

4.3.7.9. *State Facility Loss Estimation*

The estimated replacement cost of all state critical facilities located in hurricane hazard zones is \$6,867,999,216.

4.3.8. **Invasive Species**

4.3.8.1. *Location and Extent*

An invasive species is a species that is not indigenous to a given ecosystem and that, when introduced to a non-native environment, is likely to cause economic or environmental harm, or pose a hazard to human health. The Commonwealth of Pennsylvania plays host to a number of invasive pathogens, insects, plants, invertebrates, fish, and higher mammals. These species have largely been introduced by the actions of humans. Common pathways for invasive species threats include unintentional release of species, the movement of goods and equipment that may unknowingly harbor species, smuggling, ship ballast, hull fouling, and escape from cultivation (PISC, 2010). Invasive species threats are generally divided into two main subsets:

- **Aquatic Invasive Species** are nonnative viruses, invertebrates, fish, and aquatic plants that threaten the diversity or abundance of native species, the ecological stability of the infested waters, human health and safety, or commercial, agriculture, aquaculture, or recreational activities dependent on such waters.
- **Terrestrial Invasive Species** are nonnative arthropods, vascular plants, higher vertebrates, or pathogens that complete their lifecycle on land instead of in an aquatic environment and whose introduction does or is likely to cause economic or environmental harm or harm to human health.

The Governor’s Invasive Species Council of Pennsylvania (PISC), the lead organization for invasive species threats, identifies a number of species threats that are or could potentially become significant in Pennsylvania but does not prioritize or rank them. These species are listed in Table 4.3.8-1.

Table 4.3.8-1 Invasive species of concern to the Commonwealth (PISC 2010).		
INVASIVE SPECIES OF CONCERN IN PENNSYLVANIA*		
Aquatic Invasive Species		
Amphibians and Reptiles		
Red-Eared Slider	Yellow-bellied Slider	
Fishes, Diseases, Invertebrates		
Northern Snakehead	Round Goby	
European Rudd	Sea Lamprey	Zebra Mussel
Tubenose Goby	West Nile Virus	Asian Clam
Asian Carp	Viral Hemorrhagic Septicemia	Rusty Crayfish
Eurasian Ruffe	Spring Viremia of Carp	Spiny Waterflea
Flathead Catfish	Quagga Mussel	Fishhook Waterflea
Mammals and Birds		
Nutria	Mute Swans	Canada Goose
Submerged Aquatic Plants		
Wild Taro	Water Chestnut	Limnophila Sessiliflora

Table 4.3.8-1 Invasive species of concern to the Commonwealth (PISC 2010).

INVASIVE SPECIES OF CONCERN IN PENNSYLVANIA*		
Aquatic Invasive Species		
Hydrilla	Eurasian Watermilfoil	Carolina fanwort
Curly Leaf Pondweed	Giant Salvinia	Parrot feather
Alligator Weed	East Indian Hygrophila	Brazilian waterweed
Water Spinach	Didymo	
Terrestrial Aquatic Plants		
Narrow Leaved Cattail	Japanese Knotweed	Giant Knotweed
Japanese Hops	Common Reed	Hybrid Cattail
Giant Hogweed	Purple Loosestrife	
Terrestrial Invasive Species		
Human and Animal Pathogens		
Avian Influenza	Plague	Q Fever
Smallpox	Salmonellosis	Chronic Wasting Disease
West Nile Virus	Brucellosis	Bovine Spongiform Encephalopathy
Foot and Mouth Disease	Anthrax	
Botulism	Glanders	
Plant Pathogens		
Chrysanthemum White Rust	Potato Wart	Plum Pox Virus
Dutch Elm Disease	White Pine Blister	Ralstonia Blight
Sudden Oak Death	European Stone Fruit Yellows	Ring Rot
Birds		
European Starling	Pigeons	House Sparrows
Monk Parakeet		
Insects and Other Invertebrates		
Japanese Beetle	Gypsy Moth	Tracheal Mite
Pine Shoot Beetle	Brown Marmorated Stink Bug	Non-Native Earthworms
Emerald Ash Borer	Ahemlock Woolly Adelgid	Potato Cyst Nematode
Exotic Bark Beetle	Elongate Hemlock Scale	Golden Nematode
Asian Longhorned Beetle	Beech Bark Scale	Soybean Cyst Nematode
Siren Wood Wasp	Varroa Mite	Giant African Snail
Higher Mammals		
Norway Rat	13-Lined Ground Squirrel	Feral Swine
House Mouse		
Vascular Plants		
Tropical Soda Apple	Goatsrue	Asiatic Bittersweet
Beach Vitex	Multiflora Rose	Japanese Knotweed
Benghal Dayflower	Johnsongrass	Tree of Heaven
Rosary Pea	Garlic Mustard	Purple Loosestrife
Cagon Grass	Mile-A-Minute	Japanese Hops
Kudzu	Canada Thistle	Common Reed
*Species listed above have been mentioned in documents of the Governor's Council on Invasive Species and do not represent a comprehensive list of invasive species threats.		

The location and extent of these invasive threats depends on the preferred habitat of the species as well as the species' ease of movement and establishment. For example, kudzu vine is an aggressive vascular plant; by virtue of its wide ecological parameters and its ease of spread, the vine is a more widespread invasive species threat. Other species' spread has been limited by state agency activity. For example, the Emerald Ash Borer's spread is slower than it would be naturally because of an aggressive quarantine and testing program. However, the Ash Borer is in 25 more counties than it was at the time of the 2010 Hazard Mitigation Plan. Overall, though, by nature of being invasive, these threats can infiltrate most areas of the Commonwealth.

Most new introductions of invasive species occur because of human activity. There are a few key pathways to introduction into Pennsylvania:

- Contamination of internationally traded products
- Hull fouling
- Ship ballast water release
- Discarded live fish bait
- Intentional release
- Escape from cultivation
- Movement of soil, compost, wood, vehicles, or other materials and equipment
- Unregulated sale of organisms
- Smuggling activities
- Hobby trading or specimen trading

4.3.8.2. *Range of Magnitude*

The magnitude of invasive species threats ranges from nuisance to widespread killer. Some invasive species like the Brown Marmorated Stink Bugs are not considered an agricultural pest and do not harm humans. Other invasive species can cause significant changes in the composition of Pennsylvania ecosystems. For example, the Emerald Ash Borer has a 99% mortality rate for any ash tree it infects. Didymo, an aggressive form of algae, can clog waterways and smother native aquatic plants and animals. Still more invasive species can cause widespread illness or death in humans; one species of particular concern with this magnitude is anthrax, considered by the Centers for Disease Control and Prevention (CDC) to be a Category A agent that may pose a significant, widespread threat to public health.

The magnitude of an invasive species threat is generally amplified when the ecosystem or host species is already stressed, such as in times of drought. The already weakened state of the native ecosystem causes it to more easily succumb to an infestation. An example of a possible worst-case scenario for invasive species is if the Emerald Ash Borer spreads to the Commonwealth's 323 million ash trees. With the high mortality rate associated with the ash borer, Pennsylvania's hardwood forests would be devastated. This would have a serious impact on Pennsylvania's logging activities and its many state parks and game lands. The economic impact could be serious, stretching from logging to tourism to other production activities

dependent on Pennsylvania lumber. A 2010 Department of Agriculture report estimated that more than 80,000 Pennsylvanians have been employed in forest product industries, and Pennsylvania is the nation’s leading producer of hardwood lumber. The economic impact of this industry is estimated at \$26 billion, a significant potential loss should a hardwood-living invasive species take root in Pennsylvania (Department of Agriculture, 2010).

4.3.8.3. Past Occurrence

Invasive species have been entering the Commonwealth since the arrival of early European settlers, but not all occurrences have required government action. The first invasive species outbreak requiring state attention occurred in 1862 when legislation was enacted to provide for the destruction of and to prevent the spread of Canada Thistle, Johnson Grass, and Marijuana. Since then, there have been 26 acts and quarantines enacted to prevent the spread of invasive species. As illustrated in Table 4.3.8-2, the volume of acts and quarantines has increased since 2000 (PISC, 2013).

YEAR	SPECIES	YEAR	SPECIES
1911	Chestnut Blight Disease	2003	Black Carp, Bighead Carp, Silver Carp
1917	Tuberculosis	2005	Eurasian Watermilfoil
1919	European Wart Disease of the Potato	2006	Chronic Wasting Disease
1923	Japanese Beetle	2006	Scrapie
1925	European Corn Borer	2006	Vesicular Stomatitis
1927	Canada Thistle, Wild Garlic, Orange Hockweed, King-Devil, Sow Thistle, Field Bindweed	2007	Emerald Ash Borer
1933	White Pine Blister	2007	Feral Pig
1933	Gypsy Moth	2008	Viral Hemorrhagic Septicemia Virus
1935	Mosquitos	2009	Avian Influenza
1953	Black Stem Rust	2009	Tuberculosis
1983-84	Avian Influenza	2009	Emerald Ash Borer (expansion of previous quarantine)
1992	Pine Shoot Beetle	2009	West Nile encephalitis, Chronic Wasting Disease, Spring Viremia of Carp, Viral Hemorrhagic Septicemia, Lymphocitic Choriomeningitis Virus, Equine Rhinopneumonitis
1996	Reptile and Amphibian Species	2010	Emerald Ash Borer (expansion of quarantine to Allegheny, Armstrong, Beaver, Bedford, Butler, Indiana, Juniata, Lawrence, Mercer, Mifflin, Washington and Westmoreland Counties)
1999	Plum Pox Virus		

The PISC has begun tackling human and animal pathogens, aquatics, insects, mammals, plant pathogens, and vascular plants through management programs between the PA Fish and Boat Commission, the Game Commission, the Department of Agriculture, and DCNR. Notably, the PISC lists management programs for feral swine, kudzu, giant hogweed, mile-a-minute, emerald ash borer, plum pox virus, zebra and quagga mussels, and viral hemorrhagic septicemia under its “completed actions.” This does not mean that these threats have been eliminated; rather, it indicates that there is an active management plan in place to reduce future occurrences.

4.3.8.4. Future Occurrence

According to the PISC, the probability of future occurrence for invasive species threats is on the rise because of the growing volume of transported goods, increasing technology, efficiency and speed of transportation and expanding international trade agreements. Expanded global trade has created opportunities for many organisms to be transported to and establish themselves in new countries and regions. In 2009 alone, Pennsylvania imported over \$115 billion in goods from abroad, including agricultural, forestry, and fisheries goods that commonly carry unknown pests (U.S. Census, 2009). Furthermore, climate change is contributing to the introduction of new invasive species. As maximum and minimum seasonal temperatures change, pests are able to establish themselves in previously inhospitable climates. This also gives introduced species an earlier start and increases the magnitude of their growth. This may shift the dominance of ecosystems in the favor of nonnative species. For more information on recent changes in extreme temperatures, see Section 4.3.4.

In order to combat the increase in future occurrences, the PISC, which is a collaboration of state agencies, public organizations, and federal agencies, released the Invasive Species Management Plan in April 2010. This plan outlines the Commonwealth’s goals for the management of the spread of nonnative invasive species as well as creates a framework for responding to threats through research, action, and public outreach and communication. More information on the Management Plan can be found online at www.invasivespeciescouncil.com. Individual management plans by PISC member agencies and organizations will also help to reduce the number and/or magnitude of invasive species threats in the future.

4.3.8.5. Environmental Impacts

There is a wide range of environmental impacts caused by invasive species. The aggressive nature of many invasive species can cause significant reductions in biodiversity by crowding out native species. This can affect the health of individual host organisms as well as the overall well-being of the affected ecosystem. Beyond causing human, animal, and plant harm, there are secondary impacts of invasive species that go beyond harm to host species and ecosystems, particular in the case of invasive species that attack forests. Pennsylvania’s forests prevent soil degradation and erosion, protect watersheds, stabilize slopes, and absorb carbon dioxide emissions. The key role of forests in the hydrologic system means that if forest land is wiped out, the effects of erosion and flooding will be amplified. There is also an impact on agricultural harvests like honey, potatoes, and stone fruits. As a state with strong agricultural population, invasive species remain a hazard for the economic livelihood of the state.

4.3.8.6. *Jurisdictional Vulnerability Assessment*

Invasive species threats do not generally impact buildings; instead, they impact landscapes, crops, and people, in the case of human-borne pathogens. Because of this wide array of invasive species present in Pennsylvania, most jurisdictions are vulnerable to some kind of invasive species threat.

However, the invasive species on the Pennsylvania Department of Agriculture's list of most significant threats attack crops and trees. As a result, the most vulnerable jurisdictions are those with the Commonwealth's highest concentration of agricultural production, as well as the highest concentration of the timber and logging industry. According to the 2011 County Business Patterns data collected for Pennsylvania, the agriculture, forestry, fishing, and hunting industry boasts an annual payroll of nearly \$86 million across the nearly 500 establishments in Pennsylvania. The counties with the highest concentration of logging establishments are Elk (20 establishments), Bradford (14 establishments), McKean (16 establishments), Crawford (13 establishments), and Jefferson Counties (11 establishments); the counties with the highest agricultural production are:

1. Lancaster County (18.5% of state total sales)
2. Chester County (9.5% of state total sales)
3. Berks County (6.3% of state total sales)
4. Franklin County (5.2% of state total sales)
5. Lebanon County (4.4% of state total sales)
6. Adams County (3.7% of state total sales)
7. York County (3.7% of state total sales)
8. Cumberland County (2.3% of state total sales)
9. Schuylkill (2.1% of state total sales)
10. Bradford County (2.1% of state total sales)

In addition, a number of counties have identified invasive species, forest diseases, and infestations as significant concerns, as shown in Table 4.3.8-3. As stated in Section 4.1, the decision by a county to profile a hazard is one indicator of the presence of risk from that hazard. This indicator should be viewed complementary to other analysis in this section. Together this analysis from reputable sources addresses different aspects of risk for a full risk profile.

Of the 40 counties which currently have calculated risk factor values for invasive species, the average value is 2.3; this average does not include Lebanon, Montour, Perry, and Philadelphia, who use an alternate Risk Factor/Ranking system. The State Risk Factor for invasive species is 2, while the Pennsylvania THIRA scored invasive species as a 7 out of 10. For more details on the State Risk Factor and THIRA rankings, please see Section 4.1.

Table 4.3.8-3 Counties profiling invasive species hazards with hazard ranking and risk factor (if available).				
COUNTY	Profiled Hazard	Did Not Profile Hazard	Ranking (if available)	Risk Factor (If available)
Adams		X	High	3.4
Allegheny		X		
Armstrong		X		
Beaver		X		
Bedford	X		Medium	2.3
Berks		X		
Blair		X		
Bradford		X		
Bucks		X		
Butler		X		
Cambria		X		
Cameron		X		
Carbon		X		
Centre		X		
Chester		X		
Clarion		X		
Clearfield		X		
Clinton		X		
Columbia		X		
Crawford		X		
Cumberland		X		
Dauphin		X		
Delaware		X		
Elk		X		
Erie	X		Low	1.6
Fayette		X		
Forest		X		
Franklin		X		
Fulton		X		
Greene		X		
Huntingdon		X		
Indiana	X		Medium	2.0
Jefferson		X		

Table 4.3.8-3 Counties profiling invasive species hazards with hazard ranking and risk factor (if available).				
COUNTY	Profiled Hazard	Did Not Profile Hazard	Ranking (if available)	Risk Factor (if available)
Juniata		X		
Lackawanna		X		
Lancaster		X		
Lawrence		X		
Lebanon*		X		
Lehigh		X		
Luzerne		X		
Lycoming		X		
McKean	X		Medium	2.3
Mercer		X		
Mifflin	x		Not Ranked	5.55
Monroe		X		
Montgomery		X		
Montour*		X		
Northampton		X		
Northumberland		X		
Perry*	x		Not Ranked	5.55
Philadelphia**		X		
Pike		X		
Potter		X		
Schuylkill		X		
Snyder		X		
Somerset		X		
Sullivan		X		
Susquehanna		X		
Tioga		X		
Union		X		
Venango		X		
Warren		X		
Washington		X		
Wayne		X		
Westmoreland		X		
Wyoming		X		
York	X		Low	1.8

Table 4.3.8-3 Counties profiling invasive species hazards with hazard ranking and risk factor (if available).				
COUNTY	Profiled Hazard	Did Not Profile Hazard	Ranking (if available)	Risk Factor (If available)
<p>* Lebanon, Montour, and Perry use an alternate weighted ranking where Risk Factor = Frequency x [(0.25 x Critical facilities) + (0.40 x Social) + (0.25 x Economic) + (0.10 x Environmental)]. While this risk factor was used to comparatively rank hazards, the number does not correspond to a high-medium-low rating.</p> <p>**Philadelphia uses an A, B, C rating system where A is high, B is medium, and C is low.</p>				

4.3.8.7. State Facility Vulnerability Assessment

Invasive species do not pose a direct threat to state critical facility buildings. However, the Commonwealth identifies 106 food and agriculture-related critical facilities, including seed producers, dairies, and other farm producers; it can be expected that invasive species will have either a direct effect on critical facilities in this category by hindering production or an indirect effect by increasing the cost of food production inputs. However, the exact vulnerability depends on the species in question.

State facility vulnerability is low for invasive species when referring to buildings owned by the state, but the 6,569 buildings owned and leased by the Department of Conservation and Natural Resources, Game Commission, and Fish and Boat Commission are potentially more at risk if they are sited in Pennsylvania’s wild and natural areas. Additionally, while they are not identified as state critical facilities, the Commonwealth owns and administers 2.5 million acres of state forests that provide clean water, recreational opportunities, habitat for wildlife, and places to enjoy the tranquility of nature. These forests are constantly vulnerable to invasive species threats.

4.3.8.8. Jurisdictional Loss Estimation

Nationally, the United States Department of Agriculture estimates that lost agricultural production, pest management costs, and monetary losses from decreased tourism and recreation surpass \$138 billion annually. In Pennsylvania, losses will depend from jurisdiction to jurisdiction depending on the aggressiveness of the invasive species of concern. Jurisdictional losses due to invasive species threats stem from three sources: lost revenue from diseased, damaged, or deceased crops, livestock, lumber, etc; economic losses from the cost of eradication programs; and losses in the form of illness or death of humans.

Jurisdictional loss estimates stems from lost agricultural and wood product revenues statewide. Table 4.3.8-4 examines the potential losses to vulnerable jurisdictions in the form of agricultural land and market value of agricultural products. If an invasive species threat were to eliminate these counties’ agricultural yield, total losses could reach \$2.5 billion. County-by-county loss estimates for timber, lumber and wood products are unavailable, but DCNR estimates that the total value of all Pennsylvania wood products is \$5.5 billion (PADCNR, 2004).

Table 4.3.8-4 Estimated agricultural jurisdictional losses due to Invasive Species.		
COUNTY	TOTAL ACRES IN FARMS	MARKET VALUE OF ALL AGRICULTURAL PRODUCTS (\$)
Berks	222,119	\$367,840,000
Chester	166,891	\$553,290,000
Franklin	242,634	\$304,450,000
Lancaster	425,336	\$1,072,151,000
Lebanon	113,486	\$257,097,000
TOTAL	1,170,466	\$2,554,828,000

4.3.8.9. State Facility Loss Estimation

The state critical facilities most vulnerable to invasive species threats are privately held organizations; as a result, replacement value estimates are not available. Looking more broadly, the Pennsylvania Wilds Initiative, a consortium of thirteen counties in north-central Pennsylvania with significant forest resources, recently indicated that their 2 million acres of public natural landscape represent a \$126 million dollar state investment (PA Wilds, 2010). An aggressive invasive species threat to these or other state-owned lands could result in significant economic loss. Additionally, the total value of Pennsylvania’s agricultural products is nearly \$6 billion; an invasive species that affects agricultural products and production can cause significant losses to the Commonwealth’s economy.

Aside from losses to state facilities, combatting invasive species is an expensive task. DCNR states in its Invasive Species Management Plan that in 2011, they spent \$220,000 on suppressing the Hemlock Woolly Adelgid alone; other forest pest surveys cost \$500,000 per year, and the gypsy moth suppression program ranges from \$500,000 to \$10 million annually. These programs could cause an undue burden on budgets should invasive species grow.

4.3.9. Landslide

4.3.9.1. Location and Extent

Rockfalls and other slope failures occur in areas of Pennsylvania with moderate to steep slopes. Many slope failures are associated with precipitation events – periods of sustained above-average precipitation, specific rainstorms, or snowmelt events. Areas experiencing erosion, decline in vegetation cover and earthquakes are also susceptible to landslides. Landslides can also occur on manmade slopes such as along highways or through development that contributes to slope failure by altering the natural slope gradient, increasing soil water content or removing vegetation cover. Figure 4.3.9-1 shows the range of landslide susceptibility and incidence for Pennsylvania indicating which areas are most likely to experience landslide events.

Landslides have occurred in many parts of Pennsylvania, but are most abundant and most troublesome in much of the Appalachian Plateaus physiographic province of western and north-central Pennsylvania. This region is recognized as one of the major areas of landslide susceptibility and severity in the United States (Baker and Chieruzzi, 1959; Radbruch-Hall et al.,