

Ash Management Guidelines for Private Forest Landowners



A project of the
University of Minnesota
Extension and the Minnesota
Department of Natural Resources



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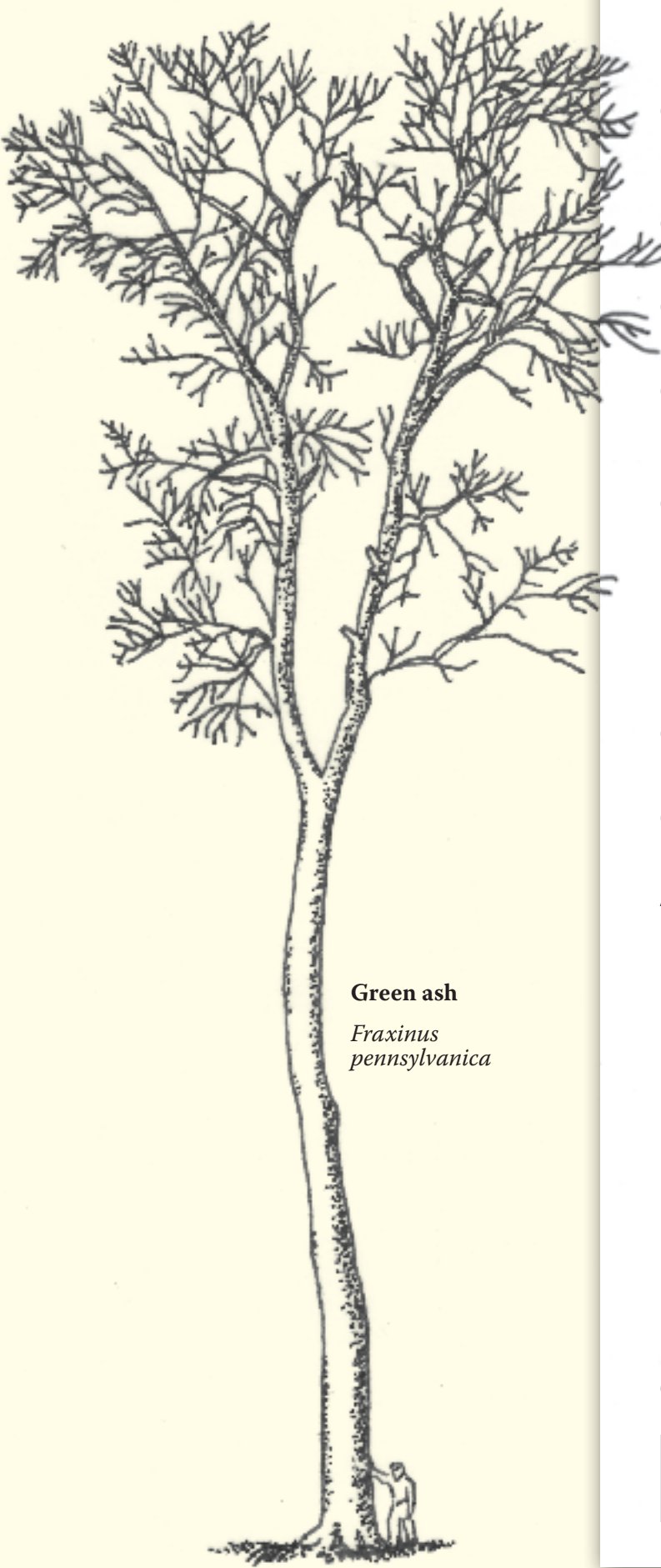
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Green ash
Fraxinus pennsylvanica

Table of Contents

Chapter 1
 A History of Minnesota’s Ash Resource:
 Current Extent and Abundance of Ash 7

Chapter 2
 Minnesota Ash Species Identification..... 10

Chapter 3
 Ash: A 21st Century Resource15

Chapter 4
 The Emerald Ash Borer: a little
 package carrying big trouble 23

Chapter 5
 The Native Plant Communities 29
Ash in the Wet Forest System32
Ash in the Floodplain Forest System 38
Ash in the Mesic Hardwood System 44
Ash in the Forested Rich Peatland System 48
Ash in the Fire Dependent System 50

Chapter 6
 Wildlife Among the Ash 54

Chapter 7
 Other Implications of EAB and Ash Trees56

Appendices

Appendix A
 Minnesota Department of Natural Resources:
 Guidelines for managing sites with ash to address
 the threat of emerald ash borer on DNR
 Forestry-administered lands 60

Appendix B
 Questions and Answers about Quarantines
 and Compliance Agreements 63

Appendix C
 Minnesota Department of Natural
 Resources Rare Species Guide 65

Appendix D
 References and Resources 66

Glossary 67

Throughout this publication, words in *bold italics* can be found in the Glossary on pages 67-68.

General Ash Management Guidelines

Introduction: Walking the Talk

There is a lot of talk about how to manage Minnesota's ash trees. The 'talk' has become the focal point of professional management discussions and policies, as well as the news around the breakfast tables of those who own nearly 50 percent of the forested land in the state: YOU, the private forest landowner.

Natural resource professionals reviewed ash management recommendations, including those for state land, developed by the Minnesota Department of Natural Resources (Appendix A). Those resources professionals wanted to offer you, the family forest landowner, another approach. This Guide will discuss some specific guidance on ash management. It was developed cooperatively with insight from many different fields related to forestry and ecosystem management. A detailed, multi-process survey allowed experts to apply their knowledge several times to offer useful management tips for the complicated and unprecedented future that faces Minnesota's forests. As a result of this effort there are some basics you should use as the foundation to build upon in your management decisions.

The following are a few baseline tips shared by a diversity of public and private professional resource managers:

- Seek and use the advice of a professional forester/forest plan writer.
- Closely monitor stands with ash.
- Plan for forest conversions when ash is a major component of your forest.
- Work with neighboring landowners to address threats on a larger scale.
- Actively discourage invasive plant and insect species; manage for native species.
- Think outside the box. Contemplate a wider choice of tree species appropriate to your sites and needs. Diversify the species you select. Tree and plant diversity will help prevent future large-scale mortality the next time we discover a major pest attacking a tree species.
- Think about replacement tree species before the ash dies.
- Underplanting. Consider planting shade-tolerant trees beneath canopies of existing trees.
- Minimize harvest damage by using the services of a professional logger who has taken training with the Minnesota Logger Education Program. Ask for credentials and references.
- Keep in mind - you can't call a logger and expect him/her to be out harvesting at your site in the next week or month. In most cases, you are going to need to set the plans in motion 2-3 years before the timber is harvested.
- Be extremely careful if using heavy equipment on very wet sites. It may be best to leave the ash alone in these areas.
- Be familiar with, and apply Best Management Practices.

Following is a detailed background of ash as a resource, ash tree identification, emerald ash borer information and identification, and ash in our woodlands and recommendations on how to manage ash forests through this transition. We hope this Guide is useful and informative as we face this unprecedented forest change together.

The Delphi Survey Process

The University of Minnesota Extension and the MN Department of Natural Resources (DNR) recognized a need to offer practical and timely ash management recommendations for family forest landowners in the emerald ash borer (EAB) era. However because EAB is such a new pest, first discovered in Michigan in 2002, and trees grow slowly – the average life span of an ash is 200 years – and science takes time; we were tasked with the nearly impossible: to predict the future. We did our best to make recommendations to manage for this uncertainty. Extension took the lead in exploring options on the best way to predict and plan for an unknown future. After much consideration and consultation with Extension’s evaluation experts, a survey process called a modified-Delphi was chosen. This process is a systematic, interactive, anonymous, structured survey method to facilitate a panel of experts to offer recommendations or opinions from many areas of expertise.

For this Ash Management project Extension facilitated three rounds of the modified-Delphi survey. Of the 31 participants not all participated in each round. This process was extensive, Round 1 (84% response rate), consisted of 19 open end questions. Participants were given two weeks to contribute to the survey. Following those two weeks Extension had two weeks to tally survey responses and create the next round of the survey based on feedback offered in the previous round. Round 2 (81% response rate) was large, 103 questions all generated from Round 1. Round 3 included all the results from Round 2 plus new information generated in Round 2. In total, Round 3 (68% response rate) was 98 questions. The results of this survey process are wide reaching, but they are not exhaustive.

When consensus couldn’t be reached we didn’t report that recommendation. It is very important to remember that none of us has a crystal ball which we can see the future of Minnesota’s ash forests. This is our best effort to find a method and experts to offer help. However it will be very important for everyone, landowners and natural resource professionals alike, to stay abreast of current research and information because recommendations are likely to change as the sciences catches up.

Forty-one experts, mostly from Minnesota, were asked to participate. They were experts in silviculture, forest hydrology, the MN DNR’s ecosystem classification system, timber harvesting, family forest landowners, forest regeneration, forests and climate change, wood utilization and logging, forest wildlife, woodland communication, EAB quarantine, EAB, cultural aspects of ash, and forest genetics. Deliberate effort was made to find experts from different organizations including the University of Minnesota, DNR, US Forest Service, private industry, Bureau of Indian Affairs, Minnesota counties, and private landowners. However, survey facilitators had little control over who actually participated in the survey. Of the 41 invited to participate 31 actually contributed in any of the three rounds. All response rates are based on the 31 experts that actually participated in at least one of the rounds.

Funding and resources for this project, beyond the valuable and extensive time contributed by the panel of experts, were offered by the University of Minnesota Extension, the MN Department of Natural Resources, Forest Stewardship Funding, and the Renewable Resources Extension Act.

In order to clearly offer you, the reader, with a quick way to assess the difference between important resource information and recommendations generated from the survey, all Survey Recommendations will be featured in these eye catching call-out boxes. Although attributed to an individual, these recommendations in the call-out boxes were approved by group consensus using the modified-Delphi process.

Suggestions from the experts during the Survey

- It is important to remember that for all ash stands considered in this survey: The effects of global climate change are too variable to make stand level decisions.
- Landowners should minimize harvesting damage; harvest using current Best Management Practices; and unless otherwise noted, harvest using current standard silvicultural practices; recognize that new practices may be developed and landowners should stay abreast of new research.
- A quarantine expert commented: “These may need to be modified for mostly pure ash stands. If EAB infestation is widespread or imminent, damage to residual timber, snag tree retention guidelines, and clearcut acreage limitations might not be important when compared to the alternative.”
- Additionally, landowners should actively discourage invasive species. They should manage for native species while preparing for an increase in secondary insects and disease on dying ash and a decrease in total stand biodiversity and changes in wildlife species using the stand.
- One expert pointed out it's very important for landowners to stay aware of where EAB is in the state. One expert on landowner communication stated, “I favor strongly encouraging management when feasible (e.g., removal of ash in conjunction with other harvests.)”
- “We should emphasize to family forest owners that change is coming and using some of the wood would be good rather than letting it all die and rot.”
- Along that same line an entomologist stated, “The goal should be to think about replacement before the ash dies because that is when the landowner has the best hopes of influencing the results.”
- A general rule of thumb for landowners should be to remove dead/dying ash trees. “If the trees are in an area where the falling trees will be a hazard to people or property then they should be removed, or at least cut down,” according to one entomologist.
- Ash mortality will cause hazards to recreational trails.
- Landowners should begin now to assess the threat to their land, map out a management strategy and take action to get that implemented.
- Efforts to leave some ash for genetic stock are more likely to survive if “neighboring threats are reduced.”
- Leave a mixture of qualities and species of ash trees for genetic diversity.
- One forest geneticist said, “If (a) harvest is in advance of EAB or far from proximity of infection point. This allows for retention of species and genetic diversity in event that EAB is controlled.”
- Another entomologist pointed out, “There are trees that have escaped attack in southeastern Michigan – we don't know why they have escaped attack - it is possible that a variety of modes of resistance to EAB attack are present in the gene pool.”
- On the bright side, one expert mentioned: After ash mortality has occurred berry product in small shrubs and trees may increase. Raspberries, highbush cranberries, Juneberries would all be stimulated by increased sunlight.

The Emerald Ash Borer & Chestnut Blight: A historical perspective

If you have been a Minnesota resident during the past half century, you likely remember the ‘great depression’ of community trees when Dutch Elm disease took its toll. Boulevard trees, back yard trees, and trees along parkways and riverwalks had to be removed because of this disease that virtually wiped out the state’s elm tree population. There are lessons to be learned. Read on.

Emerald ash borer is often compared with Dutch elm disease. There are good reasons for this comparison. Minnesotans have a cultural memory of the decline and loss of American elm in our cities. Dutch elm disease was first discovered in St. Paul in 1961, with massive death of the trees and removal not occurring until the 1970s. Many communities replaced at least some of their lost elms with ash. So it is natural to make the comparison of emerald ash borer (EAB) to Dutch elm disease, particularly in our cities. But is that really a good comparison?

Let’s look further back into our forest’s history for a different example: chestnut blight and the loss of American chestnut (*Castena dentata*). Chestnut blight led to the first large scale loss of a forest tree. American chestnut is a large, stately native tree found from Maine to Mississippi. It succumbed almost completely to chestnut blight between 1900, when the blight was first discovered in New York City, and 1940 when the blight had invaded all the commercial stands of eastern chestnut and killed most of the trees.

So what is the impact of these pests on the forest? Emerald ash borer attacks and kills virtually all ash (*Fraxinus spp.*) trees greater than 1” in diameter. Chestnut blight, while not actually killing all the trees, reduced the presence of the American chestnuts in the Appalachian forest to small bush-like sprouts growing from the trunk and roots of formerly majestic and dominate trees. This species is functionally lost to our forests.

Dutch elm disease, on the other hand, has a mortality rate of about 80%. While elm now makes up a significantly smaller percent of our urban and forested trees than before Dutch elm disease invaded, elm still exists in urban environments largely because of fungicidal treatments. In forested environments, it remains as a small understory tree. This situation is very different than the functionally nonexistent American chestnut in the eastern forest. Additionally it is important to look at the actual spread rate of these pests. Chestnut blight spread and killed chestnut trees at 32-40 km/year (Tainter & Baker, 1996). Actual spread rates for Dutch elm disease are harder to find, but it was first identified in Ohio in 1930 and eventually arrived in St. Paul, Minnesota in 1961. Even then, the first seven years it was in St. Paul there were only 30 reported cases.

Emerald ash borer, on the other hand, was first reported in Detroit, Michigan in 2002 – although dendrochronological analysis places the insect there as early as the mid-1990s (Siegert, McCullough, Liebhold, Telewski, 2008). Dendrochronology is the science of dating trees, and associated environmental events, using a tree’s growth rings. In this

circumstance, researchers in Michigan took ash trees from various locations throughout southeastern Michigan, dated their growth rings, and noted the year of attack by EAB. They then cross referenced that data with weather patterns to better assess when EAB first arrived in Michigan.

Although its “first date” in the United States is still unknown, we do know EAB was here years before it was identified and reported, and before management and quarantines were started.

In a time span of about 15 years, EAB has spread to 14 states from Minnesota to Virginia and Missouri to New York. Unlike chestnut blight, Dutch elm disease and EAB are being spread long distances in similar ways, mainly via human transportation of wood materials. Chestnut blight was spread predominately through natural movement. The future prospect for ash is not bright. Data from Michigan indicates there is little residual ash in a stand after EAB has attacked an area, and the ash seed bank survives only up to eight years. Scientists and volunteers have been working to collect and preserve ash genetic material in Minnesota for years so that science will have genes from which to work after EAB has come through.

Ash trees comprise over 50% of some stands in northern Minnesota. Conversely, elm, while an important tree species in several forest types, was almost never a majority of the trees in a stand. And, in some forest stands in Appalachia, American chestnut comprised 25% of the trees. Therefore the stand-level impact of Dutch elm disease was likely less than the anticipated stand-level impact of EAB in some ash dominated sites in northern Minnesota. However, interestingly, ash now comprises a higher percent of some Minnesotan timber types than ever before, likely due to the loss of elm. Ash filled the ecological niche created when the elm died. It is ironic that one of the ten tree species in seven of the nine timber types by geography recommended in this Guide is the introduction of disease resistant American elm to replace ash. One could conjecture that the forest is coming full circle; one invasive species removed most elms from the forest to the benefit of ash, now another invasive species will remove ash to the potential benefit of disease resistant elm.

In summary, while Dutch elm disease was and is a major forest pest in Minnesota and was devastating for both the urban and forested elms, emerald ash borer is likely to be an even bigger problem. It is expected to hit certain forest stands much harder than Dutch elm disease did – likely more on the scale of American chestnut – something for which we have virtually no living cultural memory.

It is important to remember, however, that science is moving faster than ever and genetic research has progressed markedly since the turn of the century. Foresters are now beginning to plant blight resistant American chestnuts in the forests of Appalachia, and there are disease resistant American elms we can replant in our forests. With careful monitoring, the help of science, and supportive funding the forest can grow again.





A History of Minnesota's Ash Resource

Current Extent and Abundance of Ash

Ash is one of the most widely distributed plants in Minnesota.

All 87 counties in the state have one variety of ash or another. There are three ash species in the state: black, green, and white. Ash is found in all terrestrial native habitats, and it is widely planted in yards and along boulevards.

The current ash population in Minnesota is about 176 million trees, some 8.6 percent of all forestland trees (>5" **diameter at breast height** – "**dbh**"). Ash is a significant tree on 866,000 acres of forest land. In a little more than half of these forests (463,000 acres, 53%) ash is just a component of the forest, mixed most often with other **deciduous** trees. However, ash is the dominant and sometimes the only tree on some 406,000 acres of land. Losing ash to emerald ash borer (EAB) on these lands will be obvious and locally devastating. The population of small, regenerating ash (1-4" dbh)

is incredibly high – roughly 795 million ash or roughly 5 saplings per every ash tree. If one were to consider also germinating ash (<1") there are billions if not 10s of billions of ash individuals in the state. This is so because ash is **shade tolerant** and its ecological strategy is to build a large store of seedlings beneath a **canopy** – each seedling hoping to be the lottery winner that replaces a canopy tree.

Perhaps the most striking fact about ash is that it is far more widespread as small seedlings than as trees. In other words, small ashes are often abundant in environments where ash trees rarely survive. Green ash, in particular, is constantly invading open space – including native prairies, some marshes, wet meadows, and open peatlands. Even in the forest, it is common to encounter ash seedlings and saplings without a parent tree in sight. Young, regenerating ash are, simply, everywhere.

GLOSSARY

dbh: Diameter at breast Height: The diameter of the stem of a tree measured at breast height (4.5 ft or 1.37 m) from the ground. On sloping ground the measurement is taken from the uphill side.

deciduous: Perennial plants that are normally more or less leafless for some time during the year.

shade tolerant: Having the capacity to compete for survival under shaded conditions.

canopy: The foliage cover in a forest stand consisting of one or several layers.

Chapter 1

A History of Minnesota's Ash Resource

GLOSSARY

paleoscientist: Scientists who study organisms of the past.

Shown here is a Floodplain Forest, referred to in the Native Plant Community classification as an "FF."

Historic Abundance and Change in Abundance of Ash in Minnesota

The history of ash in Minnesota is "old as dirt" – literally. Black ash was among the hardy pioneers to occupy fresh soil while glacial ice slowly melted from the landscape some 16,000 to 11,500 years ago. We know this because black ash pollen is preserved along with the pollen, wood, and leaves of other trees in the oldest sediments of our lakes. The assemblage of plant fossils includes abundant remains of spruce, with lesser amounts of ash, tamarack, fir, sage, ragweed, grasses, and sedges.

Most *paleoscientists* agree that this assemblage of fossil plant communities has no analogue in the modern vegetation of North America. Even where we have glaciers, we don't see this particular combination of plants. This suggests that the climate of the late-glacial period in Minnesota and the American Midwest, was unique to that time. Ice cores from Greenland tell us that the temperature fluctuated during that time; scientists debate about the strength of seasonality – but everyone agrees that it was wet. It is no stretch for a botanist to imagine

spruce, black ash, tamarack, fir, grasses, and sedges occurring in wet habitats because they occur in such places today. The amount of ash pollen in late glacial sediments (~10-15 percent) is the most that we see in any lake sediments from Minnesota. When Minnesota was ice-free and experiencing a much warmer climate (the modern Holocene Epoch), other native trees eventually migrated into the state. Competition with these new species, the maturation of soils, and considerably drier conditions helped to diminish ash populations. Sediments younger than about 11,000 years have little ash pollen, but it is steadily present. Apparently, the wet forest niche that favors ash has been a stable component of Minnesota's landscape since the glaciers were here. Before the arrival of EAB and concern of global warming, the 11,000-year pollen record assured Minnesotan's of an ash resource.

White settlers have significantly impacted ash populations during the course of settlement and agricultural development of Minnesota. When settlers first



Photo: Michael Lee



Chapter 1

A History of Minnesota's Ash Resource

The habitat of the green heron is small wetlands in low-lying areas. The species is most conspicuous during dusk and dawn. They prefer to be active at night, retreating to sheltered areas during the daytime.

arrived in the state, ash was a component of roughly 1,221,000 acres of forest land. Some 902,000 of these acres were directly lost to conversion of the land to something other than forest. However, this loss is partially offset by a gain of 548,000 acres where forests lacking ash were converted to types with ash.

On land that has been forest throughout the settlement period, the relative abundance of ash to other trees has gone up from 1.5 percent of forest land trees to 8.5 percent—nearly six times its historic abundance. These gains have occurred almost exclusively in habitats where ash is dominant. The acreage of *monotypic* ash forest has increased from 229,000 to about 406,000 acres. Why? Ash was excluded from habitats where fire was a chronic influence. Fire suppression has undoubtedly allowed

ash to increase in Minnesota's western and southeastern forests. But this doesn't explain the shift to monotypic forest. More likely is the fact that swamps are not prime real estate or agricultural land. Uplands were developed leaving rich black ash, tamarack, and cedar swamps, undeveloped but not untouched.

Tamarack and cedar were heavily exploited during settlement for railroad ties and rot-resistant building materials—while ash was “good firewood.”

In addition, Minnesota's tamarack population was devastated by European larch sawflies between 1900 and 1950.

Apparently, Minnesota's rich swamp forests with ash were left alone, and many with tamarack and cedar have succeeded to pure ash. In recent times, tamarack and cedar have shown little natural ability to regenerate in rich swamps.

GLOSSARY

monotypic: Referring to conservation biology and successional changes leading to a single species.

Minnesota Ash Species Identification

Ash trees are difficult to describe and can be tough to identify. Out in the woods, ash trees do not have the flashy, distinctive white bark of birch trees, nor are they majestic giants that easily tower above the canopy like our stately white pine. However, ash does have its own distinction. They are one of the last tree species to leaf out in the spring-time - and one of the first trees to drop its leaves in autumn.

Learning to identify Minnesota's ash trees will deepen your appreciation of our woods, and for a landowner, it's the first important step in learning how to care for your land. Take your time and practice throughout each of Min-

nesota's four seasons - and when all else fails ask your kids!

The classical Latin name for ash is "*Fraxinus*" meaning "spear." Ash are members of the Oleaceae, or the olive family. The flowers from the trees are pollinated from insects or through wind.

Members of the ash family have the ability to reproduce through seeds, and vegetatively through stump sprouts.

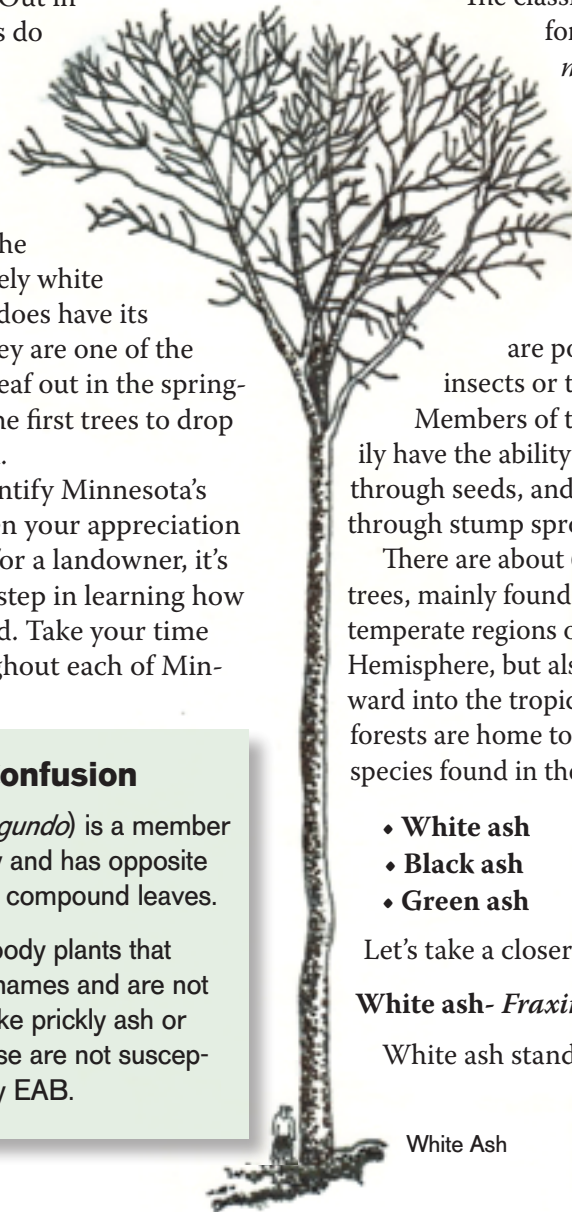
There are about 65 species of ash trees, mainly found throughout the temperate regions of the Northern Hemisphere, but also ranging southward into the tropics. Minnesota forests are home to three of the 18 species found in the United States:

- **White ash**
- **Black ash**
- **Green ash**

Let's take a closer look:

White ash- *Fraxinus americana*

White ash stands tall as a for-



White Ash

Avoid Confusion

Boxelder (*Acer negundo*) is a member of the maple family and has opposite branching and 3-5 compound leaves.

There are other woody plants that have 'ash' in their names and are not true ash species, like prickly ash or mountain ash. These are not susceptible to an attack by EAB.

est tree; its crown is relatively small. Compared to black and green ash, it is relatively uncommon, largely restricted to mesic deciduous forests in the south-east and east-central parts of the state.

You will usually find white ash in small groves, as scattered individuals, or mixed with northern red oak, basswood, or green or black ash. It is unlikely you will find white ash on active floodplains or in wet areas. It prefers fertile, loam soil on slopes along major streams.

Its seedlings like the deep shade of a mature forest, but will eventually die unless they obtain light from an opening in the canopy. The fruits of white ash mature by the beginning of September and are released during the autumn and winter. These are among the last trees to leaf out in the spring.

Black ash - *Fraxinus nigra*

Like the white ash, black ash is tall and slender with a relatively small crown. Its bark has a silvery gray tone and, unlike the other ashes, its bark is fine textured, somewhat scaly, and not furrowed. Like all ashes, its leaves are opposite on the twig. However, black ash leaves are large and rather droopy, looking much like those of a walnut.

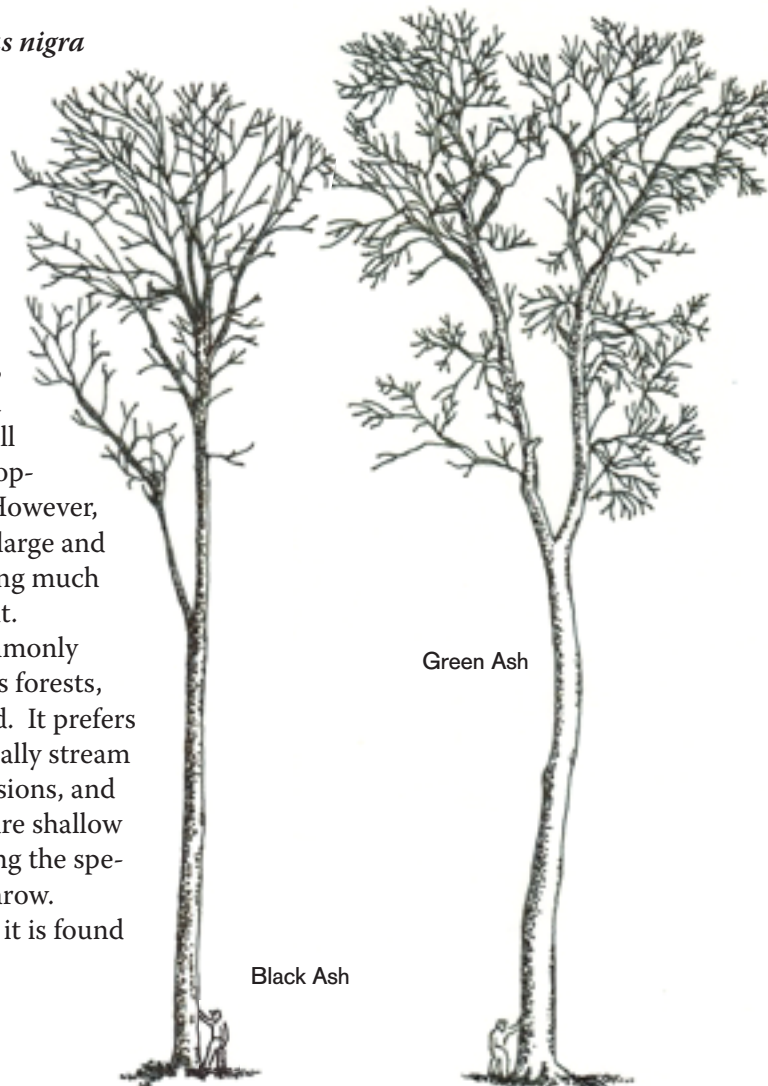
Black ash is commonly found in Minnesota's forests, especially northward. It prefers moist forests, especially stream banks, moist depressions, and swamps. The roots are shallow and spreading making the species prone to windthrow.

In upland areas, it is found

intermixed with basswood, trembling aspen, white spruce, and maples. In these environments, it can grow quite large, sometimes exceeding 100 feet. In contrast, in wet, lowland habitats black ash is a stunted, small, and spindly tree, often no more than 30 feet high with only a few branches. Black ash seedlings are more tolerant of shade than green ash. Unlike white ash, it does not aggressively colonize open lands.

Black ash seeds are recognized as an important seed source for game birds, songbirds, and small animals, and is used as browse by white-tailed deer and moose. Flowers on black ash are generally formed by the end of May, with seeds appearing in late September. Some people think the fruit has a 'spicy' odor.

(Continued on page 13)



Simple identification features common to all ash:



MN DNR

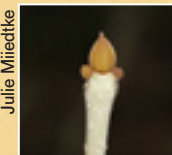
- Opposite Branching and Bud Arrangement: Branches and buds are located directly across from each other (opposite), not staggered (alternate). Note that sometimes buds, twigs and branches are lost from wind damage etc.



MN DNR

- Compound Leaves: Each leaf is composed of 5-11 leaflets, depending on the species.

Leaflet margins may be smooth or toothed.



Julie Miedtke

- Winter Buds: Have large scales and look like deer hooves.



Ohio State Univ. Extension

- Bark: Young ash trees have smooth bark. Older trees have different patterns, generally furrowed.



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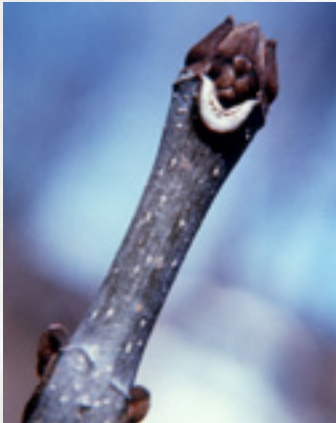
- Seeds: Called "samaras", the seeds look like canoe paddles. They mature in the fall and can persist through winter.

How to tell an ash from an ash

Identifying characteristics

White Ash

Leaf Scar/Bud



2-3 pairs of scales, rusty to dark brown. Terminal bud $\frac{1}{5}$ " long. Lateral buds are set within the leaf scar. Buds are paired with a leaf scar beneath the bud that looks like the letter "C" turned on its side.

Julie Miedtke

Bark



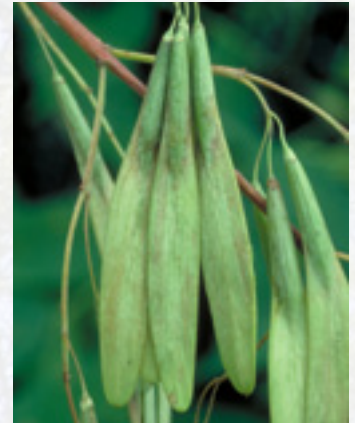
Light gray-brown bark is characterized by having deep, narrow ridges that form a diamond shaped pattern.

Leaves



8 to 12 inches long with 5 to 11 leaflets (usually 7); margin entire to partially serrate. Leaflets are stalked.

Fruits



Light-brown samara, about 1" long; wing partially surrounding the seed.

Black Ash



Buds are very dark brown in color. Generally, there is a space between the end bud and the nearest lateral buds.

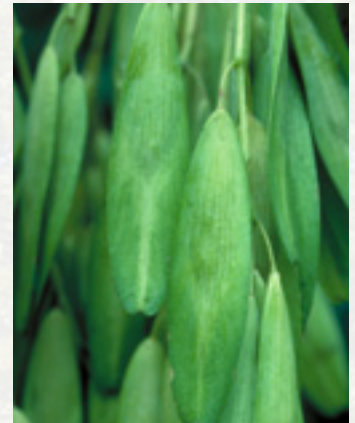
Ohio State University Extension



Grayish in color and smooth when the tree is young, attaining some of the same furrows that can be seen in the bark of both green and white, but usually not as deep.



10 to 16 inches long with 7 to 11 leaflets; margin finely serrate; leaflets have no petiole.



Samara are broad to oblong, usually 1 to $1\frac{1}{2}$ inches long, blunt at the base.

Green Ash



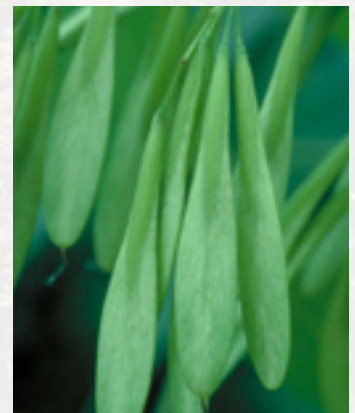
Bark rusty brown, woolly, set above leaf scar. Leaf scars nearly straight across the top. Buds are paired with a leaf scar beneath the bud that looks like a sideways "D" (like a smile).



Very similar to that of white ash but not quite as deeply furrowed.



6 to 10 inches in length with 7 to 9 leaflets; margin serrate along entire length of leaflet.



Samara typically $1\frac{1}{4}$ to $2\frac{1}{4}$ inches long and $\frac{1}{4}$ inch or less in width. The wing of this samara is more pointed than that of white ash.

Chapter 2

Minnesota Ash Species Identification

Green ash - *Fraxinus pennsylvanica*

Green ash is one of the most common of the ashes, particularly in the southern part of the state. Unlike black ash, green ash does not grow in swamps; however, you will find black and green ash growing side by side on upland sites. You will find green ash in basic (*calcareous* sites) or soils that

are slightly acidic. You will find green ash in sand, silt, clay, or loam soils, but not in *peat*. Young trees grow rapidly and will resprout if they are damaged or cut. They produce large numbers of seeds and are vigorous colonizers of abandoned agricultural and urban lands. Green ash seedlings do not survive under deep shade.



Photo: DNR/Tom Klein

GLOSSARY

calcareous: An adjective used in a wide variety of scientific disciplines, referring to the deposit of calcium carbonate or lime. In some cases it may refer to a layer of sediment or sedimentary rock, a limestone deposit. Calcareous soils are relatively alkaline, in other words they have a high pH. This is because of the very weak acidity of carbonic acid. Note that this is not the only reason for a high soil pH.

peat/peatlands: Organic soil material that originates from plants.

A mesic ash stand



Ash: A 21st Century Resource

Minnesota's ash trees are abundant in our rural and wildland areas, typically supplying between 30,000 and 40,000

cords of wood each year, mainly for pulp and paper, but also for firewood and specialty products such as cabinets, furniture, and veneer.

Let's wander through the aisles of a variety of ash products:

Economic significance and uses of wood

Working Properties

Black and green ash have lower specific gravities and lower strength properties than white ash, but they are still mod-

erately strong, hard, and stiff compared to other Minnesota native hardwoods. They also split easier, shrink more, and are average in workability and gluing.



Photo: U of M Extension/David Wilsey

When an ash log is pounded, the growth rings come off in thin layers, providing the material needed for basket making.

Opposite page: Green ash lumber showing emerald ash borer defect.



Ash wood has been gathered and shaped into snowshoes of varied design by many cultures that inhabit the boreal and sub-boreal forest ecosystems. Ash wood lends itself to manipulation and retains its given form once dry. Ash is also lightweight, making it ideal for snowshoes, toboggans, and vessels. The wood properties of ash have made them a fiber source for a few Minnesota-made products:

Pulp and Paper: Two of Minnesota's pulp and paper mills use small amounts of ash mixed with other species to create paper pulp. These mills used about 10,000 cords of ash in 2007.

Engineered Wood: Ash is used by one Minnesota mill to manufacture hardboard.

Solid Wood Products: Over 100 Minnesota sawmills use some ash, but the overall consumption is low. Total ash use in 2007 was about 9,000 cords. There are several exporters for black ash veneer. The volumes are small but these exports are high value.

Minnesota's ash paneling industry is viable, particularly when it comes to black ash. Black ash is sawn into paneling and flooring when quantities are available (and that may not be regular or often). Ash has always been an offering in the

paneling and flooring industry. Black ash is also used as a craft wood both in niche market items and traditional Minnesota-crafted items such as snowshoes and baskets. Also, ash is popular for firewood as it is easy to split.

While the industry that produces paneling and pallets is big, their use of ash isn't. There are a couple reasons for this. The size and quality of the raw ash material is undependable. Not very much ash makes it to sawlog or veneer size. The supply just doesn't lead to a consistent demand.

Another reason is that harvesting opportunities are limited to the season when the ground is frozen or dry, because ash is most often found in lowland areas. Those in the timber industry tend to focus their efforts in the winter season on species they are certain they can market.

While a number of factors make harvesting ash undesirable, other characteristics make Minnesota ash desirable for various industries. Ash has a unique, variable grain pattern that appeals to many.

It is not a "light-colored" wood, but it is not a "dark" wood either. It is somewhat vulnerable to fashion swings. If light-colored paneling is "in" to make the ceilings look higher and the room look



Photo: Dailyinvention

Ash trees are common 'urban trees,' lining the streets and boulevards of communities throughout Minnesota. And, as with most urban trees, ash trees bestow beauty, cut energy costs, and absorb and filter storm water – services estimated to be worth over \$290 million each year to Minnesota communities.

Most often, discussion centers on the large proportion of ash trees that comprise urban and suburban landscapes. Ash species were used to replace elm trees after Dutch elm disease wiped out what was once the predominant urban landscaping tree. Ash trees sometimes comprise one quarter or more of the trees in municipal areas.



Photo: John Zasada

bigger, then ash is not the first choice. But it has enough character that it can sway the opinion when it comes to choosing.

It has the “bend” that craftsmen like (e.g. in making snowshoes); the growth rings come off in thin layers when a log is

pounded, thus providing the material for basket making; and the wood color and unique grain pattern provide value and uniqueness in the creation of specialty items (e.g. ash bowls).

What about dead/dying black ash, after invasion of Emerald Ash Borer?

Firewood will be a primary market for dead ash

In many stands of ash the tree trunks are small in diameter, which makes them appealing to markets that use fiber rather than needing larger logs to create a solid wood product. The *BTU* value of ash makes it a desirable firewood source, particularly in rural Minnesota. Another attribute of ash for the home heating crowd, is the fact that it splits very easily, thus making it a preferred choice over other species of wood.

Marketing experts expect that the sheer volume of smaller diameter ash, as well as the size and location of naturally occurring ash stands will drive utiliza-

tion in the direction of firewood.

Because of ash’s splitting characteristics, homeowners are more apt to purchase truckload quantities in 100’ or tree length and do their own processing into firewood. Loggers will achieve a better production rate with this type of processing. They will not have to apply extra effort during logging and delivery, so will be more likely to harvest ash stands. *Moving firewood is not recommended. See pages 21 and 25 for details.*

It is important to note that there are markets for medium and larger ash logs as saw material and veneer logs. Sorting of larger material to higher value uses will result in greater economic returns.

Page 18: A white ash strip pack basket constructed by Mike Benedict; Inset: Black ash woven bowls crafted by Dennis Chilcote

GLOSSARY

BTU: British Thermal Unit, is a basic measure of thermal (heat) energy. One BTU is the amount of energy needed to heat one pound of water one degree Fahrenheit.

Survey Recommendations: Wood Markets

Firewood and biomass will be the main market for dead ash. Ash prices will decrease. Several experts pointed out that the transportation distance to markets and local quarantines will play a major role in future ash markets. It was also pointed out that high value ash markets will be impacted by decay fungi as ash die. Landowners should harvest ash when considering an already scheduled harvest. Landowners should assess their ash inventory and plan a replacement strategy now. One entomologist summarized several recurring comments this way: “I think landowners in the entire state should get the recommendation to consider management to reduce the amount of ash if they have a lot and they should not delay. But they also don’t need to panic. As the land gets closer to known EAB infestations the urgency increases. But I am not so sure the management recommendations would change much- reduce ash- don’t eliminate ash. Management recommendations in and around communities may be different but that will depend on the situation and how the community is dealing with EAB.” The expert panelists recommend: **Do not liquidate ash immediately.** Efforts to leave some ash for genetic stock are more likely to survive if neighboring threats are reduced.” Reduce ash populations in their stands to reduce EAB impacts.



Ash logs destined for baseball bat production.

Information on Quarantines

When ash has been killed by EAB, county-by-county quarantines will be put into effect by the Minnesota Department of Agriculture. A *quarantine* is a temporary rule intended to help prevent a potentially dangerous or destructive pest or disease organism from spreading outside a known infested area into new areas. In the case of EAB, the quarantine is designed to limit the movement of potentially infested firewood or other materials such as live ash trees that might harbor EAB larvae.

The regulations for transporting wood out of a quarantined county will require actions that will add cost to the raw wood material harvested from the forest. For many wood products, this extra processing will be cost prohibitive. The least expensive action to enable ash to be transported out of a quarantine county will involve chipping the solid wood in order to destroy the medium that EAB uses to reproduce.

Chipping will add the least cost to harvested ash wood as markets will

readily accept chips. Markets for chips in Minnesota include *biomass* burning facilities, located in both rural and urban settings, a few pulp mills, and one *oriented strand board* mill. By far, the market for fuel chips will absorb most of the volume produced by this method.

Ash prices will decrease

It is possible that large volumes of ash will be killed at the same time, necessitating the removal of more volume than could be absorbed by current markets. The effect of an oversupply of any commodity is that the unit price of that commodity drops. This situation could easily happen with ash.

It is likely that this condition would be short-lived and last until the volume of dead ash is reduced. At that point, it seems probable that, because of a scarce supply, the price of ash would begin to recover to former levels, perhaps even increasing to a premium level. Ash has never garnered a very high price in the wood stumpage market. The affect of quarantines on the movement of ash resources will potentially be major.

Specialty markets significance

Burls are abnormal growths that provide a wonderful source for decorative wood with fanciful grain or figuring. It is believed that a burl is created when there is an injury or other external stimulus that affects the growth pattern of

the tree and results in a deformity. Wood grain patterns may be wavy, swirled, marbled or feathered depending on the type of burl.

Ash is considered one of the best of these "*character woods*;" burls on ash trees are highly sought after. Ash displays a pronounced grain, with a wide to broad range of grains and color that make it uniquely the most consistent choice for those looking for character wood or real "wood" feel. Ash takes stain extremely well and its grain

Chapter 3

Ash: A 21st Century Resource

GLOSSARY

quarantine: A temporary rule intended to help prevent a potentially dangerous or destructive pest or disease organism from spreading outside a known infested area. In the case of the emerald ash borer (EAB), quarantines are designed to limit the movement of potentially infested firewood or other materials such as live ash trees that might harbor EAB larvae. For more information on quarantines see Appendix B, pages 63-64.

biomass: Harvesting the wood product obtained (usually) from in-woods chipping of all or some portion of trees including limbs, tops, and unmerchantable stems, usually for energy production.

oriented strand board: Also known as OSB or waferboard, is an engineered wood product formed by layering strands (flakes) of wood in specific orientations.

burl: An abnormal growth of woody tissue protruding outward from a tree stem or trunk.

character wood: Wood prized by artists or craftsman because of its unique or distinctive grain patterns or form. Examples of character wood include burls and crotch wood.

Ash burl, "Fraxinus cornu"

Photo: Tim Byrns

GLOSSARY

bole: The trunk or main stem of a tree.

A hand-woven,
black ash basket
taking shape

characteristics allow it to highlight a beauty only nature can provide.

Although the quality of burl is not known until you begin working with it,

Cultural significance

The unique characteristics of black ash have made it a staple of the traditional American Indian basket-making industry. U.S. Bureau of Indian Affairs forester and basket maker Michael Benedict predicts: “If and when emerald ash borer gets to the state’s remaining stands, the material will be very rare or nonexis-



Photo: U of M Extension/David Wilsey

tent in some areas.”

Ash holds cultural significance to certain communities. Many woodland communities prize ash for its characteristics and feature ash wood in practical tools, many of which have become elevated to art forms. Black ash, in particular, is prized in basketry because of the straight and smooth trunks. Once it has been felled, the tree **bole**, or trunk, is pounded to remove the sapwood layers.

Pounding the tree separates the growth rings into strips about the thickness of a nickel. Pounded strips are soaked, cleaned, and separated again into thinner strips. Depending on the thickness of the original strip, this process can occur several times, each yielding thinner and finer “ribbons” of wood.

Larger strips are used to form the basket’s base and sides. Thinner strips, or weavers, are used to weave the basket’s bottom and sides. Black ash baskets have a rich tradition. Ash baskets make excellent pack baskets and were likely used to transport goods by the voyageurs. Ash baskets bring high prices in the marketplace: large baskets can cost thousands of dollars. Basketry is not a quaint relic of the past. Today, people use this early technology to create and sustain forest-based enterprises.

For further information on Cultural Significances of Ash, see Appendix D, page 66

The Emerald Ash Borer

A little package carrying big trouble

Emerald ash borer (EAB) is a non-native insect that kills ash trees; it was found in St. Paul and near Houston County, Minnesota in 2009. EAB is the focus of efforts to guide management of ash stands on public and private forested lands. The discovery of this invasive insect in Minnesota is one of the main reasons this Guide was developed.

Life cycle

Emerald ash borer starts out as a flat, rust-colored egg, just a smidge bigger than the period at the end of this sentence. A single female will lay 80 eggs or

so on the bark of ash trees in summer.

A lanky white larva emerges, burrows into the bark, and begins eating tissues between the sapwood and bark. In the process, it cuts off the conduits that carry nutrients from roots to leaves and sun made sugars from leaves to the rest of the tree. It will feed and grow all summer.

The next spring the larva morphs into a pupa. In early summer the pupa develops into an adult beetle. Two or three weeks later, the beetle bores out of the bark, leaving a telltale D-shaped escape hole. Preparing to overwinter, a larva chews a shallow hole in the sapwood (< 1/2 inch deep). Newly emerged adults



Photo: Jeff Hahn

Adult EAB (actual size
1/3 - 1/2 inch)



Emerald ash borer shown in ash tree; size compared with a man's finger.



Serpentine larval galleries exposed by woodpecker activity.



Actual EAB larvae inside ash tree.



Thinning foliage in crown of ash tree.



"D" shaped exit hole of EAB shown on bark of white ash.

feed on ash leaves for a few weeks before mating and starting the cycle again.

Infestations can be recognized by dead and dying trees that have *serpentine galleries* on the surface of the sapwood of branches and stems, D-shaped exit holes in the bark and signs of woodpecker attack such as stripped bark on branches and stems. Eventually twigs, branches, and ultimately the whole tree dies.

Adult females can re-infest the tree or fly to a new location. Natural spread may occur up to four miles per year. An infested ash stand can be 96% dead in six years.

What you need to know

EAB kills ash trees and it does so in great numbers. Already it has killed millions of ash trees in North America. EAB will have a huge effect on Minnesota's landscape and the 937 million ash trees that grow in our cities and forests.

- You can expect EAB to spread throughout Minnesota, eventually; it may take decades.
- EAB kills all species of ash trees in Minnesota: black, green, and white.
- EAB kills 99% of North American ash trees.
- There are some trees with resistance to EAB located in China.
- Cold temperatures in Minnesota may slow EAB down, but will not eliminate them.
- Planning ahead and managing ash before EAB arrive will give you more time and will help keep your land forested.
- Natural enemies of EAB exist in China; some of these insects are being released in Minnesota to help slow the spread of EAB.
- Recognize the signs and symptoms of an EAB infested tree: heavy woodpecker activity on tree, dying branches in the top canopy, *sprouts* around the tree base, vertical cracks in the bark, S-shaped tunnels under the bark, and 1/8 inch D-shaped exit holes in the bark.
- If you have ash trees on your property, now is the time to plan for a future with fewer ash trees.



Photo: DNR

Heavy woodpecker activity on a tree is often a sign of EAB infestation.

GLOSSARY

serpentine galleries: Trails that wind and twist, like a snake.

sprouts: Shoots arising from the base or sides of a woody plant.

Do NOT transport firewood!

Do not transport firewood, even within Minnesota. A major culprit in spreading EAB and other insect pests is firewood. Larvae and pupae can hide beneath the bark and then escape as adult beetles after being transported many miles. Look at the map on page 28 of where EAB has been found. How did it hop from one state to another? Many of the places where it was found are parks and campgrounds. People carried EAB with them when they brought firewood on a picnic or camping trip.

What About the Cold?

Scientists are still studying EAB's winter survival in northern Minnesota. People with significant amounts of ash should not dismiss the threat of EAB,

regardless of where their stand is located. However, data from 2009-2010 field season shows evidence that winter survival of EAB is poorer in northern areas, and

Survey Recommendations about EAB cold hardiness

More research is needed on the hardiness of EAB; however there is enough uncertainty that landowners should know EAB may spread more slowly in northern MN. Based on preliminary research, EAB survival in northern Minnesota will be lower than in southern Minnesota and will likely reduce population buildup and spread of EAB. One genetics expert pointed out, "There is evidence to suggest that winter survival of EAB in northern MN could be expected to be lower than in southern MN. That says nothing about how lower survival rates may impact spread of the adults." "Natural spread is not the primary (or sole) issue of concern." Also according to a silviculturalist, "It's always true that bugs reproduce less in colder areas, but EAB lives in some areas in China that are much colder than MN (even northern MN), and some fairly mild areas. However, the bug might be able to undergo selection for cold tolerance in several generations, and climate change might also come into play."

Ash management recommendations should be based on the distance to a known EAB infestation. One word of caution from a harvesting expert is "please consider proximity to major roads of people moving in from EAB occupied zones. And hardiness information as it becomes more available from places like Michigan." One entomologist also pointed out that shifting climate patterns may alter EAB spread for various locations throughout the state. If management zones are desired, create them based on proximity to known EAB locations and likely next occurrences. Thoughts from another entomologist are, "the distance to a known EAB infestation and hardiness zone information right now should only affect the urgency for doing something, not the types of management recommendations. Hardiness of EAB in northern Minnesota should only influence the urgency of doing something not what is actually done."

In addition to hardiness, research about EAB and black ash may also affect future management recommendations. An important point to remember that is because EAB is a relatively new exotic pest our knowledge of the insect and our management or control recommendations will change over time, and sometimes this may change quite rapidly." Another comment from an entomologist, "I am also somewhat reluctant because we were told that Dutch elm disease wouldn't be a problem in northern Minnesota and that gypsy moth would not be as much of a problem in northern Minnesota as in southern Minnesota. Insects and diseases have a way of surprising us." Another recommendation from the panel of experts is that ash management recommendations should be based on both distance from a known EAB infestation AND hardiness zone information.

will likely reduce population build-up and the spread of EAB.

It is also VERY important that landowners stay abreast of this research as the results may have drastic impacts on ash management in northern Minnesota.

Landowners should consider both the distance their land is from a known EAB infestation, likely EAB introduction sites (possibly along roads), as well as information from the newest research in EAB cold tolerance.



Photo: clgregor

Preliminary data suggests that EAB survival may be lower in northern Minnesota than in southern Minnesota because of extremes in low temperatures in the north.

What do I do if my trees become infested?

If your ash tree is infested with EAB or is showing other signs and symptoms, visit the University of Minnesota Extension
Web site: www.extension.umn.edu/issues/eab/

To report a possible EAB infestation, contact the **Arrest the Pest Hotline** at arrest.the.pest@state.mn.us, 651-201-6684, or 888-545-6684.

Consider insecticide treatments only when your property is within 15 miles of an EAB infestation.

GLOSSARY

phloem: A layer of cells just inside the bark of plants that conducts food from the leaves to the stem and roots.

Manage ash trees to keep EAB populations low

Emerald ash borer is considered a **phloem**-feeding insect. Phloem tissue is basically the inner bark in trees. A single large tree will have much more phloem tissue than a small tree simply because of its greater bark surface area. We can estimate how much phloem tissue is available on any given acre by counting the number of ash trees and their size.

The amount of phloem available will dictate how many emerald ash borer offspring could be produced in any given area. The concept is actually quite simple, the more food that is available for emerald ash borer larvae, the greater the number of offspring that can be produced.

Ash phloem reduction is an attempt to reduce the amount of food available to EAB. A lack of food could limit how quickly an EAB population expands.

Phloem reduction is generally recommended near locations where EAB is newly introduced and would generally be considered an EAB management strategy not necessarily an ash manage-

Survey Recommendation

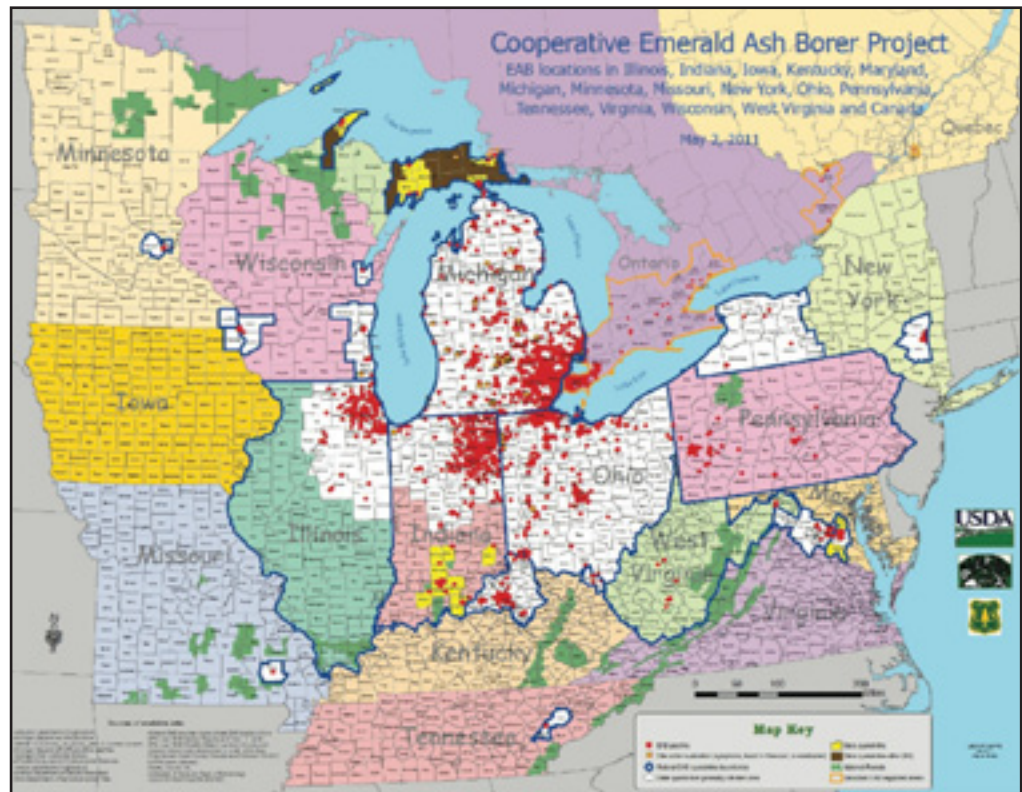
Ash phloem reduction strategy is meant for EAB management not ash management, but it could be considered when managing these stands as one of many considerations.

ment strategy. Many stands in the wet forest and floodplain forest types have large amounts of ash and therefore large amounts of ash phloem. This makes them highly vulnerable to EAB once the insect does arrive in the area.

Therefore, some professionals suggest that forest management in these areas might include some level of ash removal and replacement with other site appropriate species as a stand management tactic that could also accomplish long term phloem reduction on those sites.

Emerald ash borer locations in Midwest and eastern states.

Key:
Red dots = positive for EAB
Blue outlines = federal quarantine area



The Native Plant Communities

The Minnesota Department of Natural Resources and the U.S. Forest Service have developed a system of classifying areas of land that display similar ecological features. The system helps land managers and researchers identify, describe, and map a unit of land that has uniform ecological features.

The system uses associations of *biotic* and environmental factors, for instance: climate, geology, topography, soils, *hydrology*, and vegetation to come up with ecological patterns for areas as large as North America or as small as a single timber stand.

Following are descriptions of the five systems in which ash in Minnesota will occur. A more common term for these ecological systems is '*native plant com-*

munity.' We will use the term "native plant community" in this guide, instead of ecological classification system. Read on for a more in-depth description of a native plant community.

What is a native plant community?

The purpose of this classification is to help land managers make decisions and understand how native ecosystems function. Nearly all land management activities affect vegetation and the native vegetation provides important clues as to the potential that land has to provide timber, wildlife habitat, and recreational opportunities. Equally important, the Native Plant Community (NPC) classification tells land managers about critical habitats that Minnesota's rarest plants

GLOSSARY

biotic: Pertaining to living organisms and their ecological and physiological relations.

hydrology: The study of the movement, distribution, and quality of water on Earth and other planets, including the hydrologic cycle, water resources and environmental watershed sustainability.

native plant community: A native plant community is a group of native plants that interact with each other and with their environment in ways not greatly altered by modern human activity or by introduced organisms. These groups of native plant species form recognizable units, such as oak savannas, pine forests, or marshes that tend to repeat over space and time. Native plant communities are classified and described by considering vegetation, hydrology, landforms, soils, and natural disturbance regimes.

Identifying Your Native Plant Community

There are many kinds of vegetated areas that are not native plant communities. These include places where native species have largely been replaced by exotic or invasive species such as smooth brome grass, buckthorn, and purple loosestrife. Also, planted areas such as orchards, pine plantations, golf courses, and lawns are not native plant communities.

Areas not considered to be native plant communities include areas where modern human activities such as farming, overgrazing, non-sustainable logging, and development have destroyed or greatly altered the vegetation.

Photo by Muffet



and animals need to survive into the future. In this Guide, the NPC classification is used as a framework for organizing thoughts and facts that concern the ash resource. The classification is used to help landowners understand why ash trees grow where they do and to provide guidance on management strategies.

For some Systems, there is much to do; for others, there is little that we can do.

So, what is a native plant community? A native plant community is a group of native plants that interact with each other and with their environment in ways not greatly altered by modern human activity or by introduced organisms. These groups of native plant species form recognizable units. For instance, if you were walking through a woodland, you might immediately identify that you were walking through an oak savanna, a pine forest, or maybe sloshing through a marsh.

Hydrology and Minnesota Native Plant Communities

Soil moisture in forest soils is defined by conditions during the summer growing season. The order from dry to wet in forests dominated by ash or with a significant component of ash is: Fire-Dependent, Mesic Hardwood, Floodplain Forests, Wet Forests, and Forested Peatlands. Floodplain Forests are, of course, flooded during the spring runoff period and occasionally during other times; however, in most years during the summer months, soils are less wet than summer soils in the Wet Forest system where mucks, peats, clays, and high water tables maintain wet-mesic to wet soil moisture regimes. Floodplain Forest soils tend to dry some as the water level in the river drops from flood stage (bankfull) to summer, low flow conditions. The average position of the growing season water table below the soil surface also determines the tree species and herbaceous species associated with ash. Forested peatlands are wet year round because of restricted outflow from the peat basin. Peatlands with the highest peatland slopes

Native plant communities are named for the characteristic plant species or for a characteristic environmental feature contained within them. Examples of native plant communities in Minnesota include Dry Barrens Oak Savanna, Red Pine-White Pine Forest, Bulrush Marsh, Sedge Meadow, and *Mesic* Sandstone Cliff. For purposes of this Guide, you should know that ash will potentially be found in one of five native plant communities or systems.

Two systems: Forest Rich Peatlands and Fire Dependent typically contain minimal ash, but were included in the survey so are included here. The five systems, or native plant communities, are:

- Wet Forest System
- Floodplain System
- Mesic Hardwood System
- Forested Rich Peatland System
- Fire Dependent System

have the tallest trees because the down slope movement of water is quickened and the peat soil is thus better aerated during the summer growing season.



Photo: MN DNR

Page 30: Floodplain Forest System, Somerset Wildlife Management Area

Photo: Brian Lockhart, USDA Forest Service, Bugwood.org

GLOSSARY

Mesic: Sites or habitats characterized by intermediate moisture conditions.

Green ash leaflet, showing the compound leaf

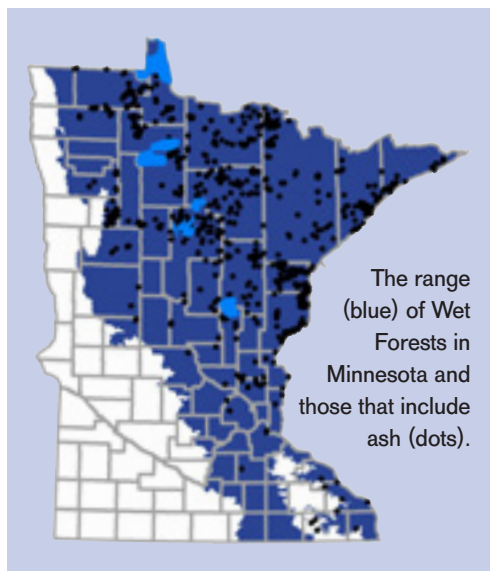
Wet Forest System

Ash in the Wet Forest System

GLOSSARY

pure stands: Forest, crop, or stand composed principally of one species, conventionally at least 80 percent based on numbers, basal areas, or volume.

Red-osier dogwood is an indicator of the Wet Forest System.



Wet Forest (WF) communities occur commonly in narrow zones along the margins of lakes, rivers, and peatlands; they also occur in shallow depressions or other settings where the water table is within reach of plant roots. The supplies of groundwater and runoff typically are at their peak early in the spring and then diminish throughout the growing season. The contribution of runoff to these systems is greatest in northeastern Minnesota; it lessens in the southwest to the point where wet forests there are fed entirely by upwelling groundwater. Black ash acts like a hydrologic pump, lowering the water table as summer progresses. *The seasonal variability in soil moisture is a hallmark of the WF System.* This variability controls the availability of the oxygen. This oxygen is essential for:

- roots to respire;
- decomposition of organic litter; and

- release of nutrients in forms that are usable by plants.

This physical environment is problematic for most of Minnesota's trees, except for ash and northern white cedar. Consequently, it is specifically these two species: ash and white cedar, that tend to dominate WF sites. Oftentimes, they are found as **pure stands** of those species. All plant communities designated as "WF" sites have some ash regeneration, and over 75% have ash trees in the canopy. Black ash is the WF specialist, occurring in 69% of all wet forests, and the average stand is 36% black ash trees.

Common Trees:

- Black ash
- Northern white cedar
- Green ash
- Balsam fir



Photo: Paul Wray/Iowa State University, Bugwood.org

Wet Forest System

- American elm
- Red maple

Understory species:

- Rough alder
- Mountain maple
- Beaked hazelnut
- Red-osier dogwood
- Swamp red current
- Red raspberry

Green ash occurs in 9% of wet forests and comprises 11% of the trees when present. White ash does not occur in wet forests. In addition to ash and cedar, wet forests are usually mixed (83%) with some other trees. Balsam fir, American elm, and red maple are the most important species to also occur in wet forests.

The ground in wet forests is covered with a luxurious growth of herbaceous plants that is usually dominated by either ferns or grass-like plants.

Herbaceous plants:

- Lady fern
- Oak fern
- Shield fern
- Crested fern
- Woodland horsetail

Grasses & Sedges:

- Bluejoint grass
- Graceful sedge
- Bristle-stalked sedge
- Bladder sedge
- Long-stalked sedge
- Awl-fruited sedge

Wildflowers:

There are two distinct seasons for wildflowers in wet forests – spring and fall.

In the spring, plants adapted to waterlogged soils thrive. Most noticeable are the yellow cowslips that define the extent of wet forests on the landscape and lend the first blush of color to a brown world recovering from winter. Annual plants that have waited all season



Photo: J.C. Lucier

Lady fern

for the soils to dry can dominate the fall wet forest. The most common are:

- Jewel weed
- Beggar's ticks
- Dwarf raspberry
- Naked miterwort
- Alpine enchanter's nightshade
- Sweet-scented bedstraw
- Common strawberry
- Canada mayflower
- Bunchberry
- Water horehound
- Goldthread
- Red-stemmed aster

Wet forests are Minnesota's most diverse kind of forest. On average, 50 different species of plants can be found in an area the size of an urban back yard; it is not uncommon to find more than 100 species. There are three reasons for this diversity. First, wet forests are often linear inclusions in uplands and some terrestrial plants find refuge in the driest habitats available in wet forests, but many wet forest plants can't tolerate upland conditions. Second, wet logs, pools of water,

Wet Forest System

Wet Forest



Photo: Juile Miedtke

raised tree bases, moss clumps, and tip-up mounds provide a great diversity of plant habitat at a fine scale. Third, as mentioned before, wet forests undergo a major change in plant habitat throughout the

season from waterlogged in the spring to rather dry in the fall. Some rare plants and animals are dependent upon wet forest habitat in Minnesota. Be wary of invasive plants and weeds in wet forest sites.

Hydrology in Wet Forest Systems

Wet Forest and Forested Peatland systems have shallow wet soils with limited water flow rates in the upper soil horizons. In these forest systems, two primary goals of any forest harvest are (1) protection of the limited soil pore space and water flow rate that exists and (2) perpetuation of the forest canopy so that maximum evapotranspiration occurs on these sites. Rutting on these sites further diminishes water flow, keeps soils colder into the growing

season, and brings the water table closer to the surface. It is not unusual for badly rutted sites in these systems to become dominated by grasses, sedges, and cattail with the exclusion of trees. Forest harvest should target perpetuation of late-succession forest canopies in the 80 to 100% range and should be done only on frozen or dry soils. It should be noted, that deep snow packs over unfrozen soils will not prevent soil compaction and rutting.

Wet Forest: Dieback and decline

Emerald Ash Borer or Dieback-which is it?

Many hardwood tree species have experienced periods of branch *dieback*, often called “decline.” Symptoms include slow growth, thin crowns, and misshapen or discolored leaves. Characteristic of these decline episodes is that one single ‘cause’ of the decline cannot easily be identified. Instead, evidence suggests that trees have been stressed and were then invaded by one or more organisms that are not normally damaging to those trees. Biotic agents such as defoliating insects or *abiotic* factors such as severe drought can predispose trees to a number of pathogenic organisms that further damage trees. However, not all affected trees will die. Once the stress is removed, many trees are able to regain normal vigor and growth.

Dieback of black ash is an example of a condition affecting trees in many areas of the Lake States and especially in northeast and north central Minnesota. For years, dieback, thin crowns, and in some stands – tree mortality have been observed. Adding to the appearance that this species is in decline is that black ash has a late *leaf*

flush and early leaf fall, therefore the trees seemingly never have full, vigorous crowns.

In recent studies, it has been found that the most seriously affected trees were nearest to roads and on the wettest sites; even then, tree mortality was relatively low. No causal agent was found affecting trees with dieback, and on many trees crown recovery (multiple years of new branch growth) was occurring.

Distinguishing between the symptoms of decline or crown dieback and EAB is extremely difficult and critical.

Landowners, especially those in the northern Wet Forest (WF) systems are encouraged to work with professional foresters to diagnosis, monitor, and carefully manage these sites.

Epicormic branching: Erratic growth from *adventitious* buds sprouting on trunks of trees may indicate dieback. It’s a coin toss as to whether the tree is recovering and beginning to rebuild its crown or dying. *Epicormic branching* may also be a symptom of a tree infested with emerald ash borer.



Photo: Juile Miedtke

GLOSSARY

dieback/decline: *The progressive dying from the extremity of any part of a tree.*

abiotic: *Nonliving parts of an ecosystem, such as soil particles, bedrock, air, and water.*

leaf flush: *The time in the season during which leaves appear on a tree.*

crown dieback: *Decline of the branches and limbs in the canopy of a tree sometimes used as an indicator of tree health.*

adventitious: *Pertaining to a plant part that develops outside the usual order of time, position, or tissue — e.g., an adventitious bud arises from any part of a stem, leaf, or root but lacks vascular connection with the pith; an adventitious root arises from parts of the plant other than a preexisting root, e.g., from a stem or leaf.*

epicormic branching: *A shoot arising spontaneously from an adventitious or dormant bud on the stem or branch of a woody plant often following exposure to increased light levels or fire.*

Ash dieback in northern
Minnesota

Wet Forest System

Survey Recommendations: Wet Forest

- If site does not have natural drainage, tree loss is likely to increase water table depth.
- Fire danger will increase when ash sites are replaced with grasses or cattails especially if the late summer or autumn is dry; fire intensity will increase.

Harvesting Wet Forest sites is very sensitive and extreme care should be taken when considering such an activity. Harvest when ground is frozen or dry. Clearcutting is not recommended. However several experts commented that strip or patch cuts may be appropriate especially when dealing with stands mixed with conifers.

Use harvesting methods appropriate to allow for desired regeneration. Consider ash phloem reduction thinnings in conjunction with a sound regeneration plan and when EAB is known within 15 miles of a site. According to one silviculture expert, "Use what works. You still have to deal with high water tables, EAB or not." Expect increasing water tables after ash has died or is harvested.

Because of the degree of uncertainty, new silvicultural practices need to be explored for Wet Forest stands because of EAB. According to one expert panelist in Ecosystem Classification System, "The concern is greatest in Wet Forests where black ash is dominant. The collapse of a local, dominant population will leave considerable niche-space open for other plants. Unfortunately, this will not always be trees. Only white cedar is similarly adapted to wet forest sites and regeneration of cedar has been nearly non-existent due to deer depredation and adequate safe sites for seedling germination and survival. In all other systems, there are other trees that can fill the niche void when ash die."

Regeneration strategies could include both natural colonization and planting. It was noted that regeneration in these stands can be tricky because of stand hydrology, so attention to micro sites and persistence will be important.

Recommended replacement trees, as ranked by the experts:

Northern Wet Forest:

(11 out of 21 species)

- Tamarack
- White cedar
- American elm (disease resistant)
- Black spruce
- Balsam poplar
- Yellow birch
- Balsam fir
- Red maple
- Quaking aspen
- Ash (for genetic material)
- Silver maple

Southern Wet Forest:

(10 out of 21 species)

- American elm (disease resistant)
- Silver maple
- Basswood
- Red maple
- Willow
- Bur oak
- Yellow birch
- Ash (for genetic material)
- Box elder
- Red elm

Opposite page: General decline in wetland black ash near Cloquet, Minnesota



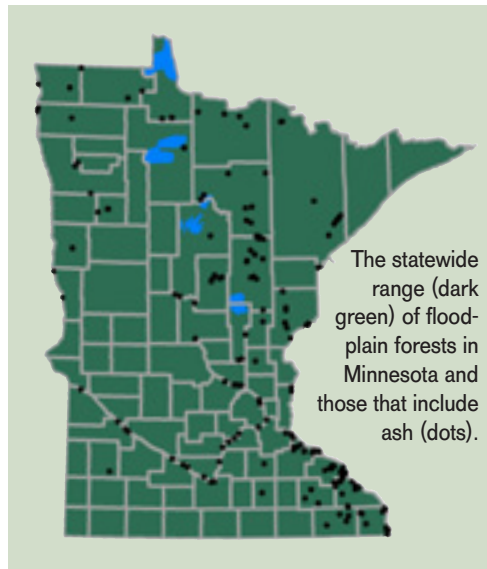
Floodplain
Forest System

Ash in the Floodplain Forest System

GLOSSARY

floodplains: The level or nearly level land with alluvial soils on either or both sides of a stream or river that is subject to overflow flooding during periods of high water.

riverine: All wetlands and deep water habitats contained within a natural or artificial channel that periodically or continuously contains moving water, or that forms a link between two bodies of standing water.



The Floodplain Forest (FF) occurs on **floodplains**, creek bottoms, and **riverine** terraces. These landforms are essentially flat, following the river's gradient. The soils in a floodplain are developed on river sediment, and the surface is commonly fluted with shallow channels and levees in a complex, swirling pattern. Floodplains are annually inundated by spring runoff; terraces and bottoms are inundated occasionally during flood events. Even at low water, the water table is normally within reach of tree roots, meaning that FF trees must solve the same problem of root respiration as the trees in the Wet Forest Plant Community. FF differ from



Canada moonseed is a plant found in the Floodplain Forest System

Photo: J.C. Lucier

Floodplain Forest System



Photo: Greg Lavaty

The Cerulean warbler has shown the steepest decline of any warbler species according to the Breeding Bird Survey. It has suffered an 83% decline over the last 40 years. The decline is attributed, in part, to the loss of bottomland habitat.

WF because organics (non-living material derived from living organisms) do NOT tend to accumulate on the surface. That means there is a water flow that delivers incredible amounts of nutrients to the FF sites. To live on an active floodplain, a tree must:

- tolerate inundation, root and bole burial by sediments;
- resist erosion;
- survive wounding from ice floes; and
- be able to invade open, fresh-soil habitats.

Common Trees:

- Silver maple
- Green ash
- Black ash (northern MN)
- White ash (southern MN only)

Occasional Tree:

- American elm
- Basswood
- Box elder
- Hackberry

Silver maple is the tree most adapted to Minnesota floodplains and it strongly dominates the forest. However, creek

bottoms, abandoned terraces, and higher *microsites* on the active floodplain approach WF habitat - and ash does well there. Ash seedlings occur in 95% of all FF, and ash trees are found in 88% of them – indicating that the ash has good success at recruiting seedlings to the canopy. Green ash is most common; occurring in 53% of all FF and it contributes 16% of the trees on average. Black ash is frequent; occurring in 38% of all FF, accounting for about 21% of the trees on average.

In general, black ash is more common in northern Minnesota and green ash more common in the south. White ash is limited to southern Minnesota and occurs in just trace amounts on FF sites. In addition to silver maple and ash, most (95%) floodplain and terrace forests are mixed with some other trees.

No Minnesota *conifer* is tolerant of flooding, and thus you will not find them in the FF community. Shrubs and small trees are essentially absent from any surface that floods regularly; rather vines are more likely to be found than are woody understory plants.

GLOSSARY

microsites: A small part of an ecosystem that differs markedly from its immediate surroundings.

conifer: A cone-bearing tree (e.g. pines, firs, spruce, cedars, redwoods, larches etc.).

Chapter 5

The Native Plant Communities

Floodplain Forest System

Vines:

- Wild grapes
- Virginia creeper
- Canada moonseed

Herbaceous plants:

- Ostrich fern
- Wood nettle
- Stinging nettle
- Tall coneflower
- Honewort
- Jewel weed
- Carrion-flower
- Sweet-scented bedstraw
- Side-flowering aster
- Ontario aster
- Kidney-leaved buttercup

Grasses:

- Rice cut grass (native)

- Virginia wildrye (native)
- Reed canary grass (invasive)

Terrace and floodplain forests in particular are not especially diverse communities. On average, 33 species of plants are found in 400m². Because of the abundance of moist mineral soil, a significant portion of the flora consists of germinating plants – many of which will not survive for long. Thus, the average number of persistent plants is rather low, the lowest of any system with ash trees.

Some rare plants and animals are dependent upon floodplain and terrace forest habitat in Minnesota.

Water & Wood: Good & Bad

Riparian forests provide a long corridor for animal habitat and migration. Natural EAB movement will be easiest along riparian corridors, effectively spreading it locally at 2-4 miles per year. Riparian forests are important because they provide shade to cool streams and normal amounts of fallen trees for wood habitat

in the water. This is especially important in sand-bedded streams that lack cobble and gravel sites for spawning, rearing, and invertebrate attachment. These corridors also provide overhead cover.

Wood in rivers is a good thing; however, too much wood can cause silt and fine sand to cover spawning and rearing

Wood jams occur approximately every 300-400 feet on the Rat Root River in northern Minnesota.

Opposite page: Floodplain Forest stand



Photo: Sandy Verry



Chapter 5
The Native Plant
Communities

Floodplain
Forest System

Excessive wood dams or beaver dams occur when early succession forests are perpetuated along streams, or when abnormal tree mortality occurs. This is the Rat Root River in northern Minnesota.

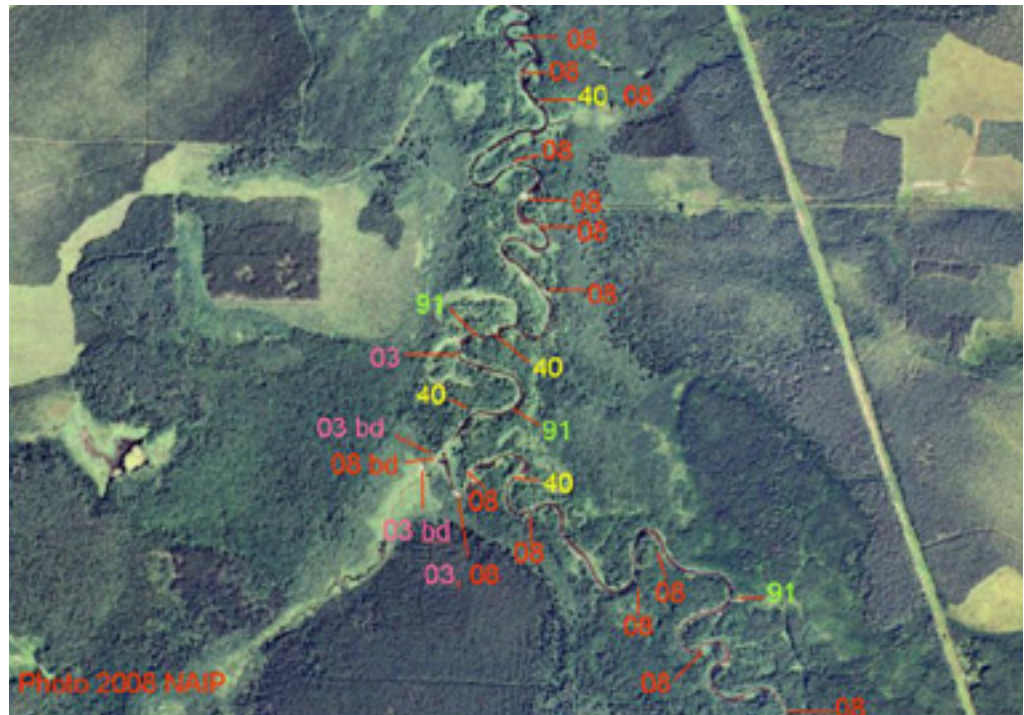


Photo: Sandy Verry

sites and lead to the widening of the river (the water cuts around the jams). Solid jams back up water causing silts and fine sands to deposit over spawning gravels. Over-wide channels also cause excessive deposition of silts and fine sands. Normal wood jams in rivers are a good thing if they occur at normal rates and the jam does not block the river. When wood jams block more than about 1/3 of the cross sectional area of a channel (area from the lowest bank top across the river and back along the channel bottom) they slow the water down and fine sand and silt, normally spit out on the floodplain, is deposited over spawning gravels. Wood jams and low beaver dams that occur every 1200 feet or so are normal; however, when wood jams occur every 300 to 400 feet, they are excessive and spawning habitat is degraded.

Excessive wood jams or beaver dams occur when *early succession* forests are perpetuated along stream corridors or when abnormal (but natural) tree mortality occurs. For example, wood jams occur every 300 to 400 feet on the 25-ft wide Rat Root River in northern Minne-

sota because of the wide spread mortality of elm killed by Dutch elm disease during the 1990s. This can also occur in typical elm-ash-spruce stands along stream corridors if emerald ash borer kills large amounts of ash.

Wider late-successional stands are needed along incised channels

Streams in Minnesota receiving the highest (worst) turbidity classifications are *incised streams*. Normal stream channels have a floodplain on one or both sides. Often where the stream runs up against a high bank on one side (a terrace) it has a lower, floodplain, bank on the other side. Normal streams have access to this floodplain (on one or two sides) during the average spring runoff period when channels usually fill to the top of and just over the lower bank in two out of three years. The bottom of incised channels has down cut (several feet) and flow during the normal spring runoff period does not make it up to the lower bank. In this situation water is trapped in the channel, velocities are high and excessive bank undercutting

GLOSSARY

early succession: The process by which one plant community is gradually replaced by another plant community. This may happen 'early' in the process or 'late,' thus the terms "early succession" and "late succession" are used to describe this process.

incised stream: Slopes along a creek, stream, or river that are eroded in a downward fashion.

Floodplain Forest System

occurs leading to extensive bank failures causing high turbidity levels in the stream water.

Trees can help reduce the amount of bank failure because their roots extend 5 to 7 feet below the bank. They bind the soil and keep the bank drier during the growing season with their high evapotranspiration. Bank failures may extend 10 to some 300 feet away from the river depending on how deeply the river has incised.

Along the Littlefork River in northern Minnesota near the town of Littlefork, the river has downcut nearly 8½ feet and yields one of the highest turbidity ratings in the state. Bank failures along the Littlefork River extend up to 350 feet from the river. Along incised river channels, forests should be managed for late

succession forest stands with near 100% forest canopies. The width of these forests should be about the width of bank failures seen along the channel.

Special wildlife considerations

Species that are most likely associated with the Floodplain Forest include the Cerulean warbler, red-shouldered hawk, red-bellied woodpecker (south expanding north), great blue heron, green heron (more south), blue-gray gnatcatcher (south), prothonotary warbler. Amphibian and reptile species include: blanding's turtle, wood turtle, wood frog, leopard frog, and mink frog. Mammals include the red bat and silver-haired bat. Note that many of these species use other habitats, in addition to the floodplain forest.

Survey Recommendations: Floodplain Forest

Hydrology is impacted more by natural drainage than tree loss. Death or removal of ash will change stream *morphology*. Better water drainage in these sites will promote tree replacement.

When a harvest is viable, *select harvest* may be the best silvicultural practice in the Floodplain Forest. Harvest only when ground is frozen or dry. On quality sites continue to manage for quality ash. On poor sites do not harvest unless a harvest achieves specific objectives. Ash phloem reduction strategy is meant for EAB management not ash management, but it could be considered when managing these stands as one of many considerations.

Recommended replacement trees (as ranked by the experts):

Northern Floodplain Forest

(10 out of 17 species)

- American elm (DED resistant)
- Silver maple
- Basswood
- Bur oak
- Swamp white oak
- Balsam fir
- Box elder
- Cottonwood
- River birch
- Paper birch

Southern Floodplain Forest

(11 out of 17 species)

- Swamp white oak
- Cottonwood
- American elm (DED resistant)
- Silver maple
- Basswood
- Black walnut
- River birch
- Bitternut hickory
- Box elder
- Hackberry
- Rock elm

GLOSSARY

morphology: The external and internal form and structure of whole plants, organs, tissues, or cells.

select harvest: A cutting that removes only a portion of trees in a stand.

Mesic Hardwood
System

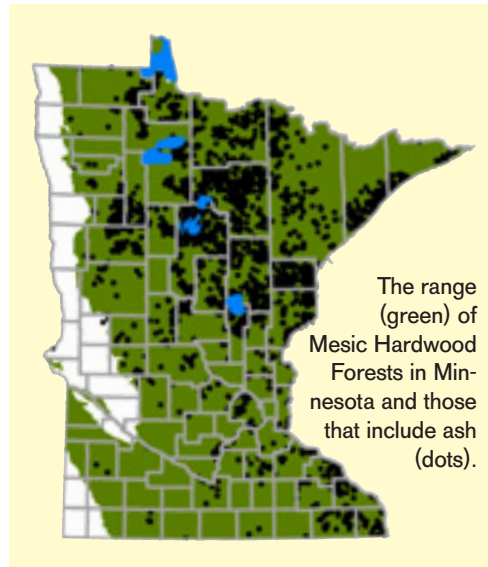
Ash in the Mesic Hardwood System

GLOSSARY

anoxia: Meaning lack of oxygen.

dominant: An individual or species of the upper layer of the canopy.

co-dominant: Defines trees with crowns forming the general level of the main canopy in even-aged groups of trees, receiving full light from above and comparatively little light from the sides.



Mesic Hardwood (MH) forests occur on upland sites with soils that retain water, and in settings where wildfires are infrequent. These forests are characterized by continuous, often dense, canopies of deciduous trees. Beneath the main canopy are successively shorter layers of vegetation, composed of seedlings, shrubs, and herbs that are adapted to a shady environment. Plants in MH communities have access to predictable supplies of water and nutrients, but their growth is limited by a lack of light.

Typical MH sites are buffered from seasonal drought by fine-textured soils that are capable of holding or perching rainfall. At the same time, these soils are well drained. This means the roots of the trees rarely suffer from diminished respiration due to soil **anoxia** (lack of oxygen). Nutrients are rapidly recycled by comparison to the other forest types.

For most of Minnesota, sugar maple and basswood are considered the **dominant** trees on MH sites; however, the

hallmark of these forests is their tendency to be of mixed composition usually involving 4-6 common species. Ash is a fairly common **co-dominant** species of the MH forest. The MH System is the only place where white ash occurs in noticeable abundance. Another important feature of the MH forests is a mixed canopy and high diversity of understory woody plants.

Ash is common, 66% of sites have ash seedlings. Ash occurs as trees on 25% of the sites. In an average stand, about 10% of the trees are ash: green and rarely, white ash which only occurs in southeastern counties.

Common Trees:

- Sugar maple
- Basswood
- White ash
- Green ash
- Black ash
- Ironwood
- Red oak
- Red maple
- Paper birch
- Yellow birch
- Quaking aspen

Shrubs:

- Beaked hazelnut
- Mountain maple
- Chokecherry
- Pagoda dogwood
- Prickly gooseberry
- Downy arrowwood
- Juneberries
- Fly honeysuckle

Herbaceous Layer:

- Lady fern
- Bracken fern
- Rattlesnake fern

Mesic Hardwood System

GLOSSARY

ephemerals: Ephemeral plants are marked by short life cycles, usually 6-8 weeks. Ephemeral means transitory or quickly fading.

Mesic hardwood forests have a diverse array of wildflowers. Some of these plants, the *ephemerals*, make their entire living in a few weeks before and during leaf-out of the maples.

Wildflowers:

- Spring beauties
- Dutchman's breeches
- Wild leeks
- Dwarf raspberry
- Large-leaved aster
- Sarsaparilla
- Yellow & sessile-leaved bellworts
- Canada mayflower
- Early meadow rue
- Clayton's sweet cicely
- Rose twistedstalk
- Hog peanut
- Wild ginger
- Wood anemone
- Yellow violets
- Sweet-scented bedstraw
- Zig-zag goldenrod
- Bluebead lily
- Hairy Solomon's seal

- Maryland black snakeroot
- Hepatica
- Starflower
- False Solomon's seal
- Wild strawberry
- Red baneberry
- Jack-in-the-pulpit
- Bloodroot

Grasses and sedges are not normally abundant and the most common are: Pennsylvania sedge, peduncled sedge, and mountain rice grass. Where exotic earthworms have infested MH forests, Pennsylvania sedge can form large, continuous lawns. Mesic hardwood forests are diverse plant communities. On average, one can find 43 different species of plants in 400m².

Some rare plants and animals are dependent upon mesic hardwood forest habitat in Minnesota.

Earthworms should be considered as a serious threat to native regeneration in the Mesic Hardwood Forest type.



Photo: MN DNR

A Mesic
Hardwood forest

Mesic Hardwood System

A Mesic stand in
early Spring



Photo: Julie Miedtke

GLOSSARY

duff: The partially decomposed organic material of the forest floor beneath the litter of freshly fallen twigs, needles, and leaves.

Earthworms & Ash: Making the Connections

Earthworms may be ‘tool of the trade’ when it comes to fishing Minnesota’s lakes. And they are considered rather good friends in the vegetable garden. However, earthworms are an unwelcome intruder in Minnesota’s hardwood forests.

Minnesota’s mesic hardwood forests developed in the absence of native earthworms. These forests grew after the last glaciers retreated. They contained a thick forest floor that served, and continues to serve as a perfect rooting medium for many species of forest herbs and tree seedlings.

Minnesota has no native earthworms. In the 1800s European settlers arrived, bringing with them European earthworm species in potted plants. European earthworms have been part of the habi-

tats surrounding human habitation ever since. The European earthworm invasion changes the structure of forest soils. The *duff* layer is consumed by the worms so that the seedbed conditions on the forest floor change from deep leaf litter to bare mineral soil during summer. The soil is also compacted, leading to more runoff during heavy rainfall events; the availability of nitrogen and phosphorus is reduced.

Earthworm invasion accentuates the already negative impact of deer browsing on native plant and tree species. Combined, these changes make trees more sensitive to drought, make regeneration of some species like sugar maple and red oak difficult, lead to reduction in the diversity of native plants, and facilitate

Do NOT release earthworms!

Earthworms should be considered as a serious threat to native regeneration in the Mesic Hardwood Forest type. Earthworms are an unwelcome intruder in Minnesota’s hardwood forests.

**Mesic Hardwood
System****GLOSSARY**

Best Management Practices: *BMPs are practical guidelines aimed at lessening non-point source pollution from forest management activities, such as road construction, skid trails, and log landings.*

the invasion of undesirable plants like buckthorn, tatarian honeysuckle, and garlic mustard.

Although it is not possible to reverse the continued migration of the earthworms, there are things people can do to help the forests recover:

1. People have always been told worms are good for the environment, so at the end of fishing vacations they dump the leftover worms near the lake. Don't do this.
2. Replanting native plant species is another way to help forests recover from earthworm damage. Native plants, grown from locally harvested seeds, are now available. Native woodland plant species are becoming available through both public and private sources.

**Hydrology and soil conditions
of Mesic Hardwoods**

Harvests of Mesic Hardwood ash forests should follow Minnesota **Best Management Practices (BMPs)** using either relative dry or frozen conditions that will support harvesting equipment without rutting soils more than 6-inches deep for distances of 100 feet or more. Management on these sites can target a management outcome of early-succession forests (usually beginning with a clear cut and, dominantly, aspen regeneration) developing into late-succession forests (with sugar maple, birch, balsam fir, basswood, white spruce, silver maple and ash) or the perpetuation of late-succession forests.

Survey Recommendations: Mesic Hardwood Forest

Gap phase dynamics will dominate forest regeneration. Ash decline and death will have limited impact on hydrology. One silviculture expert expressed concern about the hydrologic impacts of harvesting due to rutting and compaction in stands with perched water tables.

Ash should be harvested to minimize the impact of EAB in the Mesic Hardwood forest. On quality sites continue to manage for quality ash. Two experts pointed out that these sites are productive with high quality trees that are likely to have the most valuable ash which may also warrant their harvest and more management. Ash phloem reduction strategy is meant for EAB management not ash management, but it could be considered when managing these stands as one of many considerations.

Earthworms and deer browse should be considered as serious threats to native regeneration in the Mesic Forest type.

Recommended replacement trees (as ranked by the experts):

Northern Mesic Hardwood Forest

(11 of 29 species)

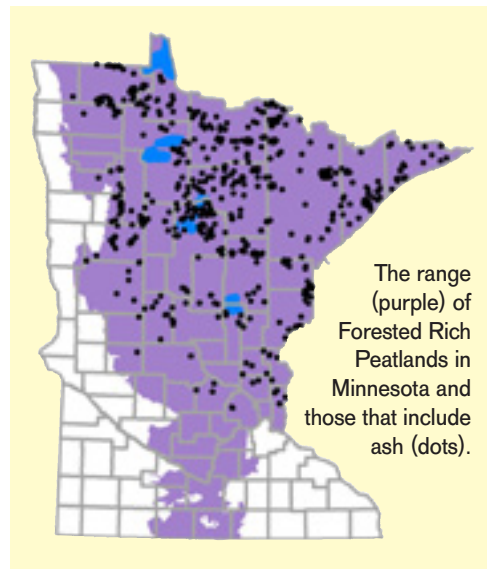
- Basswood
- White pine
- Bur oak
- Northern red oak
- Sugar maple
- American elm (DED resistant)
- Big-toothed aspen
- Quaking aspen
- White spruce
- Paper birch
- White cedar

Southern Mesic Hardwood Forest

(10 out of 29 species)

- Northern red oak
- White oak
- American elm (DED resistant)
- Bitternut hickory
- Black cherry
- Shagbark hickory
- Black walnut
- Bur oak
- Sugar maple
- Basswood

Ash in the Forested Rich Peatland System



Forested Rich Peatland (FP) forests are dominated by conifers, tamarack, northern white cedar, black spruce, and balsam fir. They occur on organic soils that are deep, actively forming peat. Sphagnum moss is the principle

peat-forming plant, although the woody remains of trees and shrubs contribute significantly to peat volume. Peat forms because FP sites are continuously waterlogged. By comparison to the atmosphere, water offers very little of the oxygen that is needed to decompose plant remains - thus the buildup of organic peat. Furthermore, Sphagnum moss depletes the groundwater of its dissolved nutrients, leaving the site acidic and so poor that the site cannot sustain large populations of decomposing microbes even though there is a large supply of "food." FP sites are, in general, poor habitat for ash trees. Like many environments, ash seedlings are fairly common, appearing in 31% of all FP forests. But, the chances of growing into a tree are slim - just 4% of FP forests actually have ash trees and, when present, they account for only 4% of the trees. Achieving tree status probably occurs on microsites where the peat is thin enough

Survey Recommendations: Forested Rich Peatlands

There will be minimal effect on Forested Rich Peatland Systems because conifers will continue to dominate these stands. Harvest when ground is frozen or dry; however, ash is too small a component of the forested rich peatland system to manage for its replacement.

Recommended replacement trees (as ranked by the experts):

Forested Rich Peatland (north only): 10 out of 11 species

- Black spruce
- Tamarack
- White cedar
- Balsam fir
- White spruce
- American elm (DED resistant)
- Paper birch
- White pine
- Quaking aspen
- Red maple

**Forested Rich
Peatland System**

Bunchberries are indicator plants of the Forested Rich Peatland System.

for ash roots to reach mineral soil. Nearly all occurrence of ash on FP sites is black ash. Green ash is rare and white ash doesn't occur in the northern part of the state where Minnesota has its peatlands. Diversity in FP forests is 40 species in 400m². Some rare plants and animals are dependent upon forested rich peatland habitat in Minnesota.

Common Trees:

- Tamarack
- Northern white cedar
- Black spruce
- Balsam fir
- Paper birch
- Red maple
- Black ash

Tall shrubs:

- Rough alder
- Bog birch
- Red-osier dogwood
- Alder-leaved buckthorn

Half-shrubs:

- Labrador tea
- Creeping snowberry
- Cranberries
- Mountain fly honeysuckle
- Red raspberry
- Velvet-leaved blueberry

Ferns:

- Marsh fern
- Crested fern
- Shield fern

Wildflowers:

- Dwarf raspberry
- False Solomon's seal
- Bunchberry
- Naked miterwort
- Starflower



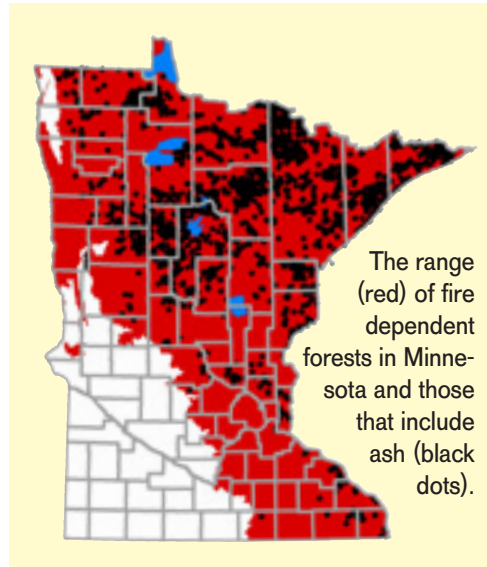
Photo: Joy Viola/Northeastern University, Bugwood.org

- Goldthread
- Canada mayflower
- Cowslips
- Twinflower
- Tufted loosestrife
- Sweet-scented bedstraw
- Marsh cinquefoil
- Water horehound
- Red-stemmed aster
- Marsh bellflower
- Willow-herbs
- Great water dock

Grasses & Sedges:

- Bluejoint
- Fowl manna grass
- Soft-leaved sedge
- Bristle-stalked sedge
- Three-fruited bog sedge
- Interior sedge
- Poor sedge

Ash in the Fire-dependent System



Many forest types, like jack pine savanna are fire-dependent. The only way to maintain these types on the landscape is by reintroducing fire.

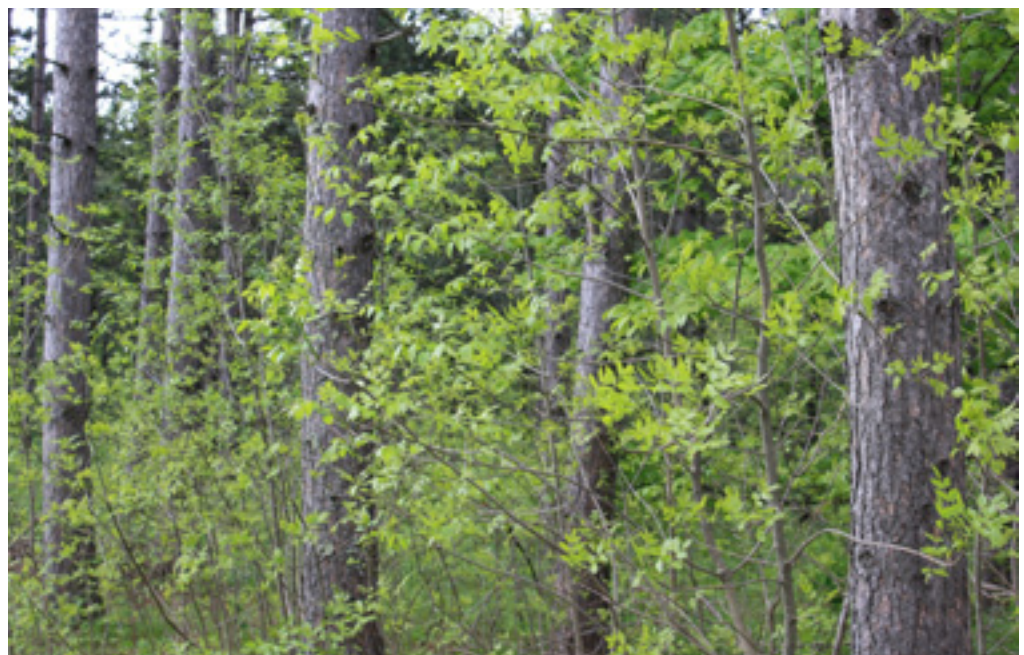
Fire-dependent forest and woodland

communities (FD), as the name implies, are strongly influenced and shaped by wildfires. Fire is important because it is the main source of mortality that selects among the species and causes the forest to regenerate. Fire is the principal means of releasing nutrients and reducing carbon stores. It does this in a way that is episodic and unpredictable when compared to systems that are adapted to annual cycles of nutrient availability. Fire creates situations where nutrients are lost rather permanently from sites by leaching them below the rooting zone and by lateral transport to wetlands, lakes, or streams.

FD communities occur on sites that cannot retain very many nutrients or much water, and fires contribute further to this by producing *hydrophobic* (water-repelling) compounds that end up in the soil. The plants that live in these communities are obviously able to survive fires

GLOSSARY

hydrophobic: Having little or no affinity for water molecules.



Red pine stand with ash in understory.

Photo: Julie Miedtke

**Fire-dependent
System**

and re-colonize a burned landscape.

Ash is poorly adapted to fire and the nutrient-poor soils of FD sites. However, fire-suppression efforts have opened FD sites to modest invasion by ash. About 20% of all FD forests have ash regeneration, but just 3% have ash trees – meaning that recruitment is poor. When present, ash trees account for about 8% of the trees on FD sites. Green ash is the most successful species in FD forests, with regeneration in 15% of the sites. As a tree, it occurs in 3% of FD forests and about 16% of the trees are ash when it is present. White and black ash occur in trace amounts on FD sites.

Common trees:

- Jack pine
- Red pine

- White pine
- Quaking aspen

Shrubs:

- American hazelnut
- Poison ivy
- Tall blackberry
- Sand cherry
- Wintergreen
- Prairie willow
- Wild rose
- Juneberry
- Grey dogwood
- Snowberry
- Pipsissewa
- Bearberry

Herbaceous plants:

- Common oak fern
- Running clubmoss

Survey Recommendations: Fire-dependent System

The effect of ash mortality due to EAB will be minimal in Fire-Dependent System. On quality sites continue to manage for quality ash. Gap phase dynamics will dominate regeneration. In areas in close proximity to EAB do not assume an unlimited number of growing years for ash trees. Reduce the ash component to less than 20%. Ash should be scattered throughout the stand rather than having areas with high densities of ash. Prepare for replacement to invasive species, for example buckthorn.

Recommended replacement trees (as ranked by the experts):

Northern Fire Dependent

(10 out of 31 species)

- Jack pine
- White pine
- Northern pin oak
- Quaking aspen
- Bur oak
- Northern red oak
- Paper birch
- White oak
- Big-toothed aspen
- Red pine

Southern Fire Dependent

(10 out of 31 species)

- Northern red oak
- Northern pin oak
- Black oak
- White oak
- White pine
- Bur oak
- Shagbark hickory
- Black cherry
- Jack pine
- Bigtoothed aspen

Chapter 5
The Native Plant
Communities

**Fire-dependent
System**

- Ground pine
- Lady fern

Grasses and Sedges:

- Bluejoint grass
- Big bluestem
- Slender wheatgrass
- Poverty grass
- Fringed brome

Wildflowers:

- Sweet coltsfoot
- Blue giant hyssop
- Northern bedstraw
- Hoary puccoon

- Wild bergamot
- Wood betony
- Lead plant
- Pale vetchling
- Veiny pea
- Pale bellwort
- Starry false Solomon's seal
- Yarrow
- Pussytoes
- Spreading dogbane
- Cow wheat
- Bastard toadflax
- Tall meadow rue



Black ash-conifer swamp located in Big Island Scientific and Natural Area, Pelican Lake in St. Louis County.

Photo: DNR/Kurt Rusterholz

A general overview of ash species dominance in Minnesota's forest systems

| | Wet Forest system | Floodplain Forest system | Mesic Hardwood system | Forested Rich Peatland system | Fire-Dependent system |
|--|--|--|---|---|---|
| Main tree species in system | Green and black ash, northern white cedar. Sometimes balsam fir, American elm, red maple. | Silver maple, American elm, green ash, black ash, hackberry, basswood, boxelder, white ash. | Sugar maple and basswood, paper birch, quaking aspen, red oak, yellow birch, white ash, green ash, black ash, ironwood, red maple. | Lowland conifer dominated; tamarack, northern white cedar, black spruce, balsam fir, paper birch, red maple and black ash common, but considered to be 'misplaced' or 'off site'. | Predominately upland conifers. Jack, red, and white pines, quaking aspen, paper birch, white spruce, bur oak, northern pin oak, northern red oak, bigtooth aspen, red maple. Some balsam fir. |
| Ash species and its dominance | Ash and white cedar dominate these sites. All sites have ash regeneration and 75% have ash trees on them. In an average stand, ash contributes 34% of the trees. | Ash seedlings occur on 95% of the sites. Ash trees are found on 88% of the sites. Green ash accounts for 16% of the trees. Black ash, in the north, accounts for 21% of the trees. | Ash is common. 66% of sites have ash seedlings. Ash occurs as trees on 25% of the sites. In an average stand, about 10% of the trees are ash; green, black and, rarely, white ash which only occurs in the southeastern counties. | Poor habitat for ash. Its presence is likely where ash roots can reach the mineral soil. Seedlings are common but only 4% make it to tree size. | Historically, ash was very infrequent. With fire-suppression in the last century, ash has an increased its presence. Primarily green ash. 20% of sites have ash seedlings but only 3% have ash trees. |
| Characters that shape this system | Found along margins of lakes, rivers and peatlands. Stands can also occur in shallow depressions where the water table is high. Water peaks in the spring and decreases in depth throughout the summer. This seasonal variability of water is the hallmark of the wet forest system. | Regular inundation by spring floods. Commonly found on flat lands along streams and rivers. Tree stems and roots must withstand a lot of mechanical damage. | Wildfires are very infrequent. The limiting factor is sunlight because the canopy is continuous, dense, and multi-layered. | Occur on deep and actively forming peat. Sphagnum moss is most common peat former. | Wildfires kill trees, set conditions for regeneration, episodic release of nutrients over decades of time. |
| Soils | Soils are under water or saturated during the growing season. This limits the oxygen and nutrient availability and the rate of decomposition. So a mucky layer is created on the surface of the soils. Peat, if formed, only reaches a depth of 10 to 40 inches. | Lots of nutrients are deposited in soils with each flood. Mucky layers do not accumulate on the soil surface. | Soils are able to retain water so many tree species can grow there. Nutrients are rapidly recycled. | Deep peat soils. Soils are so they are acidic, have low oxygen and are poor in nutrients. | Dry soils that are nutrient poor due to a long history of wildfires. Nutrients also lost through leaching down into the soil. |
| Shrubs and vines | Rough alder Mountain maple Beaked hazelnut Red-osier dogwood Swamp red current Virginia creeper Dwarf raspberry | Wild Grape Virginia creeper Canada moonseed <i>Note:</i> <i>Shrubs are generally absent from floodplain forests.</i> | Beaked hazelnut Mountain maple Chokecherry Pagoda dogwood Prickly gooseberry Downy arrowwood Juneberry Fly honeysuckle | Rough alder Bog birch Red-osier dogwood Cranberry Labrador tea Creeping snowberry Mountain fly Honeysuckle Alder-leaved buckthorn | American hazelnut Poison ivy Tall blackberry Sand cherry Wintergreen Prairie willow Wild rose Juneberries Grey dogwood Snowberry |
| Ferns and related | Lady fern Ostrich fern | Ostrich fern | Lady fern Parsnip fern | Marsh fern Crested fern | Lady fern Crested fern |

This is your field copy – take it with you into the woods and ID your ash system.



Wildlife Among the Ash



GLOSSARY

cavities: Holes in trees sometimes used for nesting and reproduction by wildlife species, most frequently birds or small mammals.

For more information on rare species on your property, see Appendix C, on page 65.

Moose are one mammal species found in ash systems

Ash stands and ash trees are used by a variety of wildlife species including large and small mammals, birds, reptiles, and amphibians. When ash stands and trees are older, they provide value as feeding sites for woodpeckers, nuthatches, and chickadees.

Cavities in these same trees, when found near permanent wetlands, are also used by several species of waterfowl including wood ducks, hooded mergansers, and goldeneyes.

In northern Minnesota, large cavities may also be used by fisher as den sites. Several species of birds use ash stands

as nesting sites including great blue and green herons, and Cerulean warbler. Birds, however, tend to be linked to habitat type not tree species so while birds may be temporarily impacted by the loss of ash, they are likely to adapt and move to other trees in the surrounding area. As younger trees or stands, ash is an important source of food for white tailed deer and moose. Forest landowners should manage for a variety of age classes when managing their ash resource because of the various values those resources provide in different age classes or growth stages.



Photo: Douglas Brown

Survey Recommendations: Wildlife

Until snags fall due to ash mortality aerial predation may increase on some birds. One wildlife expert pointed out, "This will be dependent on the density and age of other components in the stand." Secondary insects and diseases on ash will increase after EAB arrives in a stand. According to one entomologist "secondary insects will not play a significant role in increasing ash mortality; however, once these trees die, the wood boring insects and decay fungi will increase food for foraging wildlife. These dead trees may provide some opportunity for cavity nesters but experience from Michigan has shown that dead trees fall down quickly." In the short term, more snags will result from tree mortality. Temporarily downed woody material will increase salamander habitat. Woodpecker numbers will increase. One entomologist pointed out, "I get the impression that woodpeckers are not food limited - which also limits their effectiveness in controlling EAB numbers. When there are 300 EAB in a stand and the woodpeckers eat 200 it is great, but when there are 3000 EAB and the woodpeckers eat 200, it doesn't help much." In the short term cavity nesting birds will increase but several experts pointed out these trees aren't likely to remain standing for very long.

After ash mortality, cowbird predation will increase in open canopy forests; however, two experts observed that cowbirds are typically more problematic in fragmented landscapes rather than solid forest blocks. Neo-tropical song bird migration stop-overs would be impacted. According to one ecologist this may be a problem "to a small extent in some stands with high ash dominance in the north or possibly to a large extent in certain river floodplains in the south where an ash stand might be the only forest in an agriculture dominated landscape."

Another wildlife expert pointed out it's not clear how ash motility may impact bird migration routes. Beaver may increase after ash replacement has begun. Ash flower gall may decline. One final note from a forest ecologist, "A lot of unique microhabitat structures are present and stands are very important for biodiversity (amphibians, plants). Particularly if invasive plants take over, then the habitat will not support as many wildlife species and native plants."



Photo: Darek Bakken

Plant and animal species designated as "Rare, Threatened, and/or Endangered" may be found in any of the ash systems discussed in this Guide. If you wish to look up these species, refer to Appendix C: "Rare Species Guide," page 65.

Hooded
merganser

Other Implications of EAB and Ash Trees

Legal & Financial

Felling dead trees may injure people or damage vehicles and equipment, so cut down hazardous trees along trails and roads. Such actions will reduce the chances of an accident occurring which may result in a lawsuit that seeks a damage payment.

The loss of trees killed by EAB does not constitute a casualty loss reportable on income tax returns. A casualty loss must be sudden and unexpected, but infested ash trees may live for several years and their death is expected.

If you are managing your woodland as a business or investment, then you may

have inventoried your timber near the time it was acquired and set up a timber capital account showing the timber volume and the cost you incurred to acquire it. When trees are killed by EAB, your volume is reduced, but your cost basis for timber will remain the same.

Your depletion unit will rise, however, since you have a lower volume over which to spread your cost basis. A depletion unit is the cost per unit of timber (cords or 1000 board feet) that you incurred to produce your timber. When you sell timber, you can deduct a depletion allowance for the volume sold.



Ash log with EAB larval galleries

Photo: MN Dept. of Agriculture/Mark Abrahamson



Photo: Di Bedard

Wildfire, EAB, and Ash

The Emerald Ash Borer's Effects on Wildfire Potential

Ash mortality may result in increased potential for wildfire during the early spring and late fall months when the herbaceous vegetation is dry. Ash species are generally associated with vegetation communities that are considered to be fire resistant except during periods of extended drought. Therefore, in those areas where ash grows in association with other tree species, such as in northern hardwood stands or in mixed balm of Gilead/white cedar/red maple lowlands there will be little noticeable change in fire potential when the EAB invades forest stands and kills ash trees.

Standing *snag* trees will lose their bark and shed branches within a few years, minimizing fire hazard. Coarse

woody debris will decompose quickly and become *punky* (soft and crumbly), keeping fuel moisture at levels too high to support efficient combustion. Other tree species will quickly fill in the gaps left where ash once grew, as was the case when the American elm component was lost in these stands 30 to 40 years ago. The situation could be different in pure lowland black ash stands where typically a brush understory is lacking and grasses and sedges dominate the herbaceous layer. Since these ash types are considered a climax community, recruitment of other potential overstory species may be delayed. The existing herbaceous layer will respond to increased sunlight and will likely increase in density and mass. Wind exposure will also increase as the overstory declines.

The result of an emerald ash borer invasion



GLOSSARY

snag: A standing, generally unmerchantable dead tree from which the leaves and most of the branches have fallen.

punky: Soft, crumbly decayed wood that has been attacked by fungus, sometimes used as tinder.

Defects in ash trees

There are as many ways for trees to fail as there are trees. An ice storm can overload all the branches on a tree, a blustery wind can blow down a tree if its roots are restricted or a cracked tree can fail just under its own weight.

Trees are designed to easily withstand the normal windstorms and winter storms that occur, yet we have all seen trees that have failed. Trees fail when the load (weight and motion of the crown) exceeds the mechanical strength of their branches, stems or root systems. This is true for both sound and defective trees,

but defective trees can only withstand a fraction of the load that sound trees can withstand. Defective trees fail sooner than sound trees.

A sound tree becomes potentially dangerous when the tree's woody structure is weakened by one or more defects. Most defects can be linked to past wounding and decay, pest infestations, severe storms, or to growing conditions that limited the root system. Since defects, the old injury sites and nearby wood, are structurally weaker than uninjured wood, the tree is predisposed to fail at the location of the defects.

Defective trees can be found growing anywhere. Management of a defective tree is at the landowner's discretion. It is suggested that if defective trees or dead trees could fall onto structures, yards, fences, driveways or recreational trails, a landowner might consider removing them. On the positive side, defective and fallen trees provide wildlife habitat and other important ecological services. As a species group, ash are susceptible to two main defects; root system failure and branch failure. In many soil types, ash root systems are quite shallow, making the trees prone to windthrow. Commonly the entire tree and much of its root system tip over during strong winds, especially in exposed locations. Branches are likely to fail at the junction of the branch and the stem due to the presence of bark growing inside the tree and/or the presence of serious decay in the same location. Branch failure is more prevalent in large diameter trees.



Photo: Ed Czerwinski

Epicormic
branching

*For information on where to find the full resource
on defects in ash trees see Appendix D, page 66.*

Windthrow Mortality

All hardwood forests in their late-succession stages (older ages) can be perpetuated where a closed canopy is maintained over decades. Regeneration is by seedling release in canopy gaps (chronic *windthrow*), or by thinning overstocked stands. Thinning removes trees to where remaining tree canopies occupy 50 to 80% of the land area. For protection against excessive windthrow and provision of favorable riparian and stream attributes, thinning down to a canopy closure of 80% is recommended.

Exposure of stands along long edges will greatly increase the likelihood of excessive windthrow. Studies of strip cut forests in Minnesota show the balance

between stand growth and tree mortality is a function of the total stand edge and the height of the trees. Along stream corridors the stream produces one stand edge and cutting of forests landward of a forest next to the stream produces a second edge. Maintaining continuous-canopy stands along the stream or river at least 125 feet wide will ensure that normal windthrow mortality will not exceed stand growth over time. A wider stand will maximize stand growth. Many riparian forests in the Lake States have poor stocking (low canopy closure and not enough trees); though studies of the cause of this poor stocking are needed, excessive wind mortality is a prime candidate.

GLOSSARY

windthrow: A tree uprooted or broken by wind; also called "blowdown".



Photo: Eli Sagor

Blowdown in the
Boundary Waters Canoe
Area Wilderness, 1999

Appendices

Appendix A

Guidelines for managing sites with ash to address the threat of emerald ash borer on DNR Forestry-administered lands

BACKGROUND

The ash genus (*Fraxinus*) in Minnesota comprises some 900 million trees and is the second most common hardwood tree genus in the state. EAB was discovered in the United States in 2002 and is now present in 13 states and 2 Canadian Provinces. It was found in Minnesota in 2009. EAB populations can spread rapidly in infested firewood, logs, and ash nursery stock. Therefore, it is assumed that EAB will soon infest Minnesota's forested areas and cause significant impact to the ash resource. Experience from other states has shown that EAB kills 99+% of the ash in a stand once that stand becomes infested. This level of impact is greater than what occurred with American elm following the introduction of Dutch elm disease to Minnesota.

To date there has been no evidence of resistance to EAB within any North American ash species. Resistance does exist in some Asian ash species. Subtle differences in susceptibility to EAB between white, green, and black ash have been reported, but those differences are minor and should not influence management options. All three ash species in Minnesota will likely succumb to EAB attack.

SCOPE

This document applies to:

- Forested stands classified as ash coverytype
- Forested stands with an ash component of at least 20% of stand basal area but not typed as an ash coverytype. Native plant communities where ash is and can be significant include: FDw44, MHs49, MHw36, MHc47, MHn46, FFs58, FFs59, FFn57, FFn67, WFs57, WFW54, WFn53, WFn55, WFn64.
- Forested stands with ash that are free of EAB occurrence and are greater than 25 miles from the closest known EAB infestation. This distance will allow multiple entries into a stand based on an average, "natural" movement of EAB of ~2 miles per year.

ASH MANAGEMENT OBJECTIVES

- Landscape perspective: Manage ash populations in the landscape to protect sensitive wetland ecotypes, reduce outbreak costs, and restrict emerald ash borer introduction and spread without eliminating ash within forest ecosystems.
- Stand perspective: Create conditions that will reduce potential impacts and increase the resiliency of forested stands by
 - Keeping forested sites forested
 - Maintaining an ash component but reducing the size and

number of ash in the stand.

- Increasing tree species diversity.
- Management objectives should focus on ecosystem health and management, not on the emerald ash borer. The intent is to limit habitat attractiveness to EAB.
- The Division of Forestry will work within its nursery program and with other partners for maintaining representative samples of genotypes but not for processing seeds for reforestation.

CAVEATS

- There is a likelihood that the vast majority of ash trees in Minnesota will be killed by EAB regardless of the type or magnitude of actions taken.
- The large extent of the ash resource, particularly black ash, will likely mean that sufficient management actions will not occur in all stands prior to EAB becoming established in Minnesota. Forested sites will be altered or lost.
- Little is known through research and experience how to maintain black ash forested sites as forested communities once the black ash is killed or removed. On-going research and knowledge gained through experience that can be passed along to all managers will be critical to meeting long term ash management objectives. Therefore, this document presents interim guidance that will change as knowledge from research and experience is gained.

Managing forested stands with ash

- **INTERIM DIRECTIVE FOR ALL STANDS WITH ASH**
The current scientific evidence does not support investments in artificial regeneration of ash species or management practices implemented to expand or regenerate ash populations. These activities could also compromise efforts to protect sensitive wetland ecosystems through canopy diversification, reduce forest vulnerability and potentially compromise EAB response efforts.
- Ash species should not be planted on DNR administered lands for ornamental, shade or reforestation purposes. In implementing forest management practices do not structure operations to intentionally favor the regeneration or reestablishment of ash.
- Rationale: In order to avoid perpetuating habitat for EAB for future generations, the current objective is to diversify ash dominated plant communities now and into the near future.
- Actions
 - Do NOT plant ash seedlings on state administered lands or recommend ash seedlings for reforestation on private lands.
 - Do NOT use ash seed in the mix for direct seeding on state administered lands or recommend ash seeds for direct seeding on private lands.

- Create conditions favorable for regeneration of non-ash tree species. Ash regeneration can be aggressive, particularly from stump sprouting; chemical application may be necessary to reduce ash on some sites.
- Prioritize opportunities to implement management practices in stands with ash immediately irrespective of EAB outbreaks.
- **Rationale:** Given the magnitude of the ash resource in Minnesota today, forest managers must make ash management a higher priority. The proximity of EAB and the uncertainty of knowing where EAB is currently infesting ash necessitate taking immediate actions to ameliorate some of the negative consequences that have been documented in other states.
- **Actions**
- Ash stands on the annual stand exam list should be scheduled for a management action that addresses the objectives above. Do not defer stands with ash for a later action. Schedule treatment as soon as possible.
- Work with the department's planning groups to revise SFRMP objectives and stand selection criteria to address the objectives listed above.
- **GUIDELINES FOR ALL STANDS WITH ASH**
- Reduce the stocking and average diameter of the ash component
- **Rationale:** Ash phloem is the larval food source for EAB. More phloem can support greater populations of EAB within any given area. The larger the tree, the greater potential to support higher EAB populations. Reducing the ash component may reduce future impacts and may help slow the spread of EAB.
- **Actions**
- Reduce the ash component to no more than 20% of current stand basal area.
- Focus on reducing the average diameter of the residual ash component. Focusing on reducing larger trees will be more effective than removing only poles and saplings. However, if scattered larger diameter trees are left to meet leave tree guidelines or wildlife considerations, remove a larger proportion of smaller diameter ash so that the overall average diameter of the residual ash is reduced from the average ash diameter before treatment.
- Leave other species as residuals during harvesting or regenerate other, non-ash species to maintain a forested cover.
- Use intermediate stand treatments that focus on a dominant thinning technique where larger trees are selected to be cut to reduce the size and amount of ash.
- Intermediate stand treatments are often precommercial. The cut material can be left on the forest floor if biomass opportunities are limited or non-existent. EAB will not utilize dead ash trees as host material. Leaving uninfested stems on the forest floor will not create EAB habitat.
- Multiple entries may be necessary. When non-ash reproduction is at least 2 - 3 feet in height, consider another ash reduction treatment.
- Reduce the concentration of ash.
- **Rationale:** A dispersed ash component can lessen the impacts to the stand by reducing the likelihood of EAB killing large areas of ash which may or may not have an understory of other tree species. Work to create and maintain scattered ash throughout the stand rather than maintaining pure or nearly pure ash areas within the stand.
- **Actions**
- In homogeneous ash areas, focus on thinning dominant and codominant trees where all ash above a prescribed diameter limit are cut resulting in a reduction in the size and number of ash in the stand. See basal area and diameter guidance above.
- Use scattered ash in the stand to meet the basal area goal above rather than relying on pure ash areas to meet this goal.
- Transition sites to a composition that favors non-ash species
- **Rationale:** Despite all management efforts, current experience seems to indicate that EAB will kill 99% of the ash in the stand regardless of ash tree size and spatial occurrence within the stand. The ultimate strategy must be to move stands away from ash and maintain the forest community by depending on other species.
- **Actions**
- Use the native plant community field guides to determine the growth stage and refer to Silviculture Interpretation, Table PLS-2, Abundance of trees throughout succession to identify favorable ingressing species. The DNR web site for ECS information is: http://www.dnr.state.mn.us/forestry/ecs_silv/interpretations.html
- Consider the regeneration strategies (tolerance) of non-ash tree species already on the site.
- If non-ash species are few or nonexistent, consider artificial regeneration. Try aerial seeding non-ash species as well as underplanting non-ash species even in the absence of any other kinds of stand treatment.
- Consider creating canopy gaps through hand felling or girdling to provide light conditions more suitable for the establishment of underplanted or seeded non-ash species. However, openings greater than 60 feet in diameter may encourage ash regeneration.
- Use the NPC tree table, Silviculture Interpretation Table R-1, Suitability ratings of trees, to select non-ash species best adapted to the site.
- **ADDITIONAL GUIDELINES FOR BLACK ASH**
- Protect the hydrologic functions of the site to maintain a tree cover.
- **Rationale:** The guiding principle for all black ash management decisions is to protect the hydrology of the site. Black ash, because of its abundance on some sites, often controls water levels in the stand. If the black ash is cut or dies off, water levels often increase and there is a chance sites will convert to wet meadows or become dominated by alder. The greatest concerns are black ash communities classified in the wet forest system (WF).
- **Actions**
- Use the Native Plant Community information along with stand site index to help guide management decisions. The greater the site index, the more flexibility in applying a management treatment that will not cause long-term alteration of the site.
- General site index guidance:
- SI = <45: Avoid all forest management actions. Do not spend resources on these sites.
- SI = 45-55: These sites may provide limited forest management opportunities. Extreme care must be taken on these sites when trees are harvested. These sites are appropriate candidates for understory planting or direct

seeding of non-ash species.

- SI = >55: Consider management for timber with the cautions listed below for specific NPCs. Ash reduction, salvaging, and regeneration by planting, underplanting, and direct seeding to non-ash species may be appropriate. Use the NPC tree table, Silviculture Interpretation Table R-1, Suitability ratings of trees, to select non-ash species best adapted to the site.
- When working in black ash stands, always monitor treatment results and apply lessons learned to future black ash management opportunities.

• **PRECAUTIONS FOR SPECIFIC NATIVE PLANT COMMUNITIES AT RISK**

The following communities are at risk for hydrologic damage if the tree cover is significantly altered. Generally, management actions should be lightly applied, and follow up monitoring is mandatory.

WFn55 – Northern Wet Ash Swamp

- When there is substantial aspen or balm of Gilead (bam) in the stand, use partial harvesting techniques such as 2-step shelterwood and strip clearcut, or use dominant thinning when the stand is not merchantable. Suckering aspen and bam will help avoid swamping the site.
- When substantial aspen or bam is lacking:
- Stands with a site index of 55 or greater, partial harvesting and dominant thinning are possible. However, extreme care should be taken by removing not more than 50% of the basal area at one time.

- Stands with a site index under 55, avoid harvesting and intermediate stand treatment but consider establishing non-ash species.
- Underplant or aerial seed appropriate species listed in the NPC tree tables, Silviculture Interpretation Table R-1, Suitability ratings of trees, to select species alternates to ash. Browse protection will be necessary.
- In the absence of any harvesting or intermediate stand treatments, consider hand felling or girdling to create gaps for the establishment of non-ash species.

WFn64 – Northern Very Wet Ash Swamp

- Avoid harvesting or intermediate stand treatments.
- In lieu of any harvesting, consider underplanting or aerial seeding appropriate species listed in the NPC tree tables, Silviculture Interpretation Table R-1, Suitability ratings of trees, to select species alternates to ash. Browse protection will be necessary.
- Consider creating small gaps by hand felling or girdling when underplanting and seeding.

WFn57 – Southern Wet Ash Swamp

- This is a rare community often found near springs, mostly in rugged topography of the Blufflands Subsection and along the tributaries of the Minnesota and St. Croix rivers.
- Avoid any harvesting or intermediate treatments in or immediately adjacent to these communities. Allow other tree species to naturally seed or develop in the understory.

Appendix B

Questions & Answers about Quarantines and Compliance Agreements

Q1. What is a quarantine?

A1. A quarantine is a temporary rule intended to help prevent a potentially dangerous or destructive pest or disease organism from spreading outside a known infested area into new areas. In the case of emerald ash borer (EAB), the quarantine is designed to limit the movement of potentially infested firewood or other materials such as live ash trees that might harbor EAB larvae.

Q2. As of November 2009, what areas of Minnesota are currently quarantined for emerald ash borer?

A2. As of October 2009, the EAB quarantine in Minnesota consisted of the counties of Ramsey, Hennepin and Houston. See the most current EAB quarantine in Minnesota. (www.mda.state.mn.us/en/plants/pestmanagement/eab/eabquarantine.aspx)

Q3. What are regulated articles?

A3. The following are three categories of regulated articles:

- The emerald ash borer (*Agrilus planipennis*),
- Ash trees (*Fraxinus* sp.), ash limbs and branches, ash stumps and roots, ash logs, ash lumber, ash chips and ash bark chips, and
- Firewood of any hardwood (deciduous) species.

Q4. What is the definition of firewood?

A4. Firewood means wood that is cut to lengths less than four feet long. This includes firewood cut for personal use.

Q5. What is a Compliance Agreement?

A5. A Compliance Agreement is a document that describes how a company will properly treat regulated articles to mitigate the spread of EAB and adhere to the quarantine law. A MDA representative is available to discuss Compliance Agreements in more detail at the request of any business or other entity involved in moving regulated articles. MDA can provide free training on EAB and also help determine how any business can lower the risk of spreading EAB with the least amount of disruption to business practices.

Q6. Do I need a Compliance Agreement?

A6. If you are moving regulated articles (e.g., ash material or hardwood firewood) out of a quarantine area you will need a Compliance Agreement. Ash material that

originates from a non-quarantine county and transits the quarantine may require a Compliance Agreement, and it is recommended you contact MDA for further information.

Q7. How do I get a Compliance Agreement?

A7. You can contact the Arrest the Pest Hotline at 651-201-6684 in the Twin Cities or 888-545-6684 in greater Minnesota, or e-mail us at arrest.the.pest@state.mn.us and say you are interested in a Compliance Agreement for emerald ash borer. An MDA official will work with you to determine which Compliance Agreements, if any, are needed, explain the requirements, and work with you to implement any needed quarantine restrictions.

Q8. Why is all hardwood firewood regulated instead of only ash firewood?

A8. Once a log has been cut and split, it is extremely difficult to identify ash wood from other hardwood species. While this is especially true for the casual firewood user and homeowners, the experience of other EAB regulatory agencies across the nation have shown that the same has often applied to firewood businesses, too. Therefore, due to the potential risk associated with moving EAB-infested firewood, all hardwood firewood is regulated. There are no EAB quarantine restrictions on coniferous species of firewood, such as pine, spruce and fir.

Q9. Does the quarantine affect movement of hardwood (non-ash) nursery stock or hardwood (non-ash) wood products?

A9. In regards to EAB there are no restrictions on the intrastate movement of non-ash hardwood products such as nursery stock, logs, branches, green lumber or chips in Minnesota. However, the movement of all hardwood firewood out of quarantined counties is regulated.

Q10. Does the quarantine affect the movement of material within the quarantine areas?

A10. There are guidelines or best management practices for working with ash in known infested areas (PDF). There are no legal restrictions for the movement of regulated materials within the quarantine.

Q11. What can I do with my ash material from a quarantined county?

A11. There are multiple options available:

- Ash material can be brought to a disposal site within the quarantine. Download a list of known tree waste disposal sites (PDF).
- Material can be utilized within the quarantine for any legal purpose.

**If removing ash material or other regulated articles from the quarantine, the following options may be used but require a Compliance Agreement with MDA and / or USDA. We advise that this Compliance Agreement be in place before beginning processing operations. **

- Material can be chipped to 1 inch or less in two dimensions (two of three measurements-length, width and thickness-must be 1" or smaller).
- Material can be debarked, which means complete bark removal plus ½ inch of wood.
- Material can be composted; material must reach at least 140 degrees Fahrenheit for four days and the pile must be turned after four days.
- Material can be heat treated; the center of the wood must reach at least 160 degrees Fahrenheit for 75 minutes.
- Material can be kiln dried; must meet USDA guidelines.
- Material can be fumigated by a licensed fumigator.
- Material can be transported to an approved facility during the period of September 1 to April 30.

Q12. If I sign a Compliance Agreement, will I be required to keep records?

A12. Yes. If your company ships regulated articles under a compliance agreement or with MDA certification, you will need to maintain those shipping and/or certification records for 36 months, unless otherwise specified.

Q13. Do I have to keep records of shipments or treatments that do not involve regulated articles?

A13. MDA does not require records for treatment or shipment of non- regulated articles.

Q14. Can I bring firewood from a non-quarantined area into a quarantined area?

A14. There are no legal restrictions on firewood that originates from a non-quarantined county. At this time only Ramsey, Hennepin and Houston counties in Minnesota are quarantined. Firewood is allowed to come into those counties from a non-quarantined county. Once the firewood enters into a quarantined area, it becomes a regulated article.

Q15. If I have further questions about EAB or compliance agreements, or if I think I have found EAB, who do I contact?

A15. The Arrest the Pest Hotline is available for a wide variety of questions related to emerald ash borer. Contact us at the Arrest The Pest Hotline at 651-201-6684 (Metro Area), 888-545-6684 (Greater Minnesota), or arrest.the.pest@state.mn.us.

Credit to: Minnesota Department of Agriculture

Appendix C

Minnesota Department of Natural Resources Rare Species Guide

You may search for rare plant, mammal, reptile, bird, and amphibian species potentially found in the Wet Forest, Floodplain Forest, Mesic Hardwood, Forested Rich Peatland, and/or Fire Dependent system plant communities by going to the Minnesota Department of Natural Resources Rare Species Guide. <http://www.dnr.state.mn.us/rsg/index.html>

A “Filtered Search” allows you to search for rare species by habitat. You can choose to limit your search results by:

- species groups (e.g., just plants);
- status (endangered, threatened, special concern);
- county;
- Ecosystem Classification Subsection; and/or
- watershed.

Once you generate your species list, click on individual names to link to species’ profiles. Profiles include photographs, range maps, phenology information, and text.

Shown is the result of a sample search for rare, threatened and/or endangered mammals and vascular plants in the Wet Forest System.

The screenshot shows the 'Rare Species Guide: Filtered Search' page. At the top, there is a search bar and navigation links. Below the search bar, the page displays the following information:

2 result(s) for *Habitats:Wet Forest; mammal; vascular_plant; minnesota endangered;*

| Common name | Scientific name | Group | Federal status | State status |
|--------------------|----------------------------|----------------|----------------|--------------|
| Aunited Twayblade | <i>Listera auriculata</i> | vascular plant | none | endangered |
| Braun's Holly Fern | <i>Polystichum braunii</i> | vascular plant | none | endangered |

Below the table, there are several filter sections:

- Filter by group (select one or more):** Includes checkboxes for all, amphibian, bird, fish, fungus, insect, lichen, mammal (checked), moss, mussel, reptile, snail, spider, and vascular plant (checked).
- Filter by status (select one or more):** Includes checkboxes for federal endangered, federal threatened, federal candidate, state endangered (checked), state threatened, state special concern, CITIS, USPS Sensitive, and all.
- Filter by location (optional):** Includes sections for 'Select counties', 'Select ECS subsections', and 'Select watersheds'.
- Filter by habitat (optional):** Includes sections for 'Select Habitat(s)' and 'Selected Habitats: Wet Forest (116)'.

At the bottom of the filter section, there are 'go' and 'reset' buttons.

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Appendix D

References and Resources

Page 5

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GLOSSARY

abiotic: Nonliving parts of an ecosystem, such as soil particles, bedrock, air, water. See “biotic.”

adventitious: Pertaining to a plant part that develops outside the usual order position or tissue — e.g., an adventitious bud arises from any part of a stem, leaf, or root but lacks vascular connection with the pith; an adventitious root arises from parts of the plant other than a preexisting root, e.g., from a stem or leaf.

anoxia: Meaning lack of oxygen.

Best Management Practices: BMPs are practical guidelines aimed at lessening non-point source pollution from forest management activities such as road construction, skid trails and log landings.

biomass: Harvesting the wood product obtained (usually) from in-woods chipping of all or some portion of trees including limbs, tops, and unmerchantable stems, usually for energy production.

biotic: Pertaining to living organisms and their ecological and physiological relations.

bole: The trunk or main stem of a tree.

BTU: British Thermal Unit, is a basic measure of thermal (heat) energy. One BTU is the amount of energy needed to heat one pound of water one degree Fahrenheit.

burl: An abnormal growth of woody tissue protruding outward from a tree stem or trunk.

calcareous: An adjective used in a wide variety of scientific disciplines, referring to the deposit of calcium carbonate or lime. In some cases it may refer to a layer of sediment or sedimentary rock, a limestone deposit. Calcareous soils are relatively alkaline, in other words they have a high pH. This is because of the very weak acidity of carbonic acid. Note that this is not the only reason for a high soil pH.

canopy: The foliage cover in a forest stand consisting of one or several layers.

cavity: Holes in trees sometimes used for nesting and reproduction by wildlife species, most frequently birds or small mammals.

character wood: Wood prized by artists or craftsman because of its unique or distinctive grain patterns or form. Examples of character wood include burls, crotch wood.

co-dominant: Defines trees with crowns forming the general level of the main canopy in even-aged groups of trees, receiving full light from above and comparatively little light from the sides.

conifer: A cone-bearing tree (e.g. pines, firs, spruce, cedars, redwoods, larches etc.).

crown dieback: Decline of the branches and limbs in the canopy of a tree sometimes used as an indicator of tree health.

deciduous: Perennial plants that are normally more or less leafless for some time during the year.

diameter at breast height (dbh): The diameter of the stem of a tree measured at breast height (4.5 ft or 1.37 m) from the ground. On sloping ground the measure is taken from the uphill side.

dieback/decline: The progressive dying from the extremity of any part of a tree.

dominant trees: An individual or species of the upper layer of the canopy.

duff: The partially decomposed organic material of the forest floor beneath the litter of freshly fallen twigs, needles, and leaves.

early succession: The process by which one plant community is gradually replaced by another plant community. This may happen ‘early’ in the process or ‘late,’ thus the terms “early succession” and “late succession” are used to describe this process.

ephemerals: Ephemeral plants are marked by short life cycles, usually 6-8 weeks. Ephemeral means transitory or quickly fading.

epicormic branching: A shoot arising spontaneously from an adventitious or dormant bud on the stem or branch of a woody plant often following exposure to increased light levels or fire.

floodplain: The level or nearly level land with alluvial soils on either or both sides of a stream or river that is subject to overflow flooding during periods of high water.

hydrology: The study of the movement, distribution, and quality of water on Earth and other planets, including the hydrologic cycle, water resources and environmental watershed sustainability.

hydrophobic: Having little or no affinity for water molecules.

incised streams: Slopes along a creek, stream or river are eroded in a downward fashion.

leaf flush: The time in the season during which leaves appear on a tree.

mesic: Sites or habitats characterized by intermediate moisture conditions.

microsite: A small part of an ecosystem that differs markedly from its immediate surroundings.

monotypic: Referring to conservation biology and successional changes leading to a single species.

morphology: The external and internal form and structure of whole plants, organs, tissues, or cells.

native plant community: A group of native plants that interact with each other and with their environment in ways not greatly altered by modern human activity or by introduced organisms. These groups of native plant species form recognizable units, such as oak savannas, pine forests, or marshes that tend to repeat over space and time. Native plant communities are classified and described by considering vegetation, hydrology, landforms, soils, and natural disturbance regimes.

oriented strand board: Also known as OSB or wafer-board, is an engineered wood product formed by layering strands (flakes) of wood in specific orientations.

paleoscientist: Scientists who study organisms of the past.

peat/peatlands: Organic soil material that originates from plants.

phloem: A layer of cells just inside the bark of plants that conducts food from the leaves to the stem and roots.

punky: Soft, crumbly decayed wood that has been attacked by fungus, sometimes used as tinder.

pure stands: Forest, crop, or stand composed principally of one species, conventionally at least 80 percent based on numbers, basal areas, or volume.

quarantine: A temporary rule intended to help prevent a potentially dangerous or destructive pest or disease organism from spreading outside a known infested area. In the case of the emerald ash borer (EAB), quarantines are designed to limit the movement of potentially infested firewood or other materials such as live ash trees that might harbor EAB larvae.

riverine: All wetlands and deep water habitats contained within a natural or artificial channel that periodically or continuously contains moving water, or that forms a link between two bodies of standing water.

select harvest: A cutting that removes only a portion of trees in a stand.

serpentine trails: Trails that wind and twist, like a snake.

shade tolerant: Having the capacity to compete for survival under shaded conditions.

snag: A standing, generally unmerchantable dead tree from which the leaves and most of the branches have fallen.

sprouts: Shoots arising from the base or sides of a woody plant.

windthrow: A tree or trees felled or broken off by wind. Also called "blowdown."

