Some Timber Product Market and Trade Implications of an Invasive Defoliator: The Case of Asian Lymantria in the United States

Jeffrey P. Prestemon, James A. Turner, Joseph Buongiorno, Shushuai Zhu, and Ruhong Li

ABSTRACT

US policy and forest product industry decisionmakers need quantitative information about the magnitude of timber product market impacts from the possible introduction of an exotic and potentially dangerous defoliating forest pest. We applied the Global Forest Products Model to evaluate the effects on the United States of an invasion by the Asian gypsy (*Lymantria dispar* L.) and/or nun (*Lymantria monacha* L.) moths. Results suggest that the current ban on softwood log imports from the Russian Far East has little effect, beyond what market forces alone would do, on the likelihood of the introduction of the pests in the country. However, an introduction of the pests in the United States, by the timber trade or other means, could have severe impacts on the timber product market, particularly if the United States' trading partners responded by banning imports of US logs.

Keywords: exotic pest, timber markets, forest products, international trade

A number of the harmful exotic pests affecting forests have become part of the lexicon of biologists, ecologists, and foresters. The *Ophiostoma ulmi* (caused by the fungi *Ophiostoma novo-ulmi* [Brasier]), chestnut blight (caused by the fungi *Cryphonectria parasitica* [Murrill] Barr), and the European gypsy moth (*Lymantria dispar* L.) are well known for the devastation they have caused to US forests (Liebhold et al. 1995). The spread of newly introduced exotic forest pests, such as the emerald ash borer (*Agrilus planipennis* F.; Poland and McCullough 2006) and the hemlock woolly adelgid (*Adelges tsugae* Annand), is affecting urban and rural landscapes and values (Holmes et al. 2006) and the activities of recreating Americans (Rosenberger and Smith 1997). Potential threats to US forests include the nun moth (*Lymantria monacha* L.) and the Asian variety of the gypsy moth (US Forest Service 1991).

The arrival, establishment, and spread of exotic forest pests have potentially serious long-run consequences for affected forests and the ecosystem services they provide (Liebhold et al. 1995, Mack et al. 2000). This threat is heightened by the potential of exotic species to become particularly harmful because they are free of many of the constraints to establishment and spread that they face in their native environments (Williamson 1996).

The economic cost of exotic forest pests can be large, but it is difficult to determine precisely. Pimentel et al. (2005) estimate that the impact of all nonindigenous forest insects and diseases in the United States translates to annual timber losses of $4.2 billion. The US Forest Service (1991), in a risk assessment of insect defoliators associated with imports of logs of several species of larch (*Larix spp.*) from the Russian Far East,

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reported that the decline in forest growth could lead to annual US timber market losses from $2.3 billion to $3.8 billion. [1] Governments and the private sector also spend substantial amounts on research and development of technologies to monitor, detect, and control invasive pests. Annual expenditures by the US federal government on all agricultural pests increased from $500 million in the mid-1990s to over $1 billion in fiscal years 2001 to 2006 (USDA Economic Research Service 2008, USDA 2008). Between fiscal years 1995 and 2006, expenditures for exclusion, monitoring, and management rose from $400 million to over $800 million, and expenditures in response to outbreaks increased from $20 million to $530 million. An additional $500 million/year was spent on average, fiscal years 2006–2008, by the Agricultural Research Service, State Research and Economic Research Service on research activities related to pest and disease outbreaks (USDA 2008). The US Forest Service alone had a budget of $128 million for its invasive species program in 2008 (Office of the Whitehouse 2008).

This article summarizes a study of some of the potential economic impacts from two possible invasive pests: the nun moth and the Asian variety of the gypsy moth. The article outlines the methods and synthesizes the key findings. The study's goal was to compare the cost of the phytosanitary measures taken to limit imports of larch from Siberia and the Russian Far East, a principal source of invasion risk (US Forest Service 1991), with the expected timber market losses from a potential invasion. We quantified the trade that would occur in the absence of significant barriers to entry and how much trade would occur under alternative measures. In addition, we determined the effects of a global policy response to a successful invasion in the United States. The models developed to answer such questions should be useful for making risk assessments for other pests and enlighten areas needing additional research.

Forests and International Commerce

Trade and travel have long been recognized as causes of introduction of invasive pests (Elton 1958, Darwin 1859, Jenkins 1996, Haack 2001, Tkacz 2002, McCullough et al. 2006). From 1950 to 2004, world trade grew an average 5.9% per year (Hummels 2007). From 2002 to 2006, the freight volume carried by ships arriving at US ports increased by over 20%, well above the 12% increase in US gross domestic product over the same period (Figure 1). Visits to the United States by nonresidents have also grown in recent years, although not at the same rate as shipping. Studies of insect interceptions and establishment in the United States (Work et al. 2005, Haack 2006, Liebhold et al. 2006, McCullough et al. 2006) confirm the roles of increased overland, maritime, and air trade of wooden goods and passenger travel as potential pathways for the introduction of nonindigenous insect species.

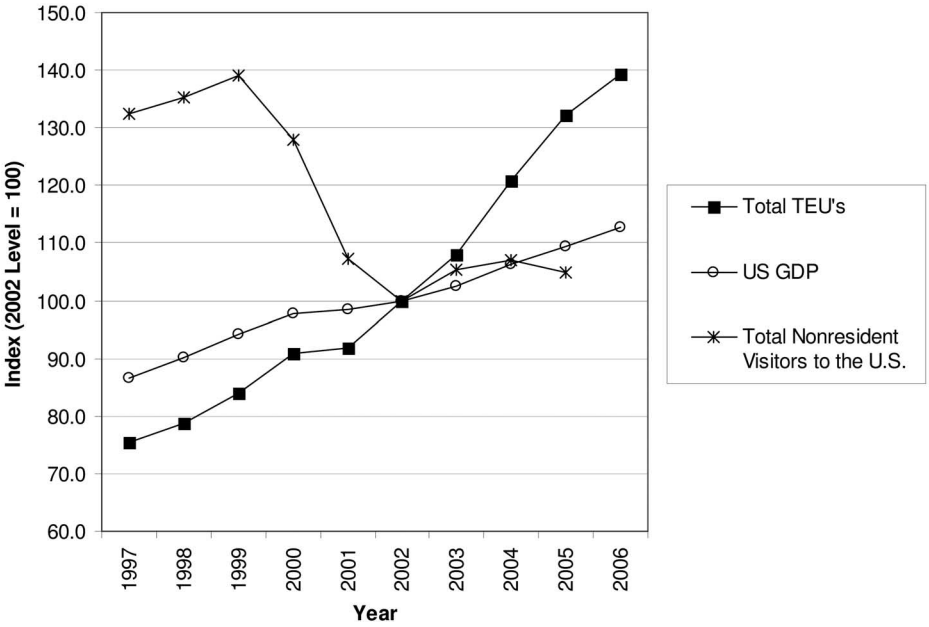

Figure 1. US trade, travel, and gross domestic product, 1997–2006, expressed as an index (2002 = 100). A 20-ft equivalent unit (TEU) is the volume equivalent of one 20 × 8 × 8 ft (6.1 × 2.44 × 2.44 m) cargo shipping container (North American Transportation Statistics 2007, US Department of Transportation Maritime Administration 2007, US Department of Commerce Bureau of Economic Analysis 2007).

The severe threat that exotic pests pose to forests has led to a variety of measures, such as phytosanitary regulations—fumigation and heat treatments, debarking, visual inspections, phytosanitary certificates,and more—or import bans (New Zealand Forest Research Institute 1999, Roberts et al. 1999). In 2001, the European Union imposed restrictions on imports of coniferous solidwood packing material from the United States, potentially infested with the pine wood nematode. In 1997, the US District Court for the Northern District of California temporarily enjoined the issuing of import licenses by the USDA Animal and Plant Health Inspection Service (APHIS) for logs from New Zealand and Chile, in response to environmental organizations suing APHIS for allowing the importation of unprocessed wood products (Collins 1999).

Although they have clear benefits in reducing the risk of damage to forest resources, trade measures to prevent pest arrivals also reduce the benefits from trade (Margolis et al. 2005). Importing countries may have to forego cheaper foreign products and raw materials (Roberts et al. 1999, Mumford 2002). Exporting countries may lose access to markets (Li et al. 2007, Turner et al. 2007). Many studies suggest that restricted trade is associated with poor economic performance (Mankiw et al. 1992, Edwards 1993, Frankel and Romer 1999) and lower welfare than would prevail under free trade.

Phytosanitary and regulatory approaches to limiting introductions sometimes fail. Monitoring, eradication, and control measures are therefore necessary to fight pests once they arrive in the country. These measures have costs, accruing to government and private owners, for periodic surveys, eradication efforts, monitoring, sanitation cutting of trees in areas of infestation, and altering forest management activities to reduce risks of establishment or growth losses (Turner et al. 2004).

The following pages address three questions in the context of the potential arrival,

establishment, and spread of the Asian gypsy and nun moths in the United States: (1) What is the potential effect on timber product markets of these invasive pests? (2) Is the current ban on log imports from the Russian Far East to prevent pest arrival likely to be effective? (3) Does the potential cost of these two pests in terms of forest loss outweigh the costs of trade reduction and economic growth due to current phytosanitary control measures?

Although we do not present a full economic assessment of the potential timber and nontimber impacts of these two Asian *Lymantria* species, we hope to show how the arrival, establishment, and spread of these pests might affect the United States' forest products sector and how policies designed to prevent their introduction might also affect timber product output and trade. Others have assessed some of the nonmarket (Jakus 1994) and nontimber product impacts of the gypsy moth in the eastern United States (Leuschner et al. 1996).

Asian *Lymantria* in the United States

The global production and trade situation means that catastrophic forest loss in the United States could have serious global effects. The United States is the world's largest importer and the second largest exporter, after Canada, of wood products (Figure 2). Its domestic roundwood production, a quarter of world output, is double that of the second largest producer, Canada (Figure 3; Food and Agriculture Organization [FAO] 2008).

The threat that invasive pests, such as the Asian gypsy and nun moths, pose to North American forests have encouraged governments to take steps to reduce the risks of their arrival, establishment, and spread. A US ban on unprocessed softwood log imports from the Russian Far East was imposed in the mid-1990s to limit the risk of introducing the Asian gypsy moth and nun moth on larch logs (US Forest Service 1991). However, little research has been done on whether such policies yield positive net benefits for the United States. Additionally, because several strategies are possible to reduce invasive pest risks, assessments of each measure's effectiveness are needed.

Policy Analysis

A collaborative study by economists of the US Forest Service, the University of Wisconsin–Madison, and the New Zealand Forest Research Institute, Ltd. (trading as Scion) has recently addressed these issues by modeling some of the effects of invasive species on the international trade of forest products. The resulting articles predicted the effects of the Asian gypsy and nun moths on the US forest sector and the effect of policies to reduce the risk of invasion (Turner et al. 2006, 2007; Prestemon et al. 2006; Li et al. 2007). The timber industry impacts had previously been assessed by US Forest Service (1991) but without addressing how US trade would be affected.

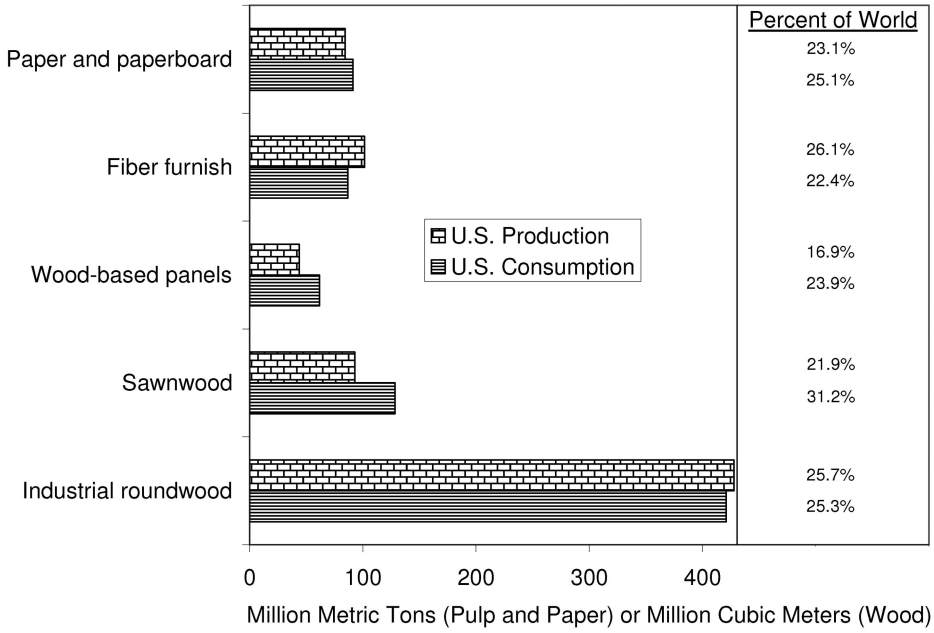

Figure 2. US production and consumption of wood products, 2006 (FAO 2008).

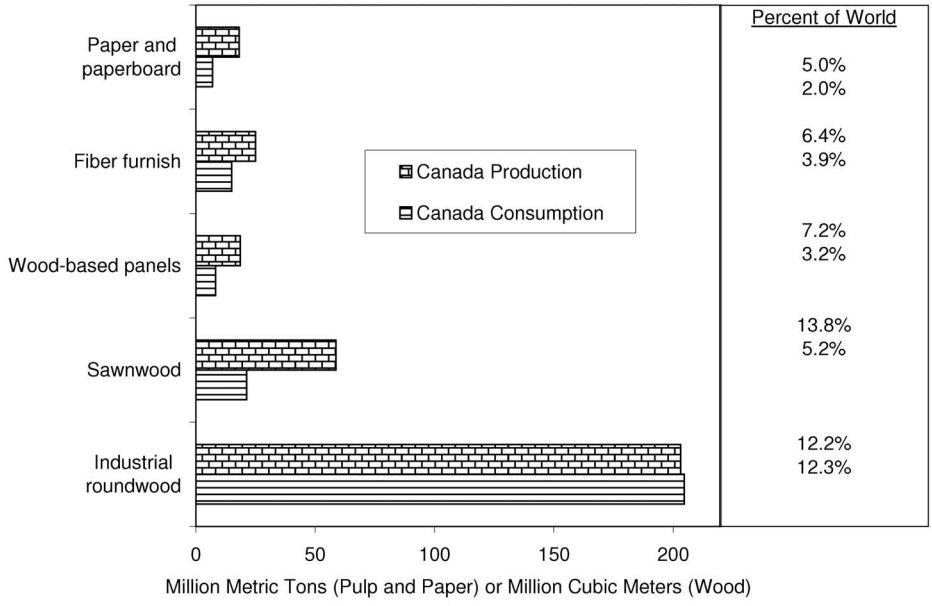

Figure 3. Canada production and consumption of wood products, 2006 (FAO 2008).

The main study tool was a model of global forest production, manufacturing, and trade—the Global Forest Products Model (GFPM; Buongiorno et al. 2003). The GFPM predicts long-run changes in forest product production, imports, exports, and prices, and forest area and stock, for 180 countries and 14 products. The model represents the interactions among countries and industries, through manufacturing, trade, and utilization. In the GFPM, prices are calculated simultaneously with trade, supply, and demand. Demand and supply are represented by econometric functions, which re-

late quantities to price and other influencing factors, and by activity analysis, which model manufacturing using input–output coefficients. GFPM base year production, consumption, trade, and price information are calibrated (Buongiorno et al. 2001) with data from the FAO of the United Nations (2008). [2]

The model was applied to determine some of the impacts of the Asian gypsy and nun moths and related policies through 2030. In particular, we predicted how catastrophic forest loss would affect trade, production, and consumption and assessed the tradeoffs between invasion risks and policy actions to reduce the risk of an invasion.

The study was conducted by modeling production and trade in wood products under four alternative policy scenarios:

1. Continuation of the current import ban and no pest invasion.
2. Removal of the import ban, but with debarking, border fumigation, border inspection, and charges on importers for monitoring and eradication costs, and no pest invasion.
3. Removal of the import ban, retaining the phytosanitary measures described in scenario 2 but with an uncontrolled invasion by the Asian gypsy or nun moths.
4. Removal of the import ban, keeping the phytosanitary requirements as in scenarios 2 and 3 but with a successful moth invasion and a resulting global ban on imports of US logs by other countries. Li et al. (2007) describe more thoroughly the effects of a complete ban on all international trade of logs as a phytosanitary measure. Although such a response may seem extreme, it provides an upper bound on the effects of the most radical response by our trading partners.

Forest inventory reduction estimates from the US Forest Service (1991, p. 5–3) were used. Based on the increase in habitat affected estimated by Roughgarden (1986). The US Forest Service (1991) determined that defoliating insects would cause a 15% net loss of growth per decade and spread moving from west to east at a rate of 20 km per year. The reduction in forest inventory used in the GFPM was 0.05% per year from 2003 to 2010, 0.09% from 2011 to 2020, and 0.12% from 2021 to 2030.

Currently, irradiation is the required treatment of imported Siberian logs. Because of its high cost, this is an effective ban on imports. For the purposes of this study, larch logs imported from Siberia would be treated like other foreign sources of softwood logs at the border. They would be subject to debarking, \$0.50/m^3; fumigation (using methyl bromide), \$2.66/m^3; and inspection, \$2.58/m^3. Costs of detection and eradication to supplement the border measures were assumed to be \$5 million/year. In case of an invasion, we assumed an annual cost of \$49 million/year to control the *Lymantria* pest with *Bacillus thurigiensis*.

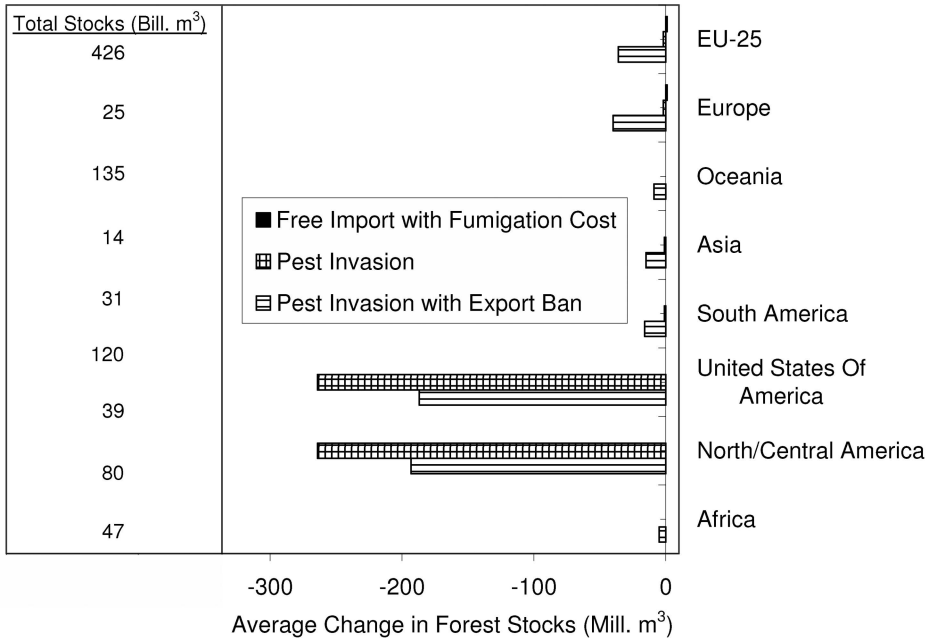

Figure 4. Average projected total stocks and projected changes of forest stock, 2002–2030 (Prestemon et al. 2006, p. 71).

Findings and Discussion

The studies led to several conclusions that help in understanding the long-run trade and policy implications of a potentially devastating forest pest. The findings have relevance for foresters and decisionmakers in the United States and abroad. Here, we concentrate on contrasting the current situation (no trade) with the successful invasion and the global trade ban against US imports. For more detailed findings of each scenario, see Prestemon et al. (2006).

Removal of the Log Import Ban Has a Limited Impact on Imports of Logs. Allowing Siberian softwood log imports into the United States would increase US log imports from Russia by a trivial 1,300 m^3/year. This is less than 0.01% of current United States log imports and suggests that the ban accomplishes little more than market forces would achieve on their own. However, without information on the extra invasion risk that a shipment of 1,300 m^3 would pose, it is not possible to determine if the ban yields a net benefit for the United States. This result also implies that tariffs applied against imports of logs from Russia would be largely irrelevant.

Successful Invasion Has a Limited Impact on United States Production and Consumption of Timber Products. The effects on industrial output from domestic forest stock losses due to the assumed arrival, establishment, and spread of the Asian gypsy and nun moths would be small (Figure 4). Lower domestic industrial roundwood supply would lead to an average 0.2% increase in US forest products prices over the period considered. A similarly small change was predicted for the net trade in all forest products, because of an increase in imports (Table 1). These limited impacts contrast with earlier findings (US Forest Service 1991). The main reason for the differences appears to be the recognition, in the studies reported here, of the substitution of reduced US supplies by imports of wood and manufactured products.

A study of the potential impact of the fungus *Nectria fuckeliana* (Booth), an exotic disease recently found in southern New Zealand plantation forests, found similarly small price and quantity effects from its further spread (Turner et al. 2007). Our findings also agree with the lack of evidence, in US historical data on wood product prices and production, of significant timber mar-

Table 1. Projected changes of United States net trade (exports minus imports), 2002–2030[a]

Product	Base level		Average annual difference from base		
	2002	2030	Fumigation with no import ban	Pest invasion	Pest invasion with export ban
Industrial roundwood	8,582	55,544	−3	−2	−25,097
Sawnwood	−32,896	−48,159	−20	−319	6,254
Wood panels	−15,572	−36,913	2	−201	4,094
Wood pulp	−1,246	−689	3	−4	180
Paper and paperboard	−7,717	8,275	2	−29	549

[a] One thousand cubic meters (industrial roundwood, sawnwood, and wood panels) or 1,000 metric tons (pulp, paper and paperboard).
Source: Prestemon et al. (2006, Table 2, p. 70).

Table 2. Projected changes of United States forest product production, 2002–2030[a]

Product	Base level		Average annual difference from base		
	2002	2030	Fumigation with no import ban	Pest invasion	Pest invasion with export ban
Industrial roundwood	404,735	653,669	−16	−896	−7,785
Sawnwood	89,151	111,286	−20	−326	6,246
Wood panels	40,517	78,837	2	−211	4,124
Wood pulp	52,669	85,662	4	−30	637
Paper and paperboard	81,792	131,939	2	−33	575

[a] One thousand cubic meters (industrial roundwood, sawnwood, and wood panels) or 1,000 metric ton (pulp, paper, and paperboard).
Source: Prestemon et al. (2006, Table 5, p. 71).

ket impacts caused by major pest infestations, such as those associated with the *O. ulmi*. When a tree species is killed off or severely limited by a forest pest, the tree species is often replaced by unaffected species that fill similar ecological niches (e.g., Parker and Leopold 1983, Castello et al. 1995). Furthermore, sectors using hardwood lumber, such as furniture manufacturers, have in the past adjusted their production in response to changed abundance of species (Luppold et al. 1998).

A Trading Partner Policy Response May Have a Large Impact on the United States. A ban on the importation of US logs by our trading partners would have a much larger effect on the forest sector than the loss of affected tree species directly caused by the moth invasion. Such a ban would lower the price of industrial roundwood in the United States and simultaneously induce drops in processed timber product prices. The most affected industries would be plywood where the average price would be 2.3% lower, chemical wood pulp (3.2% lower), and printing paper (2.3% lower).

The ban would also result in changes in US production (Table 2) and trade (Table 1). Industrial roundwood would stay in the United States to be processed domestically, improving sawnwood, panels, and paper sector trade positions. Net exports (export quantity minus import quantity) in sawnwood would increase by 6.3 million m^3/year, on average, from 2002–2030 (currently, in 2006, imports exceeded exports by 48 million m^3/year; [FAO 2008]). In wood panels, net exports would increase by 4.1 million m^3.

A foreign ban on log imports from the United States would partially mitigate losses in forest stock because of moth establishment and spread, as lower domestic prices of wood and wood products would lead to lower harvest rates. The New Zealand study of *N. fuckeliana* similarly found that foreign trade measures to prevent the introduction of pests would have larger quantity and price effects than the direct effect of the pest on forest inventory (Turner et al. 2007). The related study of Li et al. (2007) found that a progressive elimination of the world roundwood trade for phytosanitary reasons would have little effect on the forest inventory, while it would substantially increase value added in United States forest industries.

Conclusions

Wallner (2004, p. 92) reports that "Russian grain ships and US military equipment have carried the Asian gypsy moth . . . into the United States and Canada . . .", and experts have documented at least four successful introductions (and subsequent eradications) since 1990 (APHIS 2003). Thus, this invasive species has been introduced in the United States in spite of the effective ban on the importation of logs from the Russian Far East. This suggests that the probability of introducing the Asian gypsy and nun moths derives from causes beyond the trade of forest products themselves.

The answer to the question concerning the timber market consequences of the Asian gyspy and nun moths is that in contrast to the ecological effects that may be serious (Jakus 1994, Leuschner et al. 1996), the economic consequences for the US forest products sector alone are probably small. The main reason is the substitution of reduced US timber supplies by imports of roundwood and manufactured products. Forest inventory losses resulting from an invasion would be minor, and the production and trade effects would also be limited.

In addressing the effectiveness of the current trade measures focused on logs we found that the ban on log imports into the United States is essentially redundant because very few logs would be imported even without a ban. In contrast, a response by our trading partners, banning US log imports, would create much greater effects in US domestic markets, with overall negative impacts. These effects alone could justify greater US government investment in monitoring and control technologies and trade measures focused on the threat of Asian gypsy and nun moths.

The import of timber products remains a common way of introducing exotic pests (Brockerhoff et al. 2006, Haack 2006). Thus, laws against log imports or requiring their treatment before entry can be effective. Nevertheless, considering how Asian *Lymantria* was actually introduced, it appears that US policies should deal with all vessels that dock in the Russian Far East (and other source locations for pests) and subsequently visit the United States. Exotic pests can and do enter through many pathways aside from raw logs, including shipping containers, solidwood packing material, ships, and other vehicles and accompanying persons and their personal effects arriving at practically all ports of entry (Liebhold et al. 2006, McCullough et al. 2006).

A next step in any economic analysis of the ways to address the threat of exotic invasive pests would be to assess their impacts

across timber production, residential impacts, and nontimber values; quantify how all available measures alter risks; and include consideration not only of the potential costs of their establishment but also of the impacts of all such phytosanitary measures on trade and travel. Although complicated and ambitious, such an analysis could lead to a deeper understanding of how the United States can effectively reduce the risks of exotic invasive pests.

Meanwhile, the limited study described here has highlighted remaining information gaps and suggested areas for further research. In particular, the expected losses that have been reported are incomplete because they ignore the effects that an infestation would have on ecological and nontimber values provided by forests. A worthwhile line of research would quantify and possibly value at least some of the nontimber effects of infestation. In addition, even if the focus is on the forest sector, one should attempt to calculate how changes in general trade and related policies specifically affect the risk of exotic forest pest invasions. It can also be noted that, as carried out, our study evaluated only the effects of a successful moth invasion in the United States. However, the invasion could start in Canada and then spread to the United States or vice versa. Given the importance of these two countries in global markets, an approach that dealt with both countries simultaneously, not only through commodity trade as in the GFPM but also via the intracontinental spread of exotic species, could improve the analysis and potentially lead to better risk management strategies.

Endnotes

[1] With a 4% discount rate over a 50-year time horizon, and converting to 2005 dollars using the US gross domestic product deflator (US Department of Commerce Bureau of Economic Analysis 2007).

[2] The latest version of the GFPM and the related data and documentation are available online (Buongiorno et al. 2008).

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