Town of Berthoud

Forestry Department

Emerald Ash Borer Management and Response Plan

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Acknowledgments

This document was authored and prepared by Josh Embrey – Town Forester, Town of Berthoud.

Special thanks go out to the following individuals for their dedication towards supporting the Town of Berthoud's urban forest, their previous work towards emerald ash borer, and their contribution towards the development of the Town's Emerald Ash Borer Management and Response Plan:

Town of Berthoud Staff

Chris Kirk – Town Administrator

Jeremy Olinger – Deputy Town Administrator

May Soricelli –Town Board Trustee/Tree Committee Liaison

Town of Berthoud Tree Advisory Committee

Bob Schneider – Chair

Laura Davis – Vice-chair

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Introduction & Background

The Town of Berthoud is home to more than 6,000 street and public area trees (**Figure 1**) and has been recognized by Tree City USA for 36 consecutive years. Trees have a vital role in the ecological, economical, and social benefits of a community – which are all significantly important to an urban forest setting. Trees are responsible for providing ecological benefits such as improvements in water and air quality, erosion control, and as well as promoting biodiversity. Economic benefits, provided by trees, consist of lowering energy demands and increasing property and home values. Studies also suggest that trees contribute to the improvement of social aspects, specifically with the correlation of reduced crime in areas containing dense canopy levels.

Out of the near 6,000 street and public area trees in Berthoud, roughly 22% of trees are ash (*Fraxinus* spp.) (**Figure 2**). Ash trees, though not native to Colorado, have been heavily planted throughout the state as street and shade trees due to their fast growth rate and high adaptability. The two most common species of ash planted in the Front Range are green ash (*Fraxinus pennsylvanica*) and white ash (*Fraxinus americana*). However, all species of ash in the genus *Fraxinus* are at significant risk of elimination from a devastating insect: the emerald ash borer.

Emerald ash borer (*Agrilus plannipennis* Fairmaire) is a federally regulated pest and poses a tremendous threat towards natural forested areas and municipalities across North America and Canada. Emerald ash borer (EAB) is a highly destructive, non-native invasive beetle responsible for killing more than 100 million ash trees throughout the United States. Originally from Asia, the metallic wood-boring beetle was first discovered in Michigan in 2002, where it was presumably thought to be present for roughly 10 years or longer before being detected. Since then, EAB has now become established in 35 states across North America, including Colorado. In September 2013, EAB was positively identified in the City of Boulder, making it the first identification within the state of Colorado. Since its appearance in Boulder, EAB has been detected within the following cities (county): Longmont (Boulder); Gunbarrel (Boulder); Lafayette (Boulder); Lyons (Boulder); Superior (Boulder); Broomfield (Broomfield); Westminster (Adams); Berthoud (Larimer); Fort Collins (Larimer).

It is suggested that EAB is the most destructive insect to invade North America. At first, when populations are low, neglect damage from the beetle is noticed; however, EAB's "fitness" (ability to survive and reproduce) is substantially high allowing for populations to quickly increase in number. Therefore, once established and populations become highly dense, healthy ash trees can die within two-four years if untreated. Though EAB can infest new areas naturally, the main method of EAB introduction is unwilling by humans. The transportation of infested firewood, nursery stock, and other ash material is the number one factor contributing to new infestations. Once EAB is detected, federal and state agencies establish quarantine areas regulating the movement of hardwood materials within the infested area. Originally, a federal and state quarantine were placed on Boulder County; however, due to EAB's geographic distribution beyond quarantine boundaries, both quarantines have been lifted.

This EAB Management and Response Plan is intended to provide best management practices for Town of Berthoud Staff as well as residents within the Town to reference as needed. Along with providing information regarding identification and management options, this document is also intended to educate the public about EAB. This integrated plan is ongoing and subject to change as new infestations are discovered, new practices are developed, and new literature/resources are published. As Town Staff and the Tree Advisory Committee develop greater understandings of current issues and future proposals, alterations to this document will be updated and/or revised, ultimately modifying and improving the overall health, diversity, and longevity of Berthoud's urban forest.

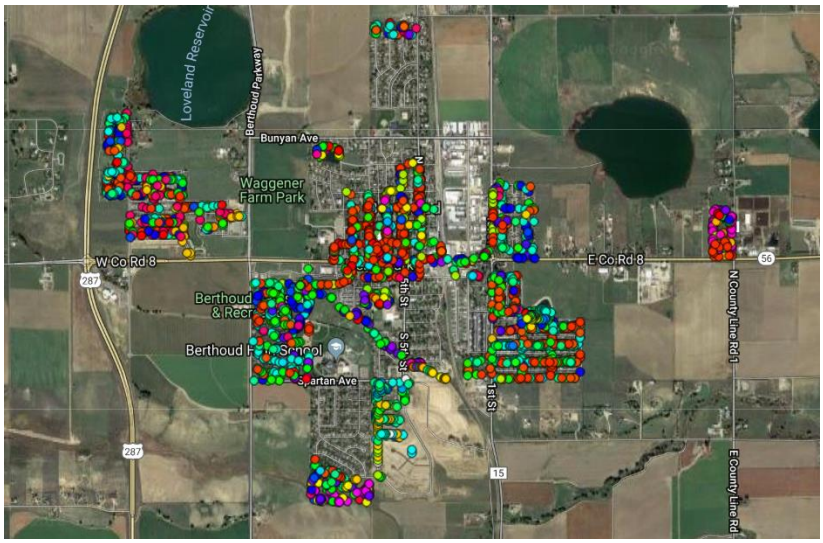

Figure 1. Town of Berthoud's street and public area tree inventory.

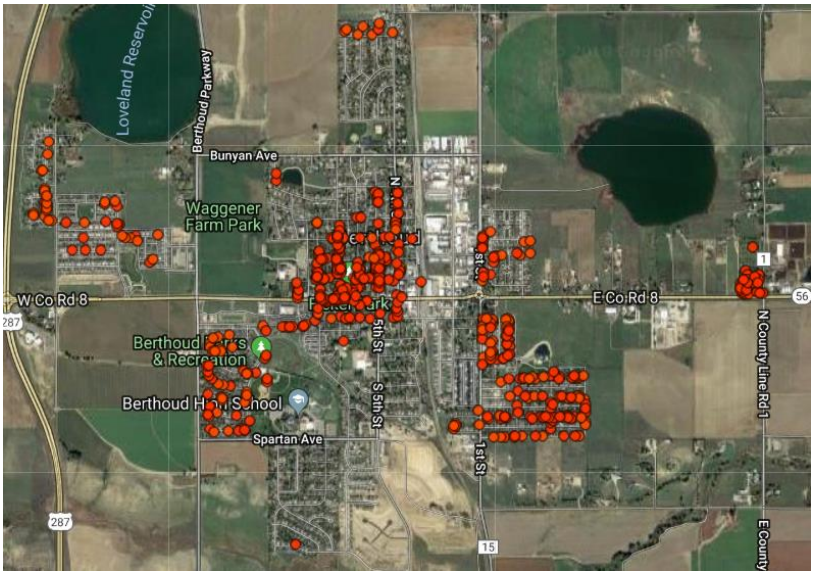

Figure 2. Town of Berthoud's street and public area ash tree locations.

EAB Identification

Adult EAB have a metallic emerald green thorax and wings, with a metallic purple/red abdomen (**Figure 3**). Typically, adults range in size from 1/2 inch-long to 1/8 inch-wide. Larvae are creamy-white with a flattened head, and can reach a length of 26-32mm (**Figure 4**). Larvae are also segmented, with the abdomen generally containing 10 segments. Though EAB identification is critical, identifying signs and symptoms of an EAB infestation – which will be later discussed in this document – is the most important key in determining whether EAB is present within an area.

Figure 3. Adult emerald ash borer. (Source: www.gainvasives.org)

Figure 4. Emerald ash borer larva. (Source: www.gainvasives.org)

Biology & Life Cycle

Considering EAB are non-native, they lack natural predators and pose a severe threat towards all ash trees in North America. Depending on environmental conditions, EAB may have a 1-2 year life cycle, though most commonly 1 year (**Figure 5**). Generally, adults begin to emerge from ash trees in early May and mid-June – leaving a distinct D-shaped exit hole – with peak emergence anywhere between mid-June to early July. However, studies suggest that adults can continue to emerge until August.

The typical life-span of adult EAB is around 2-4 weeks, with females normally showing longer longevity compared to males. After emerging, adults are required to feed on the foliage of ash before becoming sexually competent, resulting in minimal damage to the canopy. Literature suggests that adults generally fly around 0.5-1 mile from the tree they emerge from; however, under certain conditions, adults may travel up to 2 miles or more.

After reproduction, males shortly die off whereas females produce roughly 60-90 eggs. Each egg is individually laid within cracks and crevices of the bark, where they spend anywhere from 1-2 weeks before hatching and boring into the tree. Damage, which results in the death of the tree, is due from the larvae feeding in the phloem and cambium layers creating serpentine ("S-shaped") galleries. This feeding behavior disrupts the tree's ability to transport water and nutrients, ultimately killing the tree over time. Feeding typically occurs between mid-summer to fall, before developing into pupa prior to acclimating to survive the winter. When conditions are right, and pupae have developed into adults, emergence occurs and the process repeats.

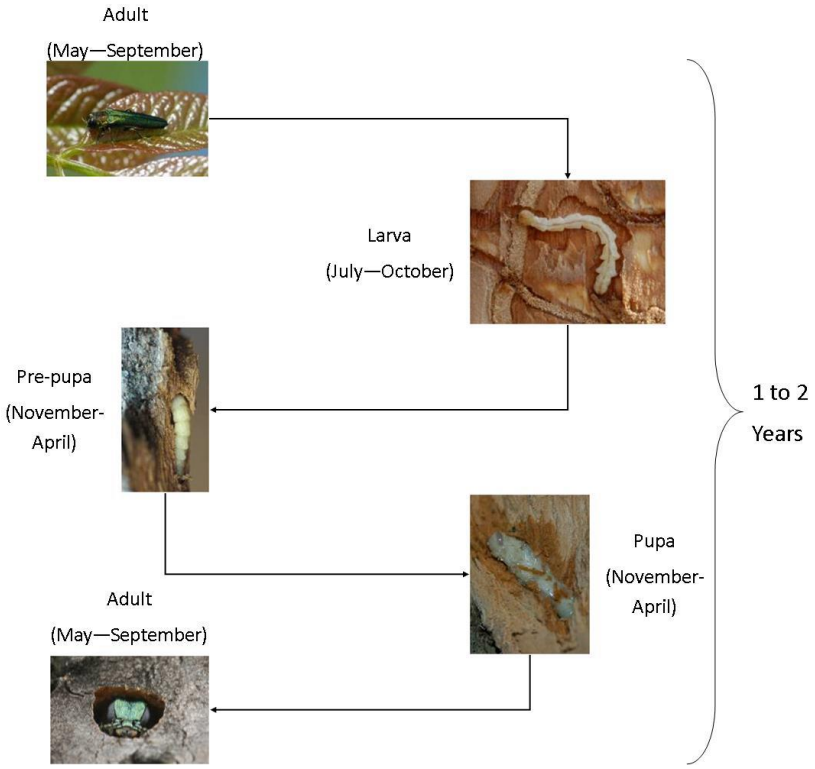

Figure 5. EAB life cycle. (Source: www.colorado.gov)

More Common Ash Boring Insects

Native ash borers can cause damage, and even death, towards ash trees, but generally pose little threat. Over time, the two have gone through a co-evolutionary process together, which is responsible for contributing to an ash's resistance towards native ash boring species. Though native ash borers and EAB share relatively similar behaviors, EAB have distinctly different signs (e.g., 1/8 inch D-shaped exit holes and S-shaped larvae feeding galleries) compared to those of the native, more common ash borers. Below is a collection of native ash borers that are commonly confused with and misidentified as emerald ash borer:

- Lilac/Ash borer (*Podosesia syringae*) (**Figure 6**)
- Flatheaded appletree borer (*Chrysobothris femorata*) (**Figure 7**)
- Redheaded ash borer (*Necolytus acuminatus*) (**Figure 8**)
- Pigeon tremex (*Tremex columba*) (**Figure 9**)
- Ash bark bettle (*Hylesinus* spp.) (**Figure 10**)
- Banded ash borer (*Neoclytus caprea*) (**Figure 11**)

Figure 6. Adult lilac/ash borer (left) and larva (right). (Source: www.extension.iastate.edu)

Figure 7. Adult flatheaded appletree borer (left) and larva (right). (Source: www.forestpests.org)

Figure 8. Adult redheaded ash borer (left) and larva (right). (Source: www.extension.iastate.edu)

Figure 9. Adult pigeon tremex (left) and larva (right). (Source: www.extension.umn.edu)

Figure 10. Adult ash bark beetle (left) and feeding galleries (right).
(Source:www.labs.russell.wisc.edu)

Figure 11. Adult banded ash borer (left) and larva (right). (Source: http://nfs.unl.edu/eab-faq)

Ash Tree Identification

Tree identification, whether leaves are present or abscised, can be a challenging task for many individuals. When identifying trees, remember to keep it simple and start with the basics. Below is a list of techniques used to correctly identify ash (*Fraxinus* spp.) species:

- Are the leaves, buds, and/or branches opposite (**Figure 12**)?
- Are the leaves compound and consist of 5-11 leaflets per leaf (**Figure 13**)?
- Is the bark arranged in a distinct diamond shaped pattern (mature trees) or is the bark relatively smooth (young trees) (**Figure 14**)?
- Are the seeds slender and present in clusters (**Figure 15**)?


Figure 12. Green ash (*Fraxinus pennsylvanica*) twig (left) and White ash (*Fraxinus americana)* twig (right). Note buds are opposite from each other. (Source: www.dendro.cnre.vt.edu)

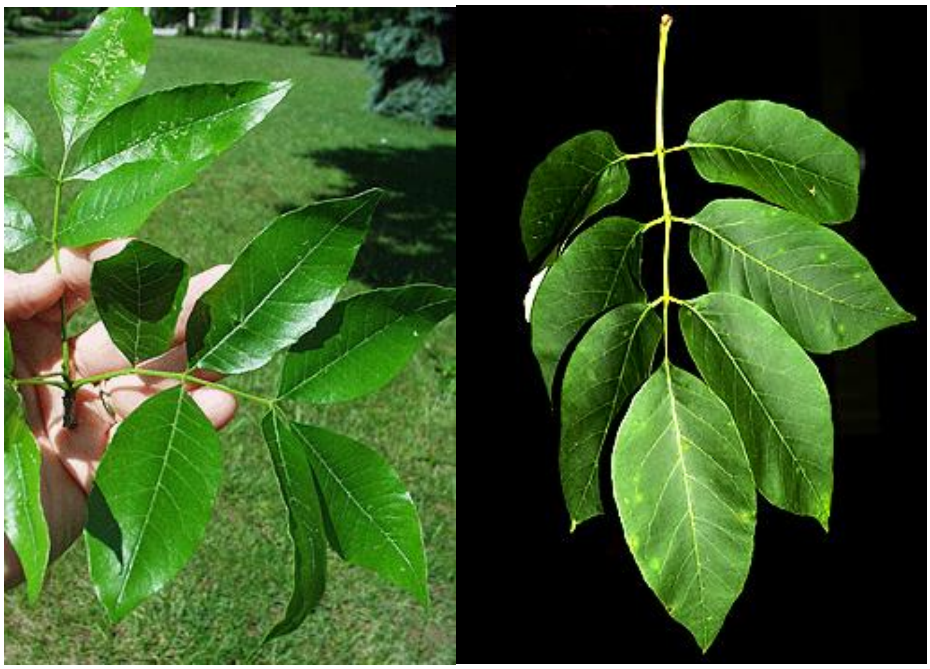

Figure 13. Compound leaves from a green ash (*Fraxinus pennsylvanica*) (left) and white ash (*Fraxinus americana)* (right). Note the leaves are opposite from each other coming off the twig and consist of roughly 7 leaflets per leaf. (Source: www.dendro.cnre.vt.edu)

Figure 14. Distinctive diamond-shaped pattern bark of a mature green ash (*Fraxinus pennsylvanica*) (left) and white ash (*Fraxinus americana*) (right). (Source: www.dendro.cnre.vt.edu)

Figure 15. Reproductive female seeds from a green ash (*Fraxinus pennsylvanica*) (left) and white ash (*Fraxinus americana*) (right). (Source: www.dendro.cnre.vt.edu)

EAB Infestation Signs & Symptoms

Early detection of EAB is one of, if not, greatest difficulties regarding EAB management, particularly when population densities are low and newly establishing. Literature suggests that noticing early signs and symptoms of an EAB outbreak can take anywhere from 2-4 years after EAB have already infested an area. Although there are other possible causes to the following, the most common signs and symptoms of an EAB infestation include:

- Canopy dieback and thinning in the upper part of the tree (**Figure 16**)
- D-shape exit holes approximately 1/8-inch wide (**Figure 17**)
- Epicormic sprouting/adventitious shoots present within the mid-canopy and/or on the lower trunk and base (**Figure 18**)
- Vertical splits in the bark (**Figure 19**)
- S-shaped tunnels/galleries present under the bark (**Figure 20**)
- Increased woodpecker activity (**Figure 21**)

Figure 16. Canopy dieback/thinning as a result of EAB infestation. (Source: http://eminnetonka.com/community-forestry/shade-tree-disease-control/emerald-ash-borer)

Figure 17. Distinct D-shaped exit hole from the emergence of an adult EAB. Note hole sizes typically measure to be around 1/8th inch. (Source: http://ky-caps.ca.uky.edu/emerald-ash-borer)

Figure 18. Epicormic sprouting/adventitious shoots produced on the lower trunk/base of ash. (Source: http://ky-caps.ca.uky.edu/emerald-ash-borer)

Figure 19. Vertical splitting of bark as a result of EAB infestation. (Source: http://ky-caps.ca.uky.edu/emerald-ash-borer)

Figure 20. S-shaped gallery present under the outer-bark layer created by EAB larva. Note the "S" gradually increases in size as the larva continues to develop and increase in size as it feeds. (Source: http://ky-caps.ca.uky.edu/emerald-ash-borer)

Figure 21. Signs of increased woodpecker activity feeding on EAB larvae. (Source: http://ky-caps.ca.uky.edu/emerald-ash-borer)

Management & Control Options

Unfortunately, there are no known methods, treatments, or practices of successful EAB eradication. As long as ash trees are present within an area, EAB will continue to survive and reproduce. However, as research and education continues to develop and expand, several management options have been developed: 1) Insecticide Treatments; 2) Removal and Replacement Strategies; and 3) Biological Controls.

1. Insecticide treatments are presumably the most effective way of controlling EAB and increasing the longevity of ash trees that were previously healthy and in good condition. Particular combinations of methods, chemicals, and timing allow to target 1-2 of the EAB life stages. Treatment costs vary in prices due to several determining factors including the size of tree, overall health/condition of tree, and how long EAB has infected the tree. However, if the decision to treat the tree is made, treatment must continue for the life of the tree. Please remember, insecticides have the potential to harm non-targeted species if improperly applied. Always carefully read warning labels, ingredients, and directions before treating or hire a licensed professional to administer the preferred treatment. Below is a list of suggested treatment methods:

    - Systemic insecticides via soil applications – the insecticides imidacloprid and dinotefuran can be applied to the root systems of ash trees, allowing the roots to transport the chemicals
    - Systemic trunk sprays – the insecticide dinotefuran can be sprayed onto the trunk of an ash tree, allowing the chemical to be absorbed through the bark
    - Systemic insecticides via trunk injections – the insecticides emamectin benzoate, azadirachtin, and imidacloprid can be injected into the lower trunk of an ash tree, allowing the tree to transport the chemical(s) via its vascular system
    - Surface-applied contact insecticides – insecticides such as bifenthrin, cyfluthrin, and permethrin can be persistently applied (as necessary) onto the tree's trunk and branches targeting adults, eggs, and newly hatched larvae

2. Removal and replacement strategies consist of cutting down undesirable ash (e.g., young, unhealthy, and/or hazardous) trees that are considered fiscally unreasonable to invest in, and subsequently replacing them with a different species of tree. Unlike treatment costs, which are required for the remainder of the trees life, this particular strategy consists of a removal cost (if a contractor is involved) and replacement cost of acquiring as well as planting a new tree. This method is a great alternative to treatment, as it promotes diversity within a forest.

3. Biological control agents are currently being focused on as more research studies are being conducted. Although there are no known natural predators for EAB in North America, researchers are aiming towards introducing potential candidates (e.g., parasitic stingless wasps) to help decrease and control the movement of EAB, as well as limit pesticide use.

To Remove & Replace or Treat an Ash

Probably the toughest choice in EAB management is the decision to remove and replace or treat an ash tree. Both methods come with costs, as well as both methods have pros and cons. For example, younger trees are typically smaller in size compared to older trees; therefore, for a removal where the cost increases as size increases, it would be financially less overall to have a younger, smaller tree removed and subsequently replaced instead of a larger diameter tree. This goes the same for treatment; typically, smaller trees cost less to treat compared to larger trees because less chemical is needed. However, a smaller tree that is half the age and size of a larger tree is going to need to be treated twice the amount overtime as the tree has many years left to live compared to the older one. Considering this subject can be a discussion, it is recommended that a forester or licensed tree professional assess the tree(s) that are in debate.

Town Surveying Efforts

Both trapping and branch sampling surveys have been conducted by Town Staff and the Tree Advisory Committee in the past for the presence of EAB, and negative results suggest that EAB was not present within Town limits at the time. For the year of 2016, and following years, the Town Forester will be surveying for the presence of EAB within the Town of Berthoud. Four surveying methods will be conducted: 1) Visual examinations of ash trees; 2) Trapping via purple-prism EAB traps; 3) Branch sampling; and 4) Rearing cages. All four methods of surveying will provide vital feedback to the Town and potentially allow for early detection of EAB within Town limits. If EAB is confirmed, these techniques can also provide data that can be utilized in estimating population densities within Berthoud and allow appropriate action to be prepared and executed towards control.

1. Visual Examinations
    - Visual examinations of ash trees will be conducted yearly throughout the Town. Observations will be made and documented as needed specifically for the previous mentioned signs and symptoms of EAB.

2. Trapping
    - Purple-prism and green multi-funnel EAB traps and lures will be used in attempt for early detection (**Figure 22**). Traps will be distributed throughout the Town's and will be hung in ash trees of varying sizes and conditions, as well as specific locations Traps will be monitored and checked twice a week when adults are most active (June – August), and then will be checked once a week throughout September.

3. Branch Sampling
    - Branch sampling will be conducted during the late fall and early winter months when EAB larva have grown in size developing larger more noticeable galleries. Branch sampling consists of whittling off the bark of a branch removed from the mid-canopy of the tree – located on the south side – revealing the inner bark layers where EAB feeding galleries are present (**Figure 23**).

4. Rearing Cages
    - Rearing cages will consist of placing cut branches (generally in late April) from suspect trees into $2ft^3$ constructed cages (**Figure 24**). Cages are stored inside and monitored biweekly until the end of August.

Figure 22. Purple-prism trap (left) and green multi-funnel trap (right) deployed in ash trees.

Figure 23. Example of the whittling process used when branch sampling for EAB larvae. (Source: www.cfs.nrcan.gc.ca)

Figure 24. EAB rearing cage. As adult EAB emerge from cut branches, they will ideally be caught in the clear jar for detection.

Town Ash Tree Treatment vs. Removal & Replacement Proposal

The Town of Berthoud's Forestry Division is responsible for the maintenance of more than 1,500 trees in the park system and public right-of-ways, with roughly 5% being ash. Currently, the Town Forester has assessed and inventoried each individual ash tree owned and maintained by the Town's Forestry Division. All ash trees have been ranked with a priority number to determine which trees are treatable and which trees need to be replaced. Trees have been assessed for overall value, size, location, canopy cover, condition and health, free-to-grow, and dominance.

The Town's Forestry Division's overall objective is to save nearly 3/4 of the public area ash trees by treatment, and subsequently removing and replacing the remaining 1/4 mostly due to the identified poor conditions of those trees. However, these ratios are subject to change due to a variety of potential future scenarios such as natural causes (e.g., storm damage, natural aging, etc.), budget allowance and increases in treatment costs. As management progresses, these numbers and inventory will be updated accordingly to reflect the changing landscape to the urban forest.

1. Trees that have been added to the treatment list are high priority trees that possess value, maturity, health, and aesthetic traits in the Town of Berthoud. Trees that have been classified as "valuable" are trees that contribute the most to ecological, economical, and social benefits to the Town landscape. Trees that have been classified as "mature" are trees that are great in size and stature, generally with a diameter at breast height (DBH) of 15 inches or greater. Trees that have been classified as "healthy" are trees that possess dense canopies and free of obvious signs of disease. Trees that have been classified as "aesthetic" are trees that are in good condition, free-to-grow, and in appropriate locations. Treatments will consist of trunk injections using the insecticide TREE-äge (emamectin benzoate). Emamectin benzoate is derived from specific soil bacterium, and studies suggest treatments are effective for 2-3 years. As budget allows, treatments will begin in 2016 and carry into 2017. Once treatments begin, those identified trees will continue to receive treatment every 2-3 years as scheduled.

2. Trees that have been added to the removal and replacement list are low priority trees that consist of young, unhealthy, and/or hazardous trees. Trees containing such criteria will not be invested in; instead, trees will be removed then replaced contributing to the diversity of the Town's urban forest. Trees that have been classified as "young" are trees that ranged in DBH of 15 inches or less*. Trees that have been classified as "unhealthy" were trees that showed obvious signs of damaging conditions including die-back in canopy and loss of branches and limbs. Trees that have been classified as "hazardous" are trees that have the potential to harm individuals and/or property if they are not removed in a timelier manner. All of the trees in this section that fall under these terms will be removed over time and replaced. This strategic process will begin in 2016 and carry into the next several years as reforestation establishes.
   [**Note: according to the Colorado Department of Agriculture, trees with a diameter of 15 inches or greater are recommended to be treated professionally via trunk injections. Considering the Town will only be treating trees using this method, trees that fall below 15 inch diameters or less will not be treated.*]

Rights-of-way & Privately Owned Ash Trees

According to *Municipal Code Section 30-2-112(B)(5)*, it is the homeowner who is responsible for the maintenance and well-being of trees adjacent to their property in the right-of-way. The Town highly recommends homeowners to treat ash trees that fall under the recommended treatment criteria; however, it is ultimately the homeowner's decision to either treat their ash tree or have it removed and replaced responsibly.

For concerned homeowners, initially your trees should be identified to make sure whether you have an ash (in the genus *Fraxinus*) or not. If so, assess your ash tree(s) for the health, age, and overall condition. Be sure to thoroughly review the Town's recommended management options prior to deciding whether you intend to invest in your ash by treating it, or removing the ash and replacing it with a different species. Below is a list of key considerations provided to assist in your decision process:

1. How valuable is the tree?
    - Does it provide ecological and economic benefits to you?
2. What is the size of your tree?
    - Is it small and easy to remove, or is it large and in good condition?
3. Is it hazardous?
    - Does it have the potential to cause damage to individuals and/or property?
4. How many ash do you have?
    - Could you remove some of the ash and replace them with different species?
5. Is your tree in the right location?
    - Is it better to remove the ash and replant a new tree in a different location?
6. How healthy is the tree?
    - Are there any signs of EAB, other ash boring insects, disease, die-back, etc.?

Disposal, Handling, and Utilization of Wood

In the case of EAB confirmation in the Town of Berthoud, or anywhere within Larimer County and/or Weld County, a federally regulated quarantine area will be placed in the Counties controlling the movement or delivery of hardwood material. If this case arises, the Town will dedicate an area for the purpose of properly disposing of ash wood. This matter is currently in discussion and the Town will inform residents when and where the location has been appointed.

In regards to wood utilization, Town staff is currently reaching out to nearby communities and discussing potential uses of wood from removed ash trees. As of now, potential uses consist of mulch, fuel for heating, slabs, rough cut lumber, landscape timbers, blanks, wood stakes, and wood pellets.

Conclusion

As EAB progressively becomes established in new areas within Colorado, the Town of Berthoud will continue to be proactive and anticipate the arrival of EAB within Berthoud Town limits. In doing such, the Town will remain up-to-date with the most current news and publications regarding EAB, and will provide ongoing public awareness to Town residents. Experts suggest that EAB will eventually spread across the entire Front Range within 10-15 years. Fortunately, Berthoud Staff and the Tree Advisory Committee have been proactive for several years now – monitoring the progress and educating the public – and is continuing to do so as the Forestry Division grows.

Public awareness and outreach is key to educating individuals the significance trees provide. Stressing the importance of not moving firewood is also vital for the prevention of new future EAB infestations. Considering EAB will continue to reproduce and spread if ash trees are left untreated or not removed, it is critically important for Town Staff and Berthoud residents to take action and have their ash trees treated or removed and replaced. Having ash trees treated ultimately allows for three key factors: 1) Protecting the tree from EAB and other ash borers; 2) Slowing the spread of EAB; and 3) Allowing time for reforestation to develop (e.g., shadow planting). Having ash trees removed and replaced ultimately allows for greater diversity and preventing future pest epidemics.

For additional information regarding EAB or the Town of Berthoud Forestry Department, please visit: http://www.berthoud.org/departments/parks-recreation/forestry.

Additional Resources

- Colorado Department of Agriculture
  - https://www.colorado.gov/agplants/emerald-ash-borer
- Emerald Ash Borer Information Network
  - http://www.emeraldashborer.info/
- Colorado State University Extension
  - http://extension.colostate.edu/
- Colorado State Forest Service
  - http://csfs.colostate.edu/
- Don't Move Firewood
  - http://www.dontmovefirewood.org/
- United States Department of Agriculture Animal and Plant Health Inspection Service
  - https://www.aphis.usda.gov/aphis/home/
- United States Department of Agriculture Forest Service
  - https://www.fs.fed.us/
- Colorado Tree Coalition
  - http://coloradotrees.org/
- National Arbor Day Foundation
  - https://www.arborday.org/