Preparation for the Emerald Ash Borer (*Agrilus planipennis*) in the North Country

*Developing an effective management design for Northern New York*

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Invasive species represent a current and extensive management problem. With the number of invasive species currently established in the US estimated at 4,300 (Corn et al. 1999), our native ecosystems are already under an extreme amount of stress. Inevitably, such species are going to have a broad impact on society. The effects are felt economically, socially, and ecologically - therein lays the complexity of managing invasions. Consequently, humans have a huge role as invested stakeholders. While we created the invasive species problem and are also the primary reason for their spread (both in the case of intentional, and unintentional introductions), we can choose to be part of the solution. In order to fully grasp the problem that invasives present us with, we must understand their biology, the effect their presence has on specific ecosystems, and how changes in the ecosystem affect the stakeholders involved. Once we have looked closely at the species-specific parameters of our invasive, and the cascade of effects they can have on identified stakeholders, then we can begin to compile effective containment plans.

The first of these parameters addresses the definition of invasive species. In defining what determines invasive from noninvasive, it becomes easier to identify the ecological ramifications of the species. The emerald ash borer (EAB) (*Agrilus planipennis*), a beetle native to Asia, is the focal species of our study. The ecological ramifications of the EAB invasion are centered on the risk they pose to our North American ash species (*Fraxinus* spp.) – a valuable tree species in several societal facets. Therefore, in any solution considerations, existing biological knowledge of the EAB is vital for successful implementation. This includes the *A.*
*A. planipennis* life cycle, feeding preferences and its consequence to our forest communities. Addressing patterns of EAB origin and spread are also essential to management strategies.

Humans, therefore, have to be recognized as a dynamic player within the EAB problem. As an extremely manipulative species, we have introduced thousands of species, including the EAB. Hence, as part of this case, we aim to include how humans are impacting the EAB spread. Thorough examination of *A. planipennis* introduction roots to North America will allow for the analysis of the emerald ash borer spread. The EAB problem is interdisciplinary and so too must the solutions. Devising appropriate measures should include the ecological and economic effects of the emerald ash borer.

I. A Brief Introduction to Invasive Species

The National Invasive Species Council (NISC), established under executive order 13112 (Clinton 1999), defined invasive species as “a species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health” (ISAC 2006). As part of the National Invasive Species Management Plan (NISMP), the NISC helped distinguish invasive from nonnative based upon the concept of associated harm. Outlined within the NISMP, nonnative species are beneficial and “support human livelihoods or preferred quality of life” (ISAC 2006), such as agricultural crops potatoes and wheat. However, with a current estimate of 50,000 nonnative species in the US (Pimental et al. 2004), related costs and risks of invasive species are pertinent.
An important factor to species invasions (Groom et al. 2006), propagule pressure determines the extent of an invasive species presence in an ecosystem. An increasing number of propagules, or invading individuals, increases the chances of establishment. Thus, greater pressure results in higher invasion risk and success. The degree of success depends on the “quality, quantity, and frequency of invading organisms” (Groom et al. 2006). Propagule pressure can also determine which species persist and why (Lockwood 2005). The invasive species that persevere in natural ecosystems must first overcome significant barriers.

In the process of invasion, species must hurdle geographic, survival, establishment, and dispersal and spread barriers to become established (ISAC 2006). Successful invaders are capable of completing the progression. Movement outside of natural home range requires conquering geographic barriers. Physical barriers, often mountain ranges or oceans, provide limitations to species spread. However, human aided transportation often causes introduction of nonnative species (ISAC 2006). Environmental conditions, such as climate, can inhibit reproduction and act as survival barriers that make local existence difficult (ISAC 2006). Further species population growth is necessary to becoming invasive, but establishment barriers impede such development. Sustainable populations allow for continued ecosystem presence, while sink populations threaten species existence (ISAC 2006). Successful invasion is possible only by overcoming dispersal and spread barriers. Therefore, movement from original site of establishment is a requirement for invasive species consideration. Species surmounting all barriers and that cause harm, as previously iterated, are deemed invasive (ISAC 2006). A
theoretical application of this process, the “ten’s rule” determines how many species eventually become invasive.

The “ten’s rule” acknowledged the average percentage of species that became successful invaders. On par, ten percent of species succeeded in progressing through each stage. The process begins with imported species. Ten percent of imported species thrive to become introduced. Ten percent of introduced species become established. And ten percent of established species become pests (Williamson and Fitter 1996). Though a good majority of invasions fail, thousands of species introductions create high propagule pressure. Humans owe this pressure largely to us. Our history is littered with examples of intentional and accidental introductions. The consequences of such actions are devastating. Invasive species are threatening and displacing native species, disrupting ecosystem dynamics while causing environmental instability. The emerald ash borer is no different. The EAB is a serious problem that threatens every ash in the United States. North American hardwood communities face the possibility of local extinctions in established *A. planipennis* regions.

II. The Emerald Ash Borer

i. Introduction to the United States

Since detection of the emerald ash borer (EAB), *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae), came in 2002, host species North American Ash (*Fraxinus spp.*) have been threatened by the beetles existence. Found originally in Southeastern Michigan and Ontario,
Canada (McCullough and Usborne 2011), \textit{A. planipennis} traveled from East Asia aboard woody packaging materials (Cappaert et al. 2005). Now present in fifteen states and two Canadian provinces (Figure 1), the EAB has killed millions of Ash trees in its wake. The emerald ash borer presents an incredible conservation challenge, especially as humans have artificially facilitated the emerald ash borer spread. The decline of ash populations in Eastern North America represents significant economic, ecological, and social losses.

(Figure 1) Current distribution of the Emerald Ash Borer (\textit{Agrilus planipennis}). Red dots represent where the initial county detection occurred. Blue lines represent Federal quarantine boundaries and Orange lines represent Canadian regulated areas. Counties that are white-filled are areas of heavily infested areas (Chaloux 2012).
ii. Economic Costs

As a valuable economic commodity, the elimination of ashes equals lost profits for individuals working in timber or wood manufacturing industries (Cappaert et al. 2005). Widespread ash mortality would threaten considerable economic revenue. The national lumber market value for ash has been estimated at $25.1 billion (US GPO 2003). Ash replacement costs mirror similar worth. Values for Michigan were estimated at $11 billion (Chornesky et al. 2005). The significant financial expenses of EAB invasion greatly articulate the gravity of the issue. Therefore, in addressing the need for conservation, economics speaks well to a general public (O’Brien 2011). However, ecological and social ash benefits also reiterate the importance for management plans.

iii. Ecological and Social Costs

Ecologically, the ash species is important in its role to the environment as food and shelter to numerous forest community organisms (Cappaert et al. 2005; Poland and McCullough 2006). Socially, ash species represent aesthetic recreational enjoyment (Robertson and Andow, working paper), especially in urban landscapes as a shade and street tree. Property values also expose the related social worth of the ash tree (ISAC 2006). Social appreciation of ashes extends to Native Americans, who use the ash in traditional activities including basket making, assembling snowshoes, constructing canoe paddles, etc (Reo 2005). From any perspective, the North American Ash is a keystone species ecologically (Burns and Honkala 1990) and culturally (Garibaldi and Turner 2004) that provides a vital role as a dynamic tree species.
iv. Importance of Reaching a Valuation Cross-section

The valuation of the ash represents an important larger context to its conservation as a species. Any assessment must remember that biases always influence our decisions. As conservation biologists, we care for the ash species in a different manner than loggers. The distinction here is that we have an intrinsic appreciation for ash whereas loggers have an instrumental admiration. Intrinsic refers to existence value, whereas instrumental applies to human use value. Applying Norton’s convergence hypothesis, no matter the stance the end goal is the same: conserve biodiversity. Recognizing the difficulties of emerald ash borer management, it becomes imperative to develop plans quickly. Methods should focus on containment and prevention of EAB spread. Of the 1.5 million square miles of ash coverage, 9% are within infested counties (NYIS). However, given the emerald ash borer host preference for American ash species (Pureswaran and Poland 2009), our forests are in serious jeopardy.

v. Life Cycle & Ecology

Under normal conditions, it will take one or two years for one EAB egg to complete development to an adult. Emerald ash borers begin as eggs, laid on rough or cracked bark areas (USDA APHIS 2011 [B]). Although egg laying varies between the months of May to August, the eggs hatch into larvae after 7-10 days. The larvae spend the remaining time until fall (Mid-June to October) developing through four stages or molts. During this time, the larvae live within the ash; between fall and the upcoming spring, larvae over winter before developing in pupa. Within
ideal lab conditions, EAB can become adults in four weeks (USDA APHIS 2011 [B]). Once pupation has finished, the emerald ash borer can remain enclosed in their chamber for 1-2 weeks before emerging from the ash via D-shaped exit holes. Upon reaching adulthood, beetles utilize a 3-week period where maturation feeding occurs prior to oviposition (USDA APHIS 2011 [B]), which starts 7-9 days after initially mating (Yu 1992). As adults, females typically live 22 days whereas males live 13 days – this is in part due to the maturation feeding that the female must undergo before being able to successfully oviposit (Bauer et al. 2004; Lyons et al. 2004; Poland and McCullough 2006). See Figure 2 for an outline of the essential detail of the EAB life cycle.

(Figure 2) Diagram of the emerald ash borer (Agrilus planipennis) life cycle (USDA APHIS 2011 [B])
The ecological importance of the life cycle of the EAB rests upon the impacts of its life cycle upon the health of ash trees. During its development, the emerald ash borer depends upon the ash for food. During the larval stages of the EAB life cycle, the young beetles depend upon the phloem and cambium of the ash tree trunks as a source of feeding. This causes interruptions in movement of water and nutrients, creating tree crown mortality (Poland and McCullough 2006). Tluczek et al. (2011) discussed the significance of phloem as a factor limiting the numbers of possible ash borers that can grow in one particular tree. It is important to recognize that during early larval development, the emerald ash borer is dependant upon a living host for growth (Petrice and Haack 2006).

vi. Native Range

The emerald ash borer (EAB) is native to China, Japan, Korea, Mongolia, Taiwan and eastern Russia where it thrives by using Chinese ash (F. chinensis) and Manchurian ash (F. mandshurica) as host trees for their reproductive cycle. The EAB’s presence in East Asia is not one of a pest, and they do not typically pose an imminent threat to their native ash (Fraxinus) species (Pureswaran & Poland 2009). Historically, there have been some instances where native Asian ash species have fallen under siege via prolific emerald ash borer population growth. In the 1960s, the EAB was threatening an introduced variety of green ash (Fraxinus pennsylvanica Marsh.) in Harbin and Shenyang, putting stress on native ashes in turn (ex. Manchurian ash); the problem was solved by removing the non-native ornamental ash (Wei et al. 2007). Thirty years later in the 1990s the EAB was severely damaging ash trees that had been introduced from North America including green ash, white ash (Fraxinus americana) and velvet ash (Fraxinus velutina
While the Manchurian ash was again caught in the crosshairs of an infestation based in these non-native ornamentals, *F. chinensis* and *F. rhynchophylla* experienced little damage (Wei et al. 2007).

vii. Host Preference

These historical instances of prolific EAB population growth point to the potential susceptibility of ornamental, non-Asian *Fraxinus* spp. to emerald ash borer colonization. Recently, the emerald ash borer feeding preference has been linked with the chemical compounds of ash species (Pureswaran and Poland 2009). While completing its development, females tend to lay eggs on green and white ashes. These tree species have a lower volatile organic compound (VOC) levels and are prone to EAB targeting (Pureswaran and Poland 2009). The heightened resistance of Asian ash species has been linked through co-evolution with emerald ash borer; Manchurian ash has been found to have a higher volatile organic compound (VOC) content than North American *Fraxinus* species. Consequently the emerald ash borer is not a serious threat to Asian ashes such as *F. mandshurica* due to lower EAB feeding preference, but American ash species have not been exposed to the EAB for long enough to adapt – lending to increased EAB-invasion success, such as that demonstrated in China during the early 1900s (Pureswaran and Poland 2009).

In the United States, there is an abundance of ash species – in particular green ash and white ash. Here in New York, our forests provide substantial fodder for developing EAB juveniles. While all American ash species are susceptible to emerald ash borer invasion, the blue
ash (*Fraxinus quadrangulata*) was viewed as less preferable when the option of green or white ash was also present. It has been shown that females dislike ovipositing on the blue ash – potentially due to the increased risk of egg mortality on a species without the preferred grooves and striations utilized by adult females to secure egg deposits (Anulewicz 2006, Anulewicz et al. 2008).

These studies suggest that both chemical and physical properties make ash species favorable targets for host targeting by adults, and successful larval feeding. These host preferences of the EAB also illuminates the vulnerability North American hardwood forest communities, especially considering the abundance of green and white ash to the ecosystem.

III. **Ash Ecology**

i. **Ash Species of New York State**

Ashes, *Fraxinus spp.*, represent an important tree species due to their abundance in forest communities and distinct ecological qualities. Losses to ash populations could significantly impact or alter ecosystems left by the void that ashes would fill. Within New York, three species of ash exist in our forests: green (*F. pennsylvanica*), white (*F. americana*) and black (*F. nigra*). Each species plays an important role within specific ecological niches. Green ash is typically found in riparian habitats, floodplains, and swamps where soil conditions are moist (Gucker 2005 [A]). Although the green ash can tolerate drought and poorly drained soils (Gucker 2005 [A]), the species grows best in fertile, well-drained soils (Stewart & Krajicek 1973). White ash
grows in lower sloped floodplain regions, where the plant can access rich well-drained soils (Griffith 1991). Black ash prefers wet habitats such as swamps, bogs, gullies, woodlands, and stream shores (Gucker 2005 [B]). Though not common within New York (NYIS), the black ash occupies low-elevation rich and wet soils (Gucker 2005 [B]). The ashes ecological diversity provides a broad spectrum for supporting wildlife.

ii. Organismal Reliance on the New York Ashes

As a result of the incredible dependence of many species on the ash, a threat to the populations represents a threat to organismal diversity. Collectively, ashes sustain a host of forest community animals. Studies suggest the use of *F. pennsylvanica* by deer as habitat. Smaller mammals also utilize the green ash for cover, including cottontail rabbits and white-tailed jackrabbits (Gucker 2005 [A]). Species foraging on green ash seeds entail white-footed mice (Snyder & Best 1989), as well as rabbits (Gucker 2005 [A]) and grouse (Twedt and Best 2004); the ash is a prolific seeder (Cappaert et al. 2005) and can support a wide variety of species. The bark of juvenile ash trees can also supply animals with feed for species such as beavers, rabbits and porcupines (Heyd 2005). For white ash, the wood duck, northern bobwhite, purple finch, pine grosbeak, fox squirrel, and mice depend upon its fruits (Schlesinger 1990). Due to the wetland environment of the black ash, various species of amphibians utilize the habitat as coverage. One study found wood frogs, spring peepers, swamp tree frogs, tree frogs and an American toad (Marshall & Buell 1955). Species using the black ash for food are moose, deer (Sims et al. 1990), beavers (Lawrence 1954), and rabbits (Guckler 2005 [B]). Ashes represent the foundation of several forest community types and help form a network of biodiversity.
iii. **Ecosystem Roles of the New York Ashes**

Ash trees support species diversity through ecological qualities. White and green ashes are characterized as pioneer species during succession (Guckler 2005 [A]; Griffith 1991). Therefore, following natural or artificial disturbances, ashes help colonize the opening forest gaps (Schlesinger 1990). One study noted the importance of early colonization. While investigating management strategies, local ash eradication permitted the invasion of nonnative plants (Hausman et al. 2010). The available void allowed for the establishment of invasive plants. In a paper examining arthropod diversity, of the 282 species associated with the ash faunal community, 43 species that were characterized as high risk were distinctly threatened by widespread ash mortality (Gandhi & Herms 2010). The same study “anticipate[d] cascading effects on other affiliated species including fungal, bacterial, and invertebrate associates and parasites, as well as vertebrate and invertebrate predators and mutualists” (Purrington & Nielsen 1987; Langor & Hergert 1993; Koh et al. 2004). Thus the potential consequences towards the natural balance of local biodiversity could be catastrophic.

IV. **Human Impacts**

As the final piece to the puzzle, humans have caused the introduction of the emerald ash borer into North America. Through international shipments, the EAB made its arrival to the United States and Canada. Many researchers believe that woody packaging materials (WPM) carried the beetle overseas (Cappaert et al. 2005) in the mid-1990s about ten years before the
emerald ash borer was first detected. Locally, humans are also responsible for its rapid dispersal across the northeast. Transportation of firewood or nursery stock that has the EAB causes the invasion to spread (Cappaert et al. 2005). The natural dispersal rate was estimated to be as low as 800 meters per year (Taylor et al. 2004), which indicates that we are huge part of the problem. While management plans must address containment of EAB, the goal is not feasible without our full participation in preventing the transportation of the ash borer. It is important that any conservation strategy articulates the underlying anthropogenic roots of *A. planipennis* to ensure full knowledge of the situation.

**Identification of Stakeholders**

Issues within conservation biology are value-laden. The emerald ash borer invasion of North American hardwood forests is the same. We often associate values with decision-making. Here, the stakeholders represent the entity that partakes in decisions. The stakeholders have certain values regarding the ash, maybe as an economic commodity, or ecological keystone species, or social recreation. The fact is that there are many, varied people with vested concern for the loss of *Fraxinus spp*. Each is out to protect their self-interests, what they believe to be important. There remains a vital connection between the stakeholder and the focal entity. Waddock (2011) characterizes this connection of the stakeholder to the central entity as “interactive and mutually influential” while also “interdependent, interconnected, and interrelated” to one another.
Within the case of the emerald ash borer, we have identified five important stakeholders: private individuals and landowners, logging and wood manufacturing industries, state government agencies, federal government agencies, and forest communities. The shared commonality of all stakeholders for the concern of preserving ash populations allows the potential for collective agreement in developing management plans. Although there are differences in how stakeholders benefit directly from ashes, the formation of a common voice for the ash is important. Each stakeholder, if knowledgeable of the circumstances, will recognize the serious threat of the emerald ash borer on *Fraxinus spp.* populations. Assuming valid ash interest, stakeholders will continue to express concern regarding the invasion spread and cooperate in determining an appropriate plan of action. If stakeholders are unaware of the issue, we will recognize the fault of education or lack of interest in containing the EAB. It is our goal to access the degree of investment of all stakeholders and the reasons for their concern over ash population losses. We aim to determine the role each stakeholder has in developing management priorities.

I. **Private Individuals and Landowners**

At the most basic level, private individuals and landowners are stakeholders of the ash populations in Northeastern hardwood forests and urban communities. In our investigation, we discovered that the New York Forest Owners Association (NYFOA) represents the collective interests of private landowners. The organization looks to support sustainable forestry practices to encourage conservation of resources. The NYFOA recognizes the ecological necessity for forests as they “protect all major water supplies in the state, help sequester carbon dioxide, and
provide clean air, wildlife habitat, biological diversity, scenic landscapes and recreational opportunities” (NYFOA, Position Statement). In concordance with protecting forests, it would seem reasonable that the group favors practices that prevent the transportation of emerald ash borer. Considering that 72% of forested land is owned privately in New York, this organization holds considerable leverage in the formation of policy that will ultimately decide how everyone should act.

The active involvement of a quality institution like the NYFOA deserves recognition to be heard at the level of state government and respective agencies such as the New York State Department of Environmental Conservation (NYS-DEC). The forest owners association requests the state to stress the importance of using “motivation incentives” (NYFOA, Service Forestry) rather than use regulatory procedures to address land stewardship. Additionally, the group favors the application of education, which is vital to any EAB management plan, as a tool that exhibits the balance between the landowners’ interests and public benefits of private forests. Although the group has no direct authority, their knowledge of the personal concerns of private citizens and landowners reveals a significant perspective that needs to be included in management strategy discussions. Cooperation with landowners is crucial to success of any plan. It is clear that the NYFOA knows its role in the EAB issue as an outlet for promotion of smart practices; such as do not move firewood, as well as education. The power of knowledge is essential to understanding the anthropogenic root of the emerald ash borer problem.

There is clear distinction that members of the NYFOA are educated. In addressing their concerns for decreased productivity, included is one that reflects on pests: “Invasive insect and
disease outbreaks which destroy forest and shade trees” (NYFOA, Service Forestry). The executive board, which established the organizations invasive species statement before the arrival of the *A. planipennis* in New York, highlighted a grave concern for potential destruction. “Invasive species have caused significant losses in forests over the past century” using examples of Dutch elm disease and chestnut blight that caused near complete species eradication (NYFOA, Invasive Species). As responsible stakeholders, the forest owners association identifies important management protocols that consist of: education; public communication; cooperation with state governmental agencies (DEC, NYS council on Invasive Species); information sharing; and proactive check of wood stocks (NYFOA, Invasive Species). The efforts suggested by the plan are inclusive of all aspects we consider critical towards containment of EAB. The protocols also suggest a deep awareness for the invasive species problem.

Members are aware of invasive species problems and the impact they have on their interests. There are landowners who seek profit from selling timber in a sustainable manner. Landowners recognize the economic benefits that forests contribute which consist of $1.6 billion for tourism, $7.4 billion in shipment value and $24 million in Christmas tree, wreath, maple syrup, and ginseng sales (NYFOA, Service Forestry). The forest also helps provide for many jobs in which families support livelihoods. There is a great deal of connection to the forest and this is reflected in the organization’s goals (NYFOA):

1. Encourage personal pursuit of land objectives using professional help to establish management guides
2. Promote awareness for ecosystem services and forest stewardship needed to preserve them

3. Support using education and research to construct economically sound practices

4. Provide public materials to increase knowledge of appropriate forestry practices and management

5. Foster discussion and collaboration between individuals and agencies

It is important to note that the forest owners association is not limiting individuals in what they can or cannot do, but encourages foresting in an appropriate manner. Education allows for the distribution of important practices and is important in addressing the anthropogenic root of the emerald ash borer invasion. Public education materials include a bimonthly “New York Forest Owner magazine” (NYFOA) that allows any individual with specific knowledge to share with other members.
II. Logging and Wood Manufacturing Companies

Timber industries within New York State are concerned with ash (*Fraxinus spp.*) population losses as ashes represent important sources of profits. As we reviewed earlier, the ash has broad wood production applications. Black ash (*F. nigra*) is good for cabinets, veneer, and indoor furniture (Collingwood and Brush 1964). Green ash (*F. pennsylvanica*) is used as tool handles, interior furnishings, and furniture (Vines 1960). White ash (*F. americana*) is known for baseball bats, cabinets, furniture, doors, and boats (Gansner and Widemann 1990).
Within Northern New York there are several wood production companies that depend on ashes as part of manufacturing their products. Foothills Forest Products and J&E Sawmill, located in St. Lawrence County, both use a combination of mixed hardwood and mixed softwood in developing goods. Of the eight wood manufacturers in St. Lawrence County, six use mixed hardwoods. The varying assets made amongst the companies include flooring, planed lumber, rough lumber, stakes, dimension, siding, squares, timbers, boxes, firewood and pallets. The impact of the emerald ash borer upon the production of such materials is unquestionably negative. However, because we do not know the extent of ash use, it is difficult to measure the extent of negative effects. Nonetheless, we can be certain of particular concerns for future ash use in wood products. Ashes are important hardwood species and the decline in populations represents loss in business sustainability.

Regardless of specific practices, since all companies are primary wood using industries, loss of ashes will result in changes in manufacturing techniques and tree species used. Primary wood users remove raw materials directly from the forest. Therefore losses that occur to ash populations represent a direct loss in raw materials. Increased scarcity results in increased costs for raw materials. Higher costs mean lower profits, unless methods are utilized to lower costs. Perhaps more less-valuable species are used other than the ash. However, this can result in reduced product quality, which threatens also threatens revenue. From a business standpoint, the emerald ash borer represents a nightmare for wood manufacturing facilities. It causes headache knowing the uncertainty of viable wood resources. Still, wood companies have an important role to play in helping to contain the emerald ash borer.
The responsibility of the private landowners ensured minimal threat of EAB transportation, but do the wood companies have the same attitude. These companies directly engage with sources for emerald ash borer transmission. It is essential to the containment of the beetle that individuals involved within the company proceed with the utmost care to deter EAB spread. The industry reflects a general concern for the sustained production of wooden goods. We are hoping this translates into responsibility for smart practices. Wood industries are in the same position as private landowners in relation to formulating policy.

If there is strong advocacy for certain management strategies, there is an increased likelihood that those suggested methods would be implemented. Collective voiced concern would represent a strong front to an important issue. However, the inherent structure of individual companies causes inefficiency in communication between producers. All manufacturers should know the current emerald ash borer situation so they can make decisions that best reflect sound management practices and protect interests. We are unaware of their knowledge regarding the current EAB status. The industry has what it takes to make a meaningful impact: the concern for emerald ash borer spread and potential drive to act accordingly to prevent transmission.

III. State Governmental Agencies

State governmental agencies, namely the New York State Department of Environmental Conservation (NYS-DEC), are concerned about the conservation for ash populations for
continued use and appreciation of all other stakeholders. As a body that has formal power to
change policy, the DEC has incredible responsibility to act appropriately in the interest of those
stakeholders who do not have voice in directly establishing protocols. However, this indicates
the importance of the agency to listen to the concerns and interests of private landowners and
logging companies to develop inclusive emerald ash borer readiness plans. We believe that the
DEC has an important stake in the issue as a conservation leader for New York and the United
States. As educated professionals, individuals involved with the agency have genuine care for the
preservation of species. They recognize the environmental importance of maintaining
biodiversity and the ash helps maintain species diversity. The agency has done an incredible
amount of work to monitor the EAB status in New York as well as to identify potential measures
that contain \( A. \text{planipennis} \).

The DEC supports continued research that seeks to present updated information on the
emerald ash borer and management options. The DEC is working with other groups, such as the
Cornell Cooperative Extension into identifying potential solutions. The DEC is also an incredible
organization when it comes to education. On their website they have effectively allowed the
public to become knowledgeable about the emerald ash borer. They are allowing people to
become front line assistants in managing the beetle through simple identification and detection.
In support of management, the DEC wants to educate people about the quarantines and
regulations established by the state and federal governments. The DEC has taken great steps to
make the EAB a community issue. The more people involved in the campaign to preserve ashes
from emerald ash borer invasion the better.
Similarly, government and respective agencies should hold themselves accountable to comparable involvement. Not only do continued efforts help in addressing the situation, but commitment at the political level shows interest and personal concern for the ash borer. People care to see that their government responds to their needs. Agencies such as the DEC should be held just as answerable. However, the track record indicates a high level of commitment to environmental issues. Their mission statement exhibits a similar tone: “To conserve, improve and protect New York's natural resources and environment and to prevent, abate and control water, land and air pollution, in order to enhance the health, safety and welfare of the people of the state and their overall economic and social well-being” (NYS DEC 2012 [B]). Under Environmental Conservation Law (ECL), the DEC is abided to serve the community in response to environmental problems. Although required by law, the DEC has a devoted interest in managing the EAB invasion within New York.

IV. Federal Governmental Agencies

Likewise, federal government agencies such as the United States Forest Service (USFS) are interested in the conservation of forests. Upon their website, it states “100 years of caring for the land and serving people” (USFS). Since the creation of the USFS, the agency has had the difficulty in managing 175 million acres (USFS) of forested land. However, the USFS does so with great conviction towards the goals of “quality land management under the sustainable multiple-use management concept to meet the diverse needs of people” (USFS). The United States Forest Service is able to accomplish this work through the collaboration of partnerships, listening to people’s needs and concerns, education, and a tireless work ethic. Through their
ecological approach to conservation, the USFS evaluates issues through excellent fieldwork. The forest service is a recognized national and international leader in conservation by way of their continuous research.

The research of the USFS supports management strategies and decisions made to preserve ash populations. While talking with DEC representatives, we learned that the USFS was investing the possibility of biological control using parasitoids. Although currently unsure if parasitoids are effective, the USFS took an important step towards improving management protocols. The forest service is not afraid to pursue ideas so long as it supports the continued protection of forests. We recognize the importance of USFS involvement in the EAB invasion. The national spread of the ash borer causes difficulty for state agencies to address the inclusive nature of the beetle. The USFS as a national agency ensures the cooperation of state conservation agencies, including the DEC. The credibility of the USFS as a leader will put pressure on the forest service to ensure appropriate conservation measures are taken. If, however, there is disagreement, the USFS must respond in a timely manner to address concerns. However, if their history proves anything, our ash populations and forest are in good hands.

V. Forest Communities

As the final stakeholder, the forest communities deserve every right to have a “voice”. Without considering the ash communities to be stakeholders in the EAB invasion, it is difficult to fully articulate the ecological importance of ashes. As stated earlier, ashes support a great amount of biodiversity. Biodiversity is key to supporting life, as we know it. For conservation
biologists, we recognize that biodiversity is important factor to supporting ecosystem dynamics. While few may understand, these dynamics represent essential services that in many ways benefit humans. Although we cannot escape from an anthropogenic perspective that focuses upon our interests, without considering the ecosystem there is no possibility to fulfill our needs. It is therefore in the responsibility for humans to act in the interest of the forests.

**Government and Policy:**

The case of the emerald ash borer provides a very interesting example of chain of authority, especially concerning the particular channels through which this invasive has been addressed. The United States’ trials addressing the emerald ash borer aided in soliciting a response from the international stage to address the trade-driven threat of untreated woody packing materials (WPM). Cascading regulation across the globe from the setting of UN WPM standards has sucked US national agencies into addressing the EAB abroad, nationally and at the state level. With the USDA working on domestic and international scales, their presence is seen within the states too; cooperation between the USDA and local state agencies is common. Upon discussing the role of state governments, we will concentrate on the role of New York state government and agencies in relation to the emerald ash borer.

I. **Influence of International Policy:**
As globalization has taken place, the international trade markets have become inundated with goods from around the world – now dispersing them in greater volume, with greater speed and to more trading partners than ever before. This has been identified as the principle method through which exotic insects, such as the emerald ash borer, are introduced to new countries and the native habitats there (USDA APHIS 2000). Woody packing materials (WPM) such as crating and pallets often harbor bark- and wood-boring insects, especially when they are: a) manufactured with recently harvested lumber, b) left untreated by heat or chemical sterilization or c) made of lumber where bark has not been fully removed (USDA APHIS 2000).

Due to the growing awareness of the role played by untreated WPM in the artificial dispersal of invasive species, worldwide standards for wood treatment were proposed by the United Nations’ Food and Agricultural Organization (FAO) in Rome on March 15th, 2002 (FAO IPPC 2002). The FOA is the secretariat of the International Plant Protection Convention (IPPC) – an agreement signed by 177 countries to work together in the interest of keeping native plants safe from the introduction and spread of pests (FAO IPPC 2012). The IPPC is enforced by the Commission on Phytosanitary Measures (CPM) which is comprised of 177 delegates – one for each of the current signatories (countries involved). These delegates meet annually during the FAO Conference, and contribute to the creation of International Standards of Phytosanitary Measures (ISPMs); the regulation and management guideline documents that dictate action in the countries who are signatories of the International Plant Protection Convention. New ISPMs are then brought home by delegates to the national plant protection organization of their country, where they are adopted and implemented (FAO IPPC 1997).
ISPM No.15, entitled “Guidelines for regulating wood packaging material in international trade”, was adopted by the IPPC as a result of the FAO Conference on March 15th, 2002 (and as amended in 2006 and 2009). This international standard describes the methods to be followed and measures to be taken in order to reduce the risk of introduction and spread of quarantine pests associated with raw wood packaging material in use in international trade (FAO IPPC 2002).

II. National Government:

The United States is one of the original charter member countries for the UN in 1945, and became a signatory of the IPPC in 1972. As required by the terms of their commitment to the IPPC, provisions had to be made in order to support an official, national plant protection organization (FAO IPPC 1997). This came to fall under the United States Department of Agriculture, and the Animal and Plant Health Inspection Service (APHIS) – a department that was formally established in 1972, although the USDA had been providing similar services for over 100 years (USDA APHIS 2007). Interestingly enough, the research and legislation coming out of the US concerning woody packing materials in the late 1990s (Haack & Cavey 1997, Czokajlo et al. 1997, US GPO 1998) appears to have not only had a strong influence on the FAO’s decision to propose ISPM No.15 in 2002, but on the US’s decision to sign similar national legislation two years earlier.

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1 In October of 2000, the U.S. Senate gave its consent to accept the newly revised IPPC. The President submitted the official letter of acceptance to the FAO Director General on October 4, 2001 (USDA APHIS 2008 [A]).
On June 20th, 2000, the United States Congress signed the Agricultural Risk Protection Act (ARPA) into law, including five main titles; Title IV lays out the Plant Protection Act (PPA) (US Congress 2000). The PPA entitles the Secretary of Agriculture and, through delegated authority, the USDA’s Animal and Plant Health Inspection Service (APHIS), with the power to prohibit or restrict the importation, exportation, and the interstate movement of plants, plant products, certain biological control organisms, noxious weeds, and plant pests (US GPO 2000). While this legislation was important in terms of delegating authority in addressing pest species, it did not include power to control the quality of woody packing materials allowed to enter or leave the United States. It was not until October of 2000 that APHIS formally released a pest risk assessment for the importation of woody packing materials into the United States (USDA APHIS 2000). Less than a year and a half later, ISPM No. 15 was proposed and accepted at the FOA Conference in Rome. The United States’ status as an IPPC signatory, combined with the final environmental impact statement regarding the import of woody packing material submitted by the USDA APHIS in August 2003, lead to the official adoption of WPM treatment standards in the US, which became effective as a federal regulation on September 16th, 2005 (USDA APHIS 2003, US GPO 2004).

Unfortunately, such as in the case of the emerald ash borer, this legislation came too late because the EAB was first officially found in Canton, Michigan in 2002, and researchers have estimated the date of EAB’s foundation was even earlier – sometime in the early to mid-1990s (Smitley et al. 2008, USDA APHIS 2011 [B]). It has been the federal regulations that emerged due to awareness of the global invasive problem and the threat associated with untreated WPM, that have actually made their greatest contribution to addressing the EAB; they have provided
the USDA with the power to create, regulate and enforce quarantines nationally and internationally (US GPO 2000). The Plant Protection and Quarantine unit (PPQ) is one of APHIS’s operational program units, and is charged with safeguarding “agriculture and natural resources from risks associated with the entry, establishment or spread of pests and noxious weeds” (USDA APHIS 2011 [A]). Through this APHIS sub-unit, pest identification and detection programs have been implemented, and through their Plant Pest Program, they work to eradicate, suppress or contain introductions of targeted pests through cooperation with stakeholders, the scientific community, state departments of agriculture, universities, and other government agencies (USDA APHIS 2011 [A]).

Information gathered by the USDA’s PPQ concerning a pest, such as the emerald ash borer, eventually leads to quarantine procedures – followed by efforts to address the pest on 3 different fronts: (i) abroad (internationally; at the source), (ii) at the border (nationally; before they get in), and (iii) across the homeland (state level; fighting back against establishing pests) (USDA APHIS 2012 [B]).

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i. Abroad (International):

Aside from the implementation of ISPM No.15 stateside in 2002 (and as revised in 2006 and 2009), there have been other efforts from the US to help aid in our national security – by working abroad (USDA APHIS 2006). With APHIS’s support as a world leader in animal and
plant health protection, many developing countries\(^2\) receive aid and direction in survey/control/suppression/eradication programs, as well as in manufacturing infrastructure and technology in order to meet US-import standards (USDA APHIS 2006, 2012 [B]). US-bound imports are also inspected by USDA officials prior to leaving certain international ports, in order to ensure that they are pest- and disease-free (US GPO 2004, USDA APHIS 2012 [B]).

Closer to home, the regional North American Plant Protection Organization (NAPPO)\(^3\) works to coordinate efforts between the US, Canada and Mexico to address potential invasion of plant pests, while also facilitating both intra- and inter-regional trade (USDA APHIS 2007). Currently, Ash imports to the US are not allowed from any other country besides Canada; imports are only allowed from counties or regions that are not regulated for EAB, and if those regions fall within an EAB-regulated province or territory, a permit must be acquired from the PPQ (US GPO 2007).

ii. **At the Boarder (National):**

The order Coleoptera (of which EAB is a member) was found to be the most commonly intercepted order of insects found in association with WPM, constituting 92% of the intercepted insects found in WPM in the United States (Haack 2001). The implementation of ISPM No.15 stateside in 2002 (and as revised in 2006 and 2009), is an important extension of the United States international efforts to promote worldwide standards for phytosanitary measures, by

\(^2\) Due to pre-existing trade negotiations such as the World Trade Organization (WTO), and North American Free Trade Agreement (NAFTA), the US has formal trade agreements with over 20 countries – many of which are under developed in their standards and regulations infrastructure (USDA APHIS 2006)

\(^3\) Formed under the International Plant Protection Convention in 1976
leading through example at home. The heat treatment program was developed by the American Lumber Standard Committee (ALSC), and The National Wood Pallet and Container Association (NWPCA) developed the Methyl Bromide Fumigation program - both through coordination with APHIS and the wood packaging industry (USDA APHIS 2011 [A]). The ALSC administers the Heat Treatment program, which requires WPM producers to enroll with an inspection agency accredited by the ALSC. WPM producers must then either purchase heat-treated lumber from an ALSC accredited agency, or become licensed to construct WPM from untreated lumber and heat-treat the lumber themselves; if they choose to become licensed, their products will be labeled with an official international IPPC stamp (Figure 4). The NWPCA follows similar standards for their fumigation program requirements (USDA APHIS 2011 [A]).

(Figure 4) – Blank, digital example of the IPPC stamp. In practice: “XX” would reflect a two letter ISO country code, “0000” is an identification mark of the wood treatment agent/ certified packaging manufacturer, and “YY” indicated the treatment used (HT = Heat Treatment/ MB = Methyl Bromide). In the space next to the treatment code, the responsible inspection agency would place it’s logo/insignia (FAO IPPC 2002).

Pre-existing, national, invasive problems such as the EAB are also addressed by the USDA APHIS (US GPO 2003). When the U.S. Congress signed the Plant Protection Act into law in 2000, it granted the Secretary of Agriculture (and by delegation, the USDA’S APHIS) the ability to prohibit or restrict the importation, exportation and the interstate movement of target plant products/pests in the United States (USDA APHIS 2011 [B]). Domestic Quarantine notices
were amended to include a subpart dedicated to the emerald ash borer; articles of interests, such as the hardwood firewood, nursery stock, green lumber or any organic material of the genus Fraxinus, became subject to quarantine regulations under these new guidelines (US GPO 2003).

iii. Across the Homeland (State):

Federal quarantines are considered preemptive - any regulation established by the USDA APHIS will displace U.S. state law in favor of U.S. Federal Law (U.S. Congress 2000). The USDA APHIS is able quarantine an entire state if the EAB is found and the state does not have adequate restrictions on interstate movement of regulated articles. If a state is deemed to lack adequate intrastate regulations, federal intrastate quarantines can also be enacted. These federal quarantines are enforced by the Investigative and Enforcement Service (IES) (USDA APHIS 2008 [B]). Most states will issue their own quarantines for intrastate movement after federal interstate quarantines have been established – it is the right of a state to provide its own intrastate regulatory action (when sufficient enforcement is deemed to be provided by APHIS) (USDA APHIS 2011 [B]). APHIS’s PPQ program for the Emerald Ash borer will then work with state’s department of agriculture (once quarantine measure have been set up) to conduct annual surveys, enforce regulations, inform the public⁴ and take steps toward controlling outbreaks (USDA APHIS 2012 [B]).

⁴ On April 3rd, 2012 the USDA APHIS launched their new, multi-state, multi-year, public education initiative called “Hungry Pests” (USDA APHIS 2012 [B]).
Other USDA national agencies besides the APHIS play important roles in addressing the EAB problem, such as the Forest Service (FS) and the National Agricultural Library (NAL). The USDA FS operates the national EAB information website through a regional grant from the FS Northeastern Area in an effort to efficiently provide comprehensive and accurate information (USDA FS 2012). The Forest Service is also responsible for the creation of the Early Warning System for forest health threats in the US (USDA FS 2004). The USDA NAL also maintains the National Invasive Species Information Center, providing impact statements, government responses and links to further research (USDA NAL 2012). A recent risk assessment concerning the movement of domestic wood packaging material (dWPM) in the use may also be an indicator of upcoming work of the USDA APHIS to look out for (USDA APHIS 2011 [C]).

III. New York State

With a firm understanding of the international and national efforts to address the accidental transport of invasive species, as well as our specific national efforts aimed specifically at addressing the EAB, we can begin to investigate the role that state governments and agencies play in regulation and enforcement.

On June 15th, 2009, the EAB was detected in Cattaraugus County in Western New York. The NYS Department of Agriculture & Markets (DAM) placed an emergency quarantine on Cattaraugus County and on the adjacent County of Chautauqua nine days later, but found that expansion of quarantine boundaries was quickly required. On October 1st, 2010, the NYS DAM
amended the New York Codes, Rules and Regulations (NYCRR) on an emergency basis to include 18 NYS counties, 11 of which are strictly serving as buffer counties, and on March 1st of 2011, the emergency quarantine laws were renewed (NYS DOS 2011). In the beginning of May, 2011, Governor Andrew M. Cuomo proclaimed that May 22nd-28th would be celebrated as Emerald Ash Borer Awareness Week in order to promote education among state residents and visitors to the EAB (Bopp 2011). Unfortunately, the following month Rochester and Buffalo were added to the list of affected counties, followed by Orange County in July, and most recently, Albany as of last month (March 2012) (NYS DEC 2012 [A]).

The Department of Environmental Conservation (DEC) coheres to the ideology that, in order for enforcement to be effective, state enforcement personnel and policies must work in concert with local and federal counterparts, and citizens must be kept informed and involved (NYS DEC 2012 [B]). This concordance requires more than a week dedicated to public awareness of the EAB – effective enforcement agencies must also be working at the state level. In New York, the DEC’s Environmental Conservation Officers (ECOs) protect the environment, natural resources and people of NYS, through law enforcement, education and public involvement. The majority of the 330+ sworn members of the Division of Law Enforcement are comprised of uniformed ECOs, who patrol different counties via marked police vehicles (NYS DEC 2012 [B]). The New York State DEC also funds the DEC’s Forest Ranger force of 134 that is charged with protecting New York’s rich and diverse forests, wild lands and wildernesses. Every day these rangers patrol their geographic locations by whatever means necessary and can enforce all state laws, especially Environmental Conservation Law (NYS DEC 2012 [B]).
These ECO and Forest Ranger officers are responsible for enforcing any and all intrastate quarantine regulations. As was stated in our previous section, the movement of firewood, nursery stock, green lumber or any organic material of the genus *Fraxinus*, is subject to quarantine regulations under Domestic Quarantine guidelines (US GPO 2003). While scaled down to a state level, these articles still require regulation within states. Any parties having violated environmental laws or regulations will be given Orders of Consent by an officer from one of the two DEC enforcement agencies; a fine and/or a Schedule of Compliance will be distributed via these Orders of Consent (NYS DEC 2012 [B]).

**Development of Strategies**

I. **Parameterizing Strategies**

While the western counties of New York have been struggling with the emerald ash borer invasion since mid-2009 (and New York’s south-eastern counties as of mid-2010) it has yet to reach the northern New York region. Unfortunately, it is an impossible task to accurately estimate its arrival. The detrimental effects of human-facilitated dispersal, as well as the positive influence of human-implemented management strategies (ex. quarantines, eradication efforts), have made it unfeasible to accurately gauge the dispersal potential of individuals from local EAB populations. Short-term, long-distance introductions of EAB via “hitch-hiking” are stochastic events, meaning that they are unpredictable; rapid dispersal over distance often results in satellite populations that grow outward from the point of infestation. Management tools also make dispersal predictions difficult because they often perform the opposite function of stochastic
dispersal events. Estimated natural rates of range expansion are often muddled by these tools – while they don’t usually result in eradication, effective tools can slow natural EAB dispersal. Therefore, for the northern regions of New York, it is imperative at this juncture to begin developing a primary management plan. In order to successfully rise to the challenge of managing this voracious pest, there are a few important factors that must first be taken into account when developing a management strategy:

1. Successful management plans will not only take the biology of the EAB into account (morphologic characteristics, life history cycle), but it will invest in taking the ecology of the EAB into account as well. This includes understanding the characteristics of the northern NY landscape and the ecology of their host trees (*Fraxinus* spp.).

2. Local communities must not only have a primary management plan, but they must also act in concert with one another. The EAB does not bound by national, state or county lines – therefore any management solution(s) identified as “best” should include a component of regional cohesion.

3. As with any management plan, in any situation, there is a component of monetary cost. This cost is not only related to the expense of the chosen management methods (ex. Trap setting, infested tree removal), but cost is also linked to the time required of forest managers, surveyors and enforcement personnel involved. Depending on state and county resources, certain management plans may not be feasible due to expense.
4. Accountability feedback on all levels (state, region, county) in the “chain of command” will also be an important requirement; the ability to enforce identified management regulations or quarantines is essential to the success of identified management strategies. Without agencies/committees/identified persons being held responsible for seeing different portions of the proposed plan through, inefficiencies and gaps in enforcement could occur without immediate notice.

5. Finally, the needs and questions of stakeholders need to be adequately addressed. Methods used for control should stray away from compounding the frustrations that citizens actively invested in *Fraxinus* spp. survival are already feeling. If a solution put into place were to fail, these are the constituents who would come forward in complaint. Not only must stakeholders be kept in the loop and involved but the more stakeholder perspectives provided, the higher the chance of a successful solution.

The impending threat of the emerald ash borer should be taken seriously, just as the preparation of contingency plans should be. By following the guidelines that these five management strategy components lay out, an ideal management situation can be teased out. Ultimately, in order for the emerald ash borer (*Agrilus planipennis*) to be adequately prepared for in northern New York, a component of regional cohesion, a channel for productive discourse between stakeholders and managers, and an economically and ecologically sensitive management plan are essential to the success of any strategy.
II. Identification of Potential Strategies

In efforts to curtail the spread of emerald ash borer, many management strategies have been considered and implemented. While the success of each method has varied significantly, here we are considering solutions without any predispositions. Generally, we can list all solutions under the following categories: community preparedness, biological control, chemical control, education, “does nothing” approach, preemptive ash removal, and ash replacement. Community preparedness relates to the construction of management plans that establish integrative protocols which basically consist of problem identification, establishment of response procedures, and methods for controlling EAB spread such as ash removal, biological control, and chemical application of insecticides. Essentially the community preparedness plans combine the remaining potential solutions in a management strategy.

Biological control utilizes the ecology natural predators or parasites to effectively kill the emerald ash borer. There are three potential suitors: Spathius agrili, which is a larval ectoparasitoid; Oobius agrili, which is an egg parasitoid, and Tetrastichus planipennisi, which is a larval endoparasitoid. These parasitoids, which all lay eggs within the emerald ash borer killing the host, are wasps found within the native range of the emerald ash borer in Asia. Specifically, the S. agrili attacks the emerald ash borer larvae from the inside out, whereas T. planipennisi attacks the larvae from the outside in. Chemical control involves the use of insecticides that are applied consistently to kill the emerald ash borer. There are four main categories of application options: soil-injection, trunk-injection, lower-trunk sprays, and protective sprays for branches, foliage, and trunk. Education seeks to raise awareness of the emerald ash borer as a problem within New York and prevent the spread of the beetle via moved firewood or nursery stock. The “do nothing” approach is simply put. Preemptive ash removal is a method that involves the
cutting of all ashes in a given location to ensure that the population is not effected. Ash replacement is similar to removal, but replaces the species with another comparable tree.

III. Identification of Feasible Strategies

In suggesting the list of feasible management strategies, we first have to consider on what grounds are the solutions not possible. Solutions can be impractical due to high costs associated with implementation. Economically, the method would cost too much for the end resulting benefit. Physically, the solutions might be impractical for the regional scale of Northern New York that we are considering. In this context, the solution may only work on a smaller context, such as tree by tree basis or on a few acres of land, but would take considerable human effort in order to execute. Ecologically, the solution may not be as successful in containing the emerald ash borer spread. Also, some solutions may have a different approach than what is possible, given the current status of the emerald ash borer invasion.

Of the solutions listed, the “do nothing” approach, preemptive removal of ashes, and ash replacement are considered unfeasible. With the “do nothing” approach, this method ignores the ecological and social reasons for EAB spread. There is no effort made to address the important fact that we are responsible for the movement of the emerald ash borer. Education, on the other hand, allows people to become aware of the situation and help in the prevention of EAB spread. People might never realize that the reason for ash population losses in their backyard is because they transported contaminated firewood. There are also associated economic costs with the “do nothing” approach. In order to beautify towns and cities of dead ashes, removal of ash trees would be required. The process of ash removal is very expensive, which would cause doing nothing to be economically infeasible. Doing nothing also does not provide a great strategy if the objective is to conserve ash populations. Ash removal, like previously mentioned, is
economically costly. If a cost-benefit analysis for removal was done, the costs would weigh significantly more than the benefits. From a time-management perspective, ash removal is not feasible considering the amount of ash trees in New York and the potential for a significant portion of them to become infected. Additionally, the removal of ashes does little as a preventative measure and is more reactionary. For similar reasons, the replacement of ashes is also infeasible. High costs, high labor intensive process with little success in preventing the spread of the emerald ash borer.

IV. Identification of Best Strategies

As indicated when we parameterized solutions, the best methods were those that were constructed with the ecology and biology of the emerald ash borer. Also, top solutions would recognize that the EAB has little preoccupation with political boundaries, necessitating the need for regional cohesion. Best plans could be implemented regionally instead of locally, allowing for regional adaptation; such measures would increase execution efficiency and greater prevention of EAB spread would be possible.

While biological and chemical controls are both good strategies, these methods alone are not capable of preventing the EAB spread. Therefore with the combination of education and the formation of a community preparedness plan, such containment is possible. Chemical control, while effective to some regard for preventing EAB infection, is not a guarantee and has high economic costs, especially since they have to be applied on an individual tree basis. Insecticides were also found to be less consistently effective in larger ash trees (Herms et al. 2009). This limitation is too significant to consider chemical control to be a best solution. Similarly, biological control has limitations that as of now make it infeasible to apply on a larger regional scale. The application of wasps to prevent the spread of EAB is a terrific idea, considering there
no environmental impacts, unlike those associated with using chemical insecticides, and if 100% successful, provides a chance for at least local eradication of emerald ash borer. But similar to using insecticides, at the moment its very small scale. Regionally, there is no existence for biological control because we currently do not know if the solution is viable. Community preparedness and education are the best solutions because of the possibility of averting emerald ash borer spread.

**Ease of Implementation**

The ease of implementation is contingent upon the associated societal costs and their response to the decision of solutions. Society values three assets most importantly in life: time, money and culture. Time is significant because in recognizing the temporal requirements to implement a solution, we justify whether or not the allotted time required is worth the effort. Also, because the EAB issue is time-sensitive, the implementation process has to be relatively efficient so that further spread of the EAB renders the management efforts useless in preventing EAB invasion. Such results might frustrate individuals involved and cause further animosity towards execution. Money: without it there is no implementation. Although we choose solutions based on cost efficiency, funds are still required for education and to provide staff that will effectively lead in developing community management plans. If insufficient funding exists, such programs will not have the same merit. Culturally, there are significant reasons for why adaptation to management strategies might endanger values. For those individuals who do not see the value in protecting biodiversity for any reasons, it will be difficult to convince them to share the costs without seeing the benefits. Traditions of the Native Americans could be in
danger as well with the limitations of ash movement within quarantined zones. We have no idea how native tribes will react. Therefore, local resistance could represent one scenario in which the unwillingness to cooperate could seriously jeopardize the implementation of community preparedness plans. Even if initial execution is possible, communication and collaboration are essential to effective community plans and without them, management of the EAB invasion is no longer possible. The same is true when lack of support or involvement occurs.

**Step-by-Step Implementation Plan**

As part of the step-by-step implementation plan, we begin by recognizing the problem. In order to address the spread of the emerald ash borer, we had to become fluent in the situation. Hence, we define the problem. We establish the parameters we want to address and therefore helps us realize the threats the EAB poses to our interests. Secondly, we need to identify the parties at risk due to emerald ash borer invasion. This relates to the stakeholders we identified earlier within our case study. We want to address the concerns of all individuals in community preparedness plans to ensure full cooperation. After addressing who is concerned, we must determine how they are concerned with the spread of the EAB. For stakeholders who care about the ash because of its recreational value, their perspective on the structure of a community plan would be different than that of someone who values the ash as an economic commodity. As there is a need for eventual funding to development and continued maintenance of community plans, we need to evaluate which of the stakeholders would be interested in supporting the cause financially. Without proper funds, executing management plans is not possible.
In order to ensure effective communication, we then need to facilitate the discussion of the emerald ash borer between stakeholders, including most importantly governmental agencies. Since the agencies have the power to instill legislation and regulations, they need to reflect the current needs and want of all invested stakeholders. Easier implementation of the community plan will result. By involving the stakeholders, you are committing them to the problem and to take action, which will hopefully spark continued interest. Once all parties have made the effort to share concerns, they must acknowledge all available solutions on the table. Stakeholders should share the responsibility in determining what solutions work best, especially for different regions as adaptations are likely required. Within this process, solutions are eliminated and a list of suggested best solutions is facilitated. Early and continued involvement ensures more effective implementation. Within this step, funds are finalized. Important details such as how funds are raised and the amount of money needed at certain time intervals are discussed and agreed upon. A list of sponsors who agree to help monetarily should be included.

After much collaboration, finalized solutions should be made at this juncture. Hopefully there is general consensus on the agreed-upon methods to implement. At this moment, a timeline of events listed in order of priority to be accomplished should be created. Note that solutions should mention how funds are going to be raised. If not already initiated, raising funds is the next crucial step. Remember to seek out those who have committed to raising money for the EAB management. At the appropriate time, execution of the solution should begin. All necessary funds are available to allow for execution. All players involved are engaged in instigating the plan. Soon after initiation, it is crucial to look forward at potential roadblocks that could hinder full implementation. If foreseeable events are possible, take the time to develop steps to prevent them. Through the process, it is critical to ask for feedback from individuals and stakeholders.
Ask for suggestions for improvement, because plans require constant evolution. The issue of the emerald ash borer is long-term and the success of any solution relies upon adjustment. We must continue to fight for what we believe in. Maintaining a positive outlook is important to sustain enthusiasm for a critical conservation problem that is the emerald ash borer.

**Acknowledgements**

We would like to thank Dr. Erika Barthelmess for her continued help over the course of the case study. We also appreciate her comments on the rough draft in preparation for the final draft. We would like to thank Jon and Leah in their peer review. St. Lawrence University has been kind enough to allow us the use of the Madill Science Library and Owen D. Young Library as workplaces for writing and research. Special thanks to Eric Williams-Bergen for his help in the initial process of finding research guides.

**Footnotes**

1. In October of 2000, the U.S. Senate gave its consent to accept the newly revised IPPC. The President submitted the official letter of acceptance to the FAO Director General on October 4, 2001 (USDA APHIS 2008 [A]).

2. Due to pre-existing trade negotiations such as the World Trade Organization (WTO), and North American Free Trade Agreement (NAFTA), the US has formal trade agreements with over 20 countries – many of which are under developed in their standards and regulations infrastructure (USDA APHIS 2006)

3. Formed under the International Plant Protection Convention in 1976
4. On April 3rd, 2012 the USDA APHIS launched their new, multi-state, multi-year, public education initiative called “Hungry Pests” (USDA APHIS 2012 [B]).

**Appendix**

For more information regarding the management strategies taken by other states see the links below.

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<th>State</th>
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<td><a href="http://www.mda.state.mn.us/plants/pestmanagement/eab/eabmanual.aspx">http://www.mda.state.mn.us/plants/pestmanagement/eab/eabmanual.aspx</a></td>
</tr>
</tbody>
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**Works Cited**


Waddock S. 2011. We Are All Stakeholders of Gaia: A Normative Perspective on Stakeholder Thinking. Organization Environment 2011 24: 192-212
