land primarily used for residential housing
d. Other (please describe): _____

3) There are many different types of forest landowners in Maine. How would you describe the type(s) of ownership in which your land is held? Check all that apply.

____ Family Forest (Individual, family, or joint)
____ Trust (Held in trust, land trust or real estate investment trust)
____ Company, producing forest products
____ Timber Investment Management Organization (institutional investor)
____ Club or Association (e.g., Appalachian Mountain Club)
____ Other (please specify): _____

4) What are the primary reasons you own your land in Maine?
Please list up to 3 reasons by priority: 1= first, 2 = second, and 3 = third priority (3 choices)

____ Timber or Forest Products
____ Agricultural
____ Residence
____ Recreation
____ Protection of Natural Resources
____ Privacy
____ Aesthetics
____ Real Estate Investment
____ Tax Shelter
____ Other (please describe):_____

5) How many years have you owned land in Maine?

_____ Years

6) Approximately how many acres do you own/manage in Maine? (1 choice)

____ Less than 10 acres
____ 10 - 49 acres
____ 50 - 99 acres
____ 100 - 999 acres
____ 1,000 - 9,999 acres
____ 10,000 or more acres

7) There are three native ash tree species that comprise roughly 2 percent of the trees in Maine. Do you know if you have the following ash trees on lands you own or manage? (Choose 1 for each species)

Brown/Black: Yes ( ) No ( ) I don't know ( )
Green: Yes ( ) No ( ) I don't know ( )
White: Yes ( ) No ( ) I don't know ( )

Only those meeting conditional statements above would populate Question 8

8) How abundant is the ash on your property?

Very little ash on my property: 1 2 3 4 5 6 7 : Most of my property is ash

B. Next, we are going to ask you questions about invasive forest pests and your awareness of these pests. Invasive forest pests include insects that are native to another region and, when brought to another area, spread widely and cause harm to trees.

9)

	Yes	No	I don't know / I am not sure
Have you heard of the insect pest Emerald Ash Borer (EAB) being in Maine?			
Has your property been affected by EAB?			

10) On a scale of 1 to 5, would you say that EAB is:

Of no concern to me	1	2	3	4	5	Of serious concern to me
Does not matter to me	1	2	3	4	5	Matters to me
Does not impact what I do with the land that I own	1	2	3	4	5	Impacts what I do with the land that I own
Does not impact others nearby me	1	2	3	4	5	Impacts others nearby me
Does not have an impact to others in Maine	1	2	3	4	5	Impacts others in Maine

11) Please indicate your level of agreement or disagreement with the following statements about EAB.

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
a. There is not much a landowner can do to prepare for the impacts of EAB					
b. As long as EAB continues to spread throughout my state, my efforts to sustain ash are useless					
c. In the long run, things will balance out with EAB					
d. The EAB threat is exaggerated					
e. EAB has the ability to kill all or nearly all native ash species					
f. Other tree species can fulfill environmental roles of ash trees					
g. Other tree species can grow in the place of ash trees and provide the same or increased value					

C. In this section, we'd like to have you answer questions to better understand your knowledge of Wabanaki Tribal Nations in Maine and the potential cultural and economic impacts of EAB.

The Tribal Nations of the Wabanaki Confederacy: Aroostook Band of Micmacs, Houlton Band of Maliseet, Passamaquoddy Tribe at Pleasant Point Sipayik, Passamaquoddy Tribe at Indian Township, and Penobscot Nation.

12) How familiar are you with:

The Wabanaki Tribal Nations that are located in the state of Maine?	Unfamiliar (1)	(2)	(3)	Somewhat familiar (4)	(5)	(6)	Very familiar (7)
The connection between Wabanaki Tribal Citizens and the ash trees in Maine?	Unfamiliar (1)	(2)	(3)	Somewhat familiar (4)	(5)	(6)	Very familiar (7)
The economic and cultural value of ash to Wabanaki Tribal Nations in Maine?	Unfamiliar (1)	(2)	(3)	Somewhat familiar (4)	(5)	(6)	Very familiar (7)

13) In Maine, which species of ash tree is traditionally used in the production of baskets?
White Ash _____ Brown/Black Ash _____ Green Ash _____ I am not sure _____

14) Are you aware of the connection of the ash trees to the creation story for Wabanaki Tribal Nations in Maine?
( ) Yes ( ) Somewhat ( ) No

Only those meeting conditional statements above would populate Question 15 to 17
15) Have you ever allowed a Tribal artisan to harvest black/brown ash from your property to produce baskets?
( ) Yes ( ) No

16) Would you ever consider the opportunity to allow a Tribal artisan to harvest brown ash on your property to produce baskets?
Extremely unlikely 1 2 3 4 5 6 7 Extremely likely

17) Knowing the cultural values of black/brown ash trees: are you likely to consider conservation practices that sustain ash on your property?
Extremely unlikely 1 2 3 4 5 6 7 Extremely likely

18) A conservation measure being taken in Maine is the collection and storage of ash tree seeds which can enable replanting efforts following EAB impacts. Would you ever consider allowing trained seed collectors to harvest ash seed on their woodlot?
Extremely unlikely 1 2 3 4 5 6 7 Extremely likely

D. In this section we are going to ask you about specific management strategies and practices related to EAB adaptation and re-establishment. You will only be asked further questions on those strategies that you would consider.

20) Participate in a monitoring program to assist efforts with detection of EAB (1 choice)
_____ I have done this.
_____ I plan to do this.
_____ I am interested in doing this.
_____ I might consider this.
_____ I have no interest in doing this.

21) Plan to harvest all or majority of merchantable ash trees ahead of EAB (1 choice)
_____ I have done this.
_____ I plan to do this.
_____ I am interested in doing this.
_____ I might consider this.
_____ I have no interest in doing this.

22) Identify sites to reserve ash trees with different size classes ahead of EAB in efforts to save resistant ash or restore ash (1 choice)
_____ I have done this.
_____ I plan to do this.
_____ I am interested in doing this.
_____ I might consider this.
_____ I have no interest in doing this.

23) Allow for the collection of ash seeds by seed collectors to support potential future replanting for ash (1 choice)

_____ I have done this.
_____ I plan to do this.
_____ I am interested in doing this.
_____ I might consider this.
_____ I have no interest in doing this.

24) Consider practices to protecting certain ash trees for scenic, economic, seed source values using chemical treatment (pesticides) (1 choice)

_____ I have done this.
_____ I plan to do this.
_____ I am interested in doing this.
_____ I might consider this.
_____ I have no interest in doing this.

25) Consider practices to cooperate with the state in efforts of introduction and monitoring of biological controls such as insects that kill EAB (1 choice)

_____ I have done this.
_____ I plan to do this.
_____ I am interested in doing this.
_____ I might consider this.
_____ I have no interest in doing this.

Only those meeting conditional statements above would populate Questions 26 to 31

26) You indicated that you have done, plan to do, are interested, or might consider doing the following strategy:
Participate in a monitoring program to assist efforts with detection of EAB
Please select why:

___ To maintain existing forest conditions
___ To restore to past forest conditions
___ To change forest conditions to allow other trees to replace ash
___ Other reason (not listed): _____
___ I don't know

27) You indicated that you have done, plan to do, are interested, or might consider doing the following strategy:
Plan to harvest all ash trees ahead of EAB
Please select why:

___ To maintain existing forest conditions
___ To restore to past forest conditions
___ To change forest conditions to allow other trees to replace ash
___ Other reason (not listed): _____
___ I don't know

28) You indicated that you have done, plan to do, are interested, or might consider doing the following strategy:
Identify sites to reserve ash trees with different size classes ahead of EAB in efforts to save resistant ash or restore ash
Please select why:

___ To maintain existing forest conditions
___ To restore to past forest conditions
___ To change forest conditions to allow other trees to replace ash
___ Other reason (not listed): _____
___ I don't know

29) You indicated that you have done, plan to do, are interested, or might consider doing the following strategy:
Allow collectors of ash seeds for the potential of replanting in the future ash trees
Please select why:

___ To maintain existing forest conditions
___ To restore to past forest conditions
___ To change forest conditions to allow other trees to replace ash
___ Other reason (not listed): _____
___ I don't know

30) You indicated that you have done, plan to do, are interested, or might consider doing the following strategy:
Consider practices to protecting certain ash trees for scenic, economic, seed source using chemical treatment (pesticides)
Please select why:

___ To maintain existing forest conditions
___ To restore to past forest conditions
___ To change forest conditions to allow other trees to replace ash
___ Other reason (not listed): _____
___ I don't know

31) You indicated that you have done, plan to do, are interested, or might consider doing the following strategy:
Consider practices to cooperate with the state in efforts of introduction and monitoring of biological control agents, such as wasps, that kill EAB
Please select why:

___ To maintain existing forest conditions
___ To restore to past forest conditions
___ To change forest conditions to allow other trees to replace ash
___ Other reason (not listed): _____
___ I don't know

32) How influential would the following social or economic factors be for you to participate in your ash management decisions in general?

	Extremely influential	Very influential	Somewhat influential	Slightly influential	Not at all influential
Fits with the long-term management goals of the land					
You think the practice is likely to succeed					
Other landowners have successfully implemented the practice					
Public perception of the practice					
Other landowner's perception of the practice					
The practice will serve as a demonstration					
Economic returns of the practice					
Cost of the practice					
Cost-share funding available for the practice					

E. In this last section, we would like to ask questions about your background, which will help us to compare your answers to those of other participants. All questions are optional, and all are confidential.

34) What county(ies) is/are your land in? (Select all that apply). (multiple choice)
( ) Androscoggin ( ) Aroostook
( ) Cumberland ( ) Franklin
( ) Hancock ( ) Kennebec
( ) Knox ( ) Lincoln
( ) Oxford ( ) Penobscot
( ) Piscataquis ( ) Sagadahoc
( ) Somerset ( ) Waldo
( ) Washington ( ) York

35) What state do you currently have residence in?
Drop down of all 50 states

36) What state(s) do you currently own land or property in?
All 50 states listed

37) Do you have a forest management plan for the land you own in Maine?
( ) Yes ( ) No ( ) I don't know/I am not sure

Only those meeting conditional statements above would populate Questions 38 and 39

38) Is your forest management plan associated with any of the following? Please check all that apply.
( ) WOODSwise Stewardship Plan
( ) General Tree Growth Plan
( ) American Tree Farm System
( ) NRCS Forest Stewardship Plan
( ) Private Internal Plan
( ) Forest certification program (SFI, FSC, etc.)
( ) Conservation easement
( ) No organizational affiliation
( ) Other, please list: _____

39) Is there specifically inclusion of ash species in your management plan(s)?
( ) Yes ( ) No ( ) I don't know/I am not sure

40) Where do you find your information on invasive forest pests? Please check all that apply.
_____ Maine Forest Service website
_____ Webinars and trainings
_____ Communication with other landowners
_____ USDA APHIS or US Forest Service websites
_____ Scientific publications
_____ State or federal reports and other publications
_____ University Cooperative Extension Offices
_____ Other, please list: _____

41) In what year were you born?
Drop down menu

42) What is the highest level of education you have completed? (1 choice)

_____ Less than high school degree
_____ High school graduate (high school diploma or equivalent including GED)
_____ Some college but no degree
_____ Trade school diploma
_____ Associate degree in college (2-year)
_____ Bachelor's degree in college (4-year)
_____ Master's degree
_____ Doctoral degree
_____ Professional degree (PhD, MD, etc.)

43) Choose one or more races that you consider yourself to be: (multiple choice)

_____ American Indian or Alaska Native
_____ Asian
_____ Black or African American
_____ Native Hawaiian or Pacific Islander
_____ White
_____ Other: _____
_____ Prefer not to answer

44) Which sector or profession **most** aligns with the work you do?

____ Municipality
____ State government
____ Federal agency
____ Conservation organization
____ Agriculture/Farming
____ Private consulting
____ Forest products industry
____ Forester or logger
____ University/Research
____ Business owner
____ Non-profit organization
____ Other: _____

45) What is your gender identity? (1 choice)

_____ Male
_____ Female
_____ Non-binary
_____ Prefer not to say/identify
_____ Other:

46) How did you hear about this survey?

___ Forester that you work with
___ Logger that you work with
___ Email from Forest Stewards Guild
___ Email from the New England Society of American Foresters
___ Email from the Maine Woodland Owners
___ Email from the New England Chapters for the Association of Consulting Foresters
___ Email from the Maine Forest Products Council
___ A Maine Forest Service listserv
___ The Maine Stewardship Foresters email list
___ Social media from municipal government
___ Notified by fellow landowner or neighbor
___ Other: _____

Only those meeting conditional statements above would populate Question 47

47) As you selected your sector or profession as forester or logger, we invite you to take part in our accompanying survey focused on perspectives from foresters and loggers.
Link: https://umaine.qualtrics.com/jfe/form/SV_3mJ9HJ4hYLGZ0jA

Thank you for taking the time to share your perspectives with us. We are looking for additional landowners to take the survey up until March 4, 2022.

Please consider sharing the original email invitation you received or this [https://umaine.qualtrics.com/jfe/form/SV_3wpusDg8P2y15e6] with two or more of your fellow landowners and neighbors, especially those who may have ash trees on their property.

If you think you have detected EAB, please report to the Maine Department of Agriculture, Conservation and Forestry by CLICKING HERE.

Thank you!

APPENDIX 2: Ash Collection Kit and Identification Information

Ash Seed Collection Kit: Recommended Checklist

This checklist was developed for a small group of two to four people to work together on the two stages of seed collection: scouting a forest stand for ash and collecting the seed. The quantities suggested for this checklist reflect what can fit in about one large plastic tub, other than the pruning poles, to be taken to the field for scouting trees and collecting seed. Cost and quantity of items will vary depending on the number of people collecting, the quantity of seed collected, and quality of certain items. For items that are more expensive, like the GPS units, we have provided a suggestion of the model, but that is not required. Particular information regarding certain items are explained here below. Please note that items or companies referred to on this list are not endorsed by the University of Maine School of Forest Resources or APCAW.

GPS unit: For a Global Positioning Systems unit we recommend a Garmin eTrex 10. This is an easy-to-use GPS unit that is great for all range of users, particularly beginners. While a GPS unit is not required, it provides the best data for seed collectors to return to ash tree locations for collection and for researchers to spatially analyze the data of ash tree location. In 2021, these cost about $110.

Binoculars: The Nikon Trailblazer 8×25 ATB binoculars are lightweight and small for easy packing and use. When these were selected, they came with a case and cleaning kit for about $90. Binoculars are important to be able to identify the sex of an ash tree from the ground in springtime, as well as to see seed throughout the summer and fall. Decent binoculars are essential for seed scouting and collecting.

Flagging tape, aluminum tags, roofing nails, and hammer/mallet/hatchet: All of these items can be purchased online from a forestry supplier or hardware store. It is important to know what colors of flagging tape are already being used in the forest, as they can mean different things to different people. If you have access to scouting and collecting on land that you do not own, it is best to find out what color flagging may already be used in the forest and discuss what color you plan to use before going into the woods. It is important to choose a color that you and your collecting team can see well. We suggest putting a piece of this flagging tape on equipment you bring in the woods, as the bright color can help you find dropped or misplaced items. Aluminum tags should be large enough to mark them if needed and the

roofing nails that can be pounded through to secure to a tree. A hammer, mallet or hatchet can be used to place these.

State gazetteer or paper map: The Maine Atlas and Gazetteer, originally produced by DeLorme, now Garmin and published by Rand McNally, are about $25. These are used widely by locals and travelers alike and provide excellent maps for both driving and topographic backcountry uses for those scouting ash on unknown forests. It is very important to have paper maps when in the forest, as Maine is very rural and service for cell phones is not guaranteed.

Safety vests: These do not need to be expensive and can be purchased relatively cheap. Forestry safety vests are specialized to have pockets on the front and back and can be used to bring items into the forest without needing a backpack but can be upwards of $80 each. Regardless of price, it is important to have bright safety gear all times of the year, especially in the fall when it could be close to hunting season. Always wear bright colors for safety, as you can be seen by the rest of your team or safety personnel if there was an emergency or you got lost.

Backpack: If you do not have a safety vest with pockets, a backpack may be important to carry smaller items, like flagging tape, clipboards, pens, and pencils. This does not need to be expensive or kept specifically with your seed collecting kit. It is your preference to how you want to carry your materials into the forest and keep yourself organized.

Pruning pole (head, adapter, extensions): These items were recommended to us by experienced seed collectors and are at the high end of quality and were purchased by our team from a forestry supplier store. The pruning head was a Jameson PH-11 Tree Trimmer Head, which was about $51. The adapter, which fits the pruning head to the extension pole, is specific to the Jameson PH-11 and costs about $17. The extension poles were 6-foot Jameson JE Series Foam Core Dielectric Fiberglass, and it is recommended to purchase at least three poles. Each pole cost about $80, making the cost for poles $240, and the total cost for pruning pole equipment around $308. It is important to mention that these poles are recommended for their quality and for the safety of the user. If you are a private landowner, you may already own your own pruning equipment, and therefore, not need to purchase this for your kit. Due to the height of mature ash tree branches which produce seed, it is recommended to have a pruning pole that can safely and securely reach and remove these branches. Pruning poles with all their extensions are heavy and require strength of the user to safely operate. The specific items are recommended for their

ruggedness and use by experienced seed collectors; however, their brand is not required for seed collecting. A note on the Jameson JE Series Foam Core Dielectric Fiberglass: dielectric fiberglass was prioritized because it is non-conductive to electrical force. This type of pole will act as an insulator protecting the user of the pole if for some reason it came in contact with power lines. This could occur because some brown ash trees are roadside and located adjacent to electrical power lines.

Tarp: There is not a specific brand of tarp recommended. The tarp should be large enough to place under a tree while collecting seed to provide a falling branch a place to land and prevent seed from spreading on the ground. This is important for late season collection when seed clusters dry out and fall from the branches far easier than earlier in the season. A tarp may be able to collect more seed as branches are being taken down, and less seed could get lost on the ground. This makes it easier to pick up seed on a tarp, rather than the forest floor.

Safety glasses: There is not a specific brand or type of safety glasses recommended, but it is stressed that everyone in the seed collection group has eye protection. Falling tree branches and seed can be dangerous and eye protection is a must.

Rope: We recommend at least 200 feet of 650 lb. paracord/parachute cord, which can be purchased by the spool. At the time this list was put together, a spool cost about $20 online. A bright color is recommended to be able to see easily in the forest. This will be used with the pruning pole.

Hardhats: Hardhats are personal protective equipment that is specific to each person, and were not purchased for the seed collection kits given to the Wabanaki tribes by our research team at the creation of this list. Therefore, we do not have a recommendation for hardhats, but we do strongly recommend the use of hardhats and head protection when harvesting ash seed to protect the collectors.

Loppers/branch cutters: This is an item that homeowners may already have. The Corona lopper that we have chosen is 29 inches long to be able to reach smaller branches closer to the ground, but also to clear brush around the base of a tree. Clearing the base of the tree from brush will make it easier to place the tarp.

Collection Stage	Item	Quantity and notes	Cost (approximate)
SCOUTING TREES	GPS unit	1 GPS and batteries / Garmin eTrex 10	*$110 each*
	Pens/pencils	5	*Less than $0.50 a pen or pencil, depending on how large of a box purchased*
	Clipboard	2	*Less than $2 a clipboard if purchased in bulk*
	Binoculars	1 / Nikon Trailblazer 8x25 ATB	*$90 each*
	Flagging tape	3 rolls	*Less than $3 per roll when purchased in bulk*
	Aluminum tags (for trees)	30+	*100 tags can be found for around $25*
	Roofing nails (and container for nails)	1 box	*100 pack of 1 inch roofing nails can be found for around $4. Box to store can be found for under $5 at a dollar store.*
	Hammer/mallet/ hatchet	1	*Forestry Suppliers has hatchets for $52*
	State gazetteer or map of area	1 / Maine Atlas and Gazetteer	*$25 each*
	Safety vests	As many as in the group	*Up to $80 each for forestry safety vests*
	Backpack	1	*Less than $20*
	Maine Forest Service: “Forest Trees of Maine”	1	*$15 from Maine Dept. of Ag., Conservation and Forestry*
COLLECTING SEED	Tarp	1 (10ft x 12ft)	*Less than $15*
	Pruning pole head trimmer	1 / Jameson PH-11 Tree Trimmer Head	*$51 each*
	Pruning pole adapter	1 / specific to the Jameson PH-11 head trimmer	*$17 each*

	Pruning pole extensions	3 / 6’ Jameson JE Series Foam Core Dielectric Fiberglass	*$80 each x 3 = $240 total*
	Safety glasses	1 for each member of the group	*Less than $2 each when purchased in bulk*
	Paper lunch or grocery bags	50 small bags, 20 large bags	*Less than $10 for 100 small (4lb) bags. Less than $13 for 25 large (57lb) large bags.*
	Stapler and staples	1 stapler, 1 box of staples	*Less than $10 for a stapler with staples. Box of 5,000 staples is less than $5.*
	Rope	200’ of 650 lb. para-cord/parachute cord	*$20 a spool*
	Hardhat	It is recommended that those using pruning poles protect their heads while cutting branches.	*Less than $35 on ForestrySuppliers.com*
	Loppers/handheld branch cutters	1 / Corona loppers 29”	*$35 each*

APPENDIX 3: Ash Identification Table

ASHES *The Important Distinctions*

	**White Ash** *Fraxinus americana*	**Green Ash*** *Fraxinus pennsylvanica*	**Black Ash** *Fraxinus nigra*
LEAVES			
LEAFLETS	5–9, usually 7	7–9	7–11
DESCRIPTION	Leaflets are mostly entire, borne on stalks, without hairs below. Turn purple in autumn	Leaflets borne on stalks. Hairy below and on rachis. Turn yellow or bronze in autumn.	Toothed leaflets which are without stalks except the one at the end. Hairs lacking below except for buff-colored hairs at the junction of the leaflets and the rachis. Turn yellow in autumn.
BUDS			
SIZE	⅛ inch	⅛ inch	Less than ¼ inch
SHAPE	Blunt-pointed	Cone-shaped	Sharply-pointed
COLOR	Brown	Brown with rusty or dull red hairs	Black or very dark
FRUIT			
WINGS	Wing terminal	Seed body grading gradually into wing	Flat, completely surrounds seed body
SEED BODY	Cigar-shaped	Funnel-shaped	Slightly twisted, less than half the length of the fruit
TWIGS			
TEXTURE	Smooth and shiny, often with slight bloom, very brittle	Somewhat covered with downy hairs	Smooth, not shiny
COLOR	Gray or greenish-brown, inner bark bright brick red	Greenish-gray, inner bark cinnamon-colored	Pale gray, inner bark dirty white

*Specimens of green ash which lack hairs on the twigs or leaflets, but otherwise fit the above description, were formally designated as var. lanceolata. They are now designated under the species due to the many gradations of the hairiness character.

APPENDIX 4: National Seed Laboratory Data Sheet

Ash Seed Collection Data Sheet

Date of collection: _____

Collector's name: _____

Species (check one): __ Black ___ Blue

__ Green ___ Pumpkin ___ White

Seed Lot Identification

Collector's ID number _____

Seed lot number _____

State _____ County_____

GPS Coordinates (Decimal degrees) : lat ____._____ long ____._____ elevation _____meters

Directions to the site if not using GPS: _____

_____

Number of ash trees within 20 to 40 feet of this tree: ___ 0, ___ 1, ___ 2 to 4, __ 5 or more

Number of other trees that are not ash within 100 feet this tree: ___ 0, __ 1, __ 2, __ 4 or more

Distance between this tree and nearest other ash tree from which seeds were collected.

____ 100 feet (minimum), ___ 200 feet, ___ more than 200 feet

Emerald ash borer (EAB) present in surrounding area: Yes_____ No _____

Signs of EAB present on collection tree (check all that apply):

_____ epicormic sprouting _____ canopy thinning _____ blonding _____ 'D' shaped exit holes

Soil: ___ Rocky ___ Gravel ___ Sand ___ Loam ___ Clay

Site type: ___ upland __ wetland __aquatic.

Complete only for upland sites Topography: ___ Flat ___ Slope (Aspect: ___ N ___ S ___ E ___ W

_____

Twig sample has been put in bag ___ Trunk and whole tree photos have been taken _____

APPENDIX 5: National Plant Germplasm Facility Data Sheet

DATA COLLECTION FORM

Site # _____ Date Harvested (DD/MM/YY)_____

Genus_____ Species _____

Location Name _____

Directions_____

Lat/Long source: ☐GPS ☐Map Map Datum: _____

Plant Description _____

_____

_____

_____

Collector(s) Contact Information:

Name(s)_____Institution_____

Distance to planted/cultivated ash trees (miles): _____

No. plants found _____ No. plants sampled _____ Site size (m^2) _____

Herbarium specimen: ☐ yes ☐ no Herbarium Specimen # :_____

Pop. abundance: ☐ abundant ☐ frequent ☐ occasional ☐ rare

SITE DESCRIPTION:
Exposure _____ Slope _____ Aspect _____

Site Physical _____

_____

Site Vegetative _____

_____

_____

Soil Type _____

GPS COORDINATES FOR SAMPLES:
Tree: _____Lat: _____ N S Long: _____ E W
Tree: _____Lat: _____ N S Long: _____ E W
Tree: _____Lat: _____ N S Long: _____ E W
Tree: _____Lat: _____ N S Long: _____ E W
Tree: _____Lat: _____ N S Long: _____ E W
Tree: _____Lat: _____ N S Long: _____ E W
Tree: _____Lat: _____ N S Long: _____ E W
Tree: _____Lat: _____ N S Long: _____ E W
Tree: _____Lat: _____ N S Long: _____ E W
Tree: _____Lat: _____ N S Long: _____ E W
Tree: _____Lat: _____ N S Long: _____ E W

APPENDIX 6: National Plant Germplasm Facility Data Sheet – Definitions

Site #: Typically, a three digit number assigned by the collector to represent a single locality (e.g. state park, watershed, natural area, or any other type of defined area, etc.) or population.

Date Harvested: Date when the sample was harvested

Location Name: Name for the location or population being sampled (e.g., state park, watershed, natural area, or any other type of defined area, etc.)

Directions: General description on how to find the location/population. Typically provided as a legal description or approximate distance from a specific landmark (e.g., city, lake, etc.)

Lat/Long source: Indicates how GPS coordinates were obtained (map or GPS unit)

Map Datum: Indicated type of datum used with GPS unit, typically recorded as NAD83

Plant Description: Brief description of the plan that was harvested, typically includes approximate size of specimen, may also include additional interesting comments referring to growth habit, fall color, phenology, etc.

Exposure: full sub/shade

Slope: Slope or gradient of the sampled habitat

Aspect: Direction in which the slope faces of the sampled habitat (e.g., north, east, south, west)

Site Physical: Description of the immediate surrounding (e.g., habitat type(s))

Site Vegetation: Listing of associated plant species growing in the immediate surroundings

Soil Type: Description of the soil type for the immediate surrounding

Tree#: Typically, a three-digit number assigned by the collector to represent a single mother tree sample

Lat. And Long: GPS coordinates marking the location of the sample harvested

APPENDIX 7: Ash Seed Shipment Supplemental Materials

7.1 Instructions for sending seeds to the Black Box

USDA U.S. DEPARTMENT OF AGRICULTURE

NATIONAL LABORATORY FOR GENETIC RESOURCES PRESERVATION

Instructions for Sending Seeds to NLGRP for Black Box Storage

Before sending a shipment, please ensure:

1. A Material Transfer Agreement (MTA) is in place. The final fully executed copy will come from the Technology Transfer Assistant at USDA and will have a Black Box MTA # (located at the bottom of the document) and all signatures.

2. The Black Box Deposit template (MTA Appendix 1) has been filled out according to the instructions, and the file has been sent to NLGRP-Blackbox@usda.gov prior to shipment.

3. If you have already sent us your first shipment under the current MTA, you have included a Letter of Transmittal.

International Depositors: Before shipping, please email NLGRP-Blackbox@usda.gov for import instructions. NLGRP will provide depositor with an appropriate permit/shipping label (if applicable). The NLGRP Import Instruction Letter provides the current instructions needed to import material in accordance with USDA, Animal and Plant Health Inspection Service (APHIS) regulations. Because regulations change, please request an Import Instruction Letter each time you send us a deposit. Please follow all instructions carefully. **Material may be destroyed or returned if conditions and regulations are not met.**

Domestic Depositors: Any required state and/or federal permits must be in place prior to shipment.

Packaging & Shipping Instructions

- Please ensure seed is dried and package in moisture proof packaging such as heat-sealed foil laminate pouches. If seed drying is not possible, please contact NLGRP-Blackbox@usda.gov to discuss having NLGRP equilibrate and package seed for storage.

- Label each packet with depositor organization, depositor inventory identifier and genus species.

- Our seed storage racks have an opening of 86 cm wide x 75 cm deep x 55 cm high. Please send your seed in boxes sized to be stacked in this space. Our recommended box size is 42.5 cm wide x 37.5 cm deep x 15.25 cm high.

- If multiple boxes are shipped, each must have a packing list of the box contents (this can be a print out of the Black Box deposit spreadsheet (MTA Appendix 1 inventory), by box). Numerically label each box (1 of 5, 2 of 5, etc). Please be sure the corresponding box number appears in the spreadsheet.

- Ship seed via expedited service. Email NLGRP-Blackbox@usda.gov with shipping date and tracking information.

NLGRP Shipping Address (for domestic shipments only. International shipments refer to Import Instruction Letter):
USDA, ARS, NLGRP
Attn: Black Box Storage
1111 South Mason Street
Fort Collins, CO 80521

Current as of 11/10/2022

7.2 Material Transfer Agreement for Black Box submission

U.S. Department of Agriculture
Agricultural Research Service

BLACK BOX GERMPLASM STORAGE DEPOSIT AGREEMENT

PARTIES:

ARS: USDA, ARS, Plains Area
National Laboratory for Genetic Resource Preservation (NLGRP)
1111 S Mason St.
Fort Collins, CO 80521

ARS Scientist:
Tel:
E-mail:

Depositor: Organization:

Address:

City: State: Zip:

Depositor Scientist:

Tel:

FAX:

E-mail:

PREAMBLE:

The U.S. Department of Agriculture, Agricultural Research Service, established the National Plant Germplasm System (NPGS). The mission of the NPGS is to support agricultural production by: (1) acquiring crop germplasm; (2) conserving crop germplasm; (3) evaluating and characterizing crop germplasm; (4) documenting crop germplasm; and (5) distributing crop germplasm. The National Laboratory for Genetic Resource Preservation (NLGRP), with extensive capacity and infrastructure, provides security back-up storage of seeds for other governmental agencies, botanical gardens, national genebanks in other countries, international genebanks, NGOs and Native American tribes. Free, back-up storage at NLGRP protects genetic resource collections from irreplaceable loss and ensures long-term benefits of genetic resources.

PURPOSE:

To provide "Black Box storage" (defined jointly by CONDITIONS 1 through 19) at ARS NLGRP for packets of seed sent by Depositor (defined as 'Material')

Brief Description of Material(s):

PROCESS:

For newly deposited Material, Depositor shall:

1. Provide a seed packet inventory spreadsheet identifying the material being deposited (Appendix 1) and include a paper copy of the seed packet Inventory in each shipment. This paper copy included in each shipment shall also cross-reference the contents of each individual box/seed packet in the shipment with each individual item listed in the electronic version of the seed packet Inventory;

2. E-mail a complete Seed Packet Inventory covering the contents of each shipment to ARS in xls format to NLGRP-Blackbox@usda.gov before shipment;

3. Ship Material to the ARS NLGRP in mutually agreed on packaging to the ARS address listed in the Deposit Instructions (Appendix 1); and

4. Pay all costs associated with shipping the Material.

Depositor may:

1. Deposit additional Material with ARS over the term of the Agreement. Additional Material shall be shipped as detailed above with a Letter of Transmittal that shall refer to this Agreement and bind Depositor and ARS to the terms of this Agreement for the additional Material shipped to ARS. (See Appendix 1 – Black Box Deposit Instructions, Template for Letter of Transmittal)

CONDITIONS:

The Material is deposited with ARS under the following conditions:

1. The Material shall only be used for "Black Box" storage and shall not be part of the NPGS collection.

2. ARS shall not use the Material for any other purpose including but not limited to research, breeding, training, propagation, characterization, viability testing and regeneration.

3. ARS shall not transfer the Material, in whole or in part, to a third party. Any third party requesting a sample shall be referred to Depositor.

4. The Material is available from the Depositor in a manner that facilitates access for research, conservation and sustainable use in compliance with national laws and applicable international treaties.

5. Rights of the Depositor over the Material are not changed by this Agreement.

6. ARS will provide optimal storage conditions. ARS will be responsible for all storage costs pertaining to the Material.

7. ARS shall not be liable for any damage caused to the Material by any reason. In the event of loss or destruction of Material at NLGRP, NLGRP will inform Depositor in writing of the loss and the reasons therefore.

8. ARS will return Material to Depositor at Depositor's written request. Any written notice given under this Article shall identify the specific seed lots of Material that are to be withdrawn. ARS will return the requested

seed lots of Material within a period of one (1) year from the date of receipt of such written notice. The costs of packaging and shipping in respect of the return of the seed lots of Material shall be borne by the Depositor. ARS will continue to exercise all care and diligence over the seed lots from the time notice is received until actual shipment of the seed lots of Material.

9. Depositor shall not in any way state or imply that this Agreement or the results of this Agreement is an endorsement by ARS of its organizational units, employees, products, or services; except to the extent permission is specifically granted by an authorized representative of ARS.

10. ARS shall not in any way state or imply that this Agreement or the results of this Agreement is an endorsement by Depositor of its organizational units, employees, products, or services; except to the extent permission is specifically granted by an authorized representative of Depositor.

11. The Parties acknowledge and agree to comply with all applicable laws and regulations of the Animal Plant Health and Inspection Service, the Center for Disease Control, and/or Export Control Administration pertaining to possession or transference of technical information, biological materials, pathogens, toxins, genetic elements, genetically engineered microorganisms, vaccines, and the like.

12. The provisions of this Agreement are to be deemed severable and the invalidity, illegality or unenforceability of one or more of such provisions shall not affect the validity, legality or enforceability of the remaining provisions.

13. ARS will treat all information generated or gathered under this agreement in accordance with the Freedom of Information Act.

14. This Agreement may be executed in any number of counterparts, each of which when so executed shall be deemed to be an original and all of which taken together shall constitute one and the same agreement. Signature by facsimile shall also bind each of the parties to this Agreement.

15. ARS is an agency of the U.S. Government and any rights or obligations created under this Agreement are freely transferable within the U.S. Government and shall not be deemed a "transfer."

16. This Deposit Agreement shall be construed in accordance with United States of America Federal Law as interpreted by the Federal Courts in the District of Columbia.

17. Before the expiration of this Agreement, Depositor and ARS will determine if the agreement will be renewed. If not renewed, ARS will return the Material to the Depositor.

18. Either party may unilaterally terminate this entire Agreement at any time by giving the other party written notice not less than sixty (60) calendar days prior to the desired termination date.

19. This Agreement constitutes the entire agreement between Depositor and ARS and supersedes all prior agreements and understandings between them with respect to its subject matter.

This Agreement shall become effective upon date of final signature and shall continue in effect for a period of ten (10) years.

Appendix 1

Instructions for depositing black box collections, a spreadsheet template for collection inventory and a template for the letter of transmittal (needed for shipments after the initial deposit), can be found at this website:

https://www.ars.usda.gov/plains-area/fort-collins-co/center-for-agricultural-resources-research/paagrpru/docs/plants/pages/deposit-germplasm/

For further information, please contact: NLGRP-Blackbox@usda.gov

ACCEPTED FOR THE AGRICULTURAL RESEARCH SERVICE

______________________________________ _______________
Signature (Scientific Technology Transfer Coordinator) Date

ACCEPTED FOR THE COOPERATOR:

_______________________________ __________________
Signature Date

____
Typed Name

* *

By signing below, the ARS Scientist and ARS Research Leader acknowledge that they have read, understood, and agreed to the terms and conditions of this Agreement.

_______________________________ _________________
Signature (ARS Scientist) Date

____
Typed Name

____
Signature (ARS Research Leader) Date

____
Typed Name

ARIS # ______________________
Storage Agreement: version 11/10/2022

7.3 Letter of Transmittal for Black Box Storage

Letter of Transmittal
NLGRP Blackbox Storage

Instructions:

- Depositors can send material to NLGRP for the duration of the MTA. However, after the first shipment under a given MTA, a letter of transmittal must accompany subsequent shipments.

- For subsequent shipments, cut and paste the text below onto letterhead and sign letter. Email letter along with Appendix 1 spreadsheet to NLGRP-Blackbox@usda.gov before shipping seed.

[Institute Name]
[Shipping date]

Under the USDA-ARS MTA Blackbox Storage # _____, Depositor is sending ARS additional germplasm for black box storage. Attached is an additional Appendix 1 – Seed Pack Inventory that shall be added to the Germplasm Storage Deposit Agreement as acknowledged by ARS.

- MTA # can be found on the last page of the executed agreement.

- Contact NLGRP-Blackbox@usda.gov if you have any questions.

7.4 NLGRP Blackbox Deposit Template – Instructions

	A
1	**NLGRP Blackbox Germplasm Storage - Appendix 1: Instructions**
2	
3	**Institution***: Complete institution name
4	**Date of Shipment***: Please fill in date of shipment.
5	**Number of Boxes***: Total number of boxes in shipment.
6	
7	
8	
9	**Taxon***: Genus species (Do not include species authority)
10	**Inventory Identifier***: Institute inventory identifier for the seed sample being sent to NLGRP
11	**Name/Cultivar***: Name/cultivar associated with the inventory sample
12	**Accession Identifier**: Institute accession identifer
13	**Geography of Seed Origin**: Fill out country of seed origin if known.
14	**Quantity***: Number of seed in each packet or wt in grams
15	**Quantity Units***: Count, Gram
16	**Harvest Year**: Year of seed harvest if known.
17	**Percent % Viable:** Percent of seed viability.
18	**Test Date**: Date viability tested.
19	**Box Number***: Indicate the box number the sample has been packed in. All boxes should be numerically labeled on the outside (x of x total boxes).
20	
21	
22	*** Indicates field is required**

7.5 NLGRP Blackbox Deposit Template

	A	B	C	D	E	F	G	H	I	J	K
1	Blackbox Germplasm Storage -		Current as of: 1/2022								
2	Institution:										
3	Date of Shipment:										
4	Number of Boxes:										
5											
6	*Instructions: Fill out form below. Please send this spreadsheet to NLGRP-blackbox@usda.gov before shipping. Print out this inventory and include as packing list in each box*										
7	**Taxon**	**Inventory Identifier**	**Name/Cultivar**	**Accession Identifier**	**Geography of Seed Origin**	**Quantity**	**Quantity Units**	**Harvest Year**	**% Viable**	**Test Date**	**Box Number**
8											
9											
10											
11											
12											
13											
14											
15											
16											

APPENDIX 8: Recommendations for the collections, storage, and germination of ash (*Fraxinus spp.*) seed

RECOMMENDATIONS FOR THE COLLECTION, STORAGE, AND GERMINATION OF ASH (*FRAXINUS SPP.*) SEED

Dave Ellis
Plant Genetic Resources Preservation Program
National Center for Genetic Resources Preservation
1111 South Mason Street
Fort Collins, CO 80526
telephone - 970 495 3227
fax - 970 221 1427
elvis@ars.usda.gov

Seed that is harvested when mature and processed immediately has the greatest life span during storage. Seeds infested with fungus or insects do not survive very long and may potentially infect other seeds. The recommendations below will help to acquire the highest quality seed for long term storage.

Identifying trees for collection

1) There are several species of interest: *F. americana* (white ash), *F. nigra* (black ash) and *F. pennsylvanica* (green ash) are among the ash native to the Lake States.
2) It is always a good to collect leaf samples along with seed samples so that identity can be confirmed.
3) Collect seed when it is mature. Seed maturation dates differ among ash species: Sept-Oct is generally a good time to collect black and white ash, while green ash can be collected into December. Also note that ash trees may only produce large seed crops once every 3 to 5 years.
4) Seeds are contained within fruiting bodies called *samaras*, with the seeds are at the thicker base end of the samara.
5) Collect seeds when the samaras are faded from green to yellow or brown. Seeds within samaras should be firm, crisp, white and fully elongated. Avoid collecting samaras that have signs of mold or insect infestation.
6) Record date, location (lat/long data from topo map and relevant landmarks and/or GPS coordinates) for sampled tree in field notes. Use one bag for each tree
7) Collect seeds on a non-rainy day

Collecting seeds (samaras)

1) Ash trees can be very tall. Make sure proper safety protocols are used.
2) You may want to spread sheets under the tree to collect seed that falls.
3) Clusters of samaras from low lying branches can be clipped with pruning sheers. Rope, pole pruners, shotgun or bow and arrow can be used to dislodge samaras from higher branches.
4) Pick seeds (samaras) off tree as late in the year as possible to ensure collection of mature seed. Avoid picking seed up off the ground. The trick may be to pick as late as possible but once mature, the longer you wait, the more prone the seed is to weathering, insects or fungal contamination. It is more efficient to harvest the seeds as clusters rather than picking individual seeds..
5) If leaves are available on the tree, prepare a pressed dry herbarium sample for positive identification of the species at a later date. See websites for proper preparation of herbarium samples.
6) Samaras should be a natural brown and no longer green (if seed is pale green it is ok where you cannot get back to the site in a week or two).
7) Visually inspect seed prior to collecting. When possible **do not collect seed which**:
   A) is black or dark green.
   B) has evidence of insect damage. This would appear as tiny entrance or exit holes in the seed.
   C) is non-uniform – avoid distorted, twisted seed.
   D) does not have a solid base which is thicker than the wing.
   E) is mildewed or has evidence of fungal infection (spotted/mottled-looking seed).
   F) is on the ground.
8) Once seed is picked off the tree, place the seed in a paper lunch bag and label the collection information (see number 10 below). A paper bag open at the top will provide necessary air flow to naturally dry seeds. Do not place in plastic bag or other container which does not allow air flow.
9) One paper lunch bag full of seed (4-6 cups of seed) is plenty from any one tree.
10) Use a separate bag for each batch of seed (usually seed from a single tree/bag).
11) Collection notes are usually kept in a field book with collection numbers written on the bag containing the seed. However, since multiple people will be collecting seed over many years and storage will be long-term, we recommend labeling the bag (and any pressed leaves) so that the location and identification of the source is clearly marked. The portion of the paper bag containing the label can remain with the sample in storage for positive identification of the collection decades from now. The labeling should include:
   A) The species – place question marks around the species when identification is not certain (*Fraxinus ?pennsylvanica?*).
   B) A description of where the seed was collected. Examples include:
      i) Just inside gate to Bear Park - left side of the road in Lightfoot County, MI.

ii) Right side of Elk Creek Rd, ~2.7 miles N. from the traffic light in Red Deer, WI.

iii) Moline National Park, Brookside campgroup, behind campsite #7, OH.

C) GPS/GIS coordinates and elevation when possible.

D) Description of tree:

i) Shrub or tree.

ii) Healthy or sick looking.

iii) Any Emerald Ash Borer (EAB) evidence ("D"-shaped exit holes, dead branches, lesions in bark).

iv) Evidence of other borers or insect damage.

v) Approximate height of tree.

E) Date of collection.

F) Name and contact information of person(s) collecting the seed.

12) Once collected, keep seed out of direct sunlight but in an area that allows airflow (i.e. not in a sealed cooler). Do not leave in hot car or box in the back of a pick-up truck or car in the sun.

13) Leave seeds (samaras) in paper bags open at the top for about 3 days in a dark, cool, dry location. After 3 days, clean the seed. Break apart the seed clusters so that seed is individualized and remove any branches and debris.

14) Dry samaras by spreading them thinly in a single layer on newspaper in a shallow tray. Use one tray/seed collection to avoid any chance of mixing two different seed collections.

15) Place the trays with the seed in a dark, cool, dry location. If the weather is humid, place trays in a dehumidified room with lots of airflow. They will dry out within about a week or two.

16) When samaras are dry, seeds can be cleaned. Seeds can be isolated from dried samaras by rubbing them through your palms. Remove samara fragments by shaking sample through screens. Spread cleaned seed out on tray and inspect for insect or microbial damage

17) Place the seed in an air-tight moisture-proof container containing with the collection information written on the outside of the container and the original labeling information from the collection bag inserted into the container with the seed. The portion of the collection bag with the information can be cut and inserted in with the seed.

A) Air-tight moisture-proof containers include:

i) A kitchen "seal-a-meal" self-sealing bags.

ii) A screw-top bottle or jar.

iii) A plastic zip-lock bag (least preferred as they often do not seal tight).

B) To label the outside of the container use a permanent marker – Sharpie's work great.

18) To test moisture content of the seed, place the seeds in a screw cap container containing a small package of *indicating silica gel*. If silica gel turns pink within a few hours, seeds should be removed and dried in a drier environment. If silica gel turns pink in 1-3 days, replace it with freshly activated silica gel. If silica gel remains blue for a week in the screw cap jar, the seeds are sufficiently dry for storage. Many silica gels can be reactivated by

putting it in the oven at about 250F overnight – the granules should turn from pink (moist) back to blue (dry).

19) Place the air-tight container containing the seed in a cardboard box in a freezer. Locate the freezer where someone looks at it at least weekly (preferably daily). This way any problem with the freezer will be noticed immediately. May freezers can also be equipped with an audible alarm to notify you if it is not keeping things cold.

Testing ash seed (samara) viability

When possible it is always preferable to know how good the seed is that you are storing. There are two primary reasons for this. 1) You want to ensure you are storing good, live seed and 2) you will to know if the seed deteriorates during storage to enable you to pull the seed out of storage and germinate it prior to complete loss of viability. Below we mention two methods. The first requires specialized laboratory equipment that can be found in most high school biology classes. The second method relies on germination of the seed. We recommend testing a minimum of 100 seed. In collections where few seed are available, testing 5-10 seed will suffice.

There are other methods for testing seed viability that are available and used in seed testing laboratories, yet these generally require advanced laboratory facilities. These methods include terazolium staining of the embryos and x-raying the seed. For *Fraxinus*, both methods are used, with x-raying of the seed the quicker and easier method for facilities with the equipment.

1) Physical examination of the seed. Fresh or dried seed can be examined with a microscope or magnifying glass.
   A) The narrow, pointed end of the seed is where the embryo is.
   B) Carefully cut this end open by slicing length-wise and observe the embryo
      i) The embryo should be white, solid and fill the entire seed cavity. Is the seed "fresh and filled"? If the embryo looks wilted or off color, this is not a favorable sign.
      ii) You can also observe the presence of seed insects – these are usually gray with segmented bodies and a brown head.
      iii) Basically anything other than an embryo in the seed cavity is an indication of poor seed.
2) Germination tests. This is done in 2 phases: Phase1 - stratify to break dormancy; and Phase 2 actually germinate the seed. Stratification can be done in a common refrigerator (about 45°F) for 2 to 3 months, while germination can be done in a greenhouse or cold frame.
   A) Place 100 seed in a thin layer of moist sand or moist paper towels and let this sit for 60-90 days in a refrigerator.
   B) After the cold stratification treatment, place the seed in an area with 68°F nights and 86°F days. If moist paper towels were used for the cold stratification, spread these towels out in a thin layer of sand prior to placing in a greenhouse or cold frame. Keep the seed moist during this time
   C) The number of seed germinated should be counted after 40 and 60 days. The percent of seed germinated should be recorded and kept with the seed sample.
   D) Germinated seed can be planted and grown in pots.

WEBSITES FOR INSTRUCTIONS FOR MAKING HERBARIUM SPECIMENS

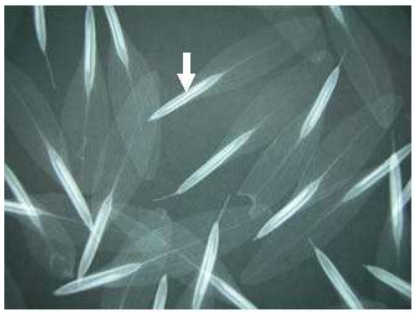
http://www.mobot.org/MOBOT/Research/Library/liesner/pressing.html
http://www.herbarium.unc.edu/chpt18.html
http://www.siu.edu/~ebl/prepare.htm
http://www.une.edu.au/botany/plant_collecting.htm
http://www.rmh.uwyo.edu/prelude/intro/rmcoll.htm
http://herbarium.usu.edu/K-12/Collecting/specimens.htm
http://www.uaf.edu/museum/herb/howtocoll.html
http://herbarium.ucdavis.edu/herbarium.html
http://www.montana.edu/wwwpb/pubs/mt8359.pdf
http://www.flmnh.ufl.edu/herbarium/voucher.htm
http://www.virtualherbarium.org/collecting.htm
http://www.herbarium.lsu.edu/makingherbspecimen.html
http://www.auburn.edu/academic/science_math/botany/herbarium/collecting.html
http://www.life.uiuc.edu/ib/335/CollectingPlants/CollectingPlants.html
http://www.montana.edu/wwwpb/pubs/mt8359.html
http://artemis.austincollege.edu/acad/bio/gdiggs/collecting.htm

The National Arboretum has offered to store herbarium voucher specimens for you. For more information or questions on herbarium specimens you should contact:

Kevin Conrad
Curator
Woody Landscape Plant Germplasm Repository
U.S. National Arboretum
ARS-USDA
10300 Baltimore Ave
Building 010A Room 233
Beltsville, MD 20705
Cell Phone 240 832 9415
ConradK@usna.ars.usda.gov

Ash seed clusters.

X-ray of filled ash seed
Note large white area which is the embryo.



X-ray of empty ash seed
Note light white area where embryo should be. Small under developed embryos are also noted (arrow).

X-ray of filled and insect damaged ash seed
Note segmented embryos (arrow) where insects have eaten.

Close-up of X-ray of insect damaged ash seed.

Evidence of insect damage to seed (arrow). Note also deformed seed (bottom).

Close up of insect entrance hole in seed.

Empty seed due to insects. Rip in seed is due to insect exiting.

Close up of grub found in ash seed.

Tetrazolium stained ash embryo. Red color indicates good (live) embryo.

Ash seed sliced longitudinally to examine the embryo. Middle embryo is good while top and bottom have insect damage.

APPENDIX 9: Online Access to Ash Collecting and Shipping Documents

Document	Publisher/Creator of Document	Online Location
Ash Identification Table	Maine Department of Agriculture, Conservation and Forestry	https://www.maine.gov/dacf/mfs /publications/handbooks_guides/ forest_trees/pdf/Ashes.pdf
National Seed Laboratory Data Sheet	USDA Forest Service, National Seed Laboratory	https://www.fs.usda.gov/nsl/ seed_collection_data_page.pdf
National Plant Germplasm Facility Data Sheet	USDA Agricultural Research Service, Plant Introduction Research	https://www.ars.usda.gov/midwest-area/ames/plant-introduction-research/home/npgs-ash-conservation-project/data-collection-form/
National Plant Germplasm Facility Data Sheet – Definitions	USDA Agricultural Research Service, Plant Introduction Research	https://www.ars.usda.gov/midwest-area/ames/plant-introduction-research/home/npgs-ash-conservation-project/data-collection-form/
Instructions for sending seeds to the Black Box	USDA Agricultural Research Service, Agricultural Genetic Resources Preservation Research	https://www.ars.usda.gov/plains-area/fort-collins-co/center-for-agricultural-resources-research/paagrpru/docs/plants/pages/deposit-germplasm/
Material Transfer Agreement for Black Box submission	USDA Agricultural Research Service, Agricultural Genetic Resources Preservation Research	https://www.ars.usda.gov/plains-area/fort-collins-co/center-for-agricultural-resources-research/paagrpru/docs/plants/pages/deposit-germplasm/
Letter of Transmittal for Black Box Storage	USDA Agricultural Research Service, Agricultural Genetic Resources Preservation Research	https://www.ars.usda.gov/plains-area/fort-collins-co/center-for-agricultural-resources-research/paagrpru/docs/plants/pages/deposit-germplasm/
NLGRP Blackbox Deposit Template – Instructions	USDA Agricultural Research Service, Agricultural Genetic Resources Preservation Research	https://www.ars.usda.gov/plains-area/fort-collins-co/center-for-agricultural-resources-research/paagrpru/docs/plants/pages/deposit-germplasm/
Recommendations for the collections, storage, and germination of ash (*Fraxinus spp.*) seed	USDA Plant Genetic Resources Preservation Program	http://www.emeraldashborer.info/ documents/Fraxinuscollection.pdf

APPENDIX 10: Ash Foliage Collection: Pennsylvania State University partnered research

Objective: Collect leaf tissue for population genomics analysis for ex situ collections

Equipment needs:

- Handheld GPS
- AA batteries
- Pencils and permanent black marker
- Coin envelopes (1 envelope used for each individual collected)*
- Plastic freezer bags (1 freezer bag for each population)*
- Silica gel*
- Clippers or pruning shears
- Leather gloves

*Materials that can be provided by Dr. Hamilton for collection

Field sampling for population genetics requires between 20 and 40 different individual trees per population. Ideally, if there are male and female trees they should be identified and collected separately. For each species at each site, collection should happen from individuals relatively spread apart from each other in the population (at least 5 feet apart, but ideally more). Where possible, leaves collected should be fully mature: young bright green leaves with limited insect or fungal damage.

Overview of Methods

Creating a Site Label and Filling out Site Level Data Sheet

On a sheet of paper, you will record the state and location you are collecting in, for example you can indicate the town or some descriptive language of the area you are making these collections in (e.g., White Mountains National Forest). Using the state and the name of the location, you will create a three-letter code to identify the population. For example: Orono, ME will be written as: ME-ORO. Record the GPS location (latitude and longitude in decimal degrees) and elevation in meters for the **first** individual tree sampled at each site. Except for the GPS coordinates, elevation and the final number of individuals collected from, most of the data can be filled out prior to going to the site.

On this datasheet of paper, you will need to record:

- Species name (Brown, green or white ash)
- The site location along with state-population codes (Orono, ME = ME-ORO)
- Data of collection (MM/DD/YY)
- Latitude (decimal degrees)
- Longitude (decimal degrees)
- Elevation (meters)
- Number of individuals collected

Labeling the Sample Envelopes and Plastic Freezer Bags

Labeling if the individual envelopes can be done prior to the site visit as well.

- For each species at the site, label 20-40 individual coin envelopes with **Species** (brown ash: BA, white ash: WA, or green ash: GA), **Population Code** and **Number** (1-40). For each envelope include an "F" for female and an "M" for male if you are able to identify the individual's sex. The final code might look something like this:

  [Species, Population Code, Number, and sex] = [BA ME-ORO-1-F]

Label coin envelopes in pencil.

- Label a large plastic freezer bag with the following information in **permanent black marker.**
  - Species
  - Population Code
  - Date of Collection
  - Latitude
  - Longitude
  - Elevation
  - Total number of individuals collected (1-40)
  - Collector name
- Include site-label datasheet (same information from above) inside the plastic freezer bag.

Post-Sampling Storage & Data Management

These activities need to be completed the same day as collection.

- **For leaves:** Fill the plastic freezer bag associated with 'leaves' with about 3+ fingers width of silica gel in the bottom of the bag. Place coin envelopes of leaves in a bag of silica gel – you should be able to get all 40 individual coin envelopes in one (1) plastic freezer bag – although, for quick drying, fewer leaves per freezer bag is helpful. Try to ensure as much air as possible is removed from plastic bags to limit potential tissue degradation before it comes fully dried.
    - A note on silica gel: silica gel can be reused once leaves have completely dried. Email Dr. Hamilton first prior to silica gel reuse.
    - Silica gel has blue beads that will change color as they begin to soak up moisture (often from blue to pink). If silica gel beads appear pink prior to use *do not use that silica gel* – check with supervisor about oven-drying for re-use.
    - If the plastic freezer bag seems very full with coin envelopes, split the coin envelopes into two (2) plastic freezer bags and indicate: No. Plastic Bags (1/2 or 2/2, or 1/3, etc.) for each plastic freezer bag.

Shipping costs will be covered by the Schatz Center for Tree Molecular Genetics.

- Email Dr. Jill Hamilton (jvh639@psu.edu) for shipping information.

    Shipping Information:

    Address: Schatz Center for Tree Molecular Genetics

323 Forest Resources Building

University Park, PA 16802

Cell number: +1 (530) 312-3118

APPENDIX 11: Brown Ash Protection and Emerald Ash Borer Management in

Maine: Social Networking Analysis Survey, 2023

I: This first section of this survey will discuss the roster of those involved with activities surrounding ash protection in Maine. Please answer the following question for each name on the roster: **Do you know the following names as part of work related to ash or EAB in Maine?**

If you answer "Yes" you will be provided with four additional questions regarding the individual you know. You will see your own name. Please respond "This is me" for yourself.

Roster of Names	Do you know the following names as part of the Ash Protection Collaboration Across Wabanakik (APCAW) events or because of their work related to ash or EAB in Maine?			
Participant 1	Yes: __	No: __	Unsure: __	This is me.: __
Participant 2	Yes: __	No: __	Unsure: __	This is me.: __
Participant 3	Yes: __	No: __	Unsure: __	This is me.: __
Participant 4	Yes: __	No: __	Unsure: __	This is me.: __
Participant 5	Yes: __	No: __	Unsure: __	This is me.: __
Participant 6	Yes: __	No: __	Unsure: __	This is me.: __
…	…	…	…	…

For each participant selected, the following questions were provided for each participant:
You selected "Yes" to Participant X.

How long have you known them to be involved with ash protection or EAB management?	Less than 1 year: __	1 to 4 years: __	5 to 10 years: __	Over 10 years: __	Unsure: __
How often do you communicate with this person on topics of ash protection or EAB management?	Daily: __	Weekly: __	Monthly: __	Yearly: __	Never: __

Do you communicate with this person because of their (Select all that apply):

- Their knowledge or expertise of natural resource policy
- Their expertise on research funding
- Their knowledge on forest management/silviculture
- Their knowledge on Tribal government
- Their access to university resources and research
- Their knowledge or experience on seed collecting
- Their cultural background as a basketmaker or ash harvester
- Their expertise as a researcher/scientist
- Their expertise on a subject related to ash or EAB
- Other (not listed): _____

II: This second section will ask questions about your awareness and knowledge of the ash and EAB issue in Maine. Please answer the following questions to the best of your ability.

What year (approximately) did you first hear about emerald ash borer?
Drop-down menu with options of "Unsure" and each year from 2002 to 2023

What is your outlook, from extremely negative to extremely positive, for the following statements?

	Extremely negative	**Fairly negative**	**Somewhat negative**	**Neutral**	**Somewhat positive**	**Fairly positive**	**Extremely positive**
The existence of brown ash on the landscape in the next 50 years in Maine:							
The use of seed collecting to protect brown ash for the future:							
The use of genetic research for brown ash in the future:							
The future of Wabanaki basketmaking in Maine:							

How effective, from extremely ineffective to extremely effective, do you think are the following efforts?

	Extremely ineffective	**Fairly ineffective**	**Somewhat ineffective**	**Neutral**	**Somewhat effective**	**Fairly effective**	**Extremely effective**
Forest management techniques or silviculture							
Biological control agents, such as insects							

What would you say are <u>strengths</u> of work being done by this network to protect ash and manage EAB spread in Maine?

_____

What would you say are weaknesses of work being done by this network to protect ash and manage EAB spread in Maine?

_____

What do you think is missing or needs to be done for the success of protecting ash and managing EAB going forward by the Ash Protection Collaboration Across Wabanakik (APCAW)?

_____

III: This final section will ask questions regarding demographics.

What sector are you employed with?
___ Federal agency
___ Private citizen or Self-employed
___ University researcher
___ Tribal Nation government
___ Non-governmental organization (NGOs)
___ Other (please specify): _____

What year were you born?
Drop-down: each year from 1935 to 2005

What state do you have residence in?
Drop-down: all 50 US states provided

If Maine is selected, the following question is prompted
You selected having residence in Maine. What county do you live in?
Drop-down: all 16 Maine counties provided

Thank you for your time in completing this survey. If you have any questions regarding this survey, please contact: Emily.t.francis@maine.edu or jdaigle@maine.edu.

BIOGRAPHY OF AUTHOR

Emily T. Francis is from Vermont. She earned her Bachelor's degree from Keene State College in 2014, and her Master's degree from the University of Northern Iowa in 2016. Both degrees were in Geography. Emily was selected for the Directorate Resource Assistant Fellowship Program with US Fish and Wildlife in 2016. After completing that program, she took a position with US Fish and Wildlife in Albuquerque, New Mexico in 2017. Emily enjoyed almost two years in the high desert before switching to the DC Metro area to work at the National Science Foundation. She moved to Maine to attend the University of Maine in January 2020. Fiber arts, specifically knitting and crocheting, are some of Emily's passions, along with spending time with her family, friends and the many dogs in her life. Emily is a candidate for the Doctor of Philosophy degree in Forest Resources from the University of Maine in August of 2024.