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Report to the Ranking Minority Member, Committee on Commerce, House of Representatives

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PESTICIDES

The Phaseout of Methyl Bromide in the United States

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GAO

United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and Economic Development Division

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The Honorable John D. Dingell
Ranking Minority Member
Committee on Commerce
House of Representatives

Dear Mr. Dingell:

Emissions of various chemicals are depleting the stratospheric ozone layer, which shields the earth from the sun's harmful ultraviolet rays.[1] According to the Environmental Protection Agency (EPA), increased ultraviolet radiation reaching the earth's surface can, over time, raise the incidence of skin cancer and cataracts and weaken the immune system in humans, as well as damage the environment.

To protect the ozone layer, 24 nations, including the United States, signed the Montreal Protocol in September 1987, agreeing to place controls on and perform further assessments of major ozone-depleting substances. In 1990, the Congress amended the Clean Air Act to, among other things, require EPA to identify ozone-depleting substances and phase out their production. In December 1993, EPA issued regulations under these provisions to phase out methyl bromide, a widely used agricultural pesticide identified by scientists as an ozone-depleting substance. EPA's regulations freeze the production and importation of methyl bromide at 1991 levels until January 1, 2001; after this date, the pesticide can no longer be produced or imported into the United States for domestic use. The Montreal Protocol—now signed by over 150 countries—freezes methyl bromide's production at 1991 levels but does not require a phaseout.

Methyl bromide has been used in agriculture since the 1930s, principally as a fumigant to control pests in the soil before planting various crops, to protect stored agricultural commodities, and to treat commodities being shipped in international trade.[2] In response to your questions about the consequences of banning methyl bromide for these purposes, we agreed to provide you with information on (1) the scientific evidence that emissions from human uses of methyl bromide are depleting the ozone layer, (2) the

[1]There are three types of ultraviolet radiation classified according to their wavelength. UV-C, the most harmful, does not reach the earth's surface. UV-B, which is somewhat less harmful, is partially absorbed by stratospheric ozone. UV-A, the least harmful, reaches the earth with little obstruction.

[2]Similarly, methyl bromide is used to fumigate certain commodities shipped between states such as California and Florida.

availability of economical and effective alternatives to the pesticide's agricultural uses, (3) the effects of banning the pesticide on U.S. trade in agricultural commodities, and (4) EPA's authority under the Clean Air Act to exempt essential uses from the phaseout.

Results in Brief

World scientists participating in the United Nations Environment Programme's assessment of ozone-depleting substances have concluded that emissions from human uses of methyl bromide contribute significantly to ozone depletion and should be controlled. Although some complex atmospheric processes are not fully understood, scientists know from laboratory measurements that bromine, a major component of methyl bromide, is very efficient in destroying ozone.

Various chemical and nonchemical pest-control alternatives are available, but none is as economical and effective as methyl bromide for its many uses. Hence, a combination of these alternatives will likely have to replace methyl bromide. The agricultural community is concerned that federal research to identify the most cost-effective alternatives or combination of alternatives is not adequately funded or coordinated. For some uses, such as treating certain commodities in trade and destroying certain organisms in the soil that can cause plant diseases, alternatives have not yet been identified.

If other countries continue to use methyl bromide after it is phased out in the United States, they may have an unfair advantage in international markets for the various agricultural commodities produced with the substance. At the next meeting of the parties to the Montreal Protocol in November 1995, U.S. officials plan to propose a worldwide phaseout similar to the U.S. one. The officials believe that the parties are likely to agree on some additional controls but not to a phaseout. In addition, a U.S. phaseout could mean that some commodities, which must now be fumigated with methyl bromide to kill pests that might damage U.S. crops, could no longer be imported into this country. Other countries have similar requirements that might affect U.S. exports.

The Clean Air Act does not authorize EPA to grant exemptions from the ban on producing and importing methyl bromide except for use in medical devices and for export to developing countries that have signed the Montreal Protocol. The Clean Air Act would have to be amended before EPA could grant exemptions from the January 1, 2001, ban for other uses.

Background

During the past decade, both international and national efforts have been made to control ozone-depleting chemicals. Shortly after the United Nations Environment Programme (UNEP) developed the Montreal Protocol on Substances that Deplete the Ozone Layer (Protocol), the Congress added title VI to the Clean Air Act to supplement the Protocol's terms and conditions. Amendments to the Protocol and regulations implementing title VI have since expanded the restrictions on individual ozone-depleting chemicals.

An ozone depletion potential (ODP) index is used under the Protocol and the Clean Air Act to gauge a substance's relative potential to deplete stratospheric ozone. This index primarily reflects the substance's (1) likely lifetime in the atmosphere and (2) efficiency in destroying ozone compared with chlorofluorocarbon-11 (CFC-11), a widely used refrigerant and major ozone depleter that is being phased out under the Protocol and the Clean Air Act. On the basis of scientific assessments performed in December 1991 and updated in June 1992, UNEP calculated that methyl bromide has an ODP of 0.7, or 70 percent of CFC-11's ozone-depleting potential.

The Protocol originally placed controls on eight major ozone depleters—five chlorofluorocarbons (CFC) and three halons—and provided for technical and scientific assessments of potential ozone-depleting substances to be undertaken at least every 4 years.[3] In November 1992, following the update of UNEP's 1991 assessment, the parties to the Protocol first imposed controls on methyl bromide. They agreed to accept UNEP's calculation of methyl bromide's ODP as 0.7, and they amended the Protocol to freeze production of the substance at 1991 levels, beginning in January 1995.[4] They did, however, create an exemption for the substance's preshipment and quarantine uses.[5] The parties also agreed to decide by January 1, 1996, how the freeze would affect the consumption of methyl bromide in developing countries. (The Protocol allows methyl bromide producers to produce 10 percent above 1991 levels for export to

[3]Halons have been used primarily as fire extinguishers in ships, planes, and military vehicles, as well as in computer facilities, telephone switching centers, and other places where materials would be damaged by the use of water or foam fire extinguishers.

[4]The agreement technically froze member countries' "consumption" levels of methyl bromide, that is, the amounts produced plus the amounts imported minus the amounts exported.

[5]Preshipment use generally refers to the treatment with methyl bromide of commodities being exported to meet the phytosanitary and sanitary (plant and animal health) requirements of the importing country. Quarantine use refers to the treatment performed or authorized by a national plant, animal, environmental protection, or health authority to prevent the introduction, establishment, or spread of harmful pests that are (1) not yet present or (2) present but not widely distributed and being officially controlled.

developing countries.) The parties further agreed to consider imposing additional controls on methyl bromide at their November 1995 meeting, after they had reviewed the results of UNEP's next round of scientific and technical assessments. These assessments were completed in late 1994.

Title VI of the Clean Air Act identifies many substances that EPA is to list as ozone depleting and requires the agency to list any others that have an ODP of 0.2 or that it finds may reasonably be anticipated to cause harm to the ozone layer. These substances are to be listed as either class I or class II, depending primarily on their ODP. The title authorizes EPA to add substances to either list and requires the agency to update both periodically. Substances that have an ODP of 0.2 or greater are to be listed as class I, and EPA is to take action to phase out their production no later than 7 years after they are listed. The schedule for phasing out the less threatening class II substances is less stringent.

In December 1991, three environmental groups petitioned EPA under the Clean Air Act to list methyl bromide as a class I substance. EPA concluded, in large part on the basis of UNEP's calculation, that methyl bromide has an ODP of 0.7, well above the act's 0.2 threshold for listing as a class I substance. In December 1993, EPA issued a rule first freezing and then banning the production and importation of methyl bromide. The freeze, which is at 1991 levels, took effect on January 1, 1994. No further reduction from 1991 levels is required until January 1, 2001, when the ban is mandated to begin. EPA imposed no further reductions during this 7-year period because it recognized that the loss of methyl bromide would be costly and it wanted to allow as much time as possible for the development of alternatives. (In promulgating the rule, EPA estimated both the costs and benefits of phasing out methyl bromide. The U.S. Department of Agriculture (USDA) and the University of California at Berkeley and the University of Florida have also estimated the costs of banning methyl bromide's agricultural uses. App. I summarizes these studies.)

Table 1 compares the controls placed on methyl bromide by the Montreal Protocol and by EPA's regulation.

Table 1: Comparison of Controls Placed on Methyl Bromide

Provision	Montreal Protocol	U.S. regulation
Freeze on production and importation	Production and importation were frozen at 1991 levels, effective January 1, 1995.	Production and importation were frozen at 1991 levels, effective January 1, 1994.
Exemptions to the freeze	Preshipment and quarantine uses were exempted. Methyl bromide producers can generally exceed their 1991 levels by 10 percent for export to developing countries. The Protocol parties are to decide by January 1, 1996, how the freeze will affect developing countries.	No exemptions have been granted yet, but EPA has the authority to grant exemptions for use in medical devices and for export to developing countries.
Ban on production and importation	No ban has been approved.	A ban on production and importation becomes effective January 1, 2001.

Methyl bromide is a highly effective fumigant used to control a broad spectrum of pests—insects, nematodes (parasitic worms), weeds, pathogens (bacteria, fungi, and viruses), and rodents. The agricultural community today uses it for over 100 crops. U.S. production in 1993 was over 60 million pounds.[6] About 80 percent is used to fumigate the soil before planting crops.[7] Another 19 percent is used to fumigate harvested agricultural commodities during storage—including those being exported from and imported into the United States—and to fumigate structures such as food processing plants, warehouses, mills, and grain elevators. A small amount is used in the production of other chemicals.

According to EPA, methyl bromide is a very toxic substance whose effects on human health depend on the concentration and duration of the exposure. Exposure to the pesticide can damage the lungs, eyes, and skin and, in severe cases, cause the central nervous and respiratory systems to fail. Gross permanent disabilities or death may result. Agricultural field workers and structural fumigators have developed respiratory, gastrointestinal, and neurological problems, including inflammation of nerves and organs and degeneration of the eyes. EPA officials told us that exposures to high concentrations have resulted in deaths.

[6]Chemical Marketing Reporter, Vol. 245, No. 1 (Jan. 3, 1994).

[7]According to a 1994 USDA report, five crops—tomatoes, strawberries, peppers, ornamentals, and tobacco—account for over 80 percent of the methyl bromide used for soil fumigation.

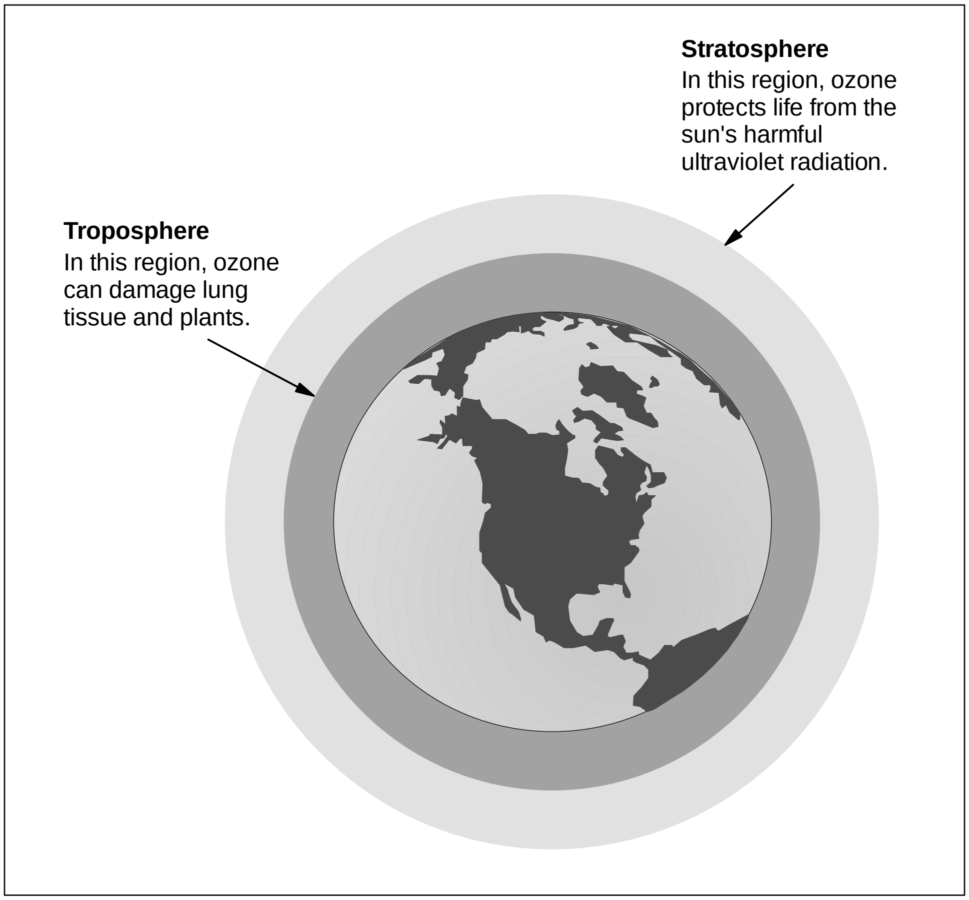
Scientific Evidence of Methyl Bromide's Role in Ozone Depletion

UNEP's scientific assessments of ozone-depleting substances have concluded that methyl bromide is a significant ozone depleter.[8] Although some uncertainties are involved in these assessments, the participating scientists are confident that methyl bromide's ODP will not drop below the 0.2 level that triggers the phaseout of the pesticide as a class I substance under the Clean Air Act.

The atmosphere is made up of distinct layers, each of which has its own composition of gases and natural processes. The troposphere extends from the earth's surface up to about 6 miles, and the stratosphere extends from the troposphere to about 30 miles above the surface. Although ozone can be harmful in the troposphere—it is a primary constituent of smog—in the stratosphere it helps protect life on earth from the sun's ultraviolet radiation. (See fig. 1.)

[8]According to the Montreal Protocol's 1992 assessment update report, modeling results suggest that emissions of methyl bromide from human activities could have accounted for about 5 to 10 percent of the current observed stratospheric ozone loss. The modeling results further suggest that this amount could grow to about 17 percent by the year 2000 if emissions continue to increase at the present rate of 5 to 6 percent per year.

Figure 1: Ozone in the Earth's Atmosphere



Ozone is continuously being produced naturally in the stratosphere by a photochemical reaction caused by the sun's rays. It is also continuously being removed by other chemical reactions. According to scientists involved in the UNEP assessment, the production and destruction of ozone are normally in balance. However, as emissions from human uses of ozone-depleting chemicals reach the stratosphere, more ozone is lost than is created, and the ozone layer is thinned. Similarly, methyl bromide is continuously being produced and removed from the atmosphere by natural processes—scientists estimate that up to 60 percent or more of the methyl bromide in the atmosphere may be released from the oceans. Again, the UNEP scientists believe that the amounts produced and removed by natural processes tend to be in balance. Therefore, their concern about methyl bromide as an ozone depleter is focused on emissions from human uses.

The scientific basis for the Montreal Protocol's freeze and EPA's phaseout was principally a 1992 assessment completed under the auspices of UNEP. This assessment, which scientists from around the world performed for the parties to the Montreal Protocol, concluded that the best estimate of methyl bromide's ODP was 0.7. The 1994 UNEP scientific assessment found that the pesticide's ODP is 0.6.

Producers of methyl bromide and members of the agricultural community have expressed concern about UNEP's estimate of the substance's ODP. More specifically, they have questioned UNEP's calculation of methyl bromide's "lifetime" in the atmosphere, which the 1994 UNEP assessment calculated to be about 1 year.[9] This calculation is important because the less time the substance is in the atmosphere, the less chance it has of reaching the stratosphere and depleting the ozone layer. UNEP's calculation of the pesticide's lifetime assumes that significant amounts of methyl bromide are being removed from the atmosphere through chemical reactions in the troposphere and through interaction with the oceans. However, some in industry and the agricultural community have suggested that soil and vegetation may also remove significant amounts of methyl bromide from the atmosphere. Scientists who participated in the UNEP assessment believe that the range of uncertainty factored into their estimates of methyl bromide's lifetime is sufficient to allow for the possibility that the substance may be removed by soil and vegetation.

The other major part of the ODP measurement is the relative efficiency of methyl bromide in destroying ozone. On the basis of laboratory measurements, the scientists who participated in the UNEP assessment estimate that bromine, a major component of methyl bromide, is about 50 times more efficient in destroying ozone than the chlorine in chlorofluorocarbons.

Additional research is addressing the scientific uncertainties currently involved in calculating methyl bromide's ODP. At this point, the scientists associated with the UNEP assessment anticipate only a further refinement of the ODP calculation. They are confident that the research results will not bring the ODP below 0.3.

[9]Various physical and chemical processes tend to break down and remove chemicals in the atmosphere. Atmospheric lifetime is a measure of how long a gas stays in the atmosphere before it is removed by these processes. Atmospheric lifetimes are commonly modeled as e-folding lifetimes, which means that the concentration of a gas is assumed to decay exponentially.

Availability of Economical and Effective Alternatives

EPA, USDA, and industry representatives generally agree that chemical substitutes and other alternatives are available today to manage many of the pests currently controlled with methyl bromide. They further agree that no one substitute or alternative is available for methyl bromide's many uses and that research is needed to identify the alternatives or combinations of alternatives that can economically and effectively replace the pesticide's individual uses. USDA and the agricultural community, however, are less optimistic than EPA that economical and effective alternatives will be identified by the time the ban on methyl bromide goes into effect in 2001. EPA, USDA, and industry are sponsoring or conducting research on alternatives, but it is not clear at this point what this research will be able to achieve over the next 5 years.

Effectiveness of Efforts to Identify Replacements Is Unclear

According to EPA, there are many chemical and nonchemical alternatives to methyl bromide. These include fumigants that can kill a range of pests similar to those killed by methyl bromide. Other chemicals—for example, insecticides, fungicides, and herbicides—with a more limited range are also available. Nonchemical alternatives include techniques such as rotating crops to avoid a buildup of pests, using plants that are more pest-resistant, and using organisms like parasitic bacteria to control weeds and nematodes.

These alternatives, according to EPA, are technically capable of controlling many of the pests currently controlled by methyl bromide. (In its 1994 report, UNEP's Methyl Bromide Technical Options Committee said that it had identified a technically feasible alternative, either currently available or at an advanced stage of development, for over 90 percent of the uses being made of methyl bromide in 1991.[10] According to the report, alternatives were not identified for controlling some soilborne viruses and other pathogens and for some quarantine procedures.) The key question—assuming that the alternatives do not pose any unmanageable health and environmental risks—is which alternative or combination of alternatives is most effective and economical in a given situation.

According to USDA officials, alternatives are not currently available for some important uses, such as treating certain quarantined commodities and responding to certain incidents or emergencies. The officials noted, for example, that ships carrying infested commodities may dock at U.S.

[10]The Methyl Bromide Technical Options Committee is one of the technical committees operating under the Technology and Economic Assessment Panel, which was established under the Montreal Protocol to perform the technical and economic assessments needed for the parties to consider controls on ozone-depleting substances.

ports, military equipment contaminated with soilborne pests may be brought back to the United States, or a destructive pest, such as the Mediterranean fruit fly, may be found in an area of California or another state. In these circumstances, they said, fumigation with methyl bromide is the only effective way to deal with the pests.

USDA officials also pointed out that numerous scientific, economic, and environmental variables have to be considered in evaluating potential replacements. Selecting a replacement can be further complicated because a use can be quite specific. For example, alternatives for preplant soil fumigation (a technique for killing pests in the soil before planting) will need to be selected on the basis of such factors as the crop grown, the pests present in the soil, the climate, and the geographical location. Government and industry researchers believe that considerable research and field testing are needed to define the alternatives' efficacy, applicability, and cost-effectiveness in given situations.

To fund research on alternatives to methyl bromide, EPA and USDA spent about $13.3 million in fiscal year 1995 and, according to agency officials, a similar amount has been requested for fiscal year 1996. However, the Crop Protection Coalition[11] estimates that about $60 million is needed annually for this research. According to the Coalition, the public sector has not mobilized sufficient resources and funds to achieve meaningful results before 2001 in either preplant or postharvest applications. The Coalition also believes that this research needs to be more effectively coordinated.

The Coalition, with USDA's and EPA's cooperation, is attempting to consolidate federal and private research activities into a single agenda reflecting a consensus on priorities. In July 1995, the Coalition issued a report on the status of research activities to (1) help prioritize projects for funding, (2) identify gaps in current research, and (3) improve the transfer of technology to users of methyl bromide.[12] According to a USDA official, the Coalition's report and research agenda will be discussed at an international research conference on alternatives and methods for reducing methyl bromide emissions that the Department is cosponsoring in November 1995 with the Coalition and EPA.

[11]A national organization of about 30 fresh fruit and vegetable producers, associations, cooperatives and related industries. During action on USDA's fiscal year 1995 appropriation, the Senate Appropriations Committee expressed its expectation that the Department would work with the Coalition on directing funds for methyl bromide research (Senate Report 103-290, June 23, 1994, p. 23).

[12]Status of Methyl Bromide Alternatives Research Activities, Crop Protection Coalition (July 1995).

New Chemical Substitutes Appear Unlikely

USDA, the Methyl Bromide Working Group—which represents methyl bromide producers and distributors—and the Crop Protection Coalition believe that very few new chemical alternatives will be available when the ban on methyl bromide goes into effect. They said that substantial development costs, research requiring multiple planting cycles, and federal/state regulatory reviews are involved in putting a new chemical on the market. They noted that moving a new pesticide from development to commercialization can take up to 10 years and cost a manufacturer from $50 million to $70 million. As part of this process, the manufacturer must develop the health and safety data that EPA requires to register a pesticide for use.

Under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), EPA decides whether to register a pesticide after assessing, among other things, the potential effects on human health and the environment of using a pesticide product according to the directions on the label. A separate registration is required for each new chemical, and an existing registration has to be amended for a new or different use. The registration process can take many years, depending on the type of substance, the complexity of the testing needed, the gaps in the data, and the nature of EPA's findings from the health and safety data submitted for the agency's review. However, EPA recently established an expedited system for reviewing alternatives to methyl bromide.[13] According to EPA, to date, no new chemicals and only a few new uses of existing chemicals have been submitted to EPA as potential alternatives to methyl bromide.

Under 1988 amendments to FIFRA, all pesticides registered before November 1984 must be reviewed for reregistration and the data supporting their registrations must be brought up to current scientific standards. Methyl bromide and a number of pesticides that have been approved for use on pests now controlled by methyl bromide are included in this group of chemicals. USDA has identified six of these chemicals as potential alternatives to methyl bromide.[14]

[13] In a July 13, 1995, pesticide regulation notice (No. 95-4), EPA explained the expedited review process and invited the submission of potential alternatives. In this notice, EPA said that if all necessary data have been submitted, the agency will work to ensure that decisions are made within 6 months on petitions for new food uses for registered pesticides, within 8 months on applications to register biological pesticides, and within 12 months on applications to register new active ingredients as reduced-risk pesticides.

[14] These chemicals are 1,3-dichloropropene, dazomet, metam-sodium, chloropicrin, phosphine, and dichlorvos.

For each of the alternatives identified by USDA, EPA has found potentially serious environmental and/or health and safety concerns. According to USDA officials, regulatory actions by EPA to ban or limit the use of these or other pesticides because of health and environmental concerns could exacerbate the economic effects of the methyl bromide phaseout by eliminating potentially effective alternatives. However, EPA officials told us that, under FIFRA, the agency balances risks and benefits, and if the benefits of using a pesticide outweigh the potential risks to people and the environment, then EPA may register or reregister the pesticide. The officials said that EPA is likely to reregister many of the chemical alternatives to methyl bromide after adopting appropriate risk mitigation measures, such as label changes. (App. II lists these and other potential alternatives to methyl bromide's agricultural uses and describes various concerns raised by EPA and others. The appendix also lists recent studies and reports by EPA, USDA, industry, and environmental groups that provide additional details on alternatives.)

Reducing Emissions and Recycling Are Not Alternatives Under the Clean Air Act

Some technically proven methods for reducing methyl bromide emissions, such as better sealing of fumigation enclosures, are available. In addition, industry is working to develop technology that can recapture and recycle a very high percentage of the methyl bromide used to fumigate commodities and structures. According to UNEP's Methyl Bromide Technical Options Committee, a few pieces of methyl bromide recovery equipment are already in use, and prototype systems capable of recycling recaptured gas for some uses will be evaluated by the end of 1995. Although using these technologies could substantially reduce emissions, the Clean Air Act does not exempt production for use in such systems from the ban. However, using recovery and recycling technology would extend the existing supply of methyl bromide when the ban on production and importation becomes effective.

Exemptions for Essential Uses May Be Necessary

In August 1995, EPA's Assistant Administrator for Air and Radiation said that the agency is aware of and understands the agricultural community's concern that it does not currently have satisfactory substitutes for all uses of methyl bromide.[15] The Assistant Administrator said that alternatives are available to effectively control many of the pests on which methyl bromide is used and that research on additional alternatives is taking place. According to the Assistant Administrator, the critical issue is whether

[15]Statement of the Assistant Administrator for Air and Radiation, EPA, before the Subcommittee on Oversight and Investigations, House Committee on Commerce (Aug. 1, 1995).

adequate alternatives will be available by the time the phaseout deadline arrives and, if they are not available, the agency will seek an appropriate solution. According to EPA, alternatives do not need to be identical to methyl bromide but they must be environmentally acceptable and must effectively and economically manage those pests that are now being controlled by the pesticide. (As discussed later, the Clean Air Act would have to be amended to give EPA the authority to grant exemptions from the ban.)

Potential Impact of Banning Methyl Bromide on U.S. Trade

Because methyl bromide is an important pesticide worldwide, a ban that took effect in the United States before similar actions were implemented in other countries could create an "uneven playing field" in international trade for U.S. producers of various agricultural commodities. The need to use more costly and/or less effective alternatives could increase the costs and reduce the yields for growers of U.S crops. In addition, some countries require certain U.S. commodities to be treated with methyl bromide as a condition of entry. These exports would likely be lost unless acceptable alternatives could be agreed upon with the importing countries. Likewise, the United States requires treatment with methyl bromide as a condition of entry for certain imports. The impact of the U.S. ban on agricultural trade, however, will depend on the controls other countries have placed on methyl bromide and on the cost-effectiveness of the alternatives available when the U.S. ban goes into effect in 2001.

Use May Continue in Many Countries

Although the parties to the Montreal Protocol are to consider placing additional controls on methyl bromide at their November 1995 meeting, they may not agree to ban the pesticide. According to U.S. officials, the United States will propose a ban, but contacts with representatives of other countries indicate that a wide range of proposals will be made at the meeting. For example, the technical assessment report prepared for the parties by UNEP's Methyl Bromide Technical Options Committee states that individual committee members estimated feasible reductions in methyl bromide emissions ranging from 50 percent by 1998 to only a few percent by 2001.

Even if the parties agree to a ban, they may give developing countries special consideration. The parties have recognized that these countries may not have the technical or financial resources to switch to alternatives or that a change may have a greater economic impact on them than on more developed countries. For example, in addition to financial and technical assistance, the Protocol gave these countries a 10-year grace period to implement the controls on CFCs and halons. The Methyl Bromide Technical Options Committee is presenting several options for the parties to consider if additional controls are placed on methyl bromide. One proposal would establish a 9-year grace period for developing countries, with reviews every 3 years to determine whether the grace period should be adjusted. Another option would cap or freeze the quantities used by developing countries and grant exemptions for preshipment and quarantine uses.

A few countries have acted independently to control their methyl bromide emissions. According to EPA, the Netherlands phased out its use of methyl bromide for soil fumigation in 1992 because of concerns that the pesticide contaminates groundwater. Germany and Switzerland have also prohibited its use on soil. Denmark and Sweden plan to phase out the pesticide's uses by 1998, as does Italy by 2000, although Italy plans to retain essential uses. The European Union plans a 25-percent reduction in use by 1998, and Canada has drafted controls calling for a 25-percent reduction by 1998.

Loss for Soil Fumigation Could Hurt U.S. Competitiveness

In response to a 1994 survey by the Methyl Bromide Technical Options Committee, 39 countries reported information on their use of methyl bromide for preplant soil fumigation. The committee also obtained estimates from industry for nine additional countries. Although the use of methyl bromide in many of these countries is small (developing countries account for about 18 percent of its use), the crops produced with it are primarily high-value cash crops, usually for export. Because these crops—for example, strawberries, tomatoes, peppers, cucumbers, and various other produce—are similar to those grown in the United States with methyl bromide, producers in these countries potentially compete with U.S. growers for both domestic and international markets for these commodities.

Studies done by USDA and for California and Florida, the two states that are the largest users of methyl bromide for soil fumigation, have concluded that alternatives to the substance are less effective in controlling soil pests and often cost more (see app. I). According to USDA officials, the higher costs and reduced yields would put U.S. growers at a disadvantage if growers in other countries could continue to use methyl bromide. For example, the Florida study stated that the use of methyl bromide is critical because of the state's environment. According to the study, producers faced with substantially reduced revenues would reduce their acreage for fresh fruit, vegetable, and fresh citrus crops. The study concluded that the primary beneficiary would be Mexico, which, the study assumed, would be given longer, as a developing country, to use methyl bromide under any future agreement reached under the Montreal Protocol. If Mexico or other developing countries expand their use of methyl bromide, the environmental benefits gained by phasing out the pesticide's use in the United States would be at least partially offset.

EPA's Methyl Bromide Program Director told us that the U.S. agricultural community's concerns about the uneven playing field may be valid. He said that Mexico may increase its production of such fruits and vegetables as tomatoes and strawberries, which are major crops for California and Florida. He added, however, that additional study would be needed to determine whether Mexico could realistically market increased amounts of these commodities in the United States. For example, could strawberries be shipped to market in time to maintain the necessary freshness? And would these fruits and vegetables be grown in Mexico at the same time of year as in the United States?

According to USDA officials, the Florida study and two recent USDA studies document the competition that the United States faces from developing countries, especially Mexico, in markets for crops whose production relies heavily on the use of methyl bromide.[16] The officials said, for example, that such competition occurs in the cucumber market in March and April, in the bell pepper market from January through March, and in the tomato market from January through April. The officials also said that Mexico has supplied nearly all of the strawberries imported into the United States over the last 5 years.

Treatment With Methyl Bromide Is Required for Certain Exports and Imports

Although less than 1 percent of the methyl bromide produced in the United States is used to treat quarantined commodities, this use is important because it permits trade in these commodities. During quarantine treatments, which are usually done at international borders, the commodities are fumigated to kill pests that could cross geographical barriers and infect susceptible crops or commodities. Quarantine requirements are negotiated between the importing and exporting countries for individual commodities, and the treatments are governed by strict regulations that require very high efficacy levels. For example, USDA's Animal and Plant Health Inspection Service (APHIS) requires efficacy levels

[16]The two USDA studies, issued by the Economic Research Service, are Competition in the U.S. Winter Fresh Vegetable Industry, Agricultural Economic Report No. 691 (July 1994), and The U.S. Strawberry Industry Statistical Bulletin No. 914 (Jan. 1995).

of 99.9968 percent for most treatments. To meet these efficacy levels, APHIS requires that certain imports be treated with methyl bromide because of its effectiveness, and some other countries, notably Japan, likewise require this treatment for certain imports from the United States.

APHIS currently requires fumigation with methyl bromide or an alternative treatment as a condition of entry into the United States for 19 fruits, 14 vegetables, and 7 nuts, seeds, and miscellaneous foods coming from certain countries (see app. III).[17] (APHIS also requires these treatments for various nonfood imports, including unprocessed seeds and nuts, hays and straw, cotton products, gums, bagging, and brassware.) About 90 percent of some U.S. imports, including apricots, nectarines, grapes, peaches, plums, and yams, are affected by these requirements. According to APHIS officials, acceptable alternatives are generally not available and the loss of methyl bromide will lead APHIS to ban imports of many economically important commodities.[18]

An April 1993 USDA study of nine imported fruits found that the loss of imports would reduce supplies and increase prices.[19] According to the study, the higher prices would increase the revenues to U.S. producers by $3.0 billion to $3.3 billion over 5 years. However, the losses to U.S. consumers from paying the higher prices would range from $4.7 billion to $5.0 billion over 5 years. The study further found that many of the imported items fill an important niche in U.S. supplies. For example, the study said that apricots, grapes, nectarines, peaches, and plums from Chile enter the United States during the winter when none or nearly none of these items are produced domestically.

In addition, U.S. exports worth over $400 million were fumigated with methyl bromide in 1994 (see app. IV). If the United States bans methyl bromide, an acceptable alternative treatment must be negotiated with the receiving countries. According to USDA officials, these negotiations can take several years and may not be successful, especially if other producers can continue to use methyl bromide and meet the quarantine requirements. EPA officials told us that they are more optimistic than USDA officials that acceptable alternatives will be available for imports and can be agreed upon for exports.

[17]According to APHIS officials, the agency will approve alternatives to methyl bromide if the exporting country can document that the alternatives will meet the required efficacy levels.

[18]According to USDA officials, import and export requirements may change from year to year.

[19]The Biologic and Economic Assessment of Methyl Bromide, National Agricultural Pesticide Impact Assessment Program, USDA (Apr. 1993).

EPA's Authority to Grant Essential Use Exemptions

On the basis of our review, we have concluded that the Clean Air Act does not currently authorize EPA to grant exemptions from the ban on methyl bromide for domestic agricultural uses, including preshipment and quarantine treatments. Supplies of methyl bromide available when the ban goes into effect on January 1, 2001, can be used, but no additional amounts can be produced or imported for domestic uses.

The Congress, in section 604 of the act, specified the conditions under which EPA may grant exemptions from the production phaseout of class I ozone-depleting substances, including methyl bromide. This section details six categories of substances for which exemptions may be granted. For four of the six categories, the exemptions are restricted to specific chemicals named in the relevant provisions, none of which is methyl bromide. For the remaining two categories—chemicals used in medical devices and exports to developing countries—EPA is authorized to promulgate exemptions for any class I substance after giving notice and an opportunity for public comment. Neither section 604 nor any other provision of title VI grants EPA general authority to issue essential use exemptions.

We identified no current uses of methyl bromide in medical devices, and it appears that an exemption for this purpose would not be applicable. However, methyl bromide could qualify for an exemption under the export provision of section 604(e). That provision imposes only three limits on the availability of the exemption: (1) it authorizes the production of only "limited quantities" (not defined in the provision), (2) the substance may be exported only to developing countries that are parties to the Montreal Protocol, and (3) the export may be only for the purpose of "satisfying the basic domestic needs of such countries."

Conclusions

UNEP's scientific assessments indicate that emissions from human uses of methyl bromide cause significant ozone depletion and should be controlled. However, a phaseout of the substance could adversely affect some parts of U.S. agriculture and trade unless adequate—that is, environmentally acceptable, effective, and economical—alternatives are identified before the ban takes effect in 5 years. More progress in identifying alternatives is being made for some uses of methyl bromide than for others. If adequate alternatives are not available by the time the ban takes effect, exemptions from the ban may be needed for some domestic uses until alternatives can be developed. However, EPA does not currently have the authority to grant exemptions for the continued production and/or importation of methyl bromide for domestic uses.

Recommendation

To provide for an orderly phaseout of methyl bromide, we recommend that the Administrator, EPA, seek changes to the Clean Air Act to authorize the agency to grant exemptions from the ban for essential uses. This authority should provide for EPA to grant exemptions after determining that adequate alternatives for a particular use are not available and that the adverse impact of not having methyl bromide for that use outweighs the negative effects on human health and the environment of further production and importation.

Agency Comments

We provided copies of a draft of this report to EPA and USDA for their review and comment. On November 3, 1995, we met with USDA officials, including the Chairman of the USDA Ad Hoc Committee for Alternatives to Methyl Bromide and the Deputy Director of the National Agricultural Pesticide Impact Assessment Program. The USDA officials generally agreed with the report's findings. The officials said that overall the report is balanced and presents the important issues and viewpoints associated with the use of methyl bromide. The officials again stressed their positions that practical or cost-effective alternatives are not available for many of methyl bromide's uses and that a unilateral ban on the pesticide is likely to hurt U.S. competitiveness in world agricultural markets.

On November 7, 1995, we met with EPA officials, including the Methyl Bromide Program Director in the Office of Air and Radiation and the Deputy Director of the Policy and Special Projects Staff in the Office of Pesticide Programs. The officials described the report's summarization of available information on the agricultural, economic, environmental, and health effects of the planned phaseout of methyl bromide as generally accurate. However, they expressed concern that the report leaves the impression that the outlook for finding alternatives to methyl bromide is more dire than warranted. In their view, the fact that no single chemical or other alternative is expected to replace methyl bromide for all of its uses does not mean that viable, economical alternatives will not be available for most uses by 2001. Furthermore, they added, even though viable, economical alternatives may not be found for some uses by 2001, current projections of large losses resulting from the phaseout cannot be relied on by any means.

EPA officials indicated that the agency would look at the need for exemptions and determine whether EPA has the authority to grant them as the deadline for the ban approaches. The officials stated that the focus now should be on identifying alternatives.

We believe that our report accurately depicts the availability of alternatives to methyl bromide at this time. We have made no judgment as to whether the alternatives will prove to be inadequate for many uses, as USDA officials have suggested, or for only a few, as EPA officials have suggested. In either case, we believe that EPA will need authority to grant exemptions. Although EPA could wait to seek such authority until the deadline approaches, it will need some lead time to propose changes to the Clean Air Act, have them approved, and issue implementing regulations.

EPA and USDA also provided some technical comments on our draft report. We have revised our report as appropriate in response to these comments.

We conducted our work from November 1994 through November 1995 in accordance with generally accepted government auditing standards. We interviewed officials from EPA, USDA, the Executive Office of the President, and the United Nations Environment Programme. We also interviewed representatives of the Methyl Bromide Working Group (producers and distributors) and the Crop Protection Coalition (a broad spectrum of methyl bromide users). In addition, we reviewed available studies on methyl bromide's contribution to the depletion of the ozone layer and economic and technical assessments of a phaseout. We also reviewed applicable laws and regulations and public comments during the proposal stage of EPA's phaseout regulation. Moreover, we attended conferences on alternatives to methyl bromide and on the status of scientific knowledge concerning methyl bromide's role in ozone depletion. Appendix V more fully discusses our scope and methodology.

As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 7 days after the date of this letter. At that time, we will send copies to the Secretary of Agriculture, the Administrator of EPA, and other interested parties. We will make copies available to others upon request.

Please call me at (202) 512-6112 if you or your staff have any questions. Major contributors to this report are listed in appendix VI.

Sincerely yours,

Peter F. Guerrero
Director, Environmental
Protection Issues

Contents

Abbreviations

APHIS	Animal and Plant Health Inspection Service
CFC	chlorofluorocarbon
EPA	Environmental Protection Agency
ODP	ozone depletion potential
UNEP	United Nations Environment Programme
USDA	U.S. Department of Agriculture

Studies of the Economic Impact of Phasing Out Methyl Bromide for Agricultural Uses

Methyl bromide is used primarily for agricultural purposes, principally for fumigating (1) the soil before planting (preplant soil fumigation) and (2) commodities after harvesting (commodity fumigation). The costs and benefits of a ban on these uses were analyzed by the Environmental Protection Agency (EPA) during the promulgation of its phaseout rule. We also identified three other studies of the potential economic impact of a phaseout on agricultural users. The U.S. Department of Agriculture's (USDA) National Agricultural Pesticide Impact Assessment Program studied the effects of a phaseout on 21 crops in six states, and the University of California at Berkeley and the University of Florida examined the impact of a phaseout in their states. Each of these studies compared the projected costs and crop yields for likely replacements with those for methyl bromide and found that growers would incur significant losses because of a ban on agricultural uses of methyl bromide. The USDA study also found that consumers would suffer a loss because supplies would be reduced and prices would be higher. Each study based its economic estimates on alternatives available at the time the study was conducted. The economic impact could change if more effective or less costly alternatives are identified in the future.

The studies by EPA and USDA arrived at substantially different estimates of the impact of a ban on methyl bromide. However, these estimates could not be easily compared because the studies made different assumptions, differed in their scope, and used different methodologies and cost data. The California and Florida studies were more limited in their scope than either the EPA or USDA studies. We did not independently evaluate these studies.

EPA's Analysis of Costs and Benefits

In 1993, EPA reviewed the costs and benefits of its regulatory action to phase out the production and importation of methyl bromide.[1] This study included information on the costs and effectiveness of potential new alternatives by the year 2001 and on the costs and benefits of improving the use of existing alternatives. On the basis of this study, EPA estimated that the total costs of a phaseout of methyl bromide between 1994 and 2010 would be $1.7 billion to $2.3 billion.[2] EPA's cost analysis examined the likely range of costs for the alternatives and coupled these assumptions with a monte carlo analysis, presenting a set of costs (median, mean,

[1]The Cost and Cost-Effectiveness of the Proposed Phaseout of Methyl Bromide, EPA (1993).

[2]The year 2010 was chosen as the end point in estimating the costs because the study team believed that forecasting the course of technological innovation and identifying alternatives to methyl bromide would be difficult beyond this date.

minimum, and maximum) that could be expected with a methyl bromide phaseout in 2001. The $1.7 billion figure represented the estimated median cost, and the $2.3 billion figure represented the mean cost. The minimum and maximum costs were estimated at approximately $7 million and roughly $16 billion, respectively. According to EPA, some available alternatives, if used after 2001, may indeed prove to be more expensive than methyl bromide, and their users may receive lower profits if the increases cannot be passed on to consumers. However, EPA said that it has found that the effects of regulatory actions that remove pesticides from the market are mitigated over time as new pest control technologies are introduced and adjustments are made to compensate for the loss of the pesticide through alternative pest control practices.

EPA estimated that the benefits of the phaseout would be between $244 billion and $952 billion. This estimate was based primarily on avoided cases of nonmelanoma cancers. According to the study, in the longer term (until 2160), a total of 2,800 skin cancer fatalities in the United States would be avoided because of the phaseout. The benefits for the period from 1994 through 2010 were estimated to be between $14 billion and $56 billion. The analysis reflected key assumptions about emissions of methyl bromide from human activities, the impact of bromine on ozone, and the likely growth in use of methyl bromide without regulations. The range in values for benefits results from different estimates of the value of a human life.

EPA recognized but did not calculate the benefits of avoiding other health and environmental problems caused by increased ultraviolet radiation, such as damage to plants and animals. EPA also did not consider the possible adverse effects on humans, plants, and animals of contact with methyl bromide during its application.

USDA's National Agricultural Pesticide Impact Assessment Program Study

In 1993, USDA published a study of the effects on U.S. agriculture of banning methyl bromide, under the National Agricultural Pesticide Impact Assessment Program.[4] The study showed that actions to ban or restrict methyl bromide's use in the United States would be costly because currently available alternative control practices are less effective or more expensive than using methyl bromide. The study estimated that the annual economic loss to producers and consumers from banning the agricultural uses of methyl bromide included in this study would be about $1.3 billion

[4] The Biologic and Economic Assessment of Methyl Bromide, National Agricultural Pesticide Impact Assessment Program (Apr. 1993).

to $1.5 billion. Of this amount, $800 million to $900 million would be attributed to the loss of methyl bromide for soil fumigation and $450 million to its loss for the fumigation of quarantine imports. An additional economic loss of about $200 million would occur if Vorlex—the alternative identified as having the most potential for succeeding methyl bromide—were no longer available. (The manufacturer had indicated to EPA that it planned to stop producing Vorlex because of high reregistration costs.)

According to the study, a phaseout, rather than an immediate ban, of methyl bromide would postpone annual losses and provide time for potential alternatives to be developed and for consumers and producers to adjust. The study concluded, however, that the likelihood of developing new, effective fumigant alternatives appears very remote.

The results of USDA's study were presented to EPA as part of the Department's comments on the agency's proposed phaseout rule. According to EPA, the study would be a useful analysis if methyl bromide were being banned immediately, but it does not consider alternatives that may be developed before the ban goes into effect. EPA also said that the study considers only alternatives that duplicate methyl bromide's ability to kill a wide range of pests and that other alternatives could be used in combination to achieve similar results. USDA officials believe that no alternatives are available for many uses.

Study by the University of California at Berkeley

A 1993 study by the University of California at Berkeley for the California Department of Food and Agriculture examined the role of methyl bromide in the state's agriculture and the impact on growers of regulatory action to further restrict or ban its use.[5] The University examined background information on the patterns and intensity of methyl bromide's uses for preplant soil and postharvest fumigation and then used a model to measure the financial impact on California growers of canceling agricultural uses of methyl bromide.

According to the University's report on the study, in the short term, the loss of methyl bromide for preplant soil fumigation would reduce net farm income in California by more than $233.8 million annually. The most significantly affected crops would be strawberries, nursery products (cut flowers and rose, fruit, vine, nut, and strawberry plants), and grapes, and

[5]Economic Impacts of Methyl Bromide Cancellation, Department of Agricultural and Resource Economics, University of California at Berkeley (Feb. 1993).

estimated net annual farm income losses would be $105.8 million, $71.7 million, and 31.3 million, respectively. Net income losses reflect differences in production costs from using alternative treatments, which are more costly for some crops, and lower revenues from reduced yields.

The report also found that the cancellation of methyl bromide for postharvest applications would have a significant impact on the profitability of California's fresh fruit and dried nut crops in the short run because fumigation by another method would cost more and take longer. For example, producers of cherries sell their highest-quality fruit on the export market and receive a premium price. If the cancellation of methyl bromide diverts all of the cherries previously sold on the export market to the domestic market, growers will lose $7.3 million annually. Likewise, walnut producers will have to ship more products to the domestic market instead of the holiday markets abroad because alternative techniques could not be used to fumigate the walnuts quickly enough to meet the holiday markets' needs. As a result, walnut producers would lose about $36.8 million annually. However, according to the study, trade negotiations could, in the long term, remove the requirements for quarantine treatments for cherries or approve alternative techniques. For walnuts, the expansion of holiday markets or earlier harvesting could help meet producers' needs.

Study by the University of Florida

A University of Florida study of the economic impact of losing methyl bromide on Florida's agriculture concluded that the environment that prevails in the state makes the use of methyl bromide critical to the competitiveness of the state's fruit and vegetable crops in U.S. and international markets.[6] The University surveyed extension specialists in the production areas and reviewed previous work on methyl bromide to identify existing production systems and possible alternatives to the use of methyl bromide. To analyze the economic impact of the ban, the University developed mathematical models of the North American winter fresh vegetable market and the world market for Florida grapefruit.

According to the study, the loss of methyl bromide would have a devastating effect on Florida's winter fresh vegetable producers. Because no viable alternatives can be effectively substituted for methyl bromide, Florida is estimated to lose over $620 million in the value of fresh fruit, vegetables, and fresh citrus (measured at the time of shipping) worth over $1 billion in total sales and more than 13,000 jobs. The study concludes

[6] The Use of Methyl Bromide and the Economic Impact of Its Proposed Ban in the Florida Fresh Fruit and Vegetable Industry, Institute of Food and Agricultural Sciences Bulletin No. 898, University of Florida at Gainesville (Nov. 1995).

that producers in the state would reduce the acreage allocated to these crops by 43 percent, from about 126,000 acres to 71,500 acres. Tomato production would decline by more than 60 percent, pepper production by 63 percent, and cucumber production by 46 percent without methyl bromide. The study also predicted that Mexico, in particular, would expand its production of vegetables, increasing its tomato production by 80 percent and its pepper production by 54 percent because, as a developing country, it was expected to have longer to use methyl bromide in producing and marketing its crops.

Potential Alternatives to Methyl Bromide for Agricultural Uses

Research is currently being conducted by governmental and academic institutions, as well as by the private sector, to ensure that alternative materials and methods will be proven viable and available to the agricultural community before methyl bromide is phased out. Tables II.1 and II.2, together with the accompanying descriptions, briefly profile various alternatives to methyl bromide being evaluated by USDA and other researchers for methyl bromide's preplant and postharvest end uses and note various concerns that need to be resolved during the 5 years before the ban goes into effect.

Table II.1: Potential Alternatives for Methyl Bromide's Preplant End Uses

	Soil use areas		
Alternatives	Small fruit and vegetable farms	Nurseries	Orchards and vineyards
Chemical			
1,3-Dichloropropene	x	x	x
Dazomet	x	x	x
Metam-sodium	x	x	x
Sodium tetrathiocarbonate	x		x
Formalin/formaldehyde	x	x	x
Chloropicrin	x	x	x
Nonfumigant narrow-spectrum pesticides	x	x	x
Future and preliminary research alternatives	x	x	x
Nonchemical			
Steam	x	x	
Solar heating	x	x	x
Hydroponics	x	x	
Organic matter	x	x	x
Plant modification	x	x	x
Crop rotation	x		
Future and preliminary research alternatives	x	x	x
Integrated pest management	x	x	x

Source: EPA and USDA studies, conference proceedings, and discussions between GAO and representatives of government and industry organizations.

Descriptions of Potential Alternatives for Methyl Bromide's Preplant End Uses

1,3-Dichloropropene. A broad-spectrum liquid fumigant comparable to methyl bromide for controlling most soil pests but less effective for controlling weeds. A potential groundwater contaminant. Classified by EPA as a probable human carcinogen. Under special review by EPA because of concerns about cancer for workers and residents in and around treated fields. Use permits previously suspended by California because of health and safety concerns but currently allowed for limited use.

Dazomet. A broad-spectrum granular fumigant comparable to methyl bromide for controlling most soil pests but can be less effective for controlling nematodes (parasitic worms). Currently registered for some food crops, but approval may not be sought for all uses of methyl bromide (e.g., crops with low production acreage). Small fruit and orchard uses restricted to the propagation or outplanting of nonbearing berry, vine, fruit and nut crops and similar nonbearing plants, according to EPA. Concerns about potential genotoxicity raised by EPA. Releases methyl isothiocyanate (MITC), a potential groundwater contaminant. Concerns expressed by United Nations Environment Programme (UNEP) about contamination of groundwater.

Metam-sodium. A broad-spectrum liquid fumigant comparable to methyl bromide for controlling most soil pests but may be less effective as a nematicide. Identified by EPA as a known teratogen (i.e., cause of developmental malformations). Classified by EPA as a probable human carcinogen. Efficacy dependent on the availability of water (irrigation) to ensure even distribution in the soil. Releases methyl isothiocyanate (MITC), a potential groundwater contaminant. Concerns about contamination of groundwater expressed by EPA and UNEP.

Sodium tetrathiocarbonate. A broad-spectrum liquid fumigant found effective for many soilborne pests but not for weeds. Is considered less effective than methyl bromide for controlling nematodes. Currently registered for use on grapes and citrus and registration being sought for almonds, prunes, and peaches. Efficacy dependent on the availability of water (irrigation) to ensure even distribution in the soil. Concerns about groundwater contamination expressed by UNEP. Groundwater concerns addressed by EPA through label restrictions.

Formalin/formaldehyde. A broad-spectrum granular (paraformaldehyde) or liquid (formalin) fumigant comparable to methyl bromide for controlling fungi but less effective for controlling nematodes and weeds. Registration voluntarily canceled because of health, safety, and environmental concerns. Efficacy dependent on the availability of water (irrigation) to ensure even distribution in the soil and prevent toxicity to plants.

Chloropicrin. A broad-spectrum liquid fumigant principally used as a fungicide. Comparable to methyl bromide for controlling many soil pests but less effective for controlling nematodes and weeds. Also used for tear gas, has a pungent/noxious odor, and can be very unpleasant or even hazardous to handle. Concerns about toxicity and effects of exposure on humans raised by EPA.

Nonfumigant narrow-spectrum pesticides. Include granular or liquid nonfumigant nematicides, herbicides, and fungicides spread or sprayed on the soil before or after planting to control specific pests (nematodes, weeds, insects, fungi, or bacteria). Less effective than methyl bromide. Registered uses specific to crops and locations, varying from state to state. Some reregistration concerns raised (e.g., registered nematicides such as aldicarb, carbofuran, and oxamyl are potential groundwater contaminants).

Future and preliminary chemical research alternatives. Include new and modified pesticides (e.g., bromonitromethane and carbonyl sulfide) being researched. Will require registration and are in varying stages of research. Will take time to completely develop products and assess their suitability as replacements.

Steam. Technically feasible for soil applications and can be as effective as methyl bromide, depending on methods of application and soil conditions/temperatures. Concerns about viability raised by USDA. May be impractical for large-scale (more than 2-acre) applications because it is labor-, equipment-, and energy-intensive and current estimated costs per acre are about two to five times higher than for methyl bromide. Related equipment and services may not be readily available. Feasibility dependent in some areas on availability of energy resources and fuel costs, according to EPA.

Solar heating. Technically feasible for soil applications, depending on geographic location and climate. Can be as effective as methyl bromide, depending on application methods and soil conditions/temperatures. Requires long treatment periods and may therefore be impractical for sterilizing soil in areas with short growing seasons (e.g., northern United

States). Is likely, for the most part, to be used in combination with other alternatives (e.g., soil fumigants) rather than by itself.

Hydroponics. Relatively new plant production systems that eliminate soilborne pests by eliminating soil as the growing medium. Instead, technology uses water-retaining substrates to deliver nutrients. Cannot be used for root crops (e.g., carrots), can have high start-up costs, requires significant support services, and, in the long run, could take many years to become widely accepted and economical.

Organic matter. Incorporates soil amendments, such as compost, green waste, straw, sawdust, and animal manure, into the soil to build soil health and control some soilborne pests (e.g., nematodes and weeds). Information on efficacy generally lacking. Some amendments as or more effective than some nonfumigant pesticide alternatives used to control nematodes and possibly viable for use in combined treatments.

Plant modification. Includes techniques such as crossbreeding plants, grafting orchard and vineyard rootstocks, and changing plants' genetic makeup to obtain high resistance to pests and desirable production characteristics. Extensive research required to determine potential of some techniques as alternatives. Considered an important source of viable alternatives by USDA and as having an already demonstrated potential in breeding plants for pest resistance.

Crop rotation. Can be effective in suppressing damage by soilborne pests. Effectiveness can be improved by including plants that produce fungicidal and nematicidal substances. Limitations include land availability and required knowledge of pest dynamics, general ecology, and appropriate rotational crops in specific production areas. Research under way to address these concerns.

Future and preliminary nonchemical research alternatives. Include biocontrol methods (e.g., egg-destroying fungi) and genetic engineering (e.g., altering organisms to control plant pathogens). Registration and further research required for most. Time needed to complete development and assess suitability as replacements.

Integrated pest management. Prevents pest populations from reaching damaging levels through the use of chemical and/or nonchemical treatments and management practices, as appropriate. Requires strict monitoring of pest populations and knowledge of soil ecosystem/crop production interactions. For effective implementation, requires intensive research, training for growers, and use of some chemical control methods that require regulatory approval and may involve health, safety, and environmental concerns. Research needed to determine effective combinations. Choices potentially limited by concerns about registering or reregistering chemicals.

Table II.2: Potential Alternatives for Methyl Bromide's Postharvest End Uses

	Uses			
Alternatives	**Perishable commodities**	**Nonperishable commodities**	**Quarantine**	**Structures**
Chemical				
Phosphine		x	x	x
Sulfuryl fluoride			x	x
Dichlorvos		x		
Previously used/limited-use alternatives			x	
Nonchemical				
Irradiation	x	x	x	
Controlled/ modified atmosphere	x	x	x	x
Thermotherapy	x	x	x	x
Combination treatments	x	x	x	x

Source: EPA and USDA studies, conference proceedings, and discussions between GAO and representatives of government and industry organizations.

Descriptions of Potential Alternatives for Methyl Bromide's Postharvest End Uses

Phosphine. A gas produced when aluminum or magnesium phosphide is exposed to moisture. Primarily used to fumigate grains but can be used to control numerous pests on a wide variety of commodities and in some structures. Commodities include raw agricultural foods (e.g., grains and almonds), processed foods (e.g., cereal flours), animal feeds, and nonfood commodities (e.g., tobacco). Structural uses include disinfesting grain storage facilities, such as silos and grain bins, and other structures that are not sensitive to phosphine's highly corrosive properties, which can damage switches or electronic equipment. Also used as a quarantine treatment for nonfood commodities, such as tobacco exports and cotton products. Effectiveness comparable to methyl bromide's for allowed treatments. Not suitable for some agricultural commodities (e.g., toxic to fresh fruits and vegetables and can decrease efficiencies when longer treatment times are required, according to USDA). Poses concerns for EPA about effects of exposure on workers, mutagenicity, and neurotoxicity. Risk of corrosion can be reduced and penetration and toxicity can be enhanced by combining low doses with heat and carbon dioxide, according to EPA.

Sulfuryl fluoride. Applied as a liquid that converts to a gas and can be used for some nonfood quarantine treatments and for disinfesting some structures empty of food and food products. Effectiveness comparable to methyl bromide's but poses concerns for EPA about mutagenicity, carcinogenicity, and reproductive effects.

Dichlorvos. A volatile liquid compound with limited penetrative powers. Used primarily to control pests in nonperishable foods (e.g., dried fruits and nuts, grains, and milled products) stored in warehouses, including raw and processed products. Classified by EPA as a possible human carcinogen and under special review because of concerns about neurotoxicity and carcinogenicity.

Previously used/limited-use alternatives. Include ethylene oxide and other quarantine fumigants (hydrogen cyanide, ethylene dibromide, carbon disulfide, and ethylene dichloride) that pose concerns about health and safety. As effective as methyl bromide for quarantine treatments, but may need emergency-use permits such as USDA formerly obtained to control specific pests on specified commodities. Also include methyl bromide recovery systems being researched for quarantine applications, since use of the recycled chemical is not banned after 2001. Preliminary research indicates feasibility of designing fumigation chambers to achieve 95-percent recovery. But full development of these systems may extend beyond 2001 and poses liability concerns involving yet-to-be-established operational and performance tolerances.

Irradiation. Uses low-level gamma radiation to sterilize or kill pests in quarantine and nonquarantine applications. Can be used on most foods and grains and can be equal in effectiveness to methyl bromide. Requires considerable investment in facilities and equipment, entails additional costs to dispose of spent cobalt, and poses capacity limitation concerns. USDA concerned about some commodities' sensitivity to treatment. Still requires USDA's approval for quarantine uses, and public's acceptance is uncertain.

Controlled/modified atmosphere. Uses decreased amounts of oxygen and/or increased amounts of carbon dioxide or nitrogen to suffocate pests. May require sealed facilities. Has most potential for treating nonperishable commodities. Use in combination with other treatments being evaluated for improving efficacy levels. Requirements for sealing facilities and long treatment times can pose cost considerations. Controlled atmospheres and low temperatures used more cost-effectively than methyl bromide by the Department of Defense to successfully ship perishables, according to EPA.

Thermotherapy. Can be used to control a broad spectrum of pests infesting commodities and structures and is comparable in effectiveness to methyl bromide. Treatments include vapor heat, dry heat, hot water, quick freeze, and cold. Length of required treatment, treatment facility's size, and commodities' sensitivities to temperature pose limitations. Experimentation begun with various techniques. Combination treatments likely to be required for some combinations of pests.

Combination treatments. Chemical and/or nonchemical combinations potentially usable to control pests on many commodities and in quarantine treatments. Combinations not yet identified for all commodities or pests. Chemical and nonchemical pest control combinations indicate the best potential for controlling pests now managed by methyl bromide, according to EPA.

Sources of Detailed Information on Potential Alternatives

Listed below are recent studies and reports that provide more detailed information on these and other potential alternatives for methyl bromide's many agricultural uses, the status of their availability as viable substitutes, and research priorities for meeting users' short-, mid-, and long-term needs.

- Alternatives to Methyl Bromide: Research Needs for California, California Department of Food and Agriculture (Sacramento: Sept. 1995).
- Status of Methyl Bromide Alternatives Research Activities, Crop Protection Coalition (July 1995).
- Alternatives to Methyl Bromide: Ten Case Studies—Soil, Commodity, and Structural Use, EPA, EPA430-R-95-009 (Washington, D.C.: July 1995).
- Out of the Frying Pan, Avoiding the Fire: Ending the Use of Methyl Bromide—An Analysis of Methyl Bromide Use in California and the Alternatives, Ozone Action, Inc. (Washington, D.C.: 1995).

- 1994 Report of the Methyl Bromide Technical Options Committee for the 1995 Assessment of the Montreal Protocol on Substances That Deplete the Ozone Layer, UNEP (Nairobi, Kenya: Nov. 1994).
- Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions, sponsored by Methyl Bromide Alternatives Outreach (Orlando, Fla.: Nov. 1994).
- Alternatives to Methyl Bromide, ICF Incorporated for EPA (Washington, D.C.: Sept. 1993).
- Alternatives to Methyl Bromide: Assessment of Research Needs and Priorities, USDA (Arlington, Va.: June/July 1993).
- Methyl Bromide Substitutes and Alternatives: A Research Agenda for the 1990s, USDA (Arlington, Va.: Jan. 1993).

Food Imports Requiring Fumigation With Methyl Bromide or an Alternative Treatment as a Condition of Entry Into the United States

Fresh fruits and vegetables	Other foods
Apples	Chestnuts, unprocessed or shelled
Apricots	Citrus, frozen unpeeled or frozen peel
Asparagus	Cucurbit seeds, unprocessed, dried, roasted, or salted
Avocado	Cumin, unprocessed, roasted, or ground
Beans	Faba beans, unprocessed
Blueberries	Lentils, unprocessed
Cabbage (Brassica Oleraceae)	Peppers, dried
Cactus (Opuntia)	
Cherries	
Cipollino	
Ethrog	
Garlic	
Grapes	
Grapefruit	
Horseradish	
Kiwi fruit	
Lemons	
Lettuce	
Limes	
Nectarines	
Okra	
Oranges	
Peaches	
Pears	
Peas	
Pigeon peas	
Pineapples	
Plums	
Quinces	
Roselle	
Tangerines	
Thyme	
Yams	

Source: USDA's Animal and Plant Health Inspection Service.

Value of U.S. Exports for Which Receiving Countries Require Treatment With Methyl Bromide, 1994

Dollars in thousands

Commodity	Receiving country	Dollar value
Apples	Japan	$5,986
Blueberries	Mexico	12
Cherries	Japan	92,427
	Korea	535
Cotton	Mexico	198,399
	Bangladesh	15,867
	Pakistan	36,695
	El Salvador	18,536
	Guatemala	16,990
	Peru	10,869
Oaklogs	European Union	21,209
	Mexico	4,331
Peaches/nectarines	Japan	25
	Mexico	6,864
Strawberries	Australia	426
Walnuts in shell	Japan	1,349
Walnuts, shelled	Korea	990
Total		**$431,510**

Source: USDA.

Objectives, Scope, and Methodology

The Ranking Minority Member of the House Committee on Commerce asked that we review the concerns of the U.S. Department of Agriculture and the agricultural community about phasing out the U.S. production and importation of methyl bromide. Specifically, we agreed to develop information on (1) the scientific evidence that human uses of methyl bromide contribute to the depletion of the stratospheric ozone layer, (2) the availability of economical and effective alternatives to methyl bromide, (3) the impact of the ban on U.S. trade in agricultural commodities, and (4) EPA's authority under the Clean Air Act, as amended, to grant exemptions to the ban for essential uses. We conducted our work from November 1994 through November 1995 in accordance with generally accepted government auditing standards.

To review the scientific evidence, we consulted the reports of the United Nations Environment Programme (UNEP) on its 1991, 1992 (update of 1991), and 1994 scientific assessments of ozone depletion. We discussed the results of these studies with the Associate Director of Environment, Office of Science and Technology Policy in the Executive Office of the President and with scientists at the National Aeronautics and Space Administration who participated in the 1994 assessment. We also discussed the results with officials of USDA and EPA, including EPA's Methyl Bromide Program Director. We further discussed the scientific evidence with the Methyl Bromide Working Group, which was formed by methyl bromide producers and distributors to address scientific issues related to the phaseout, and with the Crop Protection Coalition, which represents methyl bromide users. Finally, we discussed the phaseout with a representative of the Natural Resources Defense Council, which is coordinating methyl bromide issues for various environmental groups, including the Friends of the Earth and the Environmental Defense Fund.

In addition, we reviewed scientific studies, reports, and other information either prepared by EPA or submitted by others during EPA's promulgation of the methyl bromide phaseout rule. Furthermore, we attended the "1995 Methyl Bromide State of the Science Workshop" held in June 1995. At the conference, which was sponsored by the Methyl Bromide Global Coalition in cooperation with the National Aeronautics and Space Administration, various papers were presented on the latest research developments.

At EPA, we discussed concerns about alternatives to methyl bromide with officials of the Stratospheric Protection Division and Office of Pesticide Programs. At USDA, we interviewed officials of the Agricultural Research Service, Economic Research Service, and Animal and Plant Health

Inspection Service, including the Chair of USDA's Ad Hoc Committee for Alternatives to Methyl Bromide. We further discussed substitutes for and alternatives to methyl bromide with the Methyl Bromide Working Group, the Crop Protection Coalition, the California Strawberry Commission, and several strawberry growers in California. In addition, we reviewed studies, reports, and other information on the availability and suitability of substitutes and alternatives provided by these officials. We also reviewed the assessment reports of UNEP's Technology and Economics Assessment Panel, Methyl Bromide Technical Options Committee, and Economics Committee and attended the "Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions," which was held in November 1994. Furthermore we reviewed the applicable EPA supporting documents and the information submitted to the agency during the promulgation of the phaseout rule.

We discussed the trade implications of the phaseout with officials of USDA's Economic Research Service, Agricultural Research Service, and Animal and Plant Health Inspection Service; EPA's Methyl Bromide Program; the Crop Protection Coalition; and the Methyl Bromide Working Group. In addition, we reviewed studies, reports, and other documents prepared by these organizations on the phaseout's effects on trade in agricultural commodities. We also reviewed the 1994 assessment reports of UNEP's Technology and Economics Assessment Panel, Methyl Bromide Technical Options Committee, and Economics Committee. Finally, we obtained information from the Animal and Plant Health Inspection Service on U.S. imports and exports of commodities treated with methyl bromide.

To determine whether the Clean Air Act provides EPA with the authority to grant essential use exemptions to the phaseout rule, our Office of General Counsel reviewed the Clean Air Act and its legislative history.

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