Nursery Pest Management Final Environmental Impact Statement

United States Forest Service

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Final Environmental Impact Statement for Nursery Pest Management

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Abstract
The Forest Service, in compliance with the National Environmental Policy Act of 1969, is presenting three alternative ways of managing pests (weeds, diseases, insects, and animals) at the Lucky Peak Nursery in the Intermountain Region.

The alternatives are:

A. Manage pests using all control methods—biological, chemical, and cultural. Use an undocumented decision-making process.

B. Manage pests without using chemical pesticides. Use only biological and cultural control methods. Use a documented decision-making process.

C. Manage pests using all control methods; the use of biological and cultural controls will be emphasized. Use a documented decision-making process.

Alternative A is the “No Action” alternative; it describes current pest control practices at the Lucky Peak Nursery.

Alternative C is the Forest Service’s preferred alternative.

Note to Reviewers
A precedent established in court obliges reviewers participating in the National Environmental Policy Act (NEPA) process to alert the agency to their positions and contentions in a meaningful way. Also important to those concerned with the issues presented in this environmental impact statement (EIS) is another legal precedent which established that environmental objections that could have been raised at the draft stage may be waived if they are not raised until after completion of the final environmental impact statement (FEIS).
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Introduction

This Final Environmental Impact Statement analyzes choices for pest control methods to use at the Lucky Peak Nursery located near Boise, Idaho (see Figure S-I). In this summary we'll talk about the need for such an analysis, the purpose of the document, the nursery, the environment that would be affected by different pest control methods, the issues surrounding the choices, the proposed alternatives, the consequences of implementing the alternatives, and the alternative preferred by the responsible official, the Forest Supervisor of the Boise National Forest.

An environmental impact statement documents the research about an environment and what could happen to that environment if we initiate activities that will change it in a major way. In this case, the environment is the Lucky Peak Nursery. We include the people who work there or live nearby, the seedlings that grow there, the soil and water, the fish and wildlife, and the nearby community that could be affected by the economics of growing trees and reforesting the national forests.

In this document we have analyzed various alternatives for pest control. Pest control methods have the potential to change the environment in several ways. Although manual and mechanical methods of pest control can affect the environment, it is chemical pesticides that cause the most concern because of their potential to harm human health, water supplies, wildlife, and fish.

How This Document is Organized

An environmental impact statement is organized in several sections, and it sometimes appears confusing and difficult to follow the issues or to find out about the particular topics that are of most interest to you. This is how the document is organized:

- Chapter 1 discusses the purpose and need for the environmental impact statement.
- Chapter 2 describes the proposed alternatives or choices. We compare the choices and the consequences of implementing them (based on the analysis in Chapter 4) We identify a preferred alternative.

Lucky Peak Nursery
Boise National Forest
Location: Boise, Idaho
Seedbed Acres: 62 (average 28.7 in use)
Seedling capacity: 8.2 million
Chapter 3 describes the nursery site and the environment surrounding it. You might want to read this chapter before reading Chapter 2 to get a picture of the nursery and the environment that is going to be analyzed. Here we talk about the size of the nursery, climate, soils, water, wildlife and fish, seedlings, workers, neighbors, and community.

Chapter 4 describes the consequences of implementing the alternatives proposed in Chapter 2. We analyze the possible ways the environment—soil, water, people, wildlife, fish, local economy—would be affected if we implemented any one of the proposed alternatives. This is an exercise in projection based on analyses and the risk assessment—our best ideas about what might happen in the near future and in the long-term.

Following these four chapters are a bibliography, glossary, list of preparers, and list of agencies, organizations, businesses, schools, libraries, and individuals who received this document to review.

Several appendices are also part of the document.

Appendix A describes the process of making sure that employees, neighbors, and other interested individuals or groups were involved in naming the issues, determining the alternatives, and reviewing the document.

Appendix B describes pest control methods in more detail.

Appendix C covers nursery pests found at Lucky Peak Nursery—weeds, diseases, insects, and animals.

Appendix D is a risk assessment that includes analyses of the effects of pest control methods (mainly chemical pesticides) on human health and the environment.

Appendix E describes monitoring plans to make sure effects of pest control methods on human health and the environment, especially soil and water, are measured so nursery managers can adjust treatments accordingly.

Appendix F describes and charts the integrated pest management (IPM) process.

Appendix G lists research needed in order to progress toward the best possible nursery pest management practices.

Appendix H contains the Biological Assessment of Threatened and Endangered species. It evaluates the potential for effects upon Threatened and Endangered species which may at times frequent the nursery.

Purpose and Need

Our purpose is to analyze different pest control methods and the subsequent effects on Lucky Peak Nursery and the surrounding environment if implemented; to weigh the effects and recommend the pest control program we believe would be best for growing healthy seedlings for reforestation while protecting human health and the environment.

We prepared this analysis because any major undertaking by a federal agency that has the potential to be harmful to human health and the environment (water, soil, wildlife, fisheries) needs to be examined and documented so that wise choices can be made to protect ourselves and the environment we live in. The National Environmental Policy Act (NEPA) regulations guide our analysis and the format of the document.

Pest control at Lucky Peak Nursery is a topic of enough magnitude to merit preparation of an environmental impact statement because of the importance of growing healthy seedlings for reforestation in the Intermountain Region of the United States Department of Agriculture, Forest Service.

Pests—weeds, diseases, insects, and animals—can, if ignored, cause damage and loss of seedlings. Pest control choices include biological, chemical, and cultural methods.

Definitions

Here are a few definitions of terms we use throughout this document:

**Biological Treatment** - The utilization of natural enemies (such as predators, parasites, and diseases) to control pests.

**Chemical Treatment** - Using chemical pesticides to control weeds, diseases, insects, and animals.

**Cultural Treatment** - Using certain nursery practices (such as weed control, or improved water drainage) to make the habitat less favorable for pests. This includes manual and mechanical methods.

**Manual Treatment** - Using hand methods to remove pests.

**Mechanical Treatment** - Using machines or traps to prevent, suppress, or remove pests.

**Pesticide** - An agent used to destroy pests.

- **Herbicides** - control weeds.
- **Fungicides** - control fungi which can cause seedling diseases.
- **Insecticides** - control insects.
- **Fumigants** - control living organisms in the soil.
The Issues

Three primary issues surfaced when we visited with employees and neighbors at the Lucky Peak Nursery, early in the process of preparing this document. These issues are: human health, environmental quality, and economic considerations. Based on these issues, we developed alternatives and analyzed the effects of implementing the alternatives.

The Environment

The Lucky Peak Nursery, located near Boise, Idaho, on the Boise National Forest, is the only Forest Service nursery in the Intermountain Region. Its mission is to provide quality seedlings for national forests in southern Idaho, Utah, Nevada, Arizona, and New Mexico. In addition, the nursery staff works to develop the best possible methods for producing quality seedlings, to demonstrate successful tree growing practices, and to share new technology.

The Lucky Peak Nursery is located 15 miles east of Boise. Winters are usually cold with rain and some snow on the ground between October and April. Summers are warm and dry. The nursery covers 298 acres. Usually, about 62 acres are planted in seedlings every year. The nursery has the capacity to grow 7.1 to 8.2 million seedlings annually. The primary conifer seedling species are: ponderosa pine, lodgepole pine, Douglas-fir, Engelmann spruce, and western larch. Shrubs, such as bitterbrush, are grown for wildlife habitat improvements.

The resources and environment we talk about at Lucky Peak Nursery include:

- People (employees, neighbors, visitors);
- Soil; Water; Wildlife; Fish; Threatened and Endangered Species; Pests and Pest Control Treatments.

People: The nursery generally employs 6 permanent full-time staff and about 15 part-time staff. Additionally, about 90 to 100 workers are contracted and another 45 Forest Service employees are hired to lift, pack, and sort seedlings on a seasonal basis, usually in early spring. These permanent, part-time, and seasonal workers are the people most likely to be affected by the choice of pest control methods.

A number of people live at the nursery or visit the nursery and the areas nearby. Three nursery employees and their families live in residences on the nursery grounds. A fire crew occupies a mobile home located on the nursery site during the summer months. Even more people use the area for recreation. There is a nature trail here that is visited frequently. Deer hunters use nearby areas, and people boat, swim, water ski, and fish in the Lucky Peak Lake, a reservoir on the Boise River that borders the nursery on the east. These people who live here, or visit the nursery grounds or nearby areas will also be affected by the choice of pest control methods.

Soil: The nursery is situated on a lava flow bench between the Boise River to the east and a granitic ridge on the west. Soils on the east side of the nursery are composed of a mixture of basaltic and granitic materials, dark colored with some silt and clay. Along the west side of the nursery soils are mainly granitic, lighter, and sandier.

Summary
Biological treatments: Biological control is the deliberate use of natural enemies such as predators, parasites, and diseases to control nursery pests. Here are some examples of treatments that are considered experimental for use in bare root conifer nurseries: beneficial insects to control weeds and insect pests; naturally occurring microorganisms such as fungi and bacteria to control a specific insect or weed; beneficial pathogens that might protect seeds or seedling roots; and allelopathy, the use of chemicals produced by plants to control or inhibit the growth of other plants (weeds).

Chemical treatments: Although not the only method used, chemical pesticides have been an important pest control tool at the Lucky Peak Nursery. Table S-1 lists the current chemical pesticides used in a year. (For more information see Appendices B and D.)

Cultural treatments: A number of cultural treatments are used at the Lucky Peak Nursery. These include normal nursery practices such as mulching, improving drainage, and adding soil amendments to make the the habitat less favorable for weeds, diseases, insects, and animals. Cultural control methods include manual and mechanical techniques - hand weeding and machine cultivating, for instance. Other preventive practices include: spacing seedlings farther apart in the seedbeds to reduce the humid conditions between seedlings that favor the growth of gray mold; planting disease-susceptible species in well drained, disease-free areas; and avoiding areas prone to pest damage.

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Common Trade Name</th>
<th>Target Pest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fumigants</td>
<td>Basamid</td>
<td>Pathogenic fungi, Weeds, Insects, Nematodes</td>
</tr>
<tr>
<td>Dazomet</td>
<td>Pathofume, Dowfume, Terr-O Gas</td>
<td></td>
</tr>
<tr>
<td>Methyl bromide</td>
<td>+ chloropicrin</td>
<td></td>
</tr>
<tr>
<td>Herbicides</td>
<td>Dacthal</td>
<td>Weeds</td>
</tr>
<tr>
<td>DCPA</td>
<td>Roundup, Accord</td>
<td></td>
</tr>
<tr>
<td>Glyphosate</td>
<td>Devrinol</td>
<td></td>
</tr>
<tr>
<td>Napropamide</td>
<td>Goal</td>
<td></td>
</tr>
<tr>
<td>Oxyfluorfen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fungicides</td>
<td>Benlate</td>
<td>Pathogenic fungi</td>
</tr>
<tr>
<td>Benomyl</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metalaxyl</td>
<td>Ridomil, Subdue</td>
<td></td>
</tr>
</tbody>
</table>

*Additional or replacement chemicals may be added in the event that: a particular chemical pesticide is no longer marketed, is removed from the market place, less toxic pesticides become available, new pests appear that respond better to another pesticide, new crops are propagated requiring different pesticides.*
The Proposed Alternatives

Considering the primary issues of human health, environmental quality, and economic considerations, combined with the mission of the nursery to produce healthy seedlings for reforestation of federal lands in southern Idaho, Utah, Nevada, and New Mexico, and based on what employees and other interested people suggested, we proposed three alternatives.

Alternative A - No Action
Continue Present Management

This alternative would permit the use of all pest control methods for controlling weeds, insects, diseases, and animal pests at the nursery. This is the current pest management practice.

The nursery manager would use an undocumented decision-making process to select pest treatments. This means decisions would be based on past experience with the pest and based on the calendar (seasonal treatments) with limited emphasis on monitoring plans to determine pest levels, damage, and results of treatments.

All control methods would be studied before use for potential effects on human health, but there would be no documented human health monitoring plan.

Mitigating measures designed to prevent, reduce, or compensate for harm to the environment will be in place with this alternative. A documented environmental monitoring program would continue.

Seedling quality standards and production goals would be met. Costs of the control methods would not exceed nursery budgets in the short or long-term.

Alternative B
Biological and Cultural Controls Only
No Chemical Pesticides

All biological and cultural methods would be permitted to control weeds, insects, diseases, and animal pests. Chemical pesticides would not be used.

The nursery manager would use a documented decision-making process to determine treatments. This means monitoring pest numbers and damage levels, eventually establishing acceptable damage thresholds, selecting the treatment, and monitoring the results.

All control methods would be studied before use for potential effects on human health, but there would be no documented human health monitoring plan.

Alternative C
Integrated Pest Management

All methods of pest control – biological, chemical, and cultural – would be permitted to control weeds, diseases, insects and animal pests; biological and cultural methods would be preferred.

The nursery manager would use a documented decision-making process and incorporate the tenets of IPM (integrated pest management). This would include an emphasis on developing pest damage level thresholds and record keeping systems to track treatment decisions and the results.

All control methods would be studied before use for potential effects on human health. A documented human health monitoring plan would be implemented.

Mitigating measures designed to prevent, reduce, or compensate for harm to the environment will be in place with this alternative. A documented environmental monitoring program would be implemented.

Seedling quality standards and production goals would be met and costs would not exceed nursery budgets in the near or distant future.

Comparison of the Alternatives

Table S-2 shows the similarities and differences between the proposed alternatives. One of the important differences among the alternatives is the decision-making process that would be used to decide if, when, and how to treat pest problems. Another important difference among the alternatives is the range of control methods available to the manager.

See Chapter 2 for a more detailed discussion of the proposed alternatives, comparison of alternatives, and mitigating measures designed to prevent, reduce or eliminate harmful effects on human health and the environment.
Table 5-1
Comparison of the Characteristics of the Alternatives for Tree Nursery Pest Management

<table>
<thead>
<tr>
<th>Decision Making Process</th>
<th>Control Methods Permitted</th>
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<tr>
<td>Alternative A</td>
<td>Undocumented</td>
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<td></td>
<td>All Biological, Chemical, and Cultural Methods</td>
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<tr>
<td>Alternative B</td>
<td>Documented</td>
</tr>
<tr>
<td></td>
<td>No Chemical Pesticides; Biological and Cultural Methods Only</td>
</tr>
<tr>
<td>Alternative C</td>
<td>Documented</td>
</tr>
<tr>
<td></td>
<td>All Biological, Chemical, and Cultural Methods</td>
</tr>
</tbody>
</table>

Decision-Making and IPM

What distinguishes undocumented decision-making from documented, and what is IPM (integrated pest management)? Following are some short explanations.

Undocumented decision-making: This is the way nursery managers have been making pest treatment decisions for years, and it usually works. It is sometimes intuitive, sometimes based on many years of experience, or on seasonal conditions, tied to the calendar; it also incorporates new data and technology. It usually lacks thorough documentation and monitoring systems and so it is difficult to track successes and failures or pass knowledge on to the next manager.

documented decision-making: This process would require the manager to keep track of the reasons for selecting treatments. It would require monitoring pests and pest damage in the seedbeds and monitoring again after treatment to see how successful the treatment was. Ultimately this process would lead to the establishment of damage level thresholds. Documented decision-making is part of an IPM program. We propose documented decision-making as part of Alternatives B, and C.

IPM (Integrated Pest Management): This is a system that integrates all methods of pest control, monitors pests and pest levels, incorporates knowledge about pest behavior so that treatments can be timed to be most effective, and monitors after treatment to determine the effectiveness of that treatment. A fairly consistent result of IPM is a reduction in the use of chemical pesticides, often as a result of monitoring pest levels and timing the treatments accordingly, or as a result of more knowledge about the pest, the damage level threshold, and new biological methods that are becoming available. Monitoring pests and damage levels does not preclude preventative measures or early treatments that can be initiated before pests or the damage they cause are visible. Based on past experience, nursery managers could use prevention techniques such as mulching and spacing, or early treatment, such as soil fumigation.

Mitigation Measures

All of the proposed alternatives include mitigating measures designed to prevent, reduce or compensate for harmful effects to humans and the environment that could result from the implementation of pest control treatments. For a more detailed discussion of these, see Chapter 2.

Mitigation measures are based on Forest Service policy, nursery operation and safety plans, information from research publications, and field experience. Measures designed to protect human health are based on the human health risk assessment (Appendix D).

Mitigation Measures For All Control Methods

Pest control treatment could be stopped or deferred.


The nursery will have a plan for managing human health risks.

The nursery will have an environmental monitoring plan.

The nursery manager will provide training and information to employees about pest control practices.

Mitigation Measures For Biological Control Methods

All Forest Service uses of biological control methods would be in cooperation with the USDA Agricultural Research Service or under individual, approved state programs.

If applicable, the nursery manager would inform downstream water users who could be affected by biological contamination of surface or groundwater.
Mitigation Measures
For Chemical Pesticides

All applicable state and federal laws and Environmental Protection Agency labelling instructions would be applied to all alternatives which include the use of chemical pesticides for control of weeds, diseases, insects, and animal pests at the Lucky Peak Nursery.

Measures that go beyond these standard regulations to prevent, reduce, or compensate for adverse environmental impacts are:

Notification and Restriction
Downstream water users and adjacent landowners who could be directly affected by drift, water transport from normal operations, or an accidental spill, will be notified (normally 15 days) prior to the chemical application.

No employees or contract workers will be permitted to work within 100 feet of a nursery seedbed fumigated with methyl bromide + chloropicrin for 3 days or until the tarps are lifted. Vehicle and foot traffic through the 100-foot buffer zone is permitted.

Tarps should be lifted from methyl bromide + chloropicrin applications when a minimum number of employees or contract workers are present.

If tarps are lifted during regular work hours, all employees or contract workers not engaged in tarp lifting will be moved upwind and away from the tarp lifting.

After fumigation, the tarp will be monitored routinely for rips or gaps where gas could escape.

Do not fumigate with methyl bromide + chloropicrin within 100 feet of residential private property.

Protective Clothing
Appropriate protective clothing will be worn by all workers (both Forest Service employees and contract workers).

Human Health Risk Management
Workers (both Forest Service and contract) who know that they are extremely sensitive to pesticides will not be assigned to application projects. Workers who display symptoms of extreme sensitivity to pesticides during application will be removed from the project.

For chemical pesticides with moderate and high risks, nursery managers will develop new worker and chemical use schedules to reduce worker exposure to these chemicals. See Chapter 4 and Appendix D for a discussion of Margin of Safety. The new schedules may include one or all of these options:

- lengthen reentry times for workers
- wear appropriate protective clothing
- reduce worker exposure periods to chemical pesticides
- reduce chemical pesticide application rates
- reduce the number of chemical pesticide applications

Mitigation Measures
For Adding and Replacing Chemical Pesticides

- The nursery manager will seek public input on the proposal.
- A human health risk assessment will be prepared for the additional pesticide.
- Interdisciplinary specialists will analyze the environmental impacts of using the additional pesticide.
- Considering results of the risk assessment and the environmental consequences, the nursery manager will identify the appropriate NEPA documentation to be prepared.
- The nursery manager will direct preparation of the documentation and see that it adheres to the principles of Integrated Pest Management, in making a decision to add or replace a chemical pesticide.

Mitigation Measures
For Cultural Controls

A Project Risk Plan will be developed to mitigate adverse affects of cultural control methods.

Consequences

Mitigation measures are the safeguards that make the proposals possible or practicable in light of issues of human health and environmental protection. When these measures are in place, risks are decreased.

With these mitigation measures in place, we compare the consequences of implementing the proposed alternatives. How would each one of them affect human health, the environment (water, soil, wildlife and fish), and economics?

Table S-3 compares the three alternatives based on the primary issues presented to us by employees and others. Human health and environmental quality are straightforward; the goal is to protect health and the environment as much as possible. Economic concerns range wider and include cost-efficiency, number of people employed, and seedling production. Although seedling production levels might vary according to alternative, seedling quality standards would be met.
Human Health Risk - Manual and Mechanical Methods

Column 1
- Manual and mechanical treatments are used mainly for weed control. Workers run the risk of sprains, sun exposure, heat exhaustion, or back injury from hand weeding and possible injuries from mechanical equipment.
- Alternative A has a low human health risk from mechanical and manual methods because herbicides would be the primary means of weed control. There would be less use of manual and mechanical weed control methods, and therefore, low risk.
- Alternative B has a high human health risk from mechanical and manual methods because it does not allow chemical pesticides; herbicides would not be used. Manual and mechanical weed control methods would be extensively used, increasing the risks of injury from these methods.
- Alternative C would have a moderate human health risk from mechanical and manual methods because combinations of manual, mechanical, and chemical methods would be used.

Summary - 15
Adverse Effects on Environmental Quality - Water and Soil

Column 4

- Alternative A would have moderate adverse effects on soil and water because a range of chemical pesticides with varying persistence and leaching ability would be used, and chemical pesticide use would be determined by an undocumented decision-making process. Without a documented decision-making process, there is a greater probability for incorrect timing of applications, and use of more toxic products.

- Alternative B would have a moderate adverse effect on soil and water because chemical pesticides would not be used. The other control methods would have very minor effects on soil and water.

- Alternative C would have a low adverse effect on soil and water. Although a range of chemical pesticides with varying persistence and leaching ability could be used, pesticide use would be determined by a documented decision-making process.

Economic Considerations - Cost-Efficiency

Column 5

- Cost-efficiency is defined as the ability to meet production goals at the least cost. Quality standards would be met in all alternatives, but the quantity of seedlings produced may differ.

- Alternatives A and C would result in high cost-efficiency because all methods, including pesticides, would be allowed; weed control with herbicides costs less than weed control by manual and mechanical means.

- Alternative B would result in low cost-efficiency because the most cost-efficient tools, chemical pesticides, could not be used. Seedling production goals would not be met because, at present, non-chemical pesticide methods for controlling some insects and diseases in the nursery are not available.

Economic Considerations - Number of People Employed

Column 6

- Alternative A would result in relatively low employment because the primary workers involved with pest control would be 1 or 2 chemical applicators, plus a few hand weeder.

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Region 4 FEIS

Economic Considerations - Seedling Production

Column 7

- Alternatives A and C would result in high seedling production because all methods would be available to control pests effectively. A minimum number of seedlings would die or be culled because of pest damage.

- Alternative B would result in low seedling production; first-year seedling losses would be significant due to soil-borne diseases which currently are controlled only by fumigation; some other pests, currently controlled only by pesticides, may also kill or damage seedlings.

The Preferred Alternative

After analyzing the possible environmental consequences of implementing the proposed alternatives, we compared the differences, weighed the positive and negative aspects, and came to consensus on a recommended alternative.

We are recommending Alternative C - Integrated Pest Management - because allowing the use of all pest control methods will ensure that Lucky Peak Nursery fulfills its mission to produce healthy trees for reforestation of federal lands in the Intermountain Region of the Forest Service.

At the same time, Alternative C responds favorably to the issues of human health, environmental quality, and economics because an integrated pest management program, with its emphasis on monitoring and documented decision-making, will most likely lead to a reduction of the use of chemicals. This alternative encourages the selection of biological and cultural methods and an active search for opportunities to reduce reliance on chemical pesticides.
Chapter 1

Purpose and Need

The purpose of this environmental impact statement (EIS) is to analyze ways to manage pests (weeds, diseases, insects, and other animals) at the Lucky Peak Nursery in the Intermountain Region of the Forest Service (see Figure I-1). Pest management at Lucky Peak is necessary in order to grow sufficient quantities of healthy seedlings. We propose several alternatives for pest management and analyze the potential effects or consequences of the proposed alternatives on the environment.

Why Does the Forest Service Operate Nurseries?

Federal nurseries have provided reforestation planting stock to National Forests since the early 1900s. At that time, the singular mission of these facilities was to ensure the availability of suitable planting stock for the new Forest Reserves in a developing frontier region where seedlings were not available from other sources. Based upon the success of these original nurseries and a continuing need for an appropriate supply of planting materials, many U.S.D.A. Forest Service nurseries were added to meet the following goals:

1. produce planting stock;
2. field test new technology and research findings;
3. demonstrate state of the art nursery practices; and
4. develop and maintain seed supplies.

The Forest Service operates a nursery in the Intermountain Region to produce seedlings for planting on National Forest lands following timber harvest, or deforestation by catastrophic occurrences such as wildfire, high winds, or flooding. Approximately 88 percent of the trees needed annually for reforestation on National Forests in the region are grown by the Lucky Peak Nursery, as well as 95 percent of the trees needed in the Southwest Region. The remaining trees needed for reforestation in the Intermountain Region are produced by the Coeur d’Alene Nursery, a Forest Service nursery in the Northern Region, and others.

The Lucky Peak Nursery, named for a nearby mountain, is administered by the Boise National Forest and is located 15 miles east of Boise, Idaho.
The nursery was established in 1959 with only 5 acres being leveled and sown. Today, on 61 acres of fields, the nursery produces $7 \times 10^{6}$ million seedlings each year. The mission of the Lucky Peak Nursery is “to produce requested volumes of seedlings that will survive and grow well. In accomplishing this mission, we will strive to maximize efficiency, safety, and to enjoy the challenge of producing seedlings for tomorrow’s forests”.

Managing Nursery Pests

An important part of tree nursery management is controlling competing and unwanted plants, diseases, insects, and other animals. Without control of these organisms which kill or damage seedlings, the desired quantity and quality of seedlings could not be produced. Methods used to control these pests could have environmental impacts, especially on soil, water, and wildlife.

To control pests, nursery managers use a combination of biological controls, chemical pesticides, and cultural treatments, which include manual and mechanical methods. The use of these controls raises issues of their effects on human health, environmental quality, and economics. Most of the concerns revolve around chemical pesticide use. In this document, we use the term pest control interchangeably with pest management to refer to a wide spectrum of prevention and control treatments. (See Appendix B.)

Why This EIS?

Nursery pest management is being analyzed and documented for all the Forest Service nurseries in response to the growing public concern about the use of pesticides. On June 19, 1989, a Notice of Intent was published in the Federal Register to announce the preparation of an EIS for nursery pest management programs in the Intermountain Region. The decision to prepare a separate nursery EIS for the Lucky Peak Nursery was based on several factors. These included:

1) recognition that the use of chemicals at nurseries is more specialized, confined, and repetitive than on general forest sites, and includes fungicides, insecticides, fumigants and herbicides;

2) recognition that the use of pesticides has potentially significant impacts on human health and the environment;

3) recognition of the need to update the nursery pest management program to more thoroughly address current issues and meet National Environmental Policy Act (NEPA) requirements;

4) re-examination of the management objectives for the nursery pest management program, based on the current direction and philosophy.
In October, 1986, the Forest Service Intermountain region issued the Intermountain Region Noxious Weed and Poisonous Plant Control Program Final Environmental Impact Statement and Record of Decision. This nursery pest management EIS is related to, but separate from the noxious weed EIS which does not include tree nursery operations. This nursery pest management EIS focuses only on the nursery and will analyze not only the effects of managing unwanted vegetation, but also the effects of managing diseases, insects, and other animals.

Scope

Managing competing and unwanted plants, animals, insects, and diseases in a tree nursery setting is a complex process.

The nursery manager has three types of pest control methods available: biological, chemical, and cultural. A biological method is the deliberate use of natural enemies to control pests. A cultural method is one that uses certain nursery practices to make the habitat less favorable for pests. A chemical method is the deliberate use of chemicals to control pests. All of these methods are used at the Lucky Peak Nursery.

A tree nursery is an intensive agricultural operation; management of each nursery is therefore very site-specific. It is not the purpose of this document to determine what specific management practice should be used at a nursery. The decision of whether, and how, to treat a problem is the responsibility of the nursery manager. One of the purposes of this EIS is to ensure that the nursery manager has the most comprehensive information available for pest control methods. From this information, the manager can select the pest control method that will work best and minimize potential impacts to human health and the environment.

Issues

All Forest Service actions that affect the physical and biological environment at the nursery are regulated in part by NEPA (the National Environmental Policy Act). NEPA is the basic law that governs federal actions and the environment. This law requires the Forest Service to analyze and, if found to be significant, disclose the potential environmental consequences of major projects in a document such as this draft environmental impact statement. An interdisciplinary team was formed to conduct an environmental analysis and write an environmental impact statement.

The regulations for implementing NEPA require that important environmental issues be identified early in the process, and that these issues serve as a basis for the alternatives. The issues presented here were distilled from the comments of the general public, interested groups, government agencies, and Forest Service people, especially nursery employees. These groups participated in public involvement efforts that provided information on the issues the environmental impact statement should address. (See Appendix A.)

After reviewing material from the public meetings, and reading the comments from the public, agencies, and Forest Service employees, the interdisciplinary team identified three major issues associated with the management of pests in a tree nursery:

Human Health: People are concerned about the health effects of pesticide use on the public and employees, especially hazards from pesticide drift. They are also concerned about the effects of pesticide exposure specific to women. Forest Service employees want to ensure we continue to provide safety training and other information in the use of chemical pesticides.

In this EIS we will evaluate the herbicides, fumigants, fungicides, rodenticides, and insecticides currently used at the nursery; additions or replacements will be substituted in the future as some pesticides are removed, less toxic pesticides are available, or new pests appear that respond to other pesticides. The goal of the Forest Service in dealing with human health issues is to create an environment of cooperation and understanding rather than an adversarial situation. Principal elements to be considered in evaluating the impact of various control methods on human health include analyzing accidental, chronic, and perceived health risks. The risks to be evaluated will include all methods of pest control, including use of biological methods, chemical pesticides, and cultural methods.

When dealing with human health issues, what we don't know is often as important as what we do know. The relative uncertainty of information and the level and importance of missing information will also be disclosed and considered.

Environmental Quality: People are concerned about the effects of chemical pesticides on nursery seedlings, water quality (especially Lucky Peak Reservoir), soil productivity, and wildlife. They are concerned about the long-term effects of continued pesticide use. The disposal of left-over pesticides is also a concern. More research is needed on the effects of chemical pesticides on the physical and biological environment.

Economic Considerations: People are concerned about the cost-effectiveness of growing quality seedlings. Resources are required to control unwanted weeds, diseases, insects, and other animals in the nursery. Control methods have a range of costs associated with them; the type and extent of control used will have an effect on seedling quantity.

These issues of human health, environmental quality, and economics were used to develop the alternatives presented in Chapter 2.

Nursery Pest Management and Forest Plans

Nursery pest management plays an integral role in meeting the timely accomplishment of reforestation goals and standards associated with the Forest Plans.

This EIS looks at those nursery pest management projects collectively as a program, and analyzes and discloses their environmental impacts. In addition, it presents their implications
for the cost and amount of work needed to manage the nursery.

If a new program of nursery pest management and mitigation measures would change the way nursery pests are managed, then changes in nursery operations would be needed. While the EIS does display the nursery pest management implications of the alternatives, it does not specifically change any land use designation, expected output level, or environmental impact of the Forest Plans. Therefore, changes in Forest Plans are not anticipated.

Major Legislation Relating to This EIS

The National Environmental Policy Act of 1969 (as Amended) (NEPA)
Federal Environment Pesticide Control Act of 1972 (FEPCA)
Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA)
The National Forest Management Act of 1982 (NFMA)
Environmental Quality Improvement Act of 1970
The Water Quality Act of 1987
The Safe Drinking Water Act (Amendments of 1977)
The Endangered Species Act of 1973 (as Amended)

How This EIS Is Organized

This document is organized in four chapters. Background and support information is provided in the appendices (See Figure 1-2). The draft environmental impact statement presents three alternatives for managing pests at the Lucky Peak Nursery, and examines the potential environmental impacts of each alternative.

The analysis is presented here in draft form for public review and comment. After carefully considering comments on this draft from the public, industry, researchers, and other government agencies, the Forest Service will issue a final environmental impact statement. The Forest Supervisor will use the final environmental impact statement as the basis for selecting a pest management program for Lucky Peak Nursery.
Chapter 2
The Alternatives

This chapter presents the alternative pest management plans considered by the Forest Service for the Lucky Peak Nursery in the Intermountain Region. The chapter has several sections:

- Background Information
- Development of the Alternatives
- Alternatives Eliminated From Detailed Study
- Description of the Alternatives
- Comparison of the Alternatives
- Preferred Alternative
- Mitigation Measures

Background Information

This section discusses the pest control methods used at the tree nursery, as well as the processes managers may use to decide how and when to treat pest problems. This information is useful in understanding the alternative methods of managing pests at the Lucky Peak Nursery.

Pest Management

A tree nursery is an intensive agricultural operation. Its goal is to grow large numbers of quality seedlings cost-effectively. Plants and animals that interfere with that goal are considered to be pests. Pests are typically divided into four categories: insects, diseases, weeds, and animals. (Specific pest problems, the damage they cause, and control methods, are discussed under each nursery description and in Appendix C.) Nursery pest management practices carry with them potential environmental impacts; however, there is also the po-
potential of environmental impacts from not producing and planting trees. This would include the possibility of increased erosion, decrease in the future timber supply, and decrease in wildlife habitat.

Three categories of pest control methods are available to the nursery manager:

**Biological control** - the utilization of natural enemies to control pests  
Methods used include:  
* predatory insects, such as ladybugs  
* Chinese weeder geese

**Chemical control** - the use of a chemical to control pests  
Methods used include:  
* fumigants to control soil-borne diseases  
* fungicides to control diseases caused by fungi  
* insecticides to control insects  
* herbicides to control vegetation considered to be weeds

**Cultural control** - the use of certain nursery practices (such as weed control, improving drainage, and adding soil amendments) to make the habitat less favorable for unwanted insects, weeds, diseases, and animals, or to prevent, suppress, or remove them. This category includes the full range of manual and mechanical methods as well.  
Methods used include:  
* exclusion of pests from the nursery site  
* sanitation (e.g. removing diseased seedlings to prevent the spread of disease)  
* hand weeding  
* machine weeding  
* regulating seedling density  
* use of pest tolerant or pest-resistant seedling species  
* mowing weeds prior to seed formation  
* maintaining/improving soil drainage  
* others

A combination of some these methods is currently used to control pests at the Lucky Peak Nursery. More information on pest control practices can be found in Appendix B.

Pest control is a complicated process. The nursery manager must first decide if a pest problem is severe enough to warrant treatment, and if so, determine the best control method.

In addition to simply controlling pests, a nursery manager will generally oversow (sow more seed than is necessary) to compensate for losses from pests. Factors considered in this decision usually include cost of the seed, scarcity of the seed, and germination rate of seed zones. The nursery manager must carefully balance expected losses from pests and the amount of seed to sow, in order to meet seedling orders while producing seedlings cost-effectively.

### Integrated Nursery Pest Management

This section discusses integrated pest management (IPM) in the Forest Service: its history and the Forest Service definition of it. We also include a description of IPM for the Lucky Peak Nursery.

In 1982, the Forest Service adopted a regulation 36 CFR 219.27 that requires the use of integrated pest management when dealing with pests on Forest Service lands. It is directed primarily at the management of forest pests affecting reforestation and growth of trees in the forest. It does not specifically address pest management in forest nurseries, although most of the regulation is as pertinent to nursery pest management as it is to forest pest management.

IPM has been defined many ways. The concept of IPM was originally developed in agriculture to deal with insect pests on crop plants. The National Forest Management Act (NFMA) of 1982 synthesized agricultural IPM concepts into forest resource management. A general definition given in the Forest Service Manual 3405 Definitions states that IPM is:  
"A systematic decision-making process and the resultant management actions which derive from consideration of pest-host systems and evaluation of alternatives for managing pest populations at levels consistent with resource management objectives."

To put the Forest Service definition of IPM into the context of nursery pest management, we developed the following definition of IPM for forest nurseries:

"Integrated nursery pest management is the maintenance of seedling pests at tolerable levels by the planned use of a variety of preventive, suppressive, or regulatory methods (including no action) that are consistent with nursery management goals." It is implicit that the actions taken are the end-result of a decision-making process where pest populations and their impact on hosts are considered and control methods are analyzed for their effectiveness as well as their impacts on economics, human health, and the environment.

### Decision-Making

Biological, chemical, and cultural methods are currently used to control pests at the Lucky Peak Nursery. When the nursery manager decides to control a pest problem, one or a combination of these methods is used. An important element in pest control is the decision-making process: how the manager decides if a pest needs to be controlled, when to treat it, and with what method(s).

### Undocumented Decision-Making Process

Currently, treatment decisions are based on training, experience, and other factors such as the season and climatic conditions, as well as data on the pest population level. Research and
field trials have produced recommendations for treatment of various pests—type of treatment to use, when to use it, and how much to use. Data on pest populations are oftentimes sparse or based on casual, sporadic observations of the pest in the field. Previous population levels of the pest, climate or other factors associated with outbreaks of the pest, and the amount of damage associated with certain population levels may not be well documented or tracked.

With undocumented decision making, there may not be any overall written plans for management of each pest, and there is no framework or process for analyzing impacts of each treatment on important nursery issues (such as worker health, cost efficiency, water quality, or seedling quality) or for documenting the reasons for selection of one treatment over another. While undocumented decision making may frequently result in sound decisions, it may also result in decisions for which little or no documentation exists for the decision rationale and treatment effectiveness.

Documented Decision Making
Another strategy available to managers is a chronicled decision-making process. Utilizing this strategy, managers would continue to make pest management decisions, but they would make their decisions within a more trackable framework. Decisions would be based on documented pest status (including historical occurrence, pest life cycles, research findings, data from field monitoring—if applicable, climatic and other factors contributing to pest outbreaks, etc.), and the analysis of treatment options and their impact on nursery goals. This documented decision-making process provides an instructive record of actions taken, as well as the rationale for taking those actions.

A graphic representation of this process is displayed in Figure 11-1. An explanation of the process steps outlined in the flow chart follows:

• Environmental Impact Statement: The EIS documents the overall pest management plan for the nursery. It gives broad guidelines for managing pests and provides detailed background information on pests and control methods and the impact of each on seedling production and on nursery resources (soils, water, wildlife, etc.). It does not give specific details for managing each pest at the nursery.

• IPM Plans: An IPM plan is developed for each pest that occurs at the nursery. This plan spells out what is known about the pest, where it occurs in the nursery, factors influencing its development and spread at the nursery, and control methods that are effective at the nursery. It also describes how to monitor for the pest and the treatment methods to be used at the nursery. If monitoring methods are not effective or not developed for a particular pest, procedures are described for determining when treatments need to be implemented. The plan should be reviewed each year and revised if necessary.

• Compile Information Profile for Each Pest:
  - Describe Pest Biology and Pest Impact: For seedlings, prepare a complete description of the pest life cycle, habitat, host species, and pest threshold levels (if

known). This information should be based on a thorough literature review, and should be developed by trained pest management specialists.

  - List Treatment Alternatives (Including No Action): Available treatments, including biological, cultural, and chemical, should be listed for the pest. “No action” should be included as one possible treatment.

  - Compare Listed Treatment Alternatives: Treatments, either singly or in combination, should be compared with one another as to their effectiveness, health hazard, environmental hazard, and cost.

  - Annual Decision and Decision Rationale: The treatment program for the pest should be briefly described and reasons given for selecting various treatments. This decision should be reviewed and, if needed, revised each year prior to the growing season.

  - Pesticide Information: Product labels and Material Safety Data Sheets (MSDS’s) for pesticides which are listed as possible treatments should be included or location referenced. Similarly, information for the effect of each of these pesticides on humans and the environment should be included or location referenced.

  - Monitoring Plan and Monitoring Data Sheets: A brief description of how the pest or its damage will be monitored so that its impact can be assessed or treatments can be timed more accurately should be included. Such items as frequency of monitoring, where to look for pest or damage on plant, which crops and age of crop should be monitored, can be included in monitoring plan.

  - Identify And Analyze Available Control Methods: The various treatment methods which are known to be effective, to some degree, should be examined. These methods should already be listed as available control tactics in the IPM plan for each pest. They are evaluated for their impact on nursery goals such as cost, seedling quality, production, human health, and the environment, as well as for their effectiveness in suppressing or preventing pest damage. In addition, the seriousness of the pest problem, the physiological condition of seedlings, and whether or not the environment is conducive to a population build-up, is evaluated. The use of more than one method should also be considered.

  - Select The Method That Best Addresses Nursery Goals: The best method is selected following analysis of all the viable options, including no action. What is best will depend on nursery goals. Some general Forest Service nursery goals are displayed at the top of Figure 11-1.
• Document The Decision: The decision showing what treatment was selected, and why, is documented. Records of these decisions can be kept in a variety of ways, from brief descriptions in a log book to detailed descriptions in a computer file.

• Preventative Treatment: Sometimes, threshold levels do not exist or are not appropriate for particular pests. In these cases, if treatments are not made before the pest damages the crop, unacceptable damage occurs. Preventative treatment includes: 1) Cultural activities which make the environment less favorable for the pests, and 2) early treatment with chemicals, applied prior to pest damage, which protects the seedling from the pest or kills the pest directly. Cultural prevention activities, such as mulching seedbeds to prevent gray mold, often are planned and carried out prior to establishment of the seedling crop. The decision to carry out preventative treatments usually is based on historical occurrence of pest damage at the nursery. To aid in the decision to treat a crop prior to the appearance of damage, a number of factors might be monitored, including weather conditions, soil moisture, seedling development, abiotic damage to seedlings, presence of beneficial insects in seedbeds, as well as the historical occurrence of the pest.

Nursery employees who are trained to recognize insects, weeds, diseases, and the damage they cause will monitor and record pest and damage levels. They may also check the soil and water for disease-causing organisms or monitor one or more of the factors discussed in the preceding paragraph which might influence the occurrence of a pest. Pest monitoring is done on a regular schedule (schedules vary for each pest) and are different from environmental monitoring, which is discussed later in this chapter and in Appendix F.

• Monitoring and Threshold Analysis for Control Treatments:

  • Monitor and Analyze Pest Situation: For some pests, particularly insects, control treatments are timed to correspond to a certain population level of the pest. Other pests, such as fungi, are more difficult to detect and timing of control treatments must be based on other factors such as climate, seedling age, or physiological status of seedlings.

  • Action Thresholds: The action threshold is the number of pests or the amount of damage that is allowable before action (treatment) is taken. The information needed to develop an action threshold often can only be generated over one or more crop cycles or pest life cycles, where pest populations are tracked and specific levels of damage are correlated with specific pest population levels. Once this population/damage relationship is defined, the level of acceptable damage can be set by the nursery manager and this can be used in subsequent years as the “action threshold”: the level of pest population at which action (treatment) occurs to avoid unacceptable damage to the crop.

Monitoring the crop for damage and monitoring the population of the pest will allow the nursery to determine if the action threshold has been reached. It will also provide information about where the pest is located, what crops it is damaging, how much damage is occurring, and what the pest population is doing (increasing or decreasing).

When the thresholds are exceeded, treatment will be implemented. For pests which must be treated preventively, monitoring will not be useful for determining when to treat; it may, however, be useful for determining if preventative treatments actually reduced pest populations or damage to the crop.

• Implement Treatment: The seedling crop, seeds, seedbed, or surrounding environment is treated to control or prevent pest damage, using the selected treatment method(s).

• Evaluate Treatment Effectiveness: Selected methods should be evaluated for their effectiveness. Effectiveness will be defined in terms of the nursery goals, i.e., whether or not human health was protected, whether or not an adequate number of acceptable seedlings were produced, etc. If the selected control method is a pesticide application, effectiveness in protecting human health or the environment can be evaluated by monitoring exposure of workers before and after treatment, or by monitoring pesticide levels in the water (surface run-off or subsurface) before and after treatment.

At the same time, the effectiveness in reducing pest populations or damage can, by documentation, be evaluated by continuing to monitor pest populations or damage after the treatment was applied and comparing treated seedlings to untreated seedlings. Utilization of check or control plots will be helpful, especially when using treatment methods which are new for the nursery or for a particular seedling species or stock type. Documented evaluation may not be necessary every time a treatment is made, but evaluations at critical times or when using a new method, or on an annual schedule, are important. If the selected treatment method is not effective in terms of nursery goals, then the use of the method will be examined and modified or other viable treatment methods will be considered and tried the next time treatments are needed.

• Revise or Amend: Pest IPM Plans should be revised or amended according to information gained from use of various methods and their effectiveness. If no effective methods exist, research will be directed towards the development of new treatment methods, especially for pests for which there are no adequate control measures, or where only chemical control methods are available or effective. Basic research, as well as application of techniques developed for other crops, are needed. Additional or replacement chemical pesticides may be added to nursery pest control tools when a certain pesticide is removed from the market, a less toxic pesticide is available, or a new pest appears that requires a specific pesticide. (See Appendix G for discussion of Research Needs.)
The following chart graphically displays the steps involved in carrying out an IPM program in forest nurseries:

Nursery Goals

| Produce High Quality Seedlings | Produce Needed Seedling Quantity | Protect Human Health | Protect Environment | Cost- Efficiency |

Environmental Impact Statement

Develop Annual IPM Plan for each pest, including:
- Compile info profile for each pest (i.e. biology, life cycle, control trial results, etc.)
- Identify and analyze available control options
- Select method that best addresses nursery goals
- Document decision and rationale

Preventative Treatment(s)

Monitoring-based Treatments(s)
- Monitor Pest and/or Damage
- Action Threshold Exceeded?
  - yes
  - no

Implement Treatment

Evaluate Treatment Effectiveness

Document

yes

Effective?

Document

no

Revise or Amend

Development of the Alternatives

In June 1989, the interdisciplinary team met with employees and the nursery management team at the Lucky Peak Nursery. Nursery employees generated 47 comments which addressed varying aspects of nursery management. Personal contact with individual employees was facilitated by the Nominal Group Process, which is described in Appendix A. The team also held an evening meeting to which neighbors and interested individuals were invited. No neighbors or interested parties attended the meeting.

The team received additional input from telephone conversations, letters, and responses to newsletters. These are the alternatives that people suggested:

- Continue current pest management program (No Action)
- Don’t use chemical pesticides
- Develop a thorough integrated pest management program
- Use only chemical pesticides to control pests
- Use only biological methods to control pests
- Use only cultural methods to control pests
- Let private nurseries provide seedlings for the Forest Service.

The Forest Service is required by law to evaluate the consequences of “no action”. The law defines “no action” as not implementing a new program, that is, not changing current pest management practices. The proposal to continue current pest management practices is the “no action” alternative.

Alternatives Considered but Eliminated From Detailed Study

After initial analysis, it became clear that some of the alternatives would not control pests or were not practical for other reasons, and they were dropped from further consideration. These alternatives were dropped:

- Use only cultural methods to control nursery pests
- Use only biological methods to control nursery pests
- Use only chemical pesticides to control nursery pests

These alternatives were dropped because they allow the use of only one control method to manage pests. We know from experience that use of cultural methods alone or biological methods alone do not currently control many nursery pests (see Chapter IV Nursery Pests). Additionally, one method used continually may become ineffective or be very limiting (e.g., there may be only a few strategies under one method). It is impractical to rely on a single control method for the management of a nursery. For the reasons listed below, the three alternatives allowing only one control method were dropped from further consideration.
• Pest problems may not be controlled by the one method available under the alternative. For example, some diseases are best reduced or prevented by combining a cultural treatment such as density control with fungicide applications. Under the alternatives that propose using only cultural controls or only chemical treatments, needle diseases may not be effectively controlled, thereby reducing seedling quality and production goals.

• Pests can build resistance to a method if it is used continually and exclusively.

• Previous nursery management experience has shown the control of pests with only one method often is ineffective and costly. A combination of control methods has been shown to be the most effective and efficient way to control nursery pests.

• Pest problems vary between nurseries; a serious pest that is controlled by a cultural treatment in one nursery may be uncontrollable with the same cultural treatment in another nursery.

Another alternative suggested was to contract the growing of seedlings to private nurseries. This alternative was dropped for the following reasons:

• It is beyond the scope of this EIS.

• A nationwide analysis has already been completed to determine the number of seedlings that can be grown by private nurseries for the Bureau of Land Management and Forest Service. The analysis included a cost comparison of private nurseries versus Federal nurseries. The studies show the number of seedlings grown nationwide in private nurseries increased from 6.5 million in 1981 to 24.4 million in 1987, while Federal nursery seedling numbers decreased from 162 million in 1981 to 112 million in 1987. In addition, several Federal nurseries that were not cost efficient were closed.

• The use of chemical pesticides is not an issue limited to the Forest Service, but one also challenging state and private nurseries. Shifting the responsibility for growing the seedlings does not eliminate this issue; it simply transfers the issue to private industry.

The consensus of the private nursery managers contacted by the interdisciplinary team was that the issues of human health and the environmental effects of chemical pesticides were already being voiced by adjacent landowners.

• Private nursery contracts will not be affected by the Nursery EIS preferred alternative.

Description of the Alternatives Considered in Detail

This section describes the three alternative programs for managing pests at the Lucky Peak Nursery. The philosophy behind all the alternatives is to control pests when necessary to produce quality seedlings, while protecting human health and the environment.

These alternatives were developed from the issues discussed in Chapter 1 and Appendix A. The three major issues identified are human health, environmental quality, and economics. Under each alternative description, there is a discussion of how the alternative responds to the issues. Each of these issues is also discussed under a sub-heading in the alternative descriptions. The alternatives involve the use of mitigation measures to protect human health and environmental quality. (Mitigation measures are activities or decisions designed to prevent, reduce, or compensate for adverse environmental impacts.) Mitigation measures are discussed later in this chapter. A more complete discussion of proposed monitoring programs is in Appendix E.

All three of the alternatives contain components of an integrated pest management program. Alternatives B and C incorporate a documented decision-making process, as well as a full range of control methods. Alternative A contains an undocumented decision-making process.

Alternative A - No Action

Continue Present Pest Management

This alternative would permit the use of all pest control methods for controlling weeds, insects, diseases, and animal pests in the nursery. This is the current pest management practice at the Lucky Peak Nursery. Alternative A is somewhat responsive to the issues because it would allow the use of all pest control methods. It does not respond well to the issues of human health risks or environmental quality concerns. However, all laws are followed and label requirements met. Alternative A is the “no action” alternative.

Decision-Making Process

The manager would use an undocumented decision-making process to select the control method and time of application. Documenting all decisions for each pest treatment would not be required. Decisions would be based on nursery pest control experience as well as current nursery research findings with limited emphasis on monitoring plans to determine pest levels, damage, and result of treatment. This means that treatment alternative, all decisions outlining how to assess pest population levels or crop damage, and the rationale for them would not be trackable.
Control Methods
All biological, chemical, and cultural controls would be permitted. The most effective and efficient chemical and control methods would be used. Control methods used would continue to change, based on new research and technology, review of existing methods, and public need.

Human Health Risk
As in all alternatives, human health risks would be a concern when selecting a control method. Under this alternative, all control methods would be studied before use for potential effects on human health and would be implemented based on current Forest Service regulations, Forest Service Handbook, and existing Lucky Peak Nursery safety plans. There would be no trackable human health monitoring plan under this alternative.

Environmental Impacts
Adverse environmental impacts would be minimized through the plans and mitigation measures described in this EIS. (Mitigation measures are discussed later in this chapter; monitoring plans are discussed in Appendix F.) Uncertainty about the impact of a control method on the environment would be balanced with the impacts of not producing and not planting the trees. Existing environmental monitoring would be continued.

Economics
Seeding quality standards would be met, but production goals may not be met due to increased risk from the use of cultural techniques. Costs of the control methods would exceed nursery budgets in the short- and long-term. There would continue to be a need for pest scouts.

Alternative B
Biological and Cultural Controls Only
No Chemical Pesticides
This alternative would permit the use of only biological and cultural controls to control unwanted weeds, insects, diseases, and animals in the nurseries. Chemical pesticides would not be used. This alternative responds well to the issues of human health risk and environmental quality, since there would be no risk from chemical pesticide exposure.

Decision-Making Process
Under this alternative, nursery managers would use a chronicled decision-making process to select the control method and when to use it. There would be an emphasis on developing and using a monitoring plan to determine how to assess pest population levels on crop damage. This process is illustrated in Figure II-1.

Control Methods
All biological and cultural methods would be permitted. Chemical pesticides would not be used. Control methods used would continue to change, based on new research and technology, review of existing methods, and public need.

Human Health Risk
As in all alternatives, human health risks would be a concern when selecting a control method. Under this alternative, all control methods would be studied, before use, for potential effects on human health. There would be no risk from chemical pesticides, but there is the possibility of increased risk from the use of cultural techniques. Under this alternative, there would be no need for a human health monitoring plan for exposure to pesticides.

Environmental Impacts
Adverse environmental impacts would be minimized through the monitoring plans and mitigation measures described in this EIS. (Mitigation measures are discussed later in this chapter; monitoring plans are discussed in Appendix E.) Uncertainty about the impact of a control method on the environment would be balanced with the impact if trees were not planted and not produced.

Economics
Seeding quality standards would be met, but production goals may not be met due to seedling losses, primarily from disease. Costs of the control methods would exceed nursery budgets in the short- and long-term. There would continue to be a need to employ hand weeder; there would also be a need for pest scouts.

Alternative C
Integrated Nursery Pest Management
Permits all methods of pest control, biological, chemical, and cultural, for control of weeds, insects, diseases, and animal pests. This alternative responds to the issues because it permits the use of all control methods, within the framework of a documented decision-making process. The issues of human health and environmental quality are addressed through monitoring programs and mitigation measures. Mitigation measures designed to prevent, reduce, or compensate for harm to the environment will be placed with this alternative. A trackable environmental monitoring program would be implemented. This is the Forest Service's preferred alternative.

Decision-Making Process
Under this alternative, the nursery manager would use a documented decision-making process to incorporate the tenets of integrated pest management which include an emphasis on record keeping systems. This documenting process is illustrated in Figure II-1. There would be an emphasis on developing a monitoring plan to determine how to assess pest populations and crop damage.

Control Methods
All biological, chemical, and cultural methods would be permitted. If no effective or economical nonchemical methods exist, chemical pesticides would then be used. Control methods used would continue to change, based on new research and technology, review of existing methods, and public need. All control methods would be studied before use for potential ef-
fects on human health and will be implemented based on current regulations, Forest Service Handbook, and existing Lucky Peak Nursery safety plans.

Human Health Risk
As in all alternatives, human health risks would be a concern when selecting a control method. Under this alternative, all control methods would be studied for potential effects on human health before use, and a trackable human health monitoring plan would be followed. (See Appendix E.)

Environmental Impacts
Adverse environmental impacts would be minimized through the monitoring plans and mitigation measures described in this EIS. (Mitigation measures are discussed later in this chapter; monitoring plans are discussed in Appendix E.) Uncertainty about the impact of a control method would be balanced with the impacts on the environment of not producing and not planting the trees.

Economics
Seedling quality standards and production goals would be met. Costs of the control methods would not exceed nursery budgets in the short- or long-term. There would be a need to employ or reassign personnel to implement IPM programs.

Comparison of the Alternatives
Table II-1 compares the most important characteristics of the alternatives. Characteristics that are not presented here are not considered to differ substantially among the alternatives. One of the important differences among the alternatives is the decision-making process that would be used to decide if, when, and how to treat pest problems. The different ways pest management decisions are made is discussed earlier in this chapter in the section on decision-making for pest management. Another important difference among the alternatives is the control methods available to the manager. Some of the alternatives allow the use of the full range of methods; others restrict what can be used.

Table II-2 compares the three alternatives based on the issues presented to the interdisciplinary team. Human health and environmental quality are straightforward; the goal is to protect health and the environment as much as possible. The issue of economics is not as clear-cut. Some people want the nursery to provide as many jobs as possible; others want the nurseries to be managed as cost-efficiently as possible. Economic concerns are expressed in Table II-2 under the headings of cost-efficiency, number of people employed, and seedling production. Seedling quality standards would be met under each alternative.

A narrative summary of the comparison of effects between the alternatives is provided following Table II-2. The summary provides rationale and examines subtle differences within the broad categories of the table.

Summary of the Comparison of the Effects of the Alternatives

Human Health Risk - Manual and Mechanical Methods

Column 1
- Most mechanical and manual practices are currently directed at weed control.
- Manual weed control could result in sprains, sun exposure, heat exhaustion, and back injuries.
- Mechanical weed control could result in personal injuries from equipment operation.
- Alternative A has a low human health risk from mechanical and manual methods because herbicides are the primary means of weed control. There would be less use of manual and mechanical weed control methods and, therefore, less risk.
- Alternative B has a high human health risk from mechanical and manual methods, because herbicides are not used and manual and mechanical methods would be used extensively.
- Alternative C would have a moderate human health risk from mechanical and manual methods because combinations of manual/mechanical and chemical methods would be used.

Human Health Risk - Chemical Pesticides

Column 2
- Alternative A has the potential for moderate to high human health impacts from pesticides. There is a high probability for unwise use of pesticides (unnecessary applications, poor timing of applications, use of more toxic products) in Alternative A than in Alternative C due to the possible lack of planning and analysis prior to pesticide use.
- Alternative B has no risk because chemical pesticides would not be used.
- Alternatives C has moderate to high human health risks from pesticide use because planning and analysis would occur prior to using them. Evaluation of different treatment options, monitoring of pests or damage, timing of pesticide applications, and careful selection of products frequently reduce the number and toxicity of chemical pesticide applications. Human health monitoring would be more extensive than in Alternative A. A documented human health monitoring plan will be written as described in Appendix E.
Table II-1
Comparison of the Characteristics of the Alternatives for Tree Nursery Pest Management

<table>
<thead>
<tr>
<th>Decision Making Process</th>
<th>Control Methods Permitted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative A</td>
<td>Undocumented</td>
</tr>
<tr>
<td></td>
<td>All Biological, Chemical, and Cultural Methods Only</td>
</tr>
<tr>
<td>Alternative B</td>
<td>Documented</td>
</tr>
<tr>
<td></td>
<td>No Chemical Pesticides; Biological and Cultural Methods Only</td>
</tr>
<tr>
<td>Alternative C</td>
<td>Documented</td>
</tr>
<tr>
<td></td>
<td>Biological and, Cultural Preferred; All Biological, Chemical, and Cultural Methods Permitted</td>
</tr>
</tbody>
</table>

Table II-2
Comparison of the Effects of the Alternatives on Nursery Pest Management Issues

<table>
<thead>
<tr>
<th>Human Health Risks</th>
<th>Adverse Effects on Environment</th>
<th>Economic Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alt.</td>
<td>Column 1</td>
<td>Column 2</td>
</tr>
<tr>
<td>A</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>B</td>
<td>High</td>
<td>None</td>
</tr>
<tr>
<td>C</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

(Baseline for comparison is Alternative A)

Adverse Effects on Environmental Quality - Wildlife and Fisheries

Column 3

- Alternative A poses greater risks to wildlife and fisheries than the other alternatives because of the frequent use of chemicals with toxic qualities and no documented decision-making process. Without a trackable decision-making process, there exists a higher probability of unwise use of pesticides - unnecessary applications, incorrect timing of applications, and use of more toxic products.

- Alternative B has a low risk to wildlife and fisheries because chemicals will not be used.

- Alternative C has moderate to high risks to wildlife and fisheries. Chemicals with inherent acutely toxic qualities would be used, but because of a chronicled decision-making processes, planning and analysis would occur prior to use of pesticides. Pest monitoring to avoid unnecessary treatments, correct timing of applications, and proper selection of products frequently reduce the number and toxicity of chemical pesticide applications.
Adverse Effects on Environmental Quality - Water and Soil

Column 4

- Alternative A has moderate adverse effects on soil and water because a range of chemical pesticides with varying persistence and leaching ability will be allowed, and chemical pesticide use is determined by an undocumented decision-making process.
- Alternative B has moderate adverse effects on soil and water because of potential for increased erosion and soil compaction. The other control methods would have very minor effects on soil and water.
- Alternative C has low to moderate adverse effects on soil and water because, although a range of chemical pesticides with varying persistence and leaching ability will be used, pesticide use will be determined by a documented decision-making process, which may reduce the frequency and toxicity of chemical pesticide application.

Economic Considerations - Cost-Efficiency

Column 5

- Cost-efficiency is defined as being able to meet production goals for the least cost. Quality standards would be met in all alternatives, but the quantity of seedlings produced may differ among the alternatives.
- Alternative A would result in high cost-efficiency because use of all methods, including pesticides, would be allowed.
- Alternative B would result in low cost-efficiency because the most cost-efficient tools, chemical pesticides, could not be used. Seedling production goals would not be met, because, at present, non-chemical pesticide methods for controlling some insects and diseases at the nursery are not available.
- Alternative C might, at times, result in somewhat lower cost efficiency than Alternative A. For example, some treatments might be more expensive to implement, but will be selected because of other attributes deemed more important than cost (e.g., safer to use, or less toxic to wildlife). In many cases, however, a chemical treatment would be selected, resulting in high cost efficiency.

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Economic Considerations - Number of People Employed

Column 6

- Alternative A would result in relatively low employment because the primary workers involved with pest control would be 1 or 2 chemical applicators, plus a few hand weeder.
- Alternative B would result in relatively high employment because numerous workers would be hired to weed by hand, several to monitor pests and biocontrol agents, and several to perform additional cultural control activities.
- Alternative C would result in low to moderate levels of employment than in Alternative A because some hand weeder, 1 or 2 chemical pesticide applicators, and 1 or 2 people working with the IPM program would be needed.

Economic Considerations - Seedling Production

Column 7

- Alternatives A and C would result in high seedling production because all methods would be available to control pests effectively. A minimum number of seedlings would die or be culled because of pest damage.
- Alternative B would result in low seedling production; first-year seedling losses would be significant due to soil-borne diseases which currently are controlled only by fumigation; some other pests, currently controlled only by pesticides, may also kill or damage seedlings.

The Preferred Alternative

Alternative C is the Forest Service preferred alternative. Regulations require the Forest Service to identify a preferred alternative in the DEIS, and also to select a preferred alternative in this FEIS (final environmental impact statement) (U.S. Government 40 CFR 1502.14e).

The interdisciplinary team evaluated the alternatives, considered the public's comments, and recommended Alternative C as the preferred alternative. The Forest Supervisor reviewed the recommendation with his staff and also identified Alternative C as the preferred alternative in this Final EIS.

This alternative will permit the Forest Service to fulfill its statutory mission and responsibilities, considering economic, environmental, and technical factors. The preferred alternative also responds to the issues.
Under the preferred alternative, all control methods - cultural (which includes manual and mechanical), biological, and chemical - may be used; however, each nursery would make better use of non-chemical methods, when possible, and actively look for opportunities to reduce reliance on chemical pesticides.

**Mitigation Measures**

Mitigation measures are activities or decisions designed to prevent, reduce, or compensate for adverse environmental impacts. The mitigation measures presented here are based on Forest Service policy, nursery operation and current safety practices, safety plans, information in the research literature, and the field experience of Forest Service nursery managers and employees. For the most part, the mitigation measures are presented by pest control method. This is done because the three control methods (biological, chemical, and cultural) are very different, and therefore present a very different set of possible impacts.

These mitigation measures are to be applied in addition to Best Management Practices (BMPs). BMPs are methods, measures, or practices designed to prevent or reduce water pollution. Not limited to structural or nonstructural controls and procedures for operations and maintenance, they are usually applied as a system of practices rather than a single practice. This preventive approach helps to avoid biological or chemical contamination of surface or groundwater. For example, excess water runoff from nursery fields is controlled by collection systems which spill onto waterways with water-tolerant vegetation that absorbs the moisture.

Those mitigation measures that are designed to protect human health are based on the Human Health Risk Assessment (Appendix D). Refer to this appendix for a detailed discussion of the scientific basis for these mitigation measures.

**Mitigation Measures For All Control Measures**

These mitigation measures are applicable to all control methods and apply to all alternatives.

**Treatment**

- A no-treatment or deferred treatment option will be considered for all pest control activities.
- Treatment alternatives would be analyzed using the following criteria:
  - minimize human health risk
  - least environmental impact

**Human Health Risk Management**

Each nursery will have a plan for managing human health risks. The plan will include:

- Project Risk Plan - includes the identification of needed personal protective equipment, specific information and training (including first aid), supplies, scheduled safety meetings, and awareness of hazards.
  - The basic reference is the Forest Service Handbook 6709.11 (Health and Safety Code Handbook). This will include a Safety and Health Hazard Analysis (Form FS-6700-7) for each control method.
- Nursery Health, Safety and Wellness Plan - this will focus on ways to prevent accidents and illness among nursery workers.

**Environmental Monitoring Plan**

Each nursery will have an environmental monitoring plan. The plan would include water and soil quality monitoring procedures and standards, requirements for notification of adjacent landowners, and record-keeping guides. See Appendix E for additional information.

**Training**

Nursery managers, assisted by Forest Service personnel from the Timber Management and Pest Management units, will be responsible for providing training to assure that:

- employees acquire a working knowledge of the process for controlling pests in the nurseries.
- information exchange takes place when new or modified control methods are developed that show potential for more widespread use.
Mitigation Measures
For Biological Control Methods

These measures apply to all the alternatives and would be put into effect any time a biological control is used.

Regulatory Procedures

All Forest Service uses of biological control methods will be in cooperation with the USDA Agricultural Research Service or under individual-approved state programs.

Notification

If applicable, nursery managers will inform downstream water users who could be affected by biological contamination of surface or ground water.

Mitigation Measures
For Chemical Pesticides

The following mitigation measures apply to all alternatives that include the use of chemical pesticides for control of weeds, insects, diseases, and animals in the nurseries. These mitigation measures would apply to all alternatives except Alternative B (No Chemical Pesticides).

Notification and Restriction

- Downstream water users and adjacent landowners who could be directly affected by drift, water transport from normal operations, or an accidental spill, will be notified prior to the chemical application.
- No employees or contract workers will be permitted to work within 100 feet of a nursery seedbed fumigated with methyl bromide + chloropicrin for 3 days or until the tarp is lifted. Vehicle and foot traffic through the 100-foot buffer zone is permitted.
- Tarp should be lifted from methyl bromide + chloropicrin applications when a minimum number of employees or contract workers are present.
- If tarp is lifted during regular work hours, all employees or contract workers not engaged in tarp lifting will be moved upwind and away from the tarp lifting.
- After fumigation, tarp integrity will be monitored routinely for tears or leaks.

- Do not fumigate with methyl bromide + chloropicrin within 100 feet of residential private property.
- No employees or contract workers will be permitted to work within 50 feet of a nursery seedbed fumigated with dazomet for 3 days. Vehicle and foot traffic through the 50-foot buffer zone is permitted.
- Do not fumigate with dazomet within 50 feet of residential private property.

Protective Clothing

- Appropriate protective clothing will be worn by all workers.

Regulatory Procedures

- All applicable local, state and Federal laws, including the labeling instructions of the Environmental Protection Agency, will be strictly followed.
- Pesticides will be applied within the prescribed environmental conditions stated on the label. This includes considerations of relative humidity, wind speeds, and air temperature, when determining the timing of application in relation to drift reduction.
- Use pesticide formulations that contain only inert ingredients recognized as generally safe by EPA, or which are of low priority for testing by EPA. Use of other inert ingredients (identified by EPA as a high priority for testing or those that have been shown to be hazardous) requires full assessment of human health risks incorporated into the NEPA decision-making process.
- Water quality monitoring for detection of pesticide residues will be conducted. Monitoring of a pesticide’s application will be conducted to determine if mitigation measures are 1) being observed, 2) effective in maintaining water quality and soil productivity, and 3) in compliance with state water quality standards and pesticide label requirements.
- Pesticide use will be conducted in accordance with the direction in Forest Service Manual 2150 (Pesticide-Use Management and Coordination). This defines the authority for Forest Service use of pesticides (the Federal Insecticide, Fungicide, and Rodenticide Act). The objectives and responsibilities of the different administrative levels are documented. This directive includes the requirement for environmental documentation, safety planning, and training when pesticides are used.
- Forest Service Handbook 2109.14 (Pesticide-Use Management and Coordination Handbook) will be used to direct project planning. This establishes procedures to guide managers in planning, organizing, conducting, and reporting pesticide use projects.
Human Health Risk Management

- Workers (both Forest Service and contract) who know that they are extremely sensitive to pesticides will not be assigned to application projects. Workers who display symptoms of extreme sensitivity to pesticides during application will be removed from the project.

- For chemical pesticides with moderate and high risks, nursery managers will develop new worker and chemical use schedules to reduce worker exposure to these chemicals. See Chapter 4 and Appendix D for a discussion of Margin of Safety. The new schedules may include one or all of these options:
  - lengthen reentry times for workers
  - wear appropriate protective clothing
  - reduce worker exposure periods to chemical pesticides
  - reduce chemical pesticide application rates
  - reduce the number of chemical pesticide applications
  - self-contained mixing devices
  - enclosed tractor cabins

Mitigation Measures For Cultural Controls

This mitigation measure applies to all alternatives.

Human Health Risk Management

- A Project Risk Plan will be developed which will include a Safety and Hazard Analysis (FS-6700-T).

Mitigation Measures For Adding and Replacing Chemical Pesticides

- The nursery manager will seek public input on the proposal.
A human health risk assessment will be prepared for the additional pesticide.

Interdisciplinary specialists will analyze the environmental impacts of using the additional pesticide.

Considering results of the risk assessment and the environmental consequences, the nursery manager will identify the appropriate NEPA documentation to be prepared.

The nursery manager will direct preparation of the documentation and see that it adheres to the principles of Integrated Pest Management, in making a decision to add or replace a chemical pesticide.
Chapter 3
Affected Environment

Introduction
This chapter describes the environment at the Lucky Peak Nursery. Implementation of any of the proposed alternatives could affect or be affected by resources at the nursery. These resources include:

The Social and Economic Conditions:
- Community Information
- Economics
- Cultural Resources

The Physical Environment:
- Climate
- Geology
- Soils
- Water

The Biological Environment:
- Wildlife
- Threatened, Endangered, and Sensitive Plant and Animal Species
- Fisheries

Pest Management:
- Why Pests are a Problem in Nurseries
- Pest Control Methods Used at Lucky Peak Nursery
- Specific Pest Problems and Their Controls

Resources at the Nursery
The Lucky Peak Nursery is located near Boise, Idaho and is administered by the Boise National Forest. The nursery is 298 acres in size with 62 acres utilized for production. It has the capacity to produce 7.1 to 8.2 million seedlings per year. The main species grown here are ponderosa and lodgepole pines, Douglas-fir, Engelmann spruce, western larch, and shrubs such as bitter brush, grown for wildlife habitat improvements. The land surrounding the nursery to the north, east, and south is administered by the U.S. Army Corps of Engineers; Idaho State Highway passes the nursery on the northwest side; to the east is Lucky Peak Lake, an impoundment of the Boise River; and adjacent to the nursery's southwestern boundary is a Bureau of Land Management parcel and private land. See the Lucky Peak Master Plan, Technical Appendix Volume 2, Plate 3-6; this is a document prepared by the U.S. Army Corps of Engineers and will be referred to as LPMP.

Social and Economic Conditions
Community Information
The Lucky Peak Nursery is located in a rural, agricultural area of Ada County, about fifteen miles east of Boise. The population of Boise is about 103,000.

The dominant local industries are livestock grazing, logging, and raising agricultural crops. The Boise State University, the Boise Interagency Fire Center, and the Boise-Cascade Corporation are located in nearby Boise, where major employment is in government, education, medicine, services, and commerce. Unemployment in Idaho averages about six percent.

The nursery employs 6 full time and 15 part-time staff. During lifting and packing season, the nursery contracts 90 to 100 laborers and also employs about 45 additional Forest Service personnel from nearby National Forests.

Economic Information
The Lucky Peak Nursery has an annual budget of $825,000. Of this, $112,000 is spent for pest control. A large percentage of these funds are spent on salaries and supplies in the local community.

Recreation
The Lucky Peak Lake borders the nursery on the east and north; it is used for boating, swimming, water skiing, and fishing. A marina is located on the reservoir a few miles northeast of the nursery.

Recreational deer hunting also occurs in the area.

The nursery is visited by about 2,000 people every year; many of these are school children who come to walk the Lucky Peak Nursery Nature Trail.
Figure III-1
Lucky Peak Nursery Site Plan Map

A. Trailer Pads
B. Residence
C. Residence
D. Office
E. Seed Freezer
F. Seed Extractory
G. Multi-Purpose Building
H. Cone Shed
I. Packing Shed/Coolers
J. Shop/Warehouse
K. Gas House
L. Pesticide Building
M. Long Shed
N. Private Residence
Nearby Residences

Because the land surrounding the Lucky Peak Nursery is largely rangeland, and much of it is administered by the Army Corps of Engineers, there are a limited number of private residences in the area. The nursery manager's residence is located along the entry road to the nursery, about 100 feet from nursery seedbeds; another employee residence is located about 1/4-mile away on the northwest side of the nursery. There is also a mobile home for fire crew use, and is occupied during the summer. Another trailer, used 8 months of the year, belongs to a nursery employee. Two private residences are between 1/4- and 1/2-mile away; other residences are greater than 1/2-mile away from the nursery.

Cultural Resources

The Lucky Peak Nursery was established in 1959 when the USDA Forest Service purchased the land which had previously been used for dry-land farming. The first seeds were sown in the spring of 1960. The nursery is named for a nearby mountain.

According to the LPMP the Boise area possessed an abundance of natural resources. In the past the Shoshone-Comanche and Monoish (Bannock-Paiute) speaking people used the area on a seasonal basis to fish, hunt, and gather plant food. Six historic sites of their activity have been identified with two designated as significant and eligible for listing on the National Register of Historic Places. These sites were located in the area of the proposed Lucky Peak Lake (USACE, 1988). It is believed that archaeological sites probably existed all along the floodplains and tributary streams before the dams were built.

Euroamericans entered the area in 1811; these were fur trappers. John Fremont explored the Boise River basin in 1843. The first settlers soon followed, arriving on the Oregon Trail; most became farmers. Miners appeared in 1862 when gold was discovered in the mountains near Lucky Peak. Mining for gold and silver was a principal industry along the Boise River until about 1900. Logging, grazing, and agriculture have evolved as the primary components of the economy since the turn of the century.

Physical Environment

Climate

The climate is warm in the summer and cold in the winter, with precipitation ranging from 7.16 (1966) to 21.68 (1984). The average annual precipitation is 16 inches. Over half of the annual precipitation occurs during the cooler months. Summer rain is minor. Monthly precipitation ranges from about 1.5 inches in January to about 18. July and August. Rainless periods of several days to several weeks are common in the summer. The

Geology and Groundwater

The Lucky Peak Nursery is located at the border of two major physiographic provinces which contain the Southern Batholith Section of the Northern Rocky Mountain Province and delineates the southern part of the Idaho Batholith. The other major division is the Western Snake River Section in the southern portion of the Columbia-Snake Intermountain Province.

The Nursery itself is located on a bench overlooking the Lucky Peak Lake which impounds the waters of the Boise River. The geologic materials beneath the nursery are granitics, basalts, and alluvium from deposits of the Boise River, colluvium from the granitic slopes to the west and conglomerates in the canyon walls, which probably relate to ancient alluvial deposits of the Boise River. See geologic sketch, Figure III-2.

Three wells serve the nursery and average about 170 feet in depth. According to the well logbooks, all wells penetrated the conglomerate (cemented sand and gravel), to the contact with the reservoir level and the well water levels. Most often there is a two week response period between fluctuations in the reservoir and the well water levels. Water is also pumped directly from the reservoir.

Soils

Soil is composed of several things: many kinds and sizes of particles of clay, silt, and sand; organic matter; and soil organisms varying in size from bacteria and algae to earthworms and gophers.

The important physical, chemical, and biological properties of soil are texture, structure, organic matter content, pH, and cation exchange capacity. A soil is classified by the proportion of different sized particles it contains. A loam is a soil that contains equal parts of clay, silt, and sand. These terms refer to the size of the mineral particles that make up the soil; clay particles are smallest and sand particles are largest. Varying proportions of these different-sized particles produce different types of soils. For example, a soil with more clay than silt or sand is referred to as a clay loam. A soil with more sand than clay or silt is referred to as a sandy loam.

The texture of soil influences the development of structure or degree of soil aggregation (the clustering of individual soil particles). In turn, this affects aeration, water movement, internal drainage, root growth, and ease of cultivation, or tilth.
Figure III-2
Lucky Peak Nursery
Geologic Sketch
(Looking North)

Not to scale. Interpretations from well logs and soils survey.
Clay particles are very fine and tend to aggregate into a dense, heavy mass. Clay holds water and nutrients well but lacks pore spaces for the movement of air. In a sandy soil, the mineral particles are larger and the large pore space is greater, allowing air to move more freely, but the small pore space that retains water is lacking.

Ordinarily, a loam soil is the most suitable soil texture for agricultural purposes, since it is capable of developing soil aggregates, contains both large and small pore spaces, and retains water for plant growth.

Nursery soils, however, need to be sandy in texture so that root development is not inhibited, the soils are easily tilled, and soil particles do not cling to the roots when the seedlings are harvested. Sandy soils also provide optimum levels of air and water, rapid intake and drainage of water, and resistance to compaction by machinery.

A soil survey of the nursery was performed in 1964 by Forest Service soil specialists. According to their report:

The Lucky Peak Nursery is on a lava flow bench. It is bounded on the west by a granitic ridge of the Idaho Batholith and on the east by the Boise River Canyon (now forming the shoreline of Lucky Peak Reservoir). The bench has been covered by alluvium of granitic and basaltic composition. The thickness of the sediments diminishes from west to east, and the area has an approximate 5% slope gradient from west to east.

Two low spur ridges extend into the nursery area from the upper west side. A broad swale, probably occupied by an intermittent stream at one time, lies between the two spur ridges. Bottomland flats are on the lower east side of the area.

On the ridges along the west side, the soils are composed mainly of granitic materials. These are lighter in color and are sandier than the other soils in the area. The soils in the lower part, along the east side of the nursery, are composed of a mixture of basaltic and granitic materials. These soils are very dark colored and are finer textured (more silt and clay).

These relationships are shown in Figures III-3 and III-4.

In addition to structure and composition, several other characteristics of soil are important to the nursery manager. Soil organic matter consists of a combination of plant, animal, and microbial residues in various stages of decomposition, as well as live organisms. Organic matter is important because it enhances desirable soil characteristics such as buffer capacity, cation exchange capacity, and water retention. In most agricultural situations, the roots are left after harvest; this returns organic matter to the soil. Because the entire seedling, root and all, is removed when the trees are lifted, managers of bare-root tree nurseries are continually trying to maintain desirable soil organic matter levels. At the Lucky Peak Nursery, the organic matter content ranges from 2.86 to 5.72 percent in different areas, which is considered typical for this climate.
Soil

1) Deep, medium textured over moderately fine textured subsoils, basaltic and granitic alluvium.
2) Moderately shallow, medium textured over moderately fine textured subsoils containing hardpan.
3) Moderately deep, moderately fine texture over moderately fine to fine subsoil.
4) Deep, medium textured over moderately fine subsoils, and granite.
5) Deep, medium textured over moderately fine textured subsoils, and granite alluvium.
6) Deep, moderately coarse textured over medium textured subsoils, mainly granitic alluvium.
7) Deep, moderately coarse textured over moderately fine subsoils, basaltic and granitic alluvium.
8) Deep, moderately coarse textured over moderately fine subsoils, basaltic and granitic alluvium.
9) Deep, coarse textured over moderately coarse textured subsoils granitic origin.

*Note: Soil numbers jump from 1 to 3 (there is no 2) per the soil survey.

Soil pH is a measure of soil acidity or alkalinity. It is important because soil pH affects the availability of nutrients that are dissolved in the soil. The soil pH at the nursery ranges from 5.2 to 6.8. (7 is neutral, anything above 7 is alkaline and below 7 is acidic). The ideal pH is 5.5 to 6.5, especially for conifer nurseries.

Cation exchange capacity is a measure of the total amount of exchangeable cations that can be held by the soil. Cations are positively charged ions; of specific interest here are cations of important plant nutrients such as calcium, potassium, and magnesium. The clay particles in the soil are negatively charged; this allows them to “hold on” to positively charged mineral ions. The higher the value, the more cations the soil can hold. A higher cation exchange capacity means that the soil can hold more nutrients; it also means that more pesticide residue would be held in the soil. The cation exchange capacity ranges from 9.2 to 16.7 meq/100 grams at the nursery, which is slightly low compared to the ideal (10-20 meq/100 grams) but not unusual for these soils in this climate and parent materials.

The majority of the eight soils that were recognized in the soil survey are sandy loam in texture. The eight soils were reclassed, for purposes of this report, into four soil texture categories. In summary, the average values of soil characteristics of the four major soil textures are:

### Average Values or Conditions

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>pH (%)</th>
<th>Organic Matter Capacity (meq)</th>
<th>Cation Exchange</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loam</td>
<td>5.6</td>
<td>3.7</td>
<td>14.4</td>
</tr>
<tr>
<td>Loamy sand</td>
<td>5.65</td>
<td>4.03</td>
<td>12.1</td>
</tr>
<tr>
<td>Sandy clay loam</td>
<td>6.1</td>
<td>4.03</td>
<td>12.1</td>
</tr>
<tr>
<td>Sandy loams</td>
<td>5.63</td>
<td>4.08</td>
<td>11.4</td>
</tr>
</tbody>
</table>
These four major soil textures are expected to respond only slightly differently to pesticide applications due to the similarities of the chemical and physical characteristics of the surface soil and the slightly different physical characteristics of the subsurface soils:

**Soils Response to Pesticide Application**

<table>
<thead>
<tr>
<th>Soil Textures</th>
<th>Relative Adsorption Potential</th>
<th>Leaching Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loam</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td>Loamy sands</td>
<td>Low</td>
<td>Moderate to High</td>
</tr>
<tr>
<td>Sandy clay loams</td>
<td>Moderate</td>
<td>Low to Moderate</td>
</tr>
<tr>
<td>Sandy loams</td>
<td>Low</td>
<td>Moderate to High</td>
</tr>
</tbody>
</table>

**Water**

Water is a key resource because it is influenced by, and in turn influences, activities and resources outside the nursery. Water entering the nursery can be a source of pollutants, bringing in organisms that cause tree diseases or bringing in pesticide residues from other agricultural operations. There is also the potential for water to take pollutants out of the nursery. These impacts can be affected by nursery management.

Water also provides habitat for fish and aquatic animals, as well as plants and animals that use streamside and lakeside areas. Anaquifer found underneath the nursery provides water for wells. This water is used for drinking as well as irrigation.

**Surface Water**

There is a live stream adjacent to the nursery on the south side, Highland Creek, and the Lucky Peak Reservoir border the nursery on the east side. Surface waters, drainage from the irrigation pipelines, and well pump relief valves drain into several intermittent stream courses and, eventually, into the reservoir. There are four constructed ponds that catch the majority of runoff waters from the seedbeds before the waters reach the intermittent stream courses.

Surface erosion occasionally results from rain or rapid snowmelt events. Generally, surface erosion is not a major problem and that which does occur is mainly confined to the road...
Fortunately, the Lucky Peak Nursery applies fertilizer in split applications, that is, small dosages, spread over the growing season so that the material is taken up by the plants rather than leached below the rooting zone.

**Biological Environment**

**Wildlife**

Wildlife is a unique resource at the nursery. Some wildlife species are considered pests requiring control, while other species are considered desirable, and efforts are made to protect them and encourage their use of available habitat within the nursery.

**Current Condition**

The acreage affected by the nursery site, combined with the physical location and the agricultural nature of the management activities limits the types and numbers of wildlife species found within its boundaries. The nursery administrative site consists of approximately 298 acres with 62 acres allocated to seedbeds. During most years, an average of approximately 29 acres are utilized for nursery seedbed production; while remaining seedbeds are usually in cover crop or left fallow. The remaining 269 acres of the administrative site is maintained in native cover.

Wildlife species which find suitable habitat in a wide variety of plant communities and stand conditions will comprise a greater portion of the species found on the nursery sites. Species with specific habitat requirements not found at the nursery can only use the areas, if at all, in a transient manner.

The intense nature of the agricultural activities which take place on the nursery beds restrict their use by wildlife. The degree to which habitat areas are restrictive and frequency of management activities is a direct limitation to the numbers and kinds of wildlife found within the nursery site. While the nursery makes up a very small portion of the surrounding federal and private lands, it does provide habitat for many species of small wildlife. As would be expected, song birds and smaller members of the rodent family (numerous species of mice, moles and shrews) comprise the bulk of the wildlife present on the nursery.

Federal and private land surrounding the nursery provides habitat for up to 375 species of resident and migratory, terrestrial vertebrate wildlife (represented by reptiles, amphibians, birds, and mammals). A reference list of these species is available in the Lucky Peak Master Plan, Technical Appendix, Vol. 2.

The sage brush, grass and desert shrub vegetation on the terrain surrounding the nursery provides habitat for numerous species. Mammals commonly frequenting the area include: mule deer, jack rabbit, bats, tree and ground squirrels, Ord’s kangaroo rat, badger, striped...
skunk, rockchuck, cottontail rabbit, weasel, raccoon, bobcat, and coyote. With one exception most of these species do not regularly frequent or inhabit the nursery site. Populations of rockchucks seem out of control and present a problem of sorts at the nursery.

The nursery and surrounding area provide habitat for numerous species of birds. Among raptors, the area provides seasonal and year-round habitat for the bald eagle, red-tailed hawk, marsh hawk, American kestrel, peregrine falcon, osprey, turkey vulture, great horned owl, pygmy owl and golden eagle. Insect eating birds include the downy woodpecker, western kingbird, and cliff swallow. Omnivorous species present include California quail, chukar, Hungarian partridge, Stellar’s jay, crows, and blackbirds. Seed and/or plant eaters include the house finch, American goldfinch, mourning dove, several varieties of hummingbirds, chickadee, evening grosbeak, western meadowlark, northern oriole, western tanager, and Oregon junco. A diverse variety of migratory waterfowl also commonly pass through the area during annual migrations.

Amphibians and reptiles indigenous to the area include a variety of toads, frogs, lizards and snakes.

### Threatened, Endangered, and Sensitive Plant and Animal Species

Plant species and vertebrate animal species designated by either Federal or State authority as recovery species include the threatened and endangered categories, and the Forest Service designation of sensitive. Habitat management activities for these species are given priority to ensure their continued survival.

#### Animals

No wildlife species listed as threatened, endangered or sensitive are known to inhabit the nursery or use it on a regular basis. However, some species are native to the general area and are occasionally sighted in the vicinity of the nursery.

Vertebrate species classified in the “Endangered” status which are known to frequent the Boise National Forest are the bald eagle, peregrine falcon, and gray wolf. Peregrine falcon habitat is not available within the immediate vicinity of the nursery, although sightings have occurred. The Boise River and Lucky Peak Lake are considered to be bald eagle winter range. Bald eagle sightings have occurred in the vicinity of Lucky Peak Nursery. No sightings of gray wolf have been reported in recent times near the nursery site. Most sightings seem to be farther north in the state.

### Plants

Plant species on the Regional Foresters “Sensitive” species list which may occur in the Lucky Peak Nursery area include: *Allium aeseae*, *Hydrophyllum occidentale*, and *Primula wilcoziana*. Populations of these species have not been located on the nursery.

### Fisheries

The Lucky Peak Nursery is located on a bench several hundred feet above and overlooking Lucky Peak Lake, an impoundment of the Boise River. The Idaho Department of Fish and Game stocks Lucky Peak Lake with kokanee salmon, rainbow trout, and bass. Catfish, sturgeon, whitefish, carp, sunfish, and other species are found in the Boise River system. See Lucky Peak Master Plan Technical Appendix volume 2, SD6-17 to 19 for a list of fish species.

Lucky Peak Lake is used extensively for fishing and boating.

### Pest Management

#### Why Pests are a Problem in Nurseries

Disease and insects in forest nurseries, like those in agricultural crops, can cause significant damage in a very short period of time. Unlike diverse ecosystems such as a forest, forest nurseries grow thousands of the same species of host plant (the seedlings) in extremely close proximity to one another (20-25 seedlings per square foot), giving the pest abundant nourishment in a small amount of space and allowing it to spread from one host plant to the next with ease. The age of the host also influences its susceptibility to pest attack; seeds and young plants are very susceptible to pest attack due to the high nutritive value of the seed and the succulence of seedling tissue. In forest nurseries, all host plants are three years old or younger so that attack of young succulent tissue usually involves the whole seedling or a large portion of it (as compared to a large tree, where the young branch tips or root tips represent only a small portion of the tree).

In addition, cultural activities to promote maximum seedling growth, such as watering and fertilizing, create an environment that is often very favorable to weeds as well as the seedlings. Weed seeds are disseminated to the nursery in many ways. They are carried in on the vehicles, clothing, and shoes of nursery workers and visitors; they are pumped onto the beds in irrigation water (unless filtered out); and the greatest number are blown in from adjacent weed patches for which the nursery has no management. Some weed seeds reach the seedbeds from off- bed patches on the nursery that are not adequately controlled. Such patches occur along streams, roads, fence rows, and or any patch of unmanaged ground.
Pest Control Methods Used at Lucky Peak Nursery

Biological Control Methods

A biological control method is the utilization of natural enemies such as predators, parasites, and diseases to control nursery pests. Biological controls can be purposefully applied or naturally present. For instance, at Lucky Peak Nursery, skeleton weed is somewhat controlled by a rust disease which attacks the plant. Several less commonly used methods, such as biological pesticides and allelopathy, are still considered experimental for bare root conifer nurseries.

At other nurseries (or agricultural sites), the selected release of beneficial insects has been used to control both weeds and nursery insect pests. The release of beneficial insects is coordinated with state and local weed control programs, extension agents, and other Federal agencies. Insect releases can be effective when the population of target weeds or insects is large enough to support the insects.

Insect adults and larvae can control weeds by feeding on flowers and/or seeds, girdling roots, and forming galls (swelling and malformations). Insect release programs in the nursery have met with mixed results. However, there is an ongoing research emphasis on the development of biological controls.

The disadvantages of biological controls are the need to replace the control agents each year (if the control organism cannot be established in the nursery environment), and the intensive monitoring required to determine the control agent's effectiveness. In addition, while the introduction of host-specific insects would be carefully studied and planned in advance, there is a risk of nursery seedlings being damaged by the insect.

Some types of biological control agents have been used successfully in greenhouses, where the controlled environment limits pests from entering and the biological control from escaping. These include:

- predaceous or vegetation eating insects, other than those mentioned.
- biological pesticides - naturally occurring microorganisms such as fungi and bacteria which are isolated and processed to control a specific insect or weed.
- beneficial micro-organisms - use of micro-organisms to control an insect or weed by inducing disease conditions, inhibiting pathogen attacks, and protecting seeds or seedling roots.
- allelopathy - use of chemicals produced by plants to control or inhibit weed growth.

The continued development of biological controls offers promise for the future.

Chemical Control Methods

Chemical pesticides have been an important, although not exclusive, pest control tool at the Lucky Peak Nursery.

Five categories of chemical pesticides are commonly used in forest tree nurseries:

- herbicides are used to control weeds
- fungicides are used to control fungi that cause diseases
- insecticides are used to control insects
- rodenticides are used to control rodents
- fumigants are used to control weeds, insects, and diseases

Herbicides can be highly selective and effective in controlling unwanted vegetation. In many cases, the effects are relatively long-lasting because the chemical is carried throughout the plant; this kills the roots and minimizes resprouting. The disadvantage of herbicides is that they can kill or damage the tree seedlings if timing, formulations, and application methods are incorrect.

Fungicides are effective in controlling leaf and stem diseases and often control these diseases for the growing season after one or two applications. The disadvantage of fungicides is that they can damage seedlings if timing, formulations, and application methods are incorrect. Another problem is that most soilborne diseases are difficult to control with fungicides.

Rodenticides are effective in controlling rodents such as gophers.

Insecticides are effective in controlling insects. However, insecticides are relatively non-selective. When harmful insects are killed, populations of beneficial insects are often reduced as well. They usually remain effective only for a short period of time.

Fumigants are soil sterilants and are highly effective and efficient in controlling all soil-borne pests, including weed seeds, insect larvae, and pathogenic fungi. The advantage of a fumigant is the ability to control all soil pests with one chemical application, ensuring an initial pest free environment for new seedlings. The disadvantage is that beneficial organisms, such as earthworms and mycorrhizal fungi, are also destroyed during fumigation.

Chemical pesticides, including herbicides, fungicides, and fumigants are currently being used at the Lucky Peak Nursery. Presently, 95 percent of the chemical pesticides used in the nursery are fumigants, based on pounds of active ingredient applied (See Table III-1). Additional and replacement chemical pesticides would be added when certain pesticides are removed from the market, less toxic pesticides become available, or a new pest appears that requires a new pesticide.

All chemical pesticides used in the nursery are registered by the U.S. Environmental Protection Agency. All treatments are made following manufacturers' label restrictions and administrative directions. Chemical pesticides are usually applied in mixtures with water or...
oil carriers, wetting, sticking, or thickening agents, and stabilizers or enhancers. A complete discussion of chemical pesticides is found in Appendix B.

### Table III-1

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Pounds of Active Ingredient</th>
<th>Percent of Total</th>
<th>Target Pest</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fumigants:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dazomet (or)</td>
<td></td>
<td></td>
<td>Pathogenic fungi</td>
</tr>
<tr>
<td>Methyl Bromide</td>
<td></td>
<td></td>
<td>Weeds</td>
</tr>
<tr>
<td>+ Chloropicrin</td>
<td></td>
<td></td>
<td>Nematodes</td>
</tr>
<tr>
<td>Subtotal</td>
<td>(6300)</td>
<td>97</td>
<td></td>
</tr>
<tr>
<td><strong>Herbicides:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCPA</td>
<td>40</td>
<td>1</td>
<td>Weeds</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>5</td>
<td>&lt;1</td>
<td></td>
</tr>
<tr>
<td>Napropamide</td>
<td>62</td>
<td>&lt;1</td>
<td></td>
</tr>
<tr>
<td>Oxyfluorfen</td>
<td>24</td>
<td>&lt;1</td>
<td></td>
</tr>
<tr>
<td>Subtotal</td>
<td>(69)</td>
<td>(2)</td>
<td></td>
</tr>
<tr>
<td><strong>Fungicides:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benomyl</td>
<td>50</td>
<td>1</td>
<td>Pathogenic fungi</td>
</tr>
<tr>
<td>Metalaxyl</td>
<td>5</td>
<td>&lt;1</td>
<td></td>
</tr>
<tr>
<td>Subtotal</td>
<td>(55)</td>
<td>(1)</td>
<td></td>
</tr>
</tbody>
</table>

**Total Use** | 6424 | 100% |

---

1 Pesticide figures are based on the average annual use for the years 1985 through 1988. Figures for DCPA, napropamide, and metalaxyl are projected based on historical use at other nurseries.

2 Pesticides currently used. This table does not account for possible additional or replacement pesticides that would be added if certain pesticides were removed from the market, less toxic pesticides became available, or a new pest appears that requires a new pesticide.
Two application techniques are used in the nursery:

Mechanical Equipment - This includes tractor-mounted or tractor-towed wand or boom sprayers or a chisel blade injector. With boom sprayers, the booms are 6 to 36 inches above the ground and use spray nozzles that are designed to produce medium to large droplets under low weed species are just emerging and the weed top and also considerably reduces drift from the treated area. Mechanical applications are more precise and uniform in application and are less costly than backpack equipment.

Backpack equipment - This is generally a pressurized container equipped with an agitation device. It is strapped on the applicator's back, and carried while the contents are being sprayed. Backpack pesticide application in the nursery is limited to spot treatments or use in sensitive environmental areas.

Cultural Control Methods

A cultural control method is the use of normal nursery practices (such as mulching, improving drainage, and adding soil amendments) to make the habitat less favorable for unwanted insects, diseases, weeds, and animals, or to prevent, suppress, or remove them. Cultural control methods include manual and mechanical techniques; several of which are used at the Lucky Peak Nursery. (See Appendix C.)

Manual Methods

Weeds from the nursery beds and nursery perimeter are removed either individually by hand or by using a hand tool such as a weed hoe.

As in all methods, the timing of hand labor is important. For example, weeding crews are used when weed species are just emerging and the weed top and also are easily pulled or dug out. If weed crews are not used until weeds are fully developed, weeds are difficult to remove, both by hand or by tool, and often the root is left in the soil.

The advantage of manual control is the ability to remove weeds with minimal disturbance of nursery seedlings. Manual control can also be used to "spot weed" previously treated seedbeds or perimeters. However, when and if weeds get large, hand pulling can be very damaging to tree seedlings in the vicinity of weed roots. Another disadvantage of manual control is that it is slow and costly compared to mechanical, and especially compared to chemical methods. It often results in resprouting of weeds, since root systems are sometimes left intact.

Insects have not been controlled by manual methods in the nursery because there are no economical, effective manual methods known for the insects that occur at the tree nursery.

Diseases have not been controlled by manual methods because there are no known effective and efficient control methods.

Mechanical Methods

Mechanical methods include the use of machines to remove or control unwanted weeds, diseases, insects, and animals in the nursery.

Weeds are controlled using cultivators, rototillers, brush hoes, blades, and weed burners along roads. The cultivators, rototillers, and brush hoes are pulled by a small tractor in the seedbeds or along the nursery perimeter. Blading is also done using a small tractor along the edges of roads.

The advantages of mechanical methods are the low cost, the high efficiency, and the ability to remove most root systems. The disadvantage of mechanical controls is that they are non-selective and can damage nursery seedlings. Some resprouting of weeds can occur if the whole plant is not removed.

There are no known effective or efficient mechanical controls for insects.

Diseases are controlled by cultivating soil to improve drainage and break up soil clumps, and by improving irrigation techniques. Deep tillage and soil ripping can also be used to improve drainage.

Other Cultural Controls

These include the use of normal nursery practices to reduce or control unwanted pests. Some of these activities would probably not normally be called pest management. However, we want to list them here because we feel they can be important in preventing pests, whether by making the environment less favorable for pests or by strengthening the seedling. We consider prevention to be an important part of a pest management program.

Soil Amendments

The prevention of soilborne diseases and weeds is accomplished by maintaining good drainage and a pH that is conducive to seedling growth but below optimum for pathogen activity. Soil amendments (materials that are added to the soil) can be used to change the pH, such as the addition of elemental sulfur or lime.

Organic amendments are used to promote soil tilth, and as a conditioner. Sawdust is one organic amendment that has been used at the nursery.

Inorganic materials, such as nitrogen and phosphorus fertilizers, are also applied to ensure rapid growth of the seedlings. Nitrogen applications range from 31 to 85 pounds of nitrogen per acre, in one treatment, on the growing stock. Phosphorus is also applied on the seedlings at rates up to 54 pounds per acre, prior to sowing. The conifer seedlings receive 4 to 5
applications of Nitrogen, totaling 116 to 146 pounds per acre per rotation (depending on species).

Green Manure and Cover Crops
Green manure crops are raised primarily for their contribution to the organic matter content, while cover crops are grown as a way to protect the soil from wind and water erosion. Both types of crops are tilled into the soil to help maintain its organic matter content. Some disadvantages of using a green manure cover crop are that weeds can sometimes prosper underneath the crop, and pathogenic fungi can colonize crop residues and build up to damaging levels. In the latter situation, fumigation prior to sowing is often necessary to reduce pathogens to non-damaging levels.

Mulches
Mulches are used to provide weed control in the first year of plant life, to provide frost protection, and to conserve soil moisture.

Sanitation
Sanitation is important in preventing the spread of disease in the nursery. Some disease and insect problems are treated primarily through the removal of affected seedlings and/or the seedlings that they shed, or the removal of host plants in the vicinity of the nursery. (This is discussed in more detail later in this chapter and in Appendix C.)

Other Preventive Practices
Some diseases are best prevented through cultural practices. For example, regulation of seedling density reduces the potential for gray mold; the incidence of Phytophthora root rot can often be reduced by not planting Phytophthora-susceptible species. Other practices include the use of resistant/non-susceptible species in diseased areas and avoidance of areas prone to pest damage.

Specific Pest Problems and Their Controls
This section briefly describes known pest problems and methods used to control or manage them. See Appendix C for a more detailed discussion.

Insects
These are the insect problems that have occurred at the Lucky Peak Forest Nursery:

<table>
<thead>
<tr>
<th>Insect</th>
<th>Severity</th>
<th>Frequency</th>
<th>Usual Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armyworms</td>
<td>Many seedlings</td>
<td>Rare</td>
<td>use insecticides as needed</td>
</tr>
<tr>
<td>Several genera of Noctuides</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cranberry girdler moth</td>
<td>Moderate number of seedlings</td>
<td>Rare</td>
<td>use insecticides as needed</td>
</tr>
<tr>
<td>Chrysoteuchia topiaria</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grasshoppers</td>
<td>Many seedlings affected</td>
<td>Sporadic</td>
<td>use insecticides as needed</td>
</tr>
<tr>
<td>Many species</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pitch Moths</td>
<td>Restricted to shelterbelt trees</td>
<td>Common</td>
<td>no treatment warranted</td>
</tr>
<tr>
<td>Several unrelated Lepidoptera genera</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poplar Borers</td>
<td>Many stems affected in poplar clonebank</td>
<td>Common</td>
<td>no treatment warranted</td>
</tr>
<tr>
<td>Several genera of Cerambycidae</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Diseases

These are the diseases that have affected seedlings at the Lucky Peak Forest Nursery.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Severity</th>
<th>Frequency</th>
<th>Usual Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charcoal root disease</td>
<td>Few seedlings affected</td>
<td>Rare</td>
<td>Fumigate seed beds, rest and rotate cover crops in affected beds</td>
</tr>
<tr>
<td><em>Macrophomina phaseoli</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Damping off <em>Pythium</em> spp.</td>
<td>Moderate number affected</td>
<td>Common</td>
<td>Fumigate seed beds, replace seedlings, encourage rapid, even germination</td>
</tr>
<tr>
<td><em>Fusarium</em> spp.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fusarium root and hypocotyl roots</td>
<td>Many seedlings affected</td>
<td>Common</td>
<td>Fumigate seed beds, rinse/wash seed, apply fungicides when damage is significant</td>
</tr>
<tr>
<td><em>Fusarium</em> spp.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phytophthora root rot</td>
<td>Few seedlings affected</td>
<td>Rare</td>
<td>Fumigate seed beds, apply fungicides when damage is significant</td>
</tr>
<tr>
<td><em>Phytophthora</em> spp.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage molds, several genera</td>
<td>Few seedlings affected</td>
<td>Rare</td>
<td>Maintain storage temperature at around 33 degrees Fahrenheit, minimize soil packed with seedlings.</td>
</tr>
<tr>
<td>Western gall rust</td>
<td>Few seedlings affected</td>
<td>Rare</td>
<td>Annually check shelter-wood trees for galls</td>
</tr>
<tr>
<td><em>Endocronartium harknessii</em></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Weeds

Many weed species occur at the Lucky Peak Forest Nursery. The following species have presented the most problems.

<table>
<thead>
<tr>
<th>Weed Species</th>
<th>Frequency</th>
<th>Usual Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheeseweed</td>
<td>Common</td>
<td>Fumigate beds before planting, use mechanical and manual methods</td>
</tr>
<tr>
<td>Clovers</td>
<td>Sporadic</td>
<td>Fumigate beds before planting, apply herbicides</td>
</tr>
<tr>
<td>Fillarie</td>
<td>Common</td>
<td>Fumigate beds before planting, use mechanical and manual methods</td>
</tr>
<tr>
<td>Grasses</td>
<td>Common</td>
<td>Cultivate fallowed fields, fumigate beds before planting, apply herbicides</td>
</tr>
<tr>
<td>Kochia</td>
<td>Sporadic</td>
<td>Fumigate beds before planting, use mechanical and manual methods</td>
</tr>
<tr>
<td>Lambsquarter</td>
<td>Common</td>
<td>Fumigate beds before planting, use mechanical and manual methods</td>
</tr>
<tr>
<td>Pigweed</td>
<td>Common</td>
<td>Fumigate beds before planting, use mechanical and manual methods</td>
</tr>
</tbody>
</table>

Continued
Weeds continued

<table>
<thead>
<tr>
<th>Weed Species</th>
<th>Frequency</th>
<th>Usual Trea Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purslane</td>
<td>Common</td>
<td>Fumigate beds before planting Use manual methods</td>
</tr>
<tr>
<td>Russian Thistle</td>
<td>Common</td>
<td>Cultivate fallowed fields Fumigate beds before planting Use mechanical and manual methods</td>
</tr>
<tr>
<td>Shepards Purse</td>
<td>Common</td>
<td>Fumigate beds before planting Use mechanical and manual methods</td>
</tr>
<tr>
<td>Skeletonweed</td>
<td>Sporadic</td>
<td>Fumigate beds before planting Use biological control methods Use manual weeding</td>
</tr>
<tr>
<td>Spotted knapweed</td>
<td>Sporadic</td>
<td>Fumigate beds before planting Apply herbicides Use mechanical and manual weeding</td>
</tr>
<tr>
<td>Thistles</td>
<td>Common</td>
<td>Fumigate beds before planting Apply herbicides</td>
</tr>
</tbody>
</table>

Animals

These are the animal problems that have occurred at the Lucky Peak Forest Nursery:

Birds - The major animal pest problem at the Lucky Peak Nursery is caused by birds that eat newly sown seed. A number of methods have been used to control birds, generally aimed at trying to scare them away. These methods include firing shotguns loaded with either birdshot or “cracker” shells, and firecracker strings.

Deer and Elk - A deer and elk winter range is located west of the nursery. Deer have previously entered the nursery and trampled seedbeds and young seedling. They also browse the tips off seedlings. Fences and gates generally prevent easy access to the seedbeds. If deer or elk still manage to enter the seedbeds, firing explosive “cracker” shells sometimes frightens them away.
Chapter 4

Environmental Consequences

This chapter presents the environmental consequences that could occur if the alternatives presented in this environmental impact statement are implemented. (The alternatives are presented in detail in Chapter 2.) This chapter provides the information that is the basis for the comparison of alternatives presented in the last part of Chapter 2.

How this Chapter is Organized

The chapter opens with two general discussions - one on how the effects were estimated, and the other establishes a baseline for comparison of the different alternatives. The remainder of the chapter describes the environmental consequences of the alternatives. The discussion of consequences is organized by resource. Within resources, we discuss the effects that would occur with implementation of each alternative.

Estimating Environmental Consequences

Environmental consequences (or effects, or impacts - we use the terms interchangeably) occur when ecosystems are changed - through either management action or inaction. Under each alternative, nursery pests would be managed in a different way. In this chapter, we present the environmental consequences of those different management alternatives.

This chapter is organized by resource. Within the discussion of each resource, we present background information on the resource and the issues surrounding it. Next, we talk about each alternative and what the effects on the resource would be if that particular alternative were implemented. This discussion is guided by the issues (see Chapter 1 and Appendix A).
All of the alternatives specify mitigation measures – activities or decisions designed to prevent, reduce, or compensate for adverse environmental impacts. In estimating environmental effects, these measures are assumed to be in place and effective.

Environmental effects were estimated in many ways. Each interdisciplinary team member was responsible for estimating effects in their area of expertise. This analysis was based on scientific principles, research literature, and each team member’s field experience. Team members also consulted with many experts in the Forest Service, in other agencies, and at universities and private consulting firms. (See section on Consultation with Others.) Conclusions or statements that are not specifically referenced are the professional opinions of the interdisciplinary team members responsible for that section.

Baseline for Comparison

The environmental consequences of different alternatives can best be analyzed, described, and compared by noting their differences from a common point. The alternatives in this document all look forward. None seek to replicate past pest management practices. The “no action” alternative (Alternative A), is the pest management strategy that is currently being used at the Lucky Peak Nursery. The effects of this alternative will be used as a baseline for comparing the effects of implementing any of the other alternatives.

Although Alternative A calls for the current pest management strategy, it would continue to incorporate current technology about pesticide toxicity and efficacy.

Soil

The Issues

The issue of environmental quality relates directly to the soil resource. There is concern about the potential for chemical buildup in the soil. There is also concern about soil productivity, both in terms of chemical pesticides and from overworking the soil.

The next two sections discuss the ways pest management practices could affect the soil resource. After this background information, we discuss the specific soil-related impacts of each of the alternatives.
Impacts from the Use of Chemical Pesticides

Pesticide Buildup and Residues

There is concern that repeated chemical use in the same areas could lead to a buildup of residues in the soil. Table IV-1 shows the behavior of the 8 proposed chemicals in the soil. The half-life of a chemical pesticide is the number of days it would take for half of any residue to break down. In general, the chemicals proposed for use break down quickly, and therefore do not accumulate in the soil.

How Do Pesticides Break Down in the Soil?

Chemical pesticides break down in the soil and water in two ways; chemically and biologically. Chemical breakdown in water and soil depends on several factors, including pH, temperature, soil minerals, light, moisture, and organic matter content. When chemicals are broken down by the soil itself, the process is usually chemical. When the breakdown is done by the living organisms in the soil (such as microorganisms, animals, and plants), there are several ways the breakdown can occur.

In microorganisms, e.g., bacteria, fungi, and some algae, hydrolysis (a chemical process of decomposition involving splitting of a bond and addition of water) appears to be the major way pesticide compounds are reduced to non-toxic products. This action is governed by various enzymes contained within the organisms. Enzymes allow the microorganisms to metabolize, or "eat," the pesticide. These organisms take the chemicals they need for life, such as phosphorus and carbon, and leave behind other, usually harmless, chemicals.

Chemical degradation of pesticides in soil and water can occur when the pesticide composition is unstable at higher pHs and temperature. Where soils are alkaline and contain low organic matter content and microbial populations, basic chemical hydrolysis may be the primary reaction. Soil composition also affects the ability of a pesticide to be absorbed into the soil particles or adsorbed (adhered) to the outside of the soil particle. A high organic matter content lessens the amount of pesticide broken down through hydrolysis because the pesticide is absorbed.

Pesticides that aren't broken down can leach out of the soil. The leaching ability of a pesticide in the soil is affected by the moisture content, permeability, and "holding power" (either through absorption or adsorption) of the soil.

In all breakdown methods, the persistence of the pesticide in the environment is often given a value expressed in "half-life." A half-life is the time required for a chemical to be reduced to half of its original amount, whether by metabolic or physical decomposition. In the case of pesticides, this value may be a half-life of hours or days. While the chemical may still

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**Table IV-1**

<table>
<thead>
<tr>
<th>Herbicides</th>
<th>Solubility in Water</th>
<th>Persistence in Soil</th>
<th>Leaching Potential</th>
<th>Volatility</th>
<th>Major Degradation Mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCPA*</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
<td>Low</td>
<td>Biological</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>High</td>
<td>Moderate</td>
<td>Negligible</td>
<td>Negative</td>
<td>Biological</td>
</tr>
<tr>
<td>Napropamide</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Low</td>
<td>Biological</td>
</tr>
<tr>
<td>Oxyfluoren</td>
<td>Low</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Low</td>
<td>Biological and Chemical</td>
</tr>
</tbody>
</table>

*These materials may contain active metabolites that may have higher values.

1. Solubility: High - greater than 100 ppm; Moderate - 1 to 100 ppm; Low - less than 1 ppm.
2. Persistence: High - Half-life greater than 180 days; Moderate - Half-life of 30 - 180 days; Low - Half-life less than 30 days.
3. Volatility: High - Vapor pressure greater than 1.00 mm of Mercury; Moderate - 1.0 x 10^-4 to 1.00 mm of Mercury; Low - Vapor pressure less than 1.0 x 10^-4 mm of Mercury.

(USDA, FS 1984; USDA, FS 1986; USDA, FS 1987a; USDA, FS 1987b)
provide residual pesticidal effects during this time period, the original amount is being reduced and degraded by the methods explained above.

**Effects of Fumigation on the Soil**

Fumigation of the soil reduces soil pathogens, nematodes, weeds, and insects to acceptable levels. Beneficial microorganisms are temporarily reduced along with the pathogenic organism. Recovery of the microbes is dependent upon several factors, such as temperature, moisture, and distance to a source. The pest management benefits from fumigation are generally considered to outweigh the loss of beneficial organisms. Populations of both types of organisms usually come back to pre-fumigation levels within a year. They recolonize soils from unfumigated areas below and adjacent to the fumigated beds. Also, they can be blown in, and brought in on equipment or from water supplies. On an average, nursery beds are fumigated every 3 years or more.

**Impacts from Cultural Practices**

Nursery cultural practices, while they don't carry the risks commonly associated with chemical pesticide use, do have the potential to impact the soil resource.

A tree nursery is an intensive agricultural operation. Maintaining soil tilth, organic matter content, nutrient levels, proper pH levels, and soil erosion protection are major concerns at the nurseries. Organic residues, fertilizers, soil amendments, and green manure cover crops are frequently used to meet these concerns. (More detailed information about nursery operations can be found in Chapter 3 and on the operations chart in the back of this document.)

Considering all of the activities involved in culturing and harvesting of the seedling crops, the impacts on the soil resource are minimal and readily reversible. When looking at impacts from cultural pest control practices, it is sometimes difficult to separate out the impacts that result purely from pest control and the impacts that result from other regular nursery practices.

The major impact from cultural activities would be an increase in soil compaction because of increased tractor traffic. Soil moisture content directly affects soil compaction. In addition, soil compaction layers result from continuous cultivation. However, it is not expected that this impact would be significant. Organic amendments are used to improve the condition of the soil, and they are actually a positive impact on the soil resource. There is some evidence that flaming (the use of a controlled flame to burn weeds) can change the physical properties of the soil to facilitate the growth of certain weed species, but more research is needed to understand this.

**Consequences of Each Alternative on the Soil Resource**

**Alternative A - No Action**

Continue Present Management

The most significant impact to the soil under this alternative would be a temporary reduction of soil microorganisms from fumigation. While many of these organisms cause plant diseases, other beneficial organisms would also be destroyed by fumigation. This is considered to be an acceptable side effect. Many of these microorganisms are able to re-populate the soil within 2 years or less after fumigation.

At Lucky Peak Nursery, there is a slight chance that pesticide residues may persist in the soil into the winter months. While this is not expected to have a lasting adverse effect on the soil itself, it would present opportunities for pesticides to be carried off-site in surface runoff.

Under this alternative, cultural activities would continue as presently practiced. This is not expected to have any significant effect on the soil.

There is concern about pesticides building up in the soil and how chemical pesticides affect soil productivity. However, most of the chemicals proposed for use at the nursery break down quickly in the soil, so build-up would not be a problem. Also, some of the chemicals used, specifically the fumigants, significantly enhance seedling growth. (This is discussed in greater detail in the section on pest management impacts.)

**Alternative B**

Biological and Cultural Controls Only

No Chemical Pesticides

There would be no foreseeable impact on the soil if this alternative were implemented. There would be an increase in tractor traffic from the increased use of cultural controls. This could cause slightly increased soil compaction between the seedbeds.

**Alternative C**

Integrated Pest Management

This alternative would allow the use of all control methods with biological and cultural methods preferred. Therefore, chemical pesticides may or may not be chosen as the most effective control. The analysis of soil effects under this alternative (and all the analyses of this alternative in Chapter 4) will determine the effects of chemicals. This analysis will be readily available to assist the nursery manager in the decision-making process.
Because chemical pesticides are a part of an integrated pest management program, impacts to the soil are the same as those described under Alternative A, the pest management program currently practiced at the Lucky Peak Nursery. However, because cultural and biological methods are preferred under Alternative C, we expect increasing reliance on these methods and a reduction in the use of pesticides. Consequently, impacts to the soil from pesticides will be minimized.

Water

The Issues

The issue of environmental quality relates directly to the water resource. There is concern about pesticide residues entering streams, and the effect this would have on fish and other aquatic animals. There is also concern about effects for downstream water users, especially for drinking water, and concern about pesticide residues getting into groundwater.

The next two sections discuss ways that surface water and groundwater could be affected by tree nursery pest management practices. After this background information, we discuss the specific water-related impacts of each of the alternatives.

While pest control methods have the potential to contaminate water supplies the chances of this happening are small if the mitigation measures (see Chapter 2) are in place. The major concern here is chemical pesticide application, although activities associated with some cultural control practices also have the potential to contaminate water supplies.

Surface Water

Chemical pesticide contamination of surface water could occur if chemicals were directly applied to the water, as in the case of a spill or drift from a nearby spraying operation.

Many steps are taken to ensure that this does not happen. Spray nozzles are specifically designed to minimize drift. Mitigation measures, such as buffer strips around streams and a restriction on spraying based on wind speed, will minimize the chances of this happening. (See Chapter 2 for a complete discussion of the mitigation measures.)

Surface water contamination could also occur from equipment washing. This would be controlled through the mitigation measure which requires all equipment washing to be done in areas where the wash water will not contaminate surface or groundwater.

Surface water contamination could occur indirectly from overland flow of pesticides after application. Whether or not this would occur depends largely on the characteristics of the soil and the pesticide. For example, if a chemical adsorbs well to the soil, it will tend to stay in the soil and be broken down in place. A chemical that doesn't stick to the soil would tend to be washed away unless it breaks down quickly with irrigation or rainwater, and would be more of a potential contaminant. (See the Soils section of this chapter and Appendix B for a complete discussion of how well the various chemicals break down in the soil.)

Timing of chemical application in relation to rainfall and irrigation is also important, since the longer the period of time after application, the less the concentration of the chemical. A monitoring program will be implemented to test for residues in surface water.

Groundwater

Groundwater contamination from chemical pesticides may occur by direct or indirect applications. The most important soil factors involved in direct application include depth to a water table or aquifer and the inability of the soil particles to absorb the chemicals. Contamination by indirect application methods may result from accidents or spills.

Since the persistence of pesticides in groundwater is unknown, a monitoring program will be implemented to test for residues in the groundwater (see Appendix F).

Consequences of Each Alternative on the Water Resource

Alternative A - No Action
Continue Present Management

Alternative A poses the highest risk for chemical contamination of both surface and groundwater. This alternative permits the use of chemical pesticides, and does not call for a monitoring program. (The nursery manager could use monitoring data to predict impacts and make changes before those impacts occur.)

Despite this, the general possibility of surface water contamination is small. At Lucky Peak, there is one live stream adjacent to the nursery and the area receives about 16 inches of precipitation per year.

However, the deep soils here, which have a moderately high organic matter content, provide soil particles for adsorption therefore, the soils themselves minimize the risk. Also, most chemical pesticides are applied during the summer months, when rainfall is low.

People are concerned about chemical pesticide residues entering the surface and groundwaters. This alternative is the least responsive to this issue in that it permits the use of chemical pesticides, but does not set in place a comprehensive monitoring program so that nursery managers can track what happens to pesticide residues.
Alternative B
Biocides and Cultural Controls Only
No Chemical Pesticides

Implementation of this alternative would eliminate the major potential cause of water contamination by chemical pesticide residues. This alternative would still present risks to surface water from cultural activities that involve disturbing the ground or applying soil amendments. If done just before a heavy rain or irrigation, it is possible that sediment and/or the amendment material itself could be carried into surface waters. This would be a temporary impact.

This alternative is responsive to the issue of maintaining environmental quality in that it has very little potential for any lasting or long-term damage to environmental quality.

Alternative C
Integrated Pest Management

Under this alternative, the risks to surface and groundwater quality, detailed in Alternative A, would exist. However, if this alternative were implemented, a water quality monitoring program would be put into place.

This monitoring program would provide nursery managers with information they need to protect the water quality. For example, if routine monitoring showed that a chemical used at the nursery was appearing in nearby surface water, application practices could be changed to prevent the chemical from entering the surface drainage system. In addition, this alternative presents somewhat less of a risk than Alternative A because it is expected that, under this alternative, less pesticide would be used.

This alternative is responsive to the issue of environmental quality. While it would present the risks associated with chemical pesticide use, it would allow those risks to be managed by providing nursery managers with information on chemical pesticides in the environment.

Wildlife
The Issues

The issue of environmental quality relates directly to wildlife, because healthy wildlife populations are necessary to maintain environmental quality. People are concerned that chemical pesticide use can harm wildlife. They are also concerned about effects to themselves if they hunt, and then eat wildlife that has been in contact with nursery pesticides. (That concern relates to the issue of human health, and will be addressed in this chapter in the section on human health effects.)

The next section discusses the types of impacts that could occur to wildlife from nursery pest management practices. After that, we discuss the specific effects to wildlife from each alternative.

What are the Impacts?

Chemical Pesticides

Most of the concern about wildlife revolves around accidental exposure to chemical pesticides. Chemical pesticides have the potential for direct toxic effects on wildlife. Toxic effects can occur as a function of both the inherent toxicity of a substance and the amount of the substance to which an animal is exposed. Wildlife exposure to pesticides can occur from being sprayed directly, or by coming in contact with vegetation, other animals, soil, and water that has been contaminated. Inhalation of pesticides can occur from breathing in spray mist droplets or evaporative vapors.

Ingestion can occur from drinking water contaminated by the pesticide, feeding on treated vegetation or other animals that may have been contaminated, or eating the chemical directly if applied in a granular form. Contact can also occur through cleaning and preening functions where contaminated residues, hair, or feathers are ingested.

Other direct effects may be related to the immediate loss of a vegetative or animal (invertebrate) food source that has been treated. Individuals of a wildlife population would be forced to find other sources of forage (direct loss of food) and may expose themselves to additional predation (indirectly increasing exposure). The use of broad spectrum pesticides which have the potential to affect beneficial insects or other smaller microorganisms that make up a substantial food supply of larger wildlife species may have significant effects to individuals of a wildlife population at a nursery.

The use of broad spectrum pesticides will obviously affect more wildlife species than a species specific pesticide. Non-selective pesticides used to control insect or soil-borne pests may harm beneficial insects and soil invertebrates. Herbicide applications will not generally displace animal populations from the treatment area, but can reduce the preferred food resources of these species. The conifer seedlings may then become a more desirable forage species, relative to the other remaining plants available.

A pesticide chosen for its long lasting effects for control will have implications for those wildlife species using that habitat and food source. If a particular plant species, or group of plant species is suppressed (or eliminated) for a lengthy period of time, wildlife populations may change.

Fumigants are one type of chemical pesticide that have a noticeable effect on ground-dwelling wildlife. Fumigants are biocides; when activated they essentially kill every living thing they come into direct contact with. Fumigants are used at the nurseries to kill soil organisms that
cause tree diseases. However, a side effect of their use is the destruction of beneficial soil microorganisms, as well as other invertebrate and vertebrate species that live in the soil.

Biological Control Methods

Biological controls also present some risks for wildlife. The use of biological controls for nursery pest management has little potential to directly affect wildlife. The potential for indirect and cumulative effects is slightly greater.

Biological controls work because they are species specific. The release and establishment of biological control agents has a very low potential to adversely affect wildlife either through direct or indirect means (unless, of course, a wildlife species is the target of the control).

Before the agents are released for this purpose, the effects of using them are thoroughly studied and evaluated. Generally the process involves identifying the area and natural ecosystem that the pest is involved in. The pest is monitored for natural enemies which help to control its growth and dispersal and these are examined for their species-specific preferences. If the agent appears to have a suitable application use, USDA approval must be granted before field trials are permitted. Wildlife species may, in some cases, actually slow the establishment of the biological control agent by utilizing them as a food source.

Cultural Control Methods

Cultural controls pose a limited risk to wildlife. Manual techniques (such as hand weeding) pose essentially no threat to wildlife. Mechanical techniques pose risks from equipment injuring ground-nesting or ground-dwelling animals. Excessive tractor use in a particular area can also result in ground compaction which could disrupt the habitat of burrowing animals.

Removal of weeds by hand or mechanically will not generally displace wildlife populations from the treatment area, but can reduce the preferred food resources of these species. The conifer seedlings may then become a more desirable forage species, relative to the other remaining plants available.

How Significant Should These Impacts Be?

Although risks to wildlife from nursery pest management practices are very real, we do not think that the risks have the potential to damage populations in the long run. This conclusion is based on several factors.
Dilemma Posed by Wildlife at the Nursery

Ironically, a dilemma can result if wildlife use of the nursery is encouraged. Landscaping and the use of ornamental plants and cover crops provide a larger selection of plants and microhabitats which can be used by a greater number of wildlife species; both numbers and kinds of wildlife. Habitat improvement projects, such as raptor perch poles and bird boxes, to encourage wildlife use may result in exposure of these species to greater risks of injury during nursery operations. Additionally, the encouragement of wildlife at the nursery may result in greater pest control efforts if the numbers of wildlife interfere with the goal of seedling production. Indirect effects of increased predation of these species by others may result in a greater number of wildlife species being potentially affected by nursery operations. It should be emphasized that we are addressing effects to individuals of a wildlife population and not the population as a whole.

Conversely, wildlife species (seed-eating and insectivorous birds and mammals) provide benefits by eating of the seeds of weed species and foraging on insect populations. Raptors help to reduce rodent populations that can cause damage to nursery seedbeds. Wildlife species also have a value to the personnel who work at the nurseries (as shown by their comments in the scoping process of this document) for aesthetic, non-consumptive purposes.

Consequences of Each Alternative on the Wildlife Resource

Alternative A - No Action
Continue Present Management

The greatest chance for impacts on wildlife under this alternative would come from the use of chemical pesticides. Wildlife exposure could occur from being sprayed directly, or by coming in contact with vegetation, other animals, soil, or water that has been contaminated. It should be noted that wildlife and human toxicity can be very different for the same chemical (refer to Appendices B and D). This alternative could affect wildlife if pest control activities cause populations of wildlife food sources to decline. We do not anticipate a large impact, primarily due to the small number of individuals at risk and their ability to readily leave the area. The impacts from fumigation, which were described previously, would also apply under this alternative.

There would be some impacts to wildlife from cultural practices under this alternative. The effects described in the previous section on impacts from cultural practices are applicable here.

Concern has been expressed about environmental quality and how nursery pest management affects wildlife. Many people are especially concerned about the effects of chemical pesticides on wildlife. This alternative would allow the use of chemical pesticides. Wildlife impacts under this alternative would be negligible.

Alternative B
Biological and Cultural Controls Only

This alternative would eliminate the risks to wildlife from chemical pesticide use, but would create a slightly higher risk from cultural practices than the other alternatives. These risks include destruction of burrows from soil compaction, as well as disruption of field nest sites from machinery. These problems can be mitigated by flagging nest sites.

This alternative eliminates concerns about the effects of pesticides on wildlife because it does not allow the use of chemicals.

Alternative C
Integrated Pest Management

The impacts on wildlife under this alternative would be similar to those under Alternative A. We expect that overall, fewer chemicals would be used under this alternative, and risks from chemicals would be decreased.

Threatened, Endangered, and Sensitive Plant and Animal Species

The Issues

The issue of environmental quality is directly related to the stability and survival of species classified as threatened and endangered and sensitive species. The species of concern are identified (i.e., "listed") in the Threatened and Endangered section of Chapter III.

Concern has been expressed that nursery management activities should be sensitive to the habitat requirements of plants and animals classified as threatened and endangered which may reside in the vicinity of the nursery.
Consequences of Implementing Any of the Alternatives

Implementation of Alternatives A, B, or C would have no known negative impacts to any plant or animal species presently "listed" as threatened, endangered or sensitive. The Boise National Forest provides habitat for three federally listed endangered species. These species are peregrine falcon, bald eagle and gray wolf. Peregrine falcons have been sighted in the general area on occasion and some bald eagles winter in the vicinity of Lucky Peak Reservoir. Impacts to these species would be unlikely to do to the duration of their stay (transient use), the time of year they are present (primarily during the winter for bald eagles) and habitat limitations on the nursery site. The nursery site itself represents a miniscule portion of available habitat surrounding the the reservoir. Gray wolf sightings in this area are very rare. No impacts are anticipated do to the general absence of a population.

The Regional Forester's sensitive species list includes 17 vertebrate species. A complete list of these species is located in Appendix H. Of the species listed, only the mountain quail has potential to occur within the vicinity of the project area. Potential for impacts to mountain quail is considered to be extremely low due to the small size of the project area (61 acres) compared to the larger area that they occupy.

No known negative impacts to plants "listed" as sensitive would occur, as they are not presently known to occur on the nursery site.

Fisheries

The Issues

People are concerned about the fate of chemical pesticides in the environment, and about the potential for fish and other aquatic animals to be exposed to chemicals and then consumed as food. The latter relates directly to the issues of environmental quality and human health and are addressed in the section titled Human Health Impacts.

Impacts on Fisheries and the Riparian Zone

Nursery pest management practices that disturb the vegetation, soil, or water of the riparian zone, or that cause increased sedimentation, could have effects on aquatic systems and fish populations.

Increased erosion and sedimentation can inhibit fry emergence (Tagart 1976), reduce fish feeding success, and cause channel aggradation (raising of the bed surface due to deposition).

This can lead to loss of pool habitat (Cederholm and others 1981). While the majority of fish spawning and rearing occurs in second-and third-order streams, the small first-order tributaries are of vital importance to the quality of downstream habitat (Sedell and others 1981). A description of stream orders can be found in Chapter 3. These channels carry water, sediment, nutrients, and woody debris from the upper portions of the watershed to the larger streams.

First-order streams are the most vulnerable to impacts from mechanical methods. Intermittent streams transporting sediment to fish-bearing streams are potential sources of significant impact.

None of the alternatives should result in substantial adverse effects on the fisheries resource due to alteration of the riparian area, or from increased sedimentation due to nursery pest management activities. At Lucky Peak Nursery, there are no perennial streams that are influenced by nursery activities. However, an intermittent stream does flow through the nursery. Two of the drainage ditches from the fields carry excess water into this stream channel. Runoff water from the seedbeds is primarily diverted into catch ponds where the water either soaks in or evaporates. The escarpment overlooking Lucky Peak Reservoir is located about 800 feet from the edge of the nearest seedbeds. With the exception of extremely wet weather, overflow from these ponds generally does not flow into Lucky Peak Reservoir.

The likelihood of exposure of fish populations to toxic concentrations of pesticides used for nursery management is low. If exposure were to occur due to drift from applications, concentrations would be of short duration in flowing water.

Bioaccumulation is the uptake and temporary storage of a chemical in animal flesh and organs. Bioconcentration is the increase in the concentration of a chemical within organisms as it moves up through the food chain. Both are most likely to occur when an organism is exposed to a persistent chemical of low water solubility and high lipid solubility. The pesticides reviewed for nursery use in this EIS generally do not meet these criteria (Lorz and others 1979). Although some of the chemicals proposed for use are known to bioaccumulate (see Appendix B), the potential for bioaccumulation or bioconcentration of any of the pesticides considered in this EIS is slight.

We feel this is the case because for toxic effects to occur in a species, both exposure to a substance and exposure to a toxic concentration of it are needed. In the forest aquatic environment, contamination is predominantly from short-term acute exposures, due to drift or accidental spill, rather than long-term chronic exposures (Norris and others 1983). Appendix B describes the relative toxicity of the pesticides considered in this EIS. This is based on the lowest concentration (reported in the literature) that kills 50 percent of the fish in a 96-hour period (96-hour LC50).

Water quality factors such as temperature, hardness, salinity, oxygen and carbon dioxide content, and pH may affect fish response to pesticides in the laboratory and field (Lorz and Norris 1983).
In general, "cold-water" fish, such as salmon and trout, are more sensitive to pesticides and other pollutants than "warm-water" fish, such as bass and carp (Lorz and others 1979). Juveniles and fry are typically more sensitive than adults.

In addition to measures intended to control drift, applications are timed to reduce risks of pesticide mobilization in ephemeral channels or overland flow, and preventative measures are taken to reduce the chance of accidental spills. These and other mitigation measures are monitored to ensure compliance with standards.

Mitigation measures regulating use of pesticides should prevent entry of biologically significant levels into surface waters. Short-term, acute concentrations could occur due to accidental spills or unpredicted weather conditions during or immediately following application.

Consequences of Each Alternative on the Fisheries Resources and the Riparian Zone

Alternative A - No Action
Continue Present Management

The effects under this alternative should be low for the reasons detailed above. The nursery has no perennial streams immediately adjacent to the seedbeds. This, combined with the fact that in routine practice chemicals will not be used near any water, should effectively prevent stream and lake contamination from chemical pesticide application.

The potential for pesticide residues to be carried into nearby streams and Lucky Peak Reservoir very low because of the surface drainage system and distance to streams and the lake.

Alternative B
Biological and Cultural Controls Only
No Chemical Pesticides

This alternative does not present any of the potential effects associated with chemical pesticide use. There would be the possibility of an increase in effects associated with cultural controls, such as increased stream sedimentation. However, just as the potential for chemical pesticide residues entering streams is small because of limited live water at the nursery, the potential for increased sedimentation is also small.

Alternative C
Integrated Pest Management

The impacts under this alternative would be similar to those described for Alternative A. However, eventually chemical pesticide use would probably decrease under under this alternative; subsequently, the potential for occurrence would lessen.

Nursery Pests

The Issues

Nursery pest management was not raised very often as a specific issue at the nursery. Instead, pest management was seen as a part of other issues. Concerns about effectiveness were
expressed through the issue of economics. Concerns about the safety of treatment methods were expressed through the issues of human health and environmental quality.

Nursery pests fall into four categories listed by descending relative importance: diseases, insects, weeds, and animal pests. In classifying pests as a resource, we hope to emphasize that they are a part of the natural world, just as are the other resources considered in this chapter.

This section describes the current pest situation at the nursery (Alternative A-No Action) and projects what the pest situation would be under each of the other alternatives (Alternatives B and C). Specific descriptions of pests and treatments currently used can be found in Chapter 3, Appendix B, and Appendix C.

Although pest problems do vary, by far and away the most serious problem at the Lucky Peak Nursery is disease, such as damping-off or root rot, caused by soil-borne disease organisms (Marshall, 1986). The only cost-effective and reliable treatment known for this type of disease is fumigation. Fumigants are biocidal and are applied to the soil prior to sowing. They kill all living organisms to a depth of 10 to 15 inches. This enables seedlings to get a good start in soil that is free of disease organisms. Over time, the organisms that were not killed (those deeper in the soil than 10 to 15 inches) and those on the boundaries between fumigated and non-fumigated areas reinfect fumigated soil and are able to attack seedlings.

Stem and foliage diseases and insects, while they do cause problems, are not as serious as the soil-borne diseases. Insect problems are usually treated on an as-needed basis; stem and foliage diseases are often treated with fungicide applications.

Weed problems and solutions do not differ appreciably between nurseries. The consequences of the alternatives on weeds depend mainly on the type of weed being controlled. For example, weeds that propagate vegetatively from live root segments left in the soil do not respond well to mechanical or manual weed control methods; chemicals work best on these weeds. Shallow-rooted weeds that can be uprooted completely and that do not propagate vegetatively can easily be controlled mechanically or manually.

How Do Pests Affect Seedlings?

Pests affect the individual seedlings in a number of ways. Diseases kill or deform and weaken seedlings. Root diseases reduce seedling root mass by killing existing roots and retarding or eliminating new root growth. Seedlings are thus unable to take up enough water and nutrients to support new growth and transpiration. They will be stunted or killed either by malnutrition or desiccation. Desiccation may be avoided in the nursery by watering, but seedlings will not be able to withstand the rigors of competition and summer drought on most planting sites.

Impacts of Each Alternative on Pest Control

The short-term and long-term impacts of each alternative are summarized in Tables IV-2 and IV-3.

Alternative A

Soilborne Diseases

Under this alternative, there would be no change in our effectiveness at controlling soilborne diseases; therefore we would not expect the amount of disease at the Lucky Peak Nursery to vary much from current amounts. The incidence of soilborne diseases varies considerably. Likely, a great deal of this variation is due to different soil types, compartment cropping, and treatment history.

Seedling mortality due to soilborne diseases, even with the use of fumigants, averages about 10 percent annually at the Lucky Peak Forest Nursery. Spruce and Douglas-fir seedlings are much more susceptible to soilborne diseases at the Lucky Peak Nursery than pine species. To compensate for anticipated losses, Douglas-fir and spruce beds are oversown about 40% while pine species are typically oversown by 10-15%.

Foliage and Stem Diseases

There would be no change in the amount of foliage or stem diseases at Lucky Peak Nursery if this alternative is selected. Rarely are applications of fungicides made to control gray mold, other foliage diseases, or stem diseases. The number of trees culled during packing due to foliage disease is also low.
Table IV-2

Short-Term Effect of Each Alternative on Pest Populations

<table>
<thead>
<tr>
<th>Soilborne Diseases</th>
<th>Stem &amp; Foliage Diseases</th>
<th>Insects Weeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative A:</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td>Alternative B:</td>
<td>Large increase</td>
<td>Large increase</td>
</tr>
<tr>
<td>Alternative C:</td>
<td>Some increase</td>
<td>Little/no increase</td>
</tr>
</tbody>
</table>

Table IV-3

Long-term Effect of Each Alternative on Pest Populations

<table>
<thead>
<tr>
<th>Soilborne Diseases</th>
<th>Stem &amp; Foliage Diseases</th>
<th>Insects Weeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative A:</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td>Alternative B:</td>
<td>*</td>
<td>Some increase</td>
</tr>
<tr>
<td>Alternative C:</td>
<td>No increase</td>
<td>No increase</td>
</tr>
</tbody>
</table>

* Dependent on development of effective non-chemical control methods.

Insect Damage

There would be no change in the amount of insect damage at Lucky Peak Nursery if this alternative is selected. Damage from insects is sporadic and generally minor. However, in the event of a large insect outbreak, insecticides could be used and insect populations could be quickly and effectively controlled if the appropriate insecticide was registered and available.

Insecticides are used to control cranberry girdler only when girdler populations reach a threshold level. In the event of an outbreak of insects other than the above, insecticides could be used and insect populations could be quickly and effectively controlled if the appropriate insecticide was registered and available.

Weed Control

This alternative would result in effective weed control because all treatment methods would be available.

Alternative B

Soilborne Diseases

Chemical pesticides would not be used at all under this alternative. Without fumigants, losses from soilborne diseases would increase significantly. Based on other nursery studies in the northwest where seedling survival and packable seedlings were compared in fumigated and non-fumigated soil, we would expect crop reductions of 20 percent or greater for the first few years if this alternative is chosen (see Tables IV-4 and IV-5).

If no other control measures were used, we would expect losses due to soilborne diseases to increase annually due to ever-increasing pathogen populations (pathogenic fungi can survive for several years in the soil. With each succeeding year, more inoculum would be present in the soil, resulting in more disease. More disease, in turn, would result in greater amounts of inoculum produced). Alternatively, we might see some "natural" reduction in soil-borne diseases after several years without chemicals due to increased populations of beneficial microorganisms in the soil.
Foliage and Stem Diseases

We would expect some increase in damage by foliage diseases at the Lucky Peak Forest Nursery if this alternative is adopted. However, the frequency at which foliage and stem diseases occur at the nursery is very low, due primarily to the dry climate which does not favor the spread and development of above-ground fungal pathogens. Fungicides have never been used at the nursery to control western gall rust; this disease can easily be controlled by removing the source of inoculum (galls on branches or stems of mature windrow or landscape trees adjacent to or within the nursery). Therefore, elimination of pesticides will have no impact on control on western gall rust.

Insect Damage

A severe increase in the amount of damage by insects at Lucky Peak Nursery could be expected if this alternative is selected. Damage from sporadic infestations of armyworms, cranberry girdler moth, and grasshoppers, while rare in occurrence, could be devastating. Previously, insecticides have been used to treat these insects when damage is apparent, and projections indicate significant losses are foreseeable. If no insecticides could be used, damage from these insects would greatly increase, and most likely with catastrophic results.

A note of caution in making these predictions: Discontinuation of a broad spectrum biocide such as methyl bromide + chloropicrin may result in the buildup of insect or disease pests which were never a problem or which were never detected in the past. Although it is difficult to predict what new pests may develop under this regime, the potential for them arising should not be ignored. For example, pests which spend more than one season in the soil (such as the June beetle or nematodes) would carry over and intensify from one crop to the next in the absence of fumigation. Similar situations might arise with long-term absence of herbicides to control vegetation on the nursery periphery. Insects whose primary hosts are periphery weeds or sod, such as the cranberry girdler moth or armyworms, would be expected to increase as these hosts increased; if conifers were suitable secondary hosts, substantial damage might occur in the conifer crop especially in beds adjacent to weedy areas.
Weed Damage

Fumigants, as well as herbicides, would not be used under this alternative, and fumigants do have some benefits in killing weed seeds in the soil. Therefore, with both fumigants and herbicides restricted by this alternative, there would be a great increase in cultural and manual seeding techniques.

Alternative C

With this alternative, we would expect no long-term increase in pest damage and might even expect a decrease. In the short-term, some increases in damage might be seen as new methods are implemented and refined. All methods of control would be available for use; however, with emphasis on monitoring pest populations and treating only when pest populations reach a certain level, pesticide use may decrease substantially, especially use of fumigants.

Since monitoring and using threshold levels for determining when and where to treat pests is an integral part of the IPM process, implementation of this alternative will require a pest or damage monitoring program and setting treatment threshold levels for each pest or the damage they cause.

Soilborne Diseases

We expect no significant long-term increase in soilborne diseases if this alternative is selected. Some increase might be seen in the short-term as new methods and more selective treatments are implemented.

Initially, fumigation would be used to treat the majority of seed bed area in the nursery; a portion of the nursery would be devoted to evaluation of new alternate methods (such as use of less hazardous chemicals, alternating fumigants, cover crop manipulation, addition of antagonistic organisms or addition of disease-suppressive organic material). When the small field trials indicate that a particular method is effective in preventing significant damping-off or Fusarium disease, large scale or operational use of the new method or material can then be tried so that the economics and practical feasibility of using it can be evaluated.

Sampling of soilborne pathogen populations and determining damage and losses associated with specific populations would need to be carried out for several years to determine threshold levels at which treatment is necessary to prevent unacceptable loss. Once these threshold levels were set, then soil or seedlings can be sampled to determine the populations of the pathogens; if over the threshold, then soil or seedings would be treated.

Currently, we have some crude threshold population levels established during previous evaluations of the soilborne pathogens Fusarium and Pythium (Marshall, 1985; Marshall, 1986).

Foliage and Stem Diseases

At the Lucky Peak Nursery, there would be little or no increase in stem and foliage diseases if this alternative is selected. Currently cultural and mechanical methods are adequate for controlling these above-ground diseases. Chemical controls have been used infrequently in the past ten years. The amount of damage (mortality or cull) associated with various levels of disease would need to be determined for each foliage or stem disease in order to define threshold levels for treatment. Consistent, systematic monitoring for disease would occur and the extent and severity of disease would determine if and when treatment was necessary and what method(s) to use.

Insect Damage

Insect damage should show little or no increase if this alternative is selected. To date, insects at the Lucky Peak Nursery have caused moderate amounts of damage and generally have been managed only when a crisis looms. The amount of damage associated with various population levels needs to be determined for each insect in order to define threshold levels for treatment. Under this alternative, consistent, systematic monitoring of damaging insects would occur.

Weed Damage

Weed control should be more effective under this alternative than any other alternative. All control methods would be allowed, and weed populations would be monitored, so treatments would be timed to be most effective. (This would probably have the biggest benefit for chemical treatments, although cultural treatments should be more effective based on monitoring information as well.)
Social and Economic Impacts

The Issues

The alternatives could affect social and economic issues in many ways. Economic issues can be divided into two areas of concern. Some people are concerned that the nursery provide jobs for the community; others are concerned that the nursery be operated cost-efficiently.

In addition to considering the economic impacts of the alternative nursery pest management plans, the Forest Service is required by law to consider the effects of the alternatives on several other social and cultural resources. These will be discussed after the section on economic effects.

Employment

Employment at the nursery varies by season. During the busiest period (lifting and packing of the trees, usually in the spring), about 145 people are employed. With the exception of nursery workers who are hired specifically for lifting and packing, most nursery employees work for several months a year, or all year, and perform several job functions during their work year. Most of these are jobs related to pest management.

Alternatives B and C would require formal pest monitoring. To do this, the nurseries would need to employ pest scouts. These are people who go into the seedbeds on a regular basis to survey pest populations and damage levels. At the nursery, employees tend to do various jobs over the course of the growing cycle, so it is probable that pest scouting would be assigned to current employees on a rotating basis.

Alternative B does not allow for the use of any pesticides and therefore would not employ pesticide applicators. Those employees who previously applied chemicals could be assigned other pest-control jobs, such as weed cultivation.

Handweeding might be necessary with Alternative B and, if so, additional people may need to be hired for weeding.

Pest Control Costs

It is difficult to compare the cost of pest control under the three alternatives. This is due to two factors: (1) the nature and magnitude of pest problems at the nursery changes from year to year. (2) labor costs for variable pest-control related tasks are difficult to track.

In considering which of the alternatives would be the most cost-efficient, it is important to understand how the Forest Service nurseries price seedlings. For any particular crop, all the costs of producing that crop are spread over the seedlings that are salable. In other words, if 100 seedlings were planted, and 90 survived, but only 70 passed quality standards, the cost of all 100 seedlings would be averaged over the 70 that could be sold. Therefore, we can see that cost is not only a function of dollars spent but also a function of the number of seedlings in a crop that pass quality standards.

Quality standards would remain constant, regardless of which alternative is implemented.

Consequences of Each Alternative on Economic Issues

Alternative A - No Action
Continue Present Management

This alternative would be among the most cost-efficient, at least in the short run. Over the course of many years, however, it is possible that chemical material and application costs could rise substantially.

This alternative represents the current pest management strategy at the nursery, and therefore would not result in any employment changes.

Alternative B
Biological and Cultural Controls Only
No Chemical Pesticides

This alternative is responsive to the economic issue of jobs, but not to the issue of cost-effectiveness.

Under this alternative, chemical pesticides would not be used. This should result in a large increase in seedling costs. Hand weeding costs would increase; chemical pesticide costs would be eliminated. The increased cost of seedlings would result from the fact that a much larger percentage of trees would not meet quality standards and would have to be culled. As was explained above, the cost of a seedling is calculated by spreading all costs over those seedlings that are actually sold. Therefore, if more trees are culled, the cost of the remaining trees rises accordingly.

We do not feel that we have enough information to accurately predict exactly how much seedling costs would rise under this alternative. We do expect that culled rates would increase by about 20 percent. We could assume that costs would then rise about the same amount.
under this alternative. This increase, however, may be defrayed by the reduction of costs associated with pesticide use.

This alternative is responsive to the issue of jobs because more workers would be needed for hand weeding and other non-chemical control tasks. Because this alternative would require formal pest monitoring, there would be a need for pest scouts.

Alternative C
Integrated Pest Management

It is anticipated that this alternative would be as cost-effective as Alternative A to implement. It would allow all control methods to be used, meaning the nursery manager could pick cost effective treatments. It would also require formal pest monitoring before treatment. This might eliminate some on treatments that are not really required to keep pests below the threshold, which would result in a cost saving because less chemical pesticides would be used.

Cull percentage should remain about the same as it is now. As the nursery manager becomes skilled in using monitoring data to time treatments, cull percentage may go down because pest damage would be stopped sooner.

People involved with implementing an IPM program (pest scouts, record keepers, etc.) would need to be employed, so a slight change in employment should result; this could mean a new position or an established position with new duties. Therefore, this alternative should maintain employment at about the current level or slightly increase employment.

This alternative is responsive to the economic issue of cost-effectiveness and somewhat responsive to the issue of jobs.

Human Health Impacts
The Issues

Human health is a very important issue to all the people we talked to about nursery pest management. Most, but not all, of the concern centers around chemical pesticide use. People want to know what chemicals are being used at the nursery, what their chances are of being exposed, and what is known about the possible effects of being exposed. Some nursery workers are concerned about allergic reactions to chemical pesticides.

Nursery employees who work in the field are concerned about sun exposure, humidity, and the minor injuries and aches they experience as part of their work.

Very few people live near the nursery. The people living closest to the nursery are employees of the nursery and their dependents. The nearest non-Forest Service homes are located between 1/4- and 1/2-mile from the nursery.

This discussion of human health effects is divided into several sections:

Human health impacts from nursery pest management
- Effects of non-chemical controls
- Effects of chemical controls – includes information on toxicity, inert ingredients, and exposure

Consequences of the Alternatives on Human Health

Human Health Impacts from Nursery Pest Management

In this chapter, we use the terms consequences, impacts, and effects interchangeably. In this section on human health consequences, we introduce a fourth term – risk. A risk is different from an effect in that an effect is something that necessarily follows from what came before, whereas a risk is the probability that something will happen.

We consider human health effects to be the risks associated with the various chemical and non-chemical control methods. This does not mean that an effect of working at a nursery will be an injury or toxic reaction to a chemical pesticide. What it does mean is that an effect of working at a nursery is the risk of injury or toxicity. That risk could be 10 percent or 90 percent, but it is a probability and not a certainty.

Nursery accident records indicate that a total of 9 reportable accidents occurred at the Lucky Peak Nursery between 1981 and 1989. However, only one of these accidents was sustained while performing pest management activities. The nature of this accident involved an employee who got a solution of water and bleach (Sodium Hydrochlorite) in the eye during the process of disinfecting a cooler. The remainder of these accidents involved personal injuries sustained during other aspects of nursery management such as lift and pack, irrigating fields and other jobs not related to pest management.

A risk assessment (such as Appendix D) is a scientific appraisal of the probability that the effects will occur – it tries to answer the question of whether the risks are 10 percent or 90 percent.

Risk management is an attempt to limit risk, whether by removing the harmful element from the environment, or instituting mitigation measures (see Chapter 2) to protect people from the risk.
The pest management program for Lucky Peak Nursery presents risks for workers from manual, mechanical, and chemical pesticide methods and for the public from chemical pesticide methods. Workers have the potential to be injured using hand tools or mechanical equipment, or may potentially suffer acute or chronic health effects from pesticide exposures. The public may be affected by low level chronic exposures to pesticides. Unacceptable risks to the public and to workers will be mitigated through risk management procedures described in this section and in the section of Chapter 2 on mitigation measures.

Each of the alternatives has a potential for impacts on the health of both workers and the public. The risk of health impacts is much greater for workers because they are subjected to repeated and more direct exposure to risk factors. Health risks to the public are likely to be experienced primarily through exposures to chemicals.

For this analysis, risks and effects are estimated only for those activities directly associated with pest management. The comparison includes analysis of injuries from manual, mechanical, and biological weed control methods and health effects from exposure to chemicals used to manage pests. The analysis does not include risks from activities that are incidental to pest management, such as transportation to job sites, and exposure to gasoline, exhaust fumes, and noise from engines (chainsaws, tractors, etc.).

Only workers, and not the public, are expected to be at risk from immediate injury from accidents. The risk of injury occurs primarily with the use of manual and mechanical weeding methods. The differences in risks among alternatives depend on the extent to which manual and mechanical methods are used. The use of these methods would be higher under Alternatives B which does not permit the use of chemical pesticides. The increased use of manual and mechanical weed control methods is likely to result in a proportionate increase in injuries to workers.

There are risks to both nursery workers and the general public from exposure to chemical pesticides. The difference in risks between the alternatives depends on which specific chemicals, of those permitted under the alternative, are deemed necessary for particular pest management situations, and the extent to which chemical methods are used in relation to other available methods. The analysis does not try to estimate the actual number of people who might be affected by exposure to these pesticides, because it would have to rely on too many disputed assumptions.

Effects of Biological Control Methods

Biological controls are not expected to have any significant impacts to human health.

Effects of Cultural Control Methods

Manual Methods

These are all related to weed control; they involve physical labor and the use of such hand tools as specialized hoes, knives, and rakes. Impacts on safety and health could include falls, sprains, and other accidental injuries; cuts caused by tools; and the possible initiation or aggravation of chronic health problems such as tendon or ligament damage or arthritis. When temperatures are high, workers may experience fatigue, heat exhaustion, or heat stroke. Individuals who are sensitive to the irritants present in some nursery materials (such as sawdust mulch, irritating plant hairs, and spines), or who are severely allergic to insect bites or stings, may experience moderate to severe health effects if exposed to those irritants or allergens.

Mechanical Methods

Mechanical methods involve the use of tractors, mowers, or cultivators, and involve health risks for the equipment operators and others working in the vicinity of the equipment. Injuries can result from accidental contact with the equipment or its attachments (blades, mowers, plows). Injuries also can result from working with machinery that tends to be slippery or oily during operation or repair. Reports from Lucky Peak Nursery indicate that such injuries occur infrequently.

Effects of Chemical Control Methods

Eight chemical pesticides are proposed for use in the alternative nursery pest management programs being evaluated in this EIS. A listing of the specific chemicals is found in Chapter 3; more information on formulations and application is found in Appendix B.

The toxicity of the 8 pesticides used for pest control at Lucky Peak Nursery has been evaluated in detail for this EIS. This evaluation, including both quantitative and qualitative analysis, was undertaken based on the high degree of concern expressed in employee and public comments.

A quantitative worst-case analysis was developed under contract with Labat-Anderson, Inc. (LAI), and is included in Appendix D. LAI worked closely with the Environmental Protection Agency (EPA) to obtain the latest information being evaluated for the reregistration of these herbicides. They also did a review of the scientific literature. A major portion of the LAI analysis was the development of possible application scenarios to assess potential exposures to the public and to contractors applying the pesticides. In addition, LAI completed a qualitative review of the available information on pesticide toxicity.
What are the Adverse Health Effects Associated With Chemical Pesticides?

Conclusions about the toxic properties of pesticides are drawn from poisoning incidents, from laboratory studies of effects seen in human volunteers, from epidemiology studies, and from laboratory studies of effects seen in animals. Each of these types of information is associated with certain advantages and disadvantages, including uncertainties in predicting the effects of a chemical on an exposed individual.

Concerns associated with pesticide use reflect that they may be responsible for poisoning, cancer, reproductive problems, birth defects, and neurological problems.

Reports of poisoning most often indicate only the effects of very large doses, and the exact dose is seldom known. Studies on human volunteers, however, are confined to relatively small doses and are limited in duration. Epidemiology studies correlate disease observed in segments of the public with exposure to chemicals in the workplace or other areas. Results of epidemiology studies depend on data that is sometimes only secondhand or questionable, and in many cases confounding factors exist, such as exposures to other chemicals or smoking. Laboratory animal studies are the most controlled of the methods and examine effects under a wide range of doses and study durations, but uncertainty is involved in extrapolating the results of these studies to humans. This uncertainty is particularly relevant where the effects are seen as equivocal or seen only at very high doses that humans are not likely to receive.

Poisoning incidents have shown that the 8 pesticides may cause severe, immediate reactions when received in high enough doses. However, such doses are rarely seen with these pesticides except in the cases of accidental or suicidal ingestion of concentrate. Even in these instances, the pesticides rarely have proven fatal. The pesticides may cause lower level immediate effects, such as nausea, dizziness, or reversible neuropathy. Longer term effects might include permanent nervous system damage; effects on reproductive success; damage to developing offspring; production of heritable mutations; damage to liver, kidneys, or other organs; damage to the function of the immune system; and cancer. These effects have been shown for a number of the 8 pesticides in laboratory animal studies, and there is suggestive evidence from epidemiology studies that these effects could occur; therefore, it is assumed here that there is a risk that they might occur at some dose levels in humans.

Toxic effects may be caused by the active ingredient in the pesticide formulation in a single dose, by a series of doses received over time (a cumulative dose), or by a combination of the pesticide active ingredient and another chemical (such as another pesticide, a carrier, or an inert used in the pesticide formulation).

Toxic Properties of the Individual Pesticides

Only a few of the 8 pesticides proposed for use have been examined in epidemiology or human studies, so judgements about risk rely most heavily on the results of studies in laboratory animals. The toxic properties of the 8 pesticides are summarized in Table IV-6. Table IV-6 categorizes health hazards for acute effects, general health effects from low-level exposures, cancer and mutagenicity, and reproductive and developmental effects according to the compound evaluation system employed by the USDA Food Safety Inspection Service. Table IV-7 provides the LD 50, and describes systemic and reproductive effects seen in laboratory studies. These tables do not show the effects expected from the nursery pest management program. Actual and potential exposures from pesticides used in the program even under worst-case conditions, will result in doses which are much smaller than the doses necessary for the health effects displayed in these tables. Data on the specific effects are based on studies detailed in Appendix D, Human Health. Table IV-8 outlines the quality of the data on which the summary profiles in Table IV-6 was based. Profiles of the toxicity of each pesticide are given in Appendix D, as are detailed discussions of toxicity.

Inert Ingredients Listing for Pesticide Formulations

Inert ingredients in pesticide formulations are an increasingly important issue, especially when some testing has shown that they may have detrimental effects to the environment, human health, and wildlife species. An inert ingredient is defined as any intentionally added ingredient in a pesticide product which has no pesticidal properties. They may be solvents, surfactants, emulsifiers, flow conditioners, and other functional ingredients. If the herbicide formulation. Cumulative effects of the known ingredients and the full formulations on lethal, sublethal, acute, chronic, and indirect effects to wildlife are relatively unknown. The inert ingredients may exert independent effects or interact synergistically with the known ingredients.

Generally, these inert ingredients are proprietary information of the pesticide manufacturer. The Environmental Protection Agency’s (EPA) toxicological tests for registration purposes have regularly concentrated only on the active ingredient of the formulation, rather than the formulation as a whole. The listing of inert ingredients in categories is an effort to help provide data where unknown chemical combinations have not been tested for their effects on human health and the environment. (See Appendix B for more information on inert ingredients.)
### Lucky Peak Nursery

#### Summary of Potential Toxic Effects for Nursery Pesticides

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Acute Toxicity</th>
<th>Systemic Toxicity</th>
<th>Carcinogenic/Mutagenic</th>
<th>Reproductive/Developmental</th>
<th>Neurotoxic</th>
<th>Immunotoxic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Herbicides</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCPA</td>
<td>N</td>
<td>L</td>
<td>N</td>
<td>L</td>
<td>I</td>
<td>I</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>N</td>
<td>L</td>
<td>I</td>
<td>M</td>
<td>I</td>
<td>N</td>
</tr>
<tr>
<td>Napropamide</td>
<td>N</td>
<td>M</td>
<td>L</td>
<td>L</td>
<td>I</td>
<td>I</td>
</tr>
<tr>
<td>Oxyfluoren</td>
<td>N</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>I</td>
<td>I</td>
</tr>
<tr>
<td><strong>Fungicides</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benomyl</td>
<td>N</td>
<td>L</td>
<td>H</td>
<td>H</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Metalaxyl</td>
<td>L</td>
<td>L</td>
<td>N</td>
<td>M</td>
<td>I</td>
<td>N</td>
</tr>
<tr>
<td><strong>Fumigants</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloropicrin^1</td>
<td>H</td>
<td>M</td>
<td>I</td>
<td>I</td>
<td>Y</td>
<td>I</td>
</tr>
<tr>
<td>Diazomet</td>
<td>L</td>
<td>M</td>
<td>L^2</td>
<td>H</td>
<td>I</td>
<td>I</td>
</tr>
<tr>
<td>Methyl bromide^2</td>
<td>H</td>
<td>H</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>I</td>
</tr>
</tbody>
</table>

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* Cancer risk is based on the presence of HCB as an impurity.

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### Key: Table IV-6

<table>
<thead>
<tr>
<th>Acute Toxicity</th>
<th>Systemic Toxicity</th>
<th>Carcinogenic/Mutagenic</th>
<th>Reproductive/Developmental</th>
<th>Neurotoxic</th>
<th>Immunotoxic</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Oral LD₅₀; mg/kg body weight)</td>
<td>(Lowest effect level mg/kg/day)</td>
<td>H Mutagen or carcinogen in at least 2 species</td>
<td>H Teratology in rodent and non-rodent species</td>
<td>Y Evidence of neurotoxic effects, exclusive of ChE inhibition</td>
<td>Y Evidence of dermal sensitization or other immunotoxic effects</td>
</tr>
<tr>
<td>H 25 or less</td>
<td>H &lt;1</td>
<td>M Weak mutagenicity, limited evidence of carcinogenicity</td>
<td>M Reproductive disturbances, no teratogenicity</td>
<td>N No evidence of neurotoxic effects</td>
<td>N No evidence of immunotoxicity</td>
</tr>
<tr>
<td>M 25-250</td>
<td>M 1-50</td>
<td>L Weak mutagenicity, no evidence of carcinogenicity</td>
<td>L No teratogenicity or disturbances of reproductive process</td>
<td>I Insufficient information</td>
<td>I Insufficient information</td>
</tr>
<tr>
<td>L 250-1000</td>
<td>L &gt;50</td>
<td>N Negative for mutagenicity and carcinogenicity</td>
<td>N Negative for mutagenicity and carcinogenicity</td>
<td>I Insufficient information</td>
<td>I Insufficient information</td>
</tr>
</tbody>
</table>

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1. Cancer risk is based on formaldehyde breakdown product.
2. Methyl bromide and chloropicrin are applied together as a mixture.
Quality of Toxicity Data

The registration process for pesticides, conducted by EPA under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) requires pesticide manufacturers to submit toxicology studies in support of registration of their product. Data gaps exist for some pesticides because a particular study has not been submitted, because submitted studies are not considered adequate according to current EPA guidelines, or because a study is still undergoing review. Although registration or reregistration of a pesticide under FIFRA requires these gaps to be filled, there are, in most instances, data available in studies already reviewed by EPA or from other sources to characterize the toxic endpoints of concern for these pesticides so that their risks can be assessed for the purposes of this EIS.

Where EPA requires two or more studies for a specified toxic endpoint (such as chronic toxicity, oncogenicity, and teratogenicity), the existing data base may have been sufficient to use in the risk assessment based on the studies that have been completed. For example, EPA requires cancer (oncogenicity) studies on two rodents—the rat and mouse—although data on just one of these species is sufficient to determine a cancer potency. The following discussion describes the quality of available data with regard to its value in the risk assessment.

The quality of available toxicity data are summarized in Table IV-8.

Pesticide Exposure

The populations that could be affected by exposure to the pesticides used in the nurseries can be divided into two groups. The first group, the workers (including both nursery employees and contractors), consists of those persons who are directly involved in the nursery operations, from the application of the pesticides to the outplanting of the nursery stock. The worker group includes the following personnel categories: mixer/loader/applicator, weeder/irrigator, inventory personnel, lifter/sorter/packer/tree planter, fumigator, and tarp lifter. The second group is the general public, which may be subject to nonoccupational exposure. This group includes the residents (or workers) living at the nursery or in homes just outside the nursery boundary. The pesticides used by the nursery and the types of workers at the nursery that are exposed to pesticides are presented in Appendix D, Section 3.

To represent the entire range of possible exposures from Forest Service nursery operations, three levels of possible exposure were analyzed: routine-typical, routine-extreme, and accidental.

Routine-typical exposures are those likely to occur under the vast majority of all applications and are based on average conditions, such as average application rate, average number of acres treated, or average time to reentry. Routine-extreme exposures represent the highest doses a person could receive under normal operating conditions. Routine-extreme exposures
Table IV-8

Lucky Peak Nursery
Quality of Nursery Pesticide Database for each Toxicity Category

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Systemic</th>
<th>Carcinogenic</th>
<th>Reproductive/Developmental</th>
<th>Mutagenic</th>
<th>Neurotoxic</th>
<th>Immune-toxic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbicides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCPA</td>
<td>A</td>
<td>S</td>
<td>M</td>
<td>A</td>
<td>I</td>
<td>M</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>A</td>
<td>M</td>
<td>A</td>
<td>A</td>
<td>I</td>
<td>M</td>
</tr>
<tr>
<td>Napropamide</td>
<td>A</td>
<td>M</td>
<td>A</td>
<td>S</td>
<td>I</td>
<td>I</td>
</tr>
<tr>
<td>Oxyfluorfen</td>
<td>A</td>
<td>M</td>
<td>A</td>
<td>A</td>
<td>I</td>
<td>I</td>
</tr>
<tr>
<td>Fungicides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benomyl</td>
<td>A</td>
<td>S</td>
<td>A</td>
<td>M</td>
<td>A</td>
<td>M</td>
</tr>
<tr>
<td>Metalaxyl</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Fumigants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloropicrin*</td>
<td>M</td>
<td>M</td>
<td>I</td>
<td>M</td>
<td>I</td>
<td>I</td>
</tr>
<tr>
<td>Dazomet</td>
<td>S</td>
<td>A</td>
<td>S</td>
<td>M</td>
<td>S</td>
<td>M</td>
</tr>
<tr>
<td>Methyl bromide*</td>
<td>A</td>
<td>A</td>
<td>M</td>
<td>A</td>
<td>A</td>
<td>I</td>
</tr>
</tbody>
</table>

* Methyl bromide and chloropicrin are applied together as a mixture.

Legend:
A Adequate data. Available studies support each other.
S Sufficient data. Usable information, but new studies could change conclusions reached.
M Marginal data. Usable information, but studies to detect endpoint are limited or have widely varying results.
I Insufficient data. Insufficient information to evaluate toxicity for endpoint.

Region 4 FEIS

Risk of Pesticides

Exposure and Dose

Two primary conditions are necessary for a person to receive a pesticide dose that may result in a toxic effect. First, the pesticide must be present in the person’s immediate environment so that it is available for intake. It must be in the air the person breathes, on the person’s skin, or in the person’s food or water. The amount of pesticide present in the person’s immediate environment is the exposure level. Second, the pesticide must then move into the person’s body by some route. If it is in the air, it must be inhaled into the air passages and lungs. If it is on the clothing or skin, it must penetrate the skin. The amount that moves into the body is the dose.

Thus, although two people may be subjected to the same level of exposure—for example, two workers applying herbicide with a tractor-mounted boom—one may get a much lower dose than the other by wearing protective clothing, using a respirator, or washing immediately after spraying. Exposure, then, is the amount of pesticide available to be taken in; dose is the amount that actually enters the body.

How Were Risks Assessed?

Risks to humans exposed to the 8 pesticides were quantified by comparing the calculated doses to workers and the public with the doses from the toxicity tests on laboratory animals. Systemic effects were evaluated based on the lowest systemic no-observed-effect level (NOEL). Reproductive effects were evaluated based on the lowest maternal, fetotoxic, or developmental NOEL.

For doses that are not likely to occur more than once, such as those received by workers spilling spray mix over their entire upper body, a dose estimate that exceeds the NOEL does
not necessarily lead to the conclusion that there will be toxic effects. All the NOELs in this risk analysis based on (or take into account) long-term exposure.

The risk analysis for fumigants has been included in a separate section primarily because the fumigants are applied by different methods than the other pesticides and behave differently in the environment. Therefore the methods of analysis and main routes of exposure are different than the other pesticides.

A worst case analysis of cancer risk was conducted for the pesticides considered to be suspect human carcinogens - DCPA, glyphosate, oxyfluorfen, benomyl, dazomet, and methyl bromide, by comparing estimates of lifetime dose with cancer potency estimates derived in the Hazard Analysis. Cancer risk from the pesticides, except fumigants, for the general public has been calculated for 5 and 30 exposures over a lifetime. Cancer risks to workers from the pesticides, except fumigants, has been calculated for an expected case assuming 5 years of employment in the nurseries and for an extreme case assuming 30 years of employment.

The risk of these herbicides causing mutations was judged on a qualitative basis, with a statement of the probable risk based on the available evidence of mutagenicity assays and carcinogenicity tests.

Synergistic Effects

Synergistic effects of chemicals are those that occur from exposure to two chemicals either simultaneously or within a relatively short period of time. Synergism occurs either when the combined effects of the two chemicals cannot be predicted based on the known toxic effects of the individual chemicals or when their combined effect is much greater than the sum of the effects of either chemical given alone.

Likelihood of Exposures to Two Pesticides

Pesticide mixtures are generally not used at the Lucky Peak Nursery. A mixture that has been used, methyl bromide + chloropicrin has shown synergistic effects in humans who have used them in nurseries and in other applications. This mixture has been approved for use by the Environmental Protection Agency.

It is possible that worker exposure to more than one pesticide could occur because pesticide residues may persist in plants and soil from one application to another. However, the 6 pesticides are known to be rapidly excreted from the body. None of the pesticides has been found to accumulate in test animal body tissues, so exposure of an individual to two pesticides, even within a relatively short time, would be unlikely to cause significant levels of residues within the body simultaneously.

Public exposures to the pesticides should be very limited, except for accidents. The probability of a large accidental exposure to any single pesticide is extremely low. Because the probability of a member of the public receiving a large exposure is so low for one pesticide, the probability of large, concurrent exposures to two pesticides is virtually negligible.

Effects on Chemically Sensitive Individuals

Factors Affecting the Sensitivity of Individuals

Factors that may affect individual susceptibility to toxic substances include diet, age, heredity, preexisting diseases, and lifestyle (Calabrese 1978). These factors have been studied in detail for very few cases, and their significance in controlling the toxicity of the proposed pesticides is not known. However, enough data have been collected on other chemicals to show that these factors can be important.

Susceptibility of Children

Children can be particularly susceptible to pesticides for quantitative and qualitative physiological reasons including smaller body size, incompletely functioning immune systems, rapidly dividing cells (increasing susceptibility to cancer), thinner blood-brain barriers, and immature reproductive systems.

Likelihood of Effects on Chemically Sensitive Individuals

Based on the current state of knowledge, individual susceptibility to the toxic effects of the 8 pesticides cannot be specifically predicted. As discussed above, safety factors have traditionally been used to account for variations in susceptibility among people. Calabrese (1985) has shown that human susceptibility to toxic substances can vary two to three orders of magnitude. Calabrese examined a number of studies of human responses to chemicals and found that the safety factor of 10 accounts for effects in 80 to 95 percent of a population. Thus, 5 to 20 percent of the population exhibit effects at doses outside the tenfold range. The margin-of-safety approach used in this risk assessment takes into account much of the variation in human response as discussed earlier by Calabrese (1985). As described in the risk assessment, a safety factor of 10 is used for interspecies variation, an additional safety factor of 10 is used for within-species variation.

Thus, the normal margin of safety of 100 for both types of variation is generally considered by toxicologists to be sufficient to ensure that the majority of people should experience no toxic effects. However, this will not cover the wide variation from the normal responses of
those few persons who may be extremely sensitive to a substance. Because of the potential hazard to sensitive individuals, nursery managers will monitor workers for evidence of unusual reactions to chemical pesticides. In addition, all nearby residents who could potentially be exposed to chemical pesticides will be notified.

Risk of General Systemic and Reproductive Effects

Risk to the Public

Tables IV-9 and IV-12 summarize the probability of health effects to the public for pesticides (IV-9) and fumigants (IV-12) at Lucky Peak Nursery. Table IV-10 summarizes the moderate and high risks to the public and what risk management actions will be taken to mitigate these risks. Appendix D, Section 4 contains the detailed risk to the public at the Lucky Peak Nursery. A discussion of risk management measures to minimize public exposure follows.

Under routine operations, public exposures result in a low or negligible probability of human health effects from dietary or dermal exposures, except:

Chloropicrin

Risk: There is a moderate risk of general health effects from dermal and inhalation exposure to chloropicrin for the public within 25 feet of a fumigation operation.

Risk Management: The nursery manager will notify residents prior to fumigation, and will not fumigate within 100 feet of residential private property.

Table IV-9

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Dietary Exposure to Game Animals</th>
<th>Dietary Exposure to Garden Vegetables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Systemic</td>
<td>Reproductive</td>
</tr>
<tr>
<td><strong>Herbicides</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCPA</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Naptropane</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Oxyfluorfen</td>
<td>L</td>
<td>N</td>
</tr>
<tr>
<td><strong>Fungicides</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benomyl</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Metalaxyl</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

* Based on public eating 0.5 kg (1.1 pounds) of rabbit dermally exposed to pesticide in a treated seedling bed or eating 0.5 kg (1.1 pounds) of a garden vegetable (lettuce) grown 100 feet from the edge of a treated bed.
Key: Table IV-9

The margin of safety is a ratio of the NOEL to the estimated dose received. For all chemical pesticides analyzed in this risk assessment, the NOEL is based on results seen in studies conducted on laboratory animals. Based on these NOEL's, the categories for exposure and associated margins of safety are:

<table>
<thead>
<tr>
<th>Probability of Health Effects, Assuming Specified Exposure Occurs</th>
<th>Calculated Margin of Safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>High (H)</td>
<td>Less than 10</td>
</tr>
<tr>
<td>Moderate (M)</td>
<td>Between 10 and 99</td>
</tr>
<tr>
<td>Low (L)</td>
<td>Between 100 and 999</td>
</tr>
<tr>
<td>Negligible (N)</td>
<td>Greater than 1,000</td>
</tr>
</tbody>
</table>

See Appendix D for complete information.

Table IV-10

Lucky Peak Nursery
Summary of Risks for the Public in Nursery Pesticide Applications and Risk Management Actions that will be Taken to Address those Risks

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Risk</th>
<th>Risk Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloropicrin</td>
<td>Moderate risk of dermal and inhalation exposure</td>
<td>Prior to fumigation with methyl bromide + chloropicrin, notify residents, and do not fumigate within 100 feet of residential private property.</td>
</tr>
</tbody>
</table>
Risk to Workers

Tables IV-11a and IV-11b, and IV-12 summarize the probability of health effects for pesticides (IV-11a, IV-11b) and fumigants (IV-12) at Lucky Peak Nursery. Probabilities were calculated assuming average exposures to pesticides. All workers in these analyses were assumed not to be wearing protective clothing in order to provide a conservative analysis. Results are given for mixers, loaders, and applicators; weeder; inventory personnel, and those who lift, sort, pack, or plant. Appendix D, Section 4 contains the detailed risk to workers at the Lucky Peak Nursery. A discussion of health effects to workers for Lucky Peak Nursery follows. The risk management for workers is summarized in chapter 2, Mitigating Measures.

Under routine operations, worker exposures result in a low or negligible probability of human health effects for all chemical pesticide use, except:

**DCPA**

**Risk:** There is a moderate risk of systemic effects to weeder and inventory personnel working with DCPA.

**Risk Management:** All workers will wear protective clothing and nursery managers will develop new worker and chemical pesticide use schedules to include one or all of these options:

- reduce worker exposure periods to chemical pesticides;
- reduce chemical pesticide application rates; and
- lengthen the time interval between pesticide application and worker contact.

**Napropamide**

**Risk:** There is a moderate risk of systemic and reproductive effects to weeder working with napropamide.

**Risk Management:** All workers will wear protective clothing and nursery managers will develop new worker and chemical pesticide use schedules to include one or all of these options:

- reduce worker exposure periods to chemical pesticides;
- reduce chemical pesticide application rates; and
- lengthen the time interval between pesticide application and worker contact.

**Benomy**

**Risk:** There is a moderate risk of systemic and reproductive/developmental effects to weeder and inventory personnel working with benomy.

**Risk Management:** All workers will wear protective clothing and nursery managers will develop new worker and chemical pesticide use schedules to include one or all of these options:

- reduce worker exposure periods to chemical pesticides;
- reduce chemical pesticide application rates; and
- lengthen the time interval between pesticide application and worker contact.

**Metalaxyl**

**Risk:** There is a moderate risk of systemic effects to weeder working with metalaxyl.

**Risk Management:** All workers will wear protective clothing and nursery managers will develop new worker and chemical pesticide use schedules to include one or all of these options:

- reduce worker exposure periods to chemical pesticides;
- reduce chemical pesticide application rates; and
- lengthen the time interval between pesticide application and worker contact.

**Methyl Bromide**

**Risk:** There is a moderate risk of general health effects from dermal and inhalation exposure to methyl bromide for drivers, co-pilots, and shoveler; there is a high risk of general health effects from dermal and inhalation exposure for tarp lifters.

**Risk Management:** All workers will wear appropriate protective clothing when applying methyl bromide + chloropicrin. Tarps will be lifted from methyl bromide applications when a minimum number of employees are present, preferably on weekends. If tarps are lifted during work hours, employees will be moved upwind of the tarp lifting. Monitoring gas levels is a standard safety procedure during tarp lifting, and will continue. No employees or contract workers will be permitted to work within 100 feet of nursery seedbeds fumigated with methyl bromide + chloropicrin for 3 days or until the tarps are lifted. Vehicle and foot traffic through the 100 foot buffer zone is permitted.
Chloropicrin

*Risk*: There is a high risk of general health effects from dermal and inhalation exposure to chloropicrin for driver and co-pilots; there is a moderate risk of general health effects from dermal and inhalation exposure for shovels. Information is insufficient to adequately characterize risks for tarp lifters.

*Risk Management*: All workers will wear appropriate protective clothing when applying methyl bromide + chloropicrin. Tarp will be lifted from methyl bromide applications when a minimum number of employees are present, preferably on weekends. If tarp are lifted during work hours, employees will be moved upwind of the tarp lifting. Monitoring gas levels is a standard safety procedure during tarp lifting, and will continue. No employees or contract workers will be permitted to work within 100 feet of nursery seedbeds fumigated with methyl bromide + chloropicrin for 3 days or until the tarp are lifted. Vehicle and foot traffic through the 100 foot buffer zone is permitted.

Dazomet

*Risk*: There is a moderate risk of general health effects to applicators of dazomet.

*Risk Management*: All workers should wear protective clothing. No employee or contract worker will be permitted to work within 50 feet of a nursery seedbed fumigated with dazomet for 3 days. Vehicle and foot traffic through the 50-foot buffer zone should be permitted.

Cancer Risk

Because the exact mechanisms and effective (threshold) doses that induce a carcinogenic response are not understood, chemicals that could induce cancer were assumed to have no threshold for effects and thus no margin of safety comparable to that used to judge the risks of systemic or reproductive effects. A risk of cancer was assumed no matter how small the dose.

A worst case analysis of cancer risk was conducted for the pesticides considered to be suspected human carcinogens- DCPA, glyphosate, oxyfluorfen, benomyl, dazomet, and methyl bromide, by comparing estimates of lifetime dose with cancer potency estimates derived in the Hazard Analysis.

Cancer Risk to the Public

Cancer risks from the pesticides, except the methyl bromide and dazomet fumigants, for the general public has been calculated for 5 to 30 exposures over a lifetime. For methyl bromide and dazomet, the cancer risk was calculated for both 5 and 10 exposures, each lasting 24 hours, over a lifetime.
### Systemic Effects

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Mixer/Loader/Applicators</th>
<th>Weeders</th>
<th>Inventory Personnel</th>
<th>Lift/Sort/Pack/Tree Planters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Herbicides</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCPA</td>
<td>N</td>
<td>M</td>
<td>M</td>
<td>N</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>N</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Napropamide</td>
<td>N</td>
<td>L</td>
<td>N</td>
<td>N/A</td>
</tr>
<tr>
<td>Oxyfluorfen</td>
<td>L</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td><strong>Fungicides</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benomyl</td>
<td>N</td>
<td>M</td>
<td>M</td>
<td>N/A</td>
</tr>
<tr>
<td>Metalaxyl</td>
<td>N</td>
<td>M</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

*Weeders, inventory personnel, lifters, sorters, packers, and tree planters are not exposed to this chemical pesticide because it is only used in non-crop areas.

### Reproductive Effects

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Mixer/Loader/Applicators</th>
<th>Weeders</th>
<th>Inventory Personnel</th>
<th>Lift/Sort/Pack/Tree Planters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Herbicides</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCPA</td>
<td>N</td>
<td>L</td>
<td>L</td>
<td>N</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>N</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Napropamide</td>
<td>L</td>
<td>M</td>
<td>L</td>
<td>N/A</td>
</tr>
<tr>
<td>Oxyfluorfen</td>
<td>L</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td><strong>Fungicides</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benomyl</td>
<td>N</td>
<td>M</td>
<td>M</td>
<td>N/A</td>
</tr>
<tr>
<td>Chlorothalonil</td>
<td>N</td>
<td>L</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

*Weeders, inventory personnel, lifters, sorters, packers, and tree planters are not exposed to this chemical pesticide because it is only used in non-crop areas.

*Lifters, sorters, packers, and tree planters are not exposed to this chemical pesticide because it is only used on seedlings which are not lifted until the following year.
The margin of safety is a ratio of the NOEL to the estimated dose received. For all chemical pesticides analyzed in this risk assessment, the NOEL is based on results seen in studies conducted on laboratory animals. Based on these NOEL’s, the categories for exposure and associated margins of safety are:

<table>
<thead>
<tr>
<th>Probability of Health Effects, Assuming Specified Exposure Occurs</th>
<th>Calculated Margin of Safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>High (H)</td>
<td>Less than 10</td>
</tr>
<tr>
<td>Moderate (M)</td>
<td>Between 10 and 99</td>
</tr>
<tr>
<td>Low (L)</td>
<td>Between 100 and 999</td>
</tr>
<tr>
<td>Negligible (N)</td>
<td>Greater than 1,000</td>
</tr>
</tbody>
</table>

See Appendix D for more complete information.

### Table IV-12

**Lucky Peak Nursery**

**Probability of Health Effects for Public and Workers Exposed to Fumigants**

**General Health Effects**

<table>
<thead>
<tr>
<th>Fumigant</th>
<th>Public</th>
<th>Workers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Driver</td>
<td>Co-pilot</td>
</tr>
<tr>
<td>Methyl bromide&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Chloropicrin&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Dazomet</td>
<td>Low</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

<sup>*</sup> Average exposures based on historical data of agricultural workers not wearing protective clothing, which provides a conservative estimate.

<sup>2</sup> Methyl bromide and chloropicrin are applied together as a mixture.

<sup>3</sup> Insufficient information.

<sup>4</sup> These workers are not involved in the use of dazomet.

---

**Key: Table IV-12**

Based on TLV (Threshold Limit Values), not NOEL’s (No Observed Effects Level), the categories for exposure and associated ratio of TLV to dose are:

<table>
<thead>
<tr>
<th>Probability of Health Effects, Assuming Specified Exposure Occurs</th>
<th>Calculated Margin of Safety (MOS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Less than 1</td>
</tr>
<tr>
<td>Moderate</td>
<td>Between 1 and 10</td>
</tr>
<tr>
<td>Low</td>
<td>Between 10 and 99</td>
</tr>
<tr>
<td>Negligible</td>
<td>Greater than 100</td>
</tr>
</tbody>
</table>

---

IV-53
The cancer risks for 30 years of dermal exposure to other chemical pesticides are less, the greatest risk being from DCPA at 7 in 1,000,000,000. The greatest public dietary risk is from 30 exposures over a lifetime to vegetables contaminated with DCPA. The risk of contracting cancer from this scenario is 2 in 10,000,000.

**Cancer Risk to Workers**

Cancer risks to workers from the chemical pesticides, except methyl bromide and dazomet fumigants, has been calculated for a typical case assuming 5 years of employment in the nursery and for an extreme case assuming 30 years employment in the nursery. The number of days of exposure per year is based on the amount of use of that chemical pesticide in the nursery. For methyl bromide and dazomet, the cancer risk was calculated for both 5 and 10 exposures, each lasting 38 hours, over a lifetime.

The highest risk to workers involved methyl bromide use. The cancer risk for 5 years of exposure for tractor drivers and co-pilots are 6 in 100,000, and 9 in 100,000, respectively. The risks for shoveler are 2 in 100,000. The risks for tarp lifters are 3 in 10,000. For 30 years of exposure, the risks to tractor drivers and co-pilots are 4 in 10,000 and 5 in 10,000, respectively. The risks to shoveler and tarp lifters are 1 in 10,000 and 2 in 1,000, respectively. A cancer risk analysis was also completed for dazomet. The cumulative risk resulting from 19 years of exposure for both drivers and co-pilots is 4 in 1,000,000.

Cancer risks to other workers from other chemical pesticides are much less, with risks to weeders being the greatest. For weeders exposed for 30 years to DCPA, the cancer risks are 1 in 100,000.

For weeders exposed to benomyl over 30 years, the cancer risks are 2 in 1,000,000. Inventory personnel exposed to DCPA over 30 years have a 1 in 1,000,000,000 risk of getting cancer. Cancer risks from 30 years of routine exposure to all other chemical pesticides for all workers are greater than 1 in 1,000,000.

**Effects of the Alternatives on Human Health**

For each alternative, we discuss human health impacts to nursery workers (chemical and non-chemical) and the public (chemical only). These impacts are based on the assumption that no protective clothing is being worn. Throughout this chapter, our analyses of effects have been based on the assumption that no mitigation measures were in place. Mitigation measures for the use of chemical pesticides include protective clothing for workers, as well as minimum distances from chemical applications to private residences.

Unfortunately, there have not been sufficient studies conducted to assess the effects (such as toxicity and carcinogenicity) of chemical pesticides when protective clothing is worn. For that reason, even though protective clothing will be worn, we are presenting these effects as if protective clothing were not being worn.

It is the goal of the nursery manager to reduce human health effects from both chemical and non-chemical pest control. There will always be risks to nursery workers, whether from accidents using non-chemical control methods or from chemical exposure. Our goal is to reduce risks as much as possible through mitigation measures and a well-trained, safety conscious workforce.

**Alternative A - No Action**

Continue Present Management

**Nursery Workers**

**Non-Chemical Control Methods**

With this alternative, the risk of injury due to an accident while using mechanized equipment and hand tools would be moderate since both chemical and non-chemical methods would be used. The risk of muscle strain injuries while performing pest control work could also occur. Training and protective clothing can reduce these risks, but they probably will never be completely eliminated.

**Chemical Control Methods**

Under this alternative, nursery workers would be at risk from detrimental health effects due to exposure to chemical pesticides. These risks include all those outlined in this chapter, such as systemic, reproductive, cancer-causing, and mutation-causing effects. Tables IV-11a and IV-11b summarize these risks for each of the chemicals at the nursery.
Public

Chemical Control Methods
Under this alternative, the public would be at to some level of risk due to exposure to pesticides. These risks are outlined in Tables IV-9, IV-10 and IV-12.

Alternative B
Biological and Cultural
Controls Only No Chemical Pesticides

Nursery Workers

Non-Chemical Control Methods
With this alternative, the risk of injury due to an accident while using mechanized equipment and hand tools would be relatively high since non-chemical methods would be used exclusively. The risk of muscle strain injuries while performing pest control work could also occur. Training and protective clothing can reduce these risks, but they probably will never be completely eliminated.

Because this alternative would not allow the use of chemical control methods, nursery managers would probably rely more heavily on cultural controls. This would increase the chances for injuries, since workers would be spending more time exposed to the risk. However, since injury rates are low now that any increases would not be significant.

Chemical Control Methods
There is no risk to nursery workers from chemicals because they are not used under this alternative.

Public

Chemical Control Methods
There is no risk to the public from chemicals because they are not used under this alternative.

Alternative C
Integrated Pest Management

Nursery Workers

Non-Chemical Control Methods
Under this alternative, the risks of injury due to use of non-chemical controls would be slightly higher than those under Alternative A. There would be more hand weeding with this alternative than with Alternative A. This might result in a slightly higher incidence of injuries such as cuts and sprains. Based on past experience at the nurseries, this difference should not be great.

Chemical Control Methods
With this alternative, the risk of detrimental health effects occurring due to chemical pesticide use would be essentially the same as with Alternative A. We would expect that fewer chemical pesticides would be used under this alternative. This would reduce worker exposure to chemicals. It could reduce the risk for effects listed in Table IV-11a, IV-11b and IV-12.

Public

Chemical Control Methods
The risks to the public with this alternative would be essentially the same as those described for Alternative A. We would expect that fewer chemical pesticides would be used if this alternative is adopted. It is possible that use of fumigants (the major type of chemical of concern for public exposure) would decrease under this alternative, so risk to the public from accidental fumigant exposure might be less. As with some of the other alternatives, however, we have no way of objectively estimating this effect, so we are describing the effects to the public under this alternative using the descriptions in Tables IV-9, IV-10 and IV-12.

Cumulative Effects

Cumulative effects are not likely to occur because none of the pesticides is persistent in the environment or in the human body; no member of the public is likely to be chronically exposed from nursery applications; and no member of the public is likely to receive simultaneous exposures from these same pesticides used in any other programs.

There are instances when it could be argued that cumulative doses could occur. If the nursery is resprayed with a pesticide before the pesticide from the previous spraying has been totally degraded, or if another use of the same pesticide occurs in the nursery and overlaps its degradation in time, then it is possible for larger pesticide doses to occur than from a single application. Cumulative exposure could also occur when an individual uses one of the pesticides in their lawn or garden, or is exposed to a pesticide from nearby agricultural areas, and is exposed to the same pesticide as a result of the Forest Service nursery application program.

Pesticide doses from the other types of sources mentioned above were not estimated in the risk assessment. However, the risks of adverse health effects from possible cumulative doses in this program should be no greater than the risks from routine-extreme exposures. The assumptions used in the risk assessment are estimated exposures from eating, drinking, and coming in contact with vegetation. These estimates are conservative enough to cover expo-
Consequences of the Alternatives on Irreversible or Irretrievable Commitment of Resources

An irreversible commitment of a resource occurs when resources are affected in a manner that cannot be reversed. For instance, if soil or water is contaminated and cannot be decontaminated, the effect is irreversible.

An irretrievable commitment of a resource occurs when resources, often minerals or fossil fuels, are used up and cannot be replaced.

Alternative A - No Action
Continue Present Management

There is a potential for irreversible groundwater contamination from years of nursery pesticide applications. However, the specific soil and water mitigating measures incorporated in this EIS are designed to prevent groundwater contamination.

Alternatives B and C
Biological and Cultural Controls Only, Integrated Pest Management, and All Pest Control Methods Except Methyl Bromide + Chloropicrin

There is a potential for irreversible groundwater contamination from years of nursery pesticide applications. However, the specific soil and water mitigating measures incorporated in this EIS are designed to prevent groundwater contamination. Alternative B would eliminate further potential groundwater contamination by eliminating pesticide use. No irreversible effects on resources have been identified.

An irretrievable effect on resources is the loss of seedling production opportunities. Seedling production would vary between alternatives, as would the costs associated with accomplishing environmentally sound pest management. The commitment of time and dollars are irretrievable when production is lost. However, they are not irreversible, since production levels can be reversed by changing nursery pest management strategies in the future. Irretrievable resource commitments are summarized below.

Consequences of the Alternatives on Energy Requirements and Conservation Potential

Alternative A - No Action
Continue Present Management

Energy requirements and conservation potential would be unchanged.

Alternatives B and C (Biological and Cultural Controls Only) and (Integrated Pest Management)

There can be some minor reductions through conservative use of tractors and other vehicles at the nurseries, but no significant opportunities to reduce fossil fuel consumption were identified.

Consequences of the Alternatives on Social and Cultural Issues

These alternatives involve activities similar or identical to activities that have been practiced at the nurseries, on the same ground, for many years. We would expect that all current Forest Service regulations concerning archeological artifacts, Native American cultures, and equal employment practices would be followed. For those reasons, we do not anticipate any adverse
Short-term Use Versus Long-term Productivity

"Short-term" uses are generally those that determine the present quality of life for the public, including employees. The short-term use of the Lucky Peak Nursery is to produce appropriate quantities of quality seedlings for reforestation of predominantly National Forest lands and other public lands. The decision to provide seedlings for reforestation was made in the early 1900's to ensure availability of suitable planting stock for the new Forest Reserves. Considering all the activities that take place in a nursery, a narrow spectrum of management activities is considered in this EIS. Pest management helps provide the production of quality and quantity seedlings required for reforestation, a short-term use of the nursery. The process presented here for managing nursery pests and many of the mitigating measures are designed to protect the long-term productivity of the land.

"Long-term productivity" refers to the capability of the land to support a sound ecosystem that will continue to produce an appropriate quantity of quality seedlings. The cultural and biological pest control methods associated with short-term uses have no known long-term effect on long-term productivity.

The chemical pesticides examined in this EIS have no known long-term effect on long-term productivity. However, it is known that many pest management activities have the potential to reduce the natural productivity of the land if certain operating guidelines are not followed. This EIS has developed mitigating measures for nursery pest management that will protect long-term productivity of nursery lands.

Incomplete or Unavailable Information

Incomplete or unavailable information was sometimes encountered in the process of preparing this EIS. The implications of these situations and how they were handled are discussed here.

The purpose of the environmental analyses contained in this EIS is to "present the environmental impacts of the proposal and the alternatives in comparative form, thus sharply defining the issues and providing a clear basis for choice among options by the decision maker and the public" (U.S. Government 40 CFR 1502.14)
Reasonably Foreseeable Significant Adverse Effects

An open public process was used in preparing this EIS to identify significant issues. Issues identified are issues because of the potential for reasonably foreseeable, significant adverse impacts on the human environment. The potential impacts are in the areas of human health, social and economic effects, and environmental effects. See Chapter I and Appendix A for a discussion of the issues and the scoping process.

Environmental Impacts

Environmental effects are reasonably well understood. The uncertainty associated with estimating environmental effects is due to the inherent variability and diversity associated with the natural environment. By using appropriate assumptions and professional judgment, effects of actions can be reasonably estimated with confidence. (These estimated effects are presented as the main part of this chapter.) While no estimate of effects for a given alternative is absolutely certain, the relative effects—compared to other alternatives—are correct. There is sufficient information with regard to environmental effects to provide a clear basis for choice among options.

Mutagenic Impacts to Seedlings

Very little has been done to determine the genetic impacts of pesticides on conifers. However, several studies have determined that there are no chromosomal changes in seedlings treated with pesticides when compared to seedlings in a control plot. The biological impact of a pesticide is influenced by its pattern of use. Frequent use of pesticides may not allow time-dependent genetic repair processes to become effective. Further monitoring is required to determine if any changes are occurring in treated seedlings (Thiesen 1989).

Human Health Concerns

Human health concerns related to managing the Lucky Peak Nursery by using chemical pesticides is an issue.

A detailed and systematic determination of the quality of available information on human health effects of pesticides is identified in the section on Human Health Effects in this chapter. Information that is incomplete or unavailable for human health effects of pesticides is summarized in Appendix D, Section 2.

The costs of obtaining more precise and conclusive data were estimated and were found to be exorbitant. While there is incomplete and unavailable information, much information about the human health effects of chemical pesticides does exist. A large portion of the information that does exist was developed in support of registration of chemical pesticides by the Environmental Protection Agency.

Information is incomplete or unavailable for human health effects of chemical pesticides.

- Field data on residue levels in plants and animals most likely to be found in and around treatment areas for the pesticides;
- Toxicity information on the synergistic effects from exposure to more than one pesticide;
- Chemical pesticide specific data gaps summarized in Table IV-8 and discussed in detail in Appendix E, Section 2; and
- Inert ingredients used in chemical pesticide formulations.

Residue data in various environmental components, including plants, animals, and water are available for the pesticides, but not for forestry applications. A conservative methodology was used to model the transport and fate of the pesticides in various environmental components.

Statement of Relevance

The relative human health effects of chemical pesticides can be compared among the alternatives. Comparisons are made in this EIS for accidents from spills for each nursery. (See the Human Health Effects section of this chapter and Appendix D, Section 4). Actual human health risks from chemical pesticides are uncertain because there is incomplete and unavailable information.

Compliance with Laws and Regulations of Other Jurisdictions

Implementation of any of the alternatives are not expected to present conflicts with federal, state, county, and/or local laws and ordinances. Implementation measures would comply with the regulations of these jurisdictions.
Summary of Information

Information that is currently available is summarized in several places in this EIS:

Chapter IV  Human Health Effects
Appendix D  Quantitative Human Health Risk Assessment
Appendix D, Section 4  Nursery-Specific Risk Analysis
Appendix D, Section 6  Details of Mutagenicity and Carcinogenicity

Evaluation of Impacts

The human health effects of the alternatives are compared in Chapter II. The detailed human health effects of the alternatives are discussed in Chapter IV. In the course of evaluating potential human health effects, three kinds of information were used: historical studies, research studies, and quantitative predictions.

Many research studies were used to determine what effects are currently known. A great number of research studies have been conducted on the use of chemical pesticides, many in support of registration by the Environmental Protection Agency. Enough information is available that risk can be reasonably characterized for all chemical pesticides being considered. Quantitative estimates of risk are contained in Appendix D, which contains a detailed quantitative human health risk assessment that considers three different scenarios: 1) routine-worst case; 2) routine-realistic, and 3) accidental spills.

Unavoidable Adverse Effects

Implementation of any alternative would result in some adverse environmental effects that cannot be avoided. The mitigating measures developed in this EIS are intended to keep the extent and duration of these effects within acceptable levels, but adverse effects cannot be completely eliminated.

Because this EIS examines alternative methods for managing nursery pests, the focus is on how the different methods could affect the environment. From this perspective, there are three areas of potentially significant adverse effects:

- Human health risks
- Environmental effects
- Economic effects

The potential for adverse effects varies with each alternative, and is discussed in detail in this EIS.
List of Preparers
Interdisciplinary Team

Don Boyer is a soil scientist on contract with the Nursery EIS team. Don has a B.S. in agronomy from Colorado State University. He has worked as a soil specialist for the USDA Soil Conservation Service for 10 years, and the USDA Forest Service for 19 years. Don retired from the Forest Service in 1983, and currently is a hazelnut farmer.

Sally Campbell is a nursery and regeneration pathologist with the USDA Forest Service in Portland, Oregon. Sally is the Nursery EIS team leader. She has a B.S. in biology from Pitzer College, and an M.S. in plant pathology from Oregon State University. She has worked for the Forest Service for 11 years.

George Matejko is a forester with the USDA Forest Service, formerly in Portland, Oregon, now in Washington, D.C. He has a B.S. in forest management from West Virginia University, and has done graduate work in hydrology. George has worked for the USDI Bureau of Land Management and the USDA Forest Service for 15 years as a hydrologist, district resource assistant, and district ranger, environmental impact statement team leader, and legislative affairs specialist.

Michael O'Day is a forest resource and computer/data systems specialist with the USDA Forest Service in Portland, Oregon. He has a B.S. in forest management from the University of Michigan. Mike has worked for the Forest Service for 9 years and was employed for 7 years with the forest products industry specializing in forest inventory and mapping.

Gloria Perez is a writer editor for the USDA Forest Service in Portland, Oregon. She has a B.S. in business marketing from Metropolitan State College. She is new to the Forest Service. Gloria had worked in customer service for 3 years and has experience in market planning, promotions, and writing and editing newsletters.

Phil Sczerzinski, Ph.D., is the group leader for a research team from Labat-Anderson, Inc., a research group located in Arlington, Virginia. Phil and his team prepared the risk assessment for this project and several others of a similar nature.

Dennis Weber is a forester with the USDA Forest Service in Portland, Oregon. He has a B.S. in forest management from the University of Wisconsin. Dennis has 14 years of professional experience as a forester and interdisciplinary land management planner on the Willamette and Mt. Hood National Forests.

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- Dan Dolata, Forester, Lucky Peak Nursery, Boise National Forest, Boise, ID.
- Judy Droddy, Business Management Assistant, USDA Forest Service, Portland, OR.
- Helen Graham, Assistant Editor, Writer, FEIS, USDA Forest Service, Timber Management, Portland, OR.
- Larry Gross, Pesticide Specialist, USDA Forest Service, WO, Washington, DC.
- Jim Hoffmann, Pathologist, Boise National Forest, Boise ID.
- Dr. Terry Lavy, University of Arkansas, Fayetteville, AR.
- Timothy Mulholland, Chemist, Labat-Anderson Inc., Washington, DC.
- Richard H. Thatcher, Nursery Manager, Lucky Peak Nursery, Boise National Forest, Boise, ID.
- Robin Weiss, Analyst, Labat-Anderson Inc, Arlington, VA.
Distribution List

These are the agencies, organizations, and individuals who were listed to receive this FEIS as of August 1993.

Federal Agencies and Officials

Advisory Council on Historic Preservation
Office of Architectural and Environmental Preservation, Washington, DC

Department of Agriculture
Agricultural Stabilization and Conservation Service, Washington, DC;
Animal and Plant Health Inspection Service, Hyattsville, MD
Office of Equal Opportunity, Washington, DC
Rural Electrification Administration, Washington, DC
Soil Conservation Service, Washington, DC
State Conservationist, Boise, ID

Forest Service, Washington, DC
Regional Offices
Alaska Region, Juneau, AK
Eastern Region, Milwaukee, WI
Intermountain Region, Ogden, UT
Northern Region, Missoula, MT
Pacific Northwest Region, Portland, OR
Pacific Southwest Region, San Francisco, CA
Rocky Mountain Region, Lakewood, CO
Southern Region, Atlanta, GA
Southwestern Region, Albuquerque, NM

National Forests and Ranger Districts in the Intermountain Region
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Boise Ranger District
Cascade Ranger District
Emmett Ranger District
Idaho City Ranger District
Lowman Ranger District

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Caribou National Forest
Malad Ranger District
Montpelier Ranger District
Pocatello Ranger District
Soda Springs Ranger District
Curec National Grasslands

Challis National Forest
Challis Ranger District
Lost River Ranger District
Middle Fork Ranger District
Yankee Fork Ranger District

Payette National Forest
Council Ranger District
Krause Ranger District
McCall Ranger District
New Meadows Ranger District
Weiser Ranger District

Salmon National Forest
Cobalt Ranger District
Leadore Ranger District
North Fork Ranger District
Salmon Ranger District

Sawtooth National Forest
Burley Ranger District
Fairfield Ranger District
Ketchum Ranger District
Sawtooth National Recreation Area
Twin Falls Ranger District

Targhee National Forest
Ashton Ranger District
Dubois Ranger District
Island Park Ranger District
Palisades Ranger District
Teton Basin Ranger District

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Ely Ranger District
Jarbridge Ranger District
Mountain City Ranger District
Santa Rosa Ranger District
Ruby Mountains Ranger District

Toiyabe National Forest
Austin Ranger District
Bridgeport Ranger District
Carson Ranger District
Las Vegas Lake Ranger District
Tonopah Ranger District

Utah:
Ashley National Forest
Duchesne Ranger District
Flaming Gorge Ranger District
Roosevelt Ranger District
Vernal Ranger District

Dixie National Forest
Cedar City District
Escalante Ranger District
Pine Valley Ranger District
Powell Ranger District
Teadale Ranger District

Fishlake National Forest
Beaver Ranger District
Fillmore Ranger District
Loa Ranger District
Richfield Ranger District

Manti-LaSal National Forest
Ferron Ranger District
Moab Ranger District
Monticello Falls Ranger District
Price Ranger District
Sanpete Ranger District

Uinta National Forest
Heber Ranger District
Pleasant Grove Ranger District
Spanish Fork Ranger District

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<td>Federal Highway Administration, Washington, DC; Northwest Mountain Region, Portland, OR</td>
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Distribution List - 4
Region 4 FEIS

Office of Pipeline Safety, Washington, DC
US Coast Guard, Water Resources Coordination, Washington, DC

Environmental Protection Agency
Federal Agency Liaison Division, Washington DC; Region 10, Seattle, WA

General Services Administration
Environmental Staff, Washington, DC

Nuclear Regulatory Commission
Environmental Projects Office, Washington, DC
Region 5, Walnut Creek, CA

State and Local

Agencies
Central District Health Department, Boise, ID
Idaho Cooperative Fish and Wildlife Research Unit, Moscow, ID
Idaho State Department of Agriculture, Boise, ID
Idaho State Department of Fish and Game, Boise, ID
Idaho State Department of Health and Welfare, Boise, ID
Idaho State Department of Lands, Boise, ID
Idaho State Department of Parks and Recreation, Boise, ID
Idaho State Department of Transportation, Boise, ID
Idaho State Department of Water Resources, Boise, ID
State Extension Services, Moscow, ID

Federal Legislators
Honorable Larry Craig, Senator, Washington, D.C.
Honorable Dirk Kempthorne, Senator, Washington, D.C.
Honorable Mike Crapo, Representative, Washington, D.C.
Honorable Larry LaRocco, Representative, Washington, D.C.

State Legislators
Governor and Secretary of State of Idaho
State Legislators of Districts of 13 thru 19 in Ada county

County Government
Ada County Commissioners, Boise, ID
Ada County Extension Agent, Boise, ID
Ada County Weed Control, Meridian, ID

Organizations and Businesses
A and L Reforestation, Boise, ID
Acarrregu Ranches, Inc., Mountain Home, ID

Distribution List - 6
Relion 4 FEfS

Steiners Construction and Repair, Caldwell, ID
Stringer Brothers, Nyssa, OR
The Hilltop Cafe, Boise, ID
The Hoedads, Eugene, OR
Trout Unlimited Idaho Council, Lewiston, ID
Western Forest Systems Nursery, Lewiston, ID
Wildlife Society, Idaho Chapter, Blackfoot, ID

Schools
University of Idaho
College of Forestry, Wildlife and Range Sciences, Moscow, ID
Forest Research Nursery, Moscow, ID
Idaho State University
Department of Biological Sciences, Pocatello, ID

Libraries
University of Idaho Library, Document Section, Moscow, ID
Idaho State University Library, Document Section, Pocatello, ID
Boise Public Library, Boise, ID

Newspapers
Idaho Statesman, Environmental Editor, Boise, ID

Individuals
John Anchustiguai, Jr., Boise, ID
Nelva Baez, McCall, ID
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Distribution List - 8
Literature Cited

All documents cited are available at universities, libraries, or from Federal agencies such as the U.S. Forest Service.

In the text of this document, references are cited in parentheses using the author-year system of citation. When an organization (such as a Governmental agency or scientific society) is listed as the author in the parenthetical citation, an acronym or an abbreviation form of that organization’s name generally is used in place of its full title. Below is a list of acronyms and abbreviations that are used in citations, along with the corresponding full titles that are used in this reference section.

USACE: U.S. Army Corps of Engineers
USDA, FS: U.S. Department of Agriculture, Forest Service

In addition, three other abbreviation are used. FSM, is used to cite Forest Service Manuals, while FSH is used to cited Forest Service Handbooks. For example, FSH 2109.11 refers to Forest Service Manual 2109.11. These manuals and handbooks are located in most Forest Service offices. The abbreviation CFR refers to the Code of Federal Regulation. A parenthetical reference such as (29 CFR 1910.1200) cites book 29, section 1910.1200 of the Code of Federal Regulation. These are available at many federal government offices, and some public and university libraries. Citation for FSM and CFR are not included in the following literature cited section since the parenthetical reference provide all the information needed to locate the document.

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WEB  Webster's Ninth New Collegiate Dictionary

A

Abiotic damage: Damage to plants caused by non-living entities such as heat, frost, or fertilizers.

Absorption: Movement of a pesticide from the surface into a body of water or of nutrients into a plant (compare with adsorption). (D & L)

Acid soil: Soil having a pH value less than 7.0. (D & L)

Action threshold: The level of a pest population at which action (treatment) occurs to avoid unacceptable damage to the crop. (VMT)

Active ingredient (a.i.): Portion of a pesticide formulation that produces the desired toxic, stimulatory, or repelling effect, expressed as a percentage. (D & L)
Acute toxicity: The toxicity of a material determined at the end of 24 hours to cause injury or death from a single dose or exposure. (W)

Adjuvant: An ingredient that improves the properties of a pesticide formulation. Includes wetting agents, spreaders, emulsifiers, dispersing agents, foam suppressants, penetrants, and correctives. (W)

Adsorption: Attraction or bonding of ions or compounds, usually temporarily, to the surface of a solid (compare with absorption). (D & L)

Adulterated pesticide: A pesticide that does not conform to the professed standard or quality as documented on its label or labeling. (W)

Aeration (soil): Process by which (1) oxygen diffuses through the soil to the root and (2) carbon dioxide and other gases released from the root diffuse to the soil surface. (D & L)

Aerobic: Occurring or growing in the presence of oxygen. (D & L)

Alkaline soil: Soil having a pH value greater than 7.0. (D & L)

Allelopathy: Production of chemical compounds by one plant which are released into the soil environment and are harmful to other nearby plants or the successful germination of seeds. (D & L, modified)

Amendment: Any substance added to a soil to alter its physical or chemical properties and thereby make that soil more useful for plant production. (D & L)

Anadromous fish: Species of fish, spawned in fresh water, which mature in the sea, and migrate back into fresh water streams to spawn. Salmon, steelhead, and shad are examples. (VMT)

Anaerobic: Occurring or growing in the absence of oxygen. (D & L)

Anion: Ion having a negative charge, e.g., Cl\(^-\) & NO\(_3\) (compare with cation). (D & L)

Annual: Plant that completes its entire life cycle from seed germination to seed production and death within a single season (compare with perennial, biennial). (D & L)

Aromatic: Solvents containing benzene, or compounds derived from benzene. (W)

Artificial regeneration: Reforestation of a stand by direct seeding or planting (compare with natural regeneration). (D & L)

Atropine (atropine sulfate): An antidote used to treat organophosphate and carbamate poisoning. (W)

Attractant, insect: A substance that lures insects to trap or poison-bait stations. Usually classed as food, oviposition, and sex attractants. (W)

Avicide: Lethal agent used to destroy birds, but also refers to materials used for repelling birds. (W)

Band application: Spreading of a chemical or fertilizer to a restricted area (such as in, on, or along a crop row), rather than over an entire field or area (compare with broadcast application). (D & L)

Bed: Elongated strip of soil in which seedlings or transplants are grown. (D & L)

Bed foot (meter): Area of seedbed 1 lineal foot (or 1 lineal meter) long times the width of the bed. (D & L)

Bio-accumulation: Uptake and temporary storage of a chemical in animal flesh and organs. Over a period of time a higher concentration of chemical may be found in the organism than in the environment. (VMT)

Biocide: Any compound capable of killing living organisms. (WEB)

Biological control: Biological control is the use of parasites, predators, or disease pathogens (bacteria, fungi, viruses, and others) to suppress pest populations to low enough levels to avoid economic losses. (W, modified)

Biological control agent: Any biological agent that adversely affects pest species. (W)

Biotic insecticide: Usually microorganisms known as insect pathogens that are applied in the same manner as conventional insecticides to control pest species. (W)

Blight: Common name for a number of different diseases on plants, especially when collapse is sudden - e.g. leaf blight, blossom blight, shoot blight. (W)

Botanical pesticide: A pesticide produced from naturally-occuring chemicals found in some plants. Examples are nicotine, pyrethrum, strychnine, and rotenone. (W)

Box pruning: Root-culturing technique that consists of the lateral pruning of roots in a four-sided-box shape around a seedling in a seedbed (compare with lateral pruning). (D & L)

Brand: The name, number, or designation of a pesticide. (W)
**Broadcast application:** Spreading of a chemical or fertilizer over an entire area or field rather than only on rows, beds, or individual plants (compare with band application). (D & L)

**Broadcast seeding:** Method of sowing in which seeds are distributed across the seedbed by hand (compare with drill seeding). (D & L)

**Broadleaf species:** Those plants classified as Dicotyledoneae; characterized by having round and flattened leaves (compare with narrow leaf species). (D & L)

**Broad-spectrum insecticides:** Nonselective, having about the same toxicity to most insects. (W)

**Buffer capacity:** Ability to resist change in pH. A soil with a high buffer capacity will have stable soil pH. (D & L)

**Bulk density (soil):** Mass (weight) of dry soil divided by soil volume, commonly expressed as pounds per cubic foot, or grams per cubic centimeter. (D & L)

**C**

**Caliper:** Stem diameter of a seedling, usually measured just above the root collar. (D & L)

**Canker:** A lesion on a stem. (W)

**Carbamate insecticide:** One of a class of insecticides derived from carbamic acid. (W)

**Carcinogen:** A substance that causes cancer in living animal tissue. (W)

**Carrier:** An inert material that serves as a diluent or vehicle for the active ingredient or toxicant. (W)

**Catch crops:** Crops which are grown and then incorporated into the soil, primarily to capture and retain nutrients on the site but also to increase soil organic matter (compare with cover crops, green manure crops). (D & L)

**Cation:** Ion having a positive charge, e.g., Ca++, Mg++ (compare with anion). (D & L)

**Cation exchange capacity (CEC):** Sum total of exchangeable cations that a soil can absorb, expressed in milliequivalents per 100 grams of soil, clay, or organic colloid. Because of the high CEC of organic matter, the buffer capacity of a soil is increased after organic amendments are added, and the soil is better able to hold cationic nutrients. (D & L)

**Causal organism:** The organism (pathogen) that produces a given disease. (W)
**Certified applicator:** Commercial or private applicator qualified to apply restricted-use pesticides as defined by the EPA. (W)

**Chemical name:** Scientific name of the active ingredient(s) found in the formulated pesticide. The name is derived from the chemical structure of the active ingredient. (W)

**Chemtree:** A toll-free, long-distance, telephone service that provides 24-hour emergency pesticide information (800-424-9300). (W)

**Chiseling:** Breaking or loosening soil, without inverting it, with a cultivator or chisel plow, generally below the normal plow depth (compare with subsoiling, ripping). (D & L)

**Chlorosis:** Yellowing of normally green plant tissue due to a lack of chlorophyll. Chlorosis can be a symptom of disease, nutrient deficiency, or inadequate light. (D & L)

**Cholinesterase (ChE):** An enzyme of the body necessary for proper nerve function that is inhibited or damaged by organophosphate or carbamate insecticides taken into the body by any route. (W)

**Chronic toxicity:** The toxicity of a material determined usually after several weeks of continuous exposure. (W)

**Clay:** Soil particle less than 0.002 mm in diameter; soil textural class characterized by a predominance of clay particles. (D & L)

**Claypan:** Dense, compact layer in the subsoil which has a much higher clay content than the overlying material, resulting from the downward movement of clay or the synthesis of clay in place during soil formation. Claypans, separated from the soil material above by a sharply defined boundary, are typically hard when dry and plastic and sticky when wet. They usually impede water and air movement and growth of plant roots (compare with hardpan). (D & L)

**Common pesticide name:** A common chemical name given to a pesticide by a recognized committee on pesticide nomenclature. Many pesticides are known by a number of trade or brand names but have only one recognized common name. Example: The common name for Sevin insecticide is carbaryl. (W)

**Compaction (soil):** Increase in bulk density, hence lower porosity, of a soil, due to the rearrangement of soil aggregates from applied loads, pressure, or vibration. The reduction of pore spaces between particles impedes gas and water exchange and also root penetration. (D & L)

**Compatible (Compatibility):** When two materials can be mixed together with neither affecting the action of the other. (W)

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**Glossary - 5**

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**Compost:** Organic residues or a mixture of organic residues and other materials (e.g., sawdust combined with nitrogen fertilizer or sewage sludge) that have been piled and allowed to undergo biological decomposition. (D & L)

**Concentration:** Content of a pesticide in a liquid or dust, for example pounds per gallon or percent by weight. (W)

**Contact herbicide:** Herbicide that kills plant tissue by direct contact rather than by translocation or root uptake (compare with systemic herbicide). (D & L)

**Contamination:** The presence of an unwanted pesticide or other material in or on a plant, animal, or their by-products; soil; water; air; structure; etc. (See residue). (W)

**Control treatment:** Zero-level application of a treatment. A control treatment (e.g., no wenching) is used to judge whether particular treatment levels (e.g., multiple wenchings) are effective (compare with standard treatment). (D & L)

**Cotyledon:** First leaf or leaves of the embryo in seed plants. In conifers, the cotyledon stage occurs after the seedling has emerged and until the primary (true) leaves develop. (D & L)

**Cover crops:** Crops grown principally to control various forms of erosion but also incorporated into the soil to increase organic matter (compare with catch crops, green manure crops). (D & L)

**Cull:** Seedling which is not acceptable because it does not meet certain size and quality standards and which is thought to have low survival and growth potential. (D & L)

**Cull factor:** Number of seedlings that do not meet shippable standards (e.g., diseased, poor form or size, damaged), expressed as a percentage. (D & L)

**Cultural control:** The use of certain nursery practices (such as seedling density, improving drainage, and adding soil amendments) to make the habitat less favorable for weeds, diseases, insects, and animals, or to prevent, suppress, or remove them. Manual and mechanical methods are part of cultural controls. (IDT)

**Cumulative pesticides:** Those chemicals which tend to accumulate or build up in the tissues of animals or in the environment (soil, water). (W)

**Curative pesticide:** A pesticide which can inhibit or eradicate a disease-causing organism after it has become established in the plant or animal. (W)

**Cuticle:** Outer waxy layer covering the epidermal cells on most plant leaves and non-corky plant stems. (WEB)

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**Glossary - 6**
D

**Damping-off:** Disease characterized by either seed decay in the soil or seedling wilting and death after germination, usually caused by soil-borne fungi. (D & L)

**Days-to-harvest:** The least number of days between the last pesticide application and the harvest date, as set by law. Same as "harvest intervals". (W)

**Decontaminate:** The removal or breakdown of any pesticide chemical from any surface or piece of equipment. (W)

**Deflocculating agent:** Material added to a spray preparation to prevent aggregation or sedimentation of the solid particles. (W)

**Defoliant:** A chemical that initiates abscission of leaf or plant parts. (W, modified)

**Degradation:** Breakdown of chemical compounds into basic components with properties different from those of the original compounds. (WEB)

**Deposit:** Quantity of a pesticide deposited on a unit area. (W)

**Dermal toxicity:** Toxicity of a material as tested on the skin, usually on the shaved belly of a rabbit; the property of a pesticide to poison an animal or human when absorbed through the skin. (W)

**Desiccant:** A chemical that induces rapid desiccation of a leaf or plant part. (W)

**Desiccation:** Accelerated drying of plant or plant parts. (W)

**Detoxify:** To make an active ingredient in a pesticide or other poisonous chemical harmless and incapable of being toxic to plants and animals. (W)

**Diluent:** Component of a dust or spray that dilutes the active ingredient. (W)

**Disinfectant:** A chemical or other agent that kills or inactivates disease-producing microorganisms in animals, seeds, or other plant parts. Also commonly refers to chemicals used to clean or surface-sterilize inanimate objects. (W)

**Disking:** Breaking up surface layers of soil with a disk implement to destroy weeds, prepare the soil for planting, or incorporate a pesticide or fertilizer. (D & L)

**Dormancy:** Condition in which a tissue predisposed to elongate does not do so even if environmental conditions are suitable for growth. Dormancy, composed of different phases, is a plant adaptation to survival under stress (e.g., frost, drought). (D & L)

**Dormant spray:** Chemical applied in winter or very early spring before treated plants have started active growth. (W)

**Dose, dosage:** Same as rate. The amount of toxicant given or applied per unit of plant, animal, or surface area. (W)

**Downward transport:** Translocation of compounds downward through the phloem of plants to root tissue, as opposed to upward transport through the xylem from roots to above-ground parts. (IDT)

**Drench:** Saturation of a soil with pesticide, usually to control root diseases. (D & L)

**Drift, spray:** Movement of airborne spray droplets from the spray nozzle beyond the intended contact area. (W)

**Drill Seeding:** Nursery sowing method in which seeds are planted in rows with a seed-drilling implement (compare with broadcast seeding). (D & L)
the Secretary of the Interior as endangered in accordance with the 1973 Endangered Species Act, as amended. (VMT)

*Endomycorrhiza(s):* Group of mycorrhizae in which the hyphal infections of host roots are intracellular. This group is not as common in conifer species as it is in many angiosperms and herbaceous species, although cedars and redwoods have endomycorrhizae. (D & L)

**Endoparasite:** A parasite that enters host tissue and feeds from within. (W)

**Environment:** All the organic and inorganic features that surround and affect a particular organism or group of organisms.

**Environmental impact statement (EIS):** A document prepared by a federal agency in which anticipated environmental effects of alternative planned courses of action are evaluated.

**Environmental Protection Agency (EPA):** The federal agency responsible for pesticide rules and regulations, and all pesticide registrations. (W)

**EPA establishment number:** A number assigned to each pesticide production plant by EPA. The number indicates the plant at which the pesticide product was produced and must appear on all labels of that product. (W)

**EPA registration number:** A number assigned to a pesticide product by EPA when the product is registered by the manufacturer or his designated agent. The number must appear on all labels for a particular product. (W)

**Eradicant:** Applies to fungicides in which a chemical is used to eliminate a pathogen from its host or environment. (W)

**Experiment:** Planned inquiry designed to obtain new facts or to confirm or deny information from previous results, to aid in making recommendations or decisions. (D & L)

**Experimental plot:** Smallest physical unit (e.g., specific length of nursery bed) to which a treatment is applied independent of other treatments. (D & L)

**Esterminate:** Often used to imply the complete extinction of a species over a large continuous area such as an island or a continent. (W)

**Fallow:** Allow cultivated land to idle during the entire or greater portion of the growing season. (D & L)

**Field capacity:** Soil water content resulting after the free water has been allowed to drain from a saturated soil for 1 to 2 days; expressed as a percentage on a dry-weight basis. (D & L)

**FIFRA:** The Federal Insecticide, Fungicide, and Rodenticide Act of 1947. (W)

**Filler:** Diluent in powder form. (W)

**Fumigant:** A chemical applied as liquid or powder which volatilizes to gases and kills nematodes, fungi, bacteria, seeds, roots, rhizomes, or entire plants. Fumigants are usually applied beneath a tarp, sheet, or other enclosure. (D & L)

**Fumigation:** Use of chemicals in gaseous form to destroy pests, usually applied under a cover or shelter. (D & L)

**Fungicide:** Chemical used to kill or inhibit fungi. (D & L)

**Fungistasis:** Inhibition of fungal growth, without destroying the fungus, by preventing the germination of conidia or other spore types. (D & L)
**Gallongage**: Number of gallons of finished spray mix applied per 1,000 square feet, acre, tree, hectare, square mile, or other unit. (W)

**General use pesticide**: A pesticide which can be purchased and used by the general public without undue hazard to the applicator and environment as long as the instructions on the label are followed carefully. (See restricted use pesticide). (W)

**Germination**: The beginning of growth of a mature, generally dormant seed. (D & L)

**Germination percent (seed)**: Percentage of seeds that germinate under standard treatment and after a given time period. This value, considered a principal index of seed quality, is used to calculate seedbed sowing density. (D & L)

**Grading**: Process of identifying and subsequently separating various classes of acceptable (shippable) and inferior (cull) stock to improve stock quality. This operation occurs after lifting and before packing and storing. (D & L)

**Granular**: A sandy or sugar-like composition as opposed to liquid composition. Can be broadcast as opposed to sprayed. (WEB)

**Green manure crops**: Crops grown primarily as organic amendments for the soil. Green manure crops are incorporated into the soil while green but before seedset, to benefit succeeding crops (compare with catch crops, cover crops). (D & L)

**Growth regulator**: Organic substance effective in minute amounts for controlling or modifying (plant or insect) growth processes. (W)

**Hardening off**: Natural process of adaptation by plants to cold or drought. Hardening off may be induced in the nursery by reducing water or by root culturing, thus preparing the seedling for overwintering, outplanting, or transplanting. (D & L, modified)

**Hardpan**: Hardened soil layer caused by cementation of soil particles with materials such as silica, sesquioxides, or calcium carbonate. The hardness does not change appreciably with changes in moisture content (compare with claypan). (D & L)

**Harvest intervals**: Period between last application of a pesticide to a crop and the harvest as permitted by law. (W)

**Herbicide**: Chemical used to kill or inhibit unwanted plants or weeds. (D & L)
their impact on hosts are considered and control methods are analyzed for their effectiveness as well as their impacts on economics, human health, and the environment. (IDT)

**Invert emulsion**: One in which the water is dispersed in oil rather than oil in water. Usually a thick, salad-dressing-like mixture results. (W)

**Kg or kilogram**: A unit of weight in the metric system equal to 2.2 pounds. (W)

**Label**: All printed material attached to or part of the pesticide container. (W)

**Labeling**: Supplemental pesticide information which complements the information on the label, but is not necessarily attached to or part of the container. (W)

**Lateral pruning**: Root-culturing technique in which blades or colters are passed between drill rows to sever long lateral roots. The purpose of lateral pruning is to facilitate lifting, stimulate root growth and fibrosity, and retard height growth (compare with box pruning). (D & L)

**LC50**: The median lethal concentration, the concentration which kills 50 percent of the test organisms, expressed as milligrams (mg), or cubic centimeters (cc), if liquid, per animal. It is also the concentration expressed as parts per million (ppm) or parts per billion (ppb) in the environment (usually water) which kills 50 percent of the test organisms exposed. (W)

**LD50**: A lethal dose for 50 percent of the test organisms. The dose of toxicant producing 50 percent mortality in a population. A value used in presenting mammalian toxicity, usually oral toxicity, expressed as milligrams of toxicant per kilogram of body weight (mg/kg). (W)

**Leaching**: Downward movement of materials in the soil solution. Soluble nutrients such as nitrate are often leached out of the seedling root zone. (D & L)

**Lifting window**: Time period of the year believed to be the best for harvesting seedlings from the seedbed, i.e., when seedlings are most resistant to handling stresses and when subsequent survival and growth potential upon outplanting are high. The lifting window will vary from year to year depending on species, variations in seed sources, and cultural regimes used before lifting. (D & L, modified)

**Lignification**: Deposition of lignin (complex aromatic compounds) in the cell walls of sclerenchyma, xylem vessels, and tracheids, making them rigid. (D & L)

**Liming**: Addition of calcium, sometimes including magnesium (dolomite), in the form of calcium carbonate, ground limestone, or hydrated lime to furnish elements for plant growth and to neutralize soil acidity. (D & L)

**Loam**: Textural class for a soil having moderate amounts of all three soil separates - sand, silt, and clay. (D & L)

**Low volume spray**: Concentrate spray, applied to uniformly cover the crop, but not as a full coverage to the point of runoff. (W)

**Margin of safety**: A margin of safety (MOS) is an arbitrary separation between the highest no-effect level of a chemical found by animal experimentation and the level of exposure estimated to be safe for humans. (O)

**mg/kg (milligrams per kilogram)**: Used to designate the amount of toxicant required per kilogram of body weight of a test organism to produce a designated effect, usually the amount necessary to kill 50 percent of the test animals. (W)

**Metabolite**: A product of metabolism. (WEB)

**Mineral soil**: Soil consisting largely of mineral matter, with organic matter usually less than 20 percent. (D & L)

**Miscible liquids**: Two or more liquids capable of being mixed in any proportions, and that will remain mixed under normal conditions. (W)

**M.L.D.**: Median lethal dose, or the LD50. (W)

**Mulch**: Layer of plant residues or other material (e.g., plastic film, paper fiber) spread upon the soil surface to protect soil, seeds, or plant roots from the effects of freezing, evaporation, crustling, weed encroachment, etc. (D & L, modified)

**Mutagen**: Substance causing genes in an organism to mutate or change. (W)

**Mycorrhiza(e)**: The biological association, usually symbiotic, between plant roots and particular fungi. (D & L)

**Narrow leaf species**: Those plants classified as Monocotyledoneae characterized by having narrow, parallel-veined leaves (compare with broadleaf species). (D & L)
Necrosis: Death of plant or animal tissue. (W)


Negligible residue: A tolerance which is set on a food or feed crop permitting an ultra-small amount of pesticide at harvest as a result of contact with the chemical. (W, modified)

N.O.E.L.: The no-observed-effect level. In a series of dose levels tested, it is the highest level at which no effect is observed. (VMT)

Nonselective pesticide: Material that is toxic to a wide range of pests or to more than one plant or animal. (D & L)

Nonvolatile: Not disposed to evaporate readily. (WEB)

Oncogenic: The property to produce tumors (not necessarily cancerous) in living tissues. (See carcinogenic). (W)

Oral toxicity: Toxicity of a compound when given by mouth. Usually expressed as number of milligrams of chemical per kilogram of body weight of animal (white rat) when given orally in a single dose that kills 50 percent of the animals. The smaller the number, the greater the toxicity. (W)

Organic matter: The complex interaction of (1) plant, animal, and microbial residues in various stages of decay, (2) humus, and (3) live organisms. Organic matter increases the buffer capacity, cation exchange capacity, and water retention of the soil and provides a substrate for microbial activity. (D & L)

Organic soil: Soil usually containing 20 percent or more organic matter. (D & L)

Organophosphate: Class of insecticides (also one or two herbicides and fungicides) derived from phosphoric acid esters, e.g., as malathion, diazinon, etc. (W)

Ornamentals: Plants, including trees, shrubs, and flowers, which function to beautify homes, gardens, and lawns; refers to stock used for landscaping rather than wildland plantings. (D & L)

Outplanting: Planting of seedlings on a forest site. (D & L)

Parasite: An organism that grows, feeds, and is sheltered on or in a different organism while contributing nothing to the survival of its host. (WEB)

Pathogen: Specific agent (usually fungus, bacterium, virus, or nematode) that can cause infectious disease. (D & L)

Pesticide: Any substance used for controlling, preventing, destroying, repelling, or mitigating any pest. Includes fungicides, herbicides, fumigants, insecticides, nematicides, rodenticides, desiccants, defoliants, plant growth regulators, etc. (W, modified)

pH: Numerical measure (negative logarithm of the hydrogen ion activity) of the acidity or alkalinity in a soil or solution. A pH reading of 7 is neutral for soils. (D & L)

Perched water table: Surface of a local zone of water saturation held above the main body of ground water by an impermeable layer, usually clay or rock, and separated from the main body of ground water by an unsaturated zone. (D & L)

Percolation rate: Downward movement of water through the soil, particularly the downward water flow in saturated or nearly saturated soil. Percolation rate is used also to calculate the internal drainage requirements of a soil. (D & L)

Perennial: Plant that continues growing from year to year. Tops may die back in winter but roots or rhizomes persist (compare with annual, biennial). (D & L)

Performance attributes: Attributes of seedling quality measured by assessing the performance of seedlings subjected to environmentally controlled test conditions, e.g., root-growth potential and frost hardness. Performance attributes reflect the sum total of material attributes. (D & L)

Permeability (soil): Soil attribute that enables water or air to move through it; determined by soil porosity. (D & L)

Persistence: The quality of an insecticide to persist as an effective residue due to its low volatility and chemical stability, e.g., certain organochlorine insecticides. (W)

Pesticide: Any substance used for controlling, preventing, destroying, repelling, or mitigating any pest. Includes fungicides, herbicides, fumigants, insecticides, nematicides, rodenticides, desiccants, defoliants, plant growth regulators, etc. (W, modified)

Pheromones: Highly potent insect sex attractants produced by the insects. For some species, laboratory-synthesized pheromones have been developed for trapping purposes. (W)

Photosynthesis: Production by plants containing chlorophyll of organic compounds from water and carbon dioxide, using energy absorbed by the chlorophyll from light. (D & L)
**Physical selectivity:** Refers to the use of broad-spectrum insecticides in such ways as to obtain selective action. This may be accomplished by timing, dosage, formulation, etc. (W)

**Physiological selectivity:** Refers to insecticides which are inherently more toxic to some insects than to others. (W)

**Phytotoxic:** Causing injury or death to plants. (D & L)

**Plant moisture stress (PMS):** Measure of plant water status; equal to the absolute value of plant water potential. PMS is an integrated index of the current moisture status of a plant, and is influenced by soil moisture status and evaporative demands of the atmosphere. (D & L)

**Plant regulator (Growth regulator):** A chemical which increases, decreases, or changes the normal growth or reproduction of a plant. (W)

**Poison:** Any chemical or agent that can cause illness or death when eaten, absorbed through the skin, or inhaled by man or animals. (W)

**Poison control center:** Information source for human and animal poisoning cases, including pesticides; usually located at major hospitals. (W)

**Pore space:** Total space not occupied by soil particles in a bulk volume of soil. (D & L)

**Porosity (soil):** Volume of total soil bulk not occupied by solid particles, expressed as a percentage. Percent porosity equals the volume of pores divided by total soil volume. (D & L)

**Postemergence:** Time period after crop plants or weeds emerge through the soil surface. (D & L)

**ppb:** Parts per billion (parts in 10-9 parts) is the number of parts of toxicant per billion parts of the substance in question. (W)

**ppm:** Parts per million (parts in 10-6 parts) is the number of parts of toxicant per million parts of the substance in question. They may include residues in soil, water, or whole animals. (W)

**Preemergence:** Time period before crop plants or weeds emerge through the soil surface. (D & L)

**Preplanting treatment:** Application of a herbicide or fertilizer, or soil tillage or other soil treatments, before a crop is planted. (D & L, modified)

**Profile (soil):** Vertical section of soil extending through all of its horizons and into the parent material. (D & L)
**Seedbed density**: Number of seedlings growing in a seedbed, expressed relative to area (e.g., number per square meter or foot) or linear measure (e.g., number per linear meter or foot). (D & L)

**Seedling**: Young tree propagated from seed. (D & L)

**Seedling quality**: Potential of a seedling to survive and grow successfully after outplanting. (D & L)

**Seedlot**: Quantity of seeds from a particular location and elevation (seed zone) which are reasonably similar or uniform in quality. The identity and integrity of each seedlot (one of the basic divisions in seedling recordkeeping) are maintained during seed storage and during the nursery production period. (D & L)

**Seed protectant**: Pesticide applied to seed before planting to protect seeds and new seedlings from diseases, insects, birds, or rodents. (D & L, modified)

**Seed zone**: Area of similar environmental conditions. Plants origination from the same seed zone are believed to be similarly adapted to the environment. (D & L)

**Selective insecticide**: One which kills selected insects, but spares many or most of the other organisms, including beneficial species, either through differential toxic action or the manner in which the insecticide is used. (W)

**Selective pesticide**: One which, while killing the pest individuals, spares much or most of the other fauna and flora, including beneficial species, either through differential toxic action or through the manner in which the pesticide is used (formulation, dosage, timing, placement, etc.). (W)

**Shippable percent**: Percentage of seedlings remaining at the end of the nursery growing period which meet certain size and form specifications (compare with tree percent, yield percent). (D & L)

**Silt**: Soil particle between 0.005 and 0.002 mm in diameter; soil textural class characterized by a predominance of silt particles. (D & L)

**Sludge**: General term for solid wastes, usually collected by sedimentation from water. Sludge is derived from many sources including agricultural wastes, brewery and canning wastes, and sewage. (D & L)

**Slurry**: Thin, watery mixture, such as liquid mud, cement, etc. Fungicides and some insecticides are applied to seeds as slurries to produce thick coating and reduce dustiness. (W)

**Soil application**: Application of pesticide made primarily to soil surface rather than to vegetation. (W)

**Saprophyte**: Organism that lives on dead or decaying organic matter. (D & L)

**Sanitation**: Removal of infested or infected plants or plant parts from the growing site to prevent spread of the pest to healthy plants. (IDT)

**Scarcification (seed)**: Process of scratching the seedcoat with abrasive material or reducing the seed coat thickness by chemical action to improve germination of seeds with hard seedcoats which are relatively impervious to water. (D & L, modified)

**Scientific name**: The one name of a plant or animal used throughout the world by scientists, and based on Latin and Greek. (W)

**Secondary pest**: A pest which usually does little if any damage but can become a serious pest under certain conditions, e.g., when insecticide applications destroy its predators and parasites. (W)

**Seedbed**: Elongated strip of prepared soil in which seeds are sown and seedlings raised. (D & L)

**Rolling**: Cultural practice used before sowing to ensure good contact between seeds and soil particles. A cylindrical roller is passed over the land to firm the soil without causing a great deal of compaction. (D & L)

**Root culture**: General term for those nursery cultural practices designed to modify seedling root growth (e.g., undercutting, trenching). (D & L)

**Rodenticide**: Pesticide applied as a bait, dust, or fumigant to destroy or repel rodents and other animals, such as moles and rabbits. (W)

**Risk characterization**: Describes the nature and magnitude of the human risk. Risk characterization uses the information gathered in other stages to represent the overall situation. The assessment of toxicity, along with levels and probability of exposure, are joined to estimate risk. (VMT)

**Risk assessment**: An analytic process that is firmly based on scientific considerations, but also requires judgements to be made when the available information is incomplete. These judgements inevitably draw on both scientific and policy considerations. (VMT)
Glossary - 21

**Soil persistence**: Length of time that a pesticide application on or in soil remains effective. (W)

**Soil test**: Chemical or physical analysis of a soil to determine texture, acidity, total salt concentration, concentration of nutrient elements, or other soil characteristics. (D & L, modified)

**Soluble powder**: A finely ground, solid material which will dissolve in water or some other liquid carrier. (W)

**Sowing**: Process of placing seeds in the seedbed at specific depth and density. (D & L)

**Spore**: A single to many-celled reproductive body in the fungi that can develop a new fungus colony. (W)

**Spot treatment**: Application to localized or restricted areas as differentiated from overall, broadcast, or complete coverage. (W)

**Spreader**: Ingredient added to spray mixture to improve contact between pesticide and plant surface. (W)

**Standard Treatment**: Treatment which simulates the operational procedures of a current practice (compare with control treatment). (D & L)

**Sterilize**: To treat with a chemical or other agent to kill every living thing in a certain area. (W)

**Sticker**: Ingredient added to spray or dust to improve its adherence to plants. (W)

**Stock type**: Seedling classification, usually by age and location in the nursery, e.g., 1 - 0, 2 - 0, etc. The first of the two digits represents the number of growing seasons spent in the seedbed, the second digit the number of growing seasons spent in a transplant bed. “1 - 0” means seedlings grown for transplanting, often under specific cultural conditions (e.g., high seedbed density). (D & L)

**Stratification (seed)**: Treatment applied before germination to overcome seed dormancy. Cold stratification consists of placing seeds in an environment of cold temperature, sufficient moisture, and oxygen for a specified time period. (D & L)

**Subsoiling**: Tillage of subsurface soil without inverting it, to break up dense soil layers that restrict water movement and root penetration (compare with ripping, chiseling). (D & L)

**Surfactant**: Chemical agents (e.g. spreaders, detergents, wetting agents) added to pesticides to make mixing easier and to assist application of a solution and adherence to the treated surface. (D & L)

Region 4 FEIS

**Suspension**: Finely divided solid particles or droplets dispersed in a liquid. (W)

**Swath**: The width of the area covered by a sprayer or duster making one sweep. (W)

**Synergism**: Increased activity resulting from the effect of one chemical on another. (W)

**Synthesize**: Production of a compound by joining various elements or simpler compounds. (W)

**Systemic**: Entering and then acting within an entire organism; used especially to describe the action of pesticides or diseases within a plant. (D & L)

**Systemic herbicide**: Herbicide which is absorbed by and then distributed within a plant, as opposed to one which functions only on contact with the plant’s surface (compare with contact herbicide). (D & L)

Region 4 FEIS

**Tank mix**: Mixture of two or more pesticides in the spray tank at time of application: Such mixture must be cleared by EPA. (W)

**Target**: The plants, animals, structures, areas, or pests to be treated with a pesticide application. (W)

**Temporary tolerance**: A tolerance established on an agricultural commodity by EPA to permit a pesticide manufacturer or his agent time, usually one year, to collect additional residue data to support a petition for a permanent tolerance; in essence, an experimental tolerance. (See tolerance). (W)

**Teratogenic**: Substance which causes physical birth defects in the offspring following exposure of the pregnant female. (W)

**Threshold level**: The pest population that triggers control action. In most cases this level is before unacceptable damage occurs. (VMT)

**Tillth**: Physical condition of soil as related to its ease of tillage, fitness as a seedbed, and impedance to seedling emergence and root growth. (D & L)

**Tolerance**: Amount of pesticide residue permitted by Federal regulation to remain on or in a crop. Expressed as parts per million (ppm). (W)

**Tolerant**: Capable of withstanding effects. (W)
Topical application: Treatment of a localized surface site such as a single leaf blade, on an insect, etc., as opposed to oral application. (W)

Top pruning: Clipping of seedling terminal leaders with a sharp blade to alter shoot:root ratio, facilitate handling, achieve uniformity in crop size, and control height growth. (D & L)

Toxic: Poisonous to living organisms. (W)

Toxicant: A poisonous substance such as the active ingredient in pesticide formulations that can injure or kill plants, animals, or microorganisms. (W)

Toxin: A naturally occurring poison produced by plants, animals, or microorganisms. Examples: poison produced by the black widow spider; venom produced by snakes; botulism toxin. (W)

Trade name (Trademark name, proprietary name, brand name): Name given a product by its manufacturer of formulator, distinguishing it as being produced or sold exclusively by that company. (W)

Translocation: Movement of compounds or elements within the cellular, tubular plumbing structures of plants. (WEB)

Transplant: Cultural practice of moving seedlings from one bed to another to promote additional growth. Also, a seedling after it has been lifted and then replanted one or more times in the nursery. (D & L)

Transplant shock: Reduced growth rate of a young tree after it has been transplanted or outplanted. (D & L)

Tree percent: Number of seedlings, irrespective of size or form, in a nursery bed at lifting compared to the number of viable seeds sown, expressed as a percentage (compare with yield percent, shipable percent). (D & L)

Ultra low volume (ULV): Sprays that are applied at 0.5 gallon or less per acre or sprays applied as the undiluted formulation. (W)

Undercutting: Root pruning in the nursery bed using a sharp blade drawn parallel to the soil surface at a regulated depth to stimulate root growth and fibrosity (compare with wrenching). (D & L)

USDA: United States Department of Agriculture

Vector: An organism, such as an insect, that transmits pathogens to plants or animals. (W)

Viability: Ability of a seed to germinate and grow under a given set of conditions; usually estimated by germination percent or other tests. (D & L)

Volatile: To vaporize. (W)

Water content (soil): Index of soil moisture status, calculated as the amount of water lost from the soil upon drying to constant weight at 105°C; usually expressed as the weight of water per unit weight of dry soil. (D & L)

Waterlogged: Saturated with water. Waterlogged soil, which may result from a high water table caused by overirrigation, seepage, or inadequate drainage, is detrimental to plant growth. (D & L)

Water table: Upper surface of the ground-water level, below which the soil is saturated with water. (D & L)

Weed: Plant growing where it is not desired. (W)

Wettable powder (WP): Powder formulation of a pesticide which contains a wetting agent so that it will readily form a suspension in water. (D & L)

Wetting agent: Compound added to a pesticide solution causing the spray droplets to spread and more thoroughly wet the leaf surface. (D & L)

Winter burn: Type of cold injury to foliage. Foliage is warmed above freezing by the winter sun during the day (even though air temperature is below freezing), then refreezes after sunset (compare with winter scald). (D & L)

Winter desication: Type of foliage injury that occurs on warm days when the ground is frozen; actually a type of physiological drought caused by excessive transpiration when frozen soils prohibit water absorption. (D & L)

Winter scald: Type of cold injury to tree bark. Bark is warmed above freezing by the winter sun during the day (even though air temperature is below freezing), then refreezes.
after sunset (compare with winter burn). (D & L)

Wrenching: Passing of an angled horizontal blade beneath the soil surface of the nursery bed at a specified depth to cut newly penetrating roots and to loosen and aerate soil. Wrenching is used to stimulate root growth and fibrosity and to regulate seedling growth (compare with undercutting). (D & L)

Y

Yield percent: Number of trees which meet a specific size criterion, regardless of form: expressed as a percentage. These seedlings may have multiple tops or damage from insects, disease, or other agents - characteristics that may make them unacceptable for shipping (compare with shippable percent, tree percent). (D & L)
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Appendix A
Public Involvement

Introduction

Public involvement was an integral part of the nursery management environmental impact statement from the early stages of preparing the DEIS (draft environmental impact statement) through the revision and the end product, this FEIS (final environmental impact statement).

According to NEPA (the National Environmental Policy Act), public issues must be addressed early in the process of preparing an EIS (environmental impact statement). We, the members of the nursery EIS team, found that the public not only told us what the issues were, but they also told us what the alternatives could be and what could be done to mitigate impacts on the environment.

We used a number of public involvement methods. Our basic technique, which fit our philosophy, was "fish bowl planning." We attempted to make our decision-making process visible to the public, to think out loud in front of everyone. We did this by first identifying all those who would or could be interested in the project. Then we sent out letters and press releases, made telephone calls, held meetings, wrote articles, produced and mailed out newsletters, and analyzed the responses we received.

The team did an initial scoping of issues and continued to process responses throughout the project. The public comments were used to help the team analyze the data, formulate, evaluate, and recommend alternatives.

Comments About the Scope of the Project

The interdisciplinary team visited Lucky Peak Nursery, near Boise, Idaho, in July 1989, to gather comments from employees, managers, nearby residents, and other interested citizens.

At the nursery we met with about 20 people: the nursery managers, permanent staff from...
Issues

Human Health

Employees are concerned about the effects of pesticides on the public and employees, especially the hazards from pesticide drift during application, and the effects specific to women. They see a need for a long-term study of the effects of pesticide exposure to nursery workers, and the need to keep records at the nursery. Exposure could include drift and residues on seedlings and equipment. Employees mentioned rock chucks as a possible cause of human health problems and suggested the need for control and proper disposal of rock chucks.

A major concern was for employee safety while using pesticides. Employees suggested training and refresher courses about safety equipment; the use, hazards, and suitability of pesticides; the disposal of pesticide containers and excess pesticides; knowledge and availability of label directions; application and handling; chemical emergency procedures; and training for non-nursery forest personnel who use the nursery pesticide storage building. Employees suggested enforcement of rules about using protective clothing and equipment.

Environmental Quality

Employees are concerned about the effects of pesticides on nursery seedlings, wildlife (deer, birds, fish), soils, and water, especially the possible effect of water runoff to the Lucky Peak Reservoir. They suggested monitoring soil and surface and ground water, for pesticide residues. They want to use pesticides that do not harm the environment.

Many employees want the sediment pond by the pesticide storage building to be cleaned out because it has smelled bad since the malathion-diesel mix used in the Forest grasshopper spray program was dumped there several years ago. They mentioned damage caused to nursery buildings caused by rock chucks digging underneath them.

A few representative comments:

"What effect does herbicide fallout (drift) have on employees?"

"Have training for employees about the different sprays."

"People should be knowledgeable about safety equipment"

"Concerned about disposal of containers, extra chemicals, and overstocking."

Economic Considerations

Employees want people to be more familiar with pesticide targets and costs; they don’t want to be forced into more expensive methods of pest control.

Suggested Alternatives

Nursery staff and employees want to see more use of pest control methods other than pesticides, for example, natural predators, other biological controls, and mechanical weeding equipment. They want the availability of all pest control tools, the flexibility to use new control methods experimentally, and a contingency plan for unusual, epidemic outbreaks. They noted the problems involved in using only one control method, such as cultural, or using chemical methods only when a crop is in jeopardy. They want to see a nationwide standardized pest monitoring plan. They question the continued use of methyl bromide + chloropicrin if dazomet is doing the job.

A few representative comments:

"Put more emphasis on biological control rather than chemical."

"Not enough importance placed on development of mechanical nursery weoders."

"Insure maximum flexibility for management objectives; need full array of tools."

Public Response to Newsletters

We mailed newsletters to nursery employees, and interested citizens and agencies in January, 1990. The mailing list included about 90 names. We presented updates on the progress of the EIS and asked for comments.
Response to January Newsletter.

About 3 percent of our readers responded - a total of three.

<table>
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<th>Categories of Respondents</th>
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<tr>
<td>State and Private Nursery</td>
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<tr>
<td>Livestock Industry</td>
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<td>Bonners Ferry</td>
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<tr>
<td>Boise</td>
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<td>Emmett</td>
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<td><strong>Total</strong></td>
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The two main topics covered by the comments we received were: (1) appreciation for our endeavors in preparing the EIS; and (2) questions about the role of private nurseries - suggestions that private nurseries could provide some or all seedlings for the Forest Service, that we do a cost analysis of private versus federal seedling production, and that we sell the nursery to the private sector.

Public Review of the Draft Environmental Impact Statement

The DEIS was issued in October of 1991. The 45-day public review period began when the Notice of Availability was published in the Federal Register.

The review period ran from October 26, 1991 to December 9, 1991. During this time we received six responses, in the form of letters. Following is a breakdown of the respondents and their geographic distribution:

| Agencies                  | 5      |
| Individual                | 1      |
| **Total**                 | **6**  |

Since response to the release of the DEIS was rather limited, the comment letters were reviewed in their entirety by all of the core IDT members. Substantive comments and suggestions were considered during preparation of the FEIS. Several changes were incorporated into the FEIS as a direct result of the reviewer comments. Following are copies of the letters of review received during the public comment period and our responses:

1. Houzt Farms                | No Response Necessary
2. US Department of Transportation | No Response Necessary
3. US Environmental Protection Agency | Response Included
4. US Department of Interior | Response Included
5. Department of Health and Human Services | No Response Necessary
6. US Soil Conservation Service | Response Included
Letter #1

Lucky Peak Nursery Pest Management Draft Environmental Impact Statement

What do you think?

Please let us know by December 9, 1991. Thank you.

Do you agree with the preferred alternative? Yes
Why or why not? This being an extension of the present plan which the appraoch adequate will make the existing environmental problems simpler. These problems will become more pressing and there will be increasing pressure by pressure on the group. These operations occur to the present situation. This would take advantage of the lack of trained experienced personnel who have the overall training problems to learn comprehensive techniques.

Alternative I prefer Alternative 1 because:

all information computerized. This would simplify the way to make operations and any future needs unchanged which the procedures or related agencies may be necessary and when it would be a question line up a great task in the past.

Letter #2

U.S. Department of Transportation
Office of the Secretary of Transportation

Ms. Sally Campbell
Nursery Environmental Impact Statement Team Leader
USDA Forest Service Pacific Northwest Region
319 SW Pine, P.O. Box 3423
Portland, OR 97208

Dear Ms. Campbell:

This office has reviewed the draft Environmental Impact Statement (EIS) for Nursery Pest Management at the Lucky Peak Nursery, Boise National Forest, Idaho. We have no comments.

We appreciate the opportunity to review this draft EIS.

Sincerely,

Eugene L. Lehr, Chief
Environmental Division

No comments
The Environmental Protection Agency (EPA) has reviewed the above referenced Draft Environmental Impact Statement (DEIS). Our review is conducted in accordance with the National Environmental Policy Act (NEPA), and EPA’s authorization under Section 309 of the Clean Air Act to determine whether the overall impacts associated with federally authorized actions are acceptable in terms of environmental quality, public health, and welfare.

In the DEIS the Forest Service has presented three alternative ways of managing pests (weeds, diseases, animals) at the Lucky Peak Nursery. Alternative C - "Integrated Pest Management" is identified as the Forest Service’s preferred alternative.

We have rated the DEIS EC-2 (Environmental Concerns - Insufficient Information). A summary of the EPA rating system for DEIS is enclosed for your reference. We have concerns regarding the potential for surface and ground water chemical contamination, and surface water eutrophication. We have requested additional information pertaining to ground water characteristics, the potential for contamination of wells, planned pest management practices which would prevent the leaching of agricultural chemicals into the ground water, and impacts to surface water and aquatic resources. Our specific comments on the DEIS which address these concerns and the need for additional information are attached. A summary of our comments will be published in the Federal Register.

Thank you for the opportunity to review the DEIS. We would be pleased to provide assistance in addressing our comments.

Sincerely,

Ronald A. Lee, Chief
Environmental Evaluation Branch

Appendix A - 9
The DEIS is heavily focused on pesticides, and their risks to human health, as the key variables in the different pest control practices discussed. In contrast, the use of fertilizers and their probable ecological impacts are issues which are only lightly touched upon. Although the DEIS does allude to their use in some sections, (e.g., on Page III-3), where it mentions that the nursery applies fertilizers in split applications, so that they are not leached below the rooting zone, of the soil with this material, it will not readily dissipate. There are documented instances of human illness and livestock deaths in Idaho from the use of methyl bromide as a soil fumigant, largely due to the tendency of the gas to remain in the air mass in low-lying areas next to the ground during air mass inversions.

Threshold Levels

Integrated pest management (IPM) is generally recognized as a sensible decision-making approach. An important step in IPM is determining whether an action threshold of a pest infestation has been exceeded. It is not clear whether "action thresholds" have been established for the pests that are expected in the nursery.
Environmental Consequences, Human Health Impacts section of the risks to people who drink contaminated water from on-site wells. This information should be provided in the FEIS.

Pg. D-2-7: Table D-2-7 compares acute toxicities of the various pesticides with household items like sugar, table salt, and caffeine. The specific circumstances under which the doses of the substances being compared are administered vary, thus negating direct comparisons. This table should be explained in more detail, to avoid generating misunderstandings (e.g., benzoil is one third as safe as sugar, etc.) by the lay public.

Pg. D-2-18: Again, as in comment above, simplistic toxicity comparisons are given with no discussions about dose, route, dilution, vehicle, surfactant, etc. For instance, Glyphosate is described as "less irritating than a standard liquid dishwashing detergent and a general all-purpose cleaner".

Pg. D-2-34: The descriptions of human toxicity for methyl bromide should include pulmonary edema as a primary endpoint (this is discussed briefly in terms of animal studies on the next page). The statistical quote from USDA documenting numerous poisonings from methyl bromide is very worthwhile. Additional available documentation would also provide a wealth of poisoning information which could complement this USDA observation.

Pg. D-3-10: Without obtaining monitoring data to help verify the numbers obtained for the specific sites at hand, the use of predictive models such as LEACH and CLEAN to assess the possible movement of agricultural chemicals does not provide such reliability. The inherent weakness of the models needs to be explained, as does the need for monitoring data to verify these predictions.

Pg. D-3-12: Table D-3-1 (see footnote a) tends to minimize the need to model methyl bromide and chloropicrin because of their rapid volatility. These are toxic compounds, and their risks are not sufficiently disclosed by such an approach. See previous comment pertaining to the persistence of these compounds in soil, air, and ground water.

Pg. D-4-18, through D-4-24: Non-cancer risks for the various non-fumigant pesticides were based on NOELs, but for the fumigants the DEIS does not use NOEL values, instead basing the risk on TLVs. This tends to create an "apples and oranges" situation in terms of introducing more variability, and therefore probably uncertainty, into the risk calculations for pesticides as a group. TLVs are designed for workplace guidelines, and are for an eight hour exposure period. However, it would be preferable to just rely on a uniform data base (e.g. IRIS, OPP registration data, whatever) and calculate from the appropriate NOELs or LOELs in the same fashion as the other pesticides evaluated in this document.

More specifically, for these soil fumigants, inhalation is not the only exposure route which needs to be taken into consideration. Possible oral and dermal exposure, as well as inhalation of soil particulates should be addressed. Where possible, risk should be calculated by using standard NOELS, LOELS, inhalation and oral RFDs, and not from the TLVs. There are also other considerations, such as soil-to-air volatilization factor, and soil particulate emission factor. For specific guidelines in calculating risks from volatile contaminants in soil, please refer to EPA Publication No. 9285.7-01B, "Risk Assessment Guidance for Superfund: Volume 1- Human Health Evaluation Manual, Part B, Development of Risk-Based Preliminary Remediation Goals", published by the U.S. EPA Office of Emergency and Remedial Response, Washington, D.C., 20460.

Pg. E-5: See previous comments regarding the leaching of methyl bromide and chloropicrin.
Comment: The DEIS is heavily focused on pesticides, and their risks to human health, as the key variables in the different pest control practices discussed. In contrast, the use of fertilizers and their probable ecological impacts are issues which are only lightly touched upon. Although the DEIS does allude to their use in some sections, (e.g., on Page III-3, where it mentions that the nursery applies fertilizers in split applications, so that they are not leached below the rooting zone, and on III-20 which mentions nitrogen and phosphorous quantities used per acre) little is said about their possible impacts on water quality.

Response: The heavy focus on pesticides is due to the purpose of the Environmental Impact Statement which is to analyze ways to manage pests at the Lucky Peak Nursery and to respond to concerns about the use of pesticides. However, we are aware of the water quality impacts associated with the use of fertilizers, soil amendments, etc. and considered them when designing the soil and water monitoring program. In 1989 lysimeters were installed to monitor the movement of nitrates and several pesticides in the soil. The information from the monitoring is used by the nursery manager to modify cultural practices as reflected in the split applications of fertilizers mentioned above.

Response: The DEIS is greatly focused on pesticides, and their risks to human health, as the key variables in the different pest control practices discussed. In contrast, the use of fertilizers and their probable ecological impacts are issues which are only lightly touched upon. Although the DEIS does allude to their use in some sections, (e.g., on Page III-3, where it mentions that the nursery applies fertilizers in split applications, so that they are not leached below the rooting zone, and on III-20 which mentions nitrogen and phosphorous quantities used per acre) little is said about their possible impacts on water quality.

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Comment: We suggest that a subsection be added to the FEIS which is devoted to the issue of eutrophication as a consequence of fertilizer use, especially since the nursery is located in such close proximity to Highland Valley Creek, Lucky Peak Reservoir, and Moree Creek. The consequences of using soil amendments (e.g., whether any of the new polymers type amendment would be) should also be more thoroughly addressed.

Response: Our focus on the EIS is management of pest control, therefore we have decided not to add this subsection but will address your concerns here.

Eutrophication in Lucky Peak Lake, which includes the Moree Creek arm of the reservoir, and Highland Valley Creek is not likely for the following reasons.

The point of the nursery nearest to the edge of the cliffs above the lake is approximately 300 feet. Currently, runoff from the fields drain into holding ponds which catch runoff from the fields and hold it in place until it evaporates or soaks in. A wildlife habitat/natural filtration system is currently in the planning stage. When completed it will process field runoff through a five stage natural filtration system. Field runoff is no longer channeled into Highland Valley Creek. Runoff from Highland Valley

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Creek was most recently sampled in 1993. The creek was sampled below the nursery complex (near the bridge on the "nature trail" and above the trailers). The water samples were analyzed for trace amounts of glyphosate, benomyl, bifencarb, and metalaxyl. None were detected.

The total annual use of fertilizers is about 14 tons consisting of 26,000 pounds of 34-0-0 nitrogen product and 3000 pounds of 0-45-0 phosphorus material. Approximately 40 tons per acre of wet sawdust (two inch application) is used as a soil amendment. The use of a polymer (Hydrosource) has been tested on two small plots within the nursery bed and on a small plot (outside the fence). Eutrophication is unlikely given the volume of Lucky Peak Reservoir (approximately 9.4 billion gallons), the inflow/outflow of the Reservoir, and internal water turnover.

Comment: More discussions should be provided on ecological risk, particularly the possible effects of pest management practices on aquatic life in the Lucky Peak ecosystem which might utilize either of the two nearby tributaries for reproductive or rearing areas.

Response: For the purpose of this EIS, we feel that the discussions in Chapter IV about consequences to the various parts of the environment, including the section "Impacts on Fisheries," responds adequately to this concern.

Comment: The DEIS does not sufficiently address the characteristics of methyl bromide in terms of its potential persistence in soils and migration into ground and surface water. Methyl bromide is three times heavier than air, and when one saturates the top portion of the soil with this material, it will not readily dissipate. There are documented instances of human illness and livestock deaths in Idaho from the use of methyl bromide as a soil fumigant, largely due to the tendency of the gas to remain in the air mass in low-lying areas next to the ground during air mass invasions.

Response: The FEIS provides what information there is about the characteristics of methyl bromide and chloropicrin, see the Risk Assessment Appendix, page 0-1-23. This information is reiterated in discussions and tables in various parts of the document. We agree that there is a potential for human health effects from the use of this pesticide; however, the mitigation measures described in Chapter II were designed to offset that potential.

In addition, the nursery uses amounts toward the lower end of the recommended usage rates which will not saturate the soil. Lucky Peak Nursery is located on a high windy plateau, where methyl bromide is unlikely to settle, and away from any areas inhabited by either livestock or humans.

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Response: To the best of our knowledge there is no groundwater user downgradient from the nursery. The nursery occupies a position at the edge of an old terrace that slopes directly into the reservoir. Any spills will be handled according to Forest Service Handbook 2109.14 (draft) "Pesticide Use Management and Coordination" which requires notification of various parties in the event of a spill.

Comment: Pg. III-5: As pertains to wells, the FEIS should provide a diagram of well logs, including construction specifics, water levels, screens, etc. It is not possible to tell from the information provided whether the wells are vulnerable. Is the water quality of the wells known, and what was the results of previous sampling.

The FEIS should discuss the vulnerability of groundwater and wells to pesticides. Describe whether there are confining or nonconfining groundwater conditions.

Response: We have included the well logs and a discussion in Appendix E (Monitoring) and referenced it on Page III-5. All of the wells on the nursery were analyzed in 1993. Analyses were performed to detect the presence of glyphosate, benomyl, bifencox, and metalaxyl. None were detected.

Comment: Pg. IV-4: Table IV-1, the leaching potential of methyl bromide and chloropirin is described as "low," however is more accurately described as "moderate." Any volatile fumigant combination which is injected in soil should be expected to pose problems under worst case situations of temperature, moisture, etc. Other fumigants such as dichloropropane/dichloropropene mixture have been found in soils and ground water in such areas as Washington's Skagit Valley, even when allegedly applied under conditions of EPA label compliance.

Response: We feel that the leaching potential would be low because of the conditions at the nursery (see response to persistence comment above), the volatility of methyl bromide/chloropirin, and the method and timing of application. CLEAMS modeling indicates that methyl bromide at Lucky Peak would not leach to groundwater or runoff to surface water. Some research shows that methyl bromide has a short persistence in soil but would leach if sufficient water was applied.

Methyl bromide and chloropirin are generally applied in September when rainfall is typically less than an inch and high soil temperatures help to volatilize the fumigant. After application, plastic sheeting remains in place for two to four days and prevents any rainfall from contributing to leaching. No irrigation water is applied until springtime after sowing and germination.

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Comment: Pg. IV-29 through IV-57: There is no mention in the Environmental Consequences, Human Health Impact section of the risks to people who drink contaminated water from on-site wells. This information should be provided in the EIS.

Response: Potable water supplies for nursery facilities and housing all come from one well. There is no indication of well contamination, and it is unlikely because of the location of the domestic well relative to the fields. Several pesticides were analyzed for presence in this well in 1993. None were detected. Because of this and because the potential presence of pesticides in runoff surface water far exceeds any in water leachate, risks from drinking contaminated groundwater were not quantified.

Comment: Pg. D-2-7: Table D-2-7 compares acute toxicities of the various pesticides with household items like sugar, table salt, and caffeine. The specific circumstances under which the doses of the substances being compared are administered varies, thus negating direct comparisons. This table should be explained in more detail, to avoid generating misunderstanding (e.g., benomyl is one third as safe as sugar, etc.) by the lay public.

Response: All toxicity values presented in this table are oral LD_50 values for rats. An additional footnote has been added to this table stating that acute oral toxicity is only one indicator of a substance's relative hazard, and referring the reader to the test for a more complete characterization of the toxicity of the nursery pesticides, including chronic toxicity endpoints.

Comment: Pg. D-2-18: Again, as in comment above, simplistic toxicity comparisons are given with no discussions about dose, route, dilution, vehicle, surfactant, etc. For instance, Glyphosate is described as "less irritating than a standard liquid dishwashing detergent and a general all-purpose cleaner."

Response: This statement has been deleted.

Comment: Pg. D-2-34: The description of human toxicity for methyl bromide should include pulmonary edema as a primary endpoint (this is discussed briefly in terms of animal studies on the next page). The statistical quote from USDA documenting numerous poisonings from methyl bromide is very worthwhile. Additional available documentation would also provide a wealth of poisoning information which could complement his USDA observation.

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Response: Pulmonary edema has been added to the human toxicity section as a toxicity endpoint in response to this comment. The summary information provided regarding poisonings due to methyl bromide is considered sufficient for the purpose of this NEPA assessment.

Comment: Pg. D-3-10: Without obtaining monitoring data to help verify the numbers obtained for the specific sites at hand, the use of predictive models such as LEACH and GLEAMS to assess the possible movement of agriculture chemicals does not provide much reliability. The inherent weakness of the models needs to be explained, as does the need for monitoring data to verify these predictions.

Response: In the absence of sampling results for surface and groundwater, the results from the LEACH and GLEAMS models provide an estimate of runoff and groundwater contamination at the Lucky Peak Nursery. We recognize that monitoring data would help verify numbers from the LEACH and GLEAMS models, and look to the use of lysimeters to provide this backup. However, thus far, we have only obtained a small amount of data which is confusing and inconclusive. High levels of nitrate nitrogen have shown up which are inconsistent with the amount of fertilizer applied at the nursery, and virtually no pesticides have been detected except for chlorothalonil which is not used at the nursery. This suggests that contamination from an offshore source is interfering with the sampling procedure; we are currently investigating this problem. However, the lysimeters are installed at all of the Forest Service nurseries, and we are finding that nurseries which could not be affected by upstream influence due to their high locations have no to very low readings of nitrates and pesticides. Efforts to gather reliable data via monitoring will continue.

Modeling limitations are explained in the Risk Assessment on page D-3-13. An additional statement about verification of the GLEAMS and LEACH Modeling results have been added in the Monitoring Appendix, page E-2.

Comment: Pg. D-3-12: Table D-3-3 (see footnote a) tends to minimize the need to model methyl bromide and chloropicrin because of their rapid volatility. These are toxic compounds, and their risks are not sufficiently disclosed by such an approach. See previous comment pertaining to the persistence of these compounds in soil, air, and ground water.

Response: In a summary of the GLEAMS modeling results for the nursery pesticides, Table D-3-6a shows no measurable fraction of applied methyl bromide would leave the field in runoff or leachate. A literature review of the fate of methyl bromide, summarized in Section D-3, indicated that it has little persistence in soil. See also previous response.

Comment: Pg. E-5: See previous comments regarding the leaching of methyl bromide and chloropicrin.

Response: Answered above.
Dear Mr. Rittersbacher:

The Department of the Interior has reviewed the Draft Environmental Impact Statement (DEIS) for the Lucky Peak Nursery Pest Management Program for the Boise National Forest. The following comments are provided for your use and information when preparing the final documents.

GENERAL COMMENTS

The U.S. Fish and Wildlife Service (FWS) supports the proposed Alternative C for Integrated Pest Management (IPM). This alternative involves a formal review of decision-making and proposed monitoring activities and emphasizes biological and/or cultural control methods. Adoption of the IPM alternative would comply with provisions of 36 CFR 119.27, which require the use of IPM practices on Forest Service lands.

SPECIFIC COMMENTS

Appendix E: Human Health and Environmental Monitoring. Overall, the environmental monitoring program needs to adequately address the issue of bioaccumulation in the food chain. While many of the chemical pesticides used at the nursery show varying degrees of toxicity to fish and wildlife, their accumulation in the food chain needs to be adequately discussed. Specific monitoring plans should be established in the final document to sample pesticide accumulation in wildlife. The FWS suggests including analyzing local salmon populations.

The FWS suggests adding the following parameters and collection sites to the monitoring plans:

- Parameters: dissolved oxygen, pH levels, ammonia, conductivity, and organic and inorganic analysis in sediment and macroinvertebrates.

- Collection sites: upstream of the nursery for comparison, within each drainage system at each drainage outlet, i.e. ponds, and at the reservoir.

Appendix E.3: Soil Monitoring Guidelines. Number 1. The FWS recommends that a more rigorous approach would be incorporated into the monitoring plan after each application to establish the necessary baseline information. After the proposed two-year duration, a permanent monitoring plan may be developed which could be less rigorous but more informative on the effects of application.

Appendix E.3.1: Other recommended monitoring. A statement of the parameters and an analysis of cumulative impacts from combined uses of pesticides, insecticides, and fertilizers should be provided in the final document. The FWS recommends that the parameters selected for the monitoring plan would incorporate as many potential combinations of parameters as possible.

Appendix E.3.2: Tables E.1: The FWS recommends that the lysimeter monitoring include all pesticides with leaching and surface runoff potential, including metalaxyl and napropamide.

SUMMARY COMMENTS

We recommend adoption of Alternative C - Integrated Pest Management which would emphasize biological and/or cultural control methods.

We appreciate the opportunity to comment.

Sincerely,

Charles P. Polixyka
Regional Environmental Officer
Responses to FWS Comments
Draft Environmental Impact Statement
Nursery Pest Management in the Intermountain Region

Comment: Appendix E: Human and Environmental Monitoring: Overall, the environmental monitoring program needs to adequately address the issue of bioaccumulation in the food system. While many of the chemical pesticides used at the nursery show varying degrees of toxicity to fish and wildlife, their monitoring plans should be included in the final document to sample pesticide accumulation in wildlife. The FWS suggests including analyzing local rodent populations.

The FWS suggests adding the following parameters and collection sites to the monitoring plans:

Parameters: dissolved oxygen, pH levels, ammonia, conductivity, and organic and inorganic analysis in sediment and macroinvertebrates.

Collection sites: upstream of the nursery for comparison, within each drainage system, at each drainage outlet, e.g. ponds, and at the reservoir.

Response: Thank you for bringing this to our attention. We have included animal monitoring guidelines in Chapter II. In the Draft EIS we cited Forest Service Handbook 2109.11 as a primary source of direction for our pesticide planning and implementation programs. The cited text was incorrect and has changed with the issuance of a new draft version of FSH 2109.14. We have included Chapter 6 (Quality Control Monitoring and Post-Treatment Evaluation) of this handbook in Appendix E. This handbook provides much of the guidance for development of our monitoring plans.

Comment: Appendix E-1 - Soil Monitoring Guidelines - Number 2: The FWS recommends that a more rigorous approach be incorporated into the monitoring plan after each application to establish the necessary baseline information. After the proposed two year duration, a permanent monitoring plan may be developed which could be less rigorous but more informative on the effects of application.

Response: The soil monitoring plan will be developed following selection of a preferred alternative by the responsible official. Your recommendation for a "rigorous approach" to monitoring after each application will be considered at that time. The plan will be developed by the Forest soil scientist, hydrologist and nursery manager. Much of their plan will be based on direction in the Forest Service Handbook cited above.

Comment: Appendix E-2 - Other recommended monitoring: A statement of the parameters and an analysis of cumulative impacts from combined uses of pesticides, insecticides, and fertilizers should be provided in the final document. The FWS recommends that the parameters selected for the monitoring plan would incorporate as many potential combinations of parameters as possible.

Response: Cumulative effects of the Preferred Alternative have already been estimated. Because monitoring plans have not yet been developed, or implemented, the cumulative effects analysis is based largely upon what we know about the behavior of the chemicals in the soil, water and air components of the environment. Much of this subjective analysis is supported by research and the professional experience of our team members and consultants. Since the monitoring plan is not yet prepared, we cannot use site-specific data acquired through monitoring to assess cumulative impacts. The Cumulative Effects are documented in Chapter IV.

Comment: Appendix E-4 - Tables E-1: The FWS recommends that the lysimeter monitoring include all pesticides with leaching and surface runoff potential, including metalaxyl and napropamide.

Response: Thank you for calling our attention to this. Table E-1 identifies benomyl and DCPA as "being tested in the lysimeter sampling". This represents the current situation. In the "Nursery Specific Monitoring" section (Appendix E-3), we have corrected our list of chemical pesticides recommended for analysis in the lysimeter monitoring program. It is our recommendation that benomyl, DCPA, metalaxyl and napropamide be included in the monitoring plan to be developed during implementation.
Mr. Dave Rittersbacher  
Forest Supervisor  
Sierra National Forests  
1150 Front Street  
Boise, Idaho  

Dear Mr. Rittersbacher:

We have reviewed the Draft Environmental Impact Statement (DEIS) for Nursery Pest Management, Intermountain Region. We are responding on behalf of the U.S. Public Health Service.

We have completed our review of the Draft Environmental Impact Statement (DEIS) for Nursery Pest Management, Intermountain Region. We are responding on behalf of the U.S. Public Health Service.

Because there will always be some risks to nursery workers, especially when pesticides are used, we agree that pesticides should be de-emphasized whenever possible when alternate methods with fewer environmental and human risks can be employed. A well-trained, safety-aware workforce should help ensure that risks are minimized, and appropriate and effective mitigation measures are implemented, monitored, and modified as necessary.

Thank you for the opportunity to review and comment on this document. Please ensure that we are included on your mailing list to receive a copy of the Final EIS, and future EIS's which may indicate potential public health impact and are developed under the National Environmental Policy Act (NEPA).

Sincerely yours,

Kenneth W. Holt, M.S.E.H.  
Special Programs Group (F29)  
National Center for Environmental Health and Injury Control

Dear Mr. Mealey:

Following are comments on subject draft environmental impact statement:

1. Idaho SCS agrees with the selected alternative. This provides the best flexibility and control and will be the most effective and safe in the long term.

2. Idaho SCS operates the Aberdeen Plant Materials Center, (PMC) at Aberdeen, Idaho. At this farm, we have a number of off-center testing areas that include some woody testing plots. Listed below are some practices that we have found useful in pest management that should be considered under "other Cultural Controls," page III 20 and under "Animals," page III 25.

a. Aberdeen PMC extensively uses perennial, perennial cover crops on odd areas, road shoulders, down the irrigation mainline, and between shrub and tree rows. A variety of perennial grasses are used that will compete well with weeds and reduce weed populations, thus reducing herbicide need. Where we have a choice, we use a relatively low-growing grass to reduce mowing needs also. Down the main line, we use tall fescue. There is considerable truck traffic down the line to change and maintain lines. Tall fescue can withstand this use quite well. There are newer cultivars of tall fescue (turf type) that are lower growing with finer leaves.

In tree/shrub rows that are sprinkler irrigated, we use red fescue as cover crop. Red fescue is a
relatively low growing, fine leaved, competitive plant. It can withstand poorly drained soils, and grows well in open sunlight to almost full shade. It competes very well with many weeds.

In tree/shrub rows that are drip irrigated, we use Cover sheep fescue, (you may also be able to use Durar hard fescue in your precipitation zone). Drip irrigation in itself reduces weeds because less area receives water. Covar and Durar are both very competitive with weeds, low growing, fine leaved, bunchgrass.

In open ditches, we use both red fescue and tall fescue.

Road shoulders are seeded to red fescue, tall fescue, or Covar sheep fescue depending on the moisture situation.

We use drip irrigation where we can for trees/shrubs. This reduces weed populations.

We keep idle ground in perennial, competitive, bunchgrass until needed for testing or production. We try to keep bare or fallow ground to a minimum.

We use crop rotations to help reduce weeds and diseases. We have experimented with using a number of annual cover crops to reduce weeds by competition and/or shading; winter rape, radish beans, Aroostock cereal rye, buckwheat, sunflowers, and others. Corn and potatoes also are used under a cooperative agreement with the University of Idaho, Agricultural Experiment Station.

We have practiced reduced tillage and no-till where possible. This reduces soil surface disturbance, thus "planting" less weed seed.

At a number of locations, we have erected several raptor poles for raptors to perch on to search for food. This gives us some long-term and continuing control of many rodents.
Comment: Idaho SCS operates the Aberdeen Plant Materials Center, (PMC) at Aberdeen, Idaho. At this farm, we have a number of off-center testing areas that include some woody testing plots. Listed below [Refer to latter] are some practices that we have found useful in pest management that should be considered under "other Cultural Controls", page 331-20 and under "Animals" page 331-25.

Response: Thank you for sharing some of the cultural practices in use at the Aberdeen Plant Materials Center. Some of these practices and the principles behind them are similar to some we currently utilize, though not specifically mentioned in the EIS. Your suggestions have been forwarded to the nursery manager.
Appendix B
Pest Control Methods

A tree nursery is an intensive agricultural operation whose goal is to grow large numbers of quality seedlings cost-effectively. Plants and animals that interfere with that goal are considered to be pests. Pests are typically divided into four categories: diseases, insects, weeds and animals.

Three types of control methods are available to the nursery manager:

**biological** - A biological control method is the deliberate use of natural enemies such as predators, parasites, and diseases to control nursery pests. In the Lucky Peak Nursery, biological controls are still considered experimental.

**chemical** - Four categories of chemical pesticides are used in the nurseries:

- herbicides are used to control weeds
- fungicides are used to control diseases caused by fungi
- insecticides are used to control insects
- fumigants are used to control weeds, insects, and diseases

**cultural** - The use of certain nursery practices (such as weed control, improving drainage, and adding soil amendments) to make the habitat less favorable for unwanted insects, weeds, diseases, and animals, or to prevent, suppress, or remove them. Manual and mechanical methods are part of cultural controls.

A combination of chemical and cultural methods is currently used to control pests in the Lucky Peak Nursery.

Pest control is a complicated process. The nursery manager must first decide if a pest problem is severe enough to warrant treatment, and if so, what the best control method is.

In addition to simply controlling pests, a nursery manager will sow more seed than is necessary to compensate for losses from pests. This is called over-sowing. The nursery manager must carefully balance between expected losses from pests and the amount to oversow, in order to meet seedling orders while producing seedlings cost-effectively.

### Biological Controls

While biological controls for some weeds exist (cinnabar moth on tansy, for example) none has been tested at Lucky Peak Nursery because nursery weed and insect populations are not large enough to support predacious insect populations.

### Chemical Controls

Chemical pesticides have been an important pest control tool in the Lucky Peak Nursery. The use of chemical pesticides has also been controversial in the Intermountain Region.

Five chemical pesticides, including one herbicide, two fungicides, and two fumigants are currently being used or are being considered for use in the Lucky Peak Nursery. Presently, the fumigants dazomet and methyl bromide + chloropicrin comprise ninety-seven percent of the chemical pesticide use in the nursery, based on pounds per acre of active ingredient applied. (See Chapter 3, Table III-1 for annual chemical pesticide use at the nursery.)

The following chemical pesticides are used at the Lucky Peak Nursery and are described in this section:

#### Herbicide

- DCPA
- Glyphosate
- Naptropanide
- Oxylthorfen

#### Fungicides

- Benomyl
- Metalaxyl

#### Fumigants

- Dazomet
- Methyl bromide + chloropicrin
**Herbicides**

**DCPA**

**Trade Name:** Dacthal®

**Chemical Name:** dimethyl 2,3,5,6-tetrachloro-1, 4-benzenedicarboxylate (DCPA)

**Use Pattern:** DCPA is a selective preemergence herbicide belonging to a broad class of benzoic acid herbicides. In Forest Service nurseries it is used for weed control in all types of nursery stock.

DCPA is widely used in agricultural crops, by lawn-care services on turf, golf course fairways, and in homeowner applications. In nursery use it is generally applied from April to August.

**Application Methods and Mode of Action:** DCPA must be placed on top of soil before the weed seed germinates. It kills germinating seeds but has little effect in postemergence applications. It kills germinating seeds but has little effect in postemergence applications. Moisture is necessary to initiate the herbicidal activity of DCPA. Therefore, irrigation must be applied if rain does not occur within a few days of application.

Granular, wettable powder, and flowable formulations are available. Standard ground spray or boom-type sprayers are normally recommended. Rates of 9.1 to 10.5 pounds of active ingredient per acre are normally used in nursery applications.

**Target Vegetation:** DCPA controls a wide range of grasses and many broadleaved weeds (cheeseweed, fallaric, lambquarters, pigweed, purslane, etc.). Season-long control can be expected.

**Potential Non-target Effect or Use Limitation:** DCPA should be applied to mineral soils. Application rate must be adjusted according to soil type, with rates increasing with clay content and percent organic matter.

**Soil Effects:** DCPA has a moderate adsorption capability to soil particles. It has a low to moderate rate of decomposition by soil organisms and a low to moderate rate of chemical decomposition. Its soil half life varies from about two to six months; it is moderately persistent in soils. Where surface erosion occurs, DCPA, as well as the contaminant HCB (metabolites resulting from reactions between the pesticide and the soil), may be carried into drainage systems.

**Wildlife Effects:** HCB shows systemic effects at low levels of exposure; there is some evidence that HCB can accumulate in the food chain.

**Human Health Effects:** See Appendix D for detailed human health information.

**Glyphosate**

**Trade Name:** Roundup®, Rodeo®

**Chemical Name:** N-(phosphonomethyl) glycine

**Use Pattern:** Glyphosate has had moderate use in the nursery program, and is regularly used in silvicultural, roadside maintenance, noxious weed control, and facilities maintenance. It is considered a broad spectrum, relatively non-selective, herbicide. It is heavily used in agriculture and industrial situations, as well as for forestry. The ability of glyphosate to control herbaceous vegetation, as well as shrubs, is an advantage in some situations.

**Application Methods and Mode of Action:** Glyphosate is absorbed primarily through plant foliage. The specific mode of action is not entirely clear, but it appears to inhibit plant elongation, inhibit synthesis of essential amino acids, and to disrupt the photosynthetic process.

In nursery use, glyphosate (as Roundup) is applied by standard ground application methods. Typical rates in Lucky Peak Nursery have been 0.1 pounds of active ingredient per acre.

**Target Vegetation:** Glyphosate effectively controls many sedges, annual and perennial grasses, and broadleaved weeds. It has also shown good results with the woody brush. It appears to be a good inhibitor of vegetative sprouting. However, evergreen shrubs and hardwoods are not affected.

**Potential Non-Target Effect or Use Limitation:** Initial activity is fairly slow after application and may not be observed for several days. Visible effects are a gradual wilting and yellowing of foliage.

**Soil Effects:** Glyphosate has a very high soil adsorption capacity. It is stable and resistant to chemical degradation; it has a moderately high rate of degradation by soil organisms.

**Wildlife Effects:** Low toxicity to birds; no bioaccumulation is known to occur.

**Human Health Effects:** See Appendix D for detailed human health information.
Napropamide

**Trade Name:** Devrinol®

**Chemical Name:** 2-(a-naphtoxy)-N,N-diethylpropionamide

**Use Pattern:** Napropamide is applied as a selective herbicide to control most annual grasses and many annual broadleaf weeds. It is registered for nursery use on Douglas-fir, true firs, spruces, and pines.

**Application Method and Mode of Action:** Napropamide is absorbed quickly by plants, particularly by plant roots. It is nonvolatile, but will photodegrade in intense sunlight on leaf or soil surfaces. It is relatively nonpersistent in the environment, with a half-life that ranges from 2 months to less than one year.

Napropamide is applied as a wettable powder or granular formulation. It is incorporated into the soil either by tilling or irrigation if rainfall does not follow application. Typical nursery application rate is 1.5 pounds of active ingredient per acre.

**Target Pests:** Annual grasses and broadleaf weeds.

**Potential Non-Target Effects or Use Limitations:** Napropamide has low volatility and can be absorbed somewhat by foliage, although it is normally applied to the soil. It is not recommended for use in soils with more than 10% organic matter.

**Soil Effects:** Volatilization of napropamide from the soil surface is negligible; however, under conditions of high sunlight intensity, some photodegradation can occur. Napropamide incorporated into the soil is more persistent. Under the conditions that are most likely to occur in agriculture or nursery use, the half-life ranges from 34 to 200 days.

**Wildlife Effects:** Napropamide has a low toxicity to wildlife and fish.

**Human Health Effects:** See Appendix D for detailed human health information.

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Oxyfluorfen

**Trade name:** Goal®

**Chemical Name:** 2-chloro-1(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl) benzene

**Use Pattern:** Oxyfluorfen is registered for use on conifer seedbeds as a preemergence spray, or as a postemergence spray after seedlings are at least 5 weeks old. It is also used to control weeds in conifer transplants. Oxyfluorfen is a dephenyl ether compound which has a number of uses in agricultural applications.

**Application Method and Mode of Action:** Weeds are killed as they come in contact with the material during emergence. Following application, the beds should be sprinkle-irrigated with 1/2 to 3/4 of an inch of water. Oxyfluorfen can be absorbed by the roots or the foliage of plants, but the proportion translocated is very low.

The emulsifiable concentrate formulation is commonly diluted with 20 gallons of water carrier per acre, and applied with pressurized ground application equipment. The soil surface should not be disturbed once the application has been made. Preemergence applications are generally made at rates of 0.25 to 1.0 pound active ingredient per acre, and postemergence at .25 to 0.5 pound active ingredient per acre. Two or three postemergence applications may be necessary.

**Target Pests:** Oxyfluorfen controls a variety of grasses and broadleaf weed species. It is normally more effective on the broadleaved weeds than on grasses.

**Potential Non-Target Effect or Use Limitation:** Oxyfluorfen is a contact herbicide that requires light for its herbicidal action. Injury to leaves and shoots is much greater than is injury to roots.

**Soil Effects:** Oxyfluorfen has a moderately high soil adsorption capacity, and a negligible degradation by chemical action or soil organisms. The soil half-life varies from 1 to 2 months. Oxyfluorfen adsorbs strongly to organic matter and is therefore resistant to leaching. It may contain the contaminant PCE, which may be slightly carcinogenic.

**Wildlife Effects:** Oxyfluorfen is highly toxic to fish and aquatic invertebrates.

**Human Health Effects:** See Appendix D for detailed human health information.
Fungicides

Benomyl

**Trade Name:** Benlate®, Tersan®

**Chemical Name:** Methyl, 1-(butylcarbamoyl)-2-benzimidazolcarbamate

**Use Pattern:** Benomyl has been used regularly in Lucky Peak Nursery, with 85 acres treated annually. The compound is also used occasionally for disease control in seed orchards and greenhouses. This fungicide is extensively used in orchard and agricultural applications.

**Application Methods and Mode of Action:** Benomyl is a systemic foliar fungicide, and is applied either to soil or to the leaf surface. Benomyl or its metabolite, MBC, enters the plant where it acts as a fungicide by interfering with the cell division process. It is absorbed by plant roots from the soil and through the cuticle of leaf surfaces.

Residual effect is excellent. While benomyl degrades rather rapidly in soil, residues, such as the MBC metabolite, are relatively persistent. Half-life is 3 to 6 months in vegetated soils, and 6 to 12 months in bare soils.

Broadcast application by standard ground spray or boom-type sprayers are most common. Use rate in Lucky Peak Nursery is 0.5 pound active ingredient per acre. A wettable powder, 50 percent active, is the most commonly used formulation.

**Target Pest:** Benomyl will effectively control a broad range of rots, molds and mildews. The most common target pests in nursery use have been botrytis, fusarium, and damping-off fungi.

**Potential Non-Target Effect or Use Limitation:** The material can serve as either a preventive or eradicating fungicide. Benomyl has also controlled certain nematodes and prevents ozone damage to plants. Resistance of certain fungus strains has been noted.

**Soil Effects:** Benomyl has a strong adsorption capacity to soil particles. It degrades rapidly by hydrolysis, and is somewhat degraded by soil organisms. The half-life of benomyl in the soil is only a few hours; however, the MBC metabolite may last 3 to 6 months on vegetated soils and 6 to 12 months on bare ground.

**Wildlife Effects:** Toxic to fish and earthworms.

**Human Health Effects:** See Appendix D for detailed human health information.

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**Metalaxyl**

**Trade Name:** Subdue®, Ridomil®, Apron®

**Chemical Name:** N-(2,6-dimethylphenyl)-N-methoxyacetyl)-alanine methyl ester

**Use Pattern:** Metalaxyl is used on Douglas-fir, spruce and other conifers. It is one of the newer fungicides, having originated in 1977.

**Application Method and Mode of Action:** In nursery use, metalaxyl is a systemic fungicide and is applied to the soil and foliage. It is readily absorbed by plant roots and foliage and translocated in plants. It has shown high postinfection eradication effectiveness.

The formulation recommended for nursery use is a 5 percent granular applied evenly over the treated area. The application rate is 1.25 lbs. active ingredient per acre. Metalaxyl is normally applied once in September.

**Target Pest:** Metalaxyl is effective in control of phytophthora root rot, damping off, and other fungal root diseases.

**Potential Non-target Effect or Use Limitation:** Repeated exclusive use of the compound may lead to a resistant strain of fungi.

Metalaxyl is susceptible to leaching and downward transport may occur if heavy precipitation amounts fall before degradation (the half-life is about 3 weeks).

**Soil Effects:** Metalaxyl has a strong adsorption capacity to organic matter and slight to no chemical degradation, but is rapidly degraded by soil organisms. Its persistence is dependent on soil organic matter, and is thus expected to be high at Lucky Peak Nursery. Its soil half life is expected to vary from 18 days to over 40 days.

**Wildlife Effects:** Metalaxyl is a moderate eye irritant in rabbits and is slightly toxic to birds and fish.

**Human Health Effects:** See Appendix D for detailed human health effects.
Fumigants

Dazomet

Trade Name: Basamid

Chemical Name: tetrahydro-3,5-dimethyl-2H-1,3,5-thiadiazine-2-thione

Use Pattern: The fumigant dazomet is used to treat 18 acres of seedbeds annually. The compound is widely used on crops outside of the United States, for control of weeds, nematodes, soil fungi, and soil insects.

Application Methods and Mode of Action: Dazomet is a soil fumigant used before planting to control germinating annual and perennial weeds, nematodes, soil fungi, and soil insects. The material is incorporated into the soil to a depth of 20 to 25 centimeters, and then sealed by smoothing and lightly irrigating the soil surface. It rapidly breaks down to form methyl isothiocyanate, formaldehyde, hydrogen sulfide, and monomethylamine. The breakdown products interact, resulting in the potent chemical action of the chemical. These products are lost from the soil within a few days as a result of a combination of volatilization and degradation.

A 98 percent granular formulation is most often used in nurseries. The average application rate (incorporated at a soil depth of 20 cm.) is 330 pounds of active ingredient per acre.

Target Pests: Principal targets have been fusarium and other nursery fungi. It also controls insects when they are underground, and germinating weeds.

Potential Non-Target Effect or Use Limitation: Dazomet is strongly toxic to all growing plants. Depending on soil type and temperature, 10 to 40 days are required before the gases disappear from the soil.

Since it contains nitrogen, some increase in plant growth through the fertilization benefit may be seen.

Soil Effects: Dazomet is weakly adsorbed by soil, and is lost from the soil through volatilization of its breakdown products.

Wildlife Effects: Dazomet is moderately toxic to all wildlife. The four breakdown products are all strong irritants.

Human Health Effects: See Appendix D for detailed human health information.
Wildlife Effects: Methyl bromide + chloropicrin is toxic to microorganisms, invertebrates, and fish. It is most toxic to mammals by inhalation.

Human Health Effects: See Appendix D for detailed human health information.

Inert Ingredients Listing for Pesticide Formulations

Inert ingredients in pesticide formulations are an increasingly important issue, especially when some testing has shown that they may have detrimental effects to the environment, human health, and wildlife species. An inert ingredient is defined as any intentionally added ingredient in a pesticide product which is not pesticidal active. They may be solvents, surfactants, emulsifiers, flow conditioners, and other functional ingredients of the herbicide formulation. Cumulative effects of the known ingredients and the full formulations on lethal, sublethal, acute, chronic, and indirect effects to human health and the environment are relatively unknown. The inert ingredients may exert independent effects or interact synergistically with the known ingredients.

Generally, these inert ingredients are proprietary information of the pesticide manufacturer. The Environmental Protection Agency’s (EPA) toxicological tests for registration purposes have regularly concentrated only on the active ingredient of the formulation, rather than the formulation as a whole. The listing of inert ingredients in categories is an effort to help provide data where unknown chemical combinations have not been tested for their effects on human health and the environment.

The Environmental Protection Agency (EPA) has identified about 1,200 inert ingredients that are used in registered pesticides. EPA reviewed the existing human health data on inert ingredients (which include common carriers), existing laboratory studies, epidemiological studies and activity/structure relationships. EPA categorized inert ingredients into one of four categories:

- List 1 - Inert Ingredients of Toxico logical Concern
- List 2 - Potentially Toxic Inert Ingredients/High Priority For Testing
- List 3 - Inert Ingredients of Unknown Toxicity
- List 4 - Inert Ingredients of Minimal Concern

EPA (U.S. Federal Register 1987) describes the construction of the four lists as follows:

**LIST 1** - EPA has identified about 50 inert ingredients as being of significant toxicological concern. This list was assembled on the basis of known toxicity to the chemical; no consideration was given to the potential for exposure. The criteria used to place chemicals on List 1 were carcinogenicity, adverse reproductive effects, neurotoxicity or other chronic effects, or developmental toxicity (birth defects). These effects must have been demonstrated in laboratory or human studies and the data subject to peer review. The criteria also included documented ecological effects and the potential for bioaccumulation. These criteria and the list itself were reviewed by the Federal Insecticide, Fungicide, Rodenticide Act (FIFRA) Scientific Advisory Panel.

**LIST 2** - EPA has further identified about 60 inert ingredients which the Agency believes are potentially toxic and should be assessed for effects of concern. Many of these inert ingredients are structurally similar to chemicals known to be toxic; some have data suggesting a basis for concern about the toxicity of the chemical. Most of the chemicals on List 2 have been designated for testing through the National Toxicology Program (NTP), the EPA Office of Toxic Substances (OTS), or other regulatory or governmental bodies. The FIFRA Scientific Advisory Panel has also reviewed this list. Because testing is ongoing for most of the chemicals on List 2, it is expected to change periodically. It is the Agency’s policy to have all additions, deletions, or changes to List 1 or 2 reviewed by the FIFRA Scientific Advisory Panel.

**LIST 3** - An inert ingredient was placed on List 3 if there was no basis for listing it on any of the other three lists. There are approximately 800 inert ingredients in this category.

**LIST 4** - Inert ingredients were put on List 4 (minimal hazard or risk) if they were generally regarded as innocuous. These included inert ingredients such as cookie crumbs, corn cobs, and substances “generally recognized as safe (GRAS)” by the FDA (U.S. Government 21 CFR 182). There are approximately 300 inert ingredients in this category.

The Forest Service has recommended to its resource managers that they not use products containing inert ingredients found on List 1 or List 2. If no product on List 3 or List 4 is available, then use of another product is allowed, with the understanding that they will evaluate the risk of the inert ingredient. Otherwise, use of products with inert ingredients found on List 1 or List 2 will be limited to stock on hand. As additional information becomes available, the lists will be updated.

The Forest Service supplied EPA with a list of all formulations of the five pesticides being considered for use in the region.

Table B-1 shows the pesticides used at the Lucky Peak Nursery along with various pesticide formulations used there and in Forest Service nurseries around the country. Any inert ingredients found on EPA List 1 or List 2 are identified.
### Cultural Methods

Cultural control is the use of certain nursery practices to make the habitat less favorable for unwanted insects, weeds, diseases, and animals, or to prevent, suppress, or remove them. Cultural controls include both manual and mechanical treatments, as well as such diverse treatments as water chlorination or planting density. Unlike biological and chemical methods, cultural controls cannot always be neatly defined. Cultural controls could be a practice which influences pests indirectly by acting on the seedling environment or which promote crop growth (such as bed density, irrigation, soil PH, organic amendments and soil drainage). Mechanical and manual cultural control methods act directly on the pests (cultivation, pulling, handpicking). Other control methods attack pests directly. This section discusses cultural methods now used at the Lucky Peak Nursery.

Cultural controls have a limited impact on the soil. Temporary impacts may occur from soil disturbing activities such as lifting during wet soil periods. This impact is reduced by applications of organic residues to increase soil organic matter. Cultivators may create an equipment pan in the soil which will interfere with water percolation and/or root penetration.

Impacts of working wet soils can frequently be avoided by waiting for soil to drain and by staying off wet soils.

In general, cultural controls will have limited direct effects to wildlife. Some bird nests could be destroyed during the spring and early summer. In general, most wildlife species will simply move out of the way when the treatment is started.

The main human health risk from these methods is accidental injury from equipment, muscle strain, heat exhaustion, and insect bites.

### Mechanical Methods

Mechanical weeding methods break down into three general tractor-mounted types of devices: cultivators; reel, flail, or rotary mowers; and weed burners.

### Cultivators

**Use Pattern:** Agricultural shovel or hoe type cultivators are not commonly used in Lucky Peak Nursery.

**Mode of Action:** Agricultural shovel or hoe type cultivators work by drawing a stationary blade through the soil, or by stirring the soil surface. This method tends to interfere with tree roots, and does not work well for weeds that regerivate from broken root segments.
Rotary basket or squirrel cage cultivators use metal frames or fiber brushes gear-driven to rotate at a speed greater than the ground speed of the tractor.

**Target Vegetation:** Agricultural cultivators do not work well on weeds which regenerate vegetatively from broken root segments or rhizomes (i.e. crab grass), or from root crowns still rooted (i.e. dandelions).

Rotary basket cultivators are most useful on small weeds in an early stage of development. Baskets are designed to stir the soil surface; brushes merely brush or scrape the surface to uproot weeds. This type of cultivator does not disturb tree roots, but this means it is ineffective on large deeply rooted weeds.

Cultivators can easily damage crop tree species by uprooting trees, breaking roots, or injuring tree stems near the ground. Stem form can be adversely affected, entry ways for fungi are created, and growth may be stunted.

**Mowers**

**Use Pattern:** Lucky Peak Nursery uses mowers in non-bed areas.

**Application Methods and Mode of Action:** Mowers are useful to keep weeds or grass in a non-seeding condition in areas where vegetation is keeping noxious weeds out or where unacceptable erosion will result from the absence of vegetation.

**Target Vegetation:** Mowers can be used on all but the most woody weed species, such as black cottonwood, or other tree-type weeds.

**Weed Burners**

**Use Pattern:** Lucky Peak Nursery has experimented with weed burners.

**Application Methods and Mode of Action:** Weed burners are useful in non-seedbed areas where weeds must be prevented from going to seed but the soil cannot be disturbed. Perennial vegetation is needed to hold down dust or prevent erosion where a burner has been used.

**Target Vegetation:** Any area of flammable weeds, except those in seedbeds occupied by crop trees, can be burned. This method should not be used if it would create a fire hazard.
References

U.S. Federal Register
1987 52 (77) 13305-13309  April 22, 1987

U.S. Government
21 CFR 182 Substances generally recognized as safe.

Appendix C
Nursery Pests
Appendix C
Nursery Pests

This appendix is divided into four sections that correspond to the major categories of nursery pests: Animals; Diseases; Insects; and Weeds. This information is provided to help the reader understand the discussions presented in chapters 1 through 4. It is not intended to be a complete guide to nursery pests, rather it focuses on major pests found at the Lucky Peak Forest Nursery.

Animals

Birds

*Brewer's Blackbird, Euphagus cyanocephalus*
* Mourning Dove, Zenaidura macroura*
* Other incidental species*

**Damage:** The major problem that birds cause at the Lucky Peak Forest Nursery is the ingestion of sown seed, reducing the number of potential seedlings.

**Management:** A number of tactics to scare birds away are utilized, with best results coming from shotgun blasts that both scatter and reduce the number of birds. Doves are game animals that may only be shot in season and with permit.

Deer and Elk

**Damage:** A deer and elk winter range is located west of the Lucky Peak Forest Nursery. During especially severe winters deer entered the nursery and fed on seedlings. In addition to browsing the tips off seedlings, both deer and elk can trample seedbeds and seedlings.

**Management:** Installed gates and fencing should be adequate to manage deer and elk problems.

Diseases

**Charcoal Root Rot**
*Macrophomina phaseoli*

**Hosts:** All conifers and a wide range of herbaceous plants that are often used as cover crops at the nursery.

**Damage:** The fungus invades roots and the root crown of seedlings, causing stunting, chlorosis, or even tree death in the nursery or when outplanted in the field.

**Management:** Most cultural and chemical controls are ineffective against the disease as the fungus produces sclerotia (hard, multicellular resting structures) that can survive many years in the soil. When discovered over a decade ago at Lucky Peak, the nursery bed was fumigated with methyl bromide + chloropicrin, fallowed for several years, and then subsurface tilled to promote drainage. The disease has not re-occurred, but is being monitored.

**Damping-off**
*Pythium and Fusarium spp.*

**Hosts:** A wide variety of plants, including most conifers.

**Damage:** Poor germination or death of seedlings shortly after emergence. In some years damping off is common and may result in significant losses.

**Management:** Pythium and Fusarium are ubiquitous fungi found in soil or on the seed itself. Management consists of utilization of high quality seed; pre-sowing treatment of soil with fumigants such as methyl bromide + chloropicrin or dazomet; and timing of stratification and sowing so that seed germinates quickly and uniformly, as seedlings are more susceptible prior to emergence. When chemical control is warranted, drenches of the fungicide benomyl may prove an effective disease control measure.
Fusarium Root and Hypocotyl Rots

*Fusarium* spp.

**Hosts:** Douglas-fir, spruce, and pines

**Damage:** The fungus infects both roots and hypocotyl tissue at the ground line. *Fusarium* root rot may or may not result in death of the seedling. *Fusarium* hypocotyl rot involves infection and decay of the hypocotyl tissue at the ground line causing the seedling to be girdled and killed.

**Management:** *Fusarium* rot can occur even in nurseries that routinely fumigate their soil prior to sowing. Current management consists of pre-sowing fumigation with methyl bromide + chloropicrin, or azomethane with followup monitoring of beds. If significant mortality is noticed, samples are taken and evaluated by either the Forest Pest Management staff in the Boise Field Office or Oregon State University, Corvallis. If remedial control measures are warranted, applications of benomyl will reduce the fungal population.

Phytophthora Root Rot

*Phytophthora* spp.

**Hosts:** Primarily Douglas-fir and spruce

**Damage:** Infection by tia *Phytophthora* species results in decay and loss of roots. Depending on the degree of infection, seedlings may be killed, stunted, or show no above-ground symptoms. Because the fungus needs high soil moisture to sporulate and infect, disease is most common in low, poorly drained areas of the nursery. In the chronically wet areas up to 100 percent of seedlings may be killed or culled. Normally losses due to the fungus are limited to scattered seedlings throughout the nursery beds.

**Management:** At the Lucky Peak Forest Nursery, *Phytophthora* root rot is mainly a site related disease, occurring in poorly drained areas. Mechanical techniques that improve drainage, such as the installation of subsurface drainage, will help to manage the disease. However, these techniques are costly. It may be more cost effective to permanently fallow these wet areas, or at least grow less susceptible tree species in the problem areas.

If detected early, the disease can often be treated in the field with metalaxyl, a systemic fungicide. Other forms of disease management include proper disposal of diseased seedlings in the field, during grading, and during storage. All seedlings showing symptoms of root rot (stunting, chlorosis, loss of roots) are culled, destroyed, and removed from the nursery. Infected beds are fumigated with methyl bromide + chloropicrin or azomethane.

Storage Molds

**Many species**

**Hosts:** All seedling species

**Damage:** Storage molds are caused by a wide variety of soil fungi which enter the storage bags on the roots or foliage of packed seedlings. Storage molds occur sporadically; their occurrence is very dependent upon environmental conditions before, during, and after storage; the physiological condition of the seedlings; and the abundance of fungal inoculum on the seedling or in the soil adhering to the roots. Fungi such as *Pythium* and *Phytophthora* can infect the lower stem and roots of stored seedlings and cause root death. The fungus *Botrytis cinerea* causes a gray mold in the field, and can infect foliage and stem tissue in storage, causing needle or branch death.

**Management:** Storage mold problems can be managed by: minimizing the amount of soil and dead foliage which is packed with seedlings; ensuring rapid cooling; maintaining storage cooler temperatures around 32 degrees Fahrenheit; checking high-risk lots periodically during storage for mold development; and minimizing storage time for high-risk lots.

Western Gall Rust

*Endocronaria* (Peridermium) *harknessii*

**Hosts:** Lodgepole and ponderosa pines

**Damage:** Western gall rust infections cause swellings on the branches or stems of nursery seedlings. When outplanted, these swellings grow larger, developing into galls that can eventually girdle and kill the stem or branch.

**Management:** The disease is spread from pine to pine and has occurred previously in the shelterbelt trees surrounding the nursery. Branch pruning eliminated the source of infection, and subsequent annual inspections have failed to detect any new infections in either the shelterbelt trees or seedlings.

Insects

**Armyworms**

Species within the family Noctuidae

**Hosts:** All nursery stock.

**Damage:** Armyworm populations fluctuate and occasionally reach damaging outbreak numbers. During these periods larvae move across the ground en masse, consuming all vegetation.
within their path. In nurseries, they defoliate seedlings and may damage buds. Severely defoliated seedlings may die.

Management: Because of the sporadic nature of armyworm outbreaks, detection is the key to successful control. Insecticides may be applied as a foliar spray.

Cranberry Girdler Moth
Chrysoteuchia topiaria

Hosts: Douglas-fir and spruce.

Damage: Larvae feed on the lower stem, above and below the ground, and on roots. During feeding, patches of bark and cortex are removed, often girdling the seedling. The insect has occurred rarely at Lucky Peak Forest Nursery, but damage was significant.

Management: Girdler damaged seedlings are culled during sorting and packing. When a potentially damaging number of insects are detected early, insecticides should be used to minimize damage.

Grasshoppers
Many species

Hosts: All nursery stock.

Damage: Grasshopper injury consists primarily of defoliation, or destruction of specific plant parts, like buds or stem tissue. In the later case, the injury far exceeds damage caused by defoliation alone, as loss of buds results in both growth loss and multiple tops, which lowers quality.

Management: Cultural control of grasshoppers includes elimination of habitats that harbor moderate densities of insects. Chemical controls are employed when populations build to damaging levels, which is an economic population density of 8 or more grasshoppers per square yard. Insecticides may be applied as broadcast sprays or impregnated into burlap material that is ingested by the grasshoppers.

Pitch Moth
Petrovea sp., Vespassima sp., and Doryetria sp.

Hosts: Shelterbelt pines

Damage: Larvae of the moths bore into new and old growth of pines at nodes or whorls of branches which results in a large accumulation of pitch. The insect then pupates within the pitch nodule. Small stems may be girdled by the larvae or weakened so that tops are broken by wind.

Management: These pests are extremely difficult to control. Mechanical control involves removing larvae from under each new pitch mass has been recommended. Surface bore treatments of liquid insecticides may help prevent attacks.

Poplar Borers
Saperda calcarata and other genera.

Hosts: Poplars in the clonebank.

Damage: The poplar borer, Saperda calcarata, attack trunks and limbs of relatively healthy trees, while some of the other borers function as secondary pests tunneling in trees under stress. Extensive mining increases the probability of wind breakage and can provide an entry port for wood decay fungi.

Management: Heavily infested stems should be removed. Prevention of borer attacks involves minimizing wounding and stress, along with applications of insecticides, to prevent borer entry into the stem.

Weeds
Weed Control Methods

Weed management at the Lucky Peak Forest Nursery is tiered to the Boise National Forest “Noxious Weed and Poisonous Plant Control Program” Environmental Assessment (June, 1988). The preferred alternative in this document is Integrated Pest Management (IPM). Under this alternative, target noxious weeds would be treated using a technical decision-making process based on economical and ecological principles. Treatment techniques, established for each situation, include integration of the following control methods.

Biological

Effective biological control methods are generally unavailable for controlling weeds at the Lucky Peak Forest Nursery. The only exception is control of rush skeletonweed with the insect Cytophora schmidtii, a midge that infests seed heads preventing development of viable seed.

Appendix C - 5
Problem Weeds

Cultural

There are several cultural management strategies for weed control at the Lucky Peak Forest Nursery.

- Do not let weeds go to seed. Fallow beds or non-seeded areas are probably the hardest to manage, as weeds can grow up, flower, and seed quickly, especially during extended wet periods. Cultivators will not eradicate large deep-rooted weeds. They must be plowed or pulled.

- Do not use mechanical methods on weeds which propagate vegetatively. Fillarie, purslane, some grasses, and clovers are examples. Tap roots are difficult to bring up completely and both deeper live root segments or root crowns will resprout.

- Manual weed control is an effective method of controlling windblown weed seeds if the weeds are pulled early to avoid damage to seedling roots. Manual control is often difficult and always the most expensive form of weed control.

Problem Weeds

The major weed problems are listed below. Other weeds also occur at the Lucky Peak Forest Nursery, however, their management does not present as significant a problem as the listed species.

Cheeseweed

*Malva* spp.

*Management:* Cheeseweed is readily recognized and can only be pulled when wet. However, because of a deep, persistent tap root, mechanical cultivation is not always effective as a control because new plants develop from defoliated tap root crowns. Manual weeding may also leave tap roots behind. Spot treatment with herbicides is effective, but damage to adjacent seedlings may occur from spray drift.

Clovers

*Trifolium* spp.

*Management:* Clovers are very difficult to control manually because stems and leaves tend to separate from root systems, leaving roots in the ground from which new plants develop. Also, mechanical cultivators are ineffective against clovers unless the plants are quite young and not deeply rooted. Herbicides are effective if wetting agents are mixed in the tank to break down the waxy cuticle on most clovers, but damage to adjacent seedlings may occur from spray drift.

Fillarie

*Erodium circutarium*

*Management:* This weed can be controlled by mechanical, manual, or chemical methods if soil conditions are moist. Roots do not come out of dry soil easily. Cultivation may spread this weed as root crowns left behind will sprout.

Grasses

Many Species

*Management:* Grasses are difficult because individual plants are small, scattered, and numerous. Given these factors, mechanical cultivation would seem ideal for controlling grasses. However, many grasses produce runners, propagating vegetatively, which necessitates a followup step of either manual or herbicide weeding. Pulling large grass clumps can uproot nearby seedlings.

Kochia

*Kochia* spp.

*Management:* Kochia is most easily controlled by mechanical cultivation, but it also can be controlled by manual or herbicide techniques.

Lamb's-quarter

*Chenopodium album*

*Management:* This weed is easily pulled manually and can be mechanically cultivated in non-bed areas because it does not propagate vegetatively. Lamb's-quarter responds well to spot treatments with herbicides.
Pigweed
Amaranthus retroflexus

Management: Pigweed is easily pulled manually and can be mechanically cultivated in fallow fields. It responds well to spot treatments of herbicides.

Purslane
Portulaca oleracea

Management: Purslane can be a problem if abundant because neither mechanical or manual control works well. Plant parts left behind after weeding can take root and produce a new weed. The weed does respond well to spot treatments with herbicides.

Russian Thistle
Salsola kali

Management: Russian thistle or tumbleweed is commonly found around the nursery. Despite its local widespread presence it can be managed fairly well with mechanical cultivation and manual weeding.

Shepard’s Purse
Capsella bursa-pastoris

Management: A common early spring weed, shepard’s purse is most readily controlled by mechanical cultivation.

Skeletonweed
Chondrilla juncea

Management: This noxious weed is best managed using the biological control of an insect, a midge, that develops in seeds’ heads and keeps the weed from developing viable seed. It can also be controlled by manual weeding.

Spotted knapweed
Centaurea maculosa

Management: This noxious weed occurs along roadsides and other dry areas surrounding the nursery. It is best controlled at the nursery by manual weeding.

Thistles
Cirsium spp.

Thistles are difficult to control. Being rhizomatous, they spread vegetatively through underground roots. Thus mechanical control methods, like cultivation and hand weeding, are ineffective as a control measure. Herbicide applications are the most effective means of controlling thistles.
APPENDIX D

HUMAN HEALTH RISK ASSESSMENT
FOR THE USE OF PESTICIDES
IN THE LUCKY PEAK NURSERY
IN USDA FOREST SERVICE INTERMOUNTAIN REGION

August 1992

Prepared for the USDA Forest Service
under contract number 53-3187-9-30

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Appendix D

Section 1

Introduction
SECTION D-1
INTRODUCTION

PURPOSE

The purpose of this assessment is to analyze the risks to human health of using 9 pesticides during the production of tree seedlings in the Lucky Peak Nursery. This nursery is located near Boise, Idaho in the U.S. Forest Service Intermountain Region.

The Lucky Peak Nursery uses pesticides to suppress weeds, insects, birds and rodents, and disease-causing fungi that destroy seedlings or impair their growth. This assessment describes the methods for analyzing pesticide use in the nursery and calculates the risks for each pesticide based on usage information for the nursery. The following 9 pesticides are examined in this risk assessment:

- **Herbicides**: DCPA, glyphosate, napropamide, oxyfluorfen
- **Fungicides**: benomyl, metalaxyl
- **Fumigants**: chloropicrin, dazomet, methyl bromide

ORGANIZATION OF THIS REPORT

This section presents the purpose, describes the structure, and outlines the methodology of the risk assessment. Section D-2, the Hazard Analysis, summarizes and discusses the toxic properties of each pesticide. Section D-3, the Exposure Analysis, outlines the nursery operations that involve pesticide application or exposure and describes the methods used to estimate levels of exposure and resultant doses to the public and workers. Section D-4, the Risk Analysis, uses the results of the hazard and exposure analyses to draw inferences about human health risks, including cancer risks, based on estimated lifetime doses to the public and workers.

OVERVIEW OF THE RISK ASSESSMENT

To assess the risk of human health effects from using pesticides in the Lucky Peak Nursery, it is necessary to estimate the human exposures that could occur as a result of pesticide applications and associated activities, and to estimate the probability and extent of adverse health effects as a result of those exposures. This risk assessment employs the three principal analytical elements that the National Research Council (1983) considers necessary for characterizing the potential adverse health effects of human exposures to existing or introduced hazards in the environment: hazard analysis, exposure analysis, and risk analysis.
1. Hazard Analysis requires gathering information to determine the toxic properties of each pesticide. Human hazard levels are derived primarily from the results of laboratory studies on animals, such as rats, mice, and rabbits; they are supplemented with information from human poisoning incidents, field studies of other organisms, and data on chemical structure.

2. Exposure Analysis involves estimating single and multiple exposures to persons potentially exposed to the pesticides and determining the doses likely to result from those estimated exposures.

3. Risk Analysis requires comparing the hazard information with the dose estimates to predict the potential for health effects to individuals under the conditions of exposure.

Figure D-1-1 illustrates the relationships among these three components. This risk assessment also identifies uncertainties, such as data gaps where scientific studies are unavailable, and describes how those uncertainties were dealt with to produce the analysis results. The discussion that follows briefly describes how each component in the structure was addressed in this risk assessment.

Hazard Analysis

The hazard involved in using each pesticide was determined from extensive literature searches summarized in background statements prepared on the pesticides for the Forest Service (USDA 1984, USDA 1986, USDA 1987) and from updated information obtained for this risk assessment. In addition, all available relevant data submitted to the Environmental Protection Agency in support of the registration of these pesticides were reviewed. These background statements and studies were reviewed to obtain toxicity reference levels, in particular, rat oral LD₅₀'s (median lethal doses, or the amount of a substance that would kill 50 percent of a laboratory test population), systemic and reproductive NOEL's (no-observed-effect levels, or the highest dose given during a laboratory study at which no adverse effects were observed), and data about cancer and mutagenicity. Where scientific uncertainty exists for a particular pesticide on a specific toxic effect—for example, mutagenicity—the basis for the uncertainty is identified. For the purposes of this risk assessment, a conclusion is drawn about whether the chemical might cause the effect, based on all pertinent available data. For example, scientific uncertainty about the results of cancer studies on glyphosate and methyl bromide is discussed. Cancer potency values derived from laboratory animal tumor data were computed for the pesticides that have produced any indication of carcinogenicity. The hazard analysis is discussed in Section D-2.

Exposure Analysis

To assess the risks associated with using pesticides in the nursery, it was necessary to document and analyze the way the Lucky Peak Nursery uses pesticides. Principal aspects of

Risk Analysis

- Compare doses to NOELs and discuss probability of adverse effects for typical, extreme, and accident scenarios
- Conduct analysis for cancer risk

Figure D-1-1. Components of the Risk Assessment Process
nursery operations that affect the potential levels of pesticide exposure were identified, including human activities in or near treated areas, application methods, application rates, the size and configuration of sprayed areas, and standard safety practices.

Two human populations are potentially affected by nursery pesticide use. The first group at risk includes members of the public who live or work near the nursery and who may come into contact with off-site drift during application; may have contact with contaminated domestic animals; or may consume contaminated water, vegetables, domestic animals, or wildlife. In this risk analysis, any effects on wildlife are considered only as they affect human consumers of that wildlife, not as they may affect the animals' health and survival. The second group at risk consists of the nursery workers who apply the pesticides (the mixers, loaders, and tractor drivers) and the nursery personnel whose tasks bring them into direct contact with the treated seedlings and soil (those who inventory seedlings; weed seedling beds; lift, sort, and pack seedlings for shipment; and outplant seedlings). During fumigation operations, tarp lifters are also potentially exposed to pesticides.

In the exposure analysis, potential exposures and resultant dose estimates were made for routine typical and extreme application operations. Potential doses from accidents were also estimated.

Several sources were used to determine exposures and resultant doses to the populations at risk. Studies investigating pesticide concentrations in the urine samples of agricultural field workers were reviewed, and those findings were applied to this analysis. In some cases, exposures and doses to the public were extrapolated from worker data to analyze realistic and extremely unlikely health effects. In other cases, possible doses to members of the public were calculated based on typical and extreme pesticide drift rates, dermal exposure and absorption rates, and food intake rates, using typical and extreme assumptions about the environmental contamination levels.

To analyze public health effects, potential doses were estimated for nearby residents assumed to be exposed to the pesticide as a result of routine activities through one of the following routes:

- Eating a garden vegetable contaminated with drift residues
- Eating beef from cattle that had grazed in nearby pastures
- Eating a rabbit or a grouse that had been dermally exposed in a treated seedling bed
- Drinking water from a source that received runoff
- Drinking water contaminated with drift residues
- Direct dermal exposure from pesticide drift
- Petting a cat or dog with pesticide residues on its fur

In the scenarios in which drift distance plays a factor (in the vegetable garden and direct dermal exposure scenarios), two potential distances from the nursery were examined—25 and 100 feet.

Routine doses were also estimated for the following workers:

- Mixer/loader/applicators using tractor-driven or hand-held equipment
- Weeners
- Inventory personnel
- Lifters, sorter/packers, and tree planters
- Fumigators
- Tarp lifters

The possibility of error exists with all human activities, so it is possible that during routine nursery operations, accidents may expose workers and persons on-site to unusually high levels of pesticides. However, since public access is limited and no aerial spraying is done, risks to the general public from these possible accidents is considered to be very small. To examine potential health effects, the following accident situations were analyzed:

- Spill of pesticide concentrate on a worker’s skin
- Direct accidental spraying of a worker
- Premature reentry of a worker into a treated area
- Inhalation exposure of workers or members of the public from an accidental fumigant release from a torn tarp or broken hose

Risk Analysis

Human health risks from the nursery operations were evaluated by comparing the estimated doses to the public and workers from herbicide and fungicide use to the laboratory-determined toxicity levels. The toxicity levels are described in the hazard analysis, while the doses were calculated for routine and accidental exposure scenarios in the exposure analysis. The risks of threshold effects were evaluated in terms of a margin of safety (MOS), which is the ratio of the dose estimated in the exposure analysis to the no-observed-effect level (NOEL). Risk
increases as the estimated dose approaches the laboratory toxicity level; that is, as the margin of safety gets smaller. In the case of fumigants, estimated exposures were compared with threshold limit values (TLV's), which are safe exposure levels for continuous exposure in the workplace.

The risk of a pesticide causing cancer was evaluated differently. It was assumed that a pesticide that may cause cancer has some chance of causing it at any dosage level. Animal studies were used to determine how this risk changes with differences in exposure; then the laboratory data were adjusted to reflect the lower dose ranges, larger size, and longer life span of humans. Cancer risk was calculated for various categories of people that may be exposed to the pesticides, based on an estimated average daily exposure over a 70-year lifetime.

The risk of heritable mutations was qualitatively evaluated, based on available test data on bacteria, yeasts, plants, mammalian cells in culture, and whole animals; but it was not quantified as the risk of cancer was. Rather, a judgment was made about the pesticide's potential for causing genetic mutations in humans at the dose levels likely to result from nursery applications; also, where appropriate, that risk was compared with the pesticide's cancer risk.

Cumulative risks were addressed for the cancer-causing potential from lifetime doses of a pesticide and for other possible health effects from pesticide accumulation in the body, caused by repeated exposures. The risk of synergistic effects is discussed, using available evidence of any enhanced toxicity in mixtures of two or more of the pesticides. The risk to sensitive individuals is also discussed qualitatively in terms of a sensitive individual's likelihood of exposure.
SECTION D-2
HAZARD ANALYSIS

INTRODUCTION
This section presents the results of the hazard analysis—a review of available toxicological information on the pesticides proposed for use at the Lucky Peak Nursery in the U.S. Forest Service Intermountain Region. The first section describes the sources of toxicity information used in the analysis. The second section defines laboratory testing terminology, subsequently used in describing each pesticide's toxic properties. The third section summarizes each pesticide's toxic properties, in terms of the effects seen in humans and in laboratory animal studies of local and systemic toxicity, reproductive and developmental toxicity, carcinogenicity, mutagenicity, neurotoxicity, and immunotoxicity.

SOURCES OF TOXICITY INFORMATION

Much of the data on pesticide toxicity have been generated to comply with the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended (7 U.S.C. 136 et seq.), which establishes procedures for registering, classifying, and regulating all pesticides. The Environmental Protection Agency (EPA) is responsible for implementing FIFRA. EPA's guidance documents for the registration or reregistration of a pesticide, which include information submitted by pesticide manufacturers for compliance with FIFRA data requirements, are available through EPA's Freedom of Information Office or the National Technical Information Service. From the series of studies submitted for registration, EPA compiles toxicity levels and related information in summary tables called "tox one-liners," which are available through EPA's Freedom of Information Office. EPA has compiled and made available "science chapters" that detail the studies submitted for FIFRA registration of a pesticide, including EPA's review and determination of the adequacy and validity of each study. No studies EPA considers invalid were used in the risk assessment. In addition, EPA's Integrated Risk Information System (IRIS), an on-line data base, provides toxicity study data on many chemicals.

A large body of additional toxicity information exists in the open literature. A number of computerized literature databases were searched, including Agricola, Agrochemicals Handbook, BIOSIS Previews, Chemical Carcinogenesis Research and Information System, Embase, Hazardous Substance Data Bank, and Medline, to locate the most current toxicity information on the pesticides.

HAZARD ANALYSIS TERMINOLOGY

Because of the obvious limitations to chemical testing on humans, most judgments about the potential hazards of pesticides to humans are based on the results of toxicity tests on laboratory animals. These toxicity test results are supplemented by information about actual human poisoning incidents and the effects on human populations when they are available. The discussion of laboratory toxicity testing that follows is extracted primarily from W.J. Hayes (1982); Klaassen et al. (1986); and Lu (1985).

Toxicity tests are designed to measure specific toxic endpoints, such as mortality or cancer, and toxicity reference levels, such as a no-observed-effect level (NOEL) in animals exposed to the chemicals. Toxicity tests vary according to the test species used, the endpoint (effect of concern), the test duration, the route of administration and the dose levels. The dosing schedule, number of test groups, and number of animals per group also vary from one test to another, but the tests are always designed to ensure statistically significant results.

Test Animal Species

Laboratory test animals function as models of the likely effects of a chemical in humans. Ideally, the test animal should metabolize the chemical compound as a human would and should have the same susceptible organ systems. On a body weight basis, humans are generally more susceptible to chemicals, probably by an approximate factor of 10 (Klaassen et al. 1986). The results of animal tests are extrapolated to humans by adjusting for differences in body weight and body surface area (as related to metabolic rate). Although no single test species has proven ideal, a number of species have proven to be reliable indicators for certain types of toxicity tests, routes of administration, and types of chemicals; in particular, rats, mice, rabbits, hamsters, guinea pigs, dogs, and monkeys. Rats and mice are most commonly used for toxicity testing because of the low cost, relative ease of handling, documentation of genetic background, documentation of susceptibility to disease, and relatively short life span of 2 to 3 years (ENVIRON Corp. 1985).

Endpoint Determination

The objective of most toxicity testing is to estimate threshold levels. For a specific toxic endpoint, the threshold level is the dose level at which the test animal first experiences the toxic effect. The threshold dose will vary among tested species and among individuals within species. Examples of toxic effects include pathologic injury to body tissue; a body dysfunction, such as respiratory failure; or another toxic endpoint, such as birth defects. It is not possible to determine threshold dose levels precisely; however, a NOEL indicates the dose at which there is no statistically or biologically significant increase in the frequency or severity of an adverse effect in individuals in an exposed group, when compared with individuals in an appropriate control group. The next higher dose level is the lowest effect level (LEL) at which adverse effects are observed. The true threshold dose level for the particular animal species in a study lies between the NOEL and the LEL.
Chemicals are generally considered to have no threshold level for inducing cancer or for causing genetic mutation. Thus, these toxic endpoints may occur (with a certain level of probability) even in the presence of extremely small quantities of the substances.

**Duration of Toxicity Tests**

The duration of toxicity tests ranges from single-dose or short-term acute and subacute tests through longer subchronic studies to chronic studies that may last the lifetime of an animal. Acute toxicity studies involve administering a single dose to each member of a test group (either at one time or in a cumulative series over a period of less than 24 hours). Subacute, subchronic, and chronic studies are used to determine the effects of multiple doses. Subacute toxicity studies involve repeated exposure to a chemical for 1 month or less. Subchronic toxicity studies generally last from 1 to 3 months, and chronic studies last for more than 3 months.

**Routes of Administration**

For assessing hazards from pesticides, the routes of administration in laboratory tests that reflect the likely types of pesticide exposures to humans include dermal (applied to the skin), inhalation (through exposure to vapors or aerosol particles), and oral by dietary (in food or water) oravage (forced into the stomach through tubing). Other administration routes used in toxicity tests include subcutaneous (injected under the skin), intraperitoneal (injected into the abdominal cavity), and intravenous (injected into a vein). Selection of the route of administration of a particular test material is based on the probable route of human exposure. Oral, dermal, and inhalation doses most nearly duplicate the likely routes of exposure for humans. Subcutaneous, intraperitoneal, and intravenous doses are used in testing drugs, but are not widely used in pesticide toxicity testing because they bypass the test animal's natural protective mechanisms.

**Dose Levels**

A dose is expressed as milligrams of a chemical per kilogram of body weight (mg/kg) of the test animal, in parts per million (ppm) in the animal's diet, or in milligrams per liter (mg/L) in the air that the animal breathes or in the water that it drinks. In chronic studies, the test substance is generally administered in the diet with specified amounts in parts per million. The known weight of the test animal over the test period is used to convert parts per million in the diet to milligrams of a chemical per kilogram of body weight per day (mg/kg/day) for extrapolation to humans. In most chronic toxicity studies, at least three dosing levels are used, in addition to a zero-dose, or control group. In general, the control group receives only the vehicle (for example, water or saline) used in administering the test material. In a dietary study, the basal feed would serve as the vehicle.

**Types of Toxicity Examined in This Risk Assessment**

**Toxicity to Humans**

The effects on humans of exposure to chemicals in the environment can be derived from the reports of observations of exposed people (human poisoning incidents), experimental studies in humans, or from epidemiological studies of exposed human populations.

**Observations of Exposure Incidents**

Information on a pesticide's effects on humans can be obtained from the reports of adverse reactions in people exposed to the chemical during normal applications or reentry to a treated area, in suicide attempts, and in reports of accidents involving exposure to pesticides. Often, only qualitative information is available on these types of incidents.

**Laboratory Studies in Humans**

Because of obvious limitations, little quantifiable information is available on the toxic effects of chemicals in humans. Available data often include the results of dermatologic or exposure testing, although occasionally studies of low-level dosing of human volunteers by oral or other routes may have been conducted.

**Epidemiology Studies**

Epidemiology studies are conducted to investigate the causes of disease in specified human populations by examining relationships between the incidences of particular disease types and factors associated with the disease, such as uses of particular substances in the workplace. One such association is the incidence of several types of cancer among agricultural workers who use various pesticides.

The National Cancer Institute has conducted studies that show fewer farmers die from cancer than would be expected based on the cancer death rate in the general U.S. population. However, farmers have a higher risk of developing lymphatic and blood-related cancers, including leukemia and cancers of the prostate, skin, and stomach than the general population, possibly due to differences in lifestyle (Blair 1982; Blair et al. 1985; Blair and Thomas 1979; Blair and White 1981, 1985; Cantor 1982; Cantor and Blair 1984; Weininger et al. 1987). In the United States, farmers have a much lower rate of lung cancer than the general population, primarily because of their lower smoking rate (Blair 1982). However, a companion study of pesticide-exposed male agricultural workers in the German Democratic Republic (Barthel 1981) found that they had a significantly higher mortality rate from lung cancer than the general population. Although no single agricultural factor has been associated consistently with an increased rate of a specific type of cancer, correlations with insecticide and herbicide use have been noted in a number of cases (Blair and White 1985; Cantor 1982; Cantor and Blair 1984; Cantor et al. 1985).
In a study of licensed pesticide applicators in Florida, excessive deaths were observed for leukemia and cancers of the brain and lungs (Blair et al. 1983). The incidence of lung cancer rose in correlation with the number of years licensed (Blair et al. 1983). In contrast, other studies have found little or no correlation between cancer incidence and pesticide use (Blair and Thomas 1979; Blair and White 1981).

**Human Reference Dose**

The EPA oral reference dose (RfD) is an estimate of the highest possible daily dose of a chemical that will pose no appreciable risk of deleterious effects to a human during his or her lifetime (EPA, 1989). The uncertainty of the estimate would span perhaps an order of magnitude. The reference dose is selected using the lowest systemic NOEL from the most relevant species and study. In most cases, existing information on toxicity in humans is insufficient, so data obtained from laboratory animal studies on the most relevant species are used to determine the reference dose. In the absence of data on the most clearly relevant species, a study using the most sensitive species (the species that exhibited the lowest NOEL) is selected for use in reference dose determination. This NOEL is divided by an uncertainty factor, usually 100, consisting of a factor of 10 to allow for the variation of response within the human population. For studies conducted in laboratory animals, a factor of 10 is used to allow for extrapolation to humans. Additional uncertainty factors may be applied to account for extrapolation from a shorter term study, overall inadequacy of data, or failure to determine a no-effect level.

The reference dose value provides a useful point from which to evaluate the potential effects of a chemical at other doses. Doses that are less than or equal to the reference dose are not likely to be associated with health risks. In some cases, the NOEL used to establish the reference dose is neither the systemic or reproductive NOEL used in this risk assessment because a lower systemic or reproductive NOEL was found in the literature. In all cases, however, the corresponding NOEL used in this risk assessment is equal to or lower than the NOEL used in reference dose determination. If an EPA reference dose has been determined, it is presented in the Toxicity to Humans discussion for each pesticide.

There are parallels between EPA’s derivation of an RfD and the methodology used to determine margins of safety in this risk assessment. Further detail is presented in Section D-4 of this appendix.

**General and Systemic Toxicity**

The types of toxicity grouped under this heading in the risk assessment include those that are observed in the acute through chronic tests that are not aimed at determining a specific toxic endpoint (such as reproductive toxicity or carcinogenicity). Dermal, eye, and inhalation toxicity also are included in this section.

**Acute and Subacute Toxicity Studies**

Acute toxicity studies are used primarily to determine the toxicity reference level, known as the median lethal dose (LD₅₀), which is the dose that kills 50 percent of the test animals within 14 days of administering a substance. The lower the LD₅₀, the greater the toxicity of the chemical. Toxic symptoms displayed by the animals are recorded throughout the study, and tissues and organs are examined for abnormalities at the end of the test. Rats and mice are most commonly used to determine oral LD₅₀’s. The LD₅₀ ranges and toxicity categories used in this risk assessment are those of the EPA classification system, using rat oral LD₁₀’s, as shown in Table D-2-1 (adapted from Maxwell 1982, as cited in Walstad and Dost 1984).

If it is likely that dermal or inhalation exposure may occur, acute toxicity testing using these routes of exposure is also performed. Rabbits are most often used to determine dermal LD₅₀’s. For the inhalation route, an LC₅₀ (median lethal concentration) is determined from continuous exposure for 4 to 24 hours.

Subacute toxicity studies include dermal irritation and sensitization tests and eye irritation tests—usually conducted with rabbits. Subacute studies also include daily dosing of laboratory animals for up to 1 month to further define short-term effects.

**Subchronic and Chronic Toxicity Studies**

Longer term studies are designed to characterize the dose-response relationship resulting from repeated exposure to a compound. A NOEL is usually determined that can be used in setting acceptable intake levels for humans. If a chemical produces effects at the lowest dose tested in a study, the NOEL must be at some lower dose. If the chemical produces no effects, even at the highest dose tested, the NOEL is equal to or greater than that dose. Another toxic endpoint of interest is the LEL, the lowest dose producing adverse effects. All other things being equal, the greater the duration of the study from which the NOEL is derived, the more reliable the resulting value for estimating effects in humans. Subchronic studies provide information on systemic effects, cumulative toxicity, the latency period (the time between exposure and manifestation of a toxic effect), the reversibility of toxic effects, and appropriate dose ranges to be used in chronic tests. Chronic tests indicate the possible impacts on the pathology and physiology of cells, tissues, organs, and organ systems that may result from long-term, low-level exposures to a chemical. The adverse effects in chronic and subchronic tests may include overt clinical signs of toxicity, reduced food consumption, abnormal body weight change, abnormal clinical hematolgy or chemistry, or visible or microscopic abnormalities in the tissue of the test organism. Chronic studies in rats or mice that continue for longer periods of time, usually about 2 years, may also be used to determine the potential for a chemical to cause an oncogenic response in test animals.
Table D-2.1

Acute Toxicity Classification and Acute Toxicities of the Nursery Pesticides and Other Chemicals

<table>
<thead>
<tr>
<th>Toxicity Category*</th>
<th>Pesticide or Other Chemical</th>
<th>Oral LD₅₀ for Rats (mg/kg)</th>
<th>Equivalent Human Dose</th>
</tr>
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<tbody>
<tr>
<td>IV. Very slight</td>
<td></td>
<td>5,000 - 50,000</td>
<td>&gt;1 pint</td>
</tr>
<tr>
<td></td>
<td>Sugar</td>
<td>3,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ethyl alcohol</td>
<td>13,700</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DCPA</td>
<td>&gt;12,500</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Benomyl</td>
<td>&gt;10,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Napropamide</td>
<td>&gt;5,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oxyflourfen</td>
<td>&gt;5,000</td>
<td></td>
</tr>
<tr>
<td>III. Slight (caution)</td>
<td>Glyphosate</td>
<td>500 - 5,000</td>
<td>1 oz. - 1 pint</td>
</tr>
<tr>
<td></td>
<td>Table salt</td>
<td>4,320</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bleach</td>
<td>3,750</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aspirin, vitamin B₉</td>
<td>2,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Metalaxyl</td>
<td>1,700</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DCA</td>
<td>669</td>
<td></td>
</tr>
<tr>
<td>II. Moderate (warning)</td>
<td>Dazomet</td>
<td>50-500</td>
<td>1 tsp. - 1 oz.</td>
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<tr>
<td></td>
<td>DDT</td>
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<tr>
<td>I. Severe (danger—poison)</td>
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<tr>
<td></td>
<td>Chloropicrin</td>
<td>37.5</td>
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</tbody>
</table>

*Categories, signal words, and LD₅₀ ranges are based on a classification system used by EPA for labeling pesticides.


Cholinesterase Inhibition

Several organophosphate and carbamate pesticides inhibit cholinesterase activity. Although cholinesterase inhibition affects the nervous system, it will be discussed under the General and Systemic Toxicity section for each applicable pesticide rather than the Neurotoxicity section because cholinesterase inhibition is usually observed at dose levels that are lower compared to the doses at which other adverse health effects are noted. Therefore, cholinesterase inhibition is often used to set the systemic NOEL used in the quantitative risk assessment. The following paragraphs provide some background information on this toxic endpoint. The discussion is drawn from Smith (1987), Cramer (1986), and Murphy (1980, as cited in Klaassen et al. 1986).

Exposure to organophosphates (such as malathion, acephate, and chlorpyrifos) or carbamates (such as carboxylic and benomyl) results in the inhibition of cholinesterase (ChE) enzyme activity, specifically, of acetylated ChE (acetylcholinesterase). Acetylcholinesterase is responsible for the breakdown of acetylcholine, a neurotransmitter that permits the transmission of nerve impulses across the nerve synapse. Inhibition of acetylcholinesterase results in accumulation of acetylcholine and the continual transmission of nerve impulses.

The extent of inhibition of ChE caused by a given dose of pesticide is usually expressed as a percentage—either a percentage of normal activity or a percentage reduction compared with normal activity.

Organophosphates and carbamates differ in some areas related to ChE inhibition. Organophosphates exhibit an irreversible pesticide-enzyme binding reaction, resulting in ChE inhibition for longer periods than those resulting from carbamates at a given dose level. This also allows the effects to accumulate, so that a sequence of low doses of an organophosphate can produce the same effect as a single higher dose. In contrast, the carbamylated ChE enzyme, formed from the reaction of ChE with carbamate pesticides, is destabilized through biochemical processes in the body, producing ChE inhibition that reverses relatively rapidly. Also, whereas organophosphate chemicals generally are metabolized in part to more active ChE inhibitors (for example, malathion to malaoxon), carbamates appear to function directly as inhibitors.

The toxic effects of ChE inhibition at low doses in humans include localized effects, such as miosis, blurred vision, and bronchial constriction; and systemic effects, such as nausea, sweating, dizziness, and muscular weakness. Effects of higher doses include irregular heartbeat, elevated blood pressure, cramps, and convulsions. In general, ChE inhibition up to 40 percent (40-percent reduction in activity) in laboratory animals and humans is tolerated well and may produce transitory, less severe symptoms. Clinically significant inhibition is considered a ChE depression of 20 percent or more compared with pretreatment values for plasma, erythrocyte, and brain ChE activities. Inhibition of ChE activity above 50 percent can lead to more severe, prolonged symptoms and, in an extreme case, death. When a fatal dose of organophosphate or carbamate has been received without emergency treatment (generally by administering the antidote atropine), death usually occurs within 24 hours.
Reproductive and Developmental Toxicity Studies

Reproduction studies are conducted to determine the effect of a chemical on reproductive success, as indicated by fertility (production of germ cells), fetotoxicity (direct toxicity to the developing fetus), maternal toxicity, and survival and weight of offspring. Reproduction studies are most often multi-generational; that is, they continue through two or three generations of treated animals. Both male and female animals, usually rats, are exposed to the chemical beginning shortly after weaning (30 to 40 days of age) and continuing through breeding, gestation, and lactation. The offspring then receive the chemical in their diet until they are about 140 days old, at which time they are bred to produce another generation. The percentage of females that conceive, number of full-term pregnancies, litter size, number of stillbirths, and number of live births are recorded. Viability counts and pup weights are noted. Indexes are scored for gestation, viability, and survival through lactation. During necropsy and histopathology examinations, special attention is given to effects on reproductive organs.

Developmental studies (also called teratogenicity studies) are used to determine the potential of a chemical to cause malformations in an embryo or a developing fetus between the time of conception and birth. For these tests, a compound is administered to gestational female animals, usually rats or rabbits, during the first trimester, and the fetuses are delivered by cesarean section 1 day before the estimated delivery date. The number of live, dead, and resorbed fetuses and skeletal and tissue abnormalities are observed.

Other reproductive toxicity studies may involve administering the test compound during only one breeding and gestational cycle instead of over two or three generations, or may be designed to evaluate perinatal and postnatal toxicity.

Carcinogenicity Studies

Description

Carcinogenicity studies are used to determine the potential for a compound to elicit a carcinogenic response in chronic studies that determine its ability to cause malignant (cancerous) or benign (noncancerous) tumors when administered over an animal's lifetime. Testing is normally conducted with rats or mice for approximately 2 years and often is combined with a chronic oral toxicity study. Several dose levels are used, with the highest set at the maximum tolerated dose, as established from preliminary studies. A control group is administered the vehicle (the liquid or food with which the test pesticide is given) alone.

Evaluation of Response

Because tumors may arise in test animals for reasons unrelated to administration of the test compound, statistical analyses are applied to the tumor incidence results to determine the significance of observed results. Klaassen et al. (1986) listed four types of responses that have generally been accepted as evidence of induction of tumors:

1. The presence of types of tumors not seen in controls
2. An increase in the incidence of the tumor types occurring in controls
3. The development of tumors earlier than in controls
4. An increased multiplicity of tumors

Some chemicals that elicit one or more of these responses may not be primary carcinogens, that is, tumor-inducers on their own, but may be enhancers or promoters. However, a carcinogenicity evaluation remains appropriate, because they may contribute to an increase in cancer incidence.

Cancer Potency Value

The cancer potency value (also called the cancer slope factor) of a chemical represents the increase in likelihood of getting a tumor over a lifetime from a unit increase (1 mg/kg/day) in the dose of the chemical. The curve relating dose to cancer probability approximates a straight line in the low-dose region. The slope of the curve in this region represents the cancer potency. This risk assessment takes a conservative approach by assuming that any dose of a carcinogen, no matter how small, has some probability of causing cancer. That is, there is no threshold or no-effect level for cancer.

Various models are used to extrapolate from the high doses used in animal studies to the lower doses that humans are likely to receive. This is an area of scientific controversy in cancer risk assessment. Several models, including the Weibull and multistage models, have been in general use for extrapolating cancer data to assess human risk (Klaassen et al. 1986). The one-hit model uses a least-squares regression procedure to derive an exponential dose-risk relationship, giving a very conservative estimate of cancer potency. When available, cancer potency values that EPA has calculated were used in this analysis. Cancer potency values calculated specifically for this analysis used either the one-hit model or the multistage model. Calculation of these cancer potency values, based on tumor data in lab studies, included multiplying by the cube root of the ratio of the weight of an average adult human (70 kilograms) to an adult rat or mouse, as appropriate. According to the Office of Science and Technology Policy (OSTP 1985), this extrapolation procedure, although commonly used, may not be warranted and may lead to an excessively conservative assessment. However, the procedure has been recommended by EPA and the Safe Drinking Water Committee of the National Academy of Sciences (Thomas 1986).

Mutagenicity Assays

Mutagenicity assays are used to determine a chemical's ability to cause physical changes (mutations) in the basic genetic material deoxyribonucleic acid (DNA), especially changes in the germ cells that could affect an embryo's viability or lead to congenital anomalies.
According to Lu (1985), the true effects of any additional mutagen in the environment may only be manifested after a lapse of several generations. Mutagenicity data on a chemical also help in evaluating carcinogenic potential, because most mutagens have been found to be carcinogens and the sequence of cellular events that lead to carcinogenesis may be initiated by a mutagenic occurrence.

The species used in these tests range from simple organisms (such as the bacteria Salmonella, Escherichia, and Streptomyces; the mold Aspergillus; the yeast Saccharomyces; and the fruit fly Drosophila), to more advanced organisms, including mammals such as mice and rats. Tests may be conducted in vivo (within the body of the living organism) or in vitro (in cells in a culture medium). There are three main categories of mutagenicity assays: (1) tests for detecting gene mutations, (2) tests for detecting chromosomal aberrations, and (3) tests for detecting DNA repair and recombination.

**Assays for Gene Mutation**

The DNA molecule consists of a coded series of linked base pairs. Gene mutations involve additions or deletions of these base pairs, or substitution of a wrong base pair in cellular DNA molecules. When this occurs, the amino acid sequence of a protein that is coded by the DNA may be altered; a new amino acid may be inserted; or a shortened protein may be formed—these changes can, in turn, affect the biological properties of the protein. Tests used to detect gene mutations include microbial assays, involving prokaryotic microorganisms (such as bacteria and cyanobacteria that lack a nucleus separated from the cytoplasm by a membrane) and eukaryotic microorganisms (organisms with a well-defined nucleus enclosed in a membrane, such as yeasts, other fungi, and mammals).

*In vitro* microbial tests in prokaryotic organisms are designed to detect reverse mutations (a mutant gene that undergoes mutation back to the wild type or most common genetic make-up of the species) and, to a limited extent, forward mutations (a wild-type gene that undergoes mutation). For example, the Ames test measures the degree of reversion of histidine-dependent mutant cells of the bacteria Salmonella typhimurium back to the wild genotype that is not dependent on histidine in the culture medium. Many chemical mutagens do not display mutagenic properties unless they have been metabolized by biological enzymes, such as those found in the liver of mammals. Therefore, many *in vitro* tests include a bioactivation system, such as a liver microsomal homogenate (59 fraction) from rats or other animals, to activate the mutagen.

A host-mediated assay is a test conducted to detect mutagenic effects in a microorganism, such as a bacterium, by injecting it into the peritoneal cavity, circulatory system, or testes of the host (usually a mouse) to allow for a better environment for bioactivation of the mutagen in vivo; the chemical being tested is also administered to the host animal. After a few hours, the microorganisms are collected and examined for signs of mutagenicity.

Other tests useful for detecting gene mutations are the fruit fly sex-linked recessive lethal test, which measures the frequency of lethal mutations; the mouse specific locus test, which detects mutagenicity in germ cells in vivo; and mammalian somatic cell assays *in vitro* using mouse lymphoma cells, human lymphoblasts, and Chinese hamster ovary cells to detect forward and reverse mutations.

**Assays for Chromosomal Aberrations**

Chromosomal aberrations are structural changes in chromosomes or changes in the number of chromosomes. Examples of tests that detect chromosomal aberrations are *in vitro* mammalian cytogenetic assays and *in vivo* rodent bone marrow micronucleus or metaphase analyses. The dominant lethal test in rodents, which determines lethal damage to germ cells, and the heritable translocation test in mice, which detects the heritability of chromosomal damage, are important tests performed with live animals. Fruit flies and other insects also are used to detect heritable chromosomal effects in vivo.

**Assays for DNA Repair and Recombination**

The existence of DNA damage caused by mutagens is detected by biologic processes, such as DNA binding or DNA repair and recombination, that occur after DNA damage. Tests for such processes use bacteria, yeast, and mammalian cells *in vitro*, with and without metabolic activation. For example, many tests use unscheduled DNA synthesis to indicate that DNA repair is occurring in human cells *in vitro*. Mitotic recombination and gene conversion assays indicate DNA damage in yeast, and the sister chromatid exchange assay indicates DNA damage in mouse lymphoma cells, Chinese hamster ovary cells, and human lymphocytes.

**Neurotoxicity Studies**

Some chemicals may have adverse effects on the nervous system. Types of neurotoxicity include neuronopathy, axonopathy, effects on myelin, or effects on the neural vascular system.

Neuronopathy includes anoxic and hypoglycemic conditions in the neurons, direct effects on the cell body of a neuron, and effects on the dendrites of a neuron.

Axonopathy is toxicity to the long axon of a neuron. Neurofilaments that are manufactured in the cell body and normally transported along the axon may instead accumulate in the proximal axon, causing it to enlarge and the distal axon to atrophy. Delayed neuroopathy, mainly manifested as muscle paralysis, is caused by organophosphorus compounds, such as tri-o-cresyl phosphate and some organophosphate insecticides. Polyneuropathy is manifested by axonal neurofilament proliferation. Agents such as tetrodotoxin may lead to blockage of impulse conduction. Exposure to agents such as botulinus toxin, tetanus toxin, carbon disulfide, DDT, and dieldrin may cause blockage of synaptic transmission.
Effects on myelin include demyelination resulting from injury to myelinating cells, such as Schwann cells and oligodendrocytes, or direct injury to the myelin sheath, generally as a result of disruption of the membrane structure.

Effects on the neural vascular system are usually marked by edema, either within the neuron or outside of it.

Cholinesterase inhibition is a neurotoxic effect. However, because it is generally observed at doses lower than other types of adverse effects that organophosphate or carbamate exposure may cause, it was discussed previously in a separate section. In the hazard analysis summaries of the pesticides’ toxicity, cholinesterase inhibition is generally reported with general and systemic effects, because it is often the toxic endpoint that results in the lowest systemic NOEL.

Several test procedures have been developed to detect neurotoxic effects. Neurologic examinations to help identify the site of adverse effects can be performed in animals or humans. The examinations include evaluating responses to sound and light stimuli, testing reflexes, observing gait abnormalities, observing spasticity or tremor, and examining muscles for atrophy, weakness, or fasciculation. Morphologic examinations are pathologic observations of abnormalities or lesions. Delayed neurotoxicity testing involves a single administration of a chemical to hens, which are readily susceptible to this type of neurotoxicity, followed by examination 8 to 10 days later for signs of distal axonopathy. Electrophysiologic examinations include measurements of conduction velocities and action potentials, electromyography, and electroencephalography. Biochemical examinations can indicate damage to or changes in the enzyme systems in neuronal glucose metabolism, the ion transport systems, protein synthesis, neuronal biochemical composition, and neurotransmitter levels and binding sites. In vitro testing on cultured nerve cells can include electrophysiologic, morphologic, or biochemical examinations. Behavioral studies look for changes in conditioned or unconditioned responses in the belief that behavioral changes are a subtle and sensitive indicator of neurotoxicity.

Immunotoxicity Studies

In general, four types of adverse effects on the immune system are possible as a result of exposure to chemical substances: immunosuppression, uncontrolled proliferation (leukemia and lymphoma), alterations of host defense mechanisms against pathogens and neoplasms, and allergy or autoimmunity. As stated by Klaassen et al. (1986),

It is becoming increasingly apparent that the immune system represents an important target organ for studying the toxicology of chemical exposure for the following reasons: immunocompetent cells require continued proliferation and differentiation for self-renewal and are thus sensitive to agents that affect cell proliferation; the cellular and molecular biology of the immune system is better understood than in many other target organ systems, and thus the mechanism(s) by which toxicants are immunomodulatory can be determined; functional assessment or enumeration of leukocytes can be easily achieved using a small volume of blood or lymphoid tissue; and finally, observations obtained in experimental animals can be confirmed in humans using leukocytes obtained by minimally invasive methods (i.e., venipuncture).

Many tests are available that incorporate or are targeted primarily at an assessment of the effects of chemicals on the immune system. They include immunocompetence tests in vivo, cell-mediated immunity assays in vivo or in vitro, the plaque assay to evaluate humoral immunity in vivo, macrophage and bone marrow assays, hematology profiles, clinical chemistry tests, serum protein studies, organ weight observations, and the histology of immune-related organs.

Allergic hypersensitivities is a particular form of immune system response to a foreign substance. Allergic hypersensitivities may be immediate, such as in anaphylactic reactions to insect bites or penicillin injections; or they may be delayed, as in the case of positive responses to tuberculin tests or contact dermatitis caused by poison ivy. Severe, immediate anaphylactic reactions, which can be fatal if not treated promptly, are antigen-antibody reactions that produce sensitivity in individuals only when the compound is a large, complex organic molecule. The delayed allergic hypersensitive reactions usually are directed against whole foreign cells (bacteria, viruses, fungi) but, as in contact dermatitis, may be induced by lower-molecular-weight substances, such as the catechols of poison ivy, cosmetic drugs, or antibiotics. Benzocaine, neomycin, formaldehyde, nickel, chromium, and thiram are all known to produce these reactions (Marzulli and Maibach 1983).

Data Gaps

Data gaps are listed at the end of each pesticide's toxicity summary. Table D-2-2 summarizes the data gaps for all of the pesticides used in the Intermountain Region. Risk assessment data gaps are those areas covered in this hazard analysis for which little or no information was available on a particular aspect of a pesticide’s toxicity. These data gaps may affect the ability to quantify risk from a pesticide, if they are in the areas of general/systemic toxicity, reproductive/developmental toxicity, or carcinogenicity. While still allowing a quantitative risk assessment, data gaps in other areas limit the full characterization of a pesticide’s effects. Where no data are available on a particular toxicity endpoint, the risk assessment, to be conservative, concludes that the compound may cause that effect.
<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Chronic/subchronic Effects</th>
<th>Teratology Reproduction Effects</th>
<th>Oncogenicity</th>
<th>Mutagenicity*</th>
<th>Neurotoxicity</th>
<th>Immunotoxicity</th>
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</table>

*Mut=gene mutation; CA=chromosomal aberrations; DNA=primary DNA damage

*"."=" = sufficient data; "X"=data gap
HERBICIDE HAZARD ANALYSES

DCPA

Toxicity to Humans

Tusing (1963, as cited in EPA 1988a) reported that oral administration of 25 or 50 mg (approximately 0.36 or 0.71 mg/kg) of the herbicide DCPA to human volunteers did not cause any adverse effects on blood chemistry, urine analysis, liver, or kidneys. A human reference dose for chronic oral exposure was established at 0.5 mg/kg/day, based on a chronic rat feeding study with a NOEL of 50 mg/kg/day (EPA 1989a). An uncertainty factor of 100 was applied to allow for interspecies extrapolation and intraspecies variation.

General and Systematic Toxicity

Acute and Subacute Toxicity

DCPA can be classified as a very slightly toxic herbicide, based on an LD₅₀ of greater than 12,500 mg/kg in rats (EPA 1988a).

Subchronic and Chronic Toxicity

A 2-year rat study resulted in a NOEL of 50 mg/kg/day, with increased kidney weights (in males) and adrenal-to-body weight ratios (in females) at the lowest effect level of 500 mg/kg/day (EPA 1989b). The NOEL of 50 mg/kg/day was used in this risk assessment. A 90-day oral toxicity study with rats resulted in a NOEL of 500 mg/kg/day (EPA 1989b). A 2-year oral toxicity study with dogs resulted in a NOEL of 250 mg/kg/day (EPA 1989b).

Reproductive and Developmental Toxicity

A teratology study with rats did not result in any adverse effects to mothers or offspring at 100 mg/kg/day (the highest dose tested) (EPA 1989b). This NOEL of 100 mg/kg/day was used in this risk assessment.

Carcinogenicity

There is no evidence that DCPA is carcinogenic. EPA has not classified the carcinogenic potential of DCPA at this time. Chronic feeding studies (2-year) with dogs and rats revealed no carcinogenic effects at the highest doses tested (EPA 1988b). However, because of the carcinogenicity of the impurity hexachlorobenzene (HCB), present in DCPA (see the Hexachlorobenzene discussion below), an assessment of cancer risk is undertaken in this analysis. The cancer potency of DCPA was calculated to be 0.0051 per mg/kg/day, based on a cancer potency of 0.03 mg/kg/day for hexachlorobenzene. The cancer potency represents the increase in likelihood of getting a tumor over a lifetime from a unit increase (1 mg/kg/day) in the dose of the chemical.

Mutagenicity

DCPA had no mutagenic activity, with or without metabolic activation, in Salmonella assays, in vivo cytogenetic tests, in DNA repair tests, or in dominant lethal tests (USDA 1987). A medium containing DCPA was fed to Oregon-R wild-type fruit flies (Drosophila melanogaster) and induced no mutations (Paradi and Lovenyak 1981, as cited in USDA 1987). Thus, there is no evidence at this time to suggest that DCPA is mutagenic.

Neurotoxicity

No information was available on which to evaluate DCPA's neurotoxic potential.

Immunotoxicity

DCPA was negative for dermal sensitization in guinea pigs (EPA 1988a).

Data Gaps

There are no data available on neurotoxicity of DCPA.

DCPA Contaminants

Hexachlorobenzene

Hexachlorobenzene (HCB) is a contaminant in DCPA and may constitute up to 0.3 percent of the formulation. Cases of human HCB poisoning reveal that severe skin disorders and fatalities resulted from chronic ingestion of 50 to 200 mg/day and that HCB may be detected in the blood following long-term or intensive occupational exposure (USDA 1987). HCB administered to hamsters throughout their life span produced significant increases in total tumors, thyroid tumors, and liver tumors (Cabral et al. 1977). The carcinogenic relationship was confirmed in Cabral et al. (1979), when mice developed a significant incidence of liver tumors after dosing with HCB in a chronic study.

2,3,7,8-TCDD

TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin) is an extremely toxic chemical that is known to be carcinogenic, teratogenic, fetotoxic, and acnegenic (EPA 1988b). EPA (1988b) describes this dioxin contaminant as being present in technical DCPA at concentrations of up to 0.27 ppb and states that the oncogenic risk associated with 2,3,7,8-TCDD is equal to or less than 1 x 10⁻⁸. Based on the EPA evaluation and the fact that technical DCPA, containing this dioxin contaminant, was used in the chronic feeding studies to determine DCPA's cancer potency...
value, it is concluded that the cancer risk from DCPA evaluated in this risk assessment accounts for the 2,3,7,8-TCDD risk. No separate risk assessment for 2,3,7,8-TCDD has been completed.

**Glyphosate**

**Toxicity to Humans**

According to EPA (1988), the herbicide glyphosate was evaluated for acute irritation, cumulative irritation, photoirritation (irritation due to the presence of the chemical and light), and allergic and photoallergic (allergic reaction due to the presence of the chemical and light) contact potential in 346 volunteers. It was less irritating than a standard liquid dishwashing detergent and a general all-purpose cleaner. There was no evidence of the induction of photoirritation or of allergic or photoallergic contact dermatitis. A reference dose for chronic oral exposure was established at 0.1 mg/kg/day, based on a three-generation rat reproduction study with a NOEL of 10 mg/kg/day and an applied uncertainty factor of 100 to allow for interspecies extrapolation and intraspecies variation (EPA 1989b).

**General and Systemic Toxicity**

**Acute and Subacute Toxicity**

Glyphosate can be classified as a slightly toxic chemical based on an oral LD₅₀ of 4,320 mg/kg in rats (EPA 1984).

**Subchronic and Chronic Toxicity**

A 26-month oral toxicity study with rats resulted in a NOEL of 31 mg/kg/day, the highest dose tested (EPA 1984). This is the systemic NOEL used in this risk assessment.

A 90-day oral toxicity study in mice resulted in a NOEL of 10,000 ppm (1,200 mg/kg/day), with reduced body weight gain at the lowest effect level of 50,000 ppm (6,000 mg/kg/day) (EPA 1984).

A chronic oral toxicity study in dogs revealed no effects at 20 mg/kg/day, and decreased absolute and relative pituitary weights at the lowest effect level of 100 mg/kg/day (EPA 1989a).

**Reproductive and Developmental Toxicity**

A three-generation reproduction study with rats resulted in a NOEL of 10 mg/kg/day (EPA 1989a), which is the reproductive NOEL for glyphosate in this risk assessment. At the lowest effect level of 30 mg/kg/day, increased incidence of renal tubular dilation was observed in pups (immature rats). Teratology studies resulted in NOEL's of 1,000 mg/kg/day in rats and 175 mg/kg/day in rabbits (EPA 1989a).

**Carcinogenicity**

A 26-month rat-feeding study found no oncogenic effects at doses up to 31 mg/kg/day (EPA 1984). However, the maximum tolerated dose may not have been reached in this study. Benign kidney tumors (renal tubular adenomas) were reported at the highest dose level (30,000 ppm) in a 2-year mouse-feeding study; however, the findings were equivocal (EPA 1986). The EPA Science Advisory Panel reviewed all relevant data, concluded that the oncogenic potential of glyphosate could not be determined from existing data, and proposed that the study be repeated to clarify these equivocal findings (EPA 1986). In view of the uncertainty regarding the carcinogenicity of glyphosate, a cancer risk analysis was conducted in this risk assessment.

A carcinogenic nitrogen derivative of glyphosate, N-nitrosoglyphosate (NNG), is not considered a potential human hazard here because NNG is not likely to form in soils at the application rates used in the nurseries. Details concerning NNG are presented in the Supplement to the Environmental Impact Statements on Management of Competing Vegetation (DOI 1986).

Glyphosate's cancer potency was based on the rate of kidney tumor formation in male mice in the feeding study as reported by EPA (1985). The upper limit of the 95-percent confidence level of the cancer potency of glyphosate calculated from the kidney tumor data was 2.4 x 10⁻⁴ per mg/kg/day.

The Science Advisory Panel of EPA considers glyphosate to be in Class D, meaning that there is inadequate evidence to draw any conclusions regarding carcinogenicity. However, EPA's Health Effects Division considers glyphosate to be in Class C, a possible human carcinogen (EPA 1989b).

**Mutagenicity**

Glyphosate was not mutagenic in microbial assays for gene mutation, chromosomal aberrations, and primary DNA damage. It was also not mutagenic in mammalian cell assay systems both in vitro and in vivo (EPA 1986). There is no evidence to indicate that glyphosate is mutagenic.

**Neurotoxicity**

No information was available on glyphosate's neurotoxic potential.
Immunotoxicity

Maibach (1976) evaluated glyphosate for skin sensitization in 204 adult human volunteers. No sensitization was induced in any of the volunteers.

Data Gaps

Available long-term rodent feeding studies that evaluated glyphosate's oncogenic potential gave equivocal results. No information was available on glyphosate's neurotoxicity.

Napropamide

Toxicity to Humans

No data are available on the toxicity of the herbicide napropamide in humans. Based on a three-generation rat reproduction study, EPA (1989) established a human reference dose (RfD) of 0.10 mg/kg/day. This RfD was estimated from a NOEL of 30 mg/kg/day, with an uncertainty factor of 300 to account for interspecies extrapolation, intraspecies variation, and the lack of a chronic feeding study in a second species.

General and Systemic Toxicity

Acute and Subacute Toxicity

Based on an LD₅₀ greater than 5,000 mg/kg, napropamide can be classified as a very slightly toxic herbicide (EPA 1984).

Chronic and Subchronic Toxicity

The lowest systemic NOEL reported for napropamide is 25 mg/kg/day, based on a 91-day rat feeding study, in which decreased uterine weights were noted at the LEL of 50 mg/kg/day (EPA 1984). Chronic 2-year feeding studies of both rats and mice yielded systemic NOEL's of 30 mg/kg/day in both cases; at the LEL's of 100 mg/kg/day, body weight inhibition was noted (EPA 1984). A systemic NOEL of 25 mg/kg/day was used in this risk assessment.

Reproductive and Developmental Toxicity

A NOEL of 30 mg/kg/day was the level reported for the fetotoxic and maternal toxic NOELs in a three-generation study of rats; at the LEL of 100 mg/kg/day, maternal and fetal decreased weight gain was observed (EPA 1984). There were no teratogenic effects reported for teratology studies at the highest doses tested in two mammalian species (200 mg/kg/day, rabbit; and 400 mg/kg/day, rat) (EPA 1984). Maternal and fetotoxic NOEL's for a rabbit teratology study were both 10 mg/kg/day (EPA 1985). A reproductive/developmental NOEL of 10 mg/kg/day was used in this risk assessment.

Carcinogenicity

Available information indicates that napropamide is not carcinogenic. Chronic feeding studies using rats and mice revealed no oncogenic effects (EPA 1984). EPA (1989) has not classified the oncogenic potential of napropamide at this time.

Mutagenicity

Five bacterial mutagenicity tests evaluated by EPA (1984) had negative results for point mutation and primary DNA damage. Stauffer Chemical Company (1984) conducted various mutagenicity tests that corroborate these negative results. Chromosome aberration testing in mouse lymphoma cells, a mouse micronucleus test, a human fibroblast DNA test, and a microbial assay using four strains of the same bacteria were all negative. One multiple endpoint test on mouse lymphoma cells gave a positive result. The weight of evidence from these tests suggests that napropamide is not mutagenic.

Neurotoxicity

No data are available on the neurotoxic effects of napropamide.

Immunotoxicity

No data are available on the immunotoxic effects of napropamide.

Data Gaps

No information was available on the toxicity of napropamide to humans and the neurotoxic or immunotoxic potential.

Oxyfluorfen

Toxicity to Humans

No data regarding human toxicity from the herbicide oxyfluorfen are available in the current literature. A human reference dose for chronic oral exposure was established at 0.003 mg/kg/day, based on a chronic feeding/oncogenicity study with mice that resulted in a NOEL of 0.3 mg/kg/day. An uncertainty factor of 100 was applied to account for interspecies extrapolation and intraspecies variation (EPA 1989a).

Acute and Subacute Toxicity

Based on an LD₅₀ greater than 5,000 mg/kg in rats (USDA 1987), oxyfluorfen can be classified as a very slightly toxic chemical.
Subchronic and Chronic Toxicity

A NOEL of 0.3 mg/kg/day resulted from a 20-month oncogenicity study with mice, with increased liver weight and abnormal gross and histopathological findings in the liver at the lowest effect level of 3 mg/kg/day (Rehm and Haas 1977, as cited in EPA 1989b). The NOEL of 0.3 mg/kg/day was used in this risk assessment.

A 2-year oral toxicity study with dogs revealed a NOEL of 2.5 mg/kg/day. Findings at the lowest effect level of 15 mg/kg/day included increased liver weight, elevated levels of liver enzymes, and histopathological changes in the liver (EPA 1989b). A 2-year feeding/oncogenicity study with rats resulted in a NOEL of 2 mg/kg/day, with histopathological changes observed in the liver at the lowest effect level of 30 mg/kg/day (EPA 1989b).

Reproductive and Developmental Toxicity

A three-generation reproduction study with rats resulted in a NOEL of 0.5 mg/kg/day (EPA 1989b) and is the reproductive NOEL used in this risk assessment. A teratology study with rats resulted in a NOEL of 100 mg/kg/day, with fetotoxic effects observed at the lowest effect level of 1.000 mg/kg/day (EPA 1989b). A teratology study with rabbits resulted in a fetotoxic and maternal NOEL of 10 mg/kg/day (EPA 1989b). Maternal toxicity was observed at the lowest effect level of 30 mg/kg/day, and included anorexia and decreased body weight gain. Fetotoxic effects at 30 mg/kg/day included fused sternae (a variation in bone formation) in the offspring.

Carcinogenicity

A chronic study in which oxyfluorfen was fed to rats for 2 years revealed no oncogenic potential (EPA 1988). A 20-month mouse-feeding study gave equivocal results (EPA 1988). Oncogenic and chronic studies of perchloroethylene (PCE), a contaminant of oxyfluorfen, have shown mixed results. Two of the negative tests, a mouse skin bioassay and a 12-month rat-feeding study, were criticized by EPA for lack of statistical validity and a maximum threshold, respectively. A rat embryo cell test and a 90-week mouse study gave statistically significant positive results. Mice exposed to very high doses of PCE given intermittently for 50 weeks (3,900 mg/kg/week) and 62 weeks (3,300 mg/kg/week) showed carcinogenic effects (NIOSH 1986, as cited in HSDB 1986).

This risk analysis assumes that oxyfluorfen, as used, is carcinogenic because of the PCE impurity present. EPA has classified oxyfluorfen into Category C, meaning that it is a possible human carcinogen (EPA 1989a).

The cancer potency of oxyfluorfen was calculated from the tumor data from studies with PCE, a contaminant of oxyfluorfen. PCE administered by gavage in a 90-week mouse study induced a statistically significant number of hepatocellular carcinomas in both sexes of mice at low- and high-dose levels (NCI 1977, as cited in EPA 1981). These tumor data, used by EPA to assess the cancer potency of oxyfluorfen because of its PCE contaminant, were used in this risk assessment. The cancer potency represents the increase in likelihood of getting a tumor over a lifetime from a unit increase (1 mg/kg/day) in the dose of the chemical. The cancer potency calculated at the upper limit of the 95-percent confidence interval was 3.41 x 10⁻¹ per mg/kg/day for PCE. This value was multiplied by 0.0002 to correct for the fraction of PCE in Goal® (an oxyfluorfen formulation), and by 4.25 to correct for the fraction of oxyfluorfen in Goal. This gives a cancer potency for oxyfluorfen of 2.93 x 10⁻¹ per mg/kg/day.

Mutagenicity

Mutagenicity assays have been performed with technical oxyfluorfen (analytical Goal of approximately 99 percent pure oxyfluorfen), with technical Goal (designated RH-2915, of approximately 72-percent oxyfluorfen purity), and with the polar fraction of technical Goal.

The polar fraction contains concentrated quantities of the impurities found in technical Goal that are believed to influence the mutagenic response observed in the positive assays with technical Goal (EPA 1981). According to EPA (1988), a bacterial Ames test, a rat cytogenicity assay, and a bacterial host-mediated assay with technical oxyfluorfen were negative for mutagenicity. Several studies were reported in EPA (1981). An assay with mouse lymphoma cells dosed with analytical Goal was negative. Technical Goal was mutagenic in a forward mutation assay with mouse lymphoma cells, but it produced no genotoxic effects in a rat cytogenicity assay. Positive results were determined in one of two Salmonella microsome assays with technical Goal. The polar fraction of technical Goal produced positive results in the same Salmonella assay, both with and without S9 activation. Assays for unscheduled DNA synthesis with technical Goal and with its polar fraction were both negative.

PCE is a contaminant of technical Goal (72 percent pure oxyfluorfen) and must be considered in evaluating the mutagenic potential of oxyfluorfen. Bacterial assays of PCE gave positive results in four out of eight tests (EPA 1981). One of the studies compared purified PCE and technical PCE and determined that the latter caused point mutations in Salmonella whereas the former did not.

EPA (1981) concluded that further study is required to define the mutagenicities of technical and analytical grades of oxyfluorfen and PCE. Thus, the evidence to date indicates that technical oxyfluorfen may be a possible human mutagen, due to the presence of PCE.

Neurotoxicity

No information was available on oxyfluorfen’s neurotoxic potential.
Immunotoxicity

No studies were available on which to base an evaluation of the immunotoxic properties of oxyfluorfen.

Data Gaps

No information was available on oxyfluorfen's potential for toxicity in humans, neurotoxicity, or immunotoxicity. The carcinogenicity information for oxyfluorfen and the impurity PCE was inconclusive. However, because PCE has demonstrated oncogenic effects in some studies, oxyfluorfen is considered carcinogenic in this risk assessment to be conservative.

FUNGICIDE HAZARD ANALYSES

Benomyl

Toxicity to Humans

According to Hayes (1982), exposure to the fungicide benomyl resulted in contact dermatitis in women of Japanese origin working in a greenhouse. However, this reaction was absent in co-workers who were similarly exposed—Japanese men and Mexican women. Ruzicka et al. (1976, as cited in Hayes 1982) reported no detectable change in the chromosomes of blood cells cultured from workers exposed to benomyl. An EPA human reference dose for chronic oral exposure was established at 0.05 mg/kg/day, based on a reproduction study in rats with a NOEL of 5 mg/kg/day and an applied uncertainty factor of 100 to account for interspecies extrapolation and intraspecies variation (EPA 1989).

General and Systematic Toxicity

Acute and Subacute Toxicity

Based on an oral LD₅₀ of greater than 10,000 mg/kg in rats (EPA 1984), benomyl is classified as a very slightly toxic chemical.

Subchronic and Chronic Toxicity

A 90-day oral toxicity study with dogs resulted in a NOEL of 12.5 mg/kg/day, with elevated liver enzyme levels observed at the lowest effect level of 62.5 mg/kg/day (EPA 1987a). The NOEL of 12.5 mg/kg/day was used as the systemic NOEL in this risk analysis.

A 2-year oral dog toxicity study resulted in a NOEL of 12.5 mg/kg/day. Adverse effects observed at the lowest effect level of 62.5 mg/kg/day included decreased body weight and cirrhosis of the liver (E. I. du Pont de Nemours & Co. 1968, as cited in EPA 1987b).

A 2-year rat study produced no adverse systemic effects at 125 mg/kg/day, the highest dose tested (EPA 1987a).

Reproductive and Developmental Toxicity

A three-generation reproduction study with rats resulted in a NOEL of 5 mg/kg/day (EPA 1987a). Decreased pup weights were observed at the lowest effect level of 25 mg/kg/day. This reproductive NOEL of 5 mg/kg/day was used in this risk analysis.

A rat teratology study resulted in a NOEL of 30 mg/kg/day. Microphthalmia (a teratogenic effect in which the eye is abnormally small) was observed at the lowest effect level of 62.5 mg/kg/day (EPA 1987a). An additional teratology study in rats resulted in a teratogenic NOEL of 31.2 mg/kg, with microphthalmia, decreased fetal body weights, and increased fetal mortality at the lowest effect level of 62.5 mg/kg/day (EPA 1987a).

A teratology study in mice produced malformations and variations in bone formation at the lowest effect level of 100 mg/kg/day and a teratogenic NOEL of 50 mg/kg/day (EPA 1987a).

According to EPA (1987a), benomyl caused the degeneration of germinal tissue and aspermatogenesis in male rats that received 3,400 mg/kg, the lowest dose tested.

Carcinogenicity

Positive oncogenicity studies include one benomyl and two methyl benzimidazole carbamate (MBC) mouse studies. MBC is a primary metabolite of benomyl and is considered by many investigators to be the biologically active agent of benomyl. This hypothesis has supporting data but has yet to be proven (USDA 1986). The 2-year benomyl feeding study showed liver neoplasms and lung carcinomas at 500 ppm, the lowest dose tested. The MBC feeding studies showed liver neoplasms after 80 weeks of 3,500 ppm dosing and liver carcinomas after 2 years of 1,500 ppm dosing. A 2-year chron. feeding study in mice revealed a significant increase in liver tumors for treated mice (EPA 1987a). EPA places this fungicide into Class C, meaning that it is a possible human carcinogen (EPA 1989).

Using the multitstage model, EPA (1988) has calculated a cancer potency value of 0.0039 per mg/kg/day.

Mutagenicity

Benomyl tested positive in 17 of 46 mutagenicity assays for a variety of bacterial, yeast, and mammalian tests (USDA 1986). Positive results were reported in two micronucleus tests in vivo—one with mice and one with rats. The rat micronucleus assay observed increased chromosomal damage in embryonic cells but showed no increase in bone marrow chromosomal aberrations. The mouse micronucleus test indicated a significant dose-related increase in bone marrow micronuclei at 250, 500, and 1,000 mg/kg. Benomyl was weakly
mutagenic in an in vitro mouse lymphoma test, both activated and nonactivated, and in a sister chromatid exchange assay in Chinese hamster ovary cells in vitro. A fruit fly mutagenicity test noted sterility in some broods. Positive mutagenic results were also observed in a prokaryotic study and in a eukaryotic study. Based on these findings, it appears that benomyl may be mutagenic.

EPA concluded that benomyl and MBC have been shown to cause weak mutagenic effects in the form of nondisjunction and aneuploidy of the cellular spindle apparatus in a variety of organisms; however, benomyl produces no effects associated with gene mutations or DNA repair activities (EPA 1987b). EPA stated that the impact of this mutagenic response on human health cannot be adequately assessed at this time. Mutagenic risk in the form of heritable spindle effects or point mutagenicity does not warrant a recommendation for regulatory action (EPA 1987b).

Neurotoxicity
No evidence of delayed neurotoxicity was found in a study of chickens (EPA 1984). No currently available information indicated that benomyl had a potential for neurotoxic effects.

Immunotoxicity
Technical benomyl produced mild sensitization in a study of male guinea pigs (Du Pont 1983). No other information was available on benomyl's potential for immunotoxicity.

Data Gaps
There were no data gaps for benomyl in this risk assessment. However, only limited information was available on neurotoxicity and immunotoxicity.

Metalaxyl
Toxicity to Humans
No data on human toxicity from the fungicide metalaxyl are available in the current literature. An EPA human reference dose was established at 0.06 mg/kg/day, using a subchronic toxicity study with dogs with a NOEL of 6.25 mg/kg/day and an applied uncertainty factor of 100 to allow for interspecies extrapolation and intraspecies variation (EPA 1989a).

General and Systemic Toxicity
Acute and Subacute Toxicity
Metalaxyl can be classified as a slightly toxic chemical based on an oral LD₅₀ of 669 mg/kg in rats (EPA 1988a).

Subchronic and Chronic Toxicity
A 6-month oral toxicity study with dogs resulted in a NOEL of 6.25 mg/kg/day, which is the systemic NOEL used in this risk assessment. At the lowest effect level of 25 mg/kg/day, test animals exhibited elevated liver enzyme levels and increased liver weight (EPA 1989b).

A 3-month oral toxicity study with rats resulted in a NOEL of 12.5 mg/kg/day, with decreased food consumption and minimal cellular hypertrophy in parenchymal cells at the lowest effect level of 62.5 mg/kg/day (EPA 1989b). A 2-year feeding study in rats also resulted in a NOEL of 12.5 mg/kg/day, with microscopically liver changes and increased liver weight observed at the lowest effect level of 62.5 mg/kg/day (EPA 1989b).

Reproductive and Developmental Toxicity
A rat teratology study resulted in a teratogenic and maternal toxic NOEL of 50 mg/kg/day (EPA 1989b). Female rats at the lowest effect level of 200 mg/kg/day had convulsions and ataxia; fetuses at this level exhibited unossified sternabrae (a skeletal variation). This reproductive NOEL of 50 mg/kg/day was used in this risk analysis.

A three-generation rat reproduction study resulted in a NOEL of 62.5 mg/kg/day, which was the highest dose tested (EPA 1989b).

A rabbit teratology study resulted in a maternal NOEL of 150 mg/kg/day. Rabbits doses at 300 mg/kg/day exhibited reduced body weight. No teratogenicity, embryotoxicity, or fetotoxicity was observed at the highest dose tested of 300 mg/kg/day (EPA 1989b).

Carcinogenicity
There is no evidence from two laboratory studies evaluated by EPA that metalaxyl is carcinogenic. A 2-year rat study found that metalaxyl was not oncogenic up to 62.5 mg/kg/day, which was the highest dose tested. Additionally, no effects were observed at doses up to the maximum tested (1,250 ppm = 187.5 mg/kg/day) in a 2-year mouse study (EPA 1985). EPA (1989a) has classified metalaxyl into Category E, meaning that there is evidence of noncarcinogenicity for humans.

Mutagenicity
Metalaxyl did not induce gene mutation in bacteria, yeast, and mouse lymphoma cells in vitro with or without metabolic activation. The fungicide also caused no structural or numerical chromosomal aberrations, as indicated by yeast, hamsters, or mice. No DNA damage was observed in bacteria, and no unscheduled DNA synthesis was noted in rat primary hepatocytes or human fibroblasts in vitro as a result of exposure to metalaxyl. These results suggest that metalaxyl is not genotoxic (EPA 1988b).
Neurotoxicity

A search of the available literature did not produce any information on the neurotoxicity of metalaxyl. One study (EPA 1988a) did, however, show no treatment-related changes in animal behavior when technical metalaxyl was administered to male and female beagle dogs at dietary concentrations of 0, 50, 250, or 1,250 ppm for 91 days.

Immunotoxicity

In a dermal sensitization study in guinea pigs, no sensitization reactions were observed; therefore, EPA (1988a) has concluded that metalaxyl is a nonsensitizer.

Data Gaps

No information was available on metalaxyl's toxicity in humans and only limited data were available on neurotoxicity.

FUMIGANT HAZARD ANALYSES

Chloropicrin

Toxicity to Humans

During World War I, the fumigant chloropicrin was referred to as "vomiting gas." Because it was not filtered from the inhaled air by certain gas masks of that era, it was mixed with other combat gases, such as phosgene. The tearing, coughing, and vomiting produced by chloropicrin inhalation caused troops to remove their masks and expose themselves to the other, more dangerous components of the mixture (Hayes 1982). These irritant properties are the reason for its mandatory inclusion as a warning agent in methyl bromide formulations, even though alone it is a fumigant. It produces severe sensory irritation in the upper respiratory passages and is extremely irritating to the eyes, mucous membranes, and stomach. It causes a smarting pain in the eyes at a concentration of 1 ppm in air (HSDB 1989). In humans, exposure to 7.5 ppm for 10 minutes is intolerable and exposure to 297.6 ppm for 10 minutes is lethal (HSDB 1989). The time-weighted average threshold limit value (TLV) for chloropicrin is 0.1 ppm (approximately 0.7 mg/m³) as a safe exposure level under average working conditions (ACGIH 1982, as cited in HSDB 1989).

General and Systemic Toxicity

Acute and Subacute Toxicity

An inhalation LC₅₀ value of 25.5 ppm (0.178 mg/L) was determined in a rat inhalation study (EPA 1987). Based on an oral LD₅₀ in rats of 37.5 mg/kg (EPA 1987), chloropicrin can be classified as severely toxic in mammals. A dermal LD₅₀ study with rabbits resulted in an LD₅₀ of 100 mg/kg (EPA 1987).

Subchronic and Chronic Toxicity

A subchronic inhalation study in rats led to the death of all the animals by day 40, as a result of respiratory insufficiency after exposure to 0.07 ppm (EPA 1981). A 6-month oral rat study resulted in a NOEL of 5 mg/kg/day. Decreased liver and spleen weights as compared with the control group were observed at the lowest effect level of 50 mg/kg/day (EPA 1987). This risk assessment used the threshold limit value (TLV) and not the NOEL for comparison of toxicity and exposure.

Reproductive and Developmental Toxicity

No teratogenic or reproduction studies were available for chloropicrin.

Carcinogenicity

NCI (1977) investigated the carcinogenic potential of chloropicrin in rats and mice. No neoplasms were observed at higher incidences in dosed rats than in the controls. No statistically significant increase of tumors was observed in mice. However, reduced survival time in rats and mice precluded a definitive determination of oncogenicity because most did not survive long enough to be at risk from late-appearing tumors. The high dose level in rats was 26 mg/kg/day and the high dose level in mice was 66 mg/kg/day. No conclusions can be drawn about chloropicrin's carcinogenic potential. EPA has not classified chloropicrin into a carcinogenicity category.

Mutagenicity

Few mutagenic assays on chloropicrin have been reported. It was found to be weakly mutagenic in the bacteria Salmonella typhimurium and nonmutagenic in two sex-linked recessive lethal tests with the fruit fly Drosophila melanogaster (USDA 1986).

Neurotoxicity

Castro (1968, as cited in USDA 1986) reported that chloropicrin does not act as an inhibitor of cholinesterase activity in human plasma in vitro. No data on neurotoxicity or behavioral effects in vivo are available.

Immunotoxicity

No information was available for assessing chloropicrin's immunotoxic potential.
Data Gaps

No information was available for chloropicrin for reproductive or developmental toxicity. Rat and mouse carcinogenicity assays were inconclusive because of the reduced survival time. Mutagenicity assays for chromosomal aberrations and primary DNA damage have not been performed. Only limited, in vitro data are available on neurotoxicity. No information was available on immunotoxicity.

Dazomet

The fumigant dazomet produces five soil degradation products: formaldehyde, methyl isothiocyanate (MITC), monomethylamine, hydrogen sulfide, and carbon disulfide. Carbon disulfide, and perhaps formaldehyde and monomethylamine, are also formed as metabolites in living organisms. The toxicity data for these products are presented following the dazomet toxicity discussions.

Toxicity to Humans

According to Gosselin et al. (1984), even dilute dazomet solutions cause skin irritation and sensitization in humans. No references dose, acceptable daily intake, or threshold limit value is available for dazomet. Smyth et al. (1966) reported that 19 of 200 human subjects were sensitized to dazomet in acetone. However, no reaction was observed when water was used as the solvent.

General and Systemic Toxicity

Acute and Subacute Toxicity

Based on the oral LD₅₀ of 320 mg/kg in rats (Smyth et al. 1966), dazomet can be classified as moderately toxic. Additional acute LD₅₀'s include 180 mg/kg for mice, 120 mg/kg for rabbits, and 160 mg/kg/day for guinea pigs (Smyth et al. 1966). Observations of acute toxicity include moderate congestion of the lungs, liver, and kidneys; opaque digestive tract membranes; convulsions; and reduced body temperature and activity (Smyth et al. 1966). In a primary dermal irritation study in rabbits, severe irritation was observed on abraded skin after 72 hours; however, no dose levels were reported (EPA 1987). The acute dermal LD₅₀ in rabbits is 7,100 mg/kg (Smyth et al. 1966). The inhalation LC₅₀ in rats was greater than 20,268 ppm (EPA 1987).

Subchronic and Chronic Toxicity

A subchronic dazomet toxicity study with rats reported decreased food consumption and body weight gain, as well as increased kidney-to-body and liver-to-body weight ratios at a dietary concentration of 500 ppm (25 mg/kg/day). There were no significant adverse effects on weight gain or organ weights at 120 ppm (6 mg/kg/day) (Smyth et al. 1966). A NOEL of less than 0.5 mg/kg/day resulted from a 2-year rat oral toxicity study, with necrosis observed in the kidney at 0.5 mg/kg/day and in the liver at 2 mg/kg/day (Gosselin et al. 1984). This risk assessment used the threshold limit value (TLV) and not the NOEL for comparison of toxicity and exposure.

Reproductive and Developmental Toxicity

USDA (1987) reports a teratogenicity study in rabbits that resulted in maternal toxicity at 50 mg/kg and fetal death at 25 mg/kg. The NOEL's were 25 mg/kg for dams and 12.5 mg/kg for offspring. This risk assessment used the threshold limit value (TLV) and not the NOEL for comparison of toxicity and exposure.

Carcinogenicity

Dazomet was found not to be oncogenic in a 2-year feeding study in rats. Two hundred male and 200 female rats were divided into 5 groups each. The males were given food mixed with dazomet at levels of 0, 0.44, 1.8, 7.0, and 30.3 mg/kg/day, and the females were fed dazomet at levels of 0, 0.50, 2.1, 7.9, and 34.0 mg/kg/day. A total of 33 tumors were found among the 156 rats that survived at least 1 year. These were distributed among organs, dosage groups, and tumor types without indication that they might be related to the feeding of dazomet (Smyth et al. 1966).

The cancer potency estimate for dazomet was based on the amount of formaldehyde formed as a soil breakdown product. Based on a Chemical Industry Institute of Toxicology (CIIT) rat study, EPA (1986) calculated a unit cancer risk of 1.3 x 10⁻³, corresponding to an exposure of 1 µg/m³ of formaldehyde continuously over a 70-year period. The potency is based on atmospheric concentration rather than feeding level, because the exposure is through inhalation. This potency was multiplied by the expected formaldehyde inhalation exposure, averaged over a 70-year lifetime, to give the carcinogenic risk.

Mutagenicity

According to EPA (1987), dazomet test results were negative for gene mutation in a sex-linked recessive lethal Drosophila assay and for chromosome aberration in a rat bone marrow cell assay. Dazomet was positive for chromosomal aberration in a mouse lymphoma assay and for primary DNA damage in a sister chromatid exchange assay, both in the absence of metabolic activation. Other studies reported dazomet as nonmutagenic in bacteria with and without metabolic activation (Shirasu et al. 1981 and Moriya et al. 1983, both as cited in USDA 1987).

Neurotoxicity

Smyth et al. (1966) reported that anesthetized dogs given intramuscular injection doses of 250 mg/kg dazomet experienced pupil dilation, increased cardiac rate and output, decreased
intestinal mobility, gradual rise in blood pressure, and an initial increase followed by a decrease in respiratory rate and volume, ending in death. This was characterized as a reaction resulting from stimulation of the sympathetic nervous system, with additional central nervous system stimulation.

**Immunotoxicity**

As stated under the Toxicity in Humans discussion, 19 of 200 human subjects were sensitized to formaldehyde in acetone. However, no reaction was observed when water was used as the solvent (Smyth et al. 1966).

**Data Gaps**

No information on the toxicity of dazomet to humans was available.

**Dazomet Degradation Products**

The following discussions present toxicity data for the dazomet degradation products: formaldehyde, methyl isothiocyanate (MITC), monomethylamine, hydrogen sulfide, and carbon disulfide.

**Formaldehyde**

In humans, formaldehyde is a skin and respiratory tract irritant and a dermal sensitizer (EPA 1976). Effects of chronic exposure include respiratory impairment and dermatitis. EPA (1976) reports that, in general, humans experience irritation at formaldehyde levels of approximately 1 ppm in the air. Menstrual disorders and secondary sterility in women have been attributed to exposure to formaldehyde (USDA 1987). The Occupational Safety and Health Administration has set a limit of 1 ppm as an 8-hour time-weighted average, but warns that 0.5 ppm should be considered an "action level" (OSHA 1987, as cited in HSDB 1989). The threshold limit value specified by the American Conference of Governmental Industrial Hygienists also is 1 ppm, as a time-weighted average (ACGIH 1988, 1989, as cited in HSDB 1989).

Formaldehyde is a slightly toxic chemical, with an LD₅₀ for rats of 800 mg/kg (USDA 1987). No toxicity to offspring was observed when mice were administered doses up to 185 mg/kg during the second week of gestation (USDA 1987). No teratogenic effects were observed in the offspring of rats who were exposed to 0.816 ppm during pregnancy (USDA 1987).

EPA (1986) reports that its review of 28 epidemiological studies of formaldehyde exposure revealed that 8 studies among different occupational groups indicated significant associations between site-specific respiratory cancer and exposure to formaldehyde. In addition, a group of professionals who are routinely exposed to formaldehyde, including anatomists, pathologists, embalmers, and undertakers, showed significantly increased mortality from leukemia and brain neoplasm. A study conducted by National Cancer Institute reported that there is little evidence that mortality from cancer is related to formaldehyde exposure at levels of workers experience (EPA 1986). However, an OSHA-National Institute of Occupational Safety and Health (NIOSH) study found a statistically significant excess in mortality caused by cancers of the buccal cavity and connective tissue in garment workers exposed to formaldehyde (EPA 1986). EPA (1986) concluded that the epidemiology of death suggested that formaldehyde may be a human carcinogen, though the evidence was classified as limited because exposures to multiple chemicals may have confounded the findings of excess cancers. EPA (1986) has placed formaldehyde in Category B1, indicating that it is a probable human carcinogen with sufficient evidence of carcinogenicity in animals and limited evidence of carcinogenicity in humans. In long-term rat and mouse inhalation studies conducted by Chemical Industry Institute of Toxicology, rats developed statistically significant numbers of nasal tumors (EPA 1986); though nasal tumors were also observed in mice, they were not statistically significant. Two other chronic inhalation studies performed on mice and hamsters did not demonstrate any carcinogenic effects (EPA 1986). Stomach tumors were observed in rats given drinking water that contained 0.5 percent formaldehyde (Takahashi et al. 1986, as cited in EPA 1986).

Formaldehyde has been reported to cause genetic mutation in fruit fly larvae, fungi, viruses, yeasts, and mammalian and human cells (EPA 1986). In vitro tests have detected single-strand breaks in DNA, sister chromatid exchange in mouse bone marrow, DNA-protein crosslinks, chromosome aberrations, and marginal results in a dominant lethal assay. After reviewing the data, the Consensus Workshop on Formaldehyde determined formaldehyde to be a weak mutagen (EPA 1986).

Formaldehyde has been demonstrated to cause changes in cerebral electric activity in humans at an exposure level of 53 ug/m³ (EPA 1976). It is capable of inducing dermal sensitization and changes in hematologic immune system elements (HSDB 1989).

**MITC**

No information is available on the toxicity of MITC to humans. Reference doses and threshold limit values are unavailable.

Based on the lowest oral LD₅₀'s of 72 mg/kg in female rats and 95 mg/kg in male rats (Schering 1983), MITC is moderately toxic. The acute inhalation LC₅₀ for rats is 1,900 g/m³ (Schering 1983). In a 3-month oral gavage study, the NOEL for mice was less than 1 mg/kg/day, the lowest dose tested (Schering 1983). Effects included stomach lesions, small cell infiltrates in liver tissues, and slight disturbance of spermatogenesis accompanied by edema of the interstitial tissue. The same effects and increased ovary and adrenal weights were noted in a 3-month rat feeding study at the lowest dose tested of 2 mg/kg/day (Schering 1983). A 12- to 13-week inhalation study with doses of 1, 10, and 45 ppm showed toxic effects at high dose levels, but no histological changes (Schering 1983). NOEL's resulting from 2-year feeding studies were 0.5 mg/kg/day in rats and 3 mg/kg/day in mice (Schering 1983).
1983). Chronic effects included reduced body weight gain and reduced water consumption. A teratology study with rabbits given MITC orally from day 6 to day 18 of gestation determined a maternal toxic NOEL of 1 mg/kg/day and a fetotoxic NOEL of 3 mg/kg/day (Schering 1983). An abnormal pattern of skeletal calcification was apparent in sacrificed embryos. In a three-generation rat reproductive study, no reproductive effects were seen at the highest dose tested of 10 mg/kg/day (Schering 1983).

No oncogenic effects were seen in a chronic toxicity study with mice given up to 200 ppm (30 mg/kg/day) or with rats given up to 50 ppm (2.5 mg/kg/day) (Schering 1983). MITC was negative for gene mutation and primary DNA damage in several assays, both with and without metabolic activation (Schering 1983).

Monomethylamine

Humans exposed briefly to monomethylamine gas at 20 to 100 ppm experience temporary eye, nose, and throat irritation; no symptoms of irritation are produced from longer exposures of less than 10 ppm (Clayton and Clayton 1982, as cited in HSDB 1986). The OSHA standard for monomethylamine gas is 10 ppm for a time-weighted average (NIOSH 1987). The threshold limit value is also 10 ppm. The acute inhalation LC₅₀ in mice is 1.893 ppm for 2 hours (NIOSH 1987). The lowest subcutaneous lethal dose is 200 mg/kg in rats and guinea pigs, 2.500 mg/kg in mice, and 2,000 mg/kg in frogs (HSDB 1986).

Hydrogen Sulfide

A human reference dose value for hydrogen sulfide was established at 0.003 mg/kg/day, based on a subchronic (105-day) oral toxicity study in pigs with a NOEL of 3.1 mg/kg/day and an uncertainty factor of 1,000 to allow for intra-species variation and interspecies variation and for subchronic exposure (EPA 1989). Humans exposed to doses of less than 50 ppm hydrogen sulfide experience irritation in the eyes, skin, and respiratory tract (Rumack 1986, as cited in HSDB 1986). The lowest lethal concentration of hydrogen sulfide gas reported for humans is 6/00 ppm for 30 minutes (NIOSH 1987). Death is caused by action on the nervous system, resulting in respiratory paralysis (Klaassen et al. 1986). The inhalation LC₅₀ in rats is 444 ppm, and in mice it is 673 ppm for 1 hour (NIOSH 1987). The lowest lethal concentration for guinea pigs is 0.719 ppm for 8 hours, and the lowest 5-minute lethal concentration found in mammals is 800 ppm (HSDB 1986). The American Conference of Governmental Industrial Hygienists threshold limit for hydrogen sulfide is 10 ppm (NIOSH 1987). The OSHA standard is 20 ppm, with a peak of 50 ppm for 10 minutes. Because of the evidence of eye injury, headaches, nausea, and insomnia following several hours of exposure to hydrogen sulfide, NIOSH adopted a maximum exposure limit of 10 ppm for 10 minutes (EPA 1989).

Carbon Disulfide

In the stomach, dazomet is broken down by digestive action to carbon disulfide. A human reference dose value was established at 0.1 mg/kg/day, based on combined inhalation and teratology study in rats and rabbits (Hardin et al., as cited in EPA 1989) and a rabbit teratology study (Price et al. 1984, as cited in EPA 1989). The Hardin et al. study reported no abnormal effects at 11 or 22 mg/kg/day; however, the teratology study with rabbits reported fetal resorptions and malformations at a level of 25 mg/kg/day. Based on these findings, EPA used the lower level of the Hardin et al. study, 11 mg/kg/day, as the NOEL. The reference dose was based on this NOEL and an uncertainty factor of 100 for inter-species variation and intraspecies variation (EPA 1989). The lowest oral lethal dose of carbon disulfide reported for humans is 14 mg/kg (HSDB 1986). Severe toxic effects have resulted from prolonged vapor exposures to concentrations as low as 0.1 mg/L (Gosselin et al. 1984). Chronic doses of carbon disulfide in humans result in motor disturbances, anemia, disturbances of cardiac rhythm, and increased urination. There is often degeneration in the liver and central nervous system, and fatty changes are found in the heart, liver, and kidneys (Thienes 1972, as cited in HSDB 1986). In a subchronic inhalation study, rabbits showed slowing of nerve conduction velocity and clinical paralysis in the hind limbs (Seppalainen and Linnoila 1975).

Carbon disulfide was not mutagenic to two strains of Salmonella or to Escherichia coli with and without metabolic activation. Negative results were also obtained in a fruit fly mutagenicity test (Donner et al. 1981, as cited in HSDB 1986). Carbon disulfide did increase the frequency of sister chromatid exchange in cultured human lymphocytes exposed to 10,200 ug/L in the medium; however, at lower concentrations no effects were observed (Bassendowska-Karska 1981, as cited in HSDB 1986; NIOSH 1987).

Methyl Bromide

Toxicity to Humans

According to USDA (1986), approximately 950 poisoning cases involving fatalities, systemic poisoning, skin injuries, and eye injuries have been reported as a result of exposure to the fumigant methyl bromide since the turn of the century. Early symptoms of methyl bromide exposure include malaise, visual disturbances, nausea and vomiting, skin irritation, eye irritation, listlessness, vertigo, and muscular weakness. Without treatment, this may progress to confusion, convulsions, and possibly death. An EPA human reference dose of 0.0014 mg/kg/day was established for methyl bromide based on a subchronic oral toxicity study in rats with a NOEL of 1.4 mg/kg/day. An uncertainty factor of 1,000 was applied in the calculation of the reference dose value to account for interspecies extrapolation, intraspecies variation, and the use of a subchronic study in estimating lifetime risk (EPA 1989a). The time-weighted average threshold limit value (TLV) for methyl bromide is 3.0 ppm (approximately 19 mg/m³) as a safe exposure level under working conditions (ACGIH 1980, as cited in NLM 1986).
General and Systemic Toxicity

Acute and Subacute Toxicity

EPA (1988) reported an oral LD$_{50}$ in rats of 214 mg/kg, which would classify methyl bromide as a moderately toxic pesticide. An acute inhalation study with mice resulted in a 1-hour mean LC$_{50}$ of 1.164 ppm (4.5 mg/L) (USDA 1986). A NOEL of 840 ppm (3.25 mg/L) was observed in mice (Alexeef 1982, as cited in USDA 1986). An additional LC$_{50}$ value in mice was reported to be 396 ppm (Bolander and Polyak 1986, as cited in USDA 1986).

Subchronic and Chronic Toxicity

A subchronic oral toxicity study with rats produced a NOEL of 1.4 mg/kg/day, with histopathological abnormalities observed in the forestomach at the lowest effect level of 7 mg/kg/day (Danse et al. 1984). A study conducted by Irish et al. (1941, as cited in EPA 1989b) exposed rats, rabbits, guinea pigs, and monkeys to methyl bromide by means of inhalation for 6 months (5 days/week). This study resulted in a NOEL of 17 ppm (3.8 mg/kg/day), based on pulmonary damage and paralysis at the lowest effect level of 33 ppm. These effects were exhibited in the rabbit, which was the most sensitive species to methyl bromide in the study. Ninety-day inhalation studies in both rats and mice resulted in NOEL’s equal to 80 ppm (USDA 1986). This risk assessment used the threshold limit value (TLV) and not the NOEL for comparison of toxicity and exposure.

Reproductive and Developmental Toxicity

USDA (1986) reports no teratogenic effects in rats following inhalation exposure to methyl bromide at a dose level of 70 ppm. EPA (1989b) reports an inhalation fetotoxic and maternal NOEL of 20 ppm in rabbits. This risk assessment used the threshold limit value (TLV) and not the NOEL for comparison of toxicity and exposure.

Carcinogenicity

Although the previously discussed Danse et al. 13-week oral toxicity rat study reported squamous cell carcinomas in the forestomach of rats at the high-dose level (50 mg/kg/day), EPA and scientists at the National Toxicology Program have questioned these results (EPA 1989b). EPA (1989b) has classified methyl bromide into Category D, meaning that the evidence is insufficient on which to base a judgment about its oncogenic potential.

Because of the conservative nature of this risk assessment, a carcinogenicity risk analysis was conducted for methyl bromide, even though existing evidence is inconclusive. The tumor data from the Danse et al. study was used to calculate a cancer potency of $1.69 \times 10^{11}$ per mg/kg/day at the upper limit of the 95-percent confidence level. It should be noted that extrapolation from this study may be inaccurate because of the short duration of the study and the cytotoxic effects (hyperplasia) noted. Evaluation of additional studies is necessary to determine a possible connection between the cytotoxic and the carcinogenic effects in the forestomach (Danse et al. 1984).

Mutagenicity

Bacterial assays have indicated that methyl bromide can be weakly to strongly mutagenic (USDA 1986). Five tests revealed positive results, including four point mutation assays with bacteria and mouse lymphoma cells and one sex-linked recessive lethal assay in fruit flies. Two tests revealed negative results for mammalian DNA damage. Methyl bromide can be considered mutagenic.

Neurotoxicity

According to USDA (1986), methyl bromide is a neurotoxic agent in mammals, causing behavioral changes, sensory impairment, motor impairment, and changes in brain biochemistry. Major neurological effects have been reported in several severe acute methyl bromide poisoning incidents, including ataxia, incoordination, Jacksonian seizures, status epilepticus, epileptiform convulsions, clonic-tonic seizures, and narcosis or unconsciousness.

Immunotoxicity

No information was available on methyl bromide’s potential for immunotoxicity.

Data Gaps

The only available study on the carcinogenic potential of methyl bromide is inconclusive. There is no information available on immunotoxicity.
INTRODUCTION

This section presents the methods used in the nursery pesticide exposure analysis. The first section of background information discusses the terminology of pesticide use and describes potential human exposure. The second section describes the environmental setting of the nursery, the operations at the nursery that involve the use of pesticides, and the growth cycle of nursery stock. The third section describes the environmental fate models that were used to estimate potential exposure. These include the modeling of pesticide residues on vegetation, modeling of pesticide drift, and water resource modeling of the potential for leaching and runoff. The fourth section presents the methodology used to calculate doses and exposures to members of the public and workers, including the lifetime doses used to evaluate the risk of cancer.

BACKGROUND INFORMATION

This section defines some terms used in the discussion of the exposure analysis methods and explains the relationship between the exposures and doses estimated in the analysis and the exposures and doses that might actually occur in future nursery operations.

Pesticide Characteristics

Most pesticides are formulated and sold by the manufacturer as emulsifiable concentrates (EC), wettable powders (WP), oil solutions, granules, dusts, or aerosols. Pesticides in liquid form are sold as concentrates with a specified number of pounds of active ingredient, usually between 1 and 10, per gallon of concentrate, with inert ingredients forming the remaining portion. Fumigants are packaged either as liquefied gases in pressurized containers and are applied by injecting the gases into the soil, often under a plastic tarp, or in granular form applied by soil incorporation.

Before an herbicide, fungicide, or insecticide is applied, it is normally mixed with a carrier, usually water, according to the manufacturer's label instructions for the particular treatment purpose and the desired application rate in pounds of active ingredient per acre. In ground applications, the concentrate is generally mixed with 50 to 100 gallons of carrier for every acre to be treated. Pesticide concentrate, stored in 5-gallon drums or wettable powder in 1- or 5-pound bags, is prepared for application and loaded into the application equipment.
Pesticide Drift

Pesticide application equipment is designed to cover the target area with a minimum of wind-borne off-target movement, called drift. Spray equipment nozzles are designed to produce medium to large droplets, because smaller droplets tend to remain airborne and drift with the air currents away from the target area. However, some insecticide sprays may use smaller droplets to ensure contact with the target pest insects. Despite the effectiveness of the application equipment, a small fraction of the droplets may break up into smaller droplets that the wind could blow offsite. In nursery operations, drift is seldom a significant problem because spray booms are generally mounted only a few feet (12 to 30 inches) above the ground and the pesticide is applied at a low pressure with large nozzles. Based on field study data (Yates et al. 1978; Byass and Lake 1977), drift beyond 25 feet is less than 1 percent of the applied rate.

Downwind movement of volatile compounds, particularly fumigants, may also be a problem. The methyl bromide and chloropicrin fumigants are applied as a gas mixture under tarp so that a majority of the volatilizing portion will remain in the soil environment. However, during application or an accident, such as a badly seated hose-fitting or a tear in a tarp, some fumigant release and subsequent drift are expected to result in off-site exposure.

Exposure and Dose

Two primary conditions are necessary for a person to receive a pesticide dose that may result in a toxic effect. First, the pesticide must be present in the person’s immediate environment so that it is available for intake. It must be in the air the person breathes, on the person’s skin, or in the person’s food or water. The amount of pesticide present in the person’s immediate environment is the exposure level. Second, the pesticide must then move into the person’s body by some route. If it is in the air, it must be inhaled into the air passages and lungs. If it is on the clothing or skin, it must be absorbed through the skin. The amount that moves into the body is the dose.

Thus, although two people may be subjected to the same level of exposure—for example, two workers applying herbicide with a tractor-mounted boom—one may get a much lower dose than the other by wearing protective clothing, using a respirator, or washing immediately after spraying. Exposure, then, is the amount of pesticide available to be taken in; dose is the amount that actually enters the body.

In this analysis, scenarios and methods were developed to determine the doses of herbicides, fungicides, and insecticides that a person might receive as a result of nursery operations. These doses were compared to the laboratory no-observed-effects level (NOEL) doses presented in Section D-2. In the case of fumigants, however, air exposures were computed, instead of doses, and compared to the threshold limit value (TLV) air concentrations. This was done because the inhalation exposure to the fumigants is much greater than the dermal exposure. Comparison of the air exposure to the TLV gives a more accurate result than conversion of the air exposure to a dose. The TLV’s are also presented in Section D-2.

NURSERY OPERATIONS

The USDA Forest Service operates one bare-root nursery in the Intermountain Region, the Lucky Peak Nursery near Boise, Idaho, which is administered by the Boise National Forest. This nursery has a total area of 296 acres, with 61 acres utilized for seedling production. The Lucky Peak Nursery uses 9 different pesticides in the nursery, and the nursery manager chooses the particular pesticides that best control the pests affecting each group of seedlings.

Description of the Lucky Peak Nursery

The Lucky Peak Nursery produces conifer seedlings which are generally lifted after approximately 2 or 3 years of growth. The nursery has the capacity to produce approximately 8.2 million seedlings annually. Species include ponderosa pine, lodgepole pine, Douglas fir, Engelmann spruce, western larch and a variety of shrubs such as bitter brush, grown for wildlife habitat. The nursery generally employs the following number of personnel annually for its operations: 1 to 2 mixer/loader/applicators, 5 to 10 weeders, 7 to 8 inventory personnel, 15 to 62 lifter/sorter/packers, 3 fumigators for methyl bromide/chloropicrin application, 6 fumigators for dazomet application, and 4 tarp lifters.

The pesticide application schedule for the nursery is shown in Table D-3-1. This schedule represents the most likely schedule, application rates and number of applications. Applications may be varied at the discretion of the nursery manager depending on climatic conditions, pest populations, and other factors.

The fields to be planted are fumigated with a methyl bromide and chloropicrin mixture in September or April and the seeds are sown in May. Approximately 18 acres of soil are fumigated annually. In some years, the fumigant dazomet is used in place of the methyl bromide/chloropicrin mixture. All seed-bed pesticides are applied with tractor-mounted booms. Glyphosate is applied to perimeter areas with scooter-mounted booms and hand-held sprayers.

There is one Forest Service residence on-site within 100 feet of the nursery beds. Another residence is located approximately a quarter mile northwest of the nursery. The land surrounding the nursery is mostly rangeland with limited private residences in the area. Directly to the north of the nursery is Mores Creek. To the east is a quarry. Beyond the quarry is the Lucky Peak Reservoir, which Mores Creek enters. To the west and south are large areas of scattered sagebrush. To the southwest is a farm residence and cultivated fields in which cows are likely to be grazing.

The nursery is visited by about 2000 people per year who come to walk on the Lucky Peak Nursery nature trail. The trail begins about 500 feet from the nearest treated field.
**Table D-3.1**

**Lucky Peak Nursery Schedule for Pesticide Applications (based on average use)**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Growth Year</th>
<th>Chemical</th>
<th>Treatment Units (max)</th>
<th>Rate (lb/acre)</th>
<th>Applications per Year (max)</th>
<th>Month of Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fencelines, Roadways</td>
<td>-</td>
<td>Glyphosate</td>
<td>3 acres</td>
<td>0.75</td>
<td>2</td>
<td>April, October</td>
</tr>
<tr>
<td>Nursery Stock</td>
<td>-</td>
<td>67% Methyl bromide/33% chloropicrin</td>
<td>18 acres</td>
<td>350.</td>
<td>1</td>
<td>April, October</td>
</tr>
<tr>
<td>Nursery Stock</td>
<td>-</td>
<td>Dazomet</td>
<td>18 acres</td>
<td>350.</td>
<td>1</td>
<td>April, October</td>
</tr>
<tr>
<td>Pine</td>
<td>1</td>
<td>Oxyfluorfen</td>
<td>15.1 acres</td>
<td>0.3</td>
<td>2</td>
<td>May, June</td>
</tr>
<tr>
<td>Douglas fir</td>
<td>1</td>
<td>Oxyfluorfen</td>
<td>1.4 acres</td>
<td>0.3</td>
<td>2</td>
<td>May, June</td>
</tr>
<tr>
<td>Pine/Spruce</td>
<td>1</td>
<td>Napropamide</td>
<td>16.5 acres</td>
<td>3.0</td>
<td>2</td>
<td>May, June</td>
</tr>
<tr>
<td>Douglas fir</td>
<td>1</td>
<td>Benomyl</td>
<td>1.4 acres</td>
<td>4.0</td>
<td>3</td>
<td>June-September</td>
</tr>
<tr>
<td>Western larch</td>
<td>1</td>
<td>Benomyl</td>
<td>0.2 acre</td>
<td>4.0</td>
<td>3</td>
<td>June-September</td>
</tr>
<tr>
<td>Spruce</td>
<td>1</td>
<td>Benomyl</td>
<td>0.5 acre</td>
<td>4.0</td>
<td>3</td>
<td>June-September</td>
</tr>
<tr>
<td>Douglas fir</td>
<td>1</td>
<td>Metalaxyl</td>
<td>2.0 acres</td>
<td>0.625</td>
<td>1</td>
<td>April</td>
</tr>
<tr>
<td>Spruce</td>
<td>1</td>
<td>Metalaxyl</td>
<td>0.3 acre</td>
<td>0.625</td>
<td>1</td>
<td>April</td>
</tr>
<tr>
<td>Western larch</td>
<td>1</td>
<td>DCPA</td>
<td>0.2 acre</td>
<td>10.5</td>
<td>2</td>
<td>May, June</td>
</tr>
<tr>
<td>Spruce</td>
<td>1</td>
<td>DCPA</td>
<td>0.5 acre</td>
<td>10.5</td>
<td>2</td>
<td>May, June</td>
</tr>
<tr>
<td>Crop</td>
<td>Growth Year</td>
<td>Chemical</td>
<td>Treatment Units (max)</td>
<td>Rate (lb/acre)</td>
<td>Applications per Year (max)</td>
<td>Month of Application</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------</td>
<td>-----------------</td>
<td>-----------------------</td>
<td>----------------</td>
<td>----------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Conifers</td>
<td>2</td>
<td>Oxyfluorfen</td>
<td>&lt;0.1 acre</td>
<td>0.3</td>
<td>2</td>
<td>April, June</td>
</tr>
<tr>
<td>Shrubs</td>
<td>2</td>
<td>Oxyfluorfen</td>
<td>&lt;0.1 acre</td>
<td>0.3</td>
<td>1</td>
<td>July</td>
</tr>
<tr>
<td>Douglas fir</td>
<td>2</td>
<td>Metalaxyl</td>
<td>4.0 acres</td>
<td>0.625</td>
<td>1</td>
<td>April</td>
</tr>
<tr>
<td>Spruce</td>
<td>2</td>
<td>Metalaxyl</td>
<td>0.3 acre</td>
<td>0.625</td>
<td>1</td>
<td>April</td>
</tr>
<tr>
<td>Conifers</td>
<td>2</td>
<td>DCPA</td>
<td>&lt;0.1 acre</td>
<td>10.5</td>
<td>2</td>
<td>May, June</td>
</tr>
<tr>
<td>Douglas fir</td>
<td>3</td>
<td>Oxyfluorfen</td>
<td>&lt;0.2 acre</td>
<td>0.3</td>
<td>2</td>
<td>April, June</td>
</tr>
<tr>
<td>Douglas fir</td>
<td>3</td>
<td>Metalaxyl</td>
<td>4.0 acres</td>
<td>0.625</td>
<td>1</td>
<td>April</td>
</tr>
<tr>
<td>Spruce</td>
<td>3</td>
<td>Metalaxyl</td>
<td>0.3 acre</td>
<td>0.625</td>
<td>1</td>
<td>April</td>
</tr>
<tr>
<td>Spruce</td>
<td>3</td>
<td>DCPA</td>
<td>&lt;0.1 acre</td>
<td>10.5</td>
<td>2</td>
<td>May, July</td>
</tr>
</tbody>
</table>
The closest water to the nursery-treated beds is a stream to the south of the nursery, about 100 feet from the treated beds. A portion of the runoff from nursery fields enters this stream, which feed directly into Lucky Peak Reservoir. The majority of the runoff from the seedbed areas drains to a tributary to Mores Creek to the east. Another portion of the nursery drainage flows north and feeds directly into Mores Creek, which is located 200 feet from treated nursery beds in this area.

There is a subsurface drainage system at the nursery and subsurface drainage is collected and released with surface drainage. All surface and subsurface drainage from the nursery eventually feeds into the Lucky Peak Reservoir, which is located 800 feet from the treated nursery beds at its nearest point. The aquifer below the nursery provides water for both drinking and irrigation, with well depths averaging 170 feet in the area. The nursery soils vary in texture from clayey loams to loamy sands.

Growth Cycle of Nursery Stock

The Lucky Peak Nursery generally sows seeds in May following the annual fumigation of approximately 18 acres of the soil in the spring or fall. At any one time, some portion of the acreage is planted in seedlings and some portion is planted in cover crop. No herbicides are used to the control weeds in the cover crop. The cover crop is worked into the soil prior to fumigation and sowing to add organic matter to the soil.

Seedlings are generally lifted after approximately 2 or 3 years of growth. Some lifting occurs in both the fall and the spring. The fall lift occurs for several days in mid-November and portions of the conifers and most of the shrubs are lifted at this time. The spring lift occurs for about two weeks in late February and early March, during which time mainly ponderosa pine and lodgepole pine are lifted. A number of herbicides and fungicides are applied as needed to control weeds and diseases. The pesticides used vary with the plant species being grown and the target pest.

PESTICIDE FATE MODELING

To estimate human exposure to pesticides, it was necessary to predict the environmental transport and fate of the pesticides. Several models were used for this purpose. Pesticide spray drift residues were estimated based on field studies. To estimate pesticide residue on vegetation, the Foliar Washoff of Pesticides (FWOP) model (Smith and Carsel 1984) was used. FWOP calculated the amount of a pesticide that washed off treated vegetation by irrigation or rainfall. The Leaching Evaluation of Agricultural Chemicals (LEACH) and Groundwater Loading Effects of Agricultural Management System (GLEAMS) models were used to evaluate pesticide leaching and runoff (Davis et al 1990a; Davis et al. 1990b; Dean et al. 1984).

Estimation of Residues on Vegetation

Pesticide residues on seedling leaf surfaces depend on a pesticide's application rate and the amount of leaf surface area available for deposition. A leaf area index (the ratio of a plant's leaf surface area to the ground surface area) for each age class of nursery stock was used to account for the decrease in dislodgable residue per unit of leaf surface area as the plants increase in size. For human exposure modeling, the indexes were set high to simulate a conservative condition where a large portion of the pesticide would be available for dermal contact. The stock was assumed to receive the full per-acre application rate on each leaf.

To estimate the amount of pesticide washed off the vegetation during irrigation or rainfall, the FWOP model calculates the rate of pesticide loss from foliage. The model uses the initial pesticide residue values, the specific first-order degradation rate constant for a pesticide on foliage, a washoff coefficient of 10 percent per centimeter of water, and the amount of irrigation water or rainfall received by the crop per day. Initial residue values were adjusted by a factor of 0.6 based on the dislodgable fraction used for non-organochlorine pesticides in the Chemical, Runoff, and Erosion from Agricultural Management Systems (CREAMS) model (USDA 1980, as cited in Smith and Carsel 1984).

When available, a pesticide's dislodgable residue decay rate was used to represent the time course of the dissipation of dislodgable residues. In cases where the dislodgable residue decay rate was unknown, a degradation coefficient was used to represent the total residue decay rate for residues in the plant and on the plant's surface. The residue decay rates are listed in Table D-3-2. In general, the decay rate represents a lower limit that likely overestimates the surface residue dissipation, and therefore overestimates doses from vegetation contact, because surface residues generally degrade faster than residues in plants.

Drift Modeling

The analysis of pesticide drift at 25 feet and at 100 feet was based entirely on published data derived from field tests of tractor spray systems (Yates et al. 1978; Byass and Lake 1977). In the study by Yates et al. (1978), glyphosate was applied to a flat, dry field of short grass and deposition was measured by means of mylar fallout sheets placed at various distances downwind. Yates et al. (1978) presented regression curves that represent deposition from one long swath of spray. To use these data to estimate spray drift from the nursery beds, a computer program was written to accumulate the residues from multiple swaths. The program also corrects for application rates and swath widths that differ from those used in the Yates et al. (1978) study.

Byass and Lake (1977) measured deposition during field tests of ground sprayers using a dye tracer. Data from two of the tests were used to calculate regression equations that could be input to the same computer program used to analyze the Yates et al. (1978) test results. One of these equations, representing a relatively high drift situation, predicted residues about twice as high as the Yates et al. (1978) test. However, the wind speed ranged from 10.6 to 15.5
### Table D-3-2

**Degradation Rates of the Lucky Peak Nursery Pesticides on Foliage**

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>$K_r$</th>
<th>Half-life (days)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbicides</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCPA</td>
<td>0.025</td>
<td>28</td>
<td>Hurto et al. 1979</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>0.050</td>
<td>14</td>
<td>Newton et al. 1984</td>
</tr>
<tr>
<td>Napropamide</td>
<td>0.010</td>
<td>5.3</td>
<td>Stauffer Chemical Company 1984</td>
</tr>
<tr>
<td>Oxyfluorfen</td>
<td>0.060</td>
<td>0.5</td>
<td>Massey 1986</td>
</tr>
<tr>
<td>Fungicides</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benomyl</td>
<td>0.022</td>
<td>32</td>
<td>Baude et al. 1974, as cited in USDA 1986</td>
</tr>
<tr>
<td>Metalaxyl</td>
<td>0.347</td>
<td>2</td>
<td>Northeastern Regional Pesticide Coordinators 1966, as cited in USDA 1987</td>
</tr>
</tbody>
</table>

*The fumigants chloropicrin, dazomet, and methyl bromide are not included in this table since there will be no foliage contact.*

*Degradation rate constant for pesticides on foliage.*

*In most cases a specific degradation rate or half-life was not reported, but it was calculated from residue information given by the author(s).*
and the runoff curve number CN—were.

The fact that Influence pesticide contamination of ground water resources include:

- All the factors listed above for surface water
- Ground water hydrology characteristics—depth to ground water, permeability of soils and rock units, and groundwater flow rate
- Irrigation and cultivation practices, such as the use of tile drains, and any practices used to increase the rate of infiltration or inhibit runoff

The Lucky Peak Nursery site was evaluated for potential contamination of subsurface water from the leaching of pesticides by rainfall or irrigation water using the LEACH methodology described below. Although the LEACH analysis predicted that pesticide contamination of groundwater or water in the unsaturated zone is unlikely, a more comprehensive model, GLEAMS, was also used to evaluate the Lucky Peak Nursery. The GLEAMS model, also described below, simulates pesticide concentrations dissolved in surface runoff, sorbed to eroded soils, and leached below the plant root zone.

The LEACH Model

Background

The Leaching Evaluation of Agricultural Chemicals (LEACH) methodology was developed for EPA to assess the potential of pesticides to leach below the plant root zone in major agricultural areas in the United States (Dean et al. 1984). The LEACH methodology predicts the probability of leaching based on 25-year simulations using the Pesticide Root Zone Model (PRZM) developed by Carssel et al. (1984). Major factors considered in the LEACH methodology include the rate of pesticide degradation and adsorption, climatic factors, and soil characteristics.

Characteristics of 19 sites across the country were evaluated to construct the curves in the LEACH Handbook. Using a sensitivity analysis, three key parameters—the chemical partition coefficient Kp, the pesticide decay rate Kd, and the runoff curve number CN—were chosen and leaching sequences were generated for important levels of these parameters. The PRZM model, which has been validated at sites around the country, was used to generate these data. The partition coefficient Kp describes the distribution of pesticide between the solution phase and the soil phase. The Kd value describes the rate of decay of the pesticide in the soil environment. The CN value is a measure of the runoff potential of a field, based on soil type and land use.

- Surface hydrology characteristics—land slope, vegetation and soil type, land management practices, and location of surface water recharge areas

The factors that influence pesticide contamination of ground water resources include:

- All the factors listed above for surface water
- Ground water hydrology characteristics—depth to ground water, permeability of soils and rock units, and groundwater flow rate
- Irrigation and cultivation practices, such as the use of tile drains, and any practices used to increase the rate of infiltration or inhibit runoff

The Lucky Peak Nursery site was evaluated for potential contamination of subsurface water from the leaching of pesticides by rainfall or irrigation water using the LEACH methodology described below. Although the LEACH analysis predicted that pesticide contamination of groundwater or water in the unsaturated zone is unlikely, a more comprehensive model, GLEAMS, was also used to evaluate the Lucky Peak Nursery. The GLEAMS model, also described below, simulates pesticide concentrations dissolved in surface runoff, sorbed to eroded soils, and leached below the plant root zone.

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Results:

The LEACH methodology was applied to all pesticides used at the Lucky Peak Nursery, assuming a silt loam soil. However, some of the nursery beds are located on soils classified as sandy loams, which generally have a greater leaching potential. The soil at the nursery is typical of the hydrologic group B, which indicates that it has a moderate runoff and leaching potential. Tree nursery crops and management practices were not considered in the development of the LEACH methodology, so for this analysis, a crop with a comparable root zone depth was chosen. The estimated effective root zone of the seedlings at the Lucky Peak Nursery is 24 inches, or approximately 61 centimeters at the time of harvesting. Wheat grown in Washington silt loam soil was selected as being the most closely representative of the Lucky Peak nursery situation.

The results of the LEACH analysis are presented in Table D-3-3. The two categories under "fraction leaching" may be interpreted as the fraction of the pesticide applied that could potentially leach below the root zone with 50 percent probability and with 1 percent probability. Thus, these probabilities represent the average and worst-case estimates, respectively, of the fraction of pesticide that is expected to move below the root zone. For example, 50 percent of the time, 0 to 3 percent of the DCPA applied to silt loam soils at Lucky Peak Nursery will potentially leach below the root zone; 1 percent of the time, 0 to 7 percent of the pesticide applied to the same area will leach below the root zone.

The LEACH methodology is used primarily as a screening tool for identifying pesticides with the potential to contaminate ground water. Of the nine pesticides used at Lucky Peak Nursery, three were flagged by LEACH as having the potential to leach below the root zone. To further define the potential impact of these pesticides, this site was evaluated in more detail using the GLEAMS model. Pesticide concentrations will be diluted upon mixing with ground water, but recharge rates, local ground water velocities, and the relative volume of the recharge will determine if dilution effects are sufficient to mitigate the regional effect of pesticide applications. A literature review for all pesticides applied at Lucky Peak Nursery is contained in the following section.

The GLEAMS Model

Background

Groundwater Loading Effects of Agricultural Management Systems (GLEAMS) is a mathematical model developed to evaluate the movement of agricultural chemicals in surface runoff and in the plant root zone resulting from agricultural management practices (Leonard et al. 1987).

The GLEAMS model is made up of three components—the hydrology component, the erosion component, and the pesticides component. The model requires an input file for each component, along with input files for daily rainfall and daily average temperature.
### Table D-3.3

**Leaching Potential of the Lucky Peak Nursery Pesticides**

<table>
<thead>
<tr>
<th>Pesticide*</th>
<th>$K_d$</th>
<th>$K_s$</th>
<th>$R$</th>
<th>Fraction Leaching$^e$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbicides</td>
<td>0-18</td>
<td>0-18</td>
<td>0-18</td>
<td>0-18</td>
</tr>
<tr>
<td>DCPA</td>
<td>0.77</td>
<td>0.023</td>
<td>3.8</td>
<td>0.3</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>18.5</td>
<td>0.023</td>
<td>69</td>
<td>NS</td>
</tr>
<tr>
<td>Napropamide</td>
<td>15.3</td>
<td>0.008</td>
<td>99</td>
<td>NS</td>
</tr>
<tr>
<td>Oxyfluorfen</td>
<td>698</td>
<td>0.017</td>
<td>2100</td>
<td>NS</td>
</tr>
<tr>
<td>Fungicides</td>
<td>7.4</td>
<td>0.002</td>
<td>28</td>
<td>0.8</td>
</tr>
<tr>
<td>Benomy</td>
<td>1.3</td>
<td>0.028</td>
<td>5.7</td>
<td>0.1</td>
</tr>
</tbody>
</table>

*The fumigants chloropicrin, dazomet, and methyl bromide are not included in this table. Since they volatize rapidly and a large portion is quickly lost to the atmosphere, the LEACH methodology was not an appropriate tool to use for their analysis.

$^b$Chemical partitioning coefficient; high values indicate low mobility, low values indicate high mobility.

$^c$Degradation rate constant for pesticides in soil.

$^d$Retardation coefficient, calculated based on the $K_d$ value and soil properties.

$^e$Fraction leaching = percent chance that at least this quantity will leach.

$^f$NS = not significant (less than 0.05% leaches).
The hydrology component of the GLEAMS model simulates all major processes that occur during a rainstorm including infiltration, soil-water movement, surface-water flow, and evapotranspiration between storms. Applied irrigation water may also be included in the model input, as well as water derived from snow melt. Water balance calculations are done using a storage routing technique that divides the plant root zone into seven layers. Characteristics of the soil profile such as porosity, water retention, and organic matter content are assigned to each soil layer by the model. Upward movement of water from evaporation and plant uptake due to transpiration are also determined layer by layer.

The erosion component of GLEAMS calculates erosion, sediment yield, and particle composition of the sediment. Both the Universal Soil Loss Equation (USLE) and the Williams-modified USLE are used to describe soil detachment and sediment transport separately (Foster et al. 1980, as cited in Knisel 1980). A combination of overland flow, channel flow, and impoundment elements may be selected by the user to characterize the field site. The model also calculates sediment characteristics so that the mass of pesticides that is sorbed to sediments can be predicted by the pesticide component.

The pesticide component of GLEAMS considers mode of application, foliar interception, degradation on plant surfaces and in soils, foliar wash-off, and adsorption and desorption processes. Lumped parameters are used to describe the dissipation of pesticides from soil and plant surfaces. Although degradation rates vary with soil properties (including soil moisture, temperature, pH, organic matter content, and soil type), these relationships are not well enough defined to allow more physically-based equations to be included in the model. Enrichment ratios and partition coefficients are used to calculate the pesticide mass sorbed to the sediment and dissolved in water. A functional relationship is developed between the partition coefficient ($K_d$) and the soil mass per unit volume of overland flow to better estimate pesticide concentration in the soil phase.

The hydrology and erosion components of GLEAMS are largely unchanged from those of the model on which it is based—Chemicals, Runoff, and Erosion from Agricultural Management Systems (CREAMS)—which has been extensively validated (Knisel 1980). The pesticide component of GLEAMS has also been validated for a relatively wide range of climatic conditions and soils, and output was determined to be logical and to reproduce field data within an acceptable range of variability (Leonard et al. 1987; Leonard and Knisel 1988).

Because of the complexity of modeling the many processes involved in determining the fate of pesticides applied to agricultural or forest lands, no models have been developed yet that are absolute predictors of non-point pollutant loads. However, the GLEAMS model has been useful in judging the relative effects of different management practices (Leonard et al. 1987; Leonard and Knisel 1988). Sensitivity analysis techniques can be used to establish a range of pesticide concentrations that may be expected in surface and ground water for a given range of pesticide parameters.

The GLEAMS model was used to examine three issues related to the fate of pesticides used at the Lucky Peak Nursery. These issues are:

- The maximum initial concentration of each pesticide that will be seen in tributaries that collect runoff from the nursery
- The percentage of the pesticides applied that are lost from the field dissolved in runoff, adsorbed to eroded sediment, and leached below the root zone
- The potential for pesticides to build up in the soil over the years of their use at the nursery

Methodology

Surface waters from the Lucky Peak Nursery drain into several intermittent streams bordering the nursery. The intermittent streams carry water from the nursery to Mores Creek, which then empties into Lucky Peak Reservoir. Three ponds were constructed to collect runoff from much of the nursery before it enters the waterways surrounding the nursery. Subsurface drainage was assumed to leach to irrigation drains, which empty into the intermittent streams previously mentioned. Potential impacts to both subsurface and surface water resources were assessed on a storm-by-storm basis from the application of all the pesticides used at the Lucky Peak Nursery.

At present, the Lucky Peak Nursery covers an area of 296 acres of which 61 acres are planted with either seedlings or cover crops. The pesticide application schedule in Table D-3-1 was used in the simulation. Pesticide parameters used in the modeling are given in Table D-3-4. A soil half-life was unavailable for chloropicrin. Based on the similar properties of the fumigants, a half-life identical to the value found for methyl bromide was used.

The nursery soil is predominantly sandy loams, loamy sands, clayey loams and loams. Soil characteristics were assumed to be loamy sands and loams throughout the site, and the model parameters were obtained from a soil survey of the nursery. The soil has a high infiltration rate in the root zone. The average organic matter content of the soil was determined to be 3.7 percent and 4.0 percent for the loam and sandy loam soil, respectively. Pesticides that leach into soils will have a greater tendency to sorb to soil particles as organic matter increases. Depending on the pesticide's chemical partition coefficient ($K_d$) and the degradation rate of the pesticide, this will limit the potential for ground water contamination.

Nursery beds slope about 6 percent and were assigned a Soil Conservation Service runoff curve number of 78, which represents straight row crops and good hydrologic conditions. Runoff from the nursery beds was assumed to drain from furrows between the beds to concrete-lined collector ditches and then to flow off the field in these ditches. Leachate was intercepted by a subsurface drainage system and deposited with the surface runoff.
### Pesticide Parameters

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Water Solubility (ppm)</th>
<th>$K_{\infty}$</th>
<th>Soil Half-life (days)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Herbicides</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCPA</td>
<td>0.5</td>
<td>21</td>
<td>30</td>
<td>SDS 1984</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>12,000</td>
<td>500</td>
<td>30</td>
<td>Knisel 1980</td>
</tr>
<tr>
<td>Napropamide</td>
<td>73</td>
<td>413</td>
<td>84</td>
<td>WSSA 1989</td>
</tr>
<tr>
<td>Oxyfluorfen</td>
<td>0.1</td>
<td>15,500</td>
<td>40</td>
<td>WSSA 1989</td>
</tr>
<tr>
<td><strong>Fungicides</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benomyl</td>
<td>0.10</td>
<td>200</td>
<td>10</td>
<td>Knisel 1980</td>
</tr>
<tr>
<td>Metalaxyl</td>
<td>7100</td>
<td>35</td>
<td>25</td>
<td>USDA 1990</td>
</tr>
<tr>
<td><strong>Fumigants</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloropicrin</td>
<td>1,621</td>
<td>62</td>
<td>0.31</td>
<td>Based on value for methyl bromide</td>
</tr>
<tr>
<td>Dazomet</td>
<td>1,200</td>
<td>67</td>
<td>2</td>
<td>USDA 1990</td>
</tr>
<tr>
<td>Methyl bromide</td>
<td>13,400</td>
<td>23.4</td>
<td>0.31</td>
<td>HSDB 1988</td>
</tr>
</tbody>
</table>

*The $K_{\infty}$ value is a ratio of the concentration of pesticide in organic carbon to the concentration of pesticide in water.*
Daily rainfall and daily average temperature data were obtained from the National Climatic Data Center for Boise, Idaho. Data for the years 1985 to 1989 were input into the model. In addition to seasonal precipitation, irrigation water was added to the model, based on the soil moisture calculated daily.

The model was developed assuming a 6 acre field size. The total amounts of pesticides in runoff and leachate were determined by the model on a per-acre basis. Total pesticide losses were based on the maximum acreage that could be treated on any given day, based on application schedules and rates.

The cumulative concentrations of each pesticide from all treated areas were estimated at the point where all runoff inputs from treated nursery beds joined with Mores Creek, using mass balance calculations. Concentrations were obtained by determining the total amount of pesticide leaving the fields, in leachate, in runoff and adsorbed to sediment.

### Results

The results of the stream concentration analysis are presented in Table D-3.5. Pesticides were assumed to not degrade after being transported from the edge of the field into the stream, and thus are given as initial concentrations. In reality, pesticides will degrade over time and the concentrations will be further diluted following mixture with additional runoff. Therefore, the values in Table D-3.5 are representative of surface water quality at the most extreme level and these conditions would only be present for a very short time.

The GLEAMS model was also used to analyze losses of the pesticides from the field and the routes of loss. The results of this analysis are presented in Table D-3.6a and Table D-3.6b. As these tables show, very little loss of pesticides from the nursery occurred as a result of leaching and water and sediment runoff. Less than 1 percent of each pesticide applied to nursery beds annually is lost in a combination of surface runoff, eroded sediment, and in water that percolates below the root zone.

This analysis indicates that little potential exists for significant portions of the pesticides used at Lucky Peak to leach below the root zone and eventually contaminate ground water supplies. In addition, the depth at which the main drinking water aquifer at Lucky Peak is found, approximately 170 feet below the surface, contributes to the unlikely chance that substantial amounts of leached pesticides would ever reach the ground water. Realistically, the leachate would be intercepted by irrigation drains or a perched aquifer first, and drained to surface waters.

The analysis also examined the potential for pesticide residuals to build up in the soil over the years of use at the Lucky Peak Nursery. Table D-3.7 indicates the soil residues remaining after a seedling growth cycle. The table lists residues at the end of each month, beginning with November when the seedlings are typically being lifted. The analysis assumes that no seeds are sown in that field and no additional pesticides are applied to that field after lifting.

---

### Table D-3.5

**Runoff Potential of Pesticides at the Lucky Peak Nursery**

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Estimated Cumulative Maximum Initial Concentrations (mg/L) in tributary*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbicides</td>
<td></td>
</tr>
<tr>
<td>DCPA</td>
<td>0.0017</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>0.0086</td>
</tr>
<tr>
<td>Napropamide</td>
<td>0.0259</td>
</tr>
<tr>
<td>Oxyfluoren</td>
<td>0.0001</td>
</tr>
<tr>
<td>Fungicides</td>
<td></td>
</tr>
<tr>
<td>Benomyl</td>
<td>0.0000</td>
</tr>
<tr>
<td>Metalaxyl</td>
<td>0.0000</td>
</tr>
<tr>
<td>Fumigants</td>
<td></td>
</tr>
<tr>
<td>Chloropicrin</td>
<td>0.0000</td>
</tr>
<tr>
<td>Dazomet</td>
<td>0.0000</td>
</tr>
<tr>
<td>Methyl bromide</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

*mg/L = milligrams of pesticide per liter of water

*concentrations were calculated for loam and loamy sand soils, with only the highest concentration reported
Table D-3-6a

Estimated Percent and Mass of Applied Pesticide Leaving the Field in Runoff, Adsorbed to Sediment, and in Leachate - Loam Soil

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>In Runoff (%)</th>
<th>Adsorbed to Sediment (%)</th>
<th>In Leachate (%)</th>
<th>Total (%)</th>
<th>Total (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Herbicides</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCPA</td>
<td>0.00*</td>
<td>0.00*</td>
<td>0.00*</td>
<td>0.00*</td>
<td>0.00</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>0.04</td>
<td>0.04</td>
<td>0.00</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Napropamide</td>
<td>0.12</td>
<td>0.16</td>
<td>0.00</td>
<td>0.28</td>
<td>0.00</td>
</tr>
<tr>
<td>Oxyfluorfen</td>
<td>0.00*</td>
<td>0.01</td>
<td>0.00</td>
<td>0.02</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Fungicides</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benomyl</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Metalaxyl</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Fumigants</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloropicrin</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Dazomet</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00*</td>
<td>0.00*</td>
<td>0.03</td>
</tr>
<tr>
<td>Methyl bromide</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

*Not significant (less than 0.01 percent).
### Table D-3.6b

**Estimated Percent and Mass of Applied Pesticide Leaving the Field in Runoff, Adsorbed to Sediment, and in Leachate - Loamy Sand Soil**

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>In Runoff (%)</th>
<th>Adsorbed to Sediment (%)</th>
<th>In Leachate (%)</th>
<th>Total (%)</th>
<th>Total (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Herbicides</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCPA</td>
<td>0.00*</td>
<td>0.00*</td>
<td>0.00*</td>
<td>0.00*</td>
<td>0.00</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>0.04</td>
<td>0.06</td>
<td>0.00</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Napropamide</td>
<td>0.14</td>
<td>0.27</td>
<td>0.00</td>
<td>0.41</td>
<td></td>
</tr>
<tr>
<td>Oxyfluorfen</td>
<td>0.00*</td>
<td>0.02</td>
<td>0.00</td>
<td>0.02</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Fungicides</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benomyl</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Metalaxyl</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Fumigants</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloropicrin</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00*</td>
<td>0.00</td>
</tr>
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<td>Dazomet</td>
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<td>0.00*</td>
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<td>0.00</td>
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</table>

*Not significant (less than 0.01 percent).*
Table D-3-7

Soil Residues (ppb) by Soil Layer After Two Consecutive Seedling Crops

| Pesticide and Soil Layer (cm) | Pesticide Residues by Soil Layer at the End of Each Month (ppb) Following a November Lifting |
|-------------------------------|===============================================================================================|
|                               | **N** | D | J | F | M | A | M | J1 | J2 | A | S | O | N | D | J | F | M |
| Herbicides                    |       |   |   |   |   |   |   |    |    |   |   |   |   |   |   |   |   |   |
| D CPA                         |       |   |   |   |   |   |   |  7.3|    |    |    |    |    |    |    |    |    |    |
| 0-1                           | NP    | NP| NP|  7.3|    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 1-10                          | NP    | NP| NP| 19.2|  5.1|    |    |    |    |    |    |    |    |    |    |    |    |    |
| 10-20                         | NP    | NP| NP|  4.7|  4.5|    |    |    |    |    |    |    |    |    |    |    |    |    |
| 20-30                         | NP    | NP| NP|  1.2|  2.0|    |    |    |    |    |    |    |    |    |    |    |    |    |
| 30-45                         | NP    | NP| NP|  0.1|  0.4|    |    |    |    |    |    |    |    |    |    |    |    |    |
| 45-60                         | NP    | NP| NP|    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Glyphosate                    |       |   |   |   |   |   |   |  59.9| 32.7|    |    |    |    |    |    |    |    |    |
| 0-1                           | 560.3 | NP| NP| 59.9| 32.7|    |    |    |    |    |    |    |    |    |    |    |    |    |
| 1-10                          | 43.7  | NP| NP|  6.1|  6.3|    |    |    |    |    |    |    |    |    |    |    |    |    |
| 10-20                         |  1.0  | NP| NP|  0.1|  0.3|    |    |    |    |    |    |    |    |    |    |    |    |    |
| 20-60                         | NP    | NP| NP|    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Napropamide                   |       |   |   |   |   |   |   |   1.4|  1.2|    |    |    |    |    |    |    |    |    |
| 0-1                           | NP    | NP| NP|  1.4|  1.2|    |    |    |    |    |    |    |    |    |    |    |    |    |
| 1-10                          | NP    | NP| NP|  0.3|  0.3|    |    |    |    |    |    |    |    |    |    |    |    |    |
| 10-60                         | NP    | NP| NP|    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Oxyfluorfen                   |       |   |   |   |   |   |   |   3.4|  1.4|    |    |    |    |    |    |    |    |    |
| 0-1                           | NP    | NP| NP|  3.4|  1.4|    |    |    |    |    |    |    |    |    |    |    |    |    |
| 1-60                          | NP    | NP| NP|    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

*The first month listed is November, when many of the seedlings are lifted from the field.

*The model predicted no percolation (NP) for this month.
Table D-3-7 (continued)

Soil Residues (ppb) by Soil Layer After Two Consecutive Seedling Crops

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<th>Pesticide and Soil Layer (cm)</th>
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<th>D</th>
<th>J</th>
<th>F</th>
<th>M</th>
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<th>M</th>
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<th>A</th>
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<tr>
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</tbody>
</table>

*The first month listed is November, when many of the seedlings are lifted from the field.
The table shows that at the time of lifting, there are no residues remaining of the fungicides benomyl and metalaxyl and the fumigants chloropicrin, dazomet, and methyl bromide. Due to the short half-lives of these pesticides, degradation to below detectable levels should occur between the time of application and the time of lifting.

The herbicide glyphosate is not applied to the seedling crops but rather to the perimeter areas based on need. Application of glyphosate is in April and October and the analysis was based on a typical application year, as indicated in Table D-3-1. The two applications of glyphosate applied to a 3-acre area were assumed to be applied to the same 3-acre area all three times. As Table D-3-7 shows, by April of the following year, just before the next year of applications commence, no residues of glyphosate remain in the soil. This analysis indicates that if glyphosate is applied to the same area of ground every year, the potential for its build-up in the soil is slight. In addition, these pesticides are only used on a as-needed basis and not necessarily applied to the same area yearly, as assumed in this analysis.

The herbicides DCPA, napropamide, and oxyfluorfen are applied to seedling beds. Based on the application schedule used in the analysis, residues of these pesticides may remain in the soil after lifting of the seedlings has occurred. However, as Table D-3-7 indicates, residue levels will become negligible by the month of April, when the field may be fumigated for planting in May. The analysis indicates the potential for build-up of DCPA, napropamide, or oxyfluorfen in the soil is slight.

**Literature Review**

This literature review provides further background information on the persistence of various pesticides and their ability to leach and contaminate water resources. This brief summary covers those pesticides that were analyzed by the LEACH and/or GLEAMS methodology.

**DCPA.** DCPA has not been found to leach after repeated applications (Miller et al. 1978; Elmore et al. 1976; Menges and Hubbard 1970; all cited in USDA 1987). Because of its relatively low incidence of detection and low toxicity, it has not been classified as a high-priority pollutant in Wisconsin, although it has been detected in wells at low levels (Holden 1986). In California, where DCPA is used extensively, only 1 in 1,729 well water samples was found to show any traces of DCPA (USDA 1987).

**Glyphosate.** Glyphosate is relatively immobile in most soil environments due to its strong adsorption to soil particles. (Rueppell et al. 1977; as cited in U.S. Department of State 1989). The EPA reports that only the state of Virginia has detected glyphosate in ground water sampling where the pesticide was applied (EPA 1988a).

**Napropamide.** Napropamide adsorbs moderately to most soils and the leaching potential depends on the clay and organic matter content of the soil (USDA 1987). Microbial breakdown seems to be the main route of degradation and half-lives have been observed to range from 8 to 12 weeks under ideal conditions (WSSA 1989).

**Oxyfluorfen.** Oxyfluorfen adsorbs strongly to soil organic matter and clay, and its solubility is low (WSSA 1989; USDA 1984). Consequently, there is little potential for it to leach (USDA 1987; WSSA 1989).

**Benomyl.** Although benomyl has a relatively low solubility it adsorbs well to soils and does not display a strong leaching potential (USDA 1987). Laboratory and greenhouse studies found that neither benomyl nor its two metabolites (MBC and 2-AB) were detected in surface runoff or in soil water, indicating immobility in soils and an inability to leach (Long and Rhodes 1974, as cited in USDA 1987). A number of studies have also reported that benomyl and its residues are moderately persistent to highly persistent in agricultural soils (USDA 1986). Holden (1986), however, reported that one of benomyl's metabolites, MBC, does display a tendency to leach.

**Metalaxyl.** In organic soils, metalaxyl tends to be persistent and immobile because it is adsorbed to soil particles, which also makes it unavailable for microbial degradation. In soils with low organic content, metalaxyl has been found to be susceptible to leaching and downward transport if a large amount of rainfall occurs (Sharom and Edgington 1982, as cited in USDA 1987; Coffey 1985, as cited in USDA 1987).

**Chloropicrin.** Very little information exists on the fate of chloropicrin in the soil and water environment. Chloropicrin has a relatively short persistence in soil and is adsorbed to soil particles. Chloropicrin is also subject to biodegradation and has not been shown to leach to any great depth in the soil (USDA 1986).

**Dazomet.** Dazomet breaks down rapidly in moist soils to form methyl isothiocyanate, formaldehyde, hydrogen sulfide, and monomethylamine. None of these products are subject to soil accumulation and the primary mode of soil loss is through volatilization. Because dazomet's products volatilize as well as biologically decompose, they do not generally leach and have not been found in ground water (USDA 1987).

**Methyl bromide.** Methyl bromide has a short persistence in soil and is adsorbed by soil particles and moisture. Due to its volatility and water solubility, it is mobile in the soil and is subject to hydrolysis and biodegradation. While it may leach in the soil it does not leach to any great depth due to its volatility. One state, Hawaii, has detected methyl bromide in the ground water (USDA 1987).

**CALCULATION OF EXPOSURES AND DOSES**

This section describes the populations who may be exposed to pesticides as a result of their use at the Lucky Peak Nursery, and describes the representative exposure scenarios used to estimate their exposures and doses.
Affected Populations

The people that could be affected by exposure to the nursery pesticides fall into two groups. The first group, the public who may be subject to nonoccupational exposure, includes residents (or workers) living at the nursery or in homes just outside the nursery boundary or members of the public using the facilities at or near the nursery. The second group, the workers (including both nursery employees and contractors), are those persons directly involved in the nursery operations, from pesticide application to the outplanting of the nursery stock. The worker group includes mixer/loader/applicators, weeder, inventory personnel, lifters, sorter/packers and tree planters, fumigators, and tarp lifters.

Exposure Scenarios

The exposure analysis is divided into two major components, based on the two populations at risk—the exposed public and the workers. To represent the entire range of possible exposures from Forest Service nursery operations, three levels of possible exposure were analyzed: routine-typical, routine-extreme, and accidental.

Routine-typical exposures, those likely to occur in the vast majority of all applications, are based on average conditions, such as average application rate, average number of acres treated, average number of applications per year, or average time to reentry of seed-beds after treatment.

Routine-extreme exposures represent the highest doses a person would be expected to receive under normal operating conditions. Routine-extreme exposures are based on conditions that result in high doses, such as using the highest application rate on the largest acreage and the maximum hours per day worked, or they are based on the upper limit of the 95-percent confidence interval of the doses observed in field studies.

Accidental exposure levels were determined for a number of possible accidents, including equipment failure, pesticide spill, pesticide spray, or failure to observe proper reentry times.

The different characteristics specified in each exposure scenario are those that affect the potential dose a human might receive. For example, for workers involved in a tractor spraying operation, the number of work-hours and the pesticide application rate are used in determining their doses. To calculate doses to nearby residents who may eat a garden vegetable containing pesticide residue, it was necessary to estimate how much pesticide residue is on the vegetable and to make a realistic assumption about how much of the vegetable is eaten.

The doses estimated in these situations are not necessarily those that will occur as a result of a given treatment operation, but are those that could occur if all of the specified conditions were met in an actual operation. Worker routine-typical doses are based on the workers wearing only cotton coveralls as protective clothing. Worker routine-extreme doses are based on actual dose levels found in field exposure studies of agricultural workers who wore no protective clothing or equipment. If workers were to wear protective clothing and equipment—such as long-sleeved shirts, gloves, coveralls, boots, and filter masks or respirators—during actual operations, their doses could be significantly lower than those estimated here. However, despite all precautions, workers present during treatment operations will be exposed to some extent.

Additional factors must be considered when evaluating the likelihood of a member of the public receiving a pesticide dose. For example, a nearby resident would receive a dose as high as the one estimated in this analysis from eating garden vegetables with pesticide residue only if all of the following conditions were met:

- The resident’s garden was close enough to the treated area to receive some level of pesticide drift.
- The weather conditions on the day of treatment were such that the pesticide happened to drift off-site in the direction of the garden.
- The resident ate the vegetable immediately after the pesticide residue landed on it without washing or rinsing it.

It is standard USDA Forest Service practice to avoid conditions that seem likely to cause drift onto a sensitive area, such as a garden, if one happens to be nearby. Also, there is only a small possibility that the resident would pick and eat a garden vegetable immediately after an application operation. Additionally, the resident probably would wash the vegetable before eating it. This combination of factors makes the possibility of the resident receiving such a dose remote.

Estimated Exposures and Doses to Members of the Public

Exposure of the public depends on the proximity of the treated nursery beds to residences, garden crops, livestock, drinking water supplies, streams, and other bodies of water. Members of the public could be exposed to nursery herbicides, fungicides, and insecticides through dermal and dietary routes and nursery fumigants by inhalation routes. This section describes exposure scenarios that represent typical and extreme dietary and dermal doses and inhalation exposures to exposed members of the public.

Dietary Doses

Pesticide may be ingested by members of the public from food containing pesticide residues. Food items such as garden vegetables may have received some level of pesticide from spray drift. Public oral doses could also result from eating beef from cattle that have fed on contaminated grass in a nearby pasture, but these exposures would be very small because of the small amount of drift associated with nursery operations.
The nurseries are intensively managed sites with very little cover suitable for many species of wildlife, and fences to limit the wildlife. However, small animals such as rodents, rabbits, and birds may frequent the nursery beds. Many species of birds—for example, robins, sparrows, doves, quail, grouse, and geese—visit the nurseries. These birds may be exposed to pesticides by moving through a treated seedling bed. Although the possibility of the public eating game that could contain pesticides is very remote, calculations were developed to estimate the levels of possible contamination in rabbits and grouse as possible human diet items. However, the time between the exposure of these game animals and their being killed and eaten, and the preparation of the meat itself by cooking, should greatly reduce any pesticide residues.

It is also possible (although highly improbable) that the public could ingest pesticide from drinking water that has received pesticide drift, runoff from a treated bed, or ground water contamination from leaching. The latter would be true only for those pesticides that have a significant potential to leach. Some nursery beds at the Lucky Peak Nursery are approximately 100 feet from open water in tributaries to Mores Creek. Therefore, the possibility of the public drinking surface water or ground water containing one of the more mobile pesticides has been examined in this analysis.

Seven exposure scenarios were used to estimate typical dietary exposures to the public. The first six scenarios are used to represent routine-typical events, while the final scenario is used to represent a routine-extreme event. The scenario are as follows:

- Eating 0.5 kg of a garden vegetable (lettuce) with drift residue that is grown 100 feet from each of the treated areas
- Eating 0.5 kg of beef from cattle grazing in nearby pastures
- Eating 0.5 kg of a rabbit that has been dermally exposed in a treated seedling bed
- Eating 0.5 kg of a grouse that has been dermally exposed in a treated seedling bed
- Drinking 2.0 liters of surface water that receives drift
- Drinking 2.0 liters of surface water that receives runoff
- Eating 0.5 kg of a garden vegetable (lettuce) with drift residue that is grown 25 feet from each of the treated areas

**Routine-Typical**

Routine-typical doses were determined for an individual eating garden vegetables which had received pesticide residues. It was assumed that no pesticide degradation in vegetables occurred between the time of application and the time of human exposure. The method described previously for estimating pesticide drift deposition on plants was used to determine pesticide residues (Hoeger and Kenaga 1972).

In determining the dose to an individual from eating beef from cattle grazing nearby, several assumptions were made. Cattle with a body weight of 550 kg were assumed to eat 12 kg of grass per day for 5 days and retain 10 percent of the total ingested pesticide. The residues in the grass were assumed to degrade over a 5-day period. The method of determining human doses from animals that may have absorbed one of the nursery pesticides tends to overestimate likely doses because it is assumed that no breakdown occurs in animals and because animals rarely retain such high levels of residue in their tissues.

In determining the dose to an individual from eating a rabbit or grouse, a game animal (1.35-kg rabbit) and a game bird (0.75-kg grouse) were assumed to get a dermal residue level, equivalent to that on vegetation, over 60 percent and 63 percent of their body surfaces, respectively. Penetration of the residue was assumed to be the same as through human skin. The rabbit and grouse also were assumed to get an oral dose from their non-absorbed dermal residue by grooming 37 and 20 percent of their body surfaces, respectively. Of each animal's total dermal and oral dose, 10 percent was assumed to be retained in the animal's flesh. A person was then assumed to eat 0.5 kg of the animal and the person's dose was calculated assuming no degradation or loss due to the preparation and cooking of the food.

In determining the dose obtained from drinking surface water with pesticide drift, the drift was assumed to land on the surface of the water which was 2 feet deep. No dilution was assumed to take place prior to the individual drinking the water.

In determining the dose obtained from drinking surface water with pesticide runoff, the surface drinking water was assumed to come from the tributary draining the central portion of the nursery, just upstream of its confluence with Mores Creek. The runoff was diluted based on the maximum number of fields treated with the pesticide on any given day in the drainage area to the tributary and the total drainage to the tributary. The amount of pesticide assumed to be available for consumption was the total pesticide available in solution in the surface water and a percentage of the portion adsorbed to the sediment.

**Routine-Extreme**

The routine-extreme scenario is based on an individual eating garden vegetables grown 25 feet from a treated bed. Vegetables grown closer to the nursery beds will be subject to higher pesticide drift deposition. All assumptions made are similar to those made in the routine-typical scenario for contaminated vegetable consumption.

**Dermal Doses**

Two scenarios were chosen as representative of potential dermal exposures to the public: direct dermal exposure to spray drift, and petting a dog with pesticide residue on its fur.
Dermal exposure was estimated for nearby residents assuming that they are directly
downwind of a nursery bed at the time of spraying, at a distance of 100 feet for the routine-
typical case and 25 feet for the routine-extreme case. Spray drift was assumed to contact 2
square feet of exposed skin, and skin penetration was assumed to be 10 percent (USDA 1984)
except in those cases for which the chemical-specific penetration rates were known. Dermal
penetration rates for the nursery pesticides are presented in Table D-3-8. The value of 10
percent has not been exceeded in most dermal absorption studies, and it has been used as a
moderately conservative value by others, including the British government, for risk
assessments.

Maximum indirect dermal exposure was estimated assuming that a dog is exposed to pesticide
by passing through a treated bed and picking up the pesticide on its fur. Half of the residue
level on the animal’s fur is assumed to be transferred to a person’s hand, and a fraction of
that subsequently absorbed, based on each pesticide’s dermal penetration rate.

**Inhalation Exposure**

Inhalation exposures would be negligible compared to dermal doses (Dubelman et al. 1982),
except in the case of exposure to fumigants; therefore, inhalation exposures were not
calculated for the other types of pesticides.

Routine-typical and routine-extreme exposures of nearby residents to methyl bromide and
chloropicrin were estimated from two field monitoring studies. Maddy et al. (1983a)
measured concentrations of methyl bromide and chloropicrin 25 feet downwind of an
application site. The 18 samples taken for methyl bromide ranged from not detectable (ND)
to 634 parts per billion (ppb) and the 18 samples taken for chloropicrin ranged from ND to
106 ppb. Maddy et al. (1984b) measured concentrations of methyl bromide and chloropicrin
50 feet downwind of an application site. The 33 samples ranged from 3 ppb to 396 ppb for
methyl bromide and ranged 1 ppb to 81 ppb for chloropicrin.

**Routine-Typical**

Routine-typical exposures were based on the mean value computed for all concentrations
measured at the application sites, which was normalized for application rate and time-
weighted for multiple readings at different locations simultaneously. These values for methyl
bromide were 0.326 parts per million (ppm) and 0.166 ppm at 25 and 50 feet downwind of
the site, respectively. The average values for chloropicrin were 0.048 ppm and 0.018 ppm at
25 and 50 feet downwind of the site, respectively.

**Routine-Extreme**

Routine extreme exposures were also based on the two exposure studies described above.
The extreme exposures were based on the upper limit of the 95 percent confidence interval
for the exposure values obtained in the studies after normalization for application rate and

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**Table D-3-8**

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</table>

*Dermal penetration rates are rates of penetration through the skin.
*Fumigants are not included since fumigant exposures are primarily through inhalation.
*No value available; a value of 10% was used, as suggested in USDA 1984.
time-weighting for multiple readings at different locations simultaneously. The values obtained for methyl bromide were 0.435 ppm and 0.217 ppm at 25 and 50 feet downwind of the site, respectively. The maximum values for chloropicrin were 0.066 ppm and 0.023 ppm at 25 and 50 feet downwind of the site, respectively.

**Accidental**

Accidental exposure of nearby residents was estimated for persons at 25 feet and 100 feet downwind of a hose break or other source release of the fumigants. The scenario was similar to the scenario used for worker exposure to an accidental release of fumigants. A Gaussian plume model using atmospheric turbulence types (Hanna et al. 1982; Pasquill 1974) was used in this calculation. Turbulence types were based, in part, on surface wind speed and amount of sunlight. Evaporation rates for the fumigants were estimated from calculations based on equations by Drivas (1982). The calculations used the vapor pressure and molecular weight of the fumigant, the ambient temperature, and wind speed. The air temperature was assumed to be 60 °F and the wind speed was 5 miles per hour.

The estimated evaporation rates were then input into the plume model. The application rate used in the model was 350 pounds per acre for a 67 percent methyl bromide and 33 percent chloropicrin mixture. Tractors were assumed to apply the fumigant while moving at a speed of 1 mile per hour.

**Lifetime Doses**

Lifetime doses to the public were calculated for the consumption of contaminated rabbit, the consumption of contaminated vegetables grown at 25 feet from treated nursery beds, the consumption of water containing pesticide drift, and direct dermal exposure 25 feet from a treated nursery bed. Cumulative lifetime doses to the public were calculated by multiplying the single doses described in this section by 5 or 30 exposures, then averaging this over a typical 70-year life span.

**Estimated Exposures and Doses to Workers**

Table D-3-9 lists the pesticides the nurseries use and the types of workers that may be exposed to each one. The nursery generally employs the following number of personnel annually for its operations: 1 to 2 mixer/loader/applicators, 5 to 10 weeders, 7 to 8 inventory personnel, 15 to 62 litter/sorter/packers, 4 to 6 fumigators for methyl bromide/chloropicrin application, 6 fumigators for dazomet application, and 4 tarp lifters. Tree planters are not employed at the Lucky Peak Nursery but they are included in this analysis since they are affected by their handling of treated seedlings.

Workers may be exposed dermally or by inhalation during routine operations, such as mixing and loading pesticides into the application equipment, applying pesticides to the soil or vegetation, fumigating or removing a fumigant tarp, working in a treated seedling bed soon
Table D-3-9

Pesticide Use and the Type of Worker Exposed in the Lucky Peak Nursery

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Use*</th>
<th>Mixer/Loader/Applicator</th>
<th>Weeder</th>
<th>Inventory Personnel</th>
<th>Lifters/Sorters</th>
<th>Packers/Tree Planters</th>
<th>Tarp Lifters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbicides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCPA</td>
<td>B</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Glyphosate</td>
<td>A, B</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Napropamide</td>
<td>B</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Oxyfluorfen</td>
<td>B</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Fungicides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benomyl</td>
<td>B</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Metalaxyl</td>
<td>B</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Fumigants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloropicrin</td>
<td>B</td>
<td>x</td>
<td></td>
<td>--</td>
<td></td>
<td>--</td>
<td>x</td>
</tr>
<tr>
<td>Dazomet</td>
<td>B</td>
<td>x</td>
<td></td>
<td>--</td>
<td></td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Methyl bromide</td>
<td>B</td>
<td>x</td>
<td></td>
<td>--</td>
<td></td>
<td>--</td>
<td>x</td>
</tr>
</tbody>
</table>

*A = general nursery treatments; B = seedbed treatments.

"x" in the column denotes exposure potential.
after pesticide application, or handling seedlings some time after the pesticide treatment during such tasks as weeding, lifting, sorting, packing, and tree outplanting.

In general, workers who use protective clothing and equipment and who adhere to proper cleanup procedures, label precautions, and reentry intervals will have significantly reduced doses. (For more details on protective clothing, see the risk analysis discussion in Section D-4 of this appendix).

The inventory personnel can be expected to have the highest doses because their contact with the vegetation may occur shortly after spraying. Lifters, sorter/packers, and tree planters have considerable contact with foliage several months after pesticide application, which would allow time for dissipation of most of the dislodgable residues.

The dermal dose to mixer/loader/applicators depends on the concentration of pesticide in the spray mix, the surface area of the person's exposed skin, the extent to which the person's clothing absorbs the pesticide, and the time that elapses before the person washes. Dermal exposure of workers in tasks other than pesticide application depends on the reentry time to the treated areas and the degree of contact with the treated plants and soils.

In the unlikely event of an accident, workers may be exposed to much greater amounts of pesticide than they would under normal circumstances. High dermal exposures would result if pesticide concentrate or some of the prepared spray mixture spilled on a worker's skin during mixing, loading, or spraying operations. A worker who is accidentally sprayed with pesticide while standing too close to a tractor applicator would receive a high dermal dose.

Doses were estimated for the following worker categories:

- Mixer/loader/applicators
- Weeder
- Inventory personnel
- Lifters, sorter/packers, and tree planters
- Fumigators
- Tarp lifters

In this risk assessment, the doses to the workers were estimated in part from the results of exposure studies of pesticide workers reported in the literature. Studies were selected that most closely represent the pesticide application practices of the Lucky Peak Nursery. However, none of the selected studies matched these practices in all respects and certain assumptions were necessary in order to extrapolate the results of the field worker studies to the exposure estimates for many nursery workers. In order to gain improved exposure estimates the Forest Service has funded an exposure study of nursery workers. The study was conducted by Dr. Terry L. Lavy of the University of Arkansas at three nurseries, the W. W. Ashe Nursery (a USDA Forest Service nursery in Brooklyn, Mississippi), the J. Herbert Stone Nursery (a USDA Forest Service nursery in Medford, Oregon), and the D.L. Phipps Nursery (a State of Oregon nursery in Elkton, OR). Twenty to twenty-eight workers from each nursery (including pesticide applicators, weeder, scouts, and packers) were monitored over a 12-week period. The total urine output was collected from each subject during the study period and analyzed for pesticide residues. In addition, dermal patches were worn by the subjects and also analyzed for pesticide residues.

The results of the analyses of both the dermal patches and the urine should provide quantitative estimates of pesticide exposure, as well as estimates of dermal absorption of each pesticide. While the field-study and sample analyses have been completed, the data analyses of all the raw data collected during the study have not been completed. This data may be available for incorporation into this risk assessment at a later date.

Mixer/Loader/Applicators

Table D-3-1 provides a list of pesticide application times that shows the most likely times when mixer/loader/applicators could be exposed to each pesticide that may be applied in a nursery. For this risk assessment it is assumed that the same personnel in each nursery apply all of the pesticides in a particular year. Thus, this assumption overestimates exposure and risk. No other workers or supervisors are assumed to be directly involved in pesticide applications.

Routine-Typical

Routine typical exposures were calculated for a given pesticide from the average application rate and average number of acres treated daily at the nursery. This analysis assumed that the mixer/loader/applicators used coveralls as a form of protection. Workers at the Lucky Peak Nursery were assumed to treat the total acreage of any given application in a single day using tractor-mounted boom sprayers.

The doses to workers were calculated based on worker exposure studies that, in most cases, involved pesticides other than those used in the nurseries. Reinert and Severn (1985) list the many different applicable studies that have been used by EPA's Exposure Assessment Branch. These include data on 34 cases of ground rig drivers, 30 cases of mixer/loaders using wettable powders, and 32 cases of mixer/loaders using emulsifiable concentrates. In extrapolating from these studies, the exposures are assumed to be directly related to the amount of pesticide applied by applicators or handled by mixer/loaders, as suggested by Reinert and Severn (1985). Studies where 2,4-D was applied were chosen because studies have shown that greater than 90 percent of the oral dose of 2,4-D in humans is rapidly excreted in urine. A
dermal and inhalation dose will react similarly once inside the body (Sauerhoff et al. 1977, as cited in Lavy et al. 1987).

The doses for mixer/loader/applicators employing tractor-mounted booms were estimated using a study by Nash et al. (1982) that measured the urinary excretion of 2,4-D of 26 workers involved in ground applications. Samples were collected for 6 consecutive days after a single exposure to 2,4-D. For this risk assessment, the routine-average estimates of doses to mixer/loader/applicators were based on the average total exposures (milligrams per kilogram of body weight) of the mixer/loader/applicators in Nash et al. (1982), corrected for the amount of pesticide applied per day and for the dermal penetration rates.

The doses for mixer/loader/applicators employing hand sprayers were estimated using a study by Lavy et al. (1987) that measured urinary excretion of 2,4-D of 20 workers involved in hand application by the backpack spray method. Samples were collected for 5 consecutive days after a single exposure to 2,4-D. For this risk assessment, the routine-average estimates of doses to mixer/loader/applicators were based on the average total exposures (milligrams per kilogram of body weight) of the mixer/loader/applicators in Lavy et al. (1987), corrected for the amount of pesticide applied per day and for the dermal penetration rates.

Routine-Extreme

The routine-extreme doses for tractor applicators and hand sprayers were based on the upper limit of the 95-percent confidence interval for the mixer/loader/applicators from the Nash et al. (1982) and Lavy et al. (1987) studies, respectively. These doses were calculated assuming that the workers wear no protective clothing or equipment. These exposures were then adjusted, based on the highest application rate and acreage for each pesticide in the nursery schedules. The dermal penetration rates used are the same as those described for the routine-average exposure for the mixer/loader/applicator.

Accidental

Two types of accidental exposures were calculated for the mixer/loader/applicators: sprays and spills. For accidental spraying, it is assumed that 2 square feet of exposed skin are sprayed at the intended application rate. For a spill, it is assumed that 500 milliliters of a liquid concentrate is spilled on clothing that allows 30 percent of the active ingredient to pass through to the skin, and 100 milliliters of the concentrate is spilled directly onto the skin (Newton and Norris 1981). Pesticides used at the Lucky Peak Nursery that are stored in a solid form were assumed to have no spill potential, unless they are mixed into a concentrated liquid solution before being diluted to the application concentration.

Weeders

Hand weeding is used in addition to herbicides to control weeds in the nursery. Weeders at the Lucky Peak Nursery are assumed work approximately 30 days per month during the months of June, July, and August. Dose estimates for weeders are based on the level of dislodgeable residues on nursery stock. Doses resulting from vegetation contact were calculated by combining the following:

- An accounting of the dislodgeable residues on the nursery stock over time, including washoff from irrigation and pesticide residue decay
- An accounting of worker activity in the nursery beds over time
- A calculation of the rate of transfer of residues from the foliage to a worker

The first item required knowledge of the rates and timing of chemical application, the nature of degradation of dislodgeable residues, and the rate of pesticide residue washoff from irrigation. Pesticides applications to pre-emergent seedlings would result in no residual pesticide on the vegetation; therefore, worker doses were not calculated for these applications.

Worker activity estimates are based on the nursery schedules and on reentry times to the treated nursery beds. Although the practices are realistic, they were chosen to represent relatively labor-intensive nursery management. Worker activity is scheduled in terms of the work operation, the date, and the number of hours per day. This information is correlated with the dislodgeable residue estimates to calculate worker doses.

The calculation of absorbed pesticide doses from worker contact with foliage was done following the procedure used in the "Unified field model" (Popendorf and Leffingwell 1982; Popendorf 1985). The unified field model calculates worker doses based on estimates of initial pesticide residue levels, dislodgeable residue decay, and dermal absorption rates of pesticides. The rate of transfer of residues from the foliage to the workers was assumed to be equivalent to 1,600 cm² of residues per hour (Popendorf 1985).

Dislodgeable residues were assumed to degrade from the day of application to the day of reentry into a nursery bed, based on the foliar degradation rate. In the absence of field studies of dislodgeable residues in the tree nurseries, field and laboratory studies of pesticide degradation rates have been used in this analysis to estimate dislodgeable residues. These studies are reasonable to use, although they do not match in all cases the environmental conditions and vegetation types of the tree nurseries.

Routine-Typical

The routine-typical exposures for weeders are based on average or realistic number of days between the pesticide application and weeder field entry. It is assumed that weeders enter fields 7 days after application of herbicides and fungicides. It was also assumed that the weeders spend 6 hours a day in the treated beds in contact with the sprayed vegetation. The fraction of each weeder's time spent in beds treated with a given pesticide was assumed to be the same as the fraction of the total nursery bed acreage treated with that chemical.
Routine-Extreme

The routine-extreme exposures for weeders are based on lower reentry times of 3 days for herbicides and fungicides. Weeders spend 8 hours in the fields. The other methods used were assumed to be similar to those described under the routine-typical scenario.

Accidental

Accidental exposure assumes premature reentry to a seed bed 2 hours after it has been treated with a pesticide. The weeders are assumed to work 10 hours in the bed. The exposure analysis methods are assumed to be the same as those described for the routine-typical scenario. Premature entry to a treated bed is unlikely to occur because treated fields are posted with the date of application and the name of the chemical applied.

Inventory Personnel

At the Lucky Peak Nursery, the inventory personnel work for approximately 15 days per year. Seedlings are generally inventoried in August. During inventory, nursery personnel count a sample of the plants and measure the height and diameter of selected plants in each nursery bed. The Lucky Peak Nursery has begun implementation of a mechanical seedling inventory system which will, in future years, reduce the amount of contact inventory personnel have with seedlings.

Routine-Typical

The routine-typical exposures for these workers are based on the average or realistic number of days between the pesticide application and inventory. The inventory personnel at the Lucky Peak Nursery are typically performing their duties during the time of year when a majority of the pesticide spraying is done. The typical interval between the time of pesticide application and inventory for each pesticide is listed in Table D-3-10. These intervals are based on whichever inventory period has the lower average interval. It was assumed that inventory personnel spend 6 hours a day in the treated beds in contact with the sprayed vegetation.

Routine-Extreme

The routine-extreme exposures are based on the lower intervals between pesticide application and inventory described in Table D-3-10. It is assumed that the inventory personnel spend 8 hours per day working in the beds. The analysis was similar to that described for the routine-typical analysis.

Table D-3-10

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Routine-Typical</th>
<th>Routine-Extreme</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Number of Days Between Pesticide Application and Exposure</td>
<td>Least Number of Days Between Pesticide Application and Exposure</td>
</tr>
<tr>
<td>Herbicides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCPA</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>Glyphosate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Napropamide</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>Oxyfluorfen</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>Fungicides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benomyl</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>Metalaxyl</td>
<td>105</td>
<td>90</td>
</tr>
</tbody>
</table>

*Chloropicrin, dazomet, and methyl bromide are not included in this table because they are not applied to the foliage. Therefore, inventory personnel will not be exposed to these pesticides.

*Glyphosate is only used in non-crop areas. Therefore, inventory personnel will not be exposed to glyphosate during routine operations.
Accidental

Accidental exposure assumes premature reentry 2 hours after pesticide spraying. Inventory personnel are assumed to work 10 hours per day in the treated bed. The exposure analysis methods are the same as those described for the routine-typical analysis.

Lifters, Sorters/Packers, and Tree Planters

During periods in November and late February and early March, the seedlings are removed (lifted) from the nursery beds and are sorted and packed for shipment to the outplanting site for field planting. All seedlings are removed from the Lucky Peak Nursery for outplanting. Workers usually spend 15 days a year in these functions. Tree planter exposures are included in this analysis, because of to the doses they may receive as a result of nursery operations. The workers have considerable contact with treated foliage, but normally a time interval of one month or more has elapsed since treatment, during which the residues have degraded or have been washed off. Tree planters would have dose levels no greater than those of lifters, sorters, and packers, and they could be even lower if further degradation of the residues occurred.

Routine-Typical

The routine-typical doses for these personnel are calculated for each pesticide using the realistic number of days between application and seedling processing listed in Table D-3-11. The methods used to calculate foliar residues and dermal exposure are the same as those described for inventory personnel and workers who were also assumed to spend 6 hours per day at these activities.

Routine-Extreme

The routine-extreme exposures for these workers are based on the least number of days between pesticide application and the lifting, sorting, and packing activities, as presented in Table D-3-11. The workers are assumed to spend 8 hours per day in the treated fields. The analysis was otherwise the same as that described for routine-typical exposures.

Accidental

Accidental exposures were calculated assuming that the residue levels are higher because of premature lifter reentry to a bed 2 hours after treatment and that the lifters work 8 hours per day in such beds. Accidental reentry is unlikely because the treated areas are posted.

Fumigants

The Lucky Peak Nursery operations include the use of the fumigants methyl bromide/chloropicrin which is 67 percent methyl bromide and 33 percent chloropicrin.

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Routine-Typical</th>
<th>Routine-Extreme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbicides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCPA</td>
<td>120</td>
<td>105</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>.4</td>
<td>.6</td>
</tr>
<tr>
<td>Napropamide</td>
<td>.4</td>
<td>.6</td>
</tr>
<tr>
<td>Oxyfluorfen</td>
<td>120</td>
<td>105</td>
</tr>
<tr>
<td>Fungicides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benomyl</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metalaxyl</td>
<td>210</td>
<td>195</td>
</tr>
</tbody>
</table>

*The number of days between application and exposure is based on the fall lifting schedule.

Chloropicrin, dazomet, and methyl bromide are not included in this table because they are not applied to the foliage. Therefore, lifters, sorters/packers, and tree planters will not be exposed to these pesticides.

Glyphosate is only used in non-crop areas. Therefore, lifter/sorter/packers and tree planters will not be exposed to glyphosate during routine operations.

Napropamide and benomyl are only used on first year seedlings. Therefore, lifter/sorter/packers and tree planters will not be exposed to these pesticides during routine operations.
Fumigants are usually applied as a gas or liquid to the soil subsurface by chisel injection. The methyl bromide/chloropicrin mixture is used to fumigate approximately 18 acres at Lucky Peak Nursery in either September or April. The Lucky Peak Nursery employs contract crews for their fumigation activities.

The following are summaries of worker exposure studies from the California Department of Food and Agriculture that were used to estimate exposure concentrations for nursery fumigators who use methyl bromide/chloropicrin.

Maddy et al. (1982) measured methyl bromide concentrations in the worker breathing zones during soil fumigation projects. Methyl bromide was applied at rates of 214 to 375 pounds per acre (lb/acre). A tarp was applied to the soil surface as the fumigant was injected to a depth of 8 inches. Air samples were collected over periods of approximately 30 minutes. The following were the measured concentrations for the three categories of workers: tractor driver, 0.29 to 5.26 ppm; copilot, not detectable (ND) to 7.42 ppm; average of 2.97 ppm; and shoveler, ND to 2.25 ppm, average of 0.67 ppm. None of the values were greater than the 15-ppm permissible exposure limit set by the California Occupational Safety and Health Administration. Three of the forty measurements were greater than 5 ppm, which is the threshold limit value (TLV). The TLV is a time-weighted average (TWA) for an 8-hour day set by the American Conference of Governmental Industrial Hygienists (ACGIH). TWA's were not calculated for this study.

Maddy et al. (1983b) measured methyl bromide and chloropicrin concentrations in other operations similar to those described above. Application rates were 300 lb/acre for a mixture of 67 percent methyl bromide and 33 percent chloropicrin and 275 lb/acre for a mixture of 75 percent methyl bromide and 25 percent chloropicrin. Air-sampling periods were approximately 45 minutes. Methyl bromide values ranged from ND to 6.3 ppm, and averages were 1.45 ppm for tractor drivers, 1.6 ppm for copilots, and 0.7 ppm (one sample) for shovelers. Chloropicrin values ranged from ND to 181 ppb, and averages were 69 ppb for tractor drivers, 41 ppb for copilots, and 45 ppb (one sample) for shovelers. TWA's were calculated when at least two measurements were made during a fumigation project. For methyl bromide, the TWA's were 1.4 ppm for tractor drivers and 1.6 ppm for copilots. The TWA's for chloropicrin were below the TLV of 100 ppb recommended by ACGIH and the short-term exposure limit of 300 ppb.

Maddy et al. (1984a) again performed breathing-zone-monitoring studies of workers, using methyl bromide and chloropicrin in three preplant soil fumigation projects. Air samples were collected for 1- to 2-hour periods. The fumigant mixture was applied at a rate of 275 lb/acre with 75 percent methyl bromide and 25 percent chloropicrin. The results of the monitoring study showed higher levels of both fumigants than did the previous studies. Sampling periods of about 1 hour from two fumigation projects produced values of methyl bromide ranging from 3.1 to 5.9 ppm for drivers and 3.8 to 8.3 ppm for copilots. Chloropicrin values ranged from 90 to 154 ppb for drivers and 86 to 190 ppb for copilots. TWA's for methyl bromide were 1.2 ppm (driver) and 1.9 ppm (copilot), and they were 35 ppb (driver) and 50 ppb (copilot) for chloropicrin.

Routine-Typical

Fumigation with methyl bromide/chloropicrin is performed by a crew consisting of a tractor operator, a chaser, and an assistant. The crew members may rotate assignments throughout the workday. Generally, workers do not wear protective clothing. The crew works at a rate of about 1 acre per hour for 8 to 11 hours per day (averaging approximately 10 hours) and they may treat 8 to 12 acres in that time.

The tractor is driven at a speed of about 1 mile per hour. The application equipment has a treatment width of 12 feet. Chisel blades, approximately 12 inches apart, inject the fumigant into the soil. Behind the injector, a plastic tarp rolls out over the treated soil and is glued to the edge of the adjacent piece of tarp that has been laid down on the previous pass. The outside edge of each strip is covered with soil. At the end of the bed, the chaser cuts the plastic and covers the end with soil.

A 1,000-foot length of nursery bed takes approximately 10 minutes to treat. It takes an additional 2 minutes to close the valves, cut the plastic, and turn the tractor around. A new roll of plastic must be loaded on the tractor for every 4,000 feet of bed treated (after approximately 48 minutes). A 15-minute break is taken each time a new roll is loaded. After about 3.5 hours of application, the fumigant tank must be exchanged for a full one. The workers take a 45-minute break each time a tank is replaced. Based on this description of fumigation practices, a worker is exposed to fumigants for approximately 5.2 hours out of a 10-hour workday.

Worker exposure studies conducted by Maddy et al. (1982; 1983b; 1984a) were used to estimate exposure concentrations for nursery workers using methyl bromide and chloropicrin. The measured concentrations in these studies were adjusted to reflect the application rates for methyl bromide and chloropicrin used in nursery operations and the duration of worker exposure to a fumigant during a typical day of nursery fumigation.

The three worker categories described under fumigation practices (tractor operator, chaser, and assistant) are considered comparable to the three categories described in the worker exposure studies (tractor driver, copilot, and shoveler).

Routine-Typical

Routine-typical exposures to methyl bromide/chloropicrin were based on the mean value computed for all concentrations measured at the application sites, which was normalized for application rate. These exposure values were determined at 25 and 50 feet downwind of the application site.
Routine-Extreme

Routine-extreme exposures to methyl bromide/chloropicrin were also based on the exposure studies described above. The extreme exposures were based on the upper limit of the 95 percent confidence interval for the exposure values obtained in the studies after normalization for application rate. The values were also obtained 25 and 50 feet downwind of the application site.

Accidental

Potential exposure of workers to fumigants by an accidental release of gas such as from a leaky hose or a broken blade was estimated with a Gaussian plume model using Pasquill atmospheric turbulence types (Hanna et al. 1982; Pasquill 1974). Turbulence types are based, in part, on surface wind speed and amount of sunlight. Evaporation rates for the fumigants were estimated from calculations based on equations in Drivas (1982). The calculations used the vapor pressure and molecular weight of the fumigant, the ambient temperature, and wind speed. The air temperature was assumed to be 60°F and the wind speed was 5 miles per hour.

The estimated evaporation rates were then input to the plume model. The application rate used in the model was 325 pounds per acre for a 67 percent methyl bromide and 33 percent chloropicrin mixture. Tractors were assumed to apply the fumigant while moving at a speed of 1 mile per hour. Exposures were estimated at a distance of 5 feet downwind of the release point.

Tarp Lifters

Tarp lifters are potentially exposed to chloropicrin and methyl bromide during their routine activities. Tarp lifters wait approximately 24 to 72 hours after application of the fumigant to remove the protective tarp. Workers generally reenter the field from 1 to 7 days after the removal of the tarp. Approximately 15 acres of tarp may be removed per day. The fields are sown and planted about 2 weeks after fumigation.

Atmospheric concentrations of methyl bromide were measured during the fumigation of bowling greens. Concentrations in the operators' breathing zone were as follows: 75 ppm at the time of application, 20 to 450 ppm during the loosening of the tarp, and 50 to 75 ppm when rolling up the tarp. Concentrations at an accidental tear in the tarp were also measured. Concentrations were 450 ppm under the tarp at the ear and 200 ppm in the worker's breathing zone just above the ear (Simpson 1967).

Methyl bromide exposures of workers removing plastic tarps have also been measured 5 to 9 days after applications to greenhouse soils (Van Den Oever et al. 1982). The mean methyl bromide concentration experienced by the workers removing the tarps in open greenhouses was 30 ppm. Average values experienced in five cases ranged from 10 to 50 ppm. Peak values were as high as 200 ppm. However, the methyl bromide application rate was relatively high: 714 lb/acre (80 grams per square meter). Exposures were adjusted, based on the application rate of methyl bromide/chloropicrin used at the Lucky Peak Nursery.

No studies were available that quantify exposures of tarp lifters to chloropicrin.

Routine-Typical

Methyl bromide exposures for routine-typical conditions for tarp lifters were estimated from the monitoring study by Van Den Oever et al. (1982). These exposures averaged 30 ppm. The air concentration was normalized for the methyl bromide application rate used at the Lucky Peak Nursery. It was assumed that a tarp lifter was exposed to this concentration throughout an 8-hour working period.

Routine-Extreme

Methyl bromide exposures for routine-extreme conditions for tarp lifters were also estimated from the monitoring study by Van Den Oever et al. (1982). The maximum average air concentration in the breathing zone for a group of workers monitored in the study was 50 ppm. The air concentration was normalized for the methyl bromide application rate used at the Lucky Peak Nursery. It was assumed that a tarp lifter was exposed to this concentration throughout an 8-hour working period.

The results of this study and the higher values measured during the fumigation of bowling greens (Simpson 1967) indicate that short-term concentrations may reach several hundred ppm. However, this routine analysis based exposures on the average air concentration over an entire workday.

Accidental

Accidental exposures of tarp lifters to methyl bromide and chloropicrin were assumed to be the same as accidental exposures to fumigant applicators.

Worker Lifetime Doses

The lifetime doses for mixer/loader/applicators were estimated using nursery schedule values for the total number of acres treated with a specific pesticide and the number of days the worker is exposed to provide such treatments. Annual doses were then multiplied by 5 years or 30 years to indicate cumulative exposures.

The total time that inventory personnel, lifters, sorter/packers, tree planters, and root treaters work was estimated, assuming that 95 percent of the time they worked the average number of days per year indicated in the worker-specific descriptions and 5 percent of the time spent in
exposure to a given chemical was assumed to be the same as the fraction of the whole nursery bed acreage treated with that chemical. This may overestimate exposure because it assumes that workers always work in treated beds and enter at the average reentry interval. The fraction of time spent in beds treated with the specific chemical was multiplied by the number of days worked per year and the daily dose to estimate an annual exposure. This was adjusted for cumulative periods of 5 years and 30 years.
SECTION D-4
RISK ANALYSIS

INTRODUCTION
This section analyzes the risks to the health of workers and members of the public that may result from any of the nine pesticides proposed for use in the Lucky Peak Nursery. In the risk analysis, the human exposure levels estimated in Section D-3 are compared with the laboratory-determined toxicity reference levels described in Section D-2.

The first subsection describes the methods used to evaluate human health risks, including the risks of acute toxic effects, chronic systemic effects, effects on reproduction (fertility, maternal and fetal toxicity, and birth defects), and cancer. The second subsection contains the results of the risk analysis for the herbicides and fungicides used at the Lucky Peak Nursery. The third subsection presents the results of the risk analysis for fumigants. The fourth subsection discusses the risks of other toxic effects, including mutagenicity, synergistic effects, effects on sensitive individuals, and cumulative effects. In the final subsection, risk reduction through the use of protective clothing and other measures is presented.

METHODOLOGY FOR ASSESSING HEALTH RISKS

Risks of Acute, General Systemic, and Reproductive Effects

In this risk analysis, the potential risks to humans exposed to the proposed nursery pesticides—three herbicides and two fungicides were evaluated by comparing the representative doses estimated in the range of exposure situations presented in Section D-3 with the results of toxicity tests on laboratory animals described in Section D-2. The risk analysis for the two proposed fumigants is based upon comparisons of air concentrations to the threshold limit value (TLV). The fumigant risk analysis is discussed separately in this section.

To quantify the risks of threshold effects for all pesticides except fumigants, the doses estimated for exposed individuals are compared to laboratory no-observed-effect levels (NOEL's) determined in the most sensitive test species. In this analysis, the ratio between the NOEL and the estimated human dose is referred to as the margin of safety (MOS):

\[
MOS = \frac{NOEL}{dose}
\]

The margin of safety allows for the uncertainty inherent in relating doses and effects seen in animals to estimated doses and effects that humans might experience. For example, an MOS of 100 means that the laboratory-determined no-observed-effect level is 100 times the estimated human dose; an MOS of 10 means the laboratory-determined no-observed-effect level is 10 times the estimated human dose. Therefore, the lower the MOS number, the greater the potential for risk.

Systemic effects are evaluated based on the lowest systemic NOEL found in a chronic study in laboratory mammals. (When subchronic studies reported effects at lower levels than chronic studies, the subchronic NOEL’s were used.) Reproductive effects are evaluated based on the lowest NOEL’s found in a two- or three-generation reproduction study or teratology study.

All the NOEL's used in this risk analysis are based on (or take into account) long-term exposure. A dose estimate that exceeds the laboratory-determined NOEL does not necessarily lead to the conclusion that there will be toxic effects. As an estimated dose approaches or exceeds a NOEL, the risk of toxic effects greatly increases; however, comparing one-time or once-a-year doses (such as those experienced by the public or in an accident) to NOEL’s derived from repeated doses in long-term studies may exaggerate the risk from those infrequent events. In this analysis, estimated doses that exceed the NOEL are also compared to available information on demonstrated effects in humans or laboratory animals resulting from acute exposures to the pesticide.

For workers, MOS’s were computed for each pesticide, application, and nursery task for routine-typical, routine-extreme, and accident situations. For the public, MOS’s were computed for routine-typical and routine-extreme situations. Because all pesticide handling and applications are confined to fenced nursery grounds and no aerial applications are used, the only accidents that may affect the public are exposures to fumigants. In all cases, the MOS’s were computed by comparing the lowest laboratory-determined NOEL’s, summarized in Table D-4.1, with the estimated doses calculated in Section D-3.

Table D-4.2 contains a summary of the observations at the lowest effect levels in the studies from which the NOEL’s were obtained. These observations may approximate the adverse effects that could be encountered if estimated exposure levels approach or exceed the NOEL.

The larger the MOS (that is, the smaller the estimated human dose compared to the laboratory NOEL), the lower the presumed risk to human health. As the estimated dose to humans approaches the NOEL, the presumed risk to humans increases. When an estimated dose exceeds a NOEL, the ratio is reversed (the dose is divided by the NOEL) to indicate the factor by which the estimated dose exceeds the NOEL. In that case, a minus sign appears with the MOS to indicate that the estimated dose exceeds the NOEL. An MOS of -5, for example, means that the estimated dose is 5 times the laboratory-determined NOEL.

A negative MOS indicates that the estimated dose (given all the assumptions of the exposure situation) may produce some toxic effects in a person of average sensitivity, although it must be remembered that the MOS is based on a laboratory dose level that produced no toxic effects in test species. When repeated doses to humans are much higher than the laboratory NOEL, there is a risk of harmful effects. Conversely, when the human dose is small
**Table D-4-1**

Toxicity Reference Values Used in Estimating Margins of Safety and Cancer Risks

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Systemic NOEL (mg/kg/day)</th>
<th>Reproductive NOEL (mg/kg/day)</th>
<th>Cancer Potency (mg/kg/day)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbicides</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCPA</td>
<td>50</td>
<td>100</td>
<td>0.00507</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>31</td>
<td>10.0</td>
<td>0.000024</td>
</tr>
<tr>
<td>Napropamide</td>
<td>25</td>
<td>10.0</td>
<td>0.0000293</td>
</tr>
<tr>
<td>Oxyfluorfen</td>
<td>0.3</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Fungicides</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benomyl</td>
<td>12.5</td>
<td>5.0</td>
<td>0.0039</td>
</tr>
<tr>
<td>Metalaxyl</td>
<td>6.25</td>
<td>50.0</td>
<td></td>
</tr>
<tr>
<td>Fumigants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloropicrin</td>
<td>0.1 ppm^1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dazomet Components</td>
<td>10.0 ppm^2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MITC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>1.0 ppm^2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monomethylamine</td>
<td>10.0 ppm^2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrogen sulfide</td>
<td>10.0 ppm^2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methyl bromide</td>
<td>5.0 ppm^2</td>
<td></td>
<td>0.169</td>
</tr>
</tbody>
</table>

*The cancer potency represents the increase in likelihood of getting a tumor over a lifetime from a unit increase (1 mg/kg/day) in the dose of the chemical.

Tab/D4-2

Laboratory Observations in Test Animals at Lowest Effect Levels for the Lucky Peak Nursery Pesticides

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Systemic Effects</th>
<th>Reproductive Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbicides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCPA</td>
<td>Increased kidney weight in males, increased adrenal to body weight ratio in females</td>
<td>No reproductive effects at the highest dose tested</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>Decreased absolute and relative pituitary weight</td>
<td>Renal tubular dilation in offspring</td>
</tr>
<tr>
<td>Napropamide</td>
<td>Decreased uterine weight; decreased body weight</td>
<td>Decreased maternal and fetal weight gain</td>
</tr>
<tr>
<td>Oxyfluorfen</td>
<td>Increased liver weight, gross and histopathological liver changes</td>
<td>Maternal anorexia and decreased weight gain, fused sternebrae in offspring</td>
</tr>
<tr>
<td>Fungicides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benomyl</td>
<td>Elevated liver enzyme levels</td>
<td>Decreased offspring weight</td>
</tr>
<tr>
<td>Metalaxyl</td>
<td>Increased alkaline phosphatase, increased liver weight</td>
<td>Maternal convulsions and atxia, fetal sternabrae unossified</td>
</tr>
<tr>
<td>Fumigants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloropicrin</td>
<td>Decreased liver and spleen weights</td>
<td>No studies available</td>
</tr>
<tr>
<td>Dazomet</td>
<td>Necrosis of the kidney</td>
<td>No studies available</td>
</tr>
<tr>
<td>Methyl bromide</td>
<td>Histopathological abnormalities in the forestomach; pulmonary damage and paralysis</td>
<td>No studies available</td>
</tr>
</tbody>
</table>
compared with the animal NOEL (for example, when the MOS is greater than 100), the risk to humans can be judged negligible. This methodology parallels the procedure that EPA uses to determine reference doses (acceptable daily intakes) for various chemical substances (see discussion in Section D-2).

In this risk analysis, MOS's greater than 1,000 are described as representing a negligible risk from that exposure. MOS's between 100 and 1,000 are said to represent a low risk. If the MOS is between 10 and 100, the risk is described as moderate. Exposures resulting in MOS's of less than 10 are described as posing significant risks. Wherever the dose exceeds the NOEL (resulting in a negative MOS), this is clearly stated in the summary of risks.

A margin of safety of 100 is generally recognized as safe for humans and is comparable to the 100-fold uncertainty factor that EPA usually uses to establish reference doses (acceptable daily intake levels) for humans. The 100-fold safety factor allows for extrapolation of the results of the study (on a per kilogram of body weight basis) from animals to humans and for variability in sensitivity among humans. Refer to the discussion of reference doses in Section D-2 for further detail.

In cases where the establishment of an RID by EPA has not been based on a subchronic study, on a study that does not meet full current standards for all aspects of chronic testing, or in cases where data gaps exist, EPA may use additional uncertainty factors in determining the RID. For napropamide, an additional uncertainty factor of 3 was used to establish the RID because of the lack of a chronic feeding study in a second species; EPA used a reproductive NOEL of 30 mg/kg/day and an uncertainty factor of 300 to set the RID for chronic exposure to napropamide at 0.1 mg/kg/day. In this risk assessment, a lower NOEL of 10 mg/kg/day was used to calculate margins of safety for reproductive effects for napropamide exposure. Since this NOEL is three times lower than the NOEL used to set the RID, it was considered unnecessary to include the additional uncertainty factor in the risk characterization in this assessment. Therefore, the risk characterization methodology described above for use with all other herbicides and fungicides in the analysis was also used for napropamide.

Risk of Cancer

As a result of the review of cancer studies presented in Section D-2, a risk analysis for cancer was conducted for six of the Lucky Peak Nursery pesticides—DCPA, glyphosate, oxyfluorfen, benomyl, dazomet, and methyl bromide. The decision to conduct a cancer risk analysis was based on positive results seen in laboratory oncogenicity studies for all the above pesticides, with the exceptions of DCPA and oxyfluorfen. DCPA and oxyfluorfen were included in the cancer risk analysis based on impurities found in their formulated products which may be carcinogenic. Dazomet has been included because one of its breakdown products, formaldehyde, has been shown to be oncogenic.

Cancer risks for the six pesticides were calculated based on the following conservative assumptions to avoid underestimating the risks:

- When more than one tumor data set was available, the data set indicating greater carcinogenic potency was chosen to compute risk.
- Carcinogenicity is not a threshold phenomenon; that is, any dose of these chemicals has some probability of causing cancer, no matter how small the dose.
- The range of doses calculated for workers and the public in the basic scenarios covers even extreme exposures that might be encountered with each application method. Unusual exposure situations, represented by accidental spraying and large pesticide spills, have also been considered.
- Cancer risks were calculated if a carcinogenic contaminant was present in the formulated product (for example, PCE in oxyfluorfen), even though the pesticidal chemical in its pure form may show negative results in oncogenicity studies.

Cancer risk to members of the public from the pesticides, except fumigants (discussed separately), was calculated for 5 and 30 exposures over a lifetime. Individual exposure routes were considered separately in estimating cumulative risk. The routes included eating contaminated rabbit, eating garden vegetables grown 25 feet from the spray site, drinking water that has been contaminated with pesticide drift from treated nursery beds, and direct exposure to drift 25 feet from the spray site.

Cancer risk to workers was calculated for the realistic case assuming 5 years of employment in the nurseries and for an extreme case assuming 30 years of employment. It is unlikely that a worker would receive exposure greater than this.

The probability of cancer occurrence over a lifetime as a result of exposure to each of the pesticides was calculated using the following equation:

\[ P = CPF \times D \times N/L \]

where:

- \( P \) = an estimate of the probability of cancer during a person’s lifetime as the result of the daily dose (D)
- \( CPF \) = cancer potency factor (see Table D-4-1)
- \( D \) = daily dose (mg/kg/day)
- \( N \) = number of days during which the daily dose (D) occurs during an individual’s lifetime
- \( L \) = the number of days in a lifetime, considered to be 25,550 for a 70-year lifespan
The resulting cancer probabilities are compared to a benchmark value of $1 \times 10^{-5}$ (or 1 in 1 million), a value commonly accepted in the scientific community as representing a cancer risk that would result in a negligible addition to the background cancer rate of approximately one in four in the United States. To put the estimated cancer risks in perspective, Table D-4-3 compares the risks associated with some of the more familiar hazards and occupations.

**HEALTH RISKS FROM HERBICIDES AND FUNGICIDES**

This section presents the results of the risk analysis for the three herbicides and two fungicides used at the Lucky Peak Nursery. These pesticides include DCPA, glyphosate, napropamide, oxyfluorfen, benomyl, and metalaxyl. A discussion of health risks associated with fumigant exposure is provided following this discussion. The estimated exposures are based on the pesticide application schedules and methods described in Section D-3. The margins of safety and cancer risk values are based on the methods described previously in this chapter.

The results of the risk analysis for the Lucky Peak Nursery from all pesticides, with the exception of the fumigants, are given in Tables D-4-4 through D-4-10. The MOS tables include risks to workers and members of the public. Margins of safety greater than 1,000 are indicated by ++.

**Risks to Exposed Members of the Public**

**Routine-Typical**

The routine-typical scenarios used to evaluate public risk to pesticide applications at the Lucky Peak Nursery include dietary exposure to food items such as beef, rabbit, grouse, and water, as well as vegetables grown 100 feet from the area of treated nurseries. Dermal exposure scenarios include exposure to a pet which has been in treated areas. All other public exposure scenarios are used in the routine-extreme analysis. Margins of safety are 100 or greater for members of the public exposed to DCPA, glyphosate, napropamide, oxyfluorfen, benomyl, and metalaxyl, indicating negligible risk. In almost all cases, the margins of safety are greater than 1,000, indicating negligible risk.

**Routine Extreme**

The routine-extreme scenarios used in this risk assessment were for vegetables grown 25 feet from a treated bed and for a person receiving a dermal exposure from drift at 25 feet from a treated bed. The margins of safety under these routine-extreme exposure conditions are greater than 100 for DCPA, glyphosate, napropamide, oxyfluorfen, benomyl, and metalaxyl, indicating low risk. In almost all cases, the margins of safety are greater than 1,000.
Table D-4.4
Margins of Safety for DCPA Use

<table>
<thead>
<tr>
<th>Dose (mg/kg/day)</th>
<th>Margin of safety relative to:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Systemic NOEL</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------</td>
</tr>
<tr>
<td><strong>Margins of Safety for Exposed Members of the Public</strong></td>
<td></td>
</tr>
<tr>
<td>Dietary exposures:</td>
<td></td>
</tr>
<tr>
<td>Beef</td>
<td>0.0006</td>
</tr>
<tr>
<td>Rabbit</td>
<td>0.0130</td>
</tr>
<tr>
<td>Grouse</td>
<td>0.0110</td>
</tr>
<tr>
<td>Vegetables, 25 ft.</td>
<td>0.0350</td>
</tr>
<tr>
<td>Vegetables, 100 ft.</td>
<td>0.0240</td>
</tr>
<tr>
<td>Water, runoff</td>
<td>0.0000</td>
</tr>
<tr>
<td>Water, drift</td>
<td>0.0001</td>
</tr>
<tr>
<td><strong>Dermal Exposures:</strong></td>
<td></td>
</tr>
<tr>
<td>At 25 feet</td>
<td>0.0011</td>
</tr>
<tr>
<td>At 100 feet</td>
<td>0.0007</td>
</tr>
<tr>
<td>Dog petting</td>
<td>0.0007</td>
</tr>
<tr>
<td><strong>Margins of Safety for Workers</strong></td>
<td></td>
</tr>
<tr>
<td>Routine-Typical:</td>
<td></td>
</tr>
<tr>
<td>Mix/Load/Applic</td>
<td>0.0024</td>
</tr>
<tr>
<td>Weeder</td>
<td>0.9747</td>
</tr>
<tr>
<td>Inventory</td>
<td>0.5692</td>
</tr>
<tr>
<td>Lift/Sort/Pack</td>
<td>0.0027</td>
</tr>
<tr>
<td>Routine-Extreme:</td>
<td></td>
</tr>
<tr>
<td>Mix/Load/Applic</td>
<td>0.0066</td>
</tr>
<tr>
<td>Weeder</td>
<td>1.4622</td>
</tr>
<tr>
<td>Inventory</td>
<td>1.2086</td>
</tr>
<tr>
<td>Lift/Sort/Pack</td>
<td>0.0729</td>
</tr>
<tr>
<td><strong>Accidents:</strong></td>
<td></td>
</tr>
<tr>
<td>Accident spray</td>
<td>0.3100</td>
</tr>
<tr>
<td>Accident spill</td>
<td>---</td>
</tr>
<tr>
<td>Early Reentry</td>
<td>1.2106</td>
</tr>
</tbody>
</table>

Margins of Safety for Giftosate Use

Table D-4.5

<table>
<thead>
<tr>
<th>Dose (mg/kg/day)</th>
<th>Margin of safety relative to:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Systemic NOEL</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------</td>
</tr>
<tr>
<td><strong>Margins of Safety for Exposed Members of the Public</strong></td>
<td></td>
</tr>
<tr>
<td>Dietary exposures:</td>
<td></td>
</tr>
<tr>
<td>Beef</td>
<td>0.0000</td>
</tr>
<tr>
<td>Rabbit</td>
<td>0.0008</td>
</tr>
<tr>
<td>Grouse</td>
<td>0.0006</td>
</tr>
<tr>
<td>Vegetables, 25 ft.</td>
<td>0.0025</td>
</tr>
<tr>
<td>Vegetables, 100 ft.</td>
<td>0.0000</td>
</tr>
<tr>
<td>Water, runoff</td>
<td>0.0000</td>
</tr>
<tr>
<td>Water, drift</td>
<td>0.0000</td>
</tr>
<tr>
<td><strong>Dermal Exposures:</strong></td>
<td></td>
</tr>
<tr>
<td>At 25 feet</td>
<td>0.0000</td>
</tr>
<tr>
<td>At 100 feet</td>
<td>0.0000</td>
</tr>
<tr>
<td>Dog petting</td>
<td>0.0000</td>
</tr>
<tr>
<td><strong>Margins of Safety for Workers</strong></td>
<td></td>
</tr>
<tr>
<td>Routine-Typical:</td>
<td></td>
</tr>
<tr>
<td>Mix/Load/Applic</td>
<td>0.0003</td>
</tr>
<tr>
<td>Weeder</td>
<td>---</td>
</tr>
<tr>
<td>Inventory</td>
<td>---</td>
</tr>
<tr>
<td>Lift/Sort/Pack</td>
<td>---</td>
</tr>
<tr>
<td>Routine-Extreme:</td>
<td></td>
</tr>
<tr>
<td>Mix/Load/Applic</td>
<td>0.0006</td>
</tr>
<tr>
<td>Weeder</td>
<td>---</td>
</tr>
<tr>
<td>Inventory</td>
<td>---</td>
</tr>
<tr>
<td>Lift/Sort/Pack</td>
<td>---</td>
</tr>
<tr>
<td><strong>Accidents:</strong></td>
<td></td>
</tr>
<tr>
<td>Accident spray</td>
<td>0.0067</td>
</tr>
<tr>
<td>Accident spill</td>
<td>0.0000</td>
</tr>
<tr>
<td>Early Reentry</td>
<td>---</td>
</tr>
</tbody>
</table>

The larger the value of the margin of safety, the more significant the dose is as compared to the NOEL, and smaller the risk. The symbol '++' indicates that the margin of safety is greater than 1,000. A negative margin of safety indicates that the dose received is greater than the NOEL.  

**Spill risk is not applicable to Giftosate because its formulations are wettable powders rather than liquids.**
Margins of Safety for Napropamide Use

<table>
<thead>
<tr>
<th>Dose (mg/kg/day)</th>
<th>Margin of safety* relative to:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NOEL</td>
</tr>
<tr>
<td>Beef</td>
<td>0.0001</td>
</tr>
<tr>
<td>Rabbit</td>
<td>0.0037</td>
</tr>
<tr>
<td>Grouse</td>
<td>0.0030</td>
</tr>
<tr>
<td>Vegetables, 25 ft.</td>
<td>0.0100</td>
</tr>
<tr>
<td>Vegetables, 100 ft.</td>
<td>0.0069</td>
</tr>
<tr>
<td>Water, runoff</td>
<td>0.0007</td>
</tr>
<tr>
<td>Water, drift</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Dermal exposures:

- At 25 feet: 0.0003
- At 100 feet: 0.0002
- Dog petting: 0.0002

Margins of Safety for Workers:

Routine-Typical:

- Mix/Load/Applic: 0.0199
- Weeder inventory: 0.0242
- Lift/Sort/Package: ---

Routine-Extreme:

- Mix/Load/Applic: 0.0442
- Weeder inventory: 0.2663
- Lift/Sort/Package: ---

Accidents:

- Accident spray: 0.069
- Accident spill: ---
- Early Reentry: 0.3637

*The larger the value of the margin of safety, the more insignificant the dose is compared to the NOEL, and smaller the risk.

Margins of Safety for Exposed Members of the Public

Dietary exposures:

- Beef
- Rabbit
- Grouse
- Vegetables, 25 ft.
- Vegetables, 100 ft.
- Water, runoff
- Water, drift

Table D-4-7

Margins of Safety for Oxyfluorfen Use

<table>
<thead>
<tr>
<th>Dose (mg/kg/day)</th>
<th>Margin of safety* relative to:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NOEL</td>
</tr>
<tr>
<td>Beef</td>
<td>0.0000</td>
</tr>
<tr>
<td>Rabbit</td>
<td>0.0004</td>
</tr>
<tr>
<td>Grouse</td>
<td>0.0003</td>
</tr>
<tr>
<td>Vegetables, 25 ft.</td>
<td>0.0010</td>
</tr>
<tr>
<td>Vegetables, 100 ft.</td>
<td>0.0007</td>
</tr>
<tr>
<td>Water, runoff</td>
<td>0.0000</td>
</tr>
<tr>
<td>Water, drift</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Dermal Exposures:

- At 25 feet: 0.0000
- At 100 feet: 0.0000
- Dog petting: 0.0000

Margins of Safety for Workers:

Routine-Typical:

- Mix/Load/Applic: 0.0019
- Weeder inventory: 0.0000
- Lift/Sort/Package: 0.0000

Routine-Extreme:

- Mix/Load/Applic: 0.0044
- Weeder inventory: 0.0007
- Lift/Sort/Package: 0.0023

Accidents:

- Accident spray: 0.0089
- Accident spill: ---
- Early Reentry: 0.0325

*The larger the value of the margin of safety, the more insignificant the dose is compared to the NOEL, and smaller the risk.

The symbol '++' indicates that the margin of safety is greater than 1,000. A negative margin of safety indicates that the dose received is greater than the NOEL.

The larger the value of the margin of safety, the more insignificant the dose is compared to the NOEL, and smaller the risk.
**Table D-4-8**

### Margins of Safety for Benomyl Use

<table>
<thead>
<tr>
<th>Margin of safety relative to:</th>
<th>Dose (mg/kg/day)</th>
<th>NOEL (12.5 mg/kg/day)</th>
<th>NOEL (5.0 mg/kg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systemic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reproductive</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Margins of safety for exposed members of the public</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dietary exposures:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beef</td>
<td>0.0002</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Rabbit</td>
<td>0.0042</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Grouse</td>
<td>0.0031</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Vegetables, 25 ft.</td>
<td>0.0130</td>
<td>960</td>
<td>380</td>
</tr>
<tr>
<td>Vegetables, 100 ft.</td>
<td>0.00092</td>
<td>**</td>
<td>540</td>
</tr>
<tr>
<td>Water, drift</td>
<td>0.0000</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td><strong>Dermal Exposures:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At 25 feet</td>
<td>0.0001</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>At 100 feet</td>
<td>0.0001</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Dog petting</td>
<td>0.0001</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td><strong>Margins of safety for workers:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Routine-Typical:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mix/Load/Applic</td>
<td>0.0012</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Weeder</td>
<td>0.1148</td>
<td>110</td>
<td>42</td>
</tr>
<tr>
<td>Inventory</td>
<td>0.0579</td>
<td>220</td>
<td>86</td>
</tr>
<tr>
<td>Lift/Sort/Pack</td>
<td>---</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td><strong>Routine-Extreme:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mix/Load/Applic</td>
<td>0.0026</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Weeder</td>
<td>0.1812</td>
<td>68</td>
<td>27</td>
</tr>
<tr>
<td>Inventory</td>
<td>0.1546</td>
<td>81</td>
<td>32</td>
</tr>
<tr>
<td>Lift/Sort/Pack</td>
<td>---</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td><strong>Accidents:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accident spray</td>
<td>0.0420</td>
<td>300</td>
<td>120</td>
</tr>
<tr>
<td>Accident spill</td>
<td>---</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Early Reentry</td>
<td>0.1713</td>
<td>73</td>
<td>29</td>
</tr>
</tbody>
</table>

---

1. The larger the value of the margin of safety, the more insignificant the dose is as compared to the NOEL, and smaller the risk. The symbol "**" indicates that the margin of safety is greater than 1.000.
2. The lift/sort/packer category also includes doses and margins of safety for tree planters.
3. Lift/sort/packer and tree planters receive negligible exposure to benomyl because it is only used on first year seedings.
4. Spill risk is not applicable to benomyl because its formulations are wettatable powders rather than liquids.

---

**Table D-4-9**

### Margins of Safety for Metalaxyl Use

<table>
<thead>
<tr>
<th>Margin of safety relative to:</th>
<th>Dose (mg/kg/day)</th>
<th>NOEL (6.25 mg/kg/day)</th>
<th>NOEL (50 mg/kg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systemic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reproductive</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Margins of safety for exposed members of the public</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dietary exposures:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beef</td>
<td>0.0000</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Rabbit</td>
<td>0.0011</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Grouse</td>
<td>0.0010</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Vegetables, 25 ft.</td>
<td>0.0021</td>
<td>31</td>
<td>250</td>
</tr>
<tr>
<td>Vegetables, 100 ft.</td>
<td>0.0014</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Water, runoff</td>
<td>0.0000</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Water, drift</td>
<td>0.0000</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td><strong>Dermal Exposures:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At 25 feet</td>
<td>0.0002</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>At 100 feet</td>
<td>0.0001</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Dog petting</td>
<td>0.0001</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td><strong>Margins of safety for workers:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Routine-Typical:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mix/Load/Applic</td>
<td>0.0029</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Weeder</td>
<td>0.0881</td>
<td>71</td>
<td>570</td>
</tr>
<tr>
<td>Inventory</td>
<td>0.0000</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Lift/Sort/Pack</td>
<td>0.0000</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td><strong>Routine-Extreme:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mix/Load/Applic</td>
<td>0.0072</td>
<td>870</td>
<td>**</td>
</tr>
<tr>
<td>Weeder</td>
<td>0.2040</td>
<td>31</td>
<td>250</td>
</tr>
<tr>
<td>Inventory</td>
<td>0.0000</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Lift/Sort/Pack</td>
<td>0.0000</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td><strong>Accidents:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accident spray</td>
<td>0.0490</td>
<td>110</td>
<td>890</td>
</tr>
<tr>
<td>Accident spill</td>
<td>110.0000</td>
<td>-42</td>
<td>-5.2</td>
</tr>
<tr>
<td>Early Reentry</td>
<td>0.2005</td>
<td>35</td>
<td>280</td>
</tr>
</tbody>
</table>

---

*The larger the value of the margin of safety, the more insignificant the dose is as compared to the NOEL, and smaller the risk. The symbol "**" indicates that the margin of safety is greater than 1.000. A negative margin of safety indicates that the dose received is greater than the NOEL.*
Table D-4-10

Margins of Safety Relative to the LD₉₀ for Worker Accidents

<table>
<thead>
<tr>
<th></th>
<th>Dose (mg/kg)</th>
<th>Oral LD₉₀ (mg/kg)</th>
<th>Margin of safety relative to Oral LD₉₀</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCPA:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spray</td>
<td>0.3100</td>
<td>12.500</td>
<td>++</td>
</tr>
<tr>
<td>Spill</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early Reentry</td>
<td>1.2106</td>
<td></td>
<td>++</td>
</tr>
<tr>
<td>Glyphosate:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spray</td>
<td>0.0067</td>
<td>4.320</td>
<td>++</td>
</tr>
<tr>
<td>Spill</td>
<td>51.0000</td>
<td></td>
<td>85</td>
</tr>
<tr>
<td>Early Reentry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Napropamide:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spray</td>
<td>0.0890</td>
<td>5.000</td>
<td>++</td>
</tr>
<tr>
<td>Spill</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early Reentry</td>
<td>0.3637</td>
<td></td>
<td>++</td>
</tr>
<tr>
<td>Oxyfluorfen:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spray</td>
<td>0.0089</td>
<td>5.000</td>
<td>++</td>
</tr>
<tr>
<td>Spill</td>
<td>86.0000</td>
<td></td>
<td>58</td>
</tr>
<tr>
<td>Early Reentry</td>
<td>0.0325</td>
<td></td>
<td>++</td>
</tr>
<tr>
<td>Benomyl:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spray</td>
<td>0.0420</td>
<td>10.000</td>
<td>++</td>
</tr>
<tr>
<td>Spill</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early Reentry</td>
<td>0.1713</td>
<td></td>
<td>++</td>
</tr>
<tr>
<td>Metalaxyl:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spray</td>
<td>0.0560</td>
<td>669.</td>
<td></td>
</tr>
<tr>
<td>Spill</td>
<td>260.0000</td>
<td></td>
<td>2.6</td>
</tr>
<tr>
<td>Early Reentry</td>
<td>0.1804</td>
<td></td>
<td>++</td>
</tr>
</tbody>
</table>

*See Section D-2 for additional information about the oral LD₉₀ for each pesticide and source.

The larger the value of the margin of safety, the more insignificant the dose is as compared to the LD₉₀, and smaller the risk. The symbol "++" indicates that the margin of safety is greater than 1,000.

Cancer Risks

Cancer risks to the public were calculated for DCPA, glyphosate, oxyfluorfen, and benomyl and are presented in Table D-4-11. Cancer risks were calculated for members of the public consuming contaminated rabbit, consuming contaminated garden vegetables grown 25 feet from a treated bed, drinking water contaminated with pesticide drift, and direct dermal exposure 25 feet from a treated bed. The risks were calculated assuming 5 and 30 exposures over a lifetime. The estimated cancer risks are less than 1 in 1 million in all cases, for both 5 and 30 exposures.

Risks to Workers

Routine-Typical

Margins of safety are 100 or greater for all workers exposed to glyphosate and oxyfluorfen, indicating low or negligible risk. Some categories of workers exposed to DCPA, napropamide, benomyl, and metalaxyl showed margins of safety of less than 100 but greater than 10, indicating moderate risk. The margins of safety for weeders and inventory personnel exposed to DCPA were calculated to be 51 and 88, respectively, based on a comparison of the estimated doses to the systemic NOEL of 50 mg/kg/day. The margins of safety for weeders exposed to napropamide was calculated to be 85, based on a comparison of the estimated dose to the reproductive NOEL of 10 mg/kg/day. Margins of safety for 42 and 86 were calculated for weeders and inventory personnel exposed to benomyl, based on comparisons of the estimated doses to a reproductive NOEL of 5 mg/kg/day. In the case of metalaxyl exposure, margins of safety for weeders was 71, based on a systemic NOEL of 6.25 mg/kg/day.

Routine-Extreme

Routine-extreme exposures to workers were based on one or more of the following conditions: higher estimates of doses from field studies; higher application rates; larger treatment areas; or shorter reentry times into treated fields.

Under routine-extreme conditions, margins of safety for all workers exposed to glyphosate are greater than 100, indicating low or negligible risk. Margins of safety for some workers exposed to DCPA, napropamide, oxyfluorfen, benomyl, and metalaxyl are less than 100, but greater than 10, indicating moderate risk. The margins of safety for weeders and inventory personnel exposed to DCPA were calculated to be 34 and 41, respectively, based on a comparison of the estimated doses to the systemic NOEL of 50 mg/kg/day. The margins of safety for weeders and inventory personnel exposed to napropamide were calculated to be 35 and 38, respectively, based on a comparison of the estimated doses to the reproductive NOEL of 10 mg/kg/day. The margin of safety for mixer/loader/applicators exposed to oxyfluorfen was 68, based on a comparison of the estimated dose to the systemic NOEL of 0.3
Cancer Risk at the Lucky Peak Nursery

<table>
<thead>
<tr>
<th></th>
<th>DCPA</th>
<th>Glyphosate</th>
<th>Oxyfluorfen</th>
<th>Benomyl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cancer Risks to Exposed Members of the Public</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Exposures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eating contaminated rabbit</td>
<td>1x10^8</td>
<td>4x10^{-12}</td>
<td>2x10^{-12}</td>
<td>3x10^{-9}</td>
</tr>
<tr>
<td>Eating contaminated vegetables</td>
<td>3x10^8</td>
<td>1x10^{-11}</td>
<td>6x10^{-12}</td>
<td>1x10^{-8}</td>
</tr>
<tr>
<td>Drinking water with drift</td>
<td>1x10^{-10}</td>
<td>4x10^{-14}</td>
<td>2x10^{-14}</td>
<td>4x10^{-11}</td>
</tr>
<tr>
<td>Dermal exposure at 25 feet</td>
<td>1x10^{-9}</td>
<td>1x10^{-13}</td>
<td>2x10^{-13}</td>
<td>1x10^{-10}</td>
</tr>
<tr>
<td>30 Exposures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eating contaminated rabbit</td>
<td>8x10^{-8}</td>
<td>2x10^{-11}</td>
<td>1x10^{-11}</td>
<td>2x10^{-8}</td>
</tr>
<tr>
<td>Eating contaminated vegetables</td>
<td>2x10^{-7}</td>
<td>7x10^{-11}</td>
<td>3x10^{-11}</td>
<td>6x10^{-8}</td>
</tr>
<tr>
<td>Drinking water with drift</td>
<td>7x10^{-10}</td>
<td>2x10^{-13}</td>
<td>1x10^{-13}</td>
<td>2x10^{-10}</td>
</tr>
<tr>
<td>Dermal exposure at 25 feet</td>
<td>7x10^{-9}</td>
<td>6x10^{-13}</td>
<td>1x10^{-12}</td>
<td>6x10^{-10}</td>
</tr>
<tr>
<td>Cancer Risks to Workers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Years of Exposure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixer/Loader/Applicators</td>
<td>8x10^{-9}</td>
<td>1x10^{-10}</td>
<td>3x10^{-11}</td>
<td>3x10^{-9}</td>
</tr>
<tr>
<td>Weedics</td>
<td>2x10^{-6}</td>
<td>....</td>
<td>7x10^{-12}</td>
<td>4x10^{-7}</td>
</tr>
<tr>
<td>Inventory personnel</td>
<td>2x10^{-7}</td>
<td>....</td>
<td>4x10^{-13}</td>
<td>4x10^{-9}</td>
</tr>
<tr>
<td>Lifter/Sorter/Packers/Planters</td>
<td>4x10^{-6}</td>
<td>....</td>
<td>....</td>
<td>....</td>
</tr>
<tr>
<td>30 Years of Exposure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixer/Loader/Applicators</td>
<td>5x10^{-8}</td>
<td>8x10^{-10}</td>
<td>2x10^{-10}</td>
<td>2x10^{-8}</td>
</tr>
<tr>
<td>Weedics</td>
<td>1x10^{-6}</td>
<td>....</td>
<td>4x10^{-11}</td>
<td>3x10^{-6}</td>
</tr>
<tr>
<td>Inventory personnel</td>
<td>1x10^{-6}</td>
<td>....</td>
<td>2x10^{-11}</td>
<td>2x10^{-7}</td>
</tr>
<tr>
<td>Lifter/Sorter/Packers/Planters</td>
<td>2x10^{-6}</td>
<td>....</td>
<td>....</td>
<td>....</td>
</tr>
</tbody>
</table>

*No exposure to glyphosate for weedics, inventory personnel, lifter/Sorter/packers, and tree planters.
*Negligible exposure to oxyfluorfen for lifter/Sorter/packers and planters.
*No exposure to benomyl for lifter/Sorter/packers and planters.

mg/kg/day. Margins of safety of 27 and 32 were calculated for weedics and inventory personnel exposed to benomyl, based on a reproductive NOEL of 5 mg/kg/day. In the case of metalaxyl exposure, margins of safety for weedics was 31, based on a systemic NOEL of 6.25 mg/kg/day.

Accidents

Three accidental scenarios were evaluated to determine possible doses to workers from such an event. These accident scenarios were based on an accidental spray of the pesticide at the application strength, an accidental spill of a concentrated form of the pesticide, and premature entry into a field following a pesticide application. Margins of safety relative to the systemic and reproductive NOEL's for each accident scenario are presented in Table D-4-4 through D-4-9. Margins of safety relative to the oral LD50 for each accident scenario are presented in Table D-4-10.

Accidental Sprays

For direct accidental spraying of a worker, the margins of safety based on the systemic and reproductive NOEL's are greater than 100 for DCPA, glyphosate, napropamide, benomyl, and metalaxyl, indicating low risk. The margin of safety for oxyfluorfen was 34, based on a comparison of the dose with the systemic NOEL of 0.3 mg/kg/day, indicating moderate risk.

Accidental spray doses were also compared to the oral LD50. The results of this analysis are presented in Table D-4-10. All margins of safety relative to the oral LD50 are greater than 1,000.

Spills

The scenario designed to examine the accidental spill of the concentrated form of the chemical produced negative margins of safety for all concentrated liquid pesticides when compared to the lower of the systemic or reproductive NOELs. This means that the dose received from the accidental spill of the concentrated formulation on a worker may exceed the NOEL level. The herbicides DCPA and napropamide and the fungicide benomyl were not included in this analysis because the Lucky Peak Nursery uses non-liquid formulations of these pesticides.

The doses obtained from the accidental spill scenario were also compared to the oral LD50 for each pesticide. The results of this analysis are presented in Table D-4-10. The margins of safety relative to the LD50 for glyphosate and oxyfluorfen both exceeded 10. The margin of safety for metalaxyl was 2.6, based on an LD50 of 669 mg/kg.

It must be noted that the dose levels resulting from the accidental spray scenario, as well as the accidental spill scenario are based on dermal penetration rates derived in studies over many days; these chemicals do not penetrate the skin immediately but over a period of time.
Thus, workers who are safety-conscious and wash the chemical off immediately after contact are likely to lower the magnitude of the dose received. The values presented in this study represent the worst situation that may occur.

**Premature Reentry**

For premature reentry, the margins of safety based on the systemic and reproductive NOEL's are less than 100 but greater than 10 for DCPA, naproamid, benomyl, and metalaxyl, indicating moderate risk. Oxyfluorfen has a margin of safety of 9.2, based on comparison of the dose with the systemic NOEL of 0.3 mg/kg/day, indicating high risk. Premature reentry doses were not calculated for glyphosate exposure because glyphosate is not used in seed bed areas.

Premature reentry doses were also compared to the oral LD₅₀. The results of this analysis are presented in Table D-4-10. All margins of safety relative to the oral LD₅₀ are greater than 1,000.

**Cancer Risks**

Cancer risks are presented in Table D-4-11. Estimated risks for 5 years of exposure are less than 1 in 1 million for all workers exposed to glyphosate, oxyfluorfen, and benomyl. Cancer risks from 5 years of exposure exceeded 1 in 1 million for weeders exposed to DCPA. Based on 30 years of exposure, cancer risks from glyphosate and oxyfluorfen for all workers are less than 1 in 1 million. Cancer risks exceed 1 in 1 million for weeders exposed to DCPA and benomyl. The highest cancer risk is 1 in 10,000 for weeders exposed to DCPA over a 30-year period.

**HEALTH RISKS FROM FUMIGANTS**

The risk analysis for the fumigants chloropicrin, dazomet, and methyl bromide is in a separate section because they are applied with different methods than the other pesticides and they behave differently in the environment; therefore, the methods of analysis and main route of exposure, inhalation, is different than for the other pesticides. In addition, the fumigant risk evaluation is based not on NOEL's but on threshold limit values (TLV's) that are considered safe exposure levels for continuous exposure in the workplace. The TLV is the estimated maximum concentration for long-term 8-hour workday exposures that will not result in any adverse effects.

If the ratio of the TLV to the estimated fumigant exposure exceeds 1, it can be assumed that there is little risk of acute health effects in an average healthy adult. Persons with compromised pulmonary function (such as emphysema), children, and those who are sensitive to the chemicals may require a higher ratio to avoid adverse effects. A TLV to exposure ratio that exceeds 10 is considered sufficient to ensure that these more sensitive persons would not suffer acute effects.

**Fumigant Risk to Exposed Members of the Public**

Normal practice with methyl bromide/chloropicrin application includes injection into the ground and immediate sealing with a plastic tarp. This analysis assumes that the public could have some low level of exposure downwind from a fumigant operation during the application while workers are injecting the gases and putting the tarp in place. It is also possible that some of the fumigants could permeate the tarp, depending on its thickness.

Dazomet is incorporated into the soil in granular form. Following application, the treated area is regularly irrigated to keep the soil surface wet and seal the evolving gases. This practice should minimize the release of breakdown product gases MITC and formaldehyde and reduce public risk considerably.

Table D-4-12 lists exposures to the public from routine-typical and routine-extreme scenarios, with ratios based on threshold values. Exposures for the routine-typical and routine-extreme scenarios are based on monitoring studies of methyl bromide/chloropicrin levels downwind of a spraying operation (Maddy et al. 1983a; Maddy et al. 1984b) and field dissipation studies of dazomet (Munnecke and Martin 1964). Routine-typical scenarios are based on the mean exposure (normalized for application rate) from all exposure measurements taken in the studies and were assumed to occur over an 8-hour period. Routine-extreme exposures were based on the upper limit of the 95-percent confidence interval of the same data, also based on an 8-hour exposure period.

**Routine-Typical**

Routine-typical exposures for the public were determined at distances of 25 and 50 feet from the edge of the treated beds. As shown in Table D-4-12, for chloropicrin, the ratio of the TLV to the exposure is 2.1 and 5.4 at distances of 25 and 50 feet, respectively. These results indicate little risk of adverse effects to healthy adult members of the public exposed to chloropicrin. However, more sensitive individuals, including children, may experience low-level adverse effects from chloropicrin use when they are near the application site during fumigation. Low-level effects that may be experienced include tearing, as well as bronchial irritation and swelling. For methyl bromide, the ratio of the TLV to the exposure is 15.3 and 30.2 at distances of 25 and 50 feet, respectively. Since the ratio exceeds 10 in both cases, no adverse effects are expected in sensitive members of the public. For dazomet, the ratio of the TLV to the exposure is greater than 10 for all breakdown products.

**Routine-Extreme**

Routine-extreme exposures for the public were also determined at distances of 25 and 50 feet from the edge of the treated beds. For chloropicrin, the ratio of the TLV to the exposure is...
Table D-4-12

Public Risks for Fumigant Exposure During Routine Operations

<table>
<thead>
<tr>
<th>Fumigant</th>
<th>Exposure* (ppm)</th>
<th>TLV* (ppm)</th>
<th>Ratio of TLV to Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Routine-Typical</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloropicrin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(at 25 feet)</td>
<td>0.048</td>
<td>0.1</td>
<td>2.1</td>
</tr>
<tr>
<td>(at 50 feet)</td>
<td>0.018</td>
<td></td>
<td>5.4</td>
</tr>
<tr>
<td>Methyl bromide</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(at 25 feet)</td>
<td>0.326</td>
<td>5.0</td>
<td>15.3</td>
</tr>
<tr>
<td>(at 50 feet)</td>
<td>0.166</td>
<td></td>
<td>30.2</td>
</tr>
<tr>
<td><strong>Dazomet Components</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(at 50 feet)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MITC</td>
<td>0.032</td>
<td>10.0</td>
<td>313</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>0.024</td>
<td>1.0</td>
<td>42</td>
</tr>
<tr>
<td>Monomethylamine</td>
<td>0.012</td>
<td>10.0</td>
<td>833</td>
</tr>
<tr>
<td>Hydrogen sulfide</td>
<td>0.032</td>
<td>10.0</td>
<td>313</td>
</tr>
<tr>
<td><strong>Routine-Extreme</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloropicrin</td>
<td></td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>(at 25 feet)</td>
<td>0.066</td>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td>(at 50 feet)</td>
<td>0.023</td>
<td></td>
<td>4.4</td>
</tr>
<tr>
<td>Methyl bromide</td>
<td></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>(at 25 feet)</td>
<td>0.435</td>
<td></td>
<td>11.5</td>
</tr>
<tr>
<td>(at 50 feet)</td>
<td>0.217</td>
<td></td>
<td>23.0</td>
</tr>
</tbody>
</table>

*Exposure is the concentration in the air.

*The threshold limit value (TLV) is the estimated maximum concentration for long-term, 8-hour workday exposures that will not result in any adverse effects.

*Based on field study by Maddy et al. 1983a.

*Based on field study by Maddy et al. 1984b.

1.5 and 4.4 at distances of 25 and 50 feet, respectively. For methyl bromide, the ratio of the TLV to the exposure is 11.5 and 23.0 at distances of 25 and 50 feet, respectively. Effects similar to those seen in the routine-typical situation exist for the public in the routine-extreme situation.

**Accidents**

The risk estimates for the accidental release of the fumigant mixture are calculated based on a 350 pound per acre application rate of a 67/33 percent mixture of methyl bromide/chloropicrin, as is used at the Lucky Peak Nursery. The accidental release scenario is based on the assumption that a chemical plume maintains a fairly stable concentration as it moves downwind, resulting in offsite exposures to members of the public comparable to exposures workers may receive onsite. Results of the analysis are presented in Table D-4-13. Even at 100 feet from the fumigation site, the ratio of the TLV to the exposure for both chloropicrin and methyl bromide is negative, indicating the possibility of adverse effects from an accidental release of the methyl bromide/chloropicrin fumigant mixture into the environment.

Accidental releases of dazomet are very unlikely because it is applied as in granular form; therefore, these exposures are not included in this analysis.

**Cancer Risk**

Cancer risk to the public from dazomet and methyl bromide exposure is shown in Table D-4-14. The risks have been calculated for 5 and 10 years, with an assumed exposure totaling 24 hours per year. Cancer risks from accidental fumigant exposure have been calculated assuming that an accidental release of methyl bromide results in a 5-minute exposure. It was then assumed that the respiration rate was 18 liters per minute and that 50 percent of the inspired fumigant was absorbed.

Cancer risk resulting from both 5 and 10 years of exposure to methyl bromide exceed 1 in 1 million. For 10 years of exposure, the cancer risk was calculated to be 1 in 50,000. Cancer risk resulting from an accidental release of methyl bromide into the air is approximately 1 in 1 million. Cancer risks resulting from exposure to the formaldehyde in dazomet are less than 1 in 1 million for both 5 and 10 years of exposure.

**Fumigant Risk to Workers**

Table D-4-15 lists the ratios of the TLV's to the average workday exposures for workers involved in routine fumigation procedures, based on exposure levels found in worker field studies (Maddy et al. 1982; Maddy et al. 1983b; Maddy et al. 1984a) and field dissipation studies of dazomet (Munnecke and Martin 1964). No studies of chloropicrin exposure for tarp lifters were found in the literature, so it was not possible to estimate these risks. Only one study included any data on chloropicrin exposure to shovelers. However, this study
### Public Risks for Accidental Fumigant Exposure

<table>
<thead>
<tr>
<th>Fumigant</th>
<th>Exposure&lt;sup&gt;b&lt;/sup&gt; (ppm)</th>
<th>TLV&lt;sup&gt;c&lt;/sup&gt; (ppm)</th>
<th>Ratio of TLV to Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloropicrin</td>
<td>0.48</td>
<td>0.1</td>
<td>-4.8</td>
</tr>
<tr>
<td></td>
<td>(at 100 feet)</td>
<td>0.36</td>
<td>-3.6</td>
</tr>
<tr>
<td>Methyl bromide</td>
<td>5.0</td>
<td>0.1</td>
<td>-59.0</td>
</tr>
<tr>
<td></td>
<td>(at 25 feet)</td>
<td>59.0</td>
<td>-11.8</td>
</tr>
<tr>
<td></td>
<td>(at 100 feet)</td>
<td>44.0</td>
<td>-8.8</td>
</tr>
</tbody>
</table>

<sup>a</sup>Based on plume model with person 25 and 100 feet from the source and wind speed at 5 miles per hour.  
<sup>b</sup>Exposure is the concentration in the air.  
<sup>c</sup>The threshold limit value (TLV) is the estimated maximum concentration for long-term, 8-hour workday exposures that will not result in any adverse effects.

---

### Cancer Risk for the Public Exposed to Fumigants

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Dazomet&lt;sup&gt;d&lt;/sup&gt;</th>
<th>Methyl bromide</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 years of exposure&lt;sup&gt;e&lt;/sup&gt;</td>
<td>8x10&lt;sup&gt;-8&lt;/sup&gt;</td>
<td>8x10&lt;sup&gt;-8&lt;/sup&gt;</td>
</tr>
<tr>
<td>10 years of exposure&lt;sup&gt;e&lt;/sup&gt;</td>
<td>2x10&lt;sup&gt;-7&lt;/sup&gt;</td>
<td>2x10&lt;sup&gt;-7&lt;/sup&gt;</td>
</tr>
<tr>
<td>Accidental exposure&lt;sup&gt;f&lt;/sup&gt;</td>
<td>...&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1x10&lt;sup&gt;-4&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>d</sup>Risk is for formaldehyde breakdown product.  
<sup>e</sup>Cancer risks are based on 24 hours of exposure per year, for either 5 or 10 years.  
<sup>f</sup>Cancer risk for accidental exposure is based on one accidental exposure for 5 minutes per lifetime.  
<sup>g</sup>Accidental exposure was not calculated for dazomet.
### Table D-4-15

**Worker Risks for Fumigant Exposure During Routine Operations**

<table>
<thead>
<tr>
<th>Fumigant</th>
<th>Average exposure for workday (ppm)</th>
<th>TLV* (ppm)</th>
<th>Ratio of TLV to Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Routine-Typical</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloropicrin</td>
<td></td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Driver</td>
<td>0.11</td>
<td>-1.1</td>
<td></td>
</tr>
<tr>
<td>Co-pilot</td>
<td>0.13</td>
<td>-1.3</td>
<td></td>
</tr>
<tr>
<td>Shoveler*</td>
<td>0.039</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>Methyl bromide</td>
<td></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Driver</td>
<td>1.5</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>Co-pilot</td>
<td>2.2</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>Shoveler</td>
<td>0.5</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>Tarp lifter</td>
<td>7.8</td>
<td>-1.6</td>
<td></td>
</tr>
<tr>
<td><strong>Dazomet components</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MITC</td>
<td>0.372</td>
<td>10.0</td>
<td>27.0</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>0.284</td>
<td>1.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Monomethylamine</td>
<td>0.142</td>
<td>10.0</td>
<td>70.0</td>
</tr>
<tr>
<td>Hydrogen sulfide</td>
<td>0.371</td>
<td>10.0</td>
<td>27.0</td>
</tr>
<tr>
<td><strong>Routine-Extreme</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloropicrin</td>
<td></td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Driver</td>
<td>0.18</td>
<td>-1.8</td>
<td></td>
</tr>
<tr>
<td>Co-pilot</td>
<td>0.26</td>
<td>-2.6</td>
<td></td>
</tr>
<tr>
<td>Shoveler*</td>
<td>0.039</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>Methyl bromide</td>
<td></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Driver</td>
<td>2.0</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>Co-pilot</td>
<td>3.0</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td>Shoveler</td>
<td>0.8</td>
<td>6.3</td>
<td></td>
</tr>
<tr>
<td>Tarp lifter</td>
<td>13.0</td>
<td>-2.6</td>
<td></td>
</tr>
</tbody>
</table>

*The threshold limit value (TLV) is the estimated maximum concentration for long-term, 8-hour workday exposures that will not result in any adverse effects.  
*Only one data point available for shovelers' exposures to chloropicrin.

(Maddy et al. 1983b) gave only one data point. This value was used to calculate the ratio of the TLV to the exposure for shovelers exposed to chloropicrin.

**Routine-Typical**

Under the routine-typical scenario, the TLV to exposure ratio for chloropicrin for both the driver and co-pilot are negative, indicating that the exposure to chloropicrin in the air is greater than the TLV. Workers applying chloropicrin are quite likely to experience the low-level effects of tearing, as well as bronchial irritation and swelling. For methyl bromide, the TLV to exposure ratios for all workers, with the exception of the tarp lifter, are greater than 1.0. During tarp lifting under routine-typical conditions, the average workday air concentration of methyl bromide is 7.8 ppm, while the TLV is only 5.0 ppm. For dazomet, the TLV to exposure ratio is greater than 10 for all breakdown products with the exception of formaldehyde. The TLV to exposure ratio for formaldehyde is 3.5.

**Routine-Extreme**

Under routine-extreme conditions, patterns similar to those seen in the routine-typical scenario are seen. Again, the workers applying chloropicrin are quite likely to experience tearing and bronchial irritation and swelling.

**Accidents**

Table D-4-16 lists the lowest TLV to exposure ratios for workers exposed to the accidental release of the fumigant into the atmosphere. The accidental exposure was calculated by the Gaussian plume model, assuming that a broken hose results in a 5-minute exposure without a respirator at a distance of 5 feet from the source. As in the routine operations, workers are at risk of low-level effects from using the methyl bromide/chloropicrin mixture.

Accidental releases of dazomet are very unlikely because it is applied as in granular form; therefore, these exposures are not included in this analysis.

**Cancer Risk**

Cancer risks to workers from methyl bromide and dazomet have been calculated assuming that workers are exposed for 38 hours per year, the average work time reported for fumigators by USDA (1986). Risks for dazomet were calculated based on the formaldehyde breakdown product. The risks are shown in Table D-4-17 for 5 and 30 years of fumigation work during a worker's 70-year lifetime. Risks are also shown in this table for accidental exposures to methyl bromide, assuming that exposure to a major accident occurs only once (or several smaller accidents occur). The accidental exposure was calculated by the Gaussian plume model, assuming that a broken hose results in a 5-minute exposure without a respirator 5 feet from the source. It was then assumed that 50 percent of the inspired fumigant is absorbed and the respiration rate is 18 liters per minute. All cancer risks from methyl bromide, with
Table D-4.16
Worker Risks for Accidental Fumigant Exposure

<table>
<thead>
<tr>
<th>Fumigant</th>
<th>Exposure* (ppm)</th>
<th>LC&lt;sub&gt;50&lt;/sub&gt; (ppm)</th>
<th>MOS based on LC&lt;sub&gt;50&lt;/sub&gt;</th>
<th>TLV&lt;sup&gt;a&lt;/sup&gt; (ppm)</th>
<th>Ratio of TLV to Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloropicrin</td>
<td>0.49</td>
<td>25.5</td>
<td>59.</td>
<td>0.1</td>
<td>-4.9</td>
</tr>
<tr>
<td>Methyl bromide</td>
<td>60</td>
<td>396.0</td>
<td>7.5</td>
<td>5.0</td>
<td>-12.0</td>
</tr>
</tbody>
</table>

*Based on plume model with worker 5 feet from the source and wind 5 miles per hour.

The threshold limit value (TLV) is the estimated maximum concentration for long-term, 8-hour workday exposures that will not result in any adverse effects.

Table D-4.17
Cancer Risk for Workers Using Fumigants

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Dazomet&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Methyl bromide</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Years of exposure&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driver</td>
<td>7x10&lt;sup&gt;7&lt;/sup&gt;</td>
<td>6x10&lt;sup&gt;5&lt;/sup&gt;</td>
</tr>
<tr>
<td>Copilot</td>
<td>7x10&lt;sup&gt;7&lt;/sup&gt;</td>
<td>9x10&lt;sup&gt;5&lt;/sup&gt;</td>
</tr>
<tr>
<td>Shoveler</td>
<td>...&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2x10&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td>Tarp Lifter</td>
<td>...&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3x10&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td>30 Years of exposure&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driver</td>
<td>4x10&lt;sup&gt;6&lt;/sup&gt;</td>
<td>4x10&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td>Copilot</td>
<td>4x10&lt;sup&gt;6&lt;/sup&gt;</td>
<td>5x10&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td>Shoveler</td>
<td>...&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1x10&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td>Tarp Lifter</td>
<td>...&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2x10&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Accidental exposure&lt;sup&gt;d&lt;/sup&gt;</td>
<td>...&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1x10&lt;sup&gt;6&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

*Risk is for formaldehyde breakdown product.

<sup>a</sup>Cancer risks are based on 38 hours of exposure per year, for either 5 or 10 years.

<sup>b</sup>Shovelers and tarp lifters do not work with dazomet.

<sup>c</sup>Cancer risk for accidental exposure is based on one accidental exposure for 5 minutes per lifetime.

<sup>d</sup>Accidental exposure was not calculated for dazomet.
the exception of the risk from accidental exposure are greater than 1 in 1 million. Cancer risks from dazomet are greater than 1 in 1 million only for 30 years of exposure. The largest cancer risk is to a tarp lifter who is exposed to methyl bromide during nursery fumigation operations for 30 years. The calculated risk indicates that 1 out of 500 tarp lifters who work for 30 years may contract cancer.

**Exposure by Diffusion of Fumigants Through the Tarp**

At the Lucky Peak Nursery, the fumigant mixture is 67 percent methyl bromide and 33 percent chloropicrin and is applied by soil injection at a rate of 350 pounds per acre. The gases are confined to the soil by overlaying a plastic tarp. It has been shown that plastic tarp are permeable to these gases (Kolbezen and Abu-El-Haj, undated). Based on results of a laboratory study, these researchers calculated that 50 to 67 percent of the fumigant mixture applied can be lost in 48 hours through a low density polyethylene (LDPE) tarp that is 1 millimeter thick. To estimate the maximum exposure to individuals downwind from a fumigation procedure from diffusion through the tarp after they are in place, the following conservative assumptions were made:

- The application rate of the methyl bromide/chloropicrin mixture is 350 lb/acre, consisting of 235 pounds of methyl bromide and 115 pounds of chloropicrin.

- Two thirds, or 67 percent, of the applied fumigant mixture diffuses through the tarp material in 48 hours. This means that 2.5 percent of the remaining fumigant under the tarp will escape every hour.

- The person is just outside of the fumigated area and is exposed just after the fumigation procedure ends and remains exposed for 8 hours. The first 8 hours of tarp diffusion represent the period when the maximum amount of fumigant is moving across the membrane.

- The escaping gas is confined to the first 5 meters above the tarp during average conditions and the first 3 meters above the tarp during extreme conditions, which simulate a temperature inversion situation.

- Because 18 acres (72,850 m²) of the nursery may be treated at once, the assumption was made that this was a square area measuring 270 meters on a side.

- For the typical scenario, the wind speed is assumed to be constant at 3 miles per hour (80.5 meters per minute). Therefore, the volume of air above a 270-meter long nursery bed will be replaced every 3.4 minutes. For the extreme scenario, the wind speed is assumed to be constant at 1 mile per hour (26.9 meter per minute).

Therefore, the volume of air above a 270-meter long nursery bed will be replaced every 10 minutes.

**Routine-Typical**

The results of this analysis are presented in Table D-4-18. Using the above assumptions, the 8-hour average concentration of chloropicrin is 0.46 ppm and the TLV to exposure ratio is negative, indicating the possibility of adverse health effects if all assumptions made in the calculations were true. The 8-hour average concentration of methyl bromide in the air under routine-typical conditions is 1.6 ppm. The TLV to exposure ratio for methyl bromide is 2.5, indicating little risk to the healthy adult. However, more sensitive individuals may experience low-level effects.

**Routine-Extreme**

If all the assumptions used in the calculations are true, the 8-hour average concentration of methyl bromide and chloropicrin in the air under routine-extreme conditions would be 2.3 ppm and 7.9 ppm, respectively. The TLV to exposure ratios for chloropicrin and methyl bromide would be 0.8 and 1.6, respectively.

If all the assumptions were met, it would be possible that exposed individuals may have adverse effects from the fumigant mixture. However, the strong irritant properties (causing tearing, coughing, and vomiting) of chloropicrin will likely force an individual to leave the area of exposure before receiving a significant dose.

Note that realistic conditions preclude exposures as high as those calculated from actually occurring.

- At the Lucky Peak Nursery, the tarp used are 1 millimeter thick, as in this analysis. However, they are constructed from a blend of low- and high-density polyethylene. This will decrease their permeability compared to that associated with the LDPE tarp. Kolbezen and Abu-El-Haj (undated) demonstrated that high-density polyethylene is 3 to 3.5 times less permeable to methyl bromide than an LDPE tarp. The particular composition of the blend used in Lucky Peak Nursery’s tarp will determine the decrease in exposures that are actually possible compared to those calculated in this analysis.

- Wind speed will often exceed 3 miles per hour, leading to more frequent replacement of the air over a nursery bed and a corresponding lower concentration of the fumigants in the air that moves downwind.

- Methyl bromide and chloropicrin that permeate through the tarp will be diffused into the surrounding air, instead of confined to a 3- or 5-meter high “block” as assumed in this analysis.
General Risks for Fumigant Exposure Through Tarp Diffusion

<table>
<thead>
<tr>
<th>Fumigant</th>
<th>Exposure (ppm)</th>
<th>TLV (ppm)</th>
<th>Ratio of TLV to Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine-Typical‡</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloropicrin</td>
<td>0.46</td>
<td>0.1</td>
<td>-4.6</td>
</tr>
<tr>
<td>Methyl bromide</td>
<td>1.6</td>
<td>5.0</td>
<td>2.5</td>
</tr>
<tr>
<td>Routine-Extreme‡</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloropicrin</td>
<td>2.3</td>
<td>0.1</td>
<td>-23</td>
</tr>
<tr>
<td>Methyl bromide</td>
<td>7.9</td>
<td>5.0</td>
<td>-1.6</td>
</tr>
</tbody>
</table>

*Exposure is the concentration in air.

‡The threshold limit value (TLV) is the estimated maximum concentration for long-term, 8-hour workday exposures that will not result in any adverse effects.

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RISK ANALYSIS OF OTHER EFFECTS

This section discusses risks other than those described under systemic and reproductive effects and cancer risk. This includes risk of heritable mutations, risks as a result of synergistic effects, risks to sensitive individuals, and cumulative effects.

Risk of Heritable Mutations

No human studies are available with which to evaluate the risk of heritable mutations that may be posed by exposure to the nursery pesticides. Furthermore, no risk assessments that quantify the probability of genetic mutations in human germ cells are available in the literature or from the Environmental Protection Agency. Laboratory studies in bacteria, yeast, mammalian cells, and animals constitute the best available information with which to approximate mutagenic potential in humans. Results of the mutagenicity assays conducted on the pesticides are summarized here; further detail is provided in Section 0-2.

Dazomet, and methyl bromide are considered to be mutagenic. Benomyl and oxyfluorfen may be mutagenic. Glyphosate, DCPA, napropamide, and metalaxyl do not appear to be mutagenic in mammals. No conclusive information is available on the mutagenicity (or carcinogenicity) of chloropicrin.

The results of carcinogenicity tests or cancer risk assessments can be used to estimate the risk of heritable mutations from those pesticides that are considered to be possible mutagens. The rationale for this assumption is summarized by the U.S. Department of Agriculture (1985), as follows:

Since mutagenicity and carcinogenicity both follow similar mechanistic steps (at least those that involve genetic toxicity), the increased risk of cancer can be used to approximate the quantitative risk of heritable mutations. The basis for this assumption is that both mutagens and at least primary carcinogens react with DNA to form a mutation or DNA lesion affecting a particular gene or set of genes. The genetic lesions then require specific metabolic processes to occur, or the cells must divide to insert the lesion into the genetic code of the cell. We believe the cancer risk provides an extreme [conservative] approximation to heritable mutations because cancer may involve many types of cells, whereas heritable mutations involve only germinal (reproductive) cells.

Synergistic Effects

Synergistic effects occur when the combined toxic effects of two or more chemicals is greater than the sum of the effects of each chemical. For example, when each is administered alone at a given dose, chemical A causes 20 percent cholinesterase inhibition and chemical B causes 10 percent cholinesterase inhibition. In the usual case, when the two doses are administered at the same time, an additive effect would be observed, resulting in 30 percent cholinesterase inhibition.
inhibition. However, if the two chemicals have a synergistic interaction, cholinesterase inhibition greater than 30 percent would be observed.

EPA (1986) states that, in the absence of evidence to the contrary, an additive risk model should be used when assessing the potential for interactive effects of exposure to more than one chemical. The EPA guidelines suggest using a hazard index (HI) as the model of additivity based on the dose and toxicity reference level (NOEL) for each chemical, as follows:

$$HI = \frac{D_1}{L_1} + \ldots + \frac{D_m}{L_m}$$

where:

- $D_i$ is the dose and
- $L_i$ is the toxicity reference level (NOEL)

As HI approaches 1, the risk from the mixture becomes greater. On the basis of the accidental exposures for adult members of the public for systemic effects for methyl bromide and chloropicrin, it appears that the risk from the mixture is twice as great as that from the constituents alone.

No information was available on the potential for synergistic or antagonistic effects from DCPA, glyphosate, napropamide, oxfluorfen, benomyl, metalaxyl, methyl bromide, dazomet, or chloropicrin.

**Effects on Sensitive Individuals**

**Individual Sensitivity**

Individual sensitivity to chemical compounds varies, and may depend on a number of factors. Doull et al. (1980) and Calabrese (1985) have presented two different models for describing interindividual variation as a result of differences in sensitivity.

Doull et al. (1980) described hypersensitivity as the response of subjects at the lower end of the frequency distribution in a quantal dose-response curve. Quantal means a subject either exhibits the toxic response or does not, at a given dose level. If the response of a population of test animals to varying doses of a chemical follows a normal distribution (bell-shaped curve), the hypersensitive individuals are those on the left side of the curve that respond at much lower doses than the average. For example, if the average individual responds with toxic symptoms at a dose of 100 mg/kg and the standard deviation of the response is 30 mg/kg, then about 95 percent of the individuals will have responded with those symptoms at doses from 40 to 160 mg/kg (2 standard deviations from the mean), and more than 99 percent of the individuals will have responded with those symptoms at doses from 10 to 190 mg/kg (3 standard deviations from the mean). Less than 0.15 percent of the population will have experienced toxicity at doses lower than 10 mg/kg. Applying this distribution of response to humans would mean that in a population of 10,000, fewer than 15 individuals would be likely to experience toxicity at doses lower than 10 mg/kg. Those 15 individuals could be considered the sensitive individuals in the population.

Calabrese (1985) has shown that human susceptibility to toxic substances can vary two to three orders of magnitude. He examined a number of studies of human responses to chemicals and found that a safety factor of 10, intended to allow for interspecies variation, accounts for effects in 80 to 95 percent of a population. Thus, he concluded that 5 to 20 percent of the population exhibit effects at doses outside the tenfold range.

**Factors Affecting Sensitivity**

Factors that may affect individual susceptibility to toxic substances include diet, age, heredity, pre-existing diseases, and lifestyle (Calabrese 1978). These factors have been studied in detail for very few cases, and their significance in controlling the toxicity of the proposed pesticides is not known. However, enough data have been collected on other chemicals to show that these factors can be important.

Elements of the diet known to affect toxicity include vitamins and minerals (Calabrese and Dorssey 1984). For example, the mineral selenium can prevent the destruction of blood-forming tissues by chronic heavy exposure to benzene. Large doses of vitamin C have also been shown to protect animals and humans from toxic effects of chronic benzene exposure. Vitamin A seems to have a preventative effect on cancer induced by chemicals such as benzo(a)pyrene (found in cigarette and wood smoke). This effect has been seen in laboratory animals and human epidemiological studies. Various levels of the B-vitamin riboflavin have also been tested with mixed results. Vitamin C has been shown to prevent nitrates from combining with amines to form nitrosamines, and vitamin E seems to be at least as effective as vitamin C. These vitamins may prevent formation of N-nitrosoglyphosate (a carcinogenic nitrosation product of glyphosate) if conditions were otherwise favorable for its formation in the human stomach (Calabrese and Dorssey 1984).

Genetic factors are also known in some cases to be important determinants of susceptibility to toxic environmental agents (Calabrese 1984). Susceptibility to irritants and allergic sensitivity vary widely among individuals and are known to be largely dependent on genetic factors. Race has been shown to be a significant factor influencing sensitivity to irritants, and some investigations have indicated that women may be more sensitive than men (Calabrese 1984).

A variety of human genetic conditions have been identified as possibly enhancing susceptibility to environmental agents. For example, persons with the blood condition beta-thalassemia may be at increased risk when exposed chronically to benzene. However, only one condition, G-6-PD deficiency, has conclusively been demonstrated to cause enhanced susceptibility to industrial pollutants. Several other genetic conditions have been shown to involve defects in the cellular mechanisms for repair of damage to DNA. Persons
with these diseases share an increased sensitivity to the effects of ultraviolet light, which can cause cancer. Cells from individuals with at least one of these diseases, xeroderma pigmentosum, are also sensitive to a variety of chemical substances implicated as causative agents of human cancers (Calabrese 1984).

Persons with other types of pre-existing medical conditions may also be at increased risk of toxic effects. For example, sensitivity to chemical skin irritants can be expected to be greater for people with a variety of chronic skin ailments. Patients with these conditions may be advised to avoid occupational exposure to irritating chemicals (Shmunes 1980, as cited in Calabrese 1984).

Allergic Hypersensitivity

A particular form of sensitivity reaction to a foreign substance is allergic hypersensitivity. These reactions may occur immediately upon exposure, as in anaphylactic reactions to insect bites or penicillin injections, or they may be delayed, as in the case of responses to tuberculin tests or contact with poison ivy. The severe, immediate anaphylactic reactions, which can be fatal if not treated shortly after onset, are antigen-antibody reactions that require large, complex organic molecules to initiate the sensitivity. The delayed allergic hypersensitive reactions are usually directed against whole cells (bacteria, viruses, fungi) but may be induced by lower molecular weight substances, such as the catechols of poison ivy, cosmetics, drugs, or antibiotics (Volk and Wheeler 1983). Benzocaine, neomycin, formaldehyde, nickel, chromium, and thiram are all known to produce these reactions (Marzulli and Maibach 1983).

Risks to Sensitive Individuals

Based on the current state of knowledge, individual susceptibility to the toxic effects of the 14 pesticides cannot be predicted with any degree of accuracy. As discussed previously, safety factors have traditionally been used to account for variations in susceptibility among people. The MOS approach used in this risk assessment takes into account much of the variation in human response, as discussed earlier by Calabrese (1985). An additional safety factor of 10 is used for interspecies variation when the study on which the NOEL is based was conducted in animals instead of humans, as is usually the case.

Thus, toxicologists generally consider an MOS of 100 to be sufficient to ensure that most people should experience no toxic effects. However, sensitive individuals may experience effects even when the MOS is equal to or greater than 100. In addition, for exposures in which the MOS is less than 100, it is more likely that a sensitive individual would experience toxic effects than an "average" person would. It must be noted, however, that sensitive individuals are thought to compose only a fraction of the human population; it is therefore unlikely that a sensitive individual would be among those few people who might be exposed in any of the applications at the Lucky Peak Nursery. It must also be noted that most of estimated public exposures are very low and in most applications no member of the public is exposed.

Cumulative Effects

Cumulative effects in members of the public resulting only from pesticide applications at the Lucky Peak Nursery are not likely to occur because of the low probability that a member of the public would receive repeated exposures to the nursery pesticides.

There are instances when it is possible for cumulative doses to occur. If the nursery is resprayed with a pesticide before the pesticide from the previous spraying has been totally degraded, then it is possible for larger pesticide doses to occur than those estimated in this risk assessment from a single application. Cumulative exposures, of which the nursery exposure is only one part, could occur if an individual is exposed to a pesticide in a non-nursery setting, such as when using a pesticide on their lawn or garden or being exposed to a pesticide from nearby agricultural areas, and is also exposed to a pesticide with a similar action (such as cholinesterase inhibition) as a result of the Forest Service Lucky Peak Nursery application program.

Pesticide doses from other sources are not estimated in this risk assessment. However, because of the conservatism inherent in the estimation of the routine-extreme exposures, it is unlikely that the risks of adverse health effects from cumulative doses that may occur are greater than the risks estimated to result from these doses.

LIMITING EXPOSURE TO REDUCE WORKER RISK

This section describes ways that nursery worker exposure can be limited to reduce risk. The ways to limit exposure discussed include the use of protective clothing, finished fabrics, laundering practices, washing and showering, personnel workday manipulation, and pesticide application scheduling.

Protective Clothing

In estimating potential exposures to workers, various assumptions (described in Section E-3) were made about the use of protective clothing by persons working directly with pesticides and the types of clothing and amount of bare skin area exposed by persons contacting treated vegetation (weeders, inventory personnel, lifters, and sorters/packers). In the calculations of routine-typical exposures, workers were assumed to wear appropriate protective clothing for their particular task. Typical protective clothing for applicators and mixer/loaders often includes longsleeve shirts or coveralls, gloves, hats, and boots. The calculations of routine-extreme exposures, it was assumed that no special protective clothing was worn. This section describes the effectiveness of different types of clothing in reducing exposure to pesticides and related factors, such as fabric finishes and laundering clothing that has pesticide residues. Research has demonstrated that protective clothing can substantially reduce worker doses. For example, in right-of-way spraying, doses received by spray gun applicators wearing clean
coveralls and gloves were reduced by 68 percent compared to doses without this protection (Lishib et al. 1984). During an aerial spraying operation, mixer/loaders wearing protective clothing reduced their exposure by 58 percent compared to the levels observed without precautions (Lavy et al. 1982).

Most exposure for pesticide applicators is dermal, not inhalation (Kolmodin-Hedman et al. 1983) and Wolfe (1972) indicated that more than 97 percent of the total exposure is dermal. Respirator use is of limited effectiveness in reducing overall doses to workers and may cause discomfort because of sweating and heat (Davis et al. 1982). Although the hands are the site of the greatest potential pesticide exposure, rubber gloves can reduce exposure to hands (Putnam et al. 1983).

Research has shown that most protective clothing, even rubber garments that were previously thought to be impermeable, allows some level of chemical penetration (Mansdorf 1986). However, even nonrubber garments can contribute significantly toward reducing exposures.

A study by Davies et al. (1982) showed that when orchard workers wore 100 percent cotton coveralls, dermal doses of the pesticide ethion were less than 15 percent of the doses received when the workers wore their own street clothes. Putnam and coworkers found that nitrofen application and mixer/loaders wearing protective clothing reduced their exposures by 94 to 99 percent compared to the doses experienced without protection (Waldron 1985). Although protective clothing generally reduces worker exposures and resulting doses, the degree of protection depends on the application system, the work practices, and the specific pesticide.

Fabric Finishes

Fabric finishes can also affect doses. Several studies (Laughlin et al. 1986; Leonas and DeJonge et al. 1986; and Keaschall et al. 1986) have shown that fluorocarbon-based soil-repellent finishes increase the effectiveness of clothing as a barrier to chemicals. Water-repellent finishes also contribute to the efficiency of protective garments. In addition, the Laughlin and Leonas studies demonstrated that a durable-press finish is undesirable in clothing worn during pesticide use because it allows increased penetration of some pesticides, notably methyl parathion. Wearing an undergarment layer, such as a tee-shirt, also decreases the chemical dose received.

Laundrying Practices

Laundrying practices are important in minimizing pesticide exposure. Heavy duty liquid detergents are more effective than powder detergents in removing oil-based chemicals and in cleaning cotton/polyester blends that have a durable-press finish (Raheel 1987). Using a prewash spray also increases chemical removal (Keaschall et al. 1986). In general, it is more difficult to remove organochlorine residues from clothing than those of organophosphates, while carbamates are easier to remove than either of these types of pesticides (Raheel 1987 and Keaschall et al. 1986).

The availability of laundering facilities at the nursery could help to reduce pesticide risk because pesticide residues in and on clothing can be transferred to the skin and subsequently absorbed. Pesticide residues on clothing could be transferred to car upholstery or items in the home and families members and other individuals could potentially be dermally exposed as well. Workers could be required to leave their work clothing at the nursery for laundering and clean clothing could be available for their use the following work day. By requiring workers to change their clothing at the end of the work day, managers would be assured that workers were not wearing the clothing for long periods of time after work hours, pesticide residues were not being transferred off nursery property on clothing, and worker clothing was being properly laundered daily.

Washing and Showering

Washing and showering can be effective in reducing pesticide exposure. Pesticides are not absorbed instantaneously through the skin; over time some portion of the pesticide available on the skin surface for absorption is absorbed. Therefore, by minimizing the available pesticide on the skin surface, doses to that worker may be reduced. Workers should be encouraged to wash their hands, arms, and other areas in contact with foliage throughout the day and shower as soon as possible after completing their work. They should also be cautioned to thoroughly wash their hands prior to eating to minimize dietary exposure to pesticide residues. Showers could be provided at the nursery to ensure that workers have a chance to shower prior to engaging in other activities.

Personnel Workday Manipulation

Individual worker exposure may be reduced by manipulating each worker's overall contact with pesticides. Methods of reducing risk include requiring longer reentry times, rotating workers, shortening daily work hours in the field, and splitting tasks between several workers. All of these options could effectively lower the total daily pesticide exposure to each worker and thus lower that worker's risk of adverse effects.

Lengthening the time interval between pesticide application and worker contact is an effective way to limit exposure for workers such as weeder, inventory personnel, lifters, sorters, packers, and tree planters. As the time interval is lengthened, less pesticide remains on the foliage, primarily because of degradation of the active ingredient and pesticide washoff from foliage by rainfall and irrigation water. By limiting the total amount of pesticide available on the foliage to transfer to the worker's clothing and skin, the dose that worker receives may be reduced.

Rotation of workers, shortening of daily work hours in contact with seedlings, and splitting of tasks among workers all serve to lessen the total contact with pesticides by reducing the duration of exposure. These methods can be used for all types of workers to reduce their risks. Rotation of workers would allow a single worker to spend portions of the day in contact with groups of seedlings containing residues from different pesticides, thus lessening
the risk from any one pesticide. As an alternative, worker hours could be reduced such that the workday was shortened or portions of the day would be spent in tasks which did not involve pesticide contact. Splitting tasks among workers would also reduce exposure by allowing more than one worker to perform a given task. As an example, one applicator could apply a pesticide in the morning and another applicator could continue the job in the afternoon. As an alternative, a single worker could apply a single pesticide to the total acreage, but the actual application would be divided into several days, thus reducing total exposure on any given day.

**Altering Application Rate and Schedule**

Changes in the pesticide application rate and schedule may also help to reduce worker risks. However, these options may not be feasible if lower application rates or changes in scheduling reduce the efficacy of the pesticide treatment program.

By lowering the application rate, the total pesticide that the mixer/loader/applicator would be exposed to is reduced. In addition, the total amount of a single pesticide sprayed on a given field is lowered, thus reducing exposure to workers such as weeders, inventory personnel, lifters, sorters, packers, and tree planters.

Alteration of the application schedule could reduce exposure in a number of ways. Alterations in scheduling include limiting the number of applications of a single pesticide on a single field, increasing the time intervals between multiple applications of a single pesticide on a single field, and altering task dates for certain nursery operations. These alterations would serve to reduce the amount of pesticide available on the foliage when workers such as weeders, inventory personnel, lifters, sorters, packers, and tree planters come in contact with the foliage to complete their tasks.
SECTION D-5
REFERENCES CITED

All documents cited in this document are available at universities, libraries, or from Federal agencies such as the U.S. Forest Service or the U.S. Environmental Protection Agency (EPA). All EPA documents can be obtained through requests to EPA’s Freedom of Information Office, Washington, DC 20460.

In the text of this document, references are cited in parentheses using the author-year system of citation. When an organization (such as a Government agency or scientific society) is listed as the author in the parenthetical citation, an acronym: or an abbreviated form of that organization’s name generally is used in place of its full title. Below is a list of acronyms and abbreviations that are used in citations, along with the corresponding full titles that are used in this reference section.

DOE U.S. Department of Energy
EPA U.S. Environmental Protection Agency
HSDB Hazardous Substances Data Bank
NCI National Cancer Institute
NLM National Library of Medicine
ODA Oregon Department of Agriculture
OSTP U.S. Office of Science and Technology Policy
USDA U.S. Department of Agriculture
WHO World Health Organization
WSSA Weed Science Society of America

SECTION D-1


SECTION D-2 (References by subsection)

Introduction, Sources of Toxicity Information, and Hazard Analysis Terminology


**Herbicide Hazard Analyses**

**DCPA**


**Glyphosate**


**Napropamide**

Stauffer Chemical Company. 1984. Toxicology summary of data on the formulations of napropamide. Farmington, CT.


Oxyfluorfen


Fungicide Hazard Analyses

Benomyl


Metalaxyl


Fumigant Hazard Analyses

Chloropicrin


D-5-5


Stauffer Chemical Company. 1984. Toxicology summary of data on the formulations of naphropamide. Farmington, CT.


U.S. Department of Agriculture. 1990. GLEAMS user manual version 1.8.55. Lab Note SEWRL-030190/FMD. Tifton, GA: USDA-ARS Southeast Watershed Research Laboratory and University of Georgia College of Agriculture Coastal Plain Experiment Station.


SECTION D-4


Appendix E

Human Health and Environmental Monitoring
Appendix E
Human Health and Environmental Monitoring

Human Health
Worker Exposure

For all Forest Service workers involved in pesticide application programs, a written record will be kept of:

- names and jobs of individuals involved,
- dates of application
- chemical(s) used,
- acres treated,
- use of protective clothing and equipment,
- duration of exposure, and
- method of application.

The Forest Service has funded a study at one state and two federal nurseries in which volunteer nursery workers participated in a human health analysis. The study, conducted by Dr. Terry Lavy (University of Arkansas), monitored worker exposure to pesticides through the use of sampling patches on clothes and by urine analysis (Lavy 1988/1990). The results of the study were released in March, 1990. Additional monitoring will be conducted where study results indicate pesticides with low Margin of Safety values for workers in specific applications.

In addition, Dr. Lavy has completed an analysis of dislodgable pesticide residues for nursery pesticides. The report of this analysis was also released in March, 1990.

Based on the results of these studies, the Forest Service will develop a documented human health monitoring plan specifying the chemical pesticides to be monitored and monitoring frequency.

Public Exposure
Where a concern for public exposures exist, the Forest Service will develop exposure monitoring plans for the project that may include water monitoring, or taking soil or plant samples.

Environmental Monitoring

Water Quality and Soil

Water quality and soil monitoring plans will emphasize sampling for chemical pesticides that may leach into the groundwater or be transported from the nursery in surface runoff.

The leaching potential for the chemical pesticides at Lucky Peak Nursery is presented in Tables E-1 and E-2. The potential transport of nursery chemical pesticides in surface runoff, in both adsorbed and dissolved phases, was derived from the adsorption, degradation and leaching rates of the specific nursery soils and pesticides.

In 1989, a research study was initiated at Lucky Peak Nursery; lysimeters (a type of ground water sampling device) were installed to monitor pesticide movement and pesticide residues at various soil depths. As the sampling procedure is refined, the data gathered will also be used to verify predictions from the LEACH and GLEAMS models (See Appendix D). The lysimeter study is under contract to the University of Arkansas and the Pacific Northwest Range and Experiment Station, Corvallis, Oregon.

Water Quality Monitoring Guidelines

1. The water quality monitoring plan will follow the guidelines described in Chapter 6 of FSH 2109.14 Draft Pesticide Use Management and Coordination Handbook, section 6.23f. The water quality monitoring plan will also be approved by the Forest hydrologist and nursery manager.

2. The monitoring plan will emphasize sampling the chemicals with the most potential to leach or be transported off site in surface runoff.

3. Baseline data and significant events, such as a storm producing overland flow, or during snowmelt, would be included.

4. Because pesticides can be both water soluble and adsorbed by soil particles, both parameters must be analyzed.
5. In the spring, samples will be collected from the drainage outlets.

6. Samples will be collected from surface runoff areas after the application of a pesticide when run-off occurs (including storms and/or irrigation).

Animal Monitoring Guidelines

1. Animal monitoring plans will follow the guidelines described in Chapter 6 of FSH 2109.14 Draft Pesticide-Use Management and Coordination Handbook, sections 6.23d, included in this appendix. Aquatic and terrestrial biota will be monitored by conducting post-treatment surveys for dead or distressed animals on a case-by-case basis.

2. Animal monitoring plans will be developed by the Boise National Forest wildlife biologist and the nursery manager.

3. Mitigation measures will be implemented when adverse effects to aquatic or terrestrial organisms and animals are indicated, based on laboratory findings. Mitigation measures include stopping, decreasing, or changing the timing of pesticide application; modifying the application method; and avoiding certain areas or animal habitats within the nursery.

Soil Monitoring Guidelines

1. Soil monitoring plans will be developed by the Forest soil scientist, hydrologist, and nursery manager. These plans will be approved by the Regional soil scientist, silviculturist, and pesticide coordinator.

2. Since the installation of the lysimeters, soil monitoring techniques have been established. Lysimeter installations have been located to sample the vadose zone (the unsaturated parent material layer between the upper soil horizons and the saturated groundwater depth) in areas most likely to indicate off-site movement, groundwater contamination or potential for contaminating irrigation or potable water supplies. Sampling would be done quarterly for two years. Based on the results of the monitoring, the nursery manager will develop a permanent plan.

Nursery Specific Monitoring

1. Continue lysimeter monitoring.

2. Surface water quality monitoring will be conducted at:

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Region 4 FEIS

a. a location on the intermittent streamcourse south of the seedbeds; downstream from where the two drainage ditches enter the stream channel.

b. the point where the intermittent stream enters Lucky Peak Nursery.

c. the outlets of the three ponds located on the east border of the nursery.

Recommended chemical pesticides for analysis:
Benomyl, DCPA, Metalaxyl, and Napropamide

Other Recommended Monitoring:
Sampling should also be conducted for nitrates used in commercial fertilizer mixes and for the heavy metals: copper, cadmium, lead, and zinc, when unprocessed sewage sludge is used as a soil amendment.

Appendix E - 4
### Table E-1

**Lucky Peak Nursery: Leaching and Surface Runoff Potential of Nursery Pesticides**

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Kd</th>
<th>Ks</th>
<th>R</th>
<th>50%</th>
<th>1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benomyl</td>
<td>7.4</td>
<td>0.002</td>
<td>28</td>
<td>0.8</td>
<td>0.18</td>
</tr>
<tr>
<td>DCPA</td>
<td>0.77</td>
<td>0.023</td>
<td>3.8</td>
<td>0.3</td>
<td>0.07</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>18.5</td>
<td>0.023</td>
<td>69</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Metalaxyl</td>
<td>1.3</td>
<td>0.028</td>
<td>57</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Oxyfluorfen</td>
<td>698</td>
<td>0.017</td>
<td>2100</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

- **Kd** - Pesticide soil adsorption factor.
- **Ks** - Pesticide degradation rate factor.
- **R** - Pesticide soil mobility factor.
- **NS** - Not Significant; less than 0.05% leaches.
- **50%** - There is a 50% chance the % listed will leach.
- **1%** - There is a 1% chance the % listed will leach.

Note: The fumigants methyl bromide + chloropicrin and dazomet are not included in this table because they volatize rapidly and a large portion is quickly lost to the atmosphere. (See Appendix D.)
Well Logs and Sampling Results

The well log information leaves a lot to be desired, but the information indicates sufficient distance between the ground surface and any aquifers. Nearly every well had inhibiting layers which are also common within the soil column. This means that most leaching will take place vertically for a few feet and then horizontally for many feet. Soil permeability in the nursery beds historically diminishes with time; keeping the soils open and draining properly is a constant problem.

All wells have concrete pads around the well head and are grouted for 20 feet with concrete.

The Dictionary of Geological Terms defines confined ground water as "artesian water." "Confining bed" is defined as that which, because of its position and its impermeability or low permeability relative to that of the aquifer gives the water in the aquifer "artesian head." Further, "artesian" refers to groundwater under sufficient hydrostatic head to rise above the aquifer containing it. Since all wells reported static water levels above the layer containing water they would be classified as confined water tables. It should also be noted that the well water levels fluctuate with the water level in the reservoir.

Well Log

Well No. 4 is 6 inches in diameter and supplies culinary water to the nursery. Ground elevation is 3125 feet.

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-11</td>
<td>top soil</td>
</tr>
<tr>
<td>11-20</td>
<td>clay &amp; gravel</td>
</tr>
<tr>
<td>20-24</td>
<td>clay and gravel sand w/ large boulders</td>
</tr>
<tr>
<td>24-37</td>
<td>decomposed granite</td>
</tr>
<tr>
<td>37-140</td>
<td>basalt, water level 2/17/84 at 136 ft.</td>
</tr>
<tr>
<td>140-190</td>
<td>monzonite sand w/sand</td>
</tr>
<tr>
<td>190-217</td>
<td>monzonite, bottom of pipe 199 ft 2/17/84 bottom of pump 394 1/2 ft deep 2/17/84</td>
</tr>
</tbody>
</table>

(depth at which water was first encountered was not given but assumed to be at about 140 to 190 ft.)

Well No. 2 is 12 inches in diameter and ground elevation is 3150 ft

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Well No. 1 Capped and not used. Elevation 3226 ft.

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-48</td>
<td>clay and boulders</td>
</tr>
<tr>
<td>48-114</td>
<td>basalt</td>
</tr>
<tr>
<td>114-143</td>
<td>quartz monzonite sand and clay</td>
</tr>
<tr>
<td>1443-176</td>
<td>monzonite</td>
</tr>
</tbody>
</table>

The Water Resources Division of the U.S.G.S. (Boise Office) sampled and tested the domestic well water quality. Sampling reveals the following:

- No heavy metals
- Dissolved NH4 - less than 0.01 mg/l
- Dissolved NO2 - less than 0.01 mg/l
- Nitrate Nitr. - 2.20 mg/l

Sampled October 17, 1991, Dr. Parliman, Hydrologist, USGS

Appendix E - 8
References

Lavy, T.L. and J.H. Massey
PESTICIDE-USE MANAGEMENT AND COORDINATION HANDBOOK

CHAPTER 6 - QUALITY CONTROL MONITORING AND POST TREATMENT EVALUATION

6.1 - General Considerations. Pesticide coordinators, incident commanders, and pesticide project directors must use quality control procedures to determine whether pesticides have been applied safely, have been restricted to intended target areas, and have not resulted in unexpected nontarget effects. Quality control monitoring is used to:

1. Evaluate and achieve quality control of pesticide projects by scrutinizing the application procedures during the project and measuring the impact of the pesticide application on nontarget components of the environment during and after the application;
2. Provide early warning of possible unforeseen impacts or conditions during a project and necessary measures to ensure the magnitude of such impacts or conditions; and
3. Determine the extent, severity, and probable duration of any potential hazard that might exist due to a pesticide misapplication or incident.

6.2 - TYPES OF QUALITY CONTROL MONITORING: Use quality control procedures and monitoring to check application equipment. Pesticide labels are being complied with, drift reduction and spray accountability are being practiced, and residue monitoring is being conducted.

6.21 - Checking Application Procedures. Use quality control monitoring procedures to ensure that pesticides are used in accordance with project plans. Incident commanders must ensure that equipment is used according to manufacturer's guidelines, that the equipment used is properly calibrated (within plus or minus 5 percent of optimum) and maintained, and that the appropriate pesticide volume is applied to the target area. To corrective action whenever there are deviations from the project safety or work plan (Sec. 1.81).

6.21a - Label Compliance. Determine label compliance. Pesticides can only be used by Forest Service personnel if the manufacturer's EPA approved label is followed (FSM 2150): 'Pesticide use inconsistent with a label' is a violation of Federal law except that the phrase does not include:

1. Applying a pesticide at any dosage, concentration, or frequency less than that specified on the labeling;
2. Applying a pesticide against any target pest not specified on the labeling, or application is to the crop, animal, or site specified on the labeling, unless the administrator has required that the labeling specifically state that the pesticide may be used only for the pests specified on the labeling after the administrator has determined that the use of the pesticide against other pests would cause an unreasonable adverse effect on the environment;
3. Employing any method of application not prohibited by the labeling; and
4. Mixing a pesticide or pesticides with a fertilizer when mixture is not prohibited by the labeling.

6.21b - Equipment Usability. Use frequent inspection procedures to evaluate the usability of equipment. This is an important aspect of pesticide application quality control. Equipment should be checked for cleanliness, loose nuts and bolts, valves, screens, filters and hoses. Leaks should be given immediate attention and worn parts should be repaired or replaced.

6.21c - Volume of Pesticide Used. Use appropriate monitoring techniques to determine the volume of pesticide used on a project to ensure quality control. Application of residual liquid or dry formulation pesticides in amounts greater or less than intended may mean that the application equipment was operating incorrectly, that the calibration was incorrect, or that a dump or spill occurred. It might also indicate that the applicator was not following procedures, causing under- or overlapping of application. Take corrective action whenever the volume of pesticide used is inconsistent with either the pesticide label or the project work plan (Sec. 1.81).

6.21d - Monitoring Flight Patterns. Use the AGDISP or FSCBG models (Sec. 1.72) to calculate effective swath widths. Once model runs have been completed, they should be checked in the field during aircraft calibration and characterization. Monitoring the flight pattern of aerial application craft is another method of quality control. Chase planes may be used to monitor swath patterns of application (i.e. are uniform, fitting edge to edge).

Use of electronic monitoring and regulating systems to monitor, control, and document pesticide applications is encouraged.

Avoid overlaps or gaps in swath application. They may result in unintended double applications of pesticide and possible adverse impact on non-target sites/organisms. Overlaps can result in a waste of pesticide, as well as deviation from the prescribed application rate per acre.

Single coverage (applying spray once over the treatment area) using proper application methods gives sufficiently even distribution with less flying time, provided that topography permits close control over swath location. To apply 10 gallons per acre with an effective swath width of 50 feet, the boom output is computed to apply 10 gallons per acre over the 50-foot swath. In steep, broken terrain, with streams or other features that must not be sprayed, double flying may be necessary to get good coverage.

Double coverage (applying one-half of the rate on two occasions) requires that each swath overlap 50 percent of the previous swath, or is double flown with a cross-over method.

Recommendations for proper flight patterns are to have pilots:

1. Fly single parallel swaths wherever possible;
2. Space flight lines at a distance apart equal to the effective swath width;
3. Calibrate the boom to discharge the desired volume per acre over the swath using the effective swath width in the flowrate calibration equation (Sec. 5.33b); and
4. Use flightrcers, markers, or electronic guidance systems to identify desired location of start points for swaths and to guide aircraft.

6.22 - Spray Deposition Accountability. Determine if the spray reached the target and where it deposited as a method of quality control. Visual
Spray Deposit Assessment: Two important factors influencing the effectiveness of aerial pesticide application are uniform spray distribution over the area and foliage coverage. The assessment of the spray pattern deposit when evaluating uniformity of spray distribution/coverage and biological effectiveness. Many factors influence the deposit of pesticides including specifications and attitude of applicator, pesticide formulation, admixtures, drop size and atomization, equipment release height, weather, canopy, and target site location.

The range of individual spray droplets atomized from a nozzle or discharged from some other device is called the droplet size spectrum. This is commonly expressed as volume median diameter (VMD). The VMD is the drop diameter that divides the spray volume into two equal parts. For example, a VMD of 400 micrometers means that 50 percent of the spray volume is in droplets smaller than 400 micrometers, and the remaining 50 percent is in droplets larger than 400 micrometers. The spray drop size is the spherical droplet diameter expressed in micrometers. One micrometer is 1/25000 (.00004) inch or 1/1000 (.001) millimeter (mm). Spray drop sizes are grouped as follows:

1. Aerosols - less than 50 micrometers.
2. Mists - 50 to 100 micrometers.
3. Fine sprays - 100 to 250 micrometers.
4. Medium sprays - 250 to 400 micrometers.
5. Coarse sprays - 400+ micrometers.

The evaluation of the numbers and sizes of spray droplets on deposited surfaces is called spray deposit assessment. Spray deposit assessment is done to:

1. Check operation of the spray equipment, make adjustments of spray equipment, and calibrate the flow rate to get uniform, consistent spray patterns and target coverage.
2. Determine the relative quantity of pesticide actually deposited in the target area.
3. Determine relative droplet size to achieve maximum coverage and to minimize drift; and
4. Maintain a record of spray coverage and distribution for the project file for future evaluation of results.

There are several types of cards paper (cards) available to help analyze spray deposition (Ch 9, Ex 42).

1. White Kromekote Paper: The most commonly used paper, as it reveals depositing drops providing they contain some color. Even undyed oil may be visible under some lighting conditions. These cards are used to check spray deposits on ground and aerial equipment, to monitor deposits in canopies and on the ground, and to monitor drift.
2. Water Sensitive Paper: A specially coated yellow paper which reveals a blue spot following exposure to aqueous spray droplets. Water sensitive paper

can be used to evaluate spray distributions, swath widths, droplet densities, and penetration of spray into the canopy. Unfortunately, exposure to other forms of water (i.e. dew) may also turn the paper blue.

3. Oil Sensitive Paper: Oil-sensitive paper consists of a blank card coated with white oil-soluble wax. The coating is dissolved when contacted by oil droplets, leaving a contrasting mark.

Some oil-based pesticides are not active on some oil-sensitive papers. Select the most appropriate paper depending on whether the spray is dyed or not.

When selecting a deposit paper it is advisable to test the paper by atomizing a small amount of the tank mix on the paper and rating the results. To obtain droplet size and volume the spray droplet stain registered on Kromekote spray cards must be converted back to the original spherical droplet size by use of a "spread factor." The spread factor is the ratio of the measured stain diameter to the droplet spherical diameter. The spread factor will vary according to the physical properties of the spray formulation, type of spray deposition, spray pattern, and spray equipment release height. This is necessary to obtain quantitative data on droplet size when using Kromekote cards.

For some situations it is desirable to add a dye to the spray. A common dye, FD&C #40 (red), is added at 0.1 percent to approximately 1 pound per 100 gallons of tank mix. The suspected carcinogenic and mutagenic properties of several dyes, including the optical brightener (fluorescent) dyes, suggest that Methyl Violet, Rhodamine B, and VT may not be appropriate for use in watersheds which supply potable water for domestic or municipal use. Since the status of these dyes may change, persons planning projects should contact Regional specialists concerning the latest recommendations of the U.S. Public Health Service, EPA.

U.S. Food and Drug Administration, U.S. Geological Survey, and State Water Quality Control Boards concerning the safety of other dyes considered for use. White Kromekote cards are excellent deposit samplers for dyed sprays. Both qualitative and quantitative data on droplet size and number can be obtained from Kromekote cards through use of a Forest Service data program (ASCAS) accessible through WO-FPM, Davis, California (Young, et al., 1977). It must be emphasized that a spread factor is required each time any component of the tank mix is changed. Spread factors for specific tank mixes/deposit papers can be obtained from WO-FPM, Davis, California, or the pesticide manufacturer.

Most dyes are unpopular with applicators as they may be difficult to remove from equipment; also, dyed sprays are highly visible, making the spray appear more dramatic and maybe even threatening. Dyes are recommended, however, when there is a need for more sensitive deposit sampling, when quantitative data are required, and when sampling of drift is critical.

Success of spray deposit assessment is dependent on part on selection and procurement of proper materials for field use. The list in Exhibit 42 identifies representative sources of spray deposit assessment materials.

Drift Reduction: An important reason for doing spray deposit assessment is to determine if offsite or non-target deposition is occurring. Aerial application of pesticides can result in drift offsite. To prevent drift, consider the following factors:

Influence of Droplet Size on Drift: The smaller a droplet, the slower it falls and the more subject it is to movement by wind and evaporation. Assuming a wind of 3 miles per hour and release from a height of 10 feet, a
coarse spray with 400-micrometer particles might drift laterally 8.5 feet; a fine spray with 100-micrometer particles might drift 48 feet. The distance increases rapidly with finer drops, with a very fine droplet, which might drift 0.7 feet, reaching distances of the same wind. These calculations are based on non-evaporating drops; therefore, the effects of evaporation must also be considered. As the droplet mass and size are reduced by evaporation, the droplet will remain airborne longer and drift farther. For example, with 50 percent relative humidity a 200-micrometer droplet of pure water at 86°F will evaporate in 56 seconds. In this length of time, it would fall 61 feet. As a spray droplet starts to fall, it also starts to evaporate, and therefore its rate of fall is reduced. Therefore, it will drift farther than would be predicted from its initial size assuming no evaporation. The oil in the normal oil-in-water emulsions vaporizes much more slowly than water, so the volume of oil to the volume of water ratio changes as the water portion evaporates.

2. Atmospheric Conditions. One of the most important and complicated factors in managing drift is understanding how weather affects sprays.

Because pesticide drift is complex, it is difficult to provide a simple set of drift management criteria. Likewise, the rationale for recommendations are equally complex. Mountainous or other complex terrain further compounds the difficulty of recommending application parameters that might be applicable to all conditions.

Ideally, in applying pesticides all drops would be deposited within the confines of the treatment block. This is probably an unattainable goal but one that should be attempted. If all drops were large, such as 400 micrometers, containment of the spray within the treatment block would be relatively easy. Unfortunately, all nozzles currently in use generate a large number of fine drops (<100 micrometers) which are in the driftable-size category.

Fine drops cannot be eliminated; therefore, the existence of small drops and their escape from the treatment block must be assumed. Large drops (>100 micrometers) can drift relatively short distances downwind of the site. Fine drops (<100 micrometers) can drift considerable distances downwind under stable atmospheric conditions. Under unstable conditions fine drops can be lifted aloft to diffuse over a larger area; therefore, spraying under stable conditions when the spray cloud remains concentrated might be more hazardous than spraying under unstable atmospheric conditions.

The first step in managing drift is to reduce the number of fine drops. This can be done by reducing shear at the nozzle, increasing nozzle orifice size, reducing boom pressure, keeping nozzles out of the aircraft’s main vortex, reducing aircraft release height, and using selective drift control adjuvants.

It is especially important for the pilot to fly at the appropriate height above the canopy for five to seven to ten and swath width reasons. The larger the drop, the time a drop travels, and the less time atmospheric conditions influence its travel, the faster the drop will reach the target. Even the effects of wind and evaporation can be reduced significantly if the spray is applied close to the target. Leaving obstacles such as snags and live trees in project areas forces the pilot to fly higher and increases the chance of drift.

While drift can be minimized by proper application methods and following suggestions discussed above, it must be borne in mind that weather is the major cause agent. An understanding of how weather influences drift can be gained by observing smoke behavior. As daily atmospheric conditions change, smoke behavior reflects the movement of air. Both wind speed and direction change with changes in surface temperature. Smoke hovers on the ground after sunset and before sunrise. Conversely, smoke rises during daylight. But whether it is daytime or nighttime, smoke will travel with the wind. Fine pesticide drops, although larger than smoke particles, behave in much the same manner.

Low humidity and wind, singly or in combination, increase evaporation of spray drops. As drops decrease in size they drift longer distances. As the sun warms the air near the surface the air rises, lifting contaminants such as suspended drift with it. This ventilation phenomenon serves to clean the atmosphere near the surface as cool, clean air in the upper atmosphere replaces warm contaminated air near the surface. These conditions are identified with lapse or unstable conditions which result from the sun warming the surface.

On the other hand, inversion or lapse conditions are common from sunset to sunrise. They may also occur during daytime when clouds insulate the earth’s surface from the sun’s rays. Inversions will not develop unless there is sufficient surface cooling; therefore, on a cloudy day there is little surface heating or cooling, and air is not placed in motion unless there is pressure-gradient-type wind.

Many pesticide operations begin in the early morning under inversion conditions. As the potential for a concentration of small drops to drift downwind exists. The larger drops land on target, or at worst, on the downwind edge of the target. As the inversion breaks up small drops begin to rise, increasing the potential for offsite drift; however, large drops land within the target, alleviating the concern of the concentrating cloud drifting downwind and off site.

Wind causes drift, but is also helpful under some circumstances in managing drift. Some factors to consider in understanding the effects of establishing wind restrictions are:

a. Wind transports particles, and the higher the velocity the larger the drop it can transport.

b. Wind impacts drops on vegetation, and the higher the velocity the greater the collection efficiency of vegetation. Therefore, wind helps to remove drops from the air.

c. Wind and roughness of the vegetation surface causes turbulence. Turbulence increases the impact of drops on vegetation.

d. Wind increases the rate of drop evaporation. As the drop is reduced in size it is more susceptible to atmospheric conditions.

e. Wind has an organized directional flow and with a moderate velocity it is usually predictable. Spray swaths can be off-set upwind to allow for lateral displacement of the spray caused by wind. This is not true of light and variable or gusting winds. Light winds <1 mph are often variable.

f. Wind causes mixing of air. Winds have a moderating effect on development of inversions. High winds can cause sufficient turbulence and mixing to preclude development of inversions.

g. Winds resulting from surface cooling are generally referred to as drainage or downslope winds. These winds are shallow or near the surface. Often the winds at the tree tops can be in the opposite direction (upslopes), which attests to the shallowness of drainage winds. Nevertheless, avoid
spraying when drainage winds are combined with a low-level inversion if there is need to avoid downslope drift.

h. Winds have a tendency to keep drops from rising. It is difficult for drops to rise under windy conditions unless there is turbulence and strong thermal radiation.

i. Wind serves to smooth out spray across swaths and helps reduce treatment skips.

In summary, wind can be used as a means to manage drift. Winds cause drops to move downwind, but winds also impact drops on vegetation and cause small drops to mix and be diluted rapidly in the atmosphere. Light winds (<3 mph) are often variable, both in direction and velocity, and are potentially dangerous because they are unpredictable. Winds can move a spray cloud off-target while doing little to dilute the concentration of drops. Each pesticide operation must be evaluated to determine how much wind is tolerable. In addition, pesticide labels and/or State regulations may specify windspeed limits for application.

Conclusive field data is lacking, but evidence is beginning to support forest management applications of pesticides under slight lapse conditions. For example, lapses may occur in western mountains on clear days approximately 15 minutes after sunrise or after downslope winds have ended. Spraying should stop when the pilot finds the conditions too turbulent to apply evenly spaced swaths, when spray clouds appear to hover or rise, or when ground observers note a lack of deposit. Stop spraying when there is evidence that large drops are being blown into buffer zones.

The maximum temperature allowable is dependent upon the above. This could be 50-80 degrees F. Winds could be 2 to 10 mph. The FSCBO model (Sec. 1.72a) can be used to show effects of temperature and humidity and should be used to determine parameters from these factors.

Suitable spraying conditions are also influenced by:

a. How the pilot sprays the block.
b. Width of buffer zones.
c. Environmental sensitivity of treatment blocks.
d. Season of year
e. Elevation and topography.
g. Tank mix characteristics.

Use the information in the following table as a helpful summary. Note that the meteorological conditions listed in the table are general examples. They will vary depending upon local situations.

<table>
<thead>
<tr>
<th>Time of Day/Night</th>
<th>Cloud Cover</th>
<th>Atmospheric Stability</th>
<th>Type Wind</th>
<th>Typical Spray Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dawn to 0600</td>
<td>Clear</td>
<td>Inversion</td>
<td>Downslope</td>
<td>&lt;6 mph</td>
</tr>
<tr>
<td></td>
<td>Overcast</td>
<td>Neutral</td>
<td>Variable</td>
<td>&lt;3 mph</td>
</tr>
<tr>
<td></td>
<td>Foggy</td>
<td>Inversion</td>
<td>Variable</td>
<td>&lt;1 mph</td>
</tr>
<tr>
<td>0600 + 15 min.</td>
<td>Clear</td>
<td>Inversion</td>
<td>Downslope</td>
<td>&lt;6 mph</td>
</tr>
<tr>
<td></td>
<td>Overcast</td>
<td>Neutral</td>
<td>Variable</td>
<td>&lt;3 mph</td>
</tr>
<tr>
<td>0615 to 0800</td>
<td>Clear</td>
<td>Lapse</td>
<td>Upslope</td>
<td>&lt;6 mph</td>
</tr>
<tr>
<td></td>
<td>Overcast</td>
<td>Neutral</td>
<td>Upslope</td>
<td>&lt;3 mph</td>
</tr>
<tr>
<td>0800 to 1000</td>
<td>Clear</td>
<td>Strong Lapse</td>
<td>Upslope</td>
<td>&lt;10 mph</td>
</tr>
<tr>
<td></td>
<td>Overcast</td>
<td>Neutral</td>
<td>Upslope</td>
<td>&lt;8 mph</td>
</tr>
<tr>
<td>1000 to 1200</td>
<td>Clear</td>
<td>Strong Lapse</td>
<td>Upslope</td>
<td>&lt;10 mph</td>
</tr>
<tr>
<td></td>
<td>Overcast</td>
<td>Neutral</td>
<td>Upslope</td>
<td>&lt;8 mph</td>
</tr>
<tr>
<td>1200 to 1700</td>
<td>Clear</td>
<td>Strong Lapse</td>
<td>Upslope</td>
<td>&lt;12 mph</td>
</tr>
<tr>
<td></td>
<td>Overcast</td>
<td>Neutral</td>
<td>Upslope</td>
<td>&lt;8 mph</td>
</tr>
<tr>
<td>1700 to Sunset</td>
<td>Clear</td>
<td>Neutral to Inversion</td>
<td>Variable</td>
<td>&lt;6 mph</td>
</tr>
</tbody>
</table>

1 Assume sunrise to be 0600 and sunset 1900, adjust schedule to local time.

2 As determined by temperature difference and smoke behavior in open, from 2-meters to top of canopy. Under inversions, air temperature at lower level is cooler than upper level; under neutral, air temperature is the same at both levels; and under lapse, lower level is warmer than upper level.

3 At 2-meters in open.

3. Tank Mix The final mix which is placed in the aircraft hopper is referred to as the tank mix. Mixes with a high percentage of water are subject to rapid evaporation when atomized. Low volatile mixes are usually less prone to drift. Reduction of droplet size by evaporation sets the stage for drift. Use of an adjuvant recommended on the pesticide label may help to reduce evaporation.

4. Method of Application Flying height should be as low as safety permits. This may be 10 to 50 feet above the vegetation. As flying height increases, spray droplets remain suspended longer and are more susceptible to wind and evaporation. Care must be exercised to ensure sharp turn-on and turn-off of the spray booms. Trailling of spray during ascent and descent to and from the target may result in spray drifting off target.

Selection of proper aerial application equipment is as important as selecting the proper pesticidal formulation. In fact, significant improvements can be made in reducing drift from normal formulations through use of proper sprayer delivery systems. Modifications of conventional application equipment or use
of specialized systems may be necessary for applying the higher viscosity sprays which are less prone to drifting.

5. Atomization of the Spray. As indicated earlier, a major factor influencing amount and distance of drift is spray droplet size. The greatest potential for reducing drift hazard is through reduction of small (less than 100-micrometer diameter) droplets. Whenever possible, this should be done by reducing the range of sizes produced rather than by increasing average drop size. Since small droplets can result in poor plant coverage, the degree of atomization (production of small droplets) is influenced by several factors including the amount of boom pressure nozzle type, nozzle location on boom, shear across nozzle orifice, aircraft speed, and physical properties of the tank mix.

a. Boom Pressure. Generally the higher the pressure the finer the atomization. Boom pressure is usually less than 15 psi.

b. Nozzle Type. Usually the smaller the orifice the smaller the droplets. There are other nozzle factors which affect the degree of atomization such as pathway of the discharge channel and use of whirl plates in the "T-Jet" hollow-cone nozzles.

c. Shear. Shear across the nozzle orifice causes droplet breakup. Shear increases as the aircraft speed increases. To reduce shear and the number of driftable droplets, nozzles are usually oriented to discharge back at 30 to 45 degrees from the horizontal.

d. Nozzle Location on Boom. Strong vortices are created during flight by helicopter rotors or the wings of fixed-wing aircraft. Droplets entrained in these vortices are propelled upwards in a circular pattern under high velocities. Droplets trapped in this motion may drift long distances. To reduce this problem when using helicopters it is recommended that nozzles do not extend beyond the length of the rotor (if rotor is 28 feet long then nozzles should be restricted to a 28 foot length of the boom). Further, it is preferred that nozzles be kept at least 3 feet inside the rotor's sweep. For fixed-wing aircraft, nozzles should be restricted to the inner 66 to 75 percent of the wing length.

e. Physical Properties of the Tank Mix. Various types of additives or adjuvants added to the tank mix will affect atomization and evaporation. Consult the label, a technical representative, or Forest Service specialists regarding the effects of additives or adjuvants and their selection.

6. Topography. Topography of the treatment site and surroundings must be considered in planning and scheduling spray operations. Most treatment sites are on sloping ground. Spray applied to slopes during early morning under inversion and stable conditions will drift downslope aided by gravitational forces. Consequently there is potential for a build-up of pesticide in canyons and valleys below the treatment site. Spray applied after the sun has warmed the surface (sometimes within a few minutes after sunrise) will move upslope with the wind, but a short distance compared to the downslope situation, since the spray is restrained by gravity. There is little potential for build-up of pesticides in canyons and valleys under late season conditions. Warm air rises and as it ascends fine drops are carried aloft and diluted in the atmosphere. It is important to evaluate site topography in relationship to weather factors.

6.21 Pesticide Residue Monitoring. Determine which pesticide projects require residue monitoring on a case by case basis. On controversial operational pesticide projects, residues monitoring may be used to determine the presence or absence of unacceptable environmental effects. On field experiments and pilot control projects residues monitoring may be required to assure registration. Monitoring sample points should be determined when monitoring plans are developed for such projects. The number of samples will vary with statistical requirements and specific conditions of the project area. The need for pesticide residue monitoring scoring and specific sample protocol should be identified in the environmental assessment for the specific pesticide-use project.

Whenver determined necessary, pesticide residue sampling may be used to measure the accumulation, movement, and degradation of pesticides following introduction into the environment. Residue monitoring activities may include monitoring pesticides or their degradation products in air, soil, water, vegetation, aquatic and terrestrial animals, and/or humans.

6.21a - Air. Monitoring air currents and wind speed during pesticide projects permits onsite adjustment of spray strategies to minimize the effects of wind direction changes which can influence spray deposit patterns both on and off site (drift).

On a pesticide project/incident the meteorologist (Sec. 3.53d) is the person responsible for making forecasts, recording weather data, and consultation on the appropriateness of conducting/continuing a spray project.

6.21b - Soil. Monitor soils in and adjacent to treatment sites before or after pesticide applications and where spills or emergency dumps of pesticides have occurred.

The objectives of soil monitoring are to determine the extent and severity of contamination and the effectiveness of measures taken to ameliorate contamination conditions.

Soil monitoring consists of taking soil samples at the immediate site of an application, spill, or emergency dump and in areas outside the affected site to provide baseline information. For pesticides that move or accumulate in the soil, samples should be taken at various depths and distances from the affected site to determine rate of movement. If soil contamination is extensive, periodic samples should be taken to determine rate of degradation and the point at which significant residues no longer persist.

6.21c - Vegetation. Use vegetation monitoring procedures to check residues in or on non-target vegetation. The objective of vegetation monitoring is to determine if residues exceed recognized safety limits or tolerances (40 CFR 180), if there be undesirable phytotoxic effects; or in experiments to determine disbalegible residue levels.

6.21d - Animals.

1. Aquatic. When water samples are collected, monitoring personnel should determine if fish or other aquatic animal mortality has occurred near the sample point(s). If damage is evident, notify Forest Service Fish and Wildlife personnel who will contact the appropriate agencies and/or individuals to conduct more intensive investigations. In some instances, such as during aerial pesticide applications, more extensive monitoring of aquatic organisms may be necessary. If so, procedures should be outlined in a monitoring plan.

2. Terrestrial. Conduct post-treatment surveys for dead or distressed animals on a case-by-case basis. If such animals are found, they should be collected and sent to an appropriate laboratory for residue analysis, or
2) buried if such impacts have been predicted, e.g., rodenticides. The results are used to determine if unanticipated impacts on terrestrial animal species have occurred. If adverse effects caused by pesticides are identified, appropriate officials must be notified and records kept.

6.2.2a - Humans. Use health monitoring to determine pesticide exposure and to protect human health. Human monitoring should be done on a case-by-case basis and should be coordinated with EPA personnel. Sampling urine during organic arsenical pesticide operations or sampling blood cholinesterase levels during organophosphate pesticide operations are examples of human monitoring activities (Sec. 3.6). Records of personal medical analyses will be maintained in confidence (PFP 339, subchapter 4-3).

The Forest Service also occasionally cooperates in the conduct of specific operational application situations to determine applicator, and other person, exposure. Another reason for monitoring is to determine if the mitigation measure in use are effective. For example, a recent publication entitled "Human Health Risk Assessment for the Use of Pesticides in USDA Forest Service Nurseries," (FS-412). October 1987 documents that for forest nursery workers it was first necessary to analyze the use of pesticides in nurseries. Major aspects of nursery operations that determine potential levels of pesticide exposure were identified, including human activities in or near proposed treatment areas, application methods, application rates, the size and configuration of sprayed areas, and mitigation measures. In this study, it was determined that two human populations are potentially affected by the use of pesticides in Forest Service nurseries. The first group consists of the nursery workers who apply the pesticides (the mixers, loaders, and tractor drivers) and the nursery workers employed in tasks that bring them to direct contact with treated seedlings and soil (those who inventory the seedlings; weed the seedling beds; lift, sort, and pack the seedlings for shipment; and plant the seedlings).

The second group at risk included the population at large who live in the vicinity of forest nurseries and who may come into contact with pesticides by (a) drift during application, have contact with contaminated domestic animals, or consume contaminated water, vegetables, domestic animals, or wildlife. Impacts on wildlife are considered only insofar as they affect human consumers and not as they affect the animal's health and survival.

In the exposure analysis, both realistic and extreme dose estimates were made for routine application operations. Doses from accidents were also estimated.

The determination of the exposure rate and the dosage of the populations at risk was based on several sources. Studies investigating pesticide concentrations in urine samples of agricultural field workers were reviewed and findings applied. In some cases, exposure and dosage to the general population is unlikely. In other cases, dosage to the general public was calculated based on realistic and extreme pesticide drift rates, dermal exposure and absorption rates, and food intake rates using realistic and unlikely assumptions concerning contamination levels.

Routine doses were estimated for the following:
1. Mixers/Loaders/Applicators;
2. Weeners and irrigators;
3. Inventory personnel.
4. Lifters, sorters, packers, and tree planters;
5. Fumigators;
6. Tarp lifters;
7. Seed treaters; and
8. Root treaters.

For the analysis of public health effects, dose estimates were made for nearby residents assumed to be exposed as a result of routine operations through one of the following routes:
1. Eating a garden vegetable (lettuce) with drift residues;
2. Eating beef from cattle grazing in nearby pastures;
3. Eating a rabbit or grouse that has been dermally exposed in a treated seedling bed;
4. Drinking water with drift residues;
5. Drinking water from a source that receives runoff;
6. Petting a cat or dog with pesticide residues on its fur.

For each of the above routes, two distances from the nursery were normally examined, 25 and 100 feet.

Because all human activities involve the possibility of error, the use of pesticides in nursery operations involves the possibility that humans may inadvertently receive unusually high exposures to the pesticides because of accidents. To examine what potential health effects could occur in an accident, the following accidental situations are usually analyzed:
1. Spills of pesticide concentrate on a worker's skin.
2. Direct accidental spraying of a worker.
3. Premature reentry of a worker into a treated area.
4. Inhalation exposure to workers or members of the public from a fumigant spill.

Because FS nurseries are fenced, access to the public is limited. In addition, aerial applications are not done; therefore, the risk to the public from accidents is considered minimal.

6.2.2b - Water. Water quality monitoring is conducted to determine if water contamination has occurred as a result of pesticide applications or incidents and if so, to what extent.

The objectives of water monitoring are to:
1. Determine if application procedures are adequate and that only acceptable levels of chemicals, if any, appear in water.
2. Provide early warning of pesticide contamination on areas, such as municipal watersheds, fish hatcheries, or near private domestic water supplies.

Sample points for water will normally be established near downstream boundaries of treatment areas.

If a spill occurs in or near water, additional monitoring may be required and proper notification of the potential hazard made. Contingency plans for such an occurrence should be outlined in the project safety plan (Sec. 1.8).

The contamination of water by pesticides is a function of various factors that may operate singly or in combination during and/or after a project. During a project the following items should be considered:

1. Nature of the chemical.
2. Accidental spill potential.
3. Application method and equipment.
4. Accidental drips or drift into water from aircraft.
5. Aquatic environment: stream depth, width and velocity; stream bottom characteristics; temperature; chemical composition and acidity; degree of saturation; suspended sediment; and dilution from seepage and tributary streams.
6. Meteorological conditions: wind speed and direction; relative humidity; temperature; and lapse rate.
7. Topography: hazard to pilot.
8. Vegetation type: tall trees, snags.
9. Buffers: width, type, and visibility from the air.
10. Proximity to water: stream density, lakes, ponds, springs, and wet areas.
11. Human factors.

Following a pesticide application, water contamination is largely a function of persistence and mobility of the pesticide. These are affected by:

1. Weather: precipitation amount and intensity, solar radiation, and temperature.
2. Buffer width.
3. Vegetation type.
5. Amount of time elapsing between the application and the first runoff-producing precipitation event.
6. Decomposition and evaporation rates of the pesticide in soil and water.
7. Toxicity and persistence of decomposition products.
8. Topography of sprayed areas.
9. Soil-vegetation complex: surface soil condition, surface soil clay content, soil bulk density, soil organic matter content, and litter layer.

Proposed pesticide-use projects should be well planned (See Chapter 1) and include a water quality monitoring section in the overall project plan.

Before a water quality monitoring plan can be written, the monitoring objectives must be specified. A complete set of objectives provides and gives reasons for the parameters to be monitored, and when, how long, and where monitoring will occur. The well-designed monitoring plan should focus on the management need for specific information to answer a question or solve a problem. The plan must also be technically feasible and within constraints of time, personnel, and funding.

The project Water Quality Monitoring Plan should include the following elements:

1. A narrative, tabular description, or map of beneficial uses of water within the affected area and within five miles downstream.
2. A statement of monitoring objectives and the methodology designed to meet objectives. The responsibilities of various individuals for monitoring hydrometeorological and surface water conditions should be clearly stated.
3. A narrative, tabular description, or map of the project area and monitoring stations.
4. A narrative or tabular description of mitigation measures related to water quality monitoring and the protection of beneficial uses.
5. A project area map of suitable scale which clearly delineates: (a) flowing streams, other bodies of water, and wetlands; (b) beneficial uses including points of diversion in relation to pesticide treatment area; and (c) monitoring reach. Topographic maps should be used whenever available.
6. A watershed map of suitable scale which permits evaluation of the potential additive effects of multiple treatment sites within the same drainage.
7. Maximum contamination potential computed for sensitive on-site and downstream locations.
8. A list of monitoring equipment indicating manufacturer, model, and serial number.
9. A statement of how and when monitoring results will be evaluated. The results should be interpreted in terms of compliance with standards, impact on beneficial uses, and adequacy of mitigation measures. Specific recommendations for improving future projects should be made where appropriate.

A complete record of all monitoring, including streamside spray cards and fluorometer readings, should be maintained for each project. Spray cards may be discarded after evaluation. Monitoring records should contain the following information:

1. Name or code of monitoring site, sample collector, date, and time.
In general, select monitoring sites to meet stated objectives. One such objective would be to sample where suspected contamination detrimental to a beneficial use is likely to be greatest. Such uses will usually be specified in the project EA, but if not, then waters which provide the following beneficial uses should be considered as sensitive areas:

1. Municipal water supply.
2. Other domestic supply waters.
3. Fish hatchery supply.
4. Fisheries.
5. Streams or lakes used for water contact recreation.
6. Irrigation supply.
7. Stock water supply.

Monitoring of waters should be conducted: 1) Downwind of the project, 2) adjacent to the downstream boundary, or 3) above a point of concern in sensitive areas. In some cases, it may be more feasible to simply estimate contamination at a downstream point by determining the dilution ratio. When selecting a downstream location the maximum potential pesticide concentration downstream should be calculated and modified by any other coefficients which can be determined. If the resulting concentration is less than the water quality objective or standard for the most constraining beneficial use, then a monitoring station may not be necessary.

Monitoring of wells in the vicinity of pesticide contamination of surface waters which exceed State and/or Federal standards and which could possibly contaminate groundwater may be necessary. When collecting groundwater samples, it is necessary to compute subsurface travel times to the sample point.

Many factors are involved in the proper selection of water sampling sites: physiographic controls, accessibility, flow, mixing, and other physical characteristics of the water body; pesticide source locations; and personnel and facilities available to conduct the study.

1. Physiographic Controls. Most monitoring is based on evaluating the impacts from overland runoff, groundwater inflow, and/or discharge directly into surface water. After determining the beneficial uses and sensitive areas, the appropriate hydrological boundaries should be defined. Sampling site locations are then established above and/or below these boundaries.

2. Accessibility. Accessibility of sampling locations is an obvious requirement which must be considered. Access through uncontaminated areas is necessary. Access should also be reasonable and appropriate with respect to transporting monitoring equipment, personnel safety, and conditions of darkness which may be encountered. Sampling costs increase as access becomes more difficult, and therefore, travel time between sampling sites should be as short as possible. Access to a post-project monitoring site during a storm may be impossible because roads may become impassable or may be administratively closed to prevent resource damage. In all cases, there will be an increased safety hazard to personnel working in the field during a storm.

3. Physical Characteristics. The ideal sampling station would be a cross section of a stream or lake at which samples from all points would yield the

2. Location of monitoring site, such as latitude and longitude, legal description, and narrative description in terms of obvious land features.
4. Type of sample, such as spray card, fluorometric, or composite.
5. Sample number or code.
6. Date of collection.
7. Monitoring results; including the results of quality assurance sampling (e.g., blind spikes).
8. Name of laboratory used and method and sensitivity of analysis.
9. Equipment used.
10. Person collecting the sample.
11. Chain of custody.
12. Other comments as necessary, such as handling and storage, time-of-travel estimate, corresponding fluorometer readings.
13. Interpretation and evaluation.

The following information is necessary for interpretation of water quality monitoring data and evaluation of best management practices. Most of this information will be found in other project records:

1. Pesticide, formulation, manufacturer, and EPA registration number.
2. Application rate.
3. Method of application and flight pattern.
4. Mitigation measures used to protect water quality.
5. Dates and times of application.
6. Weather conditions during application: air temperature, relative humidity, lapse rate, wind speed/direction.
7. Remarks on any unusual occurrence that might affect water quality monitoring results, and any deviation from the project plan which might affect water quality.

The person responsible for water monitoring should take a thorough field reconnaissance prior to the pesticide project. Field observations are important in selecting sampling locations that best fit the characteristics of the project and terrain. This reconnaissance should take place in sufficient time to provide input to project planning. Three objectives of the reconnaissance are to: 1) Identify potential monitoring sites; 2) obtain information to develop emergency monitoring plans for accidental spills; and 3) identify routes to sampling points so that monitors can avoid going through treated areas thus avoiding possible contamination.
same concentration. Because of discharge and stream bottom characteristics, this situation does not often exist in nature. There is a need, therefore, to carefully select a site which will, as nearly as possible, provide uniform flow and good mixing conditions. Any uncertainty regarding the uniformity of flow or the completeness of lateral and vertical mixing may be resolved by taking multipoint, depth-integrated samples and examining the samples prior to analysis.

4. Proximity to Spray Block. When the treatment unit lies adjacent to the stream to be sampled, the sampling point must be downstream of all small side channels flowing from the treated area. At the same time, however, the samples should be taken as close to the lower boundary as possible so that dilution does not mask contamination and the samples will represent the maximum concentration of chemicals to which aquatic organisms may have been exposed.

In determining stations for collecting water samples for laboratory and fluorometer analyses, locations should be chosen: (a) close enough to the spray project area so that accurate measurements of streamflow travel time can be obtained; (b) far enough away to ensure good mixing of water leaving the spray unit; (c) distant enough to avoid contamination of the sample bottles by drift; but (d) not so distant that incoming side streams off the project dilute and mask observation of maximum concentrations. One to two hundred feet is the minimum distance recommended.

5. Communications. Radio contact should be maintained between the project leader and the water monitor.

Water monitoring stations should be adequately marked with stakes, flagging, or tags and referenced at the time they are established. The importance of marking monitoring stations should not be underestimated. The person who originally selected the stations during the reconnaissance may not do the monitoring. Therefore, time should not be wasted in searching for an unmarked station.

Streamflow travel times can be most accurately determined using a tracer such as dye or salt. On small streams, common table salt is a good tracer when measured with a specific conductance meter. If dye is used, a type should be chosen which matches the hydrometric properties sufficiently different from those of background water, the dye which is used in the spray mix, and any suspended material.

The amount of dye necessary is dependent upon discharge and the characteristics of the channel, such as rocks, debris or vegetation which absorb dye. Generally, the longer the stream and cleaner the channel, the less the volume of dye per unit discharge needed.

Both the minimum and maximum travel times should be determined. The minimum is the time at which a particle of dye at the upstream point in the unit to the sample point at the maximum is from the uppermost portion of the unit. If there are tributaries in the unit that combine above the sample point, the travel time measurement can be more complicated.

Ideally, the travel times should be measured as close as possible to the time of spraying if this is not done and flow changes noticeably before spraying, it may be necessary to take additional travel time measurements on the day of spraying. A staff gauge is helpful to determine if significant flow changes occur. In situations of variable discharge, it may be necessary to make streamflow measurements along with travel time measurement and prepare a stage or discharge versus travel time curve. The U.S. Geological Survey's Techniques of Water-Resources Investigations publication, "Measurement of Time of Travel and Discharge in Streams by Dye Tracing," Book 1, Chapter 49 discusses this subject in detail.

The computation of potential contamination is done by relating quantitative potentials to State standards (or criteria on harmful levels) and beneficial uses.

Stream depth determines the concentration in water of any pesticide that falls into the water directly. For example, one pound of active ingredient per acre applied directly to the surface of water would produce a maximum concentration of 0.367 mg/l in water uniformly one foot deep. The same rate of application would result in a maximum concentration of 0.183 mg/l in water two feet deep, but 1.468 mg/l in water three inches deep.

Adequate discharge data are essential for computing potential contamination and estimating the total contamination loads carried by the stream. If a gauging station is not conveniently located on a selected stream, discharge data should be obtained both before and during monitoring.

Approximate peak pesticide concentrations may be computed in the following manner. The worst possible situation, except for a spill, would result from direct application of pesticide to the stream at the same rate as the spray unit. In this case, the maximum potential onsite contamination is first calculated. Stream discharges measured onsite and at a point of concern downstream are used to compute the dilution coefficient which is used in determining potential contamination at some downstream point. In addition to dilution and dispersion, peak concentrations will also diminish as a result of chemical decomposition and absorption of chemicals onto sediments and organic matter. There is considerable variation depending on stream characteristics and the pesticide in use. These additional factors are usually considered in estimating potential downstream effects because adequate data are often not available. For the purpose of quantitatively evaluating potential contamination, it is necessary to recognize the factors affecting a decreased downstream concentration but not to include them in the calculations.

The characteristic decrease in peak concentrations of pesticide pollutants with downstream movement reduces the likelihood for interaction with increasing distance below the project. The probability of direct harm is therefore greatest within the operating unit and close to the downstream edge. This probability can be expressed in terms of the degree and duration of a concentration curve that lies above these subjects in more detail.

Example: The application rate of 2,4-D is two pounds per acre. A stream borders the project for a distance of 1000 feet. It averages ten feet wide and one foot deep. The discharge is one cubic foot per second (cfs). Since velocity equals discharge divided by the value width times depth, the average velocity is 0.167 foot per second. The average depth of water upstream is 0.06 feet. The stream is 50 feet wide. The peak concentration of 2,4-D is 10 mg/l. If the concentration decays uniformly with a halftime of 100 feet, the concentration 500 feet downstream is 0.1 mg/l. If the concentration decays uniformly with a halftime of 500 feet, the concentration 500 feet downstream is 0.002 mg/l. If surface contamination alone is a concern, the concentration may be estimated by mixing the concentration in the stream with the concentration in the spray unit.
The need to detect the potential for affecting beneficial uses by contamination, as well as demonstrating compliance with laws and regulations, determines the monitoring technique to be used. The degree of contamination is determined by maximum concentration of pesticide in the water and the length of time the pesticide persists in the water at a given concentration. Two standards are generated when the EPA methodology is applied: (1) an instantaneous maximum concentration value which protects against acute effects; and (2) a 24-hour-average value to protect against chronic effects.

Individual techniques differ in their capability to assess contamination. Each technique can normally be employed for those projects which apply liquid or pelleted material through either aerial or ground spraying methods. It is important to be familiar with the inherent limitations of each technique.

Five categories of monitoring are generally employed: (1) spray assessment team member with radio near live stream; (2) pesticide residue assessment on spray cards; (3) fluorometric determination of dye concentration in the field; (4) sampling for subsequent laboratory determination of pesticide concentration; and (5) observation of vegetation in buffers.

The first three [(1) spray assessment team, (2) residue assessment, and (3) fluorometry] can be used for early warning. Only technique (4), laboratory determination of pesticide concentration, permits accurate quantification. Emergency monitoring will normally involve a combination of fluorometry for early warning and laboratory analysis to determine the concentration. Technique (5) is useful only to monitor application procedures and effectiveness of mitigation measures.

If a pesticide spills occur in or near water, emergency monitoring is required. The location, time, and volume of the spill and the type of pesticide spilled should be documented.

The following monitoring procedures should be followed in the event of a spill:

1. Immediately estimate when the pesticide first entered the water and the distance it may have traveled during the intervening time. Estimates of streamflow should be made at the spill site and for downstream points of major concern, like domestic water supply intake. Travel time between these points should be estimated. Use a dye or salt tracer to help estimate stream travel time.

2. Using the travel time measurement, estimate when the highest concentration of pesticide will reach points of concern downstream.

3. Knowledge of downstream tributary inflow is also essential in estimating potential contamination. Monitoring should follow these estimates to validate travel time estimates and document contaminant levels in the water. Obtain water samples at selected points to measure peak concentrations and to measure duration of contamination. It may be appropriate to sample at 15-minute intervals during the time of expected peak contamination and at hourly intervals thereafter for 24 hours elapsed since the spill. If laboratory sampling containers are not available, use clean glass bottles.

The specific water monitoring technique selected must conform to established monitoring objectives. Four common objectives of monitoring are to determine:

1. Onsite Instantaneous Potential Concentration
   \[ P_{i}^c = \frac{368}{H} \]
   where: \( P_{i}^c \) is peak instantaneous concentration onsite in ppb
   \( H \) is herbicide application rate in lbs/ac
   \( D \) is average water depth in feet
   \( 368 \) is a constant for transformation of \( P/D \) to ppb
   Therefore \( P_{i}^c = 368 \times 2 = 736 \) ppb

2. Onsite Twenty-Four Hour Mean Potential Concentration
   \[ MC_{0.24} = \frac{P_{i}^c \times L}{86,400} \]
   where: \( MC_{0.24} \) is the 24-hour-mean concentration onsite in ppb
   \( P_{i}^c \) is peak instantaneous concentration in ppb from equation (1)
   \( L \) is stream length in feet
   \( V \) is average stream velocity in feet per second
   \( 86,400 \) is a constant (cubic feet of streamflow per day at a flow rate of 1 cubic foot per second)
   Therefore \( MC_{0.24} = \frac{(736)(1000)}{(86,400)(1)} = 85 \) ppb

3. Downstream Instantaneous Potential Concentration
   \[ PC_{d}^c = P_{i}^c \times \frac{Q_o}{Q_d} \]
   where: \( PC_{d}^c \) is a potential instantaneous concentration at some downstream point
   \( Q_o \) is stream discharge onsite
   \( Q_d \) is stream discharge rate at some downstream point
   Therefore \( PC_{d}^c = 736 \text{ ppb} \times \frac{1 \text{ cfs}}{1000} = 74 \text{ ppb} \)

4. Downstream Twenty-Four Hour Mean Potential Concentration
   \[ MC_{d.24} = MC_{0.24} \times \frac{Q_o}{Q_d} \]
   Therefore \( MC_{d.24} = 85 \times \frac{1}{10} = 8.5 \text{ ppb} \)
4. If the contaminant is released from the source area over a period of time and there is subsurface flow, make travel time estimates for use in downstream sampling based on the expected duration of contamination. If contamination is still occurring from the spill source area when sampling is initiated, add a dye tracer to the source (if not already present in the pesticide) for as long as contamination occurs. Sample at the selected downstream point(s) at 15-minute intervals until dye is no longer visible or detectable. Continue sampling at hourly intervals for at least 24 hours after the dye has disappeared.

5. Submit individual or composite samples to an approved laboratory as soon as possible. Make arrangements to obtain test results as soon as possible. Be sure to record the chain-of-custody for all samples.

6. If dead or distressed fish or other aquatic organisms are observed, collect specimens and report accordingly.

In order to protect beneficial uses such as domestic and municipal supply, fish hatcheries, irrigation, and stock water, it may be necessary to have the capability to provide advance warning to downstream users in the event of contamination which exceeds State and Federal standards. When water quality monitoring indicates that standards may be exceeded at the point of entry for the beneficial use, the affected users and agencies listed in the Spill Contingency Plan (Sec. 8.1) should be notified immediately.

Early warning may be accomplished by using any of the following methods alone or in combination:

1. **Spray Assessment Team Member.** This technique involves the use of a spray assessment team member (Sec. 3.52c) or observer who is stationed in a safe and accessible location. She must be able to observe both the flowing stream and the pesticide application. She must also be in radio contact with the team leader at all times during the operation. If any evidence of herbicide contamination is observed, the team leader is notified immediately and she will notify the spray assessment unit leader and the operation section leader.

2. **Spray Card Monitoring.** This technique, which indicates if pesticide drift reaches cards placed next to surface waters, is a "standard method" for drift and coverage assessment. After exposure, cards are visually examined for the presence of pesticide residue. This method has limitations when used to quantify the amount of pesticide residue reaching a sampling point.

Since the number of droplets per square inch for a given diameter class is known, the potential stream concentration at the time of application could be theoretically calculated. However, such calculations would give only an approximate answer, and the specific assumptions made in the interpretation would have to be stated.

Cards should be placed at 50-100 foot intervals along the length of the stream within or adjacent to the treatment area. As a general rule, cards should not be placed underneath vegetation that may act as an umbrella. However, sometimes a stream section will have a very dense cover of vegetation that may filter out a large portion of spray drift. In this case, it may be acceptable to position cards beneath the vegetation. It should be kept in mind, however, that some residual pesticide may be washed off the leaf surfaces into the stream with the first rain. Large boulders adjacent to or within streams make excellent card placement sites, but a location that receives mist or splash from the stream should be avoided.

**Cards should not be collected by personnel involved in fluorometry or water sampling. The cards must be dry when collected; otherwise, wet droplets will smear when cards are laid together making droplet analysis impossible. Sufficient water must be available to wash off contaminated cards, or some means to prevent smearing of wet droplets must be used. For early warning the cards should be visually inspected as soon as possible after spraying.**

3. **Fluorometric Monitoring.** Fluorometry can be used to determine if a pesticide is present in the aquatic environment on a real-time basis to provide early warning or to indicate when to take a water sample for laboratory analysis. Fluorometry can also be used to screen samples to determine which is likely to contain the peak concentration. When the objective is to know if concentration levels may exceed standards or if a health hazard may exist, fluorometry provides an indirect, relative, and approximate quantification of the pesticide concentration in water when a fluorescent dye tracer is used. This technique may increase the probability of sampling the peak pesticide concentration. The concentration of pesticide present in the water is assumed to be approximately proportional to the fluorometer measurement. Since absorption, leaching, and decay rates of dyes and pesticides may differ, this procedure can be used only to measure direct introduction immediately following spraying. Results should be considered as relative estimates only. The suspected carcinogenic and mutagenic properties of several dyes, including the optical brightener (fluorescent) dyes, suggest that Methyl Violet, Rhodamine B, and WT may not be appropriate for use in waterbodies which supply potable water for domestic or municipal use. Since the status of these dyes may change, the District or Forest hydrologist should contact Regional Office pesticide coordination or watershed personnel.

**a. Fluorometry Instrument Location.** The analysis for fluorescent dye is best accomplished in a laboratory setting where the fluorometer can be supplied with a steady voltage and the risk of contamination is minimized. Usually, however, such a facility is not conveniently located with respect to the sampling points; therefore, field sampling sites should be chosen where there is no possibility of contamination by pesticide spray and where background influences from road dust and organisms in the stream are minimized. The site should be in the shade, if possible, to minimize temperature changes to the instrument and to prevent sunlight from leaking into the instrument which might cause erroneous responses. Security of the instrument should also be considered if it is to be left unattended.

**b. Equipment and Supplies.** The following items are suggested for fluorometric monitoring:

- Turner Model III or Model 10 fluorometer. Amino

   Fluorocolorimeter, or equivalent with a 110-005 cuvet door, 546 nm (primary); and 590 nm (secondary) filters; 08-047/1 far UV lamp. CAUTION: eye protection required if unshielded standard sample holder

- generator (at least 500 watt AC, gasoline with auxiliary fuel tank), or batteries and inverter

- sample bottles, 50-100 ml or an 8-dram (approx. 12 ml or 1 oz.) polypropylene glass bottle

- inert stoppers

- sample cuvettes or hose
Dyes available as either powders or solutions. The solution will usually contain 20 or 40 percent dye by weight and is easier to mix than powder. Supplies of dye should not be stored or transported with, and should at all times be kept separate from, monitoring equipment.

High-quality flint glass containers should be used for collecting samples. The number of containers needed for a given project will depend upon the number monitoring stations and frequency of sampling at each station. Two containers are recommended per monitoring event per station. Container capacity should be between 50 and 100 milliliters to provide an adequate sample volume for analysis. Containers and caps should be thoroughly cleaned before collecting samples. A hot wash with a non-fluorometric soap followed by several rinses with non-chlorinated water is sufficient. Lids or caps should be sealed by aluminum foil or other non-absorbing material.

A fluorometer requires a steady voltage to operate reliably. When a portable power source is necessary, and when a fluorometer is the only drain, a properly operating battery or 500 watt generator should be adequate. The requirement for a Turner fluorometer is a reasonable sine wave of 105-130 volts and 58-62 hertz. If there are other loads, the current should be monitored or a voltage stabilizer used. An auxiliary fuel tank will permit uninterrupted fluorometer operation when a generator is used.

C. Precheck. Prior to taking project measurements, the fluorometer and power supply must be tested together in the field. Sample dye dilutions should be tested to ensure adequate sensitivity. For example, if it is necessary to detect 10 ppb of pesticide in water, and dye to pesticide ratio is 1:50, then the fluorometer must be sensitive enough to detect 0.2 ppb of dye. Extra neutral density filters which reduce sensitivity at very low concentrations should be removed. The Turner III should be able to detect 0.1 ppb with a scale reading of 1 to 6 units depending on temperature. The Amico Fluorometer can detect less than 0.1 ppb with scale readings about 5-10 times those of the Turner III on the most sensitive scale.

D. Calculation of Dye or Pesticide Concentration. Prior to any calculations, several items must be known:

1. Percent dye solution. Caution: accuracy of the labeled percentages is not guaranteed.
2. Pounds active ingredient or acid equivalent to be sprayed per acre.
3. Gallons of spray mix per acre.
4. Threshold concentration of pesticide to be detected as related to water quality objectives.
5. Weight of 100 ml of dye and number of milliliters per pound.

\[
\text{C} \times \text{W} \times \text{P} \times \frac{1}{1000} \times \frac{1}{10^9} \times \frac{V}{G} = 45359
\]

where \( \text{C} \) is concentration of dye (or pesticide) in parts per billion

\( \text{W} \) is weight of dye (or pesticide active ingredient) solution in pounds

\( \text{P} \) is percent dye in solution expressed as a decimal.

Note: \( \text{P} \) is not used in calculation of pesticide concentration.

\( \text{V} \) is volume of spray mix in gallons.

\( \text{G} \) is specific gravity of dye (or pesticide).

3.754 is conversion constant for gallons to liters.

Example 1. Herbicide X, which is supplied as an undiluted mixture in drums, has four pounds of acid per gallon of solute, or 1.81 kg per 3.79 liters of solute, which equals 480,000 mg/l or 479,305,000 ppb.

Example 2. If the spray solution (herbicide plus oil or water plus other additives) is two pounds acid equivalent per 10 gallons of spray solution, the concentration of pesticide would be:

\[
\text{mass} = \frac{2 \text{lb} \times 45359}{10 \text{ gal} \times 3.754} = 0.24 \text{ kg/l} \times 10^9 = 21,963,121 \text{ ppb}
\]

Two samples of the mixture should be collected before the dye is added. This spray mix sample should be used as the blank for the dyed spray mix sample. One milliliter of the undyed spray mix sample should be diluted with 999 milliliters of background water prior to fluorometric analysis. The fluorescent response of the diluted, undyed tank sample should be measured and the scale reading recorded.

e. Dye to Pesticide Ratio. The suggested dye to pesticide ratio ranges from 1:10 to 1:50 depending on the dye used. If the pesticide concentration of the spray mix is 50,000 ppm, for example, then the dye concentration should be 1,000 ppm. The quantity of dye to add to the spray mix to arrive at a dye to pesticide ratio of 1:50 can be determined by solving equation (5) for \( W \), the.
weight of dye in pounds, where C, the dye concentration, is the pesticide concentration divided by 50.

\[ w = \frac{C \times V \times 10^{-9}}{P} \]  

One of the main assumptions of fluorometry is that pesticide concentration is directly proportional to dye concentration. Since fluorescent dye decays photochemically and may react with metals and pesticides, the length of time that the dye is mixed with pesticide in the tank must be kept to a minimum. The dye should be added immediately prior to application of the pesticide. It is also essential that the dye is mixed thoroughly with the spray formulation in the batch tank or aircraft spray tank.

Following thorough dye mixing and just prior to the time mixture will be needed for application, a sample of the spray mixture should be collected for use in preparing dilutions. The sample should be extracted by using a pump, siphon, or drain and should be placed in an amber bottle. Care should be taken to avoid contamination by small quantities of dye. The person operating the fluorometer should neither add the dye to the pesticide nor take samples of the mix.

f. Background Sample. Two gallons of water should be collected at the same time and placed as the control sample for use in background or blank measurement and the preparation of any dilution necessary. Since there is a variation in fluorescence with temperature, this water should be maintained at ambient stream temperature, preferably by being kept in the shade in the stream where possible. Sensitivity of detection will increase proportionally with an increase in temperature. A portable cooler works well for maintaining sample water at a constant temperature. Initial or prespray measurements of fluorescent dye concentration for the background water should be taken, and the scale reading should be recorded or the scale should be then be adjusted to read zero. Some newer direct-reading, flow-through fluorometers compensate for background fluorescence. Care should be taken when there is a need to correct for temperature changes.

g. Preparation of Reference Sample. The easiest way to detect pesticide contamination is to compare the fluorometer readings for stream samples with the reading obtained for a sample of the specified concentration. To obtain this reference measurement, a sample of the spray mix, including dye, must be diluted to the desired concentration of pesticide. If it is necessary to detect at least 10 ppm of pesticide concentration calculated by the equation (5) must be diluted to a concentration of 100 ppm. This dilution should be made by adding to the spray mix sample a volume of background water which can be calculated using this equation. Chlorinated water, which will bleach the dye, should never be used.

\[ V = \frac{C \times V \times 10^{-9}}{V_i} \]  

where \( V_i \) is volume of background water to be added in milliliters, \( V \) is volume of reference sample before dilution in milliliters, \( C \) is original pesticide concentration of spray mix in ppb, \( C_d \) is desired pesticide concentration of reference sample in ppb.

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**b. Sample Collection.** Persons adding dye to spray mixture should not be involved in sample collection and analysis because measurement of fluorescent dye in water samples is sensitive to extremely small concentrations.

Particular care is necessary to ensure that neither the person collecting water samples nor any other members of the monitoring crew have been in contact with fluorescent dye or the monitoring crew have been in contact with fluorescent dye or spray mixture during the several days prior to, the spray operation. The entire spray operation area (mixing, loading, and treatment) should be off limits to water sampling personnel.

Sampling for laboratory analysis should be done concurrently with fluorometric sampling. The sample associated with the highest fluorometer reading should be analysed by a laboratory. Samples must be kept in a cool, dark location. A cooler packed with ice provides excellent storage when in the field. The same vehicles should not be used to transport both dye and samples.

i. Sample Analysis. Sufficient time should be allowed for the fluorometer to warm up completely according to instructions provided by the manufacturer. Maximum average meter deflection should be used as the measurement. The fluorescent responses of the diluted, dyed, spray-mixture reference sample should be measured and the scale reading recorded. When measuring the reference sample, it is good practice to make a measurement using background water to keep the instrument "zeroed." A scale should be selected which will give the maximum reading for the reference sample. The same scale used to measure the reference sample should be selected for the stream samples. All reference measurements should be made using the same temperature. The plastic blank should be checked at the start to "zero" the instrument.

Background water should be measured after every second or third sample, since it is easiest to "zero" the instrument on the background sample. During measurement, the following data should be recorded: (a) reading with plastic blank; (b) reading of the background water; (c) reading of the water sample; and (d) the differences between b and c. The temperature of the sample when analysed should be recorded. Stream and air temperatures should be recorded every hour during fluorometric monitoring.

Sampling for laboratory analysis provides necessary data when the objective is to show compliance with standards. More importantly, it provides data which may be used to assess the effectiveness of mitigation measures and application methods. The official use of data from sampling efforts are used to design future projects. Professional analysis and interpretation are essential. The following equipment and procedures are applicable when sampling for laboratory analysis:

1. **Equipment.** Samples should be collected in clean, flint glass bottles with Teflon-lined screw caps. A plastic bottle should not be used since it introduces interference and absorbs some pesticides. Bottles should be rinsed with nanograde-purity solvent. An automatic sampler will allow samples to be obtained at pre-selected time intervals or stages without an operator present.

2. **Sampling Procedures.** At least one sample should be collected from the downstream sampling point nearest the spray unit. This sample should be the one most likely to contain a peak pesticide concentration. It can be either an individual sample or a composite of two to four samples depending on expected concentrations and mixing over time of travel. Samples should always be collected for analysis when early warning monitoring shows pesticide has entered the water. A duplicate sample should also be collected in case of loss or contamination during shipping or analysis.
Generally, the number and type of samples to be taken depends on the stream width, depth, discharge, and suspended sediment being transported. When the pesticide carrier is not water soluble, the pesticide will tend to remain at or near the water surface. In the case of the more water soluble pesticide applied with a water carrier, dispersion of the pesticide residues is more dependent on the vertical and lateral mixing within any given cross section of a body of water. The person collecting the samples must, therefore, not only be familiar with the mixing characteristics of streams and lakes, but also have a good understanding of the role of stream sediment transport and deposition.

Instantaneous samples should be as representative as possible of the total volume of water passing the station at any moment. Samples are usually obtained by filling a container held just beneath the surface of a body of water. This technique produces what is commonly referred to as a dip or grab sample. Using a weighted-bottle holder, which allows the bottle to be lowered to any desired depth and returned to the surface, improves on the grab sample method. If the bottle is lowered to the bottom and raised to the surface at a uniform rate, the resulting sample will roughly approximate a depth-integrated sample.

The open-mouth weighted bottle sampler does not collect a true representative sample in a flowing stream if there are many sediment particles coarser than about 0.062 mm carried in suspension. The inability to determine when the bottle becomes filled is another disadvantage which compounds the uncertainty that the collected sample truly represents the distribution of both dissolved and suspended material in the sampled water column. This method of sampling may be extremely poor for flowing streams but may be used effectively for lakes. Lake samples can be collected at selected points and then composited, or a single sample may be collected near the center of the water mass, depending on the size of the lake.

"Depth integrating" techniques should be used whenever appropriate, but for very shallow streams where the depth is insufficient to allow true depth-integration, dip samples collected at one or more verticals across the stream are appropriate. Integrated sampling, which otherwise gives a more representative sample, is usually of little importance in reference to chemicals in solution in very shallow, well-mixed streams.

Samples should be collected without stirring up bottom sediments or introducing surface debris into the water. For small streams, a grab sample should be collected at the lower end of a straight, narrow length of channel carrying a steady flow of water. On larger streams, the samples should be taken near the center of the channel at a depth of two to four inches in a well-mixed cross section, such as a drop in the channel. Do not sample in slow-moving pools or where there is a noticeable eddy effect. The container should be slowly lowered into the main flow of the stream. The bottle opening should be facing upstream so that water does not contact the sampler’s hands or boots before entering the bottle. Since boots are easily contaminated, no one should be allowed to walk in the stream above the sampling point. Contamination can also be carried upstream from boots to sample bottle by eddies. Use care so that there is no possibility that material from boots or hands could enter the sample.

Report any observable film on the water surface or odor in the air. Sample water film separately.

Each sample must be clearly identified and all pertinent information correctly and completely entered into the station record and recorded on a tag or label.
To the container. Permanently marking the sample bottle with a number is recommended. An etching tool is useful for this purpose. Information on the sample and form must be included. Details must include: (1) station identification; (2) date and time; (3) name of person collecting sample; (4) type of sample; number/code. A check of identification tags for completeness should be made prior to submitting samples for analysis.

Information obtained by monitoring is only as good as the sample collected. Equipment, containers, and personnel doing the work must be protected from any contact with pesticide or dye, and petitioning or spraying should be transported through a recently treated area except in a container in a closed vehicle. All unattended samples will be considered uncollected. Containers carried in a vehicle contaminated by a person exposed to pesticides should be considered a rejected sample collector. The entire spray operation area (mixing, loading, and treatment) is to water sampling personnel. Extreme care should be exercised to prevent sample contamination. These precautions are critical.

This concentration could easily result from contamination underling. The effect is compounded by the fact that precision is level, and values of this magnitude probably should be reduced to 10 ppb.

Sampling: A composite sample is a combination of equal parts of a sample for laboratory analysis. It is most commonly used for laboratory analysis. One sample represents a time interval or a stream section. Composite samples obtained at the quarter points of a cross section can be used in most cases, providing that the stream cross section is uniform at these points. Composites are less commonly used to represent a stream. The concentration of pesticide residue is obtained in four of the samples, the concentration of which should be at least 1 ppb to be detected. Another composite is an inability to attribute measured differences to particular sample making up the composite without further analysis. No more than four individual samples should be used in making a composite. As the number of samples in a composite increases, the sensitivity to detection is decreased because of the amount of sample detected. Given a detection limit of 0.2 ppb, a five-sample composite concentration in four of the samples, the concentration of which should be at least 1 ppb to be detected. Another composite is an inability to attribute measured differences to particular sample making up the composite without further analysis.

Monitoring: There is no standardized timing for the collection of monitoring samples. The time of sample collection depends on: (1) the characteristics of the stream; (2) the characteristics of the pesticide; (3) the characteristics of the water; (4) the water. The average stream velocity, and (5) the monitoring point and spray blocks. An example of a pet would be used to detect the peak concentrations in the system. Pesticide contamination which may occur after the aerial spraying.

b. 1 hour or less intervals during spray activity.

c. At time of expected peak concentration.

d. 1/4 to 1/2 hour following the cessation of spraying activity depending on the time of travel.

e. 24 hours after spraying.

f. First storm within 30 days.

A sample should be obtained at every station prior to spray application in order to determine ambient conditions. During the spray project, an observer must be in radio contact with the sample collector. The observer provides information concerning progression of the spray operation to determine when water samples should be collected. Three to five samples are suggested to characterize the peak concentration. It may be necessary to take these samples as close as 15 minutes apart. If analysis of a composite or the sample suggests that the spray contaminated the water with a pesticide, additional samples may be analyzed to better define the peak concentration pattern.

Normally, consideration should be given to determining a 24-hour mean concentration value where sensitive areas may be affected. All samples contributing to a 24-hour mean value should be taken at equally spaced intervals. Too many samples taken early in the period and too few later will result in a false 24-hour mean. Consideration should also be given to taking additional samples at 48 hours and 72 hours after spraying commences.

Due to poor weather, equipment failure, or the size of the area, it is often necessary to spray a unit over a period of several days. Should this occur during the spray program, each spray day is considered separately. The samples at 24, 48, and 72 hours should be taken after the last application to the unit.

When the treatment unit lies within a municipal watershed or in a watershed that supplies a fish hatchery, consideration should be given to taking additional samples 5 to 10 days after application.

5. Storm Runoff. Consideration should be given to sampling performed during initial and later storms runoff produced within 30 days after treatment to identify if pesticide is being washed into surface water as a result of mobilization in ephemeral stream channels and overland flow to channels. Representative measurements of pesticide load during storm runoff at a point that is close below the spray area and to the channel are nearly impossible to obtain. The inflow, either pesticide runoff in the first case or tributary water in the second, hogs the stream bank with very little lateral mixing for some distance. A solution for avoiding this situation is to select a site above the tributary stream or to move the site far enough downstream to allow for adequate mixing. Samples should be taken when runoff is calculated to occur at the monitoring station. A sample should be taken at the peak, and finally on the falling limb of the hydrograph. Precipitation, either on site or at the nearest representative station, should be recorded. The first storm which occurs within a week after spraying may be the most significant depending on the volume of runoff which results. Generally, the first storm which produces at least one-half inch in 24 hours is considered the most important if runoff is generated. In storm runoff the concentration of pesticide in the water will increase as the discharge increases, up to a limit after which it will decrease even though the discharge continues to increase.
Subsequent storms should be sampled only if they produce higher peak runoff. The persistence of the pesticide and/or the intensity of storms determines the length of time sampling may be required. Storms during which rainfall is more likely to transport pesticide than those occurring during the summer or fall because less water goes into the soil before runoff during the spring.

6. Sample Preservation and Storage. It is important to keep in mind the deterioration of sample quality negates all the effort and cost expended to collect good samples. In addition, all samples should be handled in accordance with Good Laboratory Practices (Sec. 1.32).

Water samples must be stored in a cool, dry location, away from sunlight, and completely removed from contaminants. Chemicals should be added only if required by the laboratory. Water samples not treated with preservative can usually be stored at about 4°C for a limited period of time. Some pesticide may require special care such as freezing. Analysis should be carried out preferably within two days from the time of collection.

When certified laboratories are used for pesticide residues monitoring the splitting of samples with a second laboratory for confirmatory analysis is usually necessary. Duplicate samples for quality control purposes should be taken throughout the monitoring period at regular intervals so that ten percent of all samples are duplicated.

Spiked samples should be submitted to all laboratories used. A relatively large-scale monitoring program should include a spiked quality control sample for each ten to twenty samples analyzed. In smaller programs, each 'batch' of samples submitted for analysis should include two quality control samples. One sample should be spiked at or near the concentration listed for the various compounds below and another spiked at two to five times this concentration. The higher concentration provides quality control in case enough pesticide has been lost from the samples to reduce the probability of detection or in case the detection capabilities of the laboratory are not as sensitive as believed. When determining peak pesticide concentrations, five grab samples should be taken, two of which should be spiked. Alternately, three grab samples may be taken and one spiked.

All quality control samples must be prepared with background water from the water body being monitored. Samples must be in the same type of container, stabilised or preserved, and otherwise handled exactly as the samples in the field. An extra sample should be collected for retention until laboratory results of the spiked samples are received. This sample should be submitted for analysis if the concentration reported for the spiked sample is higher than that prepared. If the backup sample is reported to contain pesticide, then either the sample may be contaminated or the analysis is in error.

Quality control samples of some pesticides in five-milliliter ampules are available. Additional high and low concentration samples are provided along with instructions and true values for comparison. Contact:

Chief, Quality Assurance Branch
Environmental Monitoring and Support Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
246 West St. Clair Street
Cincinnati, Ohio 45268
Phone: (513) 684-7327

Quality control samples of analytical grade, pure compounds, which must be diluted to the desired concentration, are available in a 100 milliliter size at no cost from:

Pesticide and Industrial Chemical Repository
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711
Phone: FTS 629-3951

Whenever using laboratories to assess water quality for pesticide contamination, use only those laboratories which have been certified by the EPA and/or an appropriate State. It is important to ensure documentation and validation of laboratory methodology.

The laboratory selected to perform the analysis should be informed in advance of the pesticide to be determined and information on required sample size, labeling, preservation and shipping procedures can be provided. In most cases the laboratory will provide the sampling bottles (normally glass, 1-liter, with Teflon-lined caps), and shipping containers. To avoid the risk of breakage, samples should not be placed in the corners of shipping containers. Plastic bubble wrap also works well to protect bottles during shipment. To assist the laboratory in planning its operations, notification of the approximate arrival schedule and number of samples should be provided well in advance.

Laboratory results, expressed in ppb or ppm, are generally reported no later than three months after receipt of samples, but a two to three week turnaround can be provided by most laboratories if requested. In the event of a spill, immediate analysis and reporting should be requested.

6.3 - GENERAL CONSIDERATION FOR POST-TREATMENT EVALUATIONS. Post-treatment evaluations (FSM 2158.1) are required for all projects involving pesticides, except for housekeeping-type uses, field experiments, and major uses of less than one pound active ingredient for any one project. Regardless of pesticide application method employed, or size of area treated, the effectiveness of the prevention or suppression effort must be determined. The project work plan and its associated, approved Form PS-2100-2, Pesticide Use Proposal (FSM 2153.2) will prescribe quantitative procedures by which treatment effectiveness can be assessed. For certain individual sites, this will take the form of comparative pre-suppression and post-suppression samples. For vegetation control work, pre- and post-treatment sampling of the plant population generally will be needed. Prescribed methods cannot be stipulated since the rate of the -art for sampling varies between pests. The most current and realistic sampling techniques should be tailored to individual pest conditions. Other items that should be tailored are test methods, the Investigators, the -no of procedures (1) methods of determining treatment effectiveness, (2) methods of reducing or eliminating hazard to nontarget organisms; (3) whether the dosage rate was adequate or could be reduced; (4) whether timing was correct, (5) whether treatment was applied adequately, and (6) to what extent other factors contributed to suppression of the target pest. In some cases, post-treatment evaluation should be made at successive periods after treatment.

During post-treatment evaluation, the actual effects are compared with the predicted effects of the treatment on both the pest and the forest environment. The information gained may be used in planning future work. Post-treatment evaluations can take several forms including assessments of biological effectiveness, application effectiveness, environmental impacts, human health effects, and followup action.
6.4 - Biological Effectiveness. Use post-treatment evaluations to determine the degree to which project objectives were met. If the identified objectives were not met, it may be necessary to do another biological evaluation (FSM 3420) or take corrective action to prevent recurrence of inadequate control. The information collected in a post-treatment evaluation relating to biological effectiveness should include:

6.4.1 - Pest Control. Conduct post-treatment evaluations of insects control efforts to determine:
1. Pest population reduction.
2. Foliation protection, if a defoliator is involved.
3. Likely course of infestation, if complete control was not achieved.
4. Probable reduction in damage and loss as a result of management action.

6.4.2 - Vegetation Management. Conduct post-treatment evaluations of vegetation management efforts to determine:
1. Growth reduction or mortality of undesirable plant species.
2. Phytotoxicity to desirable plant species.
3. Adequate coverage without skips.

6.4.3 - Other Pests. Conduct post-treatment evaluations of other pest control efforts to determine if:
1. Treatment objectives were achieved.
2. Recommendations for followup, such as improvements in use of the method in the future, are needed.

In addition, during a post-treatment evaluation for biological effectiveness it may be necessary to consider the potential for:
1. Pest reinvasion.
2. Pest resurgence.

6.5 - Application Effectiveness. Although the majority of monitoring for application effectiveness is done during quality control monitoring (Sec. 6.2), some post-treatment checks may be needed. For example, if it is determined that an area was missed, then re-application may be necessary. Use post treatment evaluations of application effectiveness to allow for making recommendations for improvements in:
1. Future application procedures.
2. Use of certain pesticide formulations.
3. Equipment.

6.6 - Environmental Impacts. Conduct post-treatment evaluations to determine if there were unanticipated adverse environmental impacts that resulted during the project. The impacts can be direct or long-term.

6.6.1 - Direct Impact. Components of the environment that should be considered from the standpoint of their direct effects in conducting an environmental impact, post-treatment evaluation include:
1. Water and air quality.
2. Soils.
3. Non-target vegetation and animals (parasites and predators).
5. Sensitivity, threatened, or endangered species.
6. Fish.

6.6.2 - Long-Term Effects. Pesticides can be harmful in the environment even if they do not cause direct kill on non-target plants or animals. Some pesticides can build up in the bodies of animals (including humans). These are called accumulative pesticides. The chemicals may be stored in an animal's body until they are harmful to it or to a meat-eater which feeds on it. Long-term effects include eggs that will not hatch and young that will not develop normally. The behavior of an animal may be altered so the predators can more easily catch and kill it. Many accumulative pesticides are in the chlorinated hydrocarbon family (DDT, heptachlor, and aldrin), but which have limited uses in the United States, and none in forestry.

Some pesticides stay in the environment without change for long periods of time. These are persistent pesticides. Persistent pesticides which are not stored in animal tissues are often harmless to the environment. They may stay on or in the soil and give long-term pest control without repeated applications.

Another long-term effect that should be considered is pesticide leaching into ground water supplies.

Sometimes these pesticides injure sensitive plants planted in the treated soil. In addition, in forest nurseries some persistent pesticides can affect the growth potential of future seedlings. In other cases, herbicide may affect later planted desirable species.

Pesticides which break down quickly in the environment to form harmless material are called nonpersistent. These pesticides are often broken down easily by microorganisms or sunlight or are highly soluble in water. Most organophosphate and carbamate pesticides are non-persistent.

Pesticide use can also result in cumulative effects and consideration should be given to this phenomenon. It may involve the use of pesticides in two or more drainages that come together; use of several different pesticides or other chemicals that might affect the same ecosystem.

6.7 - Human Health Effects. Conduct post-treatment evaluations of the effects of a project or pesticide on human health even though there are difficult to perform. Most accounts of adverse impact on human health are often anecdotal and cannot be confirmed by scientific fact or medical surveillance. However, it is imperative that public and employee concerns are taken account of with in a sensitive manner. It is recommended that new employees who are to be
routinely involved with pesticide use projects provide a health history that will be held in confidence.

Most human health effects would be dealt with during a project (Sec. 3.6). However, several chronic injuries can occur among employees or retirees as a result of pesticide project work and both should be considered for purposes of evaluating immediate effects, improving future operations, and documenting exposures. Cancer, for example, is a chronic disease that results from a variety of factors including occupational exposure to carcinogens, environmental contaminants, and/or food. In the U.S., about one-third of all cancers are attributable to tobacco smoking. It is estimated that work-related cancers account for anywhere from four to twenty percent of all malignancies; however, it is difficult to quantify the information because of such factors as long intervals of time between exposure and diagnosis, personal behavior patterns, job changes, exposure to other carcinogens, and lack of good records.

Therefore, Forest Service operations with potential carcinogens should be well documented in order to respond to future inquiries and/or complaints. Similarly, if there is known potential for reproductive disorders, neurotoxicity, immunosuppression, or cardiovascular disease then proper documentation and recordkeeping are important.

6.4 FOLLOWUP ACTION Consider followup action whenever a post-treatment evaluation indicates a problem with a pesticide-use project. Take corrective action as warranted. Such action may take one or more forms:

2. Conduct a new biological evaluation.
3. Recommend retreatment.
4. Describe mitigation measures for future projects.
5. Suggest equipment/pesticide formulation changes.
Appendix F
Integrated Pest Management for Bareroot Tree Nursery Operations

Introduction

This appendix defines integrated pest management (IPM) and discusses its importance to nursery pest management. It is an expansion of the discussion of IPM in Chapter 2.

In 1982, the Forest Service adopted a regulation, 36 CFR 219.27, that states: “All management prescriptions shall, consistent with the relative resource values involved, prevent or reduce serious, long-lasting hazards and damage from pest organisms, utilizing principles of integrated pest management. Under this approach, all aspects of a pest-host system should be weighed to determine situation-specific prescriptions including, as appropriate, natural controls, harvesting, use of resistant species, maintenance of diversity, removal of damaged trees, and judicious use of pesticides. The basic principle in the choice of strategy is that, in the long term, it should be ecologically acceptable and compatible with the forest ecosystem and the multiple use objectives of the (Forest) plan.”

This regulation directs the Forest Service to use integrated pest management when dealing with pests on National Forest lands. It is directed primarily at the management of forest pests affecting reforestation and growth of trees in the forest. It does not specifically address pest management in forest nurseries, although most of the regulation is as pertinent to nursery pest management as to forest pest management.

Integrated pest management has been defined many ways. The concept of IPM was originally developed in agriculture to deal with insect pests on crop plants. The following definition by Flint and van den Bosch (1987) reflects this emphasis: “Integrated pest management (IPM) is an ecologically based pest control strategy that relies heavily on natural mortality factors such as natural enemies and weather and seeks out control tactics that disrupt these factors as little as possible. IPM uses pesticides, but only after systematic monitoring of pest populations and natural control factors indicates a need. Ideally, an integrated pest management program considers all available pest control actions, including no action, and evaluates the potential interaction among various control tactics, cultural practices, weather, other pests, and the crop to be protected.”

In an attempt to carry over agricultural IPM concepts into forest resource management, the National Forest Management Act (NFMA) of 1982 defined IPM as: “A process for selecting strategies to regulate forest pests in which all aspects of a pest-host system are studied and weighed. The information considered in selecting appropriate strategies includes the impact of the unregulated pest population on various resource values, alternative regulatory tactics and strategies, and benefit/cost estimates for these alternative strategies. Regulatory strategies are based on sound silvicultural practices and ecology of the pest-host system and consist of a combination of tactics such as timber stand improvement plus selected use of pesticides. A basic principle in the choice of strategy is that it be ecologically compatible or acceptable.”

In addition, the Forest Service Manual (1983, 3405 Definitions) defines IPM as: “A systematic decision-making process and the resultant management actions which derive from consideration of pest-host systems and evaluation of alternatives for managing pest populations at levels consistent with resource management objectives.”

Another definition is presented in a Forest Service document (The Path From Here: Integrated Forest Protection for the Future, USDA Forest Service, Southwestern Region 1986) which is applicable to both agriculture and forestry: “Integrated pest management is the maintenance of destructive agents at tolerable levels by the planned use of a variety of preventive, suppressive or regulatory tactics and strategies that are economically efficient and socially acceptable. It is implicit that the actions taken are fully integrated into the total resource management process, in both planning and operation. Pest management therefore, must be geared to the life span of the tree crop as a minimum and to a larger time span where the resource planning horizon so requires” (Waters 1974 as cited in Brown and others 1986).

For this EIS, several definitions, including the one by Waters (1974), were synthesized to yield a definition of IPM that is responsive to the pest management needs in forest nurseries: “Integrated nursery pest management is the maintenance of seedling pests at tolerable levels by the planned use of a variety of preventive, suppressive or regulatory methods (including no action) that are consistent with nursery management goals. It is implicit that the actions taken are the end result of a decision making process where pest populations and their impact on hosts are considered and control methods are analyzed for their effectiveness as well as their impacts on economics, human health, and the environment.”

Decision-Making

Chemical and cultural methods are currently used to control pests at the Lucky Peak Nursery. When the nursery manager decides to control a pest problem, one or a combination of these two methods is used. An important element in pest control is the decision-making process:

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how the manager decides if a pest needs to be controlled, when to treat it, and with what method(s).

Undocumented Decision-Making Process

Currently, treatment decisions are based on training, experience, and other factors such as the season and climatic conditions, as well as data from previous research or field trials on the pest population level. Often, data on pest populations are sparse or based on casual, sporadic observations of the pest in the field. Previous population levels of the pest, climate or other factors associated with outbreaks of the pest, and the amount of damage associated with certain population levels may not be well documented or tracked.

With undocumented decision-making, there may not be any overall written plans for management of each pest and there is no framework or process for analyzing impacts of each treatment on important nursery issues (such as worker health, cost efficiency, water quality, or seedling quality) or for documenting the reasons for selection of one treatment over another. While undocumented decision-making may frequently result in sound decisions, it may also result in decisions for which little or no documentation exists for the decision rationale and treatment effectiveness.

Documented Decision-Making

Another strategy available to managers is a chronicled decision-making process. Under this process, managers would continue to make pest management decisions, but they would make their decisions within a more trackable framework. Decisions would be based on documented pest status (including historical occurrence, pest life cycles, research findings, data from field monitoring if applicable, climatic and other factors contributing to pest outbreaks, etc.) and the analysis of treatment options and their impact on nursery goals. This documented decision-making process provides an instructive record of actions taken, as well as the rationale for taking those actions.

The IPM Program

Here are explanations for the different steps outlined in Figure 1:

Environmental Impact Statement: This is the overall pest management plan for the Lucky Peak Nursery. It gives broad guidelines for managing pests and provides detailed background information on pests and control methods and the impact of each on seedling production and on nursery resources (soils, water, wildlife, etc.). It does not give specific details for managing each pest at the nursery.
IPM Plans: The nursery staff will develop an IPM plan for each pest that occurs at the nursery. This plan spells out what is known about the pest, where it occurs in the nursery, factors influencing its development and spread at the nursery, and control methods that are effective at the nursery. It also describes methods used to monitor for the pest and the treatment methods to be used. If monitoring methods are not effective or not developed for a particular pest, procedures are described for determining when treatments need to be implemented. The plan should be reviewed each year and revised, if necessary.

- Compile Information Profile for each Pest

  - Describe Pest Biology and Pest Impact: A complete description of the pest life cycle, habitat, host species, and pest threshold levels (if known) for seedlings should be prepared. This information should be based on a thorough literature review, and should be developed by trained pest management specialists.

  - List Treatment Alternatives (Including No Action): Available treatments, including biological, cultural, and chemical, should be listed for the pest. “No action” should be included as one possible treatment. Treatments should be identified as preventative (cultural prevention activities or early chemical treatments) or direct control.

  - Compare Listed Treatment Alternatives: Treatments, either singly or in combination, should be compared with one another as to their effectiveness, health hazard, environmental hazard, and cost.

  - Annual Decision and Decision Rationale: The treatment program for the pest should be briefly described and reasons given for selecting various treatments. This decision should be reviewed and, if needed, revised each year prior to the growing season.

  - Pesticide Information: Product labels and Material Safety Data Sheets (MSDS’s) for pesticides which are listed as possible treatments should be included or location referenced. Similarly, information for the effect of each of these pesticides on households and the environment should be included or location referenced.

  - Monitoring Plan and Monitoring Data Sheets: A brief description of how the pest or its damage will be monitored so that its impact can be assessed or treatments can be timed more accurately should be included. Such items as frequency of monitoring, where to look for pest or damage on plant, which crops and age of crop should be monitored, can be included in monitoring plan.
Available Control Methods: The various treatment methods, to some degree, should be examined. These methods include control tactics in the IPM plan for each pest. They are nursery goals such as cost, seedling quality, production, human as well as for their effectiveness in suppressing or preventing the pest problem, whether or not the environmental build-up, and the physiological condition of seedlings is one method should also be considered.

Best Addresses Nursery Goals: The best method is all the viable options, including no action. What is best will general Forest Service nursery goals are displayed at the top.

The decision showing what treatment was selected, and if these decisions can be kept in a variety of ways, from brief detailed descriptions in a computer file.

Point: Sometimes, threshold levels do not exist for particular pests, and control treatments are not made before the pest damages the crop, unattainable treatments include: 1) Cultural activities that make for pests, and 2) early treatment with chemicals, applied either by the nursery or kills the pest directly, such as mulching seedbeds to prevent gray mold, often are establishment of the seedling crop. The decision to carry out is based on historical occurrence of the pest damage at or before the appearance of damage, a season, including weather conditions, soil moisture, seedling, presence of beneficial insects in seedbeds, and the pest.

Hold Analysis for Control Treatments

Situation: For some pests, particularly insects, control to a certain population level of the pest. Other pests, to detect and timing of control treatments must be based on seedling age, or physiological status of seedlings.

For pests for which we can monitor population levels, action nursery manager. The action threshold is the number of what is allowable before action (treatment) is taken. The action threshold often can only be generated over one or two, where pest populations are tracked and specific levels define pest population levels. Once this population/damage acceptable damage can be set by the nursery manager and this can be used in subsequent years as the “action threshold” - the level of pest population at which action (treatment) occurs to avoid unacceptable damage to the crop.

Monitoring the crop for damage and monitoring the population of the pest will allow the nursery to determine if the action threshold has been reached. It will also provide information about where the pest is located, what crops it is damaging, how much damage is occurring, and the level of pest population is doing (increasing or decreasing). For pests which must be treated preventatively, monitoring will not be useful for determining when to treat; it may, however, be useful for determining if preventative treatments actually reduced pest populations of damage on the crop.

Implement Treatment: The seedling crop, seeds, seedbed, or surrounding environment is treated to control or prevent pest damage using the selected treatment method(s).

Evaluate Treatment Effectiveness: Selected methods should be evaluated for their effectiveness. Effectiveness will be defined in terms of the nursery goals, i.e., whether or not human health was protected, whether or not an adequate number of acceptable seedlings were produced, etc. If the selected control method is a pesticide application, effectiveness in protecting human health or the environment can be evaluated by monitoring exposure of workers before and after treatment or by monitoring pesticide levels in the water before and after treatment.

At the same time, the effectiveness in reducing pest populations or damage can be evaluated by continuing to monitor pest populations or damage after the treatment was applied and comparing treated seedlings to untreated seedlings. Utilization of check or control plots will be helpful, especially when using treatment methods which are new for the nursery or for a particular seedling species or stock type. Evaluation may not be necessary every time a treatment is made, but evaluations at critical times or when using a new method or on an annual schedule are important. If the selected treatment method is not effective in terms of nursery goals, then the use of the method will be examined and modified or other viable treatment methods will be considered and tried the next time treatments are needed.

Revise or Amend: Pest IPM Plans should be revised or amended according to information gained from use of various methods and their effectiveness. If no effective methods exist, research will be directed towards the development of new treatment methods, especially for pests for which there are no adequate control measures or where only chemical control methods are available or effective. Basic research as well as application of techniques developed for other crops are needed. (See Appendix G for discussion of research needs.)
References

Flint, M. L. and R. Van den Bosch

USDA, FS
FSM 3405 Definitions.

Brown, Dave; Samuel H. Hitt; William H. Moir, eds.

Figure F-2

Sample form for monitoring lygus bugs in the San Joaquin Valley

<table>
<thead>
<tr>
<th>Lygus Bug Monitoring</th>
<th>San Joaquin Valley</th>
</tr>
</thead>
<tbody>
<tr>
<td>Third Through Sixth Weeks Of Squaring Only</td>
<td></td>
</tr>
</tbody>
</table>

Step 1: count squares once each week
In each field quadrant, count all squares in a 40-inch section of row chosen at random.

<table>
<thead>
<tr>
<th>QUADRANT</th>
<th>SQUARES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>total:</td>
<td></td>
</tr>
</tbody>
</table>

Divide the square total by 100, then multiply by 3:

\[
\frac{\text{square total}}{100} \times 3 = \square
\]

The number in the box is the treatment threshold for this week.

Step 2: Take at least one sweep sample in each quadrant. One sample is 30 sweeps across one row with a 15-inch net. Count all lygus bugs, including nymphs, in each sample.

<table>
<thead>
<tr>
<th>SAMPLE NO.</th>
<th>LYGUS BUGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
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<td>5</td>
<td></td>
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<td>6</td>
<td></td>
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<td>7</td>
<td></td>
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<tr>
<td>8</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
<tr>
<td>total:</td>
<td></td>
</tr>
</tbody>
</table>

Divide the total by the number of sweep samples to find the average bugs per 50 sweeps:

\[
\frac{\text{total}}{\text{samples}} = \text{average}
\]

Treat when the average exceeds the treatment threshold on two consecutive sample dates 2 or 3 days apart.
Appendix G

Nursery Pest Management Research Recommendations

The following is a list of integrated nursery pest management research needs that have been identified for the Lucky Peak Nursery in Idaho.

General Research Needs

A) Develop accurate and economically feasible sampling techniques for monitoring significant pests.

B) Develop usable models to determine the relationship between pest population levels and seedling damage.

C) Develop user friendly computer programs to assist in the documented pest management decision-making process.

D) Develop an electronic record keeping system for recording and tracking pest monitoring results, pertinent weather data, and pest management decisions.

E) Survey, identify, and evaluate the impact of beneficial organisms and biological control agents present in the nursery environment. For example:

- mycorrhizal fungi,
- antagonistic and competitive fungi
- parasitic and predacious insects,
- parasitic, predacious, and antagonistic nematodes.

F) Identify nursery practices which promote survival, development, and growth of beneficial organisms.

G) Improve chemical application methods so that only the target pest is treated and chemical damage to seedlings and beneficial organisms is minimized.

Appendix G - 1
H) Identify and field test potentially effective chemical pesticides, with minimal human, wildlife, seedling, and environmental hazards.

Specific Research Needs

Seedling Quality

A) Identify soil inhabiting organisms, both beneficial and detrimental, that are present on or in seedling roots which affect lateral and feeder root development, seedling quality, and subsequent tree field survival and growth.

B) Identify the impact of these root pathogens on seedling quality in the nursery and subsequent survival and growth after outplanting.

C) Develop better methods for isolating, quantifying and evaluating populations of root pathogens and beneficial organisms in the nursery soil.

D) Identify cultural, biological and chemical methods to reduce root pathogen impacts and increase benefits from beneficial organisms.

Alternatives to Present Fumigation Procedures

A) Identify and evaluate pests which increase to action threshold levels when the soil is not fumigated. Determine the life cycle, manner of infection, and severity of infection for each.

B) Identify and field test alternative chemical control agents for use against soilborne pests.

C) Identify and field test biological control agents for use against soilborne pests.

- antagonistic and/or competitive bacteria or fungi,
- antagonistic and/or predacious nematodes,
- predaceous insects,
- mycorrhizal fungi,
- weed diseases.

D) Develop effective and practical biological control agent delivery system(s).

- seed coating.

Soilborne Pests

A) Further identify organisms causing root diseases (damping-off, root necrosis, root rot).

B) Determine roles and interactions of these pests with a variety of disease complexes.

C) Identify regenerative source(s) for the root diseases.

D) Determine locus, mode and degree of damage for the root disease organisms.

E) Determine environmental conditions necessary or conducive to pest establishment, development, and spread to adjacent seedlings.

F) Determine relationship between pest populations in soil or on seed and subsequent disease incidence and crop damage.

Ectomycorrhizal Fungi

A) Field test promising alternative ectomycorrhizal fungus species and inoculum types for operational nursery applications.

B) Identify and quantify ectomycorrhizal fungi along with associated soil factors and environmental conditions at the nursery.

Weeds and Grasses

A) Determine life cycle of specific target weeds and grasses to utilize optimum treatment types and techniques.
B) Develop a complete integrated weed and grass management program to maximize use of available cultural, biological, and chemical procedures.

C) Determine effects of various nursery cultural practices; i.e., cover crops, mulches, etc., on subsequent weed populations at the nursery.

Human Health and Environmental Quality

The following is a list of areas recognized and identified as needing (further) research (not necessarily by the Forest Service).

A) Determine the male and female reproductive health risks for all pesticides used at the nursery.

B) Determine what synergistic effects, if any, exist for secret and revealed ingredients in pesticides used at the nursery.

C) Determine susceptibility of children to all the pesticides used at the nursery.

D) Fill any data gaps identified in risk assessment (Chapter IV, Appendix E) for specific pesticides.

E) Identify the inert ingredients used in each pesticide.

F) Determine the acute toxicity of full strength formulations of each pesticide.

G) Identify the acute or chronic effects on the health of fish and wildlife from exposure to nursery pesticides.

H) Determine the environmental (breakdown) fate of the nursery pesticides in the air, soil, vegetative communities, and water.

I) Determine genetic impacts of pesticides on tree species grown at Lucky Peak Nursery.

J) Determine genetic impacts of pesticides on the various nursery pests (fungi, insects, nematodes, weeds). Alterations in pest resistance/susceptibility to various pesticides over time.
There are no federally listed plant species on the Forest. Plants on the Regional Forester's sensitive plant species include:

1. Aase's onion
2. Tolmei's onion
3. Tall swamp onion
4. Pinwood cryptantha
5. Idaho douglasi
6. Giant helioborne
7. Pussling halimolbus
8. Idaho goldenweed
9. Stipa viridula
10. Idaho salpiger

Only 61 acres are planned for treatment and will be affected activities associated with the proposed alternative. As a result, only a small portion of the species listed above are affected by the activities proposed. Peregrine falcon and wolf habitat are not found in or adjacent to the project area. Winteting bald eagles do occur within the area and winter habitat is found along the Boise River and Lucky Peak Reservoir. No bald eagle nesting habitat or foraging habitat associated with nesting is found within the project areas. Contamination of the food source from pesticide drift into the water is the primarily concern associated with this proposal. This can occur during high temperatures and humidity and windy conditions.

Of the sensitive wildlife species, only the mountain quail potentially occurs within the vicinity of the project area. Herbicide spray drifting into riparian habitats and killing the forb and grass species is the primary concern associated with this proposal.

None of the sensitive plant species occur on or immediately adjacent to the Lucky Peak Nursery.

A tree nursery is an intensive agricultural operation. Its goal is to grow large numbers of quality seedlings cost-effectively. Plants and animals that interfere with that goal are considered to be pests. Pests are typically divided into four categories: insects, diseases, weeds, and animals.

Three categories of pest control methods are available to the nursery manager:

Biological Control: The deliberate use of natural enemies to control pests. Methods include predatory insects such as ladybugs, and Chinese weaver geese.

Chemical Control: The use of a chemical to control pests. Methods include fumigants to control soil-borne diseases, fungicides to control diseases caused by fungi, insecticides to control insects, and herbicides to control vegetation considered to be weeds.

Cultural Control: The use of certain nursery practices (such as weed control, improving drainage, and adding soil amendments) to make the habitat less favorable for unwanted insects, weeds, diseases, and animals, or to prevent, suppress, or remove them. This category
A combination of some of these methods is currently used to control pests at the Lucky Peak Nursery.

II. Proposed Action

The Forest Service proposes to implement Alternative C integrated pest management at the Lucky Peak Nursery. This involves all methods to control unwanted weeds, insects and diseases and animals in the nursery.

Under this alternative, biological, chemical, and cultural methods would be permitted. Biological and cultural methods would be preferred and used if they exist and are economical. Of no effective or economical non-chemical methods exist, chemical pesticides would then be used. Control methods used would continue to change based on new research and technology, review of existing methods, and public need.

A. Mitigation Measures

Mitigation measures are activities or decisions designed to prevent, reduce, or compensate for adverse environmental impacts. The mitigation measures presented are based on Forest Service policy, nursery operation, safety plans, information in the research literature, and field experience of Forest Service nursery managers and employees. The following mitigation measures will be applied:

1. No treatment or deferred treatment option will be considered for all pest control activities.

2. Each nursery will have an environmental monitoring plan. The Plan would include water and soil quality monitoring procedures and standards, requirements for notification of adjacent landowners, and record-keeping guides.

3. All Forest Service uses of biological control methods will be in cooperation with the USDA Agricultural Research Service or under individual, approved state programs.

4. All applicable state and Federal laws, including the labelling instructions of the Environmental Protection Agency, will be strictly followed.

5. Pesticides will be applied within the prescribed environmental conditions stated on the label. This includes considerations of relative humidity, wind speeds, and air temperature, when determining the timing of application in relation to drift reduction.

6. Use pesticide formulations that contain only inert ingredients recognized as generally safe by EPA, or which are of low priority for testing by EPA. Use of other inert ingredients (identified by EPA as a high priority for testing or those that have been shown to be hazardous) requires full assessment of human health risks incorporated into the NEPA decision-making process.

7. Water quality monitoring for detection of pesticide residues will be conducted. Monitoring of a pesticide’s application will be conducted to determine if mitigation measures are 1) being observed, 2) effective in maintaining water quality and soil productivity, and 3) in compliance with state water quality standards and pesticide label requirements.

8. Pesticide use will be conducted in accordance with direction in Forest Service Manual 2150 (Pesticide-Use Management and Coordination). This defines the authority for Forest Service use of pesticides (the Federal Insecticide, Fungicide, and Rodenticide Act). The objectives and responsibilities of the different administrative levels are documented. This directive includes the requirement for environmental documentation, safety planning, and training when pesticides are used.

9. Forest Service Handbook 2109.11 (Pesticide Project Handbook) will be used to direct project planning. This establishes procedures to guide managers in planning, organizing, conducting, and reporting pesticide use projects.

10. Standards and guidelines in Forest Service Handbook 2109.12 (Pesticide Storage, Transportation, Spills, and Disposal Handbook) will be met. This defines standards for storage facilities, posting and handling, accountability, and transportation. It covers spill prevention, planning, cleanup, and container disposal requirements.

11. Forest Service Handbook 2109.13 (Pesticide Project Personnel Handbook) will be used to define responsibilities and personnel needs and training needed for pesticide application projects.

12. Project safety will be guided by Forest Service Handbook 6709.11 (Health and Safety Code Handbook, Chapter 9). This directive establishes the basic safety rules, as well as storage and disposal safety aspects. References and publications to aid in worker safety training are also identified.

13. Each nursery will provide guidance as appropriate in the form of Project Safety Plans, Environmental Monitoring Plans and Public Contact Plans. This is where specific requirements for equipment standards, training and quality control, and safety needs are identified for pesticide use.

14. Pesticide Applicator Licensing and Training will be used as a quality control measure. Training and testing of applicators covers laws and safety, protection of the environment, handling and disposal, pesticide formulations and application methods, calibration of devices, use of labels and data sheets, first aid, symptoms of pesticide exposure, and other activities.

15. Material Safety Data Sheets will be posted at storage facilities and made available to workers. These provide physical and chemical data, fire
specific health hazard information, spill or leak for worker hygiene, and special precautions. All taken to assure that equipment used for transport will not leak pesticides into water or soil as Risk Plan.

Using pesticides and cleaning equipment shall be set not run into surface waters or result in soil within the buffer strips along perennial streams spot application monitoring will be continued during tarp lifting, active clothing.

Eagles and Mtn. quail to be affected by this Mitigation measures listed above will reduce the adjacent areas. The area planned for intensive c) compared to the entire occupied area for both 1. Monitoring and adjustments in management actions do not affect these species.

2. it is estimated that no cumulative effects on sensitive species will result from implementation of presentation of the integrated pest management as identified in the EIS is not likely to affect the endangered bald eagle or affect the T.

Date

United States Department of the Interior
FISH AND WILDLIFE SERVICE
Boise Field Station
4696 Overland Road, Room 576
Boise, Idaho 83705

September 9, 1991

John Erickson, Wildlife Biologist
Boise National Forest
1750 Front Street
Boise, Idaho 83702

Re: Lucky Peak Nursery (2600)
1-4-91-92-1 (6003.0450)
T#: BFO-91-0981

Dear Mr. Erickson:

The U.S. Fish and Wildlife Service (Service) is writing to you in response to the biological assessment that was received on August 5, 1991 requesting concurrence on the determination of no effect as it relates to threatened and endangered species at Lucky Peak Nursery. We concur with your assessment that the proposed action (Alternative C) will have no adverse effect on threatened and endangered species.

In your request, you also wanted an update on federally listed species that may be in the area. In our review of species list request 1-4-91-SP-55 dated November 7, 1990 for the Lucky Peak Nursery, we did not find any other federally listed species that may be in the immediate area.

We find the 18 conservation measures described in the biological assessment that will be implemented during the nursery operation are well designed and should meet full compliance under the Endangered Species Act and Environmental Protection Agency standards.

Should new species be listed or the nursery operations be modified, particularly in the use of herbicide/pesticide control measures, we request that you consult with us on an informal basis. Thank you for the opportunity to comment of this project.

Sincerely,

Charles H. Lobdell
Field Supervisor
cc: IDFG, Region 3, Boise
IDFG, Hdqtrs, Boise