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Non-Native Invasive Forest Insects of Eastern Oregon and Washington

Abstract

An increasing number of non-native insects are reaching our ports and beyond as a result of global travel and trade, but they may also arrive from other regions of the United States. While historically, the forests east of the Cascade crest have experienced relatively few serious invaders, there is a growing concern over the increased potential for invasion by non-native insect species that may displace native species and/or cause significant economic and ecological damage to east-side forest resources. The threat posed by a non-native invasive species is that the forest may lack natural control mechanisms, and the species may become established, spread, and inflict substantial ecological and economic damage before eradication or mitigation measures can be identified and implemented. In general, treatments and practices that improve forest health reduce the risk or effects of widespread insect outbreaks for indigenous species, and have been prescribed to mitigate the effect of non-native species. However, the most effective management options focus on prevention and suppression efforts, which include investigating potential invaders and pathways of introduction, imposing regulatory restrictions, developing and implementing detection and monitoring strategies, and aggressive eradication efforts. Specific management strategies are likely to differ for each potential invader. Examples of east-side invaders include larch casebearer, which has been successfully controlled by introduced parasitoids, the gypsy moth–both Asian and European strains–which has thus far been prevented from establishing in the Pacific Northwest through diligent surveillance and immediate eradication efforts, and the balsam woolly adelgid, a sap-feeding insect that appears to be an increasing problem in the east side without an immediate solution. An increasing number of introduced woodboring insects that have been discovered in Oregon and Washington, including at least one east-side site, are also of growing concern.

Introduction

Along with the many potential benefits of increased globalization has come the increased potential for introduction of non-native species with unpredictable effects on ecosystem integrity (US Congress OTA 1993, Mattson 1997, Sommers 1999, Pimentel et al. 2000). All too frequently these effects are highly negative, as in the case of the numerous noxious weeds that threaten the health and productivity of range and forested lands of eastern Oregon and Washington (see Harrod 2001). Addressing the introduction of non-native insects poses unique challenges because of their small size, prolific numbers, and vast diversity. Eggs and other developmental stages can occur within host materials, such as fruits, logs, or manufactured wood products, even shipping pallets, without obvious outward signs of infestation. Other factors that hamper prevention and detection of exotic insects include their ability to endure extreme conditions during some life stages and/or remain in a dormant phase for extended periods of time.

The threat of forest insect introductions has increased with increased trade in wood and wood products, including lumber and shipping and packing material (Cavey 1999). Exemplifying this situation are two recent introductions in the eastern United States that grabbed headline news in the last decade: the pine shoot beetle, *Tomicus piniperda* (L.) (Coleoptera: Scolytidae) in the early 1990s (Haack and Kucera 1993), and the Asian longhorn beetle, *Anoplophora glabripennis* (Motschulsky) (Coleoptera: Scolytidae) in the late 1990s (Haack et al. 1997). Here in the Pacific Northwest, introduction from abroad of the Asian strain of the gypsy moth, *Lymantria dispar* L. (Lepidoptera: Lymantriidae), posed a serious threat in the 1990s. Although eradication efforts have been successful thus far, the threat of establishment remains (USDA FS 2000). In addition, the spread of exotic and even indigenous insects from other portions of the United States, such as the European strain of gypsy moth from the east, is an equally serious problem (Pimentel et al. 2000).

Historically, the Oregon and Washington forests east of the Cascade crest have experienced relatively few serious non-native insect invaders, although there is a growing concern over the increased potential for introductions to the disturbance-prone forest environment of the east

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side. Although native insects have a notorious role as damaging pests, they also play a wide array of essential roles in our forests from aiding decomposition to providing food for wildlife. Invaders may displace one or more native species, and thus have direct and indirect effects on biological diversity and ecosystem integrity. Unlike most indigenous insect populations, non-native species populations have the potential to grow and spread unchecked by natural controls such as predators, parasites, and host defenses. Such outbreaks can be extensive and devastating, and treatments of these outbreaks are likely to interfere with other resource management goals, such as reducing fire risk and restoration efforts. The management of outbreaks of each non-native species is likely to call for new detection tactics and control strategies.

For the purposes of this paper, the following two questions were posed regarding non-native invasive forest insect species of the east side of Oregon and Washington. How do treatment strategies designed to maintain or restore forest health and productivity affect non-native invasive species? Can such treatment strategies result in an ecosystem that is more resilient to invasion? Three non-indigenous species are discussed here as examples: two defoliating species, western larch casebearer (*Coleophora laricella* Huebner, Lepidoptera: Coleophoridae) and European and Asian gypsy moths; and a sap-feeding species, balsam woolly adelgid (*Adelges picea* (Ratzeburg), Homoptera: Adelgidae). Also included here, as an example group, are non-native woodboring insects (Coleoptera and Hymenoptera) recently reported by Mudge and colleagues (2001). The current status of some of these species and other non-native invasive forest insects for all of Oregon and Washington is reported annually as a contribution to Forest Insect and Disease Conditions in the United States by the Pacific Northwest Region's Forest Insect and Disease Group (USDA FS 2000). For more in-depth discussion of non-native invasive pests and their effects on forest and other ecosystems see, for example: Campbell and Schlarbaum 1994, Liebhold et al. 1995, Mattson 1997, and Pimental et al. 2000.

Influence of Forest Health and Productivity Treatments on Non-Native Invasive Insects

Do forest health and productivity treatment strategies affect non-native invasive species, and can forest health and productivity treatment strategies improve the probability of a positive outcome? For native forest insects, a general answer to these questions is that healthier stands are less likely to be susceptible to infestation and more tolerant of damage. Commonly applied silvicultural practices for increasing stand vigor include thinning and prescribed fire to reduce competition and crowding. Silvicultural actions are also recommended to minimize the effect of non-native invasive insects such as gypsy moth (McManus et al. 1989). Other approaches may include encouraging or replanting with resistant stock or species less preferred as hosts, but these strategies require considerable time to implement. Forested landscapes that comprise a mosaic of conifers and hardwoods at different developmental and successional stages are least likely to sustain catastrophic damage from indigenous species. However, in the absence of natural enemies and co-evolved natural defense of the host tree, introduced insects may do very well on healthy trees regardless of the landscape in which they occur. In many cases, as with the gypsy moth (see below), invasive species can be successful because of their ability to adapt to a variety of available hosts and, in the absence of effective predators, parasites, and pathogens, threaten numerous host species across the forest landscape. Tree species or vegetation structures that are relatively rare or that are located in marginal habitats may be most at risk from significant damage from invaders. One such example is pioneer subalpine fir, *Abies lasiocarpa*, which has been subject to infestation by the non-native balsam wooly adelgid (Mitchell and Buffam 2001). Similarly, young larch near forest openings are most susceptible to severe damage by larch casebearer (Tunnock and Ryan 1985).

Thus, traditional forest health and productivity treatment strategies do no appear to provide the answer to dealing with non-native invasive insects in the short term. Rather, the most effective management strategy for non-native invasives is through aggressive detection, prevention, and suppression. Based on the extent and complexity of the problem, it has been suggested that a national policy is needed to address this issue (e.g., Campbell and Schlarbaum 1994).

Preventative and Suppression Measures

Sound regulatory measures, vigilant surveillance, and immediate action to eradicate new introductions

make up the backbone of the strategies to deal with non-native invaders. This role is played principally by regulatory and resource protection agencies at both the state and federal level. Gaining knowledge, in advance, about which organisms–the unknown as well as the currently suspected or recognized ones–pose an invasive risk, identifying pathways of introduction, determining means of detection, and developing suppression methods are the combined roles of researchers, forest health practitioners, and regulatory agencies worldwide. Development and implementation of sensitive, nondestructive detection and surveillance technology is essential although often costly and labor intensive. The effective treatment of an invasive species is often time-dependent. It is important to effect eradication efforts early, before the insect can become established, and to eliminate the pathway of introduction. Once the invader is established, the total elimination of existing populations becomes problematic, and subsequent efforts may be forced to focus on control rather than eradication. Biological control treatment strategies and other approaches, such as mating disruption with semiochemicals, frequently take years to develop and are most often used in controlling established populations (see larch casebearer below). There is no one solution; each invader is likely to require the development of completely different detection tactics and management strategies, as is reflected in the examples given below. When treatment is necessary to eradicate or control a non-native invasive species, the strategy must consider the potential short- and long-term effects on the ecosystem at multiple scales. For each treatment, effects on non-target species and other unintended effects of treatment tactics and programs must be investigated. Assessing these effects is the purpose of the environmental impact statement process (e.g., USDA FS, APHIS 1995).

Non-Native Invasive Insects of East-Side Forests

Over 70 non-native forest insects were listed in the 1977 edition of Western Forest Insects (Furniss and Carolin 1977) as having become established in the West, primarily as the result of accidental introductions. Most of these occurred prior to the advent of strict quarantine regulations, beginning with the Federal Quarantine Act of 1912, and diligent monitoring activities. However, there are a number of species that have been purposefully introduced as biological control agents (e.g., Bellows et al. 1998), especially for the control of noxious weeds (Scott 1999). This list will likely increase with intensified efforts to control introduced plants through insect herbivory. There are notable examples of introductions of insect parasitoids and predators of forest insect pests, including parasitic wasps introduced to successfully control an outbreak of the larch casebearer (Ryan 1997), which is itself an introduced species. The larch casebearer example shows the difficulty and complexity of dealing with non-native insects in east-side forests.

Larch Casebearer

Larch casebearer is an introduced defoliating insect that has caused serious damage to forest health in eastern Oregon and Washington. This species, which feeds exclusively on larch (*Larix* spp.), was accidentally introduced into the eastern United States in the mid-1800s. By 1960, Larch casebearer had spread to eastern Oregon and Washington, infesting western larch (*Larix occidentalis*). The larvae of this moth feed on the internal needle tissue, which ultimately results in the loss of the needle. It is considered the most serious pest of western larch (Cochran and Seidel 1999).

A very specific treatment was developed for larch casebearer using classical biological control methodology (Ryan 1997, Bellows et al. 1998). The biological control program—the introduction of parasites and predators to control a pest problem—resulted in the establishment of two non-native parasitoids that were responsible for reducing the larch casebearer population. They appear to have been self-sustaining, to have had no undesirable non-target effects, and to have maintained acceptable levels of control for over a decade. However, changes in the larch casebearer population bear watching. Evidence of increasing populations and increased defoliation of larch was observed in eastern Oregon in the late 1990s; this situation is monitored principally by state and federal forest health protection entities (USDA FS 2000). No particular existing condition has been cited as influencing the success of the spread of larch casebearer in east-side Oregon and Washington forests. For more detailed information about this defoliator, see Tunnock and Ryan (1985) and Torgersen (2001).

European Gypsy Moth

European gypsy moth (EGM), which like larch casebearer is a defoliator, is one of two strains of the same species of moth, *Lymantria dispar*. However, unlike larch casebearer, EGM is extremely polyphagous, feeding on a wide array of deciduous hosts. The older larvae will feed on conifers when preferred hosts are not available. The EGM was intentionally introduced, and later accidentally escaped, into the northeastern United States in the mid 1800s in an effort to create a domestic silk industry (McManus et al. 1989). This strain of gypsy moth has raised havoc for decades in deciduous hardwood forests and urban environs in the eastern United States over the last century. It has been the subject of extensive research efforts by the Forest Service and others, including Animal and Plant Health Inspection Service (APHIS), State Departments of Agriculture, and universities; there are hundreds of technical publications on EGM addressing topics from basic biology to individual control tactics and landscape-level management tools for the eastern United States. Sources that provide extensive information and status of EGM include The Gypsy Moth: Research Toward Integrated Pest Management, an extensive compendium produced by the USDA Expanded Gypsy Moth Research and Development Program (Doane and McManus 1981); the Final Environmental Impact Statement for Gypsy Moth Management in the US: A Cooperative Approach (USDA FS, APHIS 1995); and GMDigest, an online source with multiple links to other relevant sites (http://fhpr8.srs.fs. fed.us/wv/gmdigest/gmdigest.html). The annual Proceedings of the Interagency Research Forum on Gypsy Moth is a source for reporting ongoing research and accomplishments (e.g., Fosbroke and Gottschalk 1999, 2000). The Forum includes other invasive species throughout the United States.

The EGM was first detected in traps in the West in Seattle in 1974 and treated in 1979 (see USDA FS 1974-1979). In the early 1980s, other infestations resulting from introductions from the eastern United States infestation were found in Oregon as well as Washington (USDA FS 1984, Bengston 1986, PDODA 1988). The female EGM is flightless, and upon emerging from her cocoon produces a pheromone attractant that draws males. Synthetically produced pheromone is used in traps to attract males in monitoring programs and also in control tactics such as trap-out or mate-disruption. The largest capture of male gypsy moths in detection traps on the west coast occurred in 1984. Permanent infestation was averted by successful and continuing aggressive eradication programs, extensive monitoring with traps baited with the female attractant pheromone, and intensive ground searches when moths were detected. The introduction and eradication of EGM has occurred throughout the 1990s. In most cases breeding populations have been limited to west-side sites in Oregon and Washington, but male adults and other life stages have been found in east-side sites (see USDA FS 1974-2000, also online at http://www.fs.fed.us/foresthealth/annual_i_d_conditions/index.html). Because of extensive established populations of EGM in the eastern United States and the existing pathways in movement of people and things, there is a persistent possibility of re-introduction. The threat of re-introduction requires state and federal agencies to maintain a continuous integrated pest management approach, which includes monitoring and detection programs and aggressive treatment of new infestations (USDA FS 2000).

Eradication treatment alternatives for EGM include two microbial insecticides (*Bacillus thuringiensis* var. *kurstaki* (Btk), specific to certain types of lepidopteran larvae, and a nuclear polyhedrosis virus (NPV), specific to gypsy moth), and chemical pesticides (e.g., carbaryl, acephate, and diflubenzuron—a growth regulator) (McManus et al. 1989). The use of the more specific microbial pesticides is preferred by federal and state agencies over the more general chemical pesticides, given concerns about human safety and non-target effects. However, the non-target effects of Btk on other Lepidoptera also raise some concerns (Miller 1990, reviewed in Reardon et al. 1994). Identification and monitoring of non-target Lepidoptera, and mitigation efforts such as exclusion of sensitive areas, are important to the success of treatment programs (e.g., Anhold and Whaley 1996). Both the Washington State Department of Fish and Wildlife and Oregon Natural Heritage Program maintain listings of insects such as Lepidoptera that are locally rare, if not threatened or endangered (see LaBonte et al. 2001).

Asian Gypsy Moth

Asian gypsy moth (AGM) is a second strain of gypsy moth potentially more damaging than EGM. Introductions have occurred in the Pacific

Northwest since the early 1990s as a consequence of increased trade from the Russian far east (e.g., Swadener 1992, Bogdanowicz et al. 1993). In this strain, the female is not flightless as in the EGM. Additionally, the AGM host plant range is considerably larger than EGM and includes not only the hardwoods preferred by EGM, but also some conifers, thus posing a greater threat to western, conifer-dominated forests. Males of both strains respond to the same pheromone, however genetic technology (Garner and Slavicek 1996) is needed to differentiate between the strains because of the visual similarity. These features present increased challenges for surveillance and eradication efforts given the greater potential for rapid spread. As with EGM, to date, permanent establishment has been successfully avoided owing to tightened regulations, diligent and extensive monitoring, and immediate eradication measures (USDA APHIS 1992, 2000). The AGM is only one of several defoliating moths that are invasive species threats; others are the nun moth (*Lymantria monacha* L.), pink gypsy moth (*L. mathura* Moore), and the Siberian moth (*Dendrolimus superans sibiricus* Tsetvrk) (Fosbroke and Gottschalk 1999 and abstracts therein).

Balsam Woolly Adelgid

Balsam woolly adelgid (BWA) is a sap-feeding insect, smaller but similar to an aphid, which was introduced into the United States from Europe around 1900. It has since spread throughout much of the United States and Canada, killing or damaging large acreages of true firs. It represents the most significant and immediate threat to true firs of the east side of Oregon and Washington (Gast et al. 1990). Adelgids introduce a substance that causes abnormal growth called "rotholtz" when feeding on stems, and "gouting" is caused when BWA feed around buds and nodes. Heavy attacks over a period of time (3-5 years in the case of subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.)) can cause tree death. Only the first immature stage is mobile, limiting dispersal of this insect; however, there are typically two generations per year, so populations can build to high numbers locally.

Damage to grand fir (*A. grandis* (Dougl.) Lindl.) in the Willamette Valley of Oregon in 1930 was the first record of BWA in the Pacific Northwest (Mitchell 1966). By 1957, over 600,000 acres of forest, including Pacific silver fir (*A. amabilis* (Dougl.)) and subalpine fir, as well as low-elevation grand fir, were infested in Oregon and Washington. By the mid 1960s, BWA had extended its range to the summit of the Cascades, and it was first reported on the east side (Umatilla National Forest) in 1974 on subalpine fir (USDA FS 1974). Interestingly, on the east side, where grand fir and the more susceptible subalpine fir are the preferred native hosts, damage has been less dramatic. However, there have been significant losses of pioneer stands of subalpine fir in disturbed and marginal environments as a result of BWA infestation (Mitchell and Buffam 2001).

This inconspicuous, tiny insect is detected primarily via the resulting damage and is difficult to observe in aerial surveys (USDA FS 2000). The current geographic expansion of BWA in the forests of the east side is the focus of surveillance monitoring by state and federal forest health protection entities (Ragenovich et al. 2000). The use of biological control—mass releases of various parasites and predators—has not appeared to have been successful to date (Schooley et al. 1984, Bellows et al. 1998). Other than salvage of dead material and thinning to produce healthier stands (Mitchell 1966), no large-scale treatment recommendations have been made. Detailed descriptions of BWA in the Pacific Northwest can be found in Mitchell (1966), Hain (1988), and Gast et al. (1990).

Exotic Woodborers

The galleries created by the immatures of woodboring species cause visual and structural damage to wood and degrade wood quality and commercial value. Vulnerable host trees and shrubs can be severely damaged and sometimes killed. Exotic woodborers (specifically beetles and wasps) have been the focus of recent surveys of timber and wood product insects conducted by the Oregon and Washington Departments of Agriculture. These surveys have been conducted principally in western Oregon (1997-2000) and Washington (1996) in sites at high risk for receiving materials that might contain exotic insects. Traps baited with selected semiochemical attractants are used to collect adults that might be emerging from material found at these sites. The presence of adult insects suggests a breeding population may exist at that site.

The results of these surveys revealed a far more serious problem than most would have imagined (Mudge et al. 2001). At the majority of sites surveyed, one or more species not native to the Pacific Northwest were detected. A few of the species were from outside the United States. However, most of these species were indigenous to elsewhere in the United States or exotics known to be established in the eastern United States but not previously reported in Oregon or Washington. While few of the non-native species detected are known to present immediate threats to forest health, one species (*Hylastes opaceus* L. Scolytidae) is a known pest of pines in Europe (Mudge et al. 2001).

This relatively unique, intensive survey for exotic woodborers by the Oregon and Washington Departments of Agriculture, which was partially supported by the USDA's Cooperative Agricultural Pest Survey program, shows the extent to which invasions have already occurred undetected. Although surveillance trapping such as this on the east side has been minimal, two exotic species of wood-boring beetles (Scolytidae) new to western North America have been detected at The Dalles (Mudge et al. 2001).

Conclusion

As shown by these examples, dealing with invasive insects is an everyday reality in east-side Oregon and Washington. Continuous surveillance and prevention efforts are needed. Pro-active steps such as the surveys for exotic woodborers conducted by Washington and Oregon Departments of Agriculture are extremely important. They provide essential baseline data for subsequent actions. Without some basic frequency data it would be difficult to determine whether a non-native species is increasing or decreasing in abundance, or if a native species is being displaced. Surveys of forest and wood product insects of all types would be extremely useful for the east side and elsewhere. However, detection technology is limited, and surveys can be labor intensive and costly. Most importantly, there is a lack of necessary taxonomic expertise. We face a growing shortage of qualified taxonomists in entomology that is at a crisis point for many taxa (e.g., Lattin 1993, New 1995). Without trained individuals to identify the specimens collected in surveys, early detection would be ineffective, and an important piece of the strategy for managing invasives could be lost.

Over the last decade, concerns over the effects of non-indigenous species on forest health and productivity have increased (Campbell and Schlarbaum 1994, Liebhold et al. 1995, Mattson 1997). According to Mattson et al. (1994), by the early 1990s over 400 species of non-native insects were known to occur on the trees and woody plants of the United States and Canada. More are arriving each year despite current prevention efforts, including increased regulations (e.g., USDA APHIS 1998, 2000). It is apparent that in east-side forests as elsewhere, there is considerable ground to cover to obtain a full understanding of the present status of non-native insects and to develop improved strategies to reduce the risk of future unwanted introductions from within and outside North America.

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Note

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