**MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER**

**UNEP**

# Methyl Bromide in the Forest Industry – Use and alternatives

Marta Pizano and Jonathan Banks
QPS Taskforce, Technology and Economic Assessment Panel, 2009

*Giant African Snail. A quarantine pest for many countries, requiring high dosages of MB for control, Queen Victoria Museum and Art Gallery, Tasmania*

*Applying MB under sheets to imported logs as a quarantine treatment (MAFF, Japan)*

*Production of conifer seedlings in substrates in Chile (photo: Marten Barel, The Netherlands)*

*Trials with a MB alternative for ISPM 15, sulfuryl fluoride + MITC (MAFF, Japan)*

**Abstract**. Logs, timber and wooden materials are notorious for their ability to carry a variety of pests of quarantine significance. Some of these pests potentially attack forests and amenity trees (standing timber), while others can attack timber in furniture, buildings and other structures. Until now, the treatment of choice has been methyl bromide (MB). Targets of MB fumigation may be insects that infest green and dry wood, nematodes (particularly pinewood nematode, *Bursaphelenchus xylophilus*) and some fungal pests of wood, notably oak wilt fungus (*Ceratocystis fagacearum*). Fumigations may also be carried out to eliminate hitchhiker pests of quarantine significance, including pest insects and snails. However, MB is a potent ozone-depleting substance, and is not presently regulated under the Montreal Protocol when used for quarantine and pre-shipment purposes (QPS). The present, exempted annual (QPS) use of MB is around 11,000 metric tonnes in total. With successful phaseout and regulation of other (controlled) uses, this QPS use has become the largest unregulated emissive use of any halogenated gas affecting the ozone layer. Alternatives and options for reducing emissions from this gas into the atmosphere are feasible. An estimated 21% of all MB used for QPS purposes is used for controlling quarantine pests in whole logs; an additional 15% is used for treating wood and wood packaging material. Key words: *Methyl bromide (MB), quarantine and pre-shipment (QPS), Montreal Protocol, ISPM, forest nurseries, alternatives.* Corresponding author: Marta Pizano mpizano@hortitecnia.com

---

## 1. Introduction

Methyl bromide (MB) is an ozone depleting substance. When this fumigant gas is emitted to the atmosphere, it is transferred by natural forces to the stratosphere where it is involved in breaking down ozone molecules in the stratosphere, causing severe damage to the ozone layer. It has a high ozone-depleting potential recognized officially at a value of 0.6. MB became a controlled ozone-depleting substance (ODS), under the Copenhagen Amendment to the Montreal Protocol in 1992, an international treaty under the United Nations Environment Programme (UNEP). Presently, the Montreal Protocol is the only environmental treaty in the world enjoying universal recognition. Reduction and phase-out schedules were agreed differently for industrialized and developing countries, and a special fund was established to help developing countries find the best alternatives to MB according to the particular sectors involved and their specific circumstances. MB use for quarantine and pre-shipment (QPS) were specifically exempted from Protocol controls.

The phase-out date for industrialized countries was set for 2005 and for developing nations for 2015. A provision for “Critical Uses” was included (i.e. for uses for which technical and economically feasible alternatives are not available) and is the only situation under which MB use is allowed in developed countries at present.

For over sixty years, MB has been used as an efficient fumigant controlling a wide range of pests and diseases principally in the following applications (MBTOC, 2007):

- Pre-plant fumigation of soil to control soil-borne pests and diseases in the production of high-value crops such as strawberries, tomatoes, flowers, peppers and melons;
- Fumigation of foodstuffs and associated storage structures to control damaging pests;
- Fumigation of certain commodities (such as grain) in trade to prevent the spread of pests and diseases.

The phase-out of methyl bromide in both developed and developing countries is well advanced, with the 2007 global consumption of methyl bromide, excepting that for quarantine and pre-shipment uses, standing at 15% per cent of the baseline for developed Parties to the Protocol (the baseline consumption was set at the level reported for 1991) and 40% of the baseline for developing Parties (for which the baseline is taken to be the average reported consumption for the period 1995-1998).

The present, exempted annual (QPS) use of MB is around 11,000 metric tonnes in total. With successful phaseout and regulation of other uses, this QPS use has become the largest unregulated emissive use of any halogenated gas affecting the ozone layer.

## 2. QPS Uses in the forestry industry (exempted uses)

International Standard Phytosanitary Measures (ISPMs) prepared by the IPPC (International Plant Protection Convention) influence the treatment of choice when it comes to controlling a quarantine pest. The main ISPM that deals specifically with a major volume use of methyl bromide is ISPM 15, as revised (IPPC 2009). The standard deals with the disinfestation of wood packaging material in international trade as a quarantine measure against various pests of wood and forests. The standard ISPM 15 specifically states that heat treatment should be used in place of methyl bromide where possible, but many countries use methyl bromide treatment to meet the standard. There is no equivalent standard for whole logs or sawn timber, though one is currently under consideration. It is IPPC policy for its members to use alternatives to methyl bromide where feasible for quarantine treatments (CPM-3).

An estimated 21% of all MB used for QPS purposes is used for controlling quarantine pests in whole logs; an additional 15% is used for treating wood and wood packaging material. Other important categories include fresh fruit and vegetables (8% of identified uses); grain, including rice (12%); and soil for preplant fumigation in situ (14%).

## 2.1 Wood and logs

Logs, timber and wooden materials (e.g. sawn timber, wooden packaging materials) are notorious for their ability to carry a variety of pests of quarantine significance. Some of these pests potentially attack forests and amenity trees (standing timber), while others can attack timber in furniture, buildings and other structures. Targets of MB fumigation may be insects that infest green and dry wood, nematodes (particularly pinewood nematode, *Bursaphelenchus xylophilus*) and some fungal pests of wood, notably oak wilt fungus (*Ceratocystis fagacearum*). Fumigations may also be carried out to eliminate hitchhiker pests of quarantine significance, including pest insects and snails.

Oak wilt

MB is the most widely used fumigant for logs but it does have some limitations i.e. limited penetration, particularly across the grain and into wet timber. Most arthropods associated with timber are quite susceptible to MB but much higher dosages are required to have mortality effect on fungi (e.g. see Rhatigan et al.1998). Green logs are problematic to treat due to the high moisture content (80%), presence of bark (very adsorbent), size and large volumes. Treatments of logs may need to be rapid, such as at point of export or import, to avoid charges and congestion at ports associated with occupying restricted port area for the treatment. Where quarantine treatments can be applied outside port areas, such as prior to export or in-transit, slower systems can be used.

There is active research in progress to develop alternatives for logs but gaining the required efficacy data is difficult as laboratory rearing has not yet been achieved to the numbers required, most insects are seasonal, the commodity is large and variable.

### *2.1.1 Chemical alternatives*

***Phosphine*** in transit on those parts of the shipment carried under deck is the only commercially used alternative currently for under bark pests. New Zealand has pioneered the use of phosphine for the in-transit fumigation of forest produce destined for Chinambut currently can only be used for the logs shipped below deck in the holds, approximately 2/3rds of a shipment. It is now in routine use as a QPS measure, replacing MB use. One of the major disadvantages of phosphine when compared to methyl bromide is the long exposure time (up to 10 days) required, but this is overcome by applying the phosphine in transit.

Asian longhorn beetle

***Sulfuryl fluoride****.* While sulfuryl fluoride has similar properties and exposure requirements at some temperatures to methyl bromide, with significantly better in penetration of wood (Scheffrahn and Thoms 1993), it is not so effective at lower temperatures and requires significantly higher dosages to compensate. China has approved a specific treatment schedule for sulfuryl fluoride on logs for fumigation in Germany and other countries prior to export.

***Methyl isothocyanate/ sulfuryl fluoride mixture****.* The mixed gas of MITC and SF was registered in Japan in 2004 for logs infested with forest insect pests. MITC used in mixture with CO2 is effective against wood borers, bark beetles, and ambrosia beetles (Naito *et al.,* 1998). It has been found to be particularly effective against pinewood nematode (Soma *et al*., 2001).

***Methyl iodide (MI)/$CO_2$ and the methyl isothocyanate (MITC)/sulfuryl fluoride mixtures*** have been registered in Japan but are not yet used commercially. Complete mortality of the pinewood nematode and the longhorn beetles, *Monochamus alternatus* and *Arhopalus rusticus,* were attained using methyl iodide 50% and carbon dioxide 50% (Kawakami *et. al* 2004). Methyl iodide has successfully killed oak wilt fungus at rates similar to methyl bromide (Tubajika, 2006).

***Cyanogen.*** Cyanogen, or ethanedinitrile, has been investigated as a replacement for MB. Registration is currently being sought in Australia. Full-scale trials using cyanogen on stacks of sawn timber have been carried out in Malaysia under MLF-funded demonstration trials for methyl bromide alternatives (UNDP - MAL/99/G68/A/2G/99). Cyanogen penetrates wood quite rapidly both across and along the grain, in contrast to MB that travels along the grain but poorly across the grain (Ren *et al*. 1997). Unlike MB, it appears to penetrate high moisture content timber well.

A new ISPM is being drafted for the international movement of wood. This will include two categories of treatments, firstly those already in use in bilateral trades and with efficacies against specific pests. The second category will be for classes of wood (round wood, sawn wood and mechanically processed wood) and will be based on the draft criteria for future ISPM No.15 treatment submissions and used the same decision-tree approach.

#### *2.1.2 Non-chemical alternatives*

***Heat treatment –*** Heat has been accepted as a quarantine treatment for logs and timber to be shipped to the USA and many other countries for many years (e.g. USDA 1996). Kiln drying of timber to a moisture content of less than 20% using temperatures over 70°C is often a commercial requirement but also has long been accepted as a quarantine treatment by most importing countries. Hot water and steam treatment has long been used for risk mitigation for hardwood veneer logs imported into New Zealand. Such logs are invariably attacked by pinhole borers (Scolytidae and Platypodidae) before shipment. Moist heat treatment is an integral part of log conditioning prior to peeling but has the additional benefit of eliminating quarantine risk.

***Irradiation.*** Gamma irradiation has been suggested as a treatment for wood and wood products (Reichmuth, 2002), and is currently approved for logs into Australia. However, its practical application must overcome a number of hurdles, such as the construction of large irradiators to handle logs and bulk wood products. The technology is also limited by poor penetration into freshly cut logs, potential damage and degradation of wood products such as fibre board and paper, variation in effect on different insect groups, and very high dosages required to eliminate fungi (Morrell 1995).

***Water soaking*** or immersion provides a process for control of pests on imported logs. Immersion of some logs destined for plywood manufacture is a useful process as it improves the quality of the products. The potential for use of water soaking for quarantine treatment of imported logs is limited by the large area of water required and the undesirable side effects of ponding large volumes of logs.

***Debarking.*** Bark removal has long been a key strategy in reducing contamination of logs and reducing the risk that logs and sawn timber carry insects and fungi of quarantine concern. While debarking removes surface contamination and also bark and cambium, areas particularly prone to pest attack; it does not affect insects and fungi already in the wood (USDA, 1992). Many countries require debarking of all imported logs. Because of the high cost, and the requirement by customers in major Asian markets that bark remain on logs, its application as a quarantine treatment is limited and frequently only carried out on high value logs.

***Microwave treatment.*** This is essentially a heat treatment using electromagnetic energy in the 10 – 30,000 MHz range. The relationship between field intensity, exposure time and mortality of individual insect species is not well understood, but has been shown to be highly variable (Ria *et al.* 1972, Ikediala *et al.* 1999).

### 2.2. Wood packaging materials (WPM)

#### *2.2.1. Chemical alternatives*

In cases where WPM has to be treated together with heat vulnerable cargoes or goods to meet ISPM 15, there is no chemical option at present other than MB treatment, but alternative chemicals are being evaluated. The 2009 revision of ISPM 15 (IPPC 2009) did not recognise any alternative to methyl bromide except heat, but several potential alternatives to heat and methyl bromide are under continued testing. Potential alternatives have been submitted to the IPPC and are under evaluation. These include SF, SF + MITC mixture, Hydrogen cyanide, microwave irradiation, phosphine and MI, and were submitted to IPPC and have been evaluated in accordance with the IPPC process. The evaluation panels have requested additional efficacy data for all these potential alternatives. It seems that species of *Agrilus planipennis* (Emerald Ash Borer), *Anoplophora glabripennis* (Asian longhorned beetle, ALB) and *Bursaphelenchus xylophilus* (Pinewood nematode, PWN) are key pests that at least need to be controlled to a very high level of quarantine security by any alternative.

A new ISPM is being drafted for the international movement of wood that will include two categories of treatments, firstly those already in use in bilateral trades and with efficacies against specific pests. The second category will be for classes of wood (round wood, sawn wood and mechanically processed wood) and will be based on the draft criteria for future ISPM No.15 treatment submissions and used the same decision-tree approach.

#### *2.2.2 Non-chemical alternatives*

***Heat treatment -*** The only alternative treatment to methyl bromide treatment accepted internationally under ISPM 15 for treatment of wood packaging materials (WPM) is heat treatment, including kiln drying. A temperature of at least 56°C, core temperature, must be maintained for at least 30 minutes (IPPC, 2006). The 2009 version of the ISPM 15 standard (IPPC 2009) specifically encourages use of heat where feasible in preference to methyl bromide.

#### *2.2.3 Not in-kind alternatives for WPM*

Not-in-kind alternatives exist for wood pallets and other wooden packaging materials. These avoid the need for MB fumigation or heat treatment. Plastic pallets (often made from recycled plastic, which makes them reusable) are commercially available and are used by many companies in the EC, the US and many other regions of the world. Cardboard pallets can be suitable for loads of about 3,000 kg, for example, and are available commercially in Australia, the EC, Kenya, New Zealand, the US and others. Plastic, cardboard, plywood and particle board can also be used, instead of wood packing materials, for boxes, containers and staves which prevent goods moving within packed shipping containers. These materials are exempt from the requirements for MB or heat treatments under the ISPM 15 standard, which refers only to solid wood packaging materials. The ISPM 15 standard excludes non-wood packaging (plastic, cardboard) and specifically excludes plywood, particle board, oriented strand board and similar processed wood that has been subjected to glue or pressure during processing (IPPC 2009). As a side benefit, a reduction in the volume of new timber used for wood pallets would bring benefits to countries where forest resources are under pressure. Kenya, for example, is estimated to use about 250,000 to 300,000 wood pallets per annum for tea exports alone. This volume of pallets comprises about 5,500-6,600 tonnes of cut timber, which requires the felling or importation of about 8,330 - 10,000 tonnes of raw timber per annum (Rodwell, 2007). This demand for timber causes problems in Kenya where the tree cover is rapidly dwindling due to other pressures such as the need for firewood (Rodwell, 2007).

### 2.4 Emission reduction and recovery

An estimated 88% of the MB applied during standard commercial practice is emitted to the atmosphere from log fumigations (TEAP, 2009). There are several commercially available processes for recapture of residual methyl bromide. Present installations have individual capacities of less than 50kg of fumigant, but higher capacity units are being currently being installed. All commercially available recapture units are based on absorption onto active carbon, but subsequent treatment of the loaded carbon differs. Efficiencies of recapture are strongly dependent on good fumigation practice that minimises leakage during the exposure to the fumigant. Taking into account losses in practice during fumigations, including sorption losses and leakage, it is estimated that 30-70% of initial dosage is available for recapture, with good practice, depending the load treated and other conditions. For forest products this may exceed 80% under gastight chamber conditions. Commercially available recapture system also offers the ability to release recaptured methyl bromide for reuse, with a saving in practice of about 30% of methyl bromide use. Costs of recapture are highly situation-dependent, but may typically add 50-100% to the cost of a fumigation (TEAP, 2009). In some specific situations, such as for log exports from the port of Nelson, NZ, recapture is required to meet local air quality regulations.

## 3. Controlled uses in the forestry industry

Except for certain circumstances classified by the US to be QPS, fumigation of land where forest seedlings are grown, is considered a controlled, non-exempted use.

### 3.1 Alternatives to MB for forest nurseries

In various countries around the world, MB was traditionally used as the fumigant of choice to sterilize soil used for the production of forest seedlings. Practically all countries however, have found alternatives to this use, which perform as efficiently as MB. Examples of such alternatives are:

#### *3.1.1 Chemical alternatives*

A good amount of research has been devoted to the identification of chemical alternatives to MB for forest nurseries, particularly in the United States. Some examples are:

- ***Chloropicrin*** alone (South 2007, 2008) or in combination with herbicides - when weeds pose problems. This option has also been adopted successfully in Chile (Barel, 2003)
- ***1,3-Dichloropropene + Chloropicrin*** (1,3-D/Pic) is a good option when there are nematodes present in the soil (South 2008).
- ***Methyl iodide*** has been found to provide control of pathogens and weeds that is not significantly different to that achieved with MB (Enebak, 2006). This is a new fumigant which is now registered in most of the United States (not California) and for which registration is presently sought in other countries (for example Turkey, Australia, Mexico, Japan)
- ***Metham sodium*** combined with Pic (Cram *et al.,* 2007) or combined with1,3-D plus Pic (South, 2008)
- ***Dazomet*** (Muckennfuss *et al*. 2005; Enebak *et al*., 2006).
- ***Dimethyldisulfide*** (DMDS) plus chloropicrin is showing promising results, especially since it does not affect populations of *Trichoderma*, a beneficial fungus that is important for proper development of forest seedlings (Quicke, 2008)

Tarping the soil with barrier films (LPBF) that greatly reduce the amount of fumigants that is released into the atmosphere is a way of reducing dosage rates of MB used in forest nurseries Enebak (2007), which can also be applied to other fumigants, for example Pic and metham sodium.

#### *3.1.2 Non-chemical alternatives*

***Substrates.*** An alternate approach to chemical soil treatments is the production of nursery stock in bags or containers of different types, using soilless substrates (MBTOC, 2007). Substrates are becoming increasingly adopted as they avoid the need for methyl bromide in many countries (Walters *et al.,* 2008). Maintaining good hygiene levels for plug plants is essential in this case, since contamination can produce outbreaks of diseases, including airborne diseases which can proliferate under the controlled conditions of plug production.

Production systems where this approach is economically feasible and allows for the production of high quality products have been identified. Good examples are found for example in Chile where large nurseries produce millions of conifer seedlings each year in substrates and Brazil, where International Paper produces over 40 million seedlings of eucalyptus and conifers every year, also in substrates (Ghini, pers. comm., 2009). After being amongst the largest users of MB in the developing world, Brazil has completely phased-out this chemical and presently restricts its use exclusively to QPS. Various materials can be used as substrates (e.g. rock wool, peat moss, rice hulls, coconut husks, gravel and bark) and can be reused after sterilizing with steam or hot water.

***Steam*** is in wide use for treating used substrates recycled for use for the production of forestry propagation materials in Europe (EC Management Strategy, 2008) as well as in other countries around the world, including developing countries.

These alternatives have proven effective even in situations where propagation materials are subjected to certification requirements.

## 4. References

Barel, M. (2003). Personal communication. Consultant, The Netherlands

Cram, M., S.A. Enebak, S.W. Fraedrich, L.D. Dwinell and S.J. Zarnoch. (2007) Evaluation of fumigants, EPTC herbicide and *Paenibacilus macerans* in the production of loblolly pine seedlings. *Forest Science* 53(1): 73 - 83

EC. European Community (2008). European Community Management Strategy for the phase-out of critical uses of Methyl Bromide. July, 2008

Enebak, 2007. Methyl bromide and the Montreal Protocol: An update on the Critical Use Exemption and Quarantine Pre-shipment process. *USDA Forest Service Proceedings* RMRS-P-50 pp 135 - 141

Enebak, S., T. Starkey, and D. McCraw. (2006). Tree seedling quality and weed control with Basamid, MBR and methyl iodide. Annual International Research Conference on Methyl Bromide Alternatives, Orlando, FL, USA.

Ghini, R. (2009)., Personal communication EMBRAPA, Brazil

Ikediala, J.N., Tang,L, Neven, L.G. and Drake, S.R. 1999. Quarantine treatment of cherries using 915 MHz microwaves: temperature mapping, codling moth mortality and fruit quality. *Postharvest Biological Technology* 16: 127-137.

IPPC (2006). ISPM No. 15. Guidelines for regulating wood packaging material in international trade (2002) with modifications to Annex 1 (2006). IPPC: Rome. 11 pp.

IPPC (2008). IPPC Recommendation. Replacement or reduction of the use of methyl bromide as a phytosanitary measure. Appendix 6. Report of the Third Session of the Commission on Phytosanitary Measures, Rome, 7-11 April 2008, 10 pp.

IPPC (2009). International standards for phytosantary measures. Revision of ISPM No. 15. Regulation of wood packaging material in international trade. https://www.ippc.int/servlet/CDSServlet?status=ND0xMzM5OSY2PWVuJjMzPSomMzc9a29z

Kawakami, F. Y. Soma, H. Komatsu and Y. Matsumoto (2004) Effects of Some Fumigants on the Pine Wood Nematode, *Bursaphelenchus xylophilus* Infesting Wooden Packages. 4. Mortality and CT Product in Methyl Bromide Fumigation with High Loading of Wood Packing Materials. *Res. Bull. Pl. Prot. Japan* 40: 7_12.

MBTOC (2007). 2006 Assessment Report of the Methyl Bromide Technical Options Committee. UNEP, Nairobi, Kenya, 485 pp.

Morrell, J.J 1995: Importation of unprocessed logs into North America: A review of pest mitigation procedures and their efficacy. *Forestry Products Journal* 45(9):41-50.

Muckennfuss A. (2005). Basamid G for weed control in forest tree nurseries. In: Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions, San Diego, California

Naito H., Y.Soma, I. Matsuoka, T.Misumi, T. Akagawa, M.Mizobuchi and F. Kawakami. 1999; Effects of methyl isothiocyanate on forest insects pests. *Res. Bull. Pl. Prot. Jap*. 35:1-4

Quicke, M., T. Starkey and S. Enebak (2008) Area-Wide demonstration of alternatives: Forest nurseries in the southern US . In: Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions, Orlando, Florida, November 11 – 14, 2008

Reichmuth, C.H. (2002). Alternatives to methyl bromide for the treatment of wood, timber and artefacts in the European community. In: International Conference on Alternatives to Methyl Bromide, March 2002, Seville, Spain.

Ren Y.L., Desmarchelier J.M. and O'Brien I.G. (1997). Improved methodology for studying diffusion, sorption and diffusion in timber fumigation. *Journal of Stored Products Research* 33: 199-208.

Rhatigan RG, Morrell JJ, Filip GM. 1998. Toxicity of methyl bromide to four pathogenic fungi in larch heartwood. *Forest Products Journal* 48: 63-67.

Ria, P.S., Ball, H.J., Nelson, S.O., and Stetson, L.E. (1972). Lethal effects of radio-frequency energy on the eggs of Tenebrio molitor. *Annals Entomological Society of America.* 65: 807-810.

Rodwell, P. (2007) Cardboard tea pallet. Mombasa, Kenya.

Scheffrahn, R.H. and Thomas, E.M. (1993). Penetration of sulfuryl fluoride and methyl bromide through selected substrates during fumigation. *Down to Earth* 48 (1).

Soma Y., H. Naito, Y. Abe, T. Misumi, M. Mizobuchi, Y Tsuchiya, I Matsuoka and F. Kawakami (2001) Effects of Some Fumigants on Mortality of the Pine Wood Nematode, *Bursaphelenchus xylophilus* Infesting Wooden Packages; 1. susceptibility of Pine Wood Nematode to methyl bromide, Methyl Isothiocyanate and Sulfuryl Fluoride. *Res. Bull. Pl. Prot. Japan* No.37: 19-26.

South (2007). Chloropicrin as a soil fumigant treatment in southern pine nurseries. *Southern Journal of Applied Forestry* 31(1) 2007

South D. B. (2008). Comments on alternatives to methyl bromide for quarantine purposes in forest nurseries. In: Dumroese RK, Riley LE, technical coordinators. *National Proceedings: Forest and Consevation Nursery Associations 2008.*

Tubajika,K.M and Barak, A.V.: Methyl Iodide and Sulfuryl Fluoride as Quarantine treatments for Solid Wood Packing Material. MBAO Conference, Orlando, Florida, 2006

UNDP (1999). Demonstration project on methyl bromide alternatives in Malaysia (MAL/99/G68/A/2G/99)

TEAP, (2009) October 2009 Report . Quarantine and Preshipment Taskfroce. Final Report. UNEP, Nairobi 332 pp.

USDA. (1996). Importation of logs, lumber, and other unmanufactured wood articles. 7CFR319.40 USDA Animal and Plant Health Inspection Service. Washington, DC.USDA 1996

USDA (1992): Pest risk assessment of the importation of *Pinus radiata* and Douglas fir logs from New Zealand. USDA, Forest Service. Miscellaneous Publication No. 1508

Walters, T., T. Miller, M. Particka, J. N. Pinkerton and I. Zasada (2008) Methyl bromide alternatives for raspberry nurseries. In: Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions, Orlando, Florida, November 11 – 14, 2008