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# Market Access for New Zealand Forest Products: An Economic and Environmental Case for Development of Alternative Phytosanitary Treatments

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## Abstract

Phytosanitary treatment of export forest products relies almost entirely on fumigation with methyl bromide, emissions of which are controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer. Adoption of cheaper, less environmentally harmful, alternative fumigants has been limited due to insufficient data on their efficacy and appropriate application technologies. The significant economic benefit of alternative fumigants provides justification for research investment. The Global Forest Products Model, a dynamic market equilibrium model that integrates wood supply, processing industries, product demand and trade, was used to calculate the direct economic benefits to New Zealand forest product exporters of gaining acceptance of phosphine fumigation for log exports to Japan, South Korea, India and China. The availability to New Zealand log exporters of a single alternative fumigant (phosphine) with associated application technologies increases log exporters present value (at 8% over 28 years) of gross annual revenue by US$318.5 million. Details of the impact of acceptance of phosphine fumigation to individual markets were also modelled. An additional risk management scenario modelled was a one-year log import ban by New Zealand's trading partners due to the presence of a quarantine pest in export logs and the lack of an alternative treatment. The economic impact of this last scenario was a decrease in the present value of forest owner gross revenue by US$369 million to US$3,007 million depending on the likelihood of a ban occurring. The value of the environmental, social and health benefits of a 70% reduction in methyl bromide emitted during forestry phytosanitary treatment (achievable using alternative fumigants for in-hold log cargo) was calculated at US$199,000/annum, a present value of US$2.2 million.

**Keywords:** methyl bromide; phytosanitary regulations; market access; spatial equilibrium model.

## Introduction

Phytosanitary treatment of export forest products is performed to achieve compliance with quarantine standards imposed by importing countries. Most countries require that logs, lumber and other forest products are free from any pest organisms that pose a biosecurity risk. Pre-shipment fumigation with methyl bromide (MeBr) is widely accepted by quarantine authorities. Future use of MeBr is, however, under threat. The Montreal Protocol on Substances that Deplete the Ozone Layer (UnitedNations Environment Programme [UNEP], 2000) restricts use of ozone depleting substances, including MeBr, though current use for quarantine and pre-shipment (QPS) treatment is permitted. Since 2002, parties have been required to report their QPS usage under the Beijing Amendment to the Protocol (UNEP, 1999). Furthermore, environmental and human health concerns at export ports where MeBr is used, and increasing compliance costs, make


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it difficult to foresee continued large-scale use of MeBr. This paper quantifies the economic benefits of using alternative treatments and the business risks associated with the New Zealand forest industry's reliance on MeBr.

## Background

Methyl bromide is believed to contribute significantly to the destruction of the earth's stratospheric ozone layer. Recognising this, the Montreal Protocol on Ozone Depleting Substances requires the phase out of certain uses of MeBr (UNEP, 2000). Most agricultural users have been forced to phase out MeBr, except for uses under critical exemptions. Currently fumigation for pre-shipment phytosanitary and quarantine treatments are exempt (UNEP, 2000). There is mounting awareness by parties to the protocol of the impact of QPS use in preventing full recovery of the ozone layer in the least time. This is expected to manifest itself in the next few years as increasing pressure to find and implement technologically and economically feasible alternatives to MeBr. Some parties to the protocol are already calling for a total phase-out of MeBr use, and MeBr use is now being phased out in Austria, Denmark, Finland, Germany, Sweden, and Iceland.

New Zealand lobbyists are campaigning on environmental, operational health and safety, and public safety grounds for the phase out of all MeBr usage by 2010. A petition by Nelson residents has led to a review of the status of MeBr by the Local Government and Environment Committee of the House of Representatives. The recommendations of this Committee include reassessment of MeBr by the Environmental Risk Management Authority, encouragement of recapture of MeBr, and best-practice audit of operators using MeBr (NZ House of Representatives, 2006). New Zealand's total imports of MeBr for QPS use were 205 t in 2004 and 155 t (preliminary figure) in 2005 (R. Washbourne, Ministry of Economic Development, pers. comm.). Around 70% of this was used for phytosanitary treatment of export forest products, compared with international QPS figures where log fumigation accounts for only 4% of usage (UNEP, 2006). New Zealand has a number of forest pests not present in other countries, and is one of the few exporters of unprocessed plantation-grown softwood logs. The importance of not only MeBr as a phytosanitary sterilant for logs in New Zealand compared with other countries, but also our unique dependence on export of green, unprocessed pine logs, means that technologies for alternative treatments will need to be tailored to our conditions and demonstrate efficacy against our pests. We are unlikely to be able to piggy-back on international research on MeBr alternatives for this application. Efficacy data to support phytosanitary treatments will require research investment from within New Zealand.

The business case for investment in research into alternative technologies is strongly supported by economic gains already achieved where alternatives, such as phosphine, have been used.

## Business case

### Logs

#### *Risk to exports*

New Zealand exports over 8.1 million m$^3$ of logs annually, with an average annual value of NZ$600 million (Table 1). Quarantine authorities in Japan and South Korea require log inspection, and treatment (if required), on arrival. At present all logs exported to Japan and South Korea are fumigated with MeBr on arrival (Peter Hill, Managing Director, Pentarch Forest Products, pers. comm.). Malaysia, China, and India all require phytosanitary disinfestation and certification by the exporting country (Ministry of Agriculture and Forestry [MAF], 2007a).

The cost of fumigation on arrival in Japan and Korea is approximately $US 2.00/m$^3$. Additional costs (approximately US$ 1.00 to 1.50/m$^3$ per day) are also incurred if ships are delayed while waiting for phytosanitary treatment. This occurs more often than not at some South Korean ports (Greg Ackroyd, Biofumigation Ltd., pers. comm.). There is an opportunity to fumigate in-transit with phosphine, saving on both fumigation costs and costs incurred by ship delays. Existing technology will allow fumigation of in-hold cargo, subject to provision of sufficient efficacy data to Japanese and South Korean quarantine authorities (Mike Goss, Fumigation Manager, Genera, pers. comm.). Fumigation of deck cargo with phosphine is an achievable goal if adequate investment is made into development of application technologies.

Any change in circumstances which reduces the acceptance of current phytosanitary protocols for logs to important markets such as South Korea or Japan (Table 1) jeopardises exports of around 4.5 million m$^3$ (NZ$465 million) of logs annually, unless alternative treatments are available.

New Zealand exporters may be forced to carry out pre-shipment treatment if Japan and/or South Korea (both of whom are parties to the Montreal protocol) choose to reduce their national MeBr emissions by requiring that disinfestation treatments be completed before ships arrive in port. This would lead to an additional 200-300 t/annum MeBr usage by New Zealand.

#### *Savings achievable using alternative fumigants*

New Zealand log exporters are in a unique position. New Zealand has the opportunity to use techniques such as in-transit phosphine fumigation (that may not be available to other exporters) because of the distance to overseas markets and elevated transit temperatures as logs cross the equator.

TABLE 1: Nominal value (NZ$ 000) of log exports to major markets 2000-2005.

| | Value of log exports ($NZ 000) by year | | | | | |
|---|---|---|---|---|---|---|
| | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** |
| China | 24 332 | 47 226 | 93 309 | 130 221 | 103 667 | 46 506 |
| India | 18 957 | 26 310 | 19 180 | 27 421 | 19 020 | 24 148 |
| Japan | 169 921 | 229 147 | 169 596 | 169 858 | 123 837 | 95 256 |
| South Korea | 308 307 | 337 668 | 386 176 | 353 692 | 293 916 | 212 257 |
| Malaysia | 2 267 | 5 393 | 1 208 | 1 719 | 6 | 14 |
| Philippines | 21 028 | 25 034 | 19 | 19 321 | 6 165 | 14 000 |
| Other countries | 28 663 | 44 874 | 44 527 | 42 610 | 18 758 | 17 909 |
| **Total** | **573 475** | **715 653** | **714 015** | **744 842** | **565 369** | **410 090** |

Ministry of Agriculture and Forestry (2007b).

The economic impact of using phosphine as an alternative to MeBr fumigation for log exports was modelled in three scenarios (Appendix 1), which are discussed later in this paper.

### *Biosecurity backstop*

The impact of a biosecurity incursion into New Zealand of a bark-beetle or wood-boring pest could have a major effect on the profitability of New Zealand forestry. Like foot and mouth disease, the most significant economic impact of an incursion is not that of reduced production capability, but of reduced ability to export (Self, 2003; Turner et al., 2007). If untreated logs were not acceptable to our major markets (i.e. an import ban is imposed as an emergency measure under the International Plant Protection Convention), and, our quarantine and pre-shipment toolbox did not contain MeBr or an effective substitute, log exports may be abruptly halted until a solution is found. The inability to export logs would have an immediate and devastating effect on forestry profitability (for example Li et al., 2007; Turner et al., 2007). Upon re-entry to these markets, it may take some time to recover to present export volumes, therefore, development of alternative treatments must be a critical component of our biosecurity risk management strategy. Therefore, the economic impact of a one-year ban on imports of New Zealand logs was modelled and is discussed later in this paper.

### Sawnwood

Sawnwood exports to Australia total about 400 000 m$^3$ (NZ$250 million) annually. These exports (as well as wood shipped to all ports from Dunedin north) must be fumigated with MeBr for six months of the year (during the flight season of the beetle *Arhopalus ferus* (Mulsant)) at a cost of NZ$600,000. Additional costs are imposed by restrictions on loading at night during the beetle's flight season. Groups opposed to emissions of MeBr are campaigning for an end to on-port fumigation. On the positive side, a change in the way the phytosanitary risk is managed could provide immediate savings to exporters of sawnwood. These savings provide the opportunity to grow New Zealand's market share by improving the competitiveness of New Zealand *Pinus radiata* (D. Don) (radiata pine) in Australian markets. The economic impact of using phosphine as an alternative to MeBr fumigation for New Zealand sawnwood exports to Australia was modelled (Appendix 1), and is discussed later in this paper.

### Environmental and health benefits of alternative treatments

### *Reduced ozone depletion*

The environmental value of reduced MeBr emissions is a complex issue. Velders et al. (2000) calculated the economic value of reduced emissions by estimating the benefit to health of avoided fatal and non-fatal skin cancers, and the avoided damage to agriculture, fisheries and materials achieved by reducing European Union emissions. They estimated the benefit to be €79.4 billion[1] (NZ$158 billion) (the present value for 2000 was calculated from 1997 figures using a 5% discount rate), achieved at a cost of reducing emissions of €24 billion (NZ $48 billion).[2] The benefit to cost ratio of EU emission reductions for MeBr was, therefore, 3.3 : 1.

The global benefit : cost ratio was even greater. Velders et al. (2000) repeated their calculations based on the following predicted benefits of reduced ozone depletion (from Environment Canada, 1997):

- approximately 19.1 million avoided cases of non-melanoma skin cancer worldwide by 2060;

[1]*Billion = 1 x 10$^9$*
[2]*Assuming an exchange rate of 1NZ$=0.50€*

- approximately 1.5 million avoided cases of melanoma skin cancer;
- approximately 333 500 avoided skin cancer deaths;
- approximately 129 million avoided cases of cataracts;
- a significant reduction in illnesses and deaths from infectious diseases;
- benefits to world fisheries of €238 billion from 1987 - 2060, because of the avoided impacts of increases in UV-B radiation on aquatic ecosystems;
- benefits to agricultural production of about €191 billion (preliminary research indicates that UV-B radiation inhibits photosynthesis, damages DNA, changes the form and structure of plants and impacts on productivity); and
- benefits to building owners from reduced damage to polyvinyl chloride (PVC) products used in the building industry estimated at €30 billion.

These estimates gave a global economic value of the environmental and health benefits of reductions of €2,020 billion (NZ$4,040 billion) for a cost of reducing MeBr emissions of €200 billion (NZ$400 billion), giving a benefit to cost ratio of 11 : 1. The estimated benefit per tonne of MeBr emission reduction is €1,848/t ($NZ3,696/t).

The use of phosphine as a fumigant for logs exported to China has meant that logs transported in-hold do not need to be fumigated with MeBr. This has replaced approximately 6 t of MeBr emissions with around 100 kg of phosphine emissions. Phosphine is broken down to phosphate, which is less toxic. If an equal value were assigned to every tonne of MeBr emitted in New Zealand as that calculated for Europe the equivalent value of reduced emissions could be estimated as: 6 t x $NZ3,696/t =$NZ22,176 per ship. If logs destined for India, Malaysia or other markets were also similarly fumigated with phosphine, New Zealand would be able to dramatically reduce domestic MeBr emissions. If the emissions of MeBr associated with phytosanitary treatment of forestry exports were reduced by 70%, the economic value of environmental and health benefits (calculated using the results of Velders et al., 2000) would be $NZ362,208 ($US199,214) annually (i.e. 200 t annual consumption x 70% used in forestry x 70% achievable reduction x $NZ3,696/t).

A simpler analogy is to compare the environmental benefit of reduced MeBr emissions with the emissions of chlorofluorocarbons (CFCs) from discarded refrigerators. Fumigating the entire cargo of a single log ship bound for China with MeBr releases around 6 t of MeBr.[3] In contrast, an average domestic refrigerator typically carries a charge of roughly 100 g of CFC. Therefore, fumigation of a single log ship could contribute as much to stratospheric ozone depletion as 36 000 discarded refrigerators.

**Health and Safety**

Annual sawnwood exports from New Zealand are approximately 1 700 000 m$^3$. The volume exported from Port of Nelson in 2006 was 165 000 m$^3$ (Ministry of Agriculture and Forestry, 2007b). Fumigation of sawnwood to kill *A. ferus* has caused concerns regarding the health and safety of port workers and local residents. As a result, the Port of Nelson has been forced to seek resource consent from the Tasman District Council for the discharge of MeBr. The port invested a large amount of time and around NZ$100,000 on a consent application which they subsequently withdrew due to the complexity of the problem (Murray McGuire, Port of Nelson, pers. comm.). Instead, a local pest and fumigation company (Genera Limited) are planning to file an application for consent to discharge MeBr. Genera estimate that the resource consent process is likely to cost them in excess of NZ$100,000, a significant cost to a small business (Mark Greenwood, Managing Director, Genera Limited pers. comm.). This process may set a precedent for all ports where MeBr is used. The recapture of MeBr, followed by either destruction or re-use, would reduce both the risk to those who could be exposed to the fumigant. This, in turn, would reduce the likelihood that businesses providing phytosanitary services would have to pass on additional costs or cease to operate due to high compliance costs. Loss of businesses providing phytosanitary services would limit the availability of these services to the forestry industry.

## Model

### *The economic impact of alternative fumigation treatments on the log and sawnwood export trade*

The impact of alternative log and sawnwood fumigation treatments on New Zealand log production and trade from 2002 to 2030 was predicted using the Global Forest Products Model (GFPM) (Buongiorno et al., 2003; Turner et al., 2006). The GFPM is a dynamic market equilibrium model that integrates the four major components of forest sector models: wood supply, processing industries, product demand, and trade.

The GFPM has previously been used to study issues such as the effects of accelerated tariff liberalization (Zhu et al., 2001), trade agreements on the New Zealand forest sector (Turner et al., 2001), illegal

*[3] MeBr has an Ozone Depletion Potential (ODP) of 0.6, CFC-11 and CC 12 are both rated as 1.0*

logging on the United States forest sector (Seneca Creek, 2004), the Free Trade Area of the Americas on forest resources (Turner et al., 2005), the economic effect of United States forest biosecurity policies (Prestemon et al., 2006), and a forest pest in New Zealand with subsequent regulatory responses in New Zealand's export markets (Turner et al., 2007).

The GFPM models wood producing, consuming, and manufacturing activities with supply and demand equations, and manufacturing input-output coefficients and costs. Countries are linked by trade. Inter-temporal linkages in the GFPM are both exogenous and endogenous. Changes in wastepaper recovery rates and techniques of production are set exogenously. Other changes are endogenous; in particular, shifts in wood supply are determined by changes in forest area and forest stock.[4]

The GFPM has been validated by making projections over historical periods – 1980 to 1994 (Buongiorno et al., 2003) and 1980 to 2000 (Turner, 2004) – conditional on known exogenous changes, such as GDP growth rates. For these validation exercises the GFPM gave acceptable predictions of general trends in production, consumption, trade and prices, though there were larger errors in annual predictions (Buongriono et al., 2003; Turner, 2004)

Most trade flows in the GFPM are between individual countries and the world market. For the present study bilateral trade flows were added for trade among New Zealand's major markets and competitors.[5] This maintained an acceptable model size, while allowing analysis of alternative fumigation treatments. Bilateral trade volumes were from the EFI/WFSE Trade Flow Database (Michie & Wardle, 1998).

**Scenarios**

In this study we have modelled the economic impact of using phosphine as an alternative to MeBr fumigation. As phosphine has recently been used to fumigate log exports to China, there are accurate operational costs enabling us to use it as a standard measure for costing alternative treatments. Other alternative treatments include sulfuryl fluoride, ethanedinitrile, cyanogen, heat treatment and integrated pest management. Either capture then destruction or re-use of MeBr are also possible options. Each of these alternatives will, to varying degrees, increase the cost of exporting logs.

The economic benefits of the six scenarios listed below were estimated:

1. this is an estimate of the benefit of securing long-term acceptance of phosphine as an alternative fumigation treatment for New Zealand log exports to China. In other words, what is the cost of reverting back to MeBr?
2. this estimates the potential benefit of using phosphine treatment for log exports to China, but avoiding the need to have a technician on-board the log ship to fumigate in-transit;
3. this estimates the potential benefit of using phosphine instead of MeBr for log exports to Japan, South Korea and India;
4. this estimates the potential benefit of phosphine fumigation of sawnwood exports to Australia;
5. this estimates the combined benefit of scenarios 2 – 4. The costs of alternative fumigation treatments were modelled in the GFPM as an increase (in the case of Scenario 1), or decrease in the logs (defined as industrial roundwood) and/or sawnwood freight cost for exports to the particular destination in 2002 (in the case of Scenario 1) or 2010 (Table 2); and
6. this estimates the cost of a one-year ban on all of New Zealand's log export markets, in 2010. Historically, such a scenario is not unprecedented. A ban was placed on imports of New Zealand logs into the United States following a Pest Risk Assessment which recommended that existing mitigation measures (debarking, MeBr fumigation, and pre-shipment inspection) were inadequate to address pests that potentially posed a risk to native pine forests in the United States (USDA, 1992). To represent this scenario in the GFPM a critical assumption is the rate at which New Zealand is able to re-grow its log exports following the ban. This is because year-to-year changes in trade in the GFPM are limited by trade inertia bounds which simulate inertia in trade patterns,[6] i.e. it takes time for markets to expand. For this scenario we assumed that for eight years exports were able to double each year, before being limited to increasing at their original rate (Figure 1).

Scenarios 1 – 4 are described in more detail in Appendix 1.

[4] *For a detailed mathematical description of the Global Forest Products Model refer to Buongiorno et al., (2003) and Prestemon et al., (2006). Turner et al., (2006) provides a complete description of model assumptions. Model data are available from the authors upon request.*

[5] *Australia, Brazil, Canada, Chile, China, Finland, India, Indonesia, Japan, South Korea, Malaysia, New Zealand, Oman, Philippines, Russian Federation, Saudi Arabia, Sweden, Thailand, United Arab Emirates, United States of America, Viet-nam, and Yemen.*

[6] *Within these bounds the actual trade was the result of market forces represented by the GFPM.*

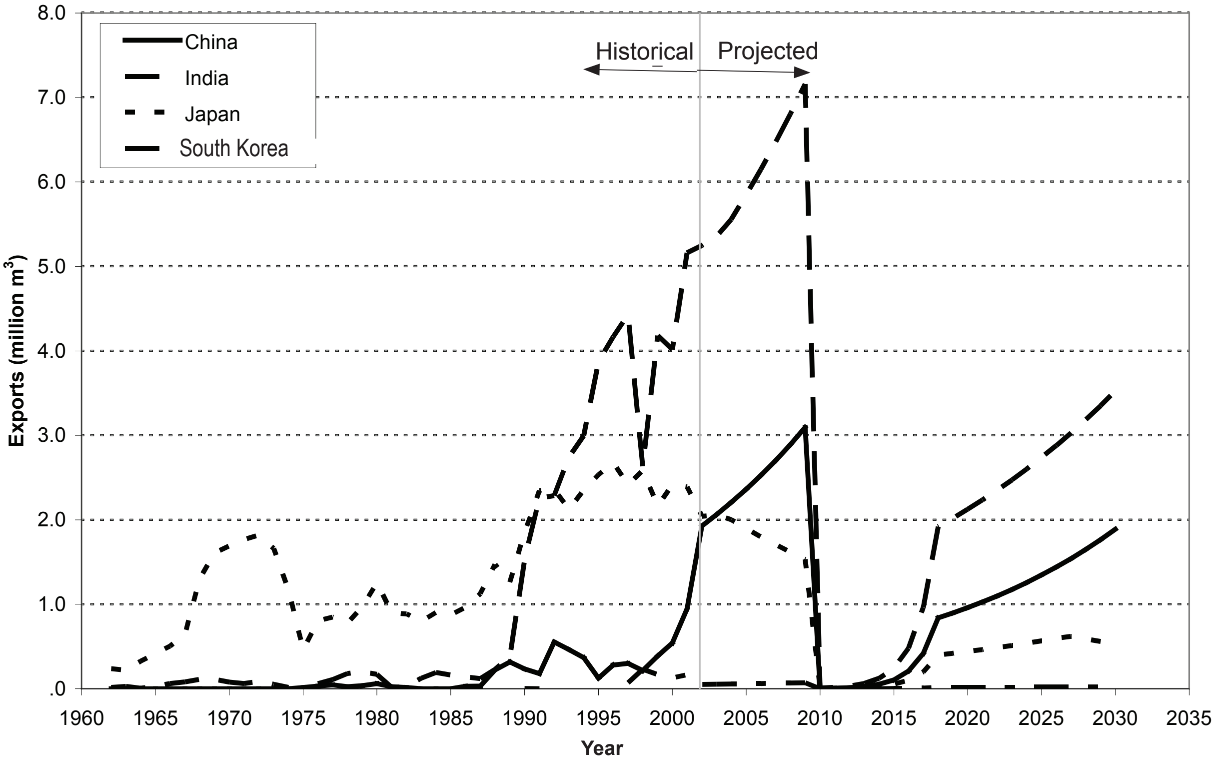


FIGURE 1: Historical (1962-2002) and projected (2003-2030) industrial roundwood exports from New Zealand, with a log import ban in New Zealand markets in 2010.

## Data

The economic impact of each of the senarios was described by the change in New Zealand industrial roundwood producer gross revenue and consumer expenditure. Industrial roundwood producer gross revenue is the value of production (quantity produced multiplied by price per unit) ignoring changes in the cost of raw material inputs to production. It was calculated in net present terms (for an 8% discount rate) over 28 years from 2002. Industrial roundwood consumer expenditure is the value of consumption (quantity consumed multiplied by price per unit). It was also calculated in net present terms. Where original costs were in NZ dollars these were converted to U.S. dollars using the long-run average exchange rate NZ$1.00 = US$0.55. Additional data are provided in Appendix 1.

## Results and Discussion

### Economic impact of alternative fumigation treatments

#### *Phosphine fumigation of New Zealand log exports: Scenarios 1 – 3*

The impact on freight costs of Scenarios 1 – 3 involving logs are shown in Table 2. The projected changes in total industrial roundwood producer revenue, consumer expenditures, production and exports of Scenarios 1 – 3 are shown in Table 3.

Scenario 1 – reverting back to MeBr, instead of the current phosphine for fumigation of New Zealand log exports to China – results in a 9700 $m^3$/annum reduction in New Zealand industrial roundwood harvests (Table 3). This is due to the lower level of industrial roundwood exports to China (13 800 $m^3$/annum) resulting from the higher cost of shipping New Zealand logs due to the more costly MeBr treatment. The economic impact on New Zealand log producers of these changes in production and trade is a US$5.7 million loss in the present value of gross revenue. This suggests that log exporters will experience a significant benefit from continuing to use and gaining acceptance of phosphine treatment as an alternative fumigation treatment of exports to China.

Scenario 2 – the use of phosphine, without a technician, to fumigate New Zealand log exports to China – results in a small increase in New Zealand's average annual industrial roundwood production (3 300 $m^3$/annum) and exports (2 600 $m^3$/annum), and a small increase in industrial roundwood producer revenue (US$3.7 million) (Table 3). This relatively minor impact is due to the small reduction in the cost of shipping New Zealand logs (US$0.18/$m^3$) achieved by not having a technician to fumigate with phosphine in-transit.

Scenario 3 – the use of phosphine, instead of the current MeBr, for fumigation of New Zealand log exports to Japan, South Korea and India – results in a 634 000 $m^3$/annum increase in New Zealand log exports (Table 3). Log exports to South Korea increase the most (651 700 $m^3$/annum). Exports to Japan and India are unchanged, and log exports to China decline slightly (13 200 $m^3$/annum). To achieve the increased log exports New Zealand industrial roundwood harvests are 407 000 $m^3$/annum higher, but domestic consumption by sawmills, wood panel mills, and pulp mills are also lower. By gaining acceptance of phosphine fumigation for log exports to Japan, South Korea and India, New Zealand log producers increase their present value of gross revenue by US$320.1 million. This arises from increased log exports and slightly higher log prices (Table 3). The gain to log producers is partly offset by a decrease in the present value of gross revenue for wood processors, though the New Zealand forest industry as a whole is US$93.6 million better off. The reduction in log exports to China is possibly due to the increase in New Zealand log prices, arising from higher demand in South Korea. The negligible impact on log exports to India may also be due to the increased. log prices, the effect of which is exaggerated by India's 5 percent *ad-valorem* tariff on log imports. Japan's log imports are unchanged by the use of phosphine fumigation possibly because of a forecast decline in Japan's demand for New Zealand logs (Turner et al., 2006)

***Phosphine fumigation of New Zealand sawnwood exports to Australia: Scenario 4***

The economic impact of using phosphine, instead of MeBr, to fumigate New Zealand sawnwood exports to Australia (Scenario 4) is shown in Table 4. The impact is considered negligible. This is possibly due to a

TABLE 2: Modelling of various scenarios on the impacts of using phosphine fumigation treatments on freight costs for New Zealand wood exports.

| Scenario | Importer(s) | Commodity Grade | Year | Change in freight cost (US$/$m^3$) |
|---|---|---|---|---|
| 1 | China | Industrial roundwood | 2002 | 1.42 |
| 2 | China | Industrial roundwood | 2010 | -0.18 |
| 3 | Japan, South Korea | Industrial roundwood | 2010 | -2.57 |
| 3 | India | Industrial roundwood | 2010 | -1.85 |
| 4 | Australia | Sawnwood | 2010 | -1.01 |

TABLE 3: Projected changes in total industrial roundwood producer revenue, consumer expenditures, production and exports of Scenarios 1 – 3.

| Category | Unit | Base Level | | Average Annual Difference from Base | | |
|---|---|---|---|---|---|---|
| | | 2002 | 2030 | (1) | (2) | (3) |
| Production | thousand $m^3$ | 27 731 | 41 431 | -10 | 3 | 407 |
| Exports | thousand $m^3$ | 9 640 | 22 437 | -14 | 3 | 634 |
| Exports to China | thousand $m^3$ | 1 928 | 12 809 | -9 | 0 | -13 |
| Japan | thousand $m^3$ | 2 040 | 500 | 1 | 0 | 0 |
| South Korea | thousand $m^3$ | 5 247 | 8 261 | -5 | 3 | 652 |
| India | thousand $m^3$ | 52 | 193 | 0 | -1 | 0 |
| Price | US$/$m^3$ | 66.0 | 66.8 | 0.0 | 0.0 | 0.8 |
| Producer revenue | US$ million | 1,830 | 2,535 | -6 | 4 | 320 |
| Consumer expenditures | US$ million | 650 | 193 | 0 | 0 | 2 |

Senario 1: fumigation of log exports to China with methyl bromide;
Senario 2: fumigation of log exports to China with phosphine (no technician);
Senario 3: fumigation of log exports to South Korea, Japan and India with phosphine.

forecast decline in Australia's demand for New Zealand sawnwood imports (Turner et al., 2006). Strong forecast growth in Australian sawnwood production, and only moderate growth in consumption, results in a decline in the Australian domestic sawnwood price to below the delivered price of New Zealand sawnwood, i.e. the New Zealand domestic price plus the freight cost is greater than the Australian domestic price. The US$1.01/$m^3$ reduction in freight cost for New Zealand sawnwood to Australia due to the use of phosphine is not large enough to reduce the delivered price of New Zealand sawnwood to below the Australian domestic price.

TABLE 4: Projected changes in sawnwood producer revenue, consumer expenditures, production and exports due to fumigation of New Zealand sawnwood exports to Australia using phosphine instead of methyl bromide - Senario 4.

| Category | Unit | Base Level 2002 | Base Level 2030 | Average Annual Difference from Base |
|---|---|---|---|---|
| Production | thousand $m^3$ | 4 352 | 6 173 | -1 |
| Exports | thousand $m^3$ | 2 037 | 3 125 | -1 |
| Exports to Australia | thousand $m^3$ | 439 | 146 | 0 |
| Price | US$/$m^3$ | 192.0 | 193.1 | 0.0 |
| Producer revenue | US$ million | 836 | 1,192 | -1 |
| Consumer expenditures | US$ million | 454 | 592 | 0 |

TABLE 5: Projected changes in industrial roundwood and sawnwood producer revenue, consumer expenditures, production and exports of Scenario 5.

| Commodity Grade | Category | | Unit | Base Level 2002 | Base Level 2030 | Average Annual Difference from Base |
|---|---|---|---|---|---|---|
| Industrial roundwood | Production | | thousand $m^3$ | 27 731 | 41 431 | 407 |
| | Exports | | thousand $m^3$ | 9 640 | 22 437 | 634 |
| | Exports to | China | thousand $m^3$ | 1 928 | 12 809 | -10 |
| | | Japan | | 2 040 | 500 | 0 |
| | | South Korea | | 5 247 | 8 261 | 649 |
| | | India | | 52 | 193 | 0 |
| | Price | | US$/ $m^3$ | 66.0 | 66.8 | 0.8 |
| | Producer revenue | | US$ million | 1,830 | 2,535 | 312 |
| | Consumer expenditures | | US$ million | 650 | 193 | 2 |
| Sawnwood | Production | | thousand $m^3$ | 4 352 | 6 173 | -171 |
| | Exports | | thousand $m^3$ | 2 037 | 3 125 | -169 |
| | Exports to Australia | | thousand $m^3$ | 439 | 146 | 0 |
| | Price | | US$/ $m^3$ | 192.0 | 193.1 | 0.7 |
| | Producer revenue | | US$ million | 836 | 1,192 | -154 |
| | Consumer expenditures | | US$ million | 454 | 592 | 11 |

### *Phosphine fumigation of both New Zealand log and sawnwood exports: Scenario 5*

Table 5 shows the combined economic impact of fumigation of log exports to China, South Korea, Japan and India, and sawnwood exports to Australia using phosphine instead of MeBr (Scenario 5). This scenario is a combination of scenarios 2 - 4. This scenario results in a 633 900 $m^3$/annum increase in New Zealand log exports (Table 5). These increased exports are predominantly to South Korea, while exports to China are 9600 $m^3$/annum lower. The latter result may be due to the reduction in delivered cost of New Zealand logs to China from using phosphine (US$0.18/$m^3$) being offset by the increased log price (US$0.80/ $m^3$) due to higher South Korean import demand. The increase in New Zealand log exports is achieved by a combination of increased production (406 500 $m^3$/ annum) and lower domestic consumption by sawmills (171 100 $m^3$/annum), wood panel mills, and pulp mills. The latter leads to a US$153.6 million decrease in the present value of sawnwood producer gross revenue.

By gaining acceptance of phosphine fumigation for log exports to Japan, South Korea, India and China, New Zealand log exporters increase their present value of gross revenue by US$318.5 million. This arises from increased log exports and slightly higher log prices. The gain to log producers is partly offset by a decrease in the present value of gross revenue for wood processors, though the New Zealand forest industry as a whole is US$92.4 million better off.

### *One-year ban on imports of New Zealand logs: Scenario 6*

Table 6 shows the economic impact of a complete ban on industrial roundwood imports from New Zealand in 2010 (Scenario 6), by all our log markets. This scenario results in an average annual 10.5 million $m^3$ reduction in New Zealand industrial roundwood exports (Table 6 and Figure 1). The reduction in New Zealand industrial roundwood exports leads to a reduction in harvests of 8.6 million $m^3$/annum. Harvests decline less than exports as domestic consumption by sawmills, wood panel mills, and pulp mills is higher (1.9 million $m^3$/ annum) due to the availability of cheaper industrial roundwood (US$15.90 $m^3$/annum lower compared with the base scenario). Lower industrial roundwood harvests combined with lower prices mean the present value of forest owner producer revenue decreases US$6,594 million under a year log import ban

To reflect the risk of New Zealand's log export markets responding with an import ban, as presented here, the predicted loss of producer revenue needs to be weighted by the likelihood of such an event occurring. The likelihood of a high impact exotic forest pest establishing in New Zealand is the combined probability of a pest arriving in New Zealand, it not being detected early enough to eradicate, and it not being controllable (see Figure 1 in Turner et al., 2004). Using the assumptions that 0.13 "high impact" pests of radiata pine arrive per year, a 30% to 50% probability of not

TABLE 6: Projected changes in industrial roundwood producer revenue, consumer expenditures, production and exports from a ban on imports of industrial roundwood from New Zealand.

| Commodity Grade | Category | | Unit | Base Level 2002 | Base Level 2030 | Average Annual Difference from Base |
|---|---|---|---|---|---|---|
| Industrial roundwood | Production | | thousand $m^3$ | 27 731 | 41 431 | -8 605 |
| | Exports | | thousand $m^3$ | 9 640 | 22 437 | -10 481 |
| | Exports to | China | thousand $m^3$ | 1 928 | 12 809 | -4 511 |
| | | Japan | | 2 040 | 500 | -405 |
| | | South Korea | | 5 247 | 8 261 | -5 163 |
| | | India | | 52 | 193 | -82 |
| | Price | | US$/ $m^3$ | 66.0 | 66.8 | -15.9 |
| | Producer revenue | | US$ million | 1,830 | 2,535 | -6,594 |
| | Consumer expenditures | | US$ million | 650 | 193 | -71 |

being detected early, and a 5% to 25% probability of not being controllable (Turner et al., 2004), the likelihood of such a pest establishing is 0.20% to 1.63% per year. The likelihood of a pest establishing during the 28-year period studied is, therefore, 5.6% to 45.6%. This implies the expected loss of forest owner producer revenue would be US$369 million to US$3,007 million.

## Conclusions

The social and environmental benefits of a 70% reduction in MeBr emissions achievable via the use of alternative treatments, though difficult to quantify, have been estimated at US$2.2 million annually (with a present value of US$24.5 million over 28 years for an 8% discount rate).

The estimated economic benefit for New Zealand log producers from the acceptance of phosphine as an alternative MeBr fumigation for log exports to China is significant. The economic benefit were phosphine fumigation accepted as an alternative to MeBr treatment of log exports to Japan, South Korea, India and China, log producers could increase the present value (at an 8% discount rate over 28 years from 2002) of gross revenue by US$320 million. Acceptance of phosphine as an alternative fumigation treatment for sawnwood exports to Australia has a negligible economic benefit due to increased Australian domestic production replacing sawnwood imports from New Zealand. The potential risk posed by not having an alternative fumigant in the event of unavailability of MeBr is temporary loss of access to all export log markets, resulting in the present value of forest owner producer revenue decreasing US$369 million to US$3,007 million depending on the likelihood of a ban occurring.

New Zealand's access to log export markets is dependent on the continued acceptance of MeBr as a fumigant for phytosanitary treatment. Emissions of MeBr will become restricted both domestically and internationally due to environmental, health and safety concerns regarding its use. Safer and cheaper alternative fumigants are available, e.g. phosphine. Acceptance of these is dependent, though, on supporting efficacy data and application technologies. This paper demonstrates that the reduced risks and potential economic benefits to the New Zealand forest industry from using alternatives to MeBr justify investment in research to achieve acceptance of these alternatives.

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## References

Buongiorno, J., Zhu, S., Zhang, D., Turner, J. A. & Tomberlin, D. (2003). *The Global Forest Products Model: Structure, Estimation and Applications*. San Diego, CA, USA: Academic Press.

Environment Canada. (1997). *Global Benefits and Costs of the Montreal Protocol on Substances that Deplete the Ozone Layer.* Ottowa, Canada: Environment Canada.

Li, R., Buongiorno, J., Zhu, S., Turner, J.A. & Prestemon, J.P.(2007). Potential economic impact of limiting the international trade of timber as a phytosanitary measure. *International Forestry Review, 9*(1), 514-525.

Ministry of Agriculture and Forestry (MAF). (2007a). *Forestry Export Phytosanitary Standards*. Retrieved 16 May 2007 from http://www.biosecurity.govt.nz/commercial-exports/forestry-exports/export-certification-standards

Ministry of Agriculture and Forestry (MAF). (2007b). *Forestry Statistics*. Retrieved 16 May 2007 from http://www.maf.govt.nz/statistics/primaryindustries/forestry/forestry-production-and-exports/2006-releases/dec-06-tables/200612-exports-sawn-timber-by-port-web.xls

Michie, B., & Wardle, P. (1998) *UNSTAT trade data as basis for analysis and projection of forest products trade flows.* (EFI Working Paper 17). Helsinki, Finland: European Forest Institute.

New Zealand House of Representatives. (2006). Petition 2002/182 of Clare Gulman and 1452 others. Report of the Local Government and Environment Committee.

Prestemon, J. P., Zhu, S., Turner, J. A., Buongiorno, J. & Li. R. (2006). The forest product trade impacts of an invasive species: Modeling structure and intervention tradeoffs. *Agricultural and Resource Economics Review, 35*(1), 128-143.

Self, N. M. (2003). Biosecurity: The implications for international forestry trade. *Proceedings of the Joint Australian and New Zealand Institute of Forestry Conference, Queenstown, April 27-May 1 2003.* pp. *26-31* Christchurch, New Zealand: New Zealand Institute of Forestry.

Seneca Creek and Associates. (2004). *"Illegal" Logging and Global Wood Markets: The Competitive Impacts on the U.S. Wood Products Industry*. (Report for American Forest and Paper Association). Poolesville, MD, USA: Seneca Creek Associates and Wood Resources International.

Turner, J. A. (2004). *Trade liberalization and forest resources: A global modeling approach.* Dissertation submitted in partial fulfillment of the requirements for the PhD (Forestry). Madison, WI, USA: Department of Forest Ecology and Management, University of Wisconsin-Madison.

Turner, J. A., Bulman, L., Richardson, B. & Moore J. (2004). A cost-benefit analysis of forest health and biosecurity research. *New Zealand Journal of Forestry Science, 34*(3), 324-343.

Turner, J. A., Buongiorno, J., Maplesden, F.M., Zhu, S., Bates, S. & Li. R. (2006). *World Wood Industries Outlook: 2005-2030.* (Forest Research Bulletin No. 230). Rotorua, New Zealand: Scion (New Zealand Forest Research Institute).

Turner, J. A., Buongiorno, J., Zhu, S., Prestemon, J. P., Li, R. & Bulman, L.( 2007). Impact of exotic forest pests on the forest sector: Nectria in New Zealand. *New Zealand Journal of Forestry Science, 37*(3), 383-411.

Turner, J. A., Buongiorno, J., Horgan, G. P. & Maplesden F. M. (2001). Liberalisation of forest product trade and the New Zealand forest sector, 2000-2015: A global modelling approach. *New Zealand Journal of Forestry Science, 31*(3), 320-338.

Turner, J. A., Buongiorno, J. & Zhu, S. (2005). Effects of the Free Trade Area of the Americas on forest resources. *Agricultural and Resource Economics Review, 34*(1), 108-114.

United Nations Environment Programme (UNEP). (1999). The secretariat for the Vienna Convention for protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer 1999, *Eleventh meeting of the parties to the Montreal Protocol on Substances that Deplete the Ozone Layer,* 29 November - 3 December 1999. Beijing, China: UNEP

United Nations Environment Programme (UNEP). (2000). *The secretariat for the Vienna Convention for protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer 2000: Montreal Protocol on Substances that Deplete the Ozone Layer.* Nairobi, Kenya: UNEP.

United Nations Environment Programme (UNEP). 2006. *The secretariat for the Vienna Convention for protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer 2006*. (Report of the Technology and Economic Assessment Panel May 2006). Geneva, Switzerland: UNEP.

United Stated Department of Agriculture (USDA). (1992). *Pest Risk Assessment of the Importation of Pinus radiata and Douglas-fir Logs from New Zealand.* (Miscellaneous Publication No. 1508). Washington, DC, USA: USDA Forest Service.

Velders, G. J. M., Slaper, H., Pearce, D. W. & Howarth, A. (2000). *Technical Report on Stratospheric Ozone Depletion in Europe: An integrated economic and environmental assessment.* (Netherlands Environmental Assessment Agency RIVM Report 481505011 prepared for the Environment Directorate-General for the European Commission.). Bilthoven, The Netherlands: Netherlands Environmental Assessment Agency.

Zhu, S., Buongiorno, J. & Brooks, D. (2001). Effects of accelerated tariff liberalization on the forest products sector: A global modeling approach. *Forest Policy and Economics, 2,* 57-78.

## Appendix 1: Alternative Fumigation Treatment Scenarios

### Treatment of Log Exports to China

*Current Treatment*: In-transit phosphine fumigation of below deck cargo costs US$0.96/m$^3$. Other costs include above-deck fumigation with MeBr and having a technician on-board (Table A1)

TABLE A1: Costs associated with below deck

| Item | Cost | Volume |
|---|---|---|
| Hold (phosphine) | US$10,588 | 22 000 m$^3$ |
| Technician on-board | US$ 3,575 | - |
| Above-deck (methyl bromide[7]) | US$14,438 | 7 740 m$^3$ |
| TOTAL | US$28,601 | 29 740 m$^3$ |

*Scenario 1:* Historical MeBr treatment of above and below deck cargo (80 g/m$^3$ in hold and 120 g/m$^3$ on wharf) and 36 hour delay in docking, costing US$2.38/m$^3$ (Table A.2), from 2002. This scenario was modelled as a US$1.42/m$^3$ increase in the cost of shipping logs to China from 2002.

TABLE A2: Costs associated with methyl bromide fumigation of log exports to China.

| Item | Cost | Volume | Time Delay |
|---|---|---|---|
| Hold (methyl bromide[7]) | US$20,213 | 22 000 m$^3$ | - |
| Above-deck (methyl bromide[8]) | US$14,438 | 7 740 m$^3$ | - |
| Ship delay | US$36,000 | - | 36 hours |
| TOTAL | US$70,651 | 29 740 m$^3$ | 36 hours |

*Scenario 2:* In-transit phosphine treatment of below deck cargo without a technician, costing US$0.78/m$^3$. Other costs include above-deck fumigation with MeBr (Table A.3). This scenario was modelled as a US$0.18/ m$^3$ reduction in the cost of shipping logs to China, from 2010.

TABLE A3: Costs associated with phosphine fumigation of log exports to China, without a technician on board.

| Item | Cost | Volume |
|---|---|---|
| Hold (phosphine) | US$10,588 | 22 000 m$^3$ |
| Above-deck (methyl bromide[8]) | US$12,728 | 7 740 m$^3$ |
| TOTAL | US$23,316 | 29 740 m$^3$ |

[7] *120 g/m$^3$*

[8] *80 g/m$^3$ based on achieving a negotiated lower fumigation rate supported by knowledge of the biology of quarantine pests*

**Appendix 1: continued**

**Treatment of Log Exports to Japan, Korea and India**

*Current Treatment:* Fumigation with MeBr on arrival in Japanese and South Korean ports costs US\$2.00/$m^3$ for fumigation plus US\$1.50/$m^3$ for an average shipping delay of one day. Log exports to India are treated with MeBr (nominally 64 g/$m^3$) before departure from New Zealand costing \$US1.43/$m^3$ for fumigation plus US\$1.21/$m^3$ for a one-day ship delay.

*Scenario 3:* In-transit phosphine treatment costs US\$0.79 for fumigation plus US\$0.14 for compliance costs for log exports to Japan and South Korea.[9] This scenario was modelled as a US\$2.57/$m^3$ reduction in cost of shipping New Zealand logs to Japan and South Korea, and a US\$1.85/$m^3$ reduction in cost of shipping logs to India, from 2010.

**Treatment of Sawnwood Exports to Australia**

*Current Treatment:* Fumigation with MeBr and delays at port[10] in Australia for six months of the year. This is estimated to cost US\$2.76/$m^3$ (including ship delays); US\$1.38/$m^3$ for a six-month period.

*Scenario 4:* Phosphine fumigation of sawnwood exports to Australia costing US\$0.74/$m^3$.[11] This is US\$0.37/$m^3$ for a six month period. This scenario was modelled as a US\$1.01/$m^3$ reduction in cost of shipping sawnwood to Australia from 2010.

[9] *Phytosanitary certificates are not required for Japan or South Korea, but would be if logs were treated prior to arrival. Therefore, a phytosanitary compliance cost would be incurred.*

[10] *If phosphine were used in transit, one day per trans-Tasman voyage could be saved. This would reduce delays from logistical issues such as prohibition of loading in ships holds at night because of insect flights etc. and result in savings of US\$1.11/$m^3$ (Gary Hailwood, Quadrant Limited, pers. comm.).*

[11] *Fumigation costs US\$0.275/$m^3$ of hold space. For a fill rate of 1 : 2.7, the cost per $m^3$ of sawnwood is US\$0.74/$m^3$.*