MANAGING ASH IN FARM WOODLOTS: SOME SUGGESTED PRESCRIPTIONS

Peter A. Williams and Terry D. Schwan[1]

Abstract.—Ash (*Fraxinus* sp.) is an important component of upland sites and is dominant in lowland sites in Southwestern Ontario. While information on emerald ash borer (*Agrilus planipennis*) (EAB) and its signs and symptoms is readily available, there is little on management options that consider EAB affects. This paper was developed from a woodlot tour designed to transfer knowledge to farmers of good forestry and stewardship practices for managing ash. Three generic strategies for certain stand types and four site-specific prescriptions for woodlots in anticipation of EAB infestation are presented. The generic strategies can be considered when developing a prescription for ash-dominant lowlands. They apply to stands infested with EAB and where EAB is expected in 5 to 10 years, or 10 years or more. The site-specific prescriptions are examples that describe applicable issues, strategies, and objectives in more detail. The proportion and size distribution of ash and the number of years anticipated before infestation are important considerations in optimizing ash growth and value and mitigating the impact of EAB on forest structure, value and function. If EAB infestation is expected in 10 years or more, three or four stand entries may be possible to influence the future forest.

INTRODUCTION

Southwestern Ontario is located north of New York and Ohio and east of Michigan. Emerald ash borer (EAB), *Agrilus planipennis,* was first discovered across the river from Detroit, MI in Windsor, Ontario in 2002. Many southern Ontario forests are even-aged or uneven-aged northern hardwood forests that can be managed using uneven-aged silvicultural systems. The Ontario Ministry of Natural Resources (OMNR) and other local institutions primarily support single-tree selection (STS) for managing hardwood and mixed forests. Comprehensive technical support for all systems is provided through the "Silvicultural Guide" (OMNR 2000). Rigorous support for STS and for shelterwoods in white pine (see Table 1 for scientific name for all plants) is provided through the Ontario Tree Marker program.

The forests subject to the greatest changes through attack by EAB are even-aged stands that have colonized former agricultural land, often on poorly-drained or clayey soils. The management of these stands and the types of impacts associated with EAB infestation have received relatively little institutional recognition or support.

This document provides several examples of silvicultural prescriptions that forestry specialists can use to develop alternatives for managing ash in southern Ontario woodlots. These stands have similarities with many forests near the Great Lakes in the United States. It has been reported there is nearly 100 percent mortality of ash over 2.5 cm in diameter at breast height (d.b.h.) (Herms et al. 2009, Knight et al. 2010) It is important to retain some ash in the forest as EAB moves through to provide for diversity, wildlife habitat, and a future seed source. However, the high mortality rate and the loss in

[1]Forester (PAW), Williams & Associates Forestry Consulting Ltd., 5369 Wellington 27, RR 1, Rockwood, Ontario N0B 2K0; and Forester (TDS), Ontario Ministry of Natural Resources, Guelph, ON. PAW is corresponding author: to contact, call 519-856-1286 or email at forstar@execulink.com.

Table 1.—Common and scientific names for tree and plant species

Common Name	Scientific Name
American basswood	*Tilia americana* L.
American elm	*Ulmus americana* L.
bitternut hickory	*Carya cordiformis* (Wangenh) K. Koch
black cherry	*Prunus serotina* Ehrh.
buckthorn	*Rhamnus* sp. or *Frangula* sp.
bur oak	*Quercus macrocarpa*
green ash	*Fraxinus pennsylvanica* Marsh.
hemlock	*Tsuga canadensis* (L.) Carr.
hophornbeam	*Ostrya virginiana* (Mill.) K. Koch
poplar	*Populus sp.*
soft maple complex	*Acer rubrum L./saccharinum L.*
sugar maple	*Acer saccharum* Marsh.
trembling aspen	*Populus tremuloides* Michx.
white ash	F*raxinus americana* L.
white pine	*Pinus strobus* L.
yellow birch	*Betula alleghaniensis* Britton

wood value when trees die suggest that a prudent land manager would carefully consider management to optimize the value of their ash resource and encourage the forest to become more resilient to EAB and other pests. It is important that forest managers begin considering their alternatives well in advance of actual infestation, especially in stands with over 30 percent ash.

ASH MANAGEMENT STRATEGIES

A stand management strategy should include plans for one or more stand entries that consider the owner's objectives, the likely time frame of infestation, ecological and economic effects of ash harvesting/mortality (current and future stand dynamics), strategies to buffer the effects of impending ash mortality on the stand, the size classes and density of ash present, and existing regeneration. In lowland ash-dominant stands (monocultures), encouraging the establishment and development of other desirable species is critical.

Stand management strategies include several assumptions:

- The number of years before the ash in the stand will be threatened or killed by EAB infestation must be estimated. For example, if EAB has been found 50 km distant, it may be 10 years before that woodlot is affected; if a dense population front was 50 km distant it may be only 5 years.
- The landowner wishes to harvest in their woodlot to optimize the economic value of ash in the woodland and mitigate the impact of the loss of ash on their forest, stand integrity, and productivity.
- Ash is an early- to mid-successional genus and that in ash-dominated stands, a harvest prescription can be implemented which can advance the succession process to develop a woodlot with a greater diversity of mid to shade tolerant tree species.

An ash component made up of vigorous trees should be maintained prior to EAB infestation in order to provide for diversity, habitat, and potential seed sources. Regeneration of desirable non-ash species must be encouraged where it is lacking. If a natural seed source is not available, consider underplanting with appropriate mid-tolerant or shade tolerant species. The short-term economic benefits of harvesting mature, seed-producing ash trees ahead of EAB ash mortality should be weighed against the negative long-term effect on the local gene pool.

This document is not comprehensive and generally applies to the types of stands described in this paper. Information presented here is meant to complement other guidelines and should be read in conjunction with OMNR Forest Health guides "A Landowner's Guide for Woodlots Threatened by Emerald Ash Borer" and "When Invasive Species Threaten Your Woodlot" along with the Regional Forest Health Network pest alert "Emerald Ash Borer (EAB) Information for Woodlot Owners". Examples presented here were applied in Wellington County (Fig. 1) but could also apply in other locales with similar forest types.

Management prescriptions are presented here for three general scenarios:

- Scenario 1: EAB is found in the woodlot.
- Scenario 2: EAB is in the county/region (a quarantine area) or nearby and is expected to infest the stand within 5 to 10 years.
- Scenario 3: EAB may affect the woodlot in more than 10 years.

In addition, prescriptions are provided for the following four actual site-specific stands located in southwestern Ontario (Table 2) where EAB is found nearby and infestation is expected within 5 to 10 years:

- A prescription for an upland tolerant hardwood forest with a higher sugar maple component.
- Three prescriptions for ash-dominant lowland forests of different age/size classes with soft maple as the other major stand component. These are even-aged stands with heavier soils on poorly drained (often seasonally inundated) agricultural sites.

Table 2.—Characteristics of forest stands located in Wellington County, Ontario, Canada

Stand No.	Stand Type	Species Composition	Age (yr)	Initial BA (m^2/ha)	Recommended Residual BA (m^2/ha)
1	Upland tolerant hardwood	30% sugar maple; 30% white ash; 10% bitternut hickory; 30% other (black cherry, hophornbeam, American basswood, poplar, white pine, yellow birch)	95	31	22
2	Lowland ash polewood (10-24 cm)	60% green ash; 20% soft maple; 20% trembling aspen; other (American elm)	~40	34	23±
3	Lowland ash small sawlog (26-36 cm)	50% green ash; 40% soft maple; 10% other (trembling aspen, American elm, sugar maple, black cherry)	50	30	20 ±
4	Lowland ash medium sawlog (38-48 cm)	80% green ash; 20% soft maple; other (American elm)	~70	47	32 ±

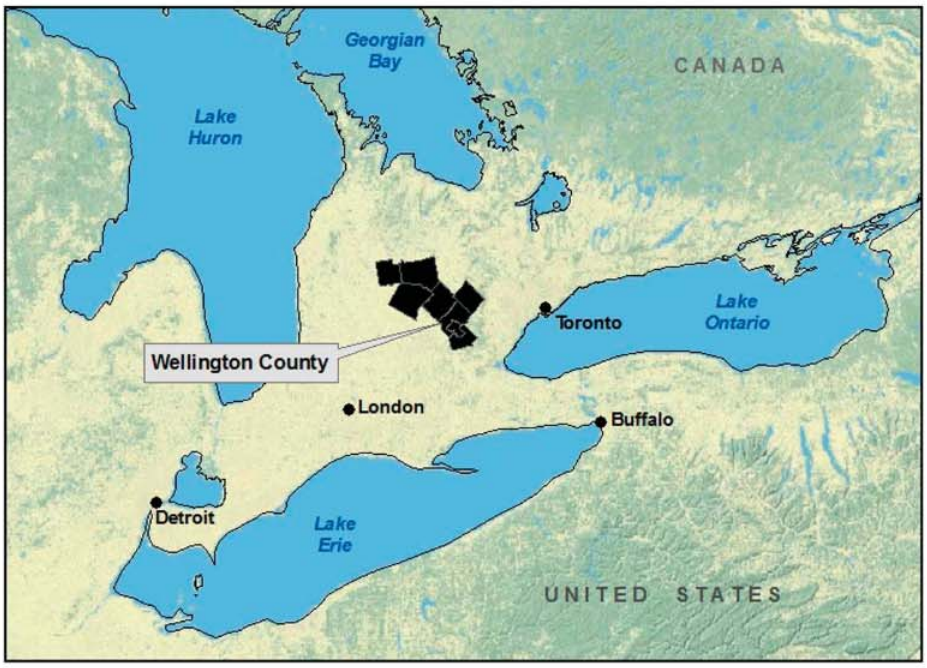

Figure 1.—Location map for study area in Wellington County, Ontario, Canada.

GENERALIZED PRESCRIPTIONS FOR STANDS WITH ASH DEPENDING ON EXPECTED TIME TO INFESTATION

Scenario 1. General Prescription Where EAB is Found in Woodlot

In stands where the ash component is greater than 30 percent stand density, it is generally recommended to salvage most saw log trees and as much fuelwood as possible to encourage the development of other species and maintain stand integrity. Recommendations will also depend on the ability of the owner or contractors to harvest smaller fuelwood trees. While it is clear that for the foreseeable future, EAB will kill most ash as it moves through the long-term future is not clear. Wood movement to less infested areas should be discouraged.

It is reasonable to assume that most or all ash that remains in a woodlot infested with EAB will be killed. Thus, it is important to retain a proportion of healthy small to medium saw log and polewood ash that will provide growing stock, seed sources, and wildlife habitat that will ease the transition of a stand to one without a significant ash component. These choices depend somewhat on the owner's objectives, stand characteristics, and the ability of the owner or contractors to harvest/salvage trees. If the owner uses fuelwood, sells it, or has other ways to salvage, the options are much greater, particularly with stands dominated by smaller ash.

In general, it is recommended to harvest/salvage larger ash (>48 cm d.b.h.) if they can be harvested without excess site disturbance or damage to non-ash species. Total basal area reduction should generally not exceed 40 percent. This can usually be achieved by harvesting the larger ash trees while thinning those of poorest health across the diameter classes and leaving a reasonable percentage of small to medium-sized ash (30 to 48 cm d.b.h.).

In ash-dominant stands, this will still leave much ash that will likely be killed by EAB. These can be salvaged for several years after mortality and used as fuel or low-grade lumber. In the meantime, their presence will provide a shelterwood effect to foster the development of residual trees and regeneration.

If the stand is a quality mixed stand, retain smaller but vigorous ash that are inconvenient to access to minimize damage to residual trees. The retained ash will likely die as EAB moves through, self-thinning and providing wildlife habitat without damaging residuals. If they survive, they may help replenish the stand.

Scenario 2. General Prescription Where EAB is in the County/ Region (a Quarantine Area) or Nearby with Expected Infestation in 5 to 10 Years

The variety of stand types, species composition, stocking, and past management only allow for general guidelines. Examples of specific situations are presented later in this paper. Because the stand is expected to be affected by EAB within the next 10 years, mark as much ash as feasible while maintaining stand integrity using two stand entries. In the first entry, ash should be marked to encourage the development of non-ash stand components and capture the value before the trees die. Retain vigorous, good-quality medium-sized trees to optimize their growth prior to infestation. This also provides the opportunity to have healthy trees going into the infestation and a choice whether to salvage them or leave them as a seed source for regeneration. A general reduction in the density of larger ash will capture their value and may help to reduce the EAB population in the stand.

Where ash makes up less than 30 percent of the stand density, a single entry using normal procedures could be used. In ash-dominant stands, this will still leave much ash that will likely be killed by EAB. These can be salvaged for several years after mortality and used as fuel or low-grade lumber. In the meantime, their presence will provide a shelterwood effect to foster the development of residual trees and regeneration. Where regeneration of non-ash species is lacking and there is limited local seed source, consider underplanting with appropriate species.

Where ash is dominant or is greater than 30 percent basal area (BA), the number of years before EAB infests the stand is an important consideration that determines the number of entries possible before mortality. It is important to consider that smaller trees can be salvaged for fuelwood up to 4 or 5 years after mortality. This provides for an additional stand entry to salvage ash trees that have died during or after the infestation.

Scenario 3: General Prescription Where EAB May Affect the Woodlot in More Than 10 Years

If it is anticipated that an ash-dominated stand will not be infested for 10 years or more, there may be time for three or four stand entries spaced 5 to 10 years apart. This will help optimize the value and growth of ash before infestation and moderate the impact of EAB on the forest. The sooner efforts begin, the more the development of species other than ash can be encouraged while still retaining healthy ash, should genetics or new control methods prevail over the EAB.

The first entry should be to reduce unacceptable growing stock (UGS) of ash and other species by harvesting with an improvement thinning in all diameter classes. Retained ash trees should be

vigorous trees with good, straight stems that will either accumulate significant volume before EAB affects the stand or will move up a product/grade class to optimize value growth. For example, a 14 inch diameter tree could grow to 16 inches in 10 years, moving from a fuelwood or pallet tree to a Grade 1 butt log. When comparing trees of similar quality, ash should be marked to release non-ash species.

With two entries before infestation, a generalized prescription for an ash-dominant stand would be to reduce basal area by an average of 30 percent at the first entry. Diseased trees, trees that are at high risk to fail, trees with height and grade limitations, and dense patches should be marked for harvest and to release better quality trees of all species.

Some vigorous dominant or codominant ash should be retained and released to encourage their value/volume growth before the next stand entry. Ash should be thinned heavily where soft maple or other non-ash advanced regeneration is in the understory.

In ash-dominant stands, this will still leave much ash that will likely be killed by EAB. These can be salvaged for several years after mortality and used as fuel or low-grade lumber. In the meantime, their presence will provide a shelterwood effect to foster the development of residual trees and regeneration. Where regeneration of non-ash species is lacking and there is limited local seed source, consider underplanting with appropriate species.

Where there is soft maple or non-ash regeneration and no larger trees to be marked, smaller ash should be thinned/marked to improve the vigor and development of the other species. Smaller ash which are below marketable size should be marked where operationally convenient (i.e., near trees marked for other reasons, to provide access to other trees, or to encourage the development of other species). Most of the remaining ash should be healthy trees with potential to grow into saw log sizes by the next stand entry (5 to 10 years), just before or when the stand becomes infested. Trees with significant wildlife value (e.g., cavity trees) should be retained.

FOUR SITE-SPECIFIC PRESCRIPTIONS WHERE ASH IS FOUND IN THE LOCAL AREA

Stand 1. Upland Tolerant Hardwood

Stand Description

This upland forest site (see Tables 2 and 3 and Fig. 2 for characteristics) was located on a drainage sideslope between a field to the north and a wetland to the south. It was made up of two even-aged patches. The main part of the stand became established after clearcutting in the early 1900s and subsequent pasturing. A strip along the field edge was likely open pasture until the 1950s when grazing was discontinued. The stand had an improvement cut during the 1980s.

The stand was mostly made up of very good quality, healthy trees, particularly sugar maple. However, the stand was overstocked, and trees were dying because of high density. To maintain tree vigour and reduce the impact of EAB (likely to affect the stand within 10 years), it was recommended to conduct a crown thinning, primarily removing ash with a lighter improvement cut for the other species.

Table 3.—Basal area (m^2/ha) distribution for four forest stands located in Wellington County, Ontario, Canada

Tree Size Classes (cm)	10-24	26-36	38-48	50-59	Total
Recommended residual basal area for STS[a]	4	5	6	5	20
Upland tolerant hardwood	6	16	7 (1)[b]	3	32
Lowland ash polewood (10-24 cm)	21	10 (6)	4 (2)		35
Lowland ash small saw log (26-36 cm)	8	12 (5)	9 (4)	4	33
Lowland ash medium saw log (38-48 cm)	8	18 (8)	15	4 (2)	45

[a]STS = Single Tree Selection system
[b]Number in parenthesis represent unacceptable growing stock (UGS) in each size-class category

Landowner Objectives

Maintain a healthy woodlot and provide income using good forestry practices.

Silvicultural Prescription

The single tree selection system should be used in this stand. The stand should be thinned to harvest/salvage larger ash, to release high quality residuals of non-ash species, to provide income, and to improve growing conditions for the remaining residuals and younger trees. Large saw log ash over 48 cm, diseased trees, trees that are high risk to fail, trees with height and grade limitations, and dense patches should be marked for harvest to release better quality trees. Smaller ash, particularly those less than 30 cm, should be marked where operationally convenient (i.e., near trees marked for other reasons, to provide access to other trees, or to encourage the development of other species). Individual/clumps of important trees (e.g., high quality maple, hemlock, yellow birch) should be released using a crop-tree strategy on at least one side. Basal area should be reduced by an average of 30 percent, leaving an average residual basal area of 22 m^2/ha. Marking should be done to reduce potential felling damage and remove UGS to improve the health, value, and growth of the residual stand. Structurally unsound and dying/dead trees that may fall on the trail should be marked for cutting. Trees with wildlife values such as stick nest, cavity trees, and hemlock, should be retained.

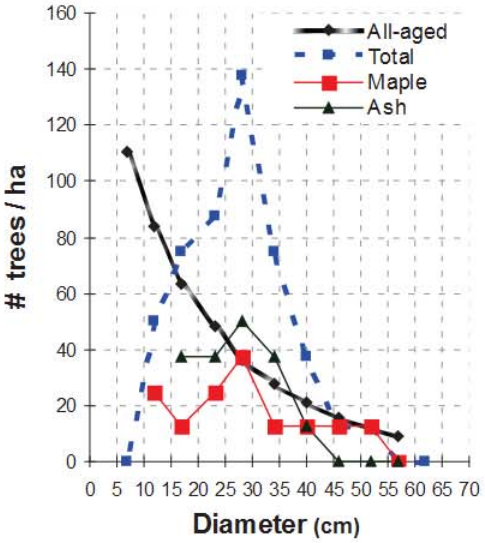

Figure 2.—Stand structure chart for Stand 1, typical upland tolerant hardwood stand.

This harvest is not likely to result in new seedling establishment because of the high residual stand density. It is recommended that the woodlot be assessed after it stabilizes in 5 years or when affected by EAB to assess stand response and develop supplementary recommendations. Otherwise, the next stand entry could be within 8 to 12 years.

Cautions

Avoid harvesting from late March through June to minimize damage to valuable regeneration and disturbing wildlife. The felling of all marked trees within 30 feet of the trail and others that may fall on the trail should be required.

Stand 2. Lowland Ash Polewood (10-24 cm d.b.h.)

Stand Description

The stand was an even-aged swamp (see Tables 2 and 3 and Fig. 3 for characteristics), seasonally inundated and traversed by an open drain. The western parts of the stand were likely open pasture in the 1950s and the rest of the stand was heavily pastured and likely diameter-limit cut in the late 1990s. It was a single-aged stand dominated by green ash that were rapidly becoming suppressed. The poplar was declining. There was a reasonable amount of soft maple in the overstory, and sapling/seedling regeneration was present. The soft maple was generally good-quality.

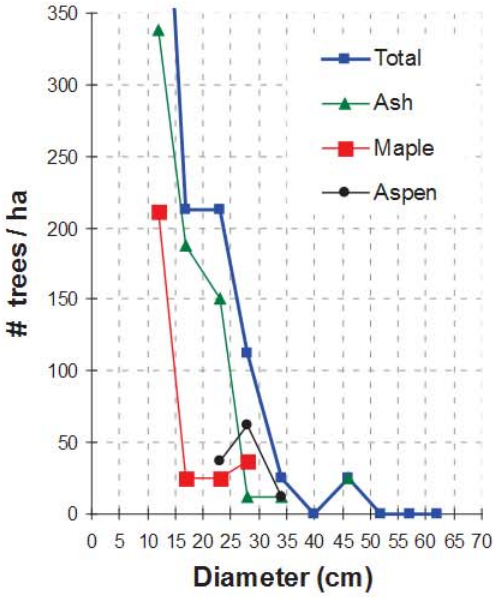

Figure 3.—Stand structure chart for Stand 2, lowland ash polewood stand.

Landowner Objectives

Maintain a healthy woodlot, improve quality and diversity of the stand, and salvage value prior to emerald ash borer infestation while encouraging development of other species.

Silvicultural Prescription

Using a shelterwood approach, the stand should be thinned heavily (30 percent or more), reducing the ash component and encouraging soft maple and other species, and regeneration. As the stand will likely be affected by EAB within the next 10 years, as much ash as feasible should be marked to reduce the future impact of this invasive pest. The ash component should be reduced by retaining the most vigorous individuals while removing UGS and intermediate/suppressed ash. Vigorous dominant or codominant trees between 30 and 48 cm should be retained and released to encourage their growth before the next stand entry. Larger soft maple should be released on at least one side by marking adjoining ash. Ash should be thinned heavily where soft maple regeneration is in the understory. Between 30 and 40 percent basal area should be marked, leaving a residual of approximately 23 m^2/ha. Most of the remaining ash should be healthy trees with the potential to grow into saw log sizes by the next stand entry (10 years). Diseased trees, trees that are high risk to fail, trees with height and grade limitations, and dense patches should be marked. Trees with wildlife values such as stick nest and cavity trees should be retained.

Assuming that this harvest is completed expeditiously, the stand should be assessed for a follow-up thinning in 2017 or sooner if the stand is being attacked by EAB. Regeneration is expected to be soft maple, ash, and aspen. The landowner should consider underplanting with appropriate species (e.g., bur oak, soft maple, yellow birch.)

Cautions

To avoid rutting, the harvest should be conducted in dryer or frozen conditions.

Stand 3. Lowland Ash Small Saw Log (26-36 cm d.b.h.)

Stand Description

The stand was an even-aged swamp (see Tables 2 and 3 and Fig. 4 for characteristics), seasonally inundated and located in a swale between two fields attached to a larger wetland to the north. The stand was likely pastured heavily until the 1960s and left to regenerate. It was a single-aged stand dominated by green ash. The stand was marked using good forestry practices in 2003, and poorly-formed saw log trees were harvested. There were many poor quality ash (firewood-sized and borderline saw logs) and patchy regeneration of ash and soft maple. Many codominant trees around 40 cm were present, with some larger dominants and many saplings. Poplar was present on the east side but was not included in the current assessment. Many of the ash had significant defects and a number were falling over. The soft maple regeneration is generally good and should be encouraged. There is a dense buckthorn understory in places.

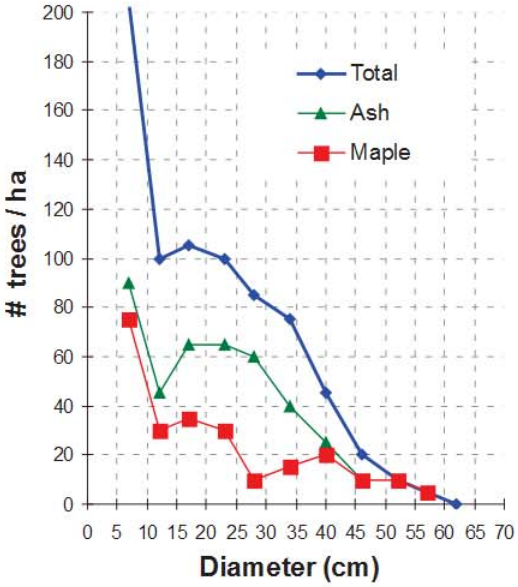

Figure 4.—Stand structure chart for Stand 3, lowland ash small saw log stand.

Landowner Objectives

Maintain a healthy woodlot, improve quality and diversity of the stand, and provide economic return using good forestry practices.

Silvicultural Prescription

The prescription is for the second entry in a three-entry shelterwood approach. The stand should be thinned heavily (30 percent), reducing the ash component and encouraging soft maple, other species, and regeneration. As the stand will likely be affected by EAB within the next 10 years, as much ash as feasible should be marked to reduce the future impact of EAB. The ash component should be reduced by harvesting larger trees (48 cm or greater), UGS, and intermediate/suppressed ash. Most of the remaining ash should be healthy trees with the potential to grow into saw log sizes by the next stand entry in10 years. Intermediate crown class and larger soft maple should be released on at least one side by marking adjoining ash. An average of 30 percent basal area should be marked, leaving a residual of approximately 20 m^2/ha. Diseased trees, trees that are high risk to fail, trees with height and grade limitations, and dense patches should be marked. Trees with wildlife values such as stick nest and cavity trees should be retained.

Assuming that this harvest is completed expeditiously, the stand should be assessed for a follow-up harvest in 2017 or sooner if the stand is being attacked by EAB. Regeneration is expected to be soft maple, ash, aspen and perhaps cherry. The landowner should consider buckthorn control to aid in the establishment of more desirable vegetation.

Cautions

Care should be taken to avoid damaging high quality residual stems, and the harvest should take place during dryer or frozen conditions to avoid rutting.

Stand 4. Lowland Ash Medium Saw Log (28-48 cm d.b.h.)

Stand Description

The stand was an even-aged swamp (see Tables 2 and 3 and Fig. 5 for characteristics), located in a swale between a field and a road. This seasonally inundated stand was connected by culverts to a larger swamp to the south. The stand was likely clearcut in the early 1900s and likely pastured heavily through the 1950s. It was an excellent single-aged stand dominated by green ash. The site quality is exceptional for green ash and soft maple, with an estimated 30 to 35-m canopy height. It does not appear that there has been any historic harvesting and the last stand disturbance was likely in the 1970s when the elm died.

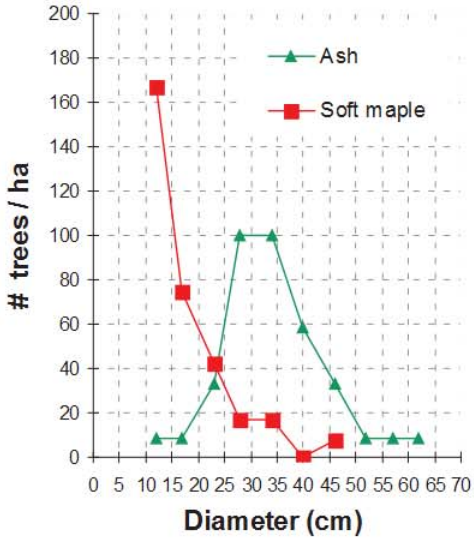

Figure 5.—Stand structure chart for Stand 4, lowland ash medium saw log stand.

Many of the trees have stagnated because of the high stand density. Because of the high proportion of ash, the excessive stocking and resulting lack of stem taper, it is clear that this stand will be devastated when emerald ash borer affects the area in an estimated 10 years. There are scattered soft maple in dominant to intermediate crown positions and scattered soft maple saplings and seedlings.

Landowner Objectives

Maintain a healthy woodlot, optimize economic returns prior to ash borer infestation and encourage the development of other species.

Silvicultural Prescription

This is the first entry in a three-entry shelterwood approach. It is recommended that two more stand entries be made within the next 10 years. The first entry should reduce the stand density by about 30 percent, with a second entry in approximately 7 years. Details of the second entry would be developed based on stand conditions and proximity of EAB infestations at that time. The first entry should harvest a significant saw log volume/acre, encourage the development of species other than ash, and retain individual ash that are increasing in volume and value.

To achieve the basal area reduction, UGS ash over 48 cm should be marked, any ash should be marked to release soft maple or other non-ash species of any size. Where soft maple or non-ash regeneration is present and there are no larger trees to be marked, smaller ash should be thinned/marked to improve the vigour and development of the other species.

To help maintain stand integrity, dominant ash with bigger crowns can be retained, and low-vigor trees should be marked. The healthy dominant trees will continue to increase in volume and help hold the stand together until the next entry). Unmerchantable UGS or UGS with large crowns may also be left to help maintain stand integrity and allow for other trees to be salvaged during this entry. Trees with significant wildlife value (e.g., cavity trees) should be retained.

Soft maple present as advanced regeneration is expected to become the main species. To improve stand diversity, bur oak, yellow birch, and hemlock could be planted in larger openings where there is no advanced regeneration.

Cautions

The stand should be cut in dry or frozen conditions to avoid rutting, although this stand is not as wet as other swamps in the area and a larger window for harvesting is present.

ACKNOWLEDGMENTS

The authors are indebted to the Wellington County Stewardship Council for sponsoring the project, to registered professional foresters Ken Elliott and Martin Streit for their extensive comments and discussion during the development of this paper, and to Taylor Scarr for his advice on emerald ash borer dynamics.

LITERATURE CITED

Herms, D.A.; Gandhi, K.J.K.; Smith, A.; Cardina, J.; Knight, K.S.; Herms, C.P.; Long, R.P.; McCullough, D.G. 2009. **Ecological impacts of emerald ash borer in forests of southeast Michigan.** In: McManus, K.A; Gottschalk, K.W., eds. Proceedings. 20th U.S. Department of Agriculture interagency research forum on invasive species 2009; 2009 January 13-16; Annapolis, MD. Gen. Tech. Rep. NRS-P-51. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station: 36-37.

Knight, K.S.; Herms, D.A.; Cardina, J.; Long, R.; Rebbeck, J.; Gandhi, K.J.K.; Smith, A.; Klooster, W.S.; Herms, C.P.; Royo, A.A. 2010. **Emerald ash borer aftermath forests: the dynamics of ash mortality and the responses of other plant species.** In: Michler, C.H.; Ginzel, M.D., eds. 2010. Proceedings of symposium on ash in North America; 2010 March 9-11; West Lafayette, IN. Gen. Tech. Rep. NRS-P-72. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station: 11.

Lyons, D.B. 2010. **Emerald ash borer.** Frontline Technical Note 110. Sault Ste. Marie, ON: Canadian Forest Service, Great Lakes Forestry Center. 4 p.

Ontario Ministry of Natural Resources (OMNR). 2000. **A silvicultural guide to managing southern Ontario forests.** Version 1.1. Toronto, Ontario: Ontario Ministry of Natural Resources. 648 p.