INVESTIGATIVE REPORT ON ASIAN SPONGY MOTH ERADICATION

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The goal of this report is to provide a resource for understanding a) the extent of impacts caused by Asian spongy moth introduction in North America and b) the resources that environmental managers are utilizing to control and eradicate the species in the Pacific Northwest region. This report may additionally be used by environmental managers as a reference in developing educational materials for diverse audiences highlighting the necessity of future eradication efforts of this invasive species.


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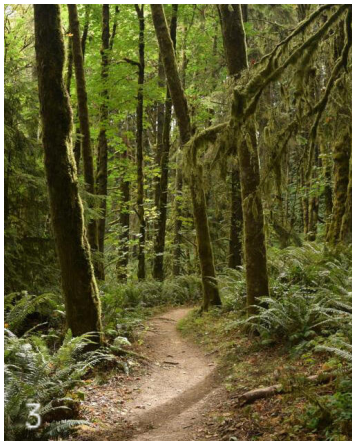
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This report is divided into five sections as follows:

History and Identification - a brief review of the donor region/invasion ecology of the Asian spongy moth, its introduction to North America, and visual identification characteristics

Impacts - a review of how the spread of Asian spongy moth populations has impacted environmental systems, the economy, and human health

Treatment Options - a review of Asian spongy moth control and eradication strategies used by environmental managers

Case Study - a review of eradication efforts performed by environmental managers in Portland, Oregon, including successes, potential improvements, and social dimensions

Conclusion - a summary of the above sections including recommendations by environmental managers and experts for future eradication efforts

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HISTORY AND IDENTIFICATION

SUMMARY: The Asian spongy moth is an invasive insect native to Eastern Asia. These moths have been introduced to North America multiple times, likely through human transportation vectors, but there are no currently established populations. They are a close relative of the European Spongy Moth, which has caused extensive damage to forests in the eastern United States. The host generalism and flight capability of Asian spongy moths potentially make them a more impactful exotic pest than the European subspecies.

The Asian Spongy Moth *(L. dispar asiatica)*, formerly known as the Asian Gypsy Moth, is an exotic pest native to East Asia in Japan, the Republic of Korea, and the coasts of eastern China and Russia (Trotter et al. 2020). Asian Spongy Moths are typically known to inhabit forests, where their larvae pose a major threat to trees through defoliation.

Asian spongy moths (ASM) develop over four life stages – egg, larvae (also referred to as the caterpillar stage), pupa, and moth. Egg masses can be observed on the limbs, leaves, and trunks of trees and other surfaces such as walls and stones. A singular egg mass contains between several hundred to more than 1,000 eggs, which are characterized by their yellow fuzzy appearance **(Figure 1)**. The egg masses are 1 ½ inches long and ¾ inches wide on average. The larvae typically hatch in the spring. Since this is ASM's active feeding life stage, this is when most of the damage they caused is seen. During June to July, ASM larvae cease their consumption of leaves and enter the pupal stage where they become dormant. After 10-14 days, adult ASM emerge from their pupal casing, completing butterfly metamorphosis (United States Department of Agriculture 2016).

Figure 1 ASM Egg Masses

Figure 2 Adult Female ASM

Figure 3 Adult Male ASM

Adult male ASM have a forewing ranging from 20-24 mm long with adult females being slightly larger, measuring between 31-35 mm. Adult male ASM are typically brown in color. White/cream-colored bodies are more common amongst adult females, and both genders possess striped patterns along the hindwing and forewing (Texas Invasive Species Institute 2014) **(Figures 2 and 3)**.

In the late 1980s and 1990s, there were changes in grain trade between North America and eastern Russian ports which allowed ASM to be introduced (Mastro et al. 2021). The first ASM detection in North America occurred in 1991 near the Port of Vancouver in British Columbia, and again shortly after in both Oregon and Washington. This introduction likely had origins in eastern Russia from a ship infested with egg masses. The larvae possibly hatched and were blown ashore by the wind. The United States Department of Agriculture and other officials in the Pacific Northwest eradicated the populations through trapping and other methods. Between 1991 and 2014, ASM had been detected and eradicated across the United States on nearly 20 separate occasions (United States Department of Agriculture 2016). These introduction events have led to the recognition of new ASM pathways of transportation to uninfested locations and environments.

The Asian spongy moth is a close relative of the European spongy moth *(L. dispar dispar)*, which are known to defoliate the leaves of trees at an average annual rate of 700,000 acres **(Figure 4)**. European spongy moths (ESM) were introduced to the eastern United States in the 1860s with the prospect of producing silk. The release of ESM ultimately led to the defoliation of over 13 million acres of forest. By 1889, 20 years after its introduction, the European spongy moth began to damage the hardwood forests in the northeastern United States. In a 43-year span between 1970 and 2013, over 80 million acres of forest were destroyed (Oregon Department of Forestry 2022).

Figure 4 Satellite Imagery depicts defoliation (brown areas) of forest in the Northeastern United States

While the Asian spongy moth has many similarities with the European spongy moth, ASM possess a broader range of host plant species (up to 100 botanical families). Additionally, the female ASM has the ability to fly long distances, unlike the flightless female European spongy moth, which have taken over 140 years to spread across the United States. The capability of long distance flight could allow the ASM population to rapidly spread (United States Department of Agriculture 2016).

Infestations and spread can occur in a variety of ways such as adult female ASM laying eggs in an area that was previously uninfested, newly hatched larvae traveling down tree crowns and being picked up by the wind, and people unintentionally transporting pupae or larvae. ASM can withstand a multitude of weather conditions ranging from the steppes of Russia to the subtropical Mediterranean, which makes transport on vessels, shipping containers, and even outdoor furniture possible (United States Department of Agriculture 2016). Due to the capability of long distance flight and a lack of natural enemies, ASM has been considered to be an important insect pest of shade trees and forests in the east coast of the United States (University of Wisconsin-Madison, n.d).

IMPACTS

SUMMARY: Establishment of Asian Spongy Moth populations in North America will likely have significant impacts on the environment, the economy, and human health. Defoliation and resulting tree mortality have the potential to modify community population dynamics and cost governmental agencies, private organizations, and other stakeholders millions of dollars in prevention, management, and lost timber sales. Exposure to ASM larvae can produce skin irritation, and altered environmental conditions may additionally impact human recreation.

The Asian spongy moth has specific functional traits that cause it to behave as a more concerning exotic pest than its European counterpart. These traits include the flight capability of females, which allow populations to disperse over a farther geographic range, and a generalist host preference – ASM larvae have been documented defoliating over 600 plant species, including conifers that are important to the Pacific Northwest environmentally, culturally, and economically (Srivastava et al. 2020). Female ASM have been observed covering distances over one mile in a single flight trip, indicating a rapid rate of spread (Akram et al. 2022). The potential impacts of ASM introduction and establishment are extensive in both magnitude and geographic range.

Environmental Impacts

The most recognizable impact of ASM establishment is the widespread defoliation of tree species by ASM larvae throughout spring and early summer **(Figure 5)**. These mass defoliation events weaken photosynthetic productivity and make trees more vulnerable to secondary causes of mortality (United States Department of Agriculture 2020). Specifically, defoliation performed by insect larvae can reduce tree growth, reduce biomass and fruit production, and eventually kill the trees themselves.

This magnitude of tree mortality/moth population increase can have widespread impacts throughout the ecosystem as a whole, including lack of sustenance for specialized herbivores, resource pulses for insectivorous species, increased bird nest predation, and altered subcanopy/herbaceous plant population dynamics due to widened canopy gaps (Leroy et al. 2021). Ecosystem services such as air purification, water quality, and habitat could be inhibited (Oregon Invasive Species Council 2016).

Figure 5 Spongy Moth Defoliation

Although no ASM populations have been established in North America, the behavior and spread of the European subspecies on the continent is reflective of how ASM establishment may equivalently impact natural communities. European spongy moths have been observed routinely defoliating 75-100% of individual trees' leaves within infested study areas in the northeastern United States (Kegg 1973). The resulting tree mortality has caused the community composition across infested regions to change, promoting the growth of subcanopy trees that previously would not have received enough sunlight to experience such growth (Fajvan and Wood 1996). Animal community composition may also be altered as mammal and bird species that rely on dead wood for nesting are provided with more resources within their habitat; for example, three woodpecker species displayed population growth across a multi-decade study of defoliation impacts by the European spongy moth across infested sites in North America (Koenig et al. 2011). Populations of insectivorous species that can capitalize on large populations of moth larvae as a food source may increase in response to moth infestation (Gale et al. 2001). Conversely, species that rely on acorns or other tree fruits may experience a decline in necessary resources within their habitat (Clotfelter et al. 2007).

Economic Impacts

Invasive pests such as the Asian spongy moth cause detrimental effects to forests leading to a substantial financial loss. The process of detecting and preventing the introduction of invasive species costs the USDA Animal and Plant Health Inspection Service $200 million annually. The cost of managing the European spongy moth in northeastern North America is estimated to be $3.2 billion per year (Bradshaw et al. 2016) **(Figure 6)**. Even with money allocated to methods of prevention, some individuals are able to slip by and continue on to be introduced and established. Between 1980 and