**4-9: Invasive Species**

The National Invasive Species Council defines an invasive species as one 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. Invasive species can overwhelm native species and their habitats, forcing the native species out. They are considered to pose the second greatest threat to biodiversity globally. Invasive plants in Vermont, such as Japanese knotweed, common reed (Phragmites), and purple loosestrife, and garlic mustard can change soil composition, change water tables, and disrupt insect cycles. They often lack food value upon which wildlife depends. Some invasive animals prey heavily upon native species while others, such as the alewife and zebra mussel, out-compete native species for food and nutrients with significant impacts reverberating up and down food chains.

The spread of invasive species is primarily caused by human activity. Common examples include[[1]](#footnote-2):

* **Ships:** Can carry aquatic organisms in their ballast water or on the hull.
* **Wood Products:** Insects can get into wood, shipping palettes, and crates that are shipped around the world as well as travel in firewood.
* **Ornamental Plants:** Some ornamental plants can escape into the wild and become invasive.
* **Pet Trade:** Some invasive species start as pets that are intentionally or accidentally released.

The Nature Conservancy reports that invasive species have contributed directly to the decline of 42% of the threatened and endangered species in the United States. Further, the annual cost to the U.S. economy is estimated at $120 billion per year, with more than 100 million acres suffering from invasive plant infestation[[2]](#footnote-3). Freshwater ecosystems and estuaries are especially vulnerable to invasion, as these areas are very difficult to contain and reverse[[3]](#footnote-4). In Vermont specifically, examples of economic impacts of invasive species can be observed in the costs of managing invasive water chestnut in Lake Champlain[[4]](#footnote-5) and payments to private landowners to improve tree regeneration and wildlife habitat by controlling buckthorn and honeysuckle in forests[[5]](#footnote-6). Additionally, water pipes in Lake Champlain must now be cleaned out regularly to rid them of invasive zebra mussels.

Water chestnuts reproduce rapidly in nutrient-rich and slow-moving waters, making Lake Champlain a hotspot for these invasives[[6]](#footnote-7). They can cause severe damage to the surrounding aquatic ecosystem it inhabits by limiting nutrients, crowding out native species, and lowering the dissolved oxygen concentration. Early detection of these plants is crucial due to their prolific nature, and they should be removed from the area quickly before they germinate[[7]](#footnote-8). Total removal can take anywhere from five to twelve years by hand or mechanically, which comes at high cost to Vermont’s economy. Early detection might lower removal time and thus lower total costs, so taxpayer dollars could be put towards other state agencies.

Buckthorn and honeysuckle crowd out native Vermont species, increasing competition for nutrients and sunlight. Honeysuckle was introduced in the area to tackle erosion and wildfire, by decreasing the wildland-urban interface, but began to reproduce rapidly and take over parts of Vermont[[8]](#footnote-9). Buckthorn operates similarly, growing leaves at a faster rate than other native plants and effectively dominating the amount of available sunlight[[9]](#footnote-10). Aside from depleting sunlight and nutrients in the area, buckthorn can act as a host for crown rust fungus and Asian soybean aphid, which can damage soybean and oat production[[10]](#footnote-11). Hand-pulling and chemical treatment are options to remove populations of buckthorn and honeysuckle, but sometimes the responsibility lies with private landowners. If populations aren’t detected early by private landowners, both plants could reproduce quickly and spread to areas across the state of Vermont affecting forest health.

 Another species that has negatively impacted aquatic ecosystems in Vermont is the zebra mussel. Zebra mussels, much like many other invasives, reproduce quickly and can cover the entirety of lake bottoms. Such a process limits the amount of sunlight and nutrients that can be received by organisms residing at lake bottoms, leading to an increase in mortality. They are also known to filter out key nutrients from the lakes they reside in, which limits resources that native species rely on. Due to how microscopic the larvae are, the species is very difficult to remove entirely, so it is crucial that steps are taken to prevent further spread and overpopulation[[11]](#footnote-12). In order to prevent further spread, as mentioned above, water pipes must be monitored and cleaned out regularly, which is a costly but necessary precaution to protect native species.

Invasive pests such as Emerald Ash Borer (EAB), first found in Vermont in 2018, have serious financial implications for forest landowners and municipalities alike. EAB feeds on ash trees in Vermont, deeply damaging each tree and hindering its ability to move carbohydrates and water resources as necessary[[12]](#footnote-13). Infected trees will die between three and five years after the introduction of EAB. Productive timber is destroyed by EAB and trees along roads become hazards as they die and pulldown powerlines. Preventative measures are crucial to prevent the further spread of these insects and protect native ash populations, such as traps, which will be further discussed below under Invasive Species Mitigation.

Additionally, invasive species can directly or indirectly cause harm to human health. Giant hogweed, wild parsnip and wild chervil are three invasive plant species in Vermont that have phytophototoxic properties, meaning direct contact of their sap with human skin can cause a chemical reaction that makes skin hypersensitive to ultraviolet light. Vermonters have received serious skin burns from the toxicity of the sap of these plants combined with exposure to sunlight. Another example is that of Japanese barberry, which has been proven to increase the incidence of Lyme disease by providing sheltered habitat that increases the abundance of small rodents, which act as hosts to the ticks that carry Lyme disease pathogens[[13]](#footnote-14).

Invasive Terrestrial Plants & Forest Pests:

Vermont’s Agency of Agricultural, Food and Markets (VAAFM) maintains a list of invasive plants and regulates their importation, movement, sale, possession, cultivation and distribution[[14]](#footnote-15) based on the following categories:

* **Noxious Weed:** any plant in any stage of development, including all current and subsequent subspecies, varieties, and cultivars, and parasitic plants whose presence, whether direct or indirect, is detrimental to the environment, crops or other desirable plants, livestock, land, or other property, or is injurious to the public health or the economy generally.
* **Class A Noxious Weed:** any noxious weed that is not native to the State, not currently known to occur in the State on the date of listing and poses a serious threat to the State.
* **Class B Noxious Weed:** any noxious weed that is not native to the State, is of limited distribution statewide, and poses a serious threat to the State, or any other designated noxious weed being managed to reduce its occurrence and impact in the State, including those on the Federal Noxious Weed List[[15]](#footnote-16).

The State also maintains a watch list[[16]](#footnote-17), updated regularly, of non-native plants that have the potential to become invasive in Vermont based on their behavior in northeastern states. One-third of the plant species found in Vermont are not native to the State, but only about 8% have the potential to create environmental and economic harm due to their ability to grow rapidly, profusely, and widely. These are the plant species monitored on the watch list, which acts as a resource for public information and to enlist volunteers to monitor potentially harmful plants in Vermont, although it has no regulatory force.

Vermont’s Department of Forests, Parks and Recreation (FPR) is responsible for survey, detection, and management of forest pests in Vermont[[17]](#footnote-18). Additionally, the Vermont Invasives Gallery of Land Invasives is a resource for identification of invasive plants and forest pests[[18]](#footnote-19).

Aquatic Invasive Species (AIS):

The Department of Environmental Conservation (DEC) has a Vermont Aquatic Invasive Species Program that coordinates management activities associated with both aquatic invasive and nuisance species. The AIS webpage has information about the types of AIS, monitoring, spread prevention, grant opportunities and laws and regulations relating to AIS[[19]](#footnote-20). The Vermont AIS Program has identified twelve high-priority invasive and nuisance species affecting the State and issues informational pamphlets in an attempt to prevent their proliferation.

Location

Invasive species are commonly introduced via travel routes, accidentally brought into Vermont with the transportation of people and goods, such as ship ballast water, firewood, shipping palettes, and crates[[20]](#footnote-21). The presence of cold Vermont winters has historically been key in keeping more southern plant and insect species from colonizing Vermont. However, as winters in Vermont become increasingly milder the ability for invasive species to overwinter and reproduce in Vermont increases. This can already be seen in the changes in distribution of Hemlock Woolly Adelgid, which has overwintered in southern Vermont counties allowing the spread of the invasive pest to continue[[21]](#footnote-22). Distribution of invasive species throughout Vermont is generally dependent on the species in question, but due to the human connection to their introduction they are often first found in close proximity to human development.

Invasive Species History

Because invasive species often spread over a long period of time, identification of a hazard event concerning invasive species is rather difficult. Vermont, like much of the eastern United States, has long been susceptible to invasive species brought from overseas – whether they were plants intentionally transported or organisms clinging to vessels[[22]](#footnote-23). The State has a long history of invasive species infestation at the aquatic (e.g. water chestnut), terrestrial (e.g. Japanese knotweed) and forest pest (e.g. Emerald ash borer) levels.

* Most notably, the emerald ash borer, first discovered in Michigan in 2002, has spread to 30 states and three Canadian provinces and was reported and confirmed to be in Vermont in 2017.
* The hemlock wolly adelgid was first discovered on native trees in Vermont for the first time in 2007. It was first introduced to the United States in the 1920s, making its way into Vermont territory 87 years later[[23]](#footnote-24).
* The zebra mussel was discovered in Lake Champlain in the summer of 1993. This discovery came shortly after the first zebra mussel was discovered in North America in the state of Michigan in the summer of 1988[[24]](#footnote-25).
* Common buckthorn was likely introduced to the state of Vermont sometime during the mid 20th century. It was brought to North America from Europe, likely for ornamental uses[[25]](#footnote-26).
* The water chestnut, which spreads rapidly across lakes and ponds, preventing recreation and choking out sunlight from native aquatic species, has been actively managed since 1982.
* Honeysuckle was introduced to North America sometime in the 1800s and has spread to many states including Vermont since then[[26]](#footnote-27). It was introduced for erosion and wildfire control but has since increased competition among native vegetation for sunlight and other natural resources.
* Japanese knotweed, an invasive plant that spreads by sprouting from broken plant rhizomes, was introduced into the United States in the 1800s and has been established in New England ever since.

Invasive Species Trends

Native forests and ecosystems are projected to experience negative impacts of these warming trends, as well[[27]](#footnote-28). With 76% of the Vermont landscape covered by forest, and more than 50 tree species, increases in average annual temperatures will force these species to adapt. Potential impacts on forests include increased stress on native tree species, shifts in forest composition due to a climate more suitable for southern species, and the potential for isolated species having a reduced ability to migrate and respond to climate change[[28]](#footnote-29). Of particular concern are the Asian longhorned beetle (not yet found in Vermont), emerald ash borer and hemlock wolly adelgid, which have killed millions of trees across the U.S. and Canada.

In 2017, the first reported cases of the emerald ash borer (EAB) occurred in Vermont in Orange, Washington and Caledonia Counties[[29]](#footnote-30). Emerald ash borer larvae burrow through the inner layer of the ash tree’s bark, impeding the tree’s ability to conduct water and nutrients throughout the tree[[30]](#footnote-31). Lacking sufficient water and nutrients, healthy ash trees can die within 1-4 years of exhibiting first signs or symptoms of ash borer invasion and, because 5% of Vermont’s trees are ash, the State’s forest composition is extremely vulnerable to this invasive species. It is estimated that the majority of ash trees infested with the emerald ash borer will die, causing public hazards from standing dead trees that may impact structures and infrastructure, as well as add to riverine debris during high precipitation events (see: Inundation Flooding & Fluvial Erosion). Since 2017, the extent of EAB invasion in Vermont as spread to 46 municipalities (Figure \_\_) and every county with the exception of Essex[[31]](#footnote-32) . General trends show that EAB is spreading throughout the state and can endanger Vermont’s entire ash tree population.

[Figure \_\_ confirm Locations of Emerald Ash Borer in Vermont]

Hemlock woolly adelgid is an invasive pest that feeds on hemlock trees, first discovered in Vermont in 2007 and primarily located in the southern counties including Bennington, Windham, and Windsor[[32]](#footnote-33). Due to our harsh winters in Vermont, hemlock woolly adelgid has not caused significant mortality among hemlocks; however, south of Vermont where winters are milder the species’ impacts are a significant concern. Based on Vermont’s trend of increasing temperature (see: Extreme Heat), this invasive is expected to be a much more significant concern in the future. In the winter of 2016-2017, a significant portion of the hemlock woolly adelgids were able to survive the winter, which was not the case in the previous three winters[[33]](#footnote-34).

In addition to concerns over Vermont’s ash population, northern hardwood species like maple, yellow birch and American beech are anticipated to be nearly eliminated in the State, replaced by those tree species that thrive in warmer, drier conditions, like oak and pine. Additionally, the changing climate will allow for greater survival and reproduction of forest pest species, as trees that are stressed due to lower water availability reduce their ability to maintain sufficient defense mechanisms, making them more vulnerable to pest invasion and disease. As trees die at an increasing rate, concerns regarding wildfire susceptibility also rise (see: Wildfire).

Along the State’s riverbanks, Japanese knotweed continues to spread uncontrollably, negatively affecting native insect populations, and therefore birds, fish and mammals, that rely on those insects as a food source. With shallow root systems, the spread of Japanese knotweed significantly reduces streambank stability, thereby exacerbating fluvial erosion (see: Inundation Flooding & Fluvial Erosion). Road maintenance efforts near ditches infested by Japanese knotweed allow for quick spread of the knotweed’s rhizomes and stems. While Japanese knotweed is already prevalent in Vermont, Figure 59 illustrates the area of potential spread based on habitat suitability.

The Steering Committee considered the probability of a plausibly significant extreme invasive species event to be Likely, with major impacts to the economy and natural environment, followed then by minor impacts to the built environment and negligible impacts to people.

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| **CLIMATE CHANGE**As Vermont’s climate continues to change throughout the 21st century invasive plants continue to expand their range as conditions become more suitable for them while native species become stressed as they are pushed towards the edges of their habitat range. This stress is not limited to natural ecosystems as increasing global temperatures will put added stress on agricultural systems leading to a decline in yield coupled with a decline in resilience to disturbances or invasive pests that can decimate populations. Changing climate can create greater pest resistance to herbicide and pesticides with a greater chance of species adaptation. Increasing global temperatures will also stress out native species, leaving them more susceptible to out-competition by better adapted invasives. Warming temperatures and an increase in mild winters (see: Extreme Cold) can allow insect borne diseases greater access to Vermont with increased chances of overwintering. These introductions may not be invasive, but it is a shift in species distribution and range that could threaten human health in the state. As the global climate continues to shift at a rapid rate, species better adapted for warmer climates will continue to proliferate, with changes in ecosystem composition threatening to destabilize basic ecosystem functions. Costs associated with the disturbances invasives cause will continue to mount, with mitigation costs also rising as it becomes increasingly difficult to manage for abundant pests with no major predator. |

Vulnerability

People

Invasive species can pose a risk to people by acting as vectors for disease as well as introducing new diseases to unprepared populations. Invasive plant life can also increase the incidence of insect borne disease by providing appropriate habitat for carriers, such as ticks (see: Infectious Disease). For those species that have been investigated, several invasive plant species such as Japanese honeysuckle and barberry have been shown to harbor and enhance tick, host, and pathogen populations by enhancing microhabitat and survival. Additionally, non-native tick species such as Asian longhorn tick have been introduced and potentially new invasive tick-borne pathogens or hosts can, and likely will, be introduced in the future[[34]](#footnote-35).

Invasive species such as the Asian Lady Beetle (*Harmonia axyridis*), which present similarly to native ladybug species, has been documented to enter structures and homes in search of overwintering sites. Typically, they will fly to buildings during autumn and congregate in large numbers in these structures. While many insects that attempt to overwinter within homes pose little harm to humans, they can act as a nuisance the beetles emit an acrid odor and can stain surfaces with their yellowish secretions when disturbed[[35]](#footnote-36). Many other invasive insects have managed to find their way into homes and other heated structures to survive the winter.

As invasive species impact the biodiversity and productivity of landscapes across Vermont, food security can become an issue. If invasives consume or out-compete native or crop species, that can lead to a decline in yield for farms across the State. Species such as the Emerald Ash Borer (EAB) can impact the health of forest stands such as ash, which can result in forests comprising of standing dead trees that have the potential to fall or drop branches that can harm workers of recreationalists below. The vast distribution of ash populations around the state can increase the chance that individual properties have ash that may eventually be impacted, increasing the vulnerability of homeowners and their properties from dead snags of ash. Many invasive species trace their origins as ornamental species that were introduced to America for gardens and other decorative purposes but made their way[[36]](#footnote-37).

Built Environment

With exponentially increasing connectivity ever since the age of exploration to globalization, human made vectors have been a primary source of invasive species transportation from continent to continent. Since the human built environment is often the first thing impacted by an invasive species during transportation, invasives have had a long history of impacts to the built environment. The United States currently lacks the comprehensive authority necessary to effectively prevent, eradicate, and control invasive species that impact the human-built environment. This prevents rapid response to some of the most damaging invasive species. Invasive species can impact different sectors of the built environment including power systems, water systems, transportation systems, and building systems[[37]](#footnote-38).

Power systems, such as hydroelectric dams, power plants, and transmission lines, can become compromised through the introduction of invasives. Invasives can work their way into critical portions of infrastructure where systems can become blocked or weakened by the invasive. Invasives can have an indirect impact on these systems.

For example, EAB targets all species of North American ash including green ash (*Fraxinus pennslyvanica*) and white ash (*Fraxinus americana*) and as a result EAB can girdle a tree within 2 years through the feeding patterns of its larvae which is planted inside the trunk. This can lead to ash stand mortality within 5 years[[38]](#footnote-39). Such a drastic decline in a species can cause snags (dead trees still standing) to fall and interfere with transmission lines or on homes and other buildings, posing a threat to homeowners with ash trees on their property. Water systems such as dams, irrigation networks, levees, and hatcheries are also under threat through the introduction of species that weaken structures as well invasives that can introduce disease or harm aquaculture operations. Transportation systems such as roads, navigation channels, airfields, and lock chambers can be subject to increased maintenance and repairs to ensure proper functionality as invasives work their way into the infrastructure. The structural integrity of buildings is also a cause for concern[[39]](#footnote-40). Invasives can be a threat to the operational capacity of many critical built systems if not managed properly.

One species of important note is Japanese knotweed[[40]](#footnote-41), originally an ornamental plant introduced into the US from Europe in the 1800s. It can establish new colonies from a small piece of root or stem and can spread when contaminated soil is transported. It grows extremely fast, is incredibly persistent, and hard to eradicate. The species is commonly found along waterways and thrives well in wet environments. And as result of the impacts of Tropical Storm Irene in Vermont, Japanese knotweed became incredibly prevalent, traveling downstream during flooding creating new colonies throughout the state. This species increases the susceptibility of erosion where present by creating dense thickets that outcompete native species, leaving the soil beneath bare, threatening riverbanks. Japanese

Knotweed stands reduce species diversity, alter natural ecosystems, and negatively impact wildlife habitat. In addition to these ecological impacts, it can have economic impacts by its ability to grow through pavement and damage infrastructure.

Natural Environment

Invasive species are considered invasive due to their ability to outcompete native species in their natural environments without the threat of a predator that can keep their populations in check. This allows invasive populations to run rampant and devastate local ecosystems. Impacts to the natural environment include habitat loss, where invasive species displace native species resulting in local extinction of species and a decline in biodiversity[[41]](#footnote-42). A decline in biodiversity often leads to a decline in the resilience of an ecosystem in the event of major disturbances. New species often lack a predator which gives them an advantage over native species while competing for limited resources. Alteration to the local ecosystems and habitats can have ripple effects that impact many other facets of life. Indirect impacts of an invading species are an important component of its overall environmental impacts. Changes in species composition was equally important as a driver of indirect effects. Successful management of invasive species is likely to require not only control of the invader but also restoration of diverse native species, as they are important for many ecosystem functions. This highlights the importance of biodiversity as a driver of ecosystem functioning also in real-world systems, this will reduce costs in the long-run[[42]](#footnote-43).

Economy

The economic and social impacts of invasive species include both direct effects of a species on property values, agricultural productivity, public utility operations, native fisheries, tourism, and outdoor recreation, as well as costs associated with invasive species control efforts. A 2021 study estimated that invasive species have cost North America $2 billion per year in the early 1960s to over $26 billion per year since 2010[[43]](#footnote-44). Invasive species cumulatively (from 1960–2017) cost the agriculture and forestry sectors US$ 527.07 billion and US$ 34.93 billion, respectively. Impacting the productivity of these economic sectors and adding costs that some businesses cannot absorb. Certain invasives such as the zebra mussel, that originated from shipping businesses with uncleaned hulls, can cut of energy to economic activities within cities by clogging intake pipes for power generation and water treatment facilities. Sea lampreys can reduce the populations of commercially significant fish species through predation without a natural predator to keep them in check[[44]](#footnote-45). Asian lady beetles are also becoming a concern of the wine industry. Due to their noxious odor, even small numbers of beetles inadvertently processed along with grapes can taint the flavor of wine[[45]](#footnote-46).

Invasive Species Current Capabilities and Mitigation

The Vermont Invasives website maintains a crowd-sourced invasive species map that allows users to upload locations and photos of invasive species, which acts as an aid in determining spread rate and control measures across the State[[46]](#footnote-47). This comprehensive website also includes information on all of the significant invasive species affecting Vermont, including identification, treatment and prevention measures. The Lake Champlain Basin Program also has information regarding the aquatic invasive species threatening the Lake Champlain Basin and how to prevent their spread[[47]](#footnote-48).

Additionally, Vermont joined the United States Department of Agriculture (USDA)’s 31-state quarantine boundary, aimed at reducing the movement of emerald ash borer-infested ash wood to un-infested regions outside of Vermont’s borders[[48]](#footnote-49). The February 2018 State of Vermont Action Plan for the Emerald Ash Borer identifies the Agency of Agriculture, Foods and Markets and the Department of Forests, Parks and Recreation as the lead agencies responsible for developing a means by which the emerald ash borer can be quickly detected/identified and managed. The intent of the Action Plan is to establish effective lines of communication between pertinent State agencies and to clearly identify the roles and responsibilities of each agency in preventing the spread of the emerald ash borer across Vermont[[49]](#footnote-50).

A new mitigation strategy against EAB was implemented in the spring and fall of 2021, in the category of biocontrol. 2,600 pupae and adult wasps belonging to the species *Tetrastichus plannipenisi*, Oobius *agrili,* and *Spathius galinae* were introduced into Vermont ecosystems in an attempt to control the population of the Emerald Ash Borer[[50]](#footnote-51). These wasps are parasitic, and lay eggs within the bodies of EAB, which kills the beetles and thus protects native ash trees in Vermont. *Oobius agrili* and *Spathius galinae* lay their eggs within EAB eggs and can withstand the cold temperatures known to the Vermont area, making them more efficient biocontrol species than the *Tetrastichus plannipenisi*[[51]](#footnote-52)*.* Throughout 2023, foresters plan to monitor the wasp species’ survival rates in order to properly identify the effectiveness of this mitigation strategy.

Given the compounding impacts invasive species have on other hazard impacts addressed in this Plan (see: Inundation Flooding & Fluvial Erosion and Wildfire), several of the high priority actions regarding hazard mapping and data sharing are pertinent to invasive species mitigation. Also, as the climate models project increases in both temperature and precipitation, it is anticipated that invasive species infestation in Vermont will continue to grow and, as such, the State’s efforts concerning education and outreach of the hazards associated with invasive species need to be bolstered in the years to come. Accordingly, an action to support the education of the general public around invasive species and their role in altering the beneficial functions of natural ecosystems was developed (see: Mitigation Strategy).

1. <https://www.vtinvasives.org/intro-to-invasives/what-are-invasive-species> [↑](#footnote-ref-2)
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3. <https://www.nature.org/ourinitiatives/urgentissues/land-conservation/forests/invasives-101.xml> [↑](#footnote-ref-4)
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10. <https://vtfishandwildlife.com/learn-more/landowner-resources/liep-invasive-species-program/terrestrial-invasive-plants/common-buckthorn> [↑](#footnote-ref-11)
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13. <https://mnfi.anr.msu.edu/invasive-species/JapaneseBarberryBCP.pdf> [↑](#footnote-ref-14)
14. <http://agriculture.vermont.gov/plant_pest/plant_weed/invasive_noxious_weeds> [↑](#footnote-ref-15)
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37. <https://www.doi.gov/sites/doi.gov/files/uploads/invasive_species_impacts_on_federal_infrastructure.pdf> [↑](#footnote-ref-38)
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