Safe Procurement and Production Manual

A Systems Approach for the Production of Healthy Nursery Stock

By John A. Griesbach, Jennifer L. Parke, Gary A. Chastagner, Niklaus J. Grünwald and John Aguirre

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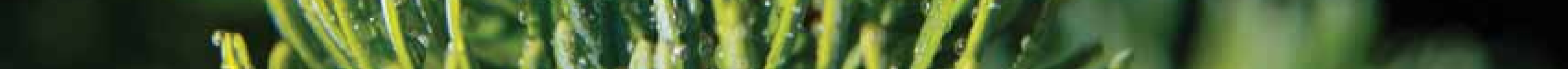

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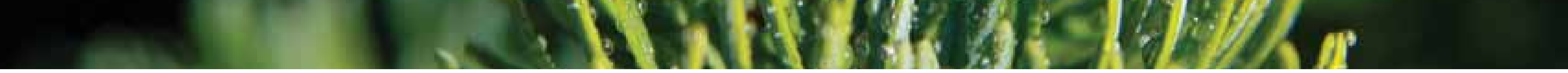

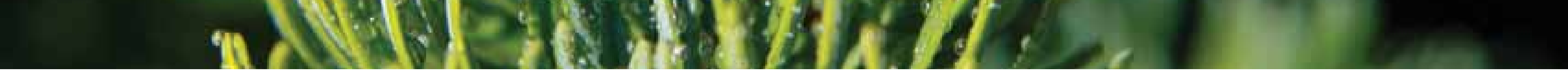

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John A. Griesbach

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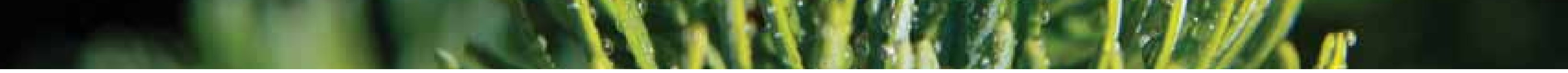
Edited by Curt Kipp

With a foreword by Jeff Stone

Oregon Association of Nurseries
Wilsonville, Oregon, USA



Dr. John A. Griesbach is a plant pathologist and the owner of Ascent Agricultural Services LLC, and courtesy faculty member, Department of Horticulture, Oregon State University. **Dr. Jennifer L. Parke** is an associate professor/senior research in the Department of Crop and Soil Science at Oregon State University. **Gary A. Chastagner** is a plant pathologist and extension specialist at Washington State University Puyallup Research and Extension Center. **Dr. Niklaus J. Grünwald** is a research plant pathologist, USDA Agricultural Research Service and associate professor (courtesy), Department of Botany and Plant Pathology, Oregon State University. **John Aguirre** served as executive director of the Oregon Association of Nurseries from 2000–2010 and is currently the president of the California Association of Winegrape Growers. **Curt Kipp** is the publications manager of the Oregon Association of Nurseries and the managing editor of *Digger* magazine. **Jeff Stone** is the executive director of the Oregon Association of Nurseries.

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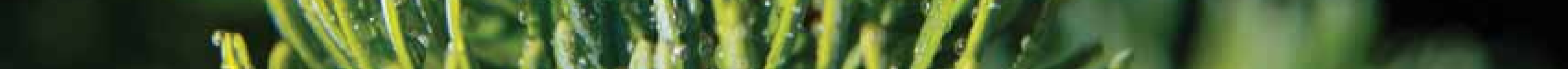

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Foreword

Nursery and greenhouse operators face an ever-increasing set of opportunities and challenges. None are more daunting, or more of a game changer, than pest and disease issues.

Oregon has a stellar reputation of producing quality plant material, which is shipped throughout the Pacific Northwest, the nation and internationally. The U.S. Department of Agriculture sees what the Oregon Association of Nurseries (OAN) sees — it is getting harder and more costly to attack an emerging pest or pathogen after it becomes an issue. It has very real economic and environmental consequences.

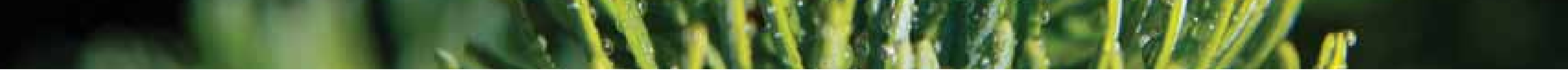
The U.S. Congress has been working with the nursery and greenhouse industry to address issues arising from pests and pathogens. This manual is a significant step forward in the creation of a grower-based systems approach to reduce the risk of infected plant material. The OAN is proud to be a forceful advocate for this important nursery industry initiative.

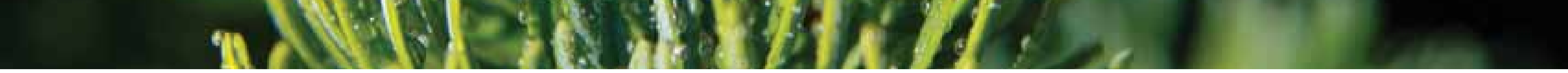
This manual provides the latest pest and pathogen research and phytosanitary strategies. It is intended to assist growers in developing a set of practices that emphasize prevention. Growers who adopt these methods will have the ability to detect pest and disease problems when they arise, and respond rapidly. As you go through the chapters of this book, you will see the systems approach laid out in a step-by-step process. Any nursery following these steps is likely to reduce their risk of infestation or damage due to pests and pathogens. This will help them maintain access to national and international markets.

There's no doubt that the nursery industry must create a continuum of risk-reduction methods to deal with pests and pathogens in nursery production. This manual is a part of a coordinated effort by Oregon's nursery and greenhouse industry to provide tools that are relevant, accessible and understandable.

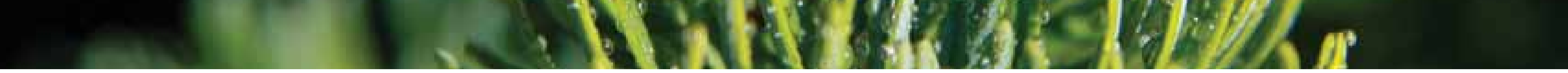
I hope you agree that the tremendous work done by authors of this manual accomplishes those goals.

Jeff Stone
Executive Director, Oregon Association of Nurseries
June 2011





Part I: A Systems Approach Introduction



***These quarantined* Rhododendron *plants are infected with the plant pathogen* Phytophthora ramorum.**

Chapter 1: The Challenge We Face

The introduction and spread of plant pests and pathogens threatens the long-term health and profitability of the nursery and greenhouse industry. As the global economy has boomed, there has been a dramatic increase in goods moved between countries and continents. These goods can include live plants from foreign sources. Sometimes, these exotic plants can bring equally exotic pests and pathogens along for the ride. These harmful organisms can lead to bad consequences for growers:

- diminished markets,
- increased restrictions,
- higher production costs,
- delayed production schedules,
- lower product quality, and
- plant loss.

Unfortunately, the rate of introduction and associated risks from these organisms is increasing dramatically. In just the past decade, the Plant Protection and Quarantine (PPQ) branch of the USDA Animal and Plant Health Inspection Service (APHIS) has identified the following exotic pests and pathogens that have gained a foothold in the United States:

- *Phytophthora ramorum* (sudden oak death)
- emerald ash borer
- citrus longhorned beetle
- citrus greening
- light brown apple moth
- European grapevine moth
- soybean rust
- sirex woodwasp
- gladiolus rust
- spotted-wing drosophila
- and many others

Federal and state inspection programs have struggled to keep pace. Many experts fear the rate of new plant pest and pathogen problems will further accelerate, placing the United States Department of Agriculture (USDA), states and industry under increasing pressure to respond.

An explosion in global trade has made it easier to move goods and services, but it has also provided pests and pathogens with a pathway to travel across oceans, posing a threat to new plant populations.

Even some interest groups outside of the nursery industry have taken notice. In a 2007 report, *An Ounce of Prevention: How to Stop Invasive Insects and Diseases from Devastating U. S. Forests*, The Nature Conservancy called on the USDA to greatly limit the importation of plants:

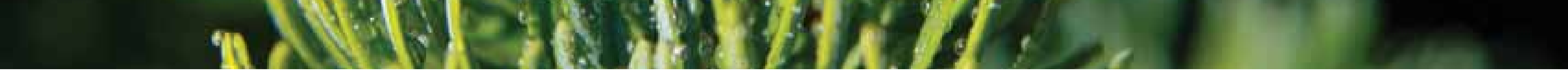
> ***"Imported nursery stock — trees, shrubs, garden plants, roots and cuttings brought in from other countries for sale to the U. S. customer — is one of the two chief pathways that bring invasive insects and diseases to American forests."***

An industry consensus

In the view of The Nature Conservancy, the USDA should only allow imports under a strict regulatory framework. But how do regulators and the industry feel about it? Policymakers, federal and state plant health officials, and nursery industry representatives increasingly agree on several of the answers:

- **We must bolster our nation's defense against damaging plant pests and pathogens.**
- **We must increase funding for surveillance, inspection and eradication activities.**
- **We must establish new procedures concerning importation of nursery stock, and**
- **We need more research on detection and mitigation.**

The Oregon Association of Nurseries (OAN) has been advocating for a nursery industry initiative to develop, test and promote a new approach to pest risk management. This must be done in partnership



with the USDA, state plant health officials and research institutions. This new approach is aimed at preventing the introduction and spread of the damaging organisms. It is called the "systems approach."

This manual was developed to give the nursery professional a ready source of information for improving sanitary and phytosanitary conditions at their facilities. The ultimate goal of this manual is to provide the nursery professional the information necessary to establish and operate an effective systems approach for their operation.

> **We believe that when it comes to preventing the introduction and spread of plant pests and pathogens, a proactive approach — one that's holistic and intelligently targets areas of highest risk — is better than a reactive approach.**

In this manual you will find the latest pest and pathogen research and phytosanitary strategies, all brought together in a user-friendly format. Additional references and information sources for nursery stock producers are provided in the appendix, along with a glossary of terms and acronyms.

Please note

The information in this guide is current as of the date of publication. Please be aware that significant changes to nursery stock regulations are underway at both federal and international levels. Newly introduced quarantine pests can also dramatically affect regulations and markets. In addition, researchers are developing new ways to address pest and pathogen problems. One can anticipate that additional best practices and critical control points will be developed.

Trade-name products and services are mentioned as illustrations only. This does not mean that authors or their affiliated organizations either endorse these products and services, or intend to discriminate against products and services not mentioned. Due to constantly changing laws and regulations, we can assume no liability for the suggested use of chemicals contained in this guide. Pesticides should be applied according to the product label directions.

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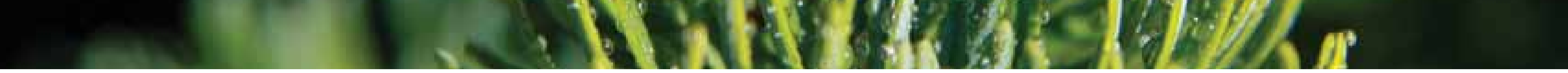


These nursery propagation beds are gently sloped to assure proper drainage. This practice reduces standing water, which in turn reduces the risk from pathogens.

Chapter 2: Systems Approaches: A New Tool

What does the term **"systems approach"** mean? In the broad sense, it isn't just about plants. Systems thinking is a method of analysis that examines how different components of a whole can influence each other. Scientists have used this holistic way of thinking to study groups of people, such as clubs or workplaces. They've also used it to study natural systems, which are called ecosystems.

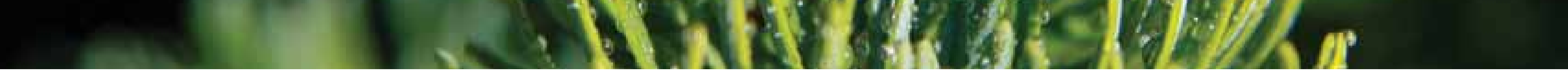
Multiple Measures — Cumulative Effect

Growers and regulators realize the benefits of applying **systems thinking** to plant pest and disease threats. Systems approaches can provide growers a new process to both control pests and diseases, and maintain access to national and international markets.

In this context, a systems approach must have two independent, different or unrelated mitigation measures that act with cumulative effect. The cumulative effects need to provide sufficient pest control to allow the products to meet an agreed-to standard. By following this approach, one can possibly avoid the need for more Draconian treatments, such as fumigation or outright quarantine.

> **For individual nurseries, the goal of the systems approach is to develop a set of practices that emphasizes prevention and provides for rapid detection and response when pest and disease problems arise.**

Elements of a systems approach should have **overlapping and cumulative benefits** that address a broad array of current and future pest and disease threats. The nursery systems approach is quite different from waiting for pest and disease problems to appear. Consider the difference between following a wellness program, and only visiting the doctor when you get sick. Which approach is more effective? A



wellness program emphasizes disease prevention, reducing the need for emergency treatment, expensive surgeries and prescription medications. Likewise, a systems approach in nurseries can prevent the need to respond with a spray program, crop destruction order or quarantine when a problem develops in the field or the greenhouse.

How It Works: Finding Key Points of Vulnerability

The systems approach identifies key points of vulnerability in the nursery operation where steps can be taken to minimize pest and disease risks. For example, incoming nursery stock can be visually examined by personnel trained to recognize unusual signs or symptoms. Likewise, it's important for a nursery to take prompt and appropriate action when pests and/or pathogens are first detected, to prevent spread and establishment within the nursery.

The systems approach does not eliminate the use of pesticides, but emphasizes disease and pest avoidance and prevention.

The systems approach is a knowledge-based approach to pest and disease management. It requires that key nursery staff members are able to recognize and prioritize the most likely and serious risks from plant pests and pathogens. Once these risks are identified, practices or tools known to be effective against those risks must be implemented. A nursery can put in place a system that can be readily managed and seamlessly incorporated into procurement, production, handling and shipping operations.

There are several different nursery programs that currently utilize the systems approach. They include the U.S. Nursery Certification Program (USNCP), two interrelated nursery certification programs in Canada, and programs based on the Hazard Analysis of Critical Control Points (HAACP) framework. Oregon's Grower-Assisted Inspection Program (GAIP) is a notable example of an HAACP-based program. Read on for a thumbnail sketch of each of these programs.

United States Nursery Certification Program (USNCP)

The USDA, several states and five companies are currently piloting a systems approach program for nurseries called the **United States Nursery Certification Program (USNCP)**. As of February 7, 2011, four nurseries in Oregon and one each in California, Washington and Georgia are currently accredited to produce and ship material with USNCP certification. (There are five companies in all participating, but seven nurseries — one company has three sites participating in the program.)

The USNCP is based on the North American Plant Protection Organization (NAPPO) standard for shipping nursery plants. The standard was negotiated between the departments of agriculture in the U.S, Canada and Mexico, and termed the Regional Standard for Phytosanitary Measures (RSPM) #24. For more information and frequently asked questions on the USNCP, certification standards, and the language of RSPM # 24, see these links:

- USNCP FAQs — **http://www.aphis.usda.gov/plant_health/acns/downloads/faqs-usncp.pdf**
- USNCP Standards — **http://www.aphis.usda.gov/plant_health/acns/downloads/USNCP-Standards.pdf**
- RSMP #24 — **http://nappo.org/Standards/NEW/RSPMNo.24-e.pdf**

The USNCP standards describe the components of the program. It spells out what the participating nursery must do for certification, and how to apply to the program.

The USNCP is built around two main control documents:

- the **phytosanitary management program** (detailed fully in **Chapter 10**),
- and the **pest management plan** (detailed fully in **Chapter 11**).

The program has significant documentation, inspection and audit requirements. There is also a requirement to track plant material from the source, through the production process and on to the recipient.

> **An attractive feature of the USNCP is that once accredited, a nursery is permitted to issue its own electronic phytosanitary documents.**

This has obvious scheduling advantages over third party-issued documents. It also benefits the regulatory agency, which can redirect inspectors to work on other, more pressing phytosanitary issues. In addition to these benefits, pilot USNCP participants report improved product quality, increased awareness of plant health and an increased ability to manage inventory.

The program is currently designed to meet the import requirements of Canada, but additional countries are expected to adopt this type of program in the future. Eventually, those nurseries that ship internationally will likely be required to be in a program such as the USNCP.

The USNCP pilot program began in 2005. USDA wants to expand the program in response to increased interest by nurseries and state departments of agriculture. At this writing, the program is undergoing a series of efficacy reviews to assess its effectiveness in comparison with traditional nursery end-point inspection and phytosanitary certification programs.

Two Programs in Canada

Other systems approaches for nursery stock production that are being used internationally include Canada's two programs. They are:

- the **Canadian Nursery Certification Program (CNCP)**, and
- the **Clean Plants Program**, formerly called the **Domestic Phytosanitary Certification Program (DPCP)**.

The CNCP is a reciprocal program mirroring the requirements of the USNCP. It is audited and accredited by the Canadian Food Inspection Agency (CFIA). The Clean Plants Program is administered by the Canadian Nursery Certification Institute, and was developed by the Canadian Nursery and Landscape Association to serve as a "feeder" program for CNCP nurseries. In-depth information about the CNCP and the Clean Plants Program can be found at the links shown in the **Appendix**.

Hazard Analysis of Critical Control Points

Other pilot efforts of the systems approach concept have been based on **hazard analysis of critical control points (HACCP)**. HACCP is a risk management program that can be applied to many different types of production systems. For example, HACCP is widely used in the food processing industry to identify and control potential sources of food-borne contaminants.

A central idea underpinning HACCP is that prevention of problems is far more cost-effective than mitigating them later on. HACCP requires that the production process is systematically and rigorously examined to identify potential hazards that may affect the final product.

> **A control point is defined as a step in a system where specific procedures can be applied to achieve a defined effect. It must be a step that can be measured, monitored, controlled and corrected (ISPM No. 14, 2002).**

> **A critical control point (CCP) is the best point, step, or procedure at which significant hazards can be prevented or reduced to minimum hazard.**

Once potential hazards and CCPs have been identified, the production process is changed to manage hazards instead of relying on end-point inspection or testing of the final product, which could result in rejection of the product.

The HACCP approach has only recently been applied to plant production systems. A modification of the HACCP approach was used to determine CCPs for contamination by *Phytophthora* spp. in Oregon nurseries (Parke et al., 2008). Guidelines for container and in-ground nursery production systems based on HACCP have been developed in Australia (BioSecure HACCP Guidelines, 2008). These guidelines provide an excellent model for implementing a similar approach in the United States.

A flow chart addresses all the general steps that occur during the nursery plant production process, and detailed tables provide control measures, critical limits, monitoring procedures, corrective actions, and recordkeeping for each step in the process. These guidelines complement and validate the Best Management Practice Guidelines for nurseries that were developed by the Nursery Industry Accreditation Scheme Australia (NIASA). Nurseries in Australia that have NIASA accreditation may become certified by complying with the BioSecure HACCP guidelines and passing an annual audit. For more information, log on to this website:

- **http://www.ngia.com.au/Category?Action=View&Category_id=135**

Grower-Assisted Inspection Program

A practical implementation of the HACCP approach has recently been established on a pilot basis by the Oregon Department of Agriculture. The **Grower-Assisted Inspection Program (GAIP)** engages nursery growers in detecting and preventing the spread of the quarantine pathogen *Phytophthora ramorum* and other foliar *Phytophthora* species.

GAIP participants are required to undergo training and become certified in *Phytophthora* disease management, and to conduct a hazard analysis for their nursery's production and procurement processes based on CCPs identified by scientists at Oregon State University (Parke et al, 2008) and others. Nursery workers can become certified by taking an online course and passing a test offered by the university. Participants also are required to develop a mitigation manual based on best cultural practices. GAIP nurseries undergo regular federally mandated inspections, and their practices are audited by the ODA. Finally, they must implement corrective actions when an audit identifies a non-compliance issue.

Although the efficacy of GAIP in reducing *Phytophthora* disease incidence is still being evaluated, it appears that nurseries are benefitting from implementing best practices that target specific CCPs. More information on GAIP and the online *Phytophthora* course can be found on the Internet:

- http://www.oregon.gov/ODA/PLANT/NURSERY/gaip.shtml
- http://ecampus.oregonstate.edu/phytophthora

A User Guide to this Book

So far, you have read about the pest and disease problems that can cause great expense and inconvenience for nursery growers. You've also familiarized yourself with the systems approach to plant pests and diseases. Hopefully, you have gained a sense of what it means and how it works.

We've told you about several programs in the United States, Australia and Canada where the systems approach is being used with success. The rest of this book is focused on helping you, the nursery professional, successfully adopt a systems approach. By doing this at your nursery, you may be able to grow healthier plants at less expense and with greater profit.

> **By making your nursery less susceptible to the introduction and spread of regulated pests and plant pathogens, you will be able to reduce the risk of quarantines and crop destruction.**

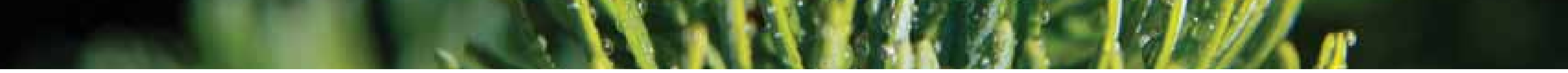
Depending on the systems approach you develop, you may also avoid end-point inspections that can add time and cost to your production processes. The ability to deliver more of your products to market and put less of them in the burn pile is another likely benefit of adopting the systems approach. Over the next several chapters of this book, we will guide you through the process of adopting a systems approach, step by step.

Part I: A Systems Approach Introduction

The four chapters in this section summarize the threat of pests and pathogens, define the systems approach, show you how to make an initial analysis of any growing operation, and offer some thoughts on how to prioritize any operational problems you may discover.

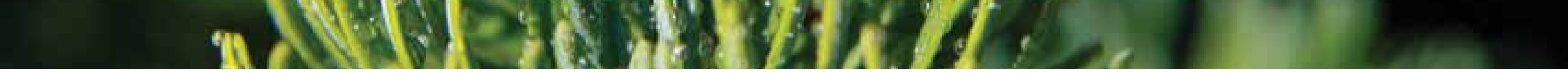
In this chapter, we discussed the overall pest and pathogen challenges that nurseries face and what could happen if we don't meet this challenge. We also talked about the systems approach and why it may be an effective option for many growers.

In this chapter, we further explored how systems approaches work, both in general and in the context of a nursery operation. We talked about key principles, and outlined some programs in various countries that tap into the systems approach for nurseries.



Part II: Voluntary Best Practices for Your Nursery

A systems approach offers practices that can make any nursery safer, more efficient and more profitable. In Part II of this guide, we spend several chapters describing best practices that any nursery can adopt, whether or not it participates in a formal systems approach certification program. These practices address every major aspect of nursery production.



Part III: The Next Step: Systems Approach Certification

In Part II of this systems approach guide, we discussed voluntary measures any nursery can adopt to reduce risks arising from pests and pathogens. Some nurseries may wish to take it a step further by seeking systems approach certification through an accredited program. The what and the how are outlined in Part III. Such programs are voluntary for now, but may be required to export to certain other countries in the near future. The U.S. Department of Agriculture is one agency that offers such certification, and the program is called the U.S. Nursery Certificaton Program (USNCP). In this section, we describe the basic requirements of this program.

Important Note: There is No Silver Bullet

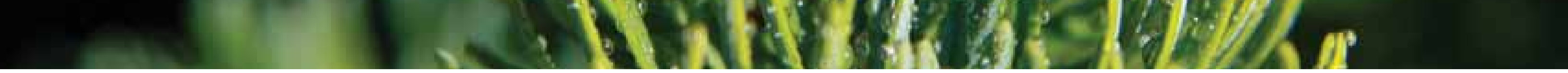
The recommendations in this manual will reduce the risk that your nursery will become infested by emerging pests or pathogens, but we recognize that nurseries may be vulnerable to new threats we cannot anticipate.

> **It's impossible to devise a single set of critical control points, or best practices, that would prevent all pests and pathogens in the entire nursery industry.**

Each nursery is unique. Growers use many different production and procurement practices. They produce many different plants that could host pests or pathogens, depending on the location and climate. And, each nursery is located in a unique environment with a unique layout. Therefore …

> **To create an effective set of voluntary best practices and critical control points, each nursery operation must evaluate its own unique risks.**

That said, many nurseries will be helped by the best practices that are detailed in this guide.



A thorough analysis of any nursery site will help identify areas of greatest risk and ways to reduce that risk. The goal is not perfection, but risk reduction.

Chapter 3: Analyzing Your Site

We've written this chapter to help you look objectively at your nursery production system from start to finish. Some of these questions are tough, and a few might reveal areas of risk that you were never aware existed. However, we believe the benefits of this process will far exceed any time, expense or discomfort.

This chapter contains a series of checklists to help you analyze every aspect of your nursery and determine where it is most vulnerable to contamination by pests and diseases. Simply go through the checklists and mark your answers — yes or no.

> **Each time you answer "no," it indicates a potential area of risk for your nursery. These areas of risk may make your nursery more susceptible to an infestation or an epidemic that could prove expensive, or perhaps even cause an economic catastrophe.**

But don't panic! Later on in this book, we'll provide you with detailed best practices that will help you reduce or eliminate the risks.

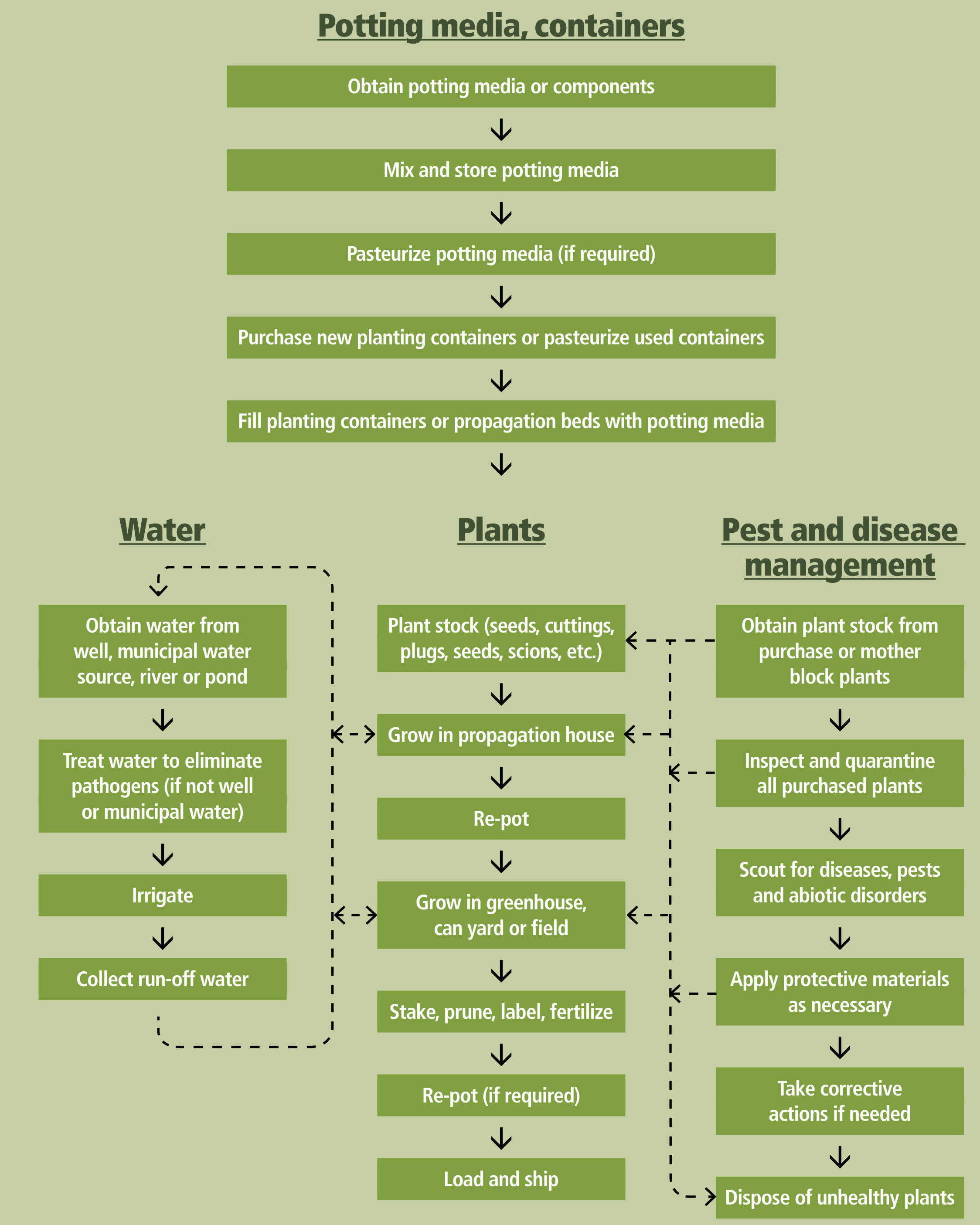
Creating a Flow Chart

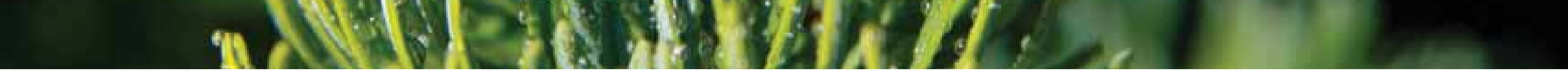
Before we begin, it may help you to create a simple production flow chart for your nursery. This will help you think about how plant materials move through your nursery and every step in your production process. Figure 3.1 (on the next page) shows an example of a production flow chart for a container nursery. If you have a different type of nursery, or even the same type of nursery, your production processes may be quite different.

Once that's completed, let's proceed to the checklists. Answer each question "yes" or "no," and remember: each "yes" answer is good, and each "no" answer indicates possible risk.

Figure 3.1

An example of a simple production flow chart for a container nursery. Each step in the process should be evaluated for its potential to introduce pests and pathogens.

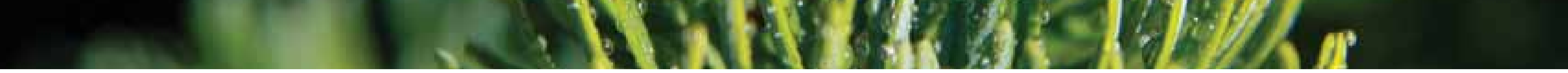




3.1. Site selection, preparation, and maintenance

First, let's examine your nursery site itself. It's important to consider if your site is built, designed and maintained to prevent the introduction and establishment of pests and pathogens. To answer that question, we'll be considering some things you might not normally think about — things such as the vegetation surrounding your site, and the roads that are crisscrossing your property. As you assess your property, you may want to walk the perimeter of your property and take notes.

	YES	NO
Is your site isolated from known or likely sources of pests and pathogens, such as forests, residential landscapes, woodlots and abandoned or poorly managed orchards and nurseries?	❑	❑
Is your site well drained? *If your site has standing water or puddles — even after significant, prolonged rainfall — then you must answer "no."*	❑	❑
Are your roads and pathways paved, graveled or rocked?	❑	❑
Are you diverting soil and water movement from adjacent properties to prevent contamination of your nursery?	❑	❑
If there are known pest and disease hosts established in your nursery's landscape, have you either removed them or do you regularly monitor them for the presence of pests and pathogens?	❑	❑
It's a fact that weeds may harbor pests and pathogens. Do you keep weeds under control?	❑	❑
Is the vegetation on properties adjacent to your nursery regularly inspected?	❑	❑
Do you make sure that native soil is never moved between different sites or greenhouses within your overall nursery operation?	❑	❑
Do you make sure unsanitized tools, equipment, vehicles, hands/gloves and shoes/boots are never moved between different sites or greenhouses within your overall nursery operation?	❑	❑
Do you have effective control systems in place to manage mammals that could be potential disease vectors, such as mice, voles, rabbits, squirrels and deer?	❑	❑



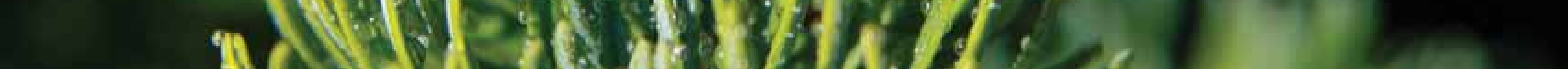
3.2. Water management

Irrigation is essential for nearly every nursery operation. But even if your plants rely solely on rain water, you still must consider what happens to that water after it hits the ground. It is all a part of water management, which is an area of considerable risk when it comes to the transmission of certain pests and pathogens.

	YES	NO
Does your irrigation water come from a municipal source or deep well? *If you answered "yes," you may skip the next two questions. If you answered "no," your answers to the next two questions will determine whether your nursery has risks related to water supply.*	❑	❑
If your water is from a surface source, such as a pond, river or recycled water, do you test it monthly using an approved method to make sure it is free of all species of *Phytophthora*? *If you answered "yes," you may skip the next question. If you answered "no," your answer to the next questions will determine whether you have risk.*	❑	❑
If your water is from a surface source, do you disinfest it using a proven and effective method? *Hint: In **Chapter 8** of this guide, **Table 8.3.2** outlines several of the methods that are effective and accepted. They include treatment with oxidizing agents, ultraviolet (UV) radiation, copper ionization, and slow sand filtration.*	❑	❑
Do you schedule your irrigation in a way that avoids overwatering, and keeps leaf wetness to a minimum?	❑	❑
Do you group plants with similar irrigation needs together?	❑	❑
Do you identify plants that are highly susceptible to foliar pathogen infections and water them with drip irrigation rather than with sprinklers?	❑	❑
Is your site well-drained?	❑	❑
Do you make sure that runoff water cannot flow through plant production areas, or is managed to avoid contact with crops?	❑	❑
Do you recapture runoff water, and subsequently treat or filter it to prevent the spread of pathogens?	❑	❑

3.3. Plant procurement

When it comes to preventing the introduction of plant pests and pathogens, it matters where you obtain your plant material. Using untested or unsafe plant sources is one major area of risk. Failing to take the proper precautions is another rather large area of risk. And even when material arrives from trusted sources, it's still important to inspect all arriving material — and even the trucks it arrived in — and take steps to prevent cross contamination. After all, it's easier to deal with diseases and pests before they get a chance to infest your nursery.



	YES	NO
Do you make sure that wild-collected foreign plant material is never brought in to the nursery directly?	❑	❑
Do you take preventive measures to avoid disease transmission when importing cultivated foreign plant material? *Hint: **Chapter 5, Section 2** lists several precautions that should be taken.*	❑	❑
Do you take preventive measures to avoid disease transmission when bringing wild-gathered domestic plant material into the nursery? *Hint: **Chapter 5, Section 3** lists several precautions that should be taken*	❑	❑
When you purchase plant material ("buy-ins") from domestic sources, do you make sure that the nursery is licensed and/or certified according to all applicable phytosanitary laws and regulations?	❑	❑
Do you reject all free "trial" plants that were not requested?	❑	❑
Do you or your staff members inspect all buy-in material at the originating nursery the growing season before they are brought in?	❑	❑
Do you inspect arriving delivery trucks and deny entry to those that are dirty or contaminated with soil?	❑	❑
Do you make sure that that arriving loads from multiple producers are not commingled?	❑	❑
Does your nursery visually inspect all incoming stock for pest and disease symptoms prior to introducing them into your nursery facility?	❑	❑
Do you refuse all shipments that contain plants with pest or disease symptoms?	❑	❑
Does your nursery off-load incoming plant shipments in an area that can be cleaned of leafy debris?	❑	❑
Are the delivery trucks loading or unloading at your nursery properly cleaned between shipments, including the removal of mud or soil from the truck body and tires?	❑	❑
Does your nursery collect plant debris from delivery trucks and dispose of it properly? *Hint: Proper disposal means burning, double bagging, deep burial or steam sterilization.*	❑	❑
Does your nursery segregate incoming plants away from existing nursery stock for at least 60 days and scout the incoming stock for pests and pathogens?	❑	❑
Do you leave a portion of incoming plants untreated by pesticides, so that disease symptoms and pest infestations still can be visualized? *Hint: Ten percent of arriving stock is a recommended portion to set aside.*	❑	❑
Does your nursery quickly treat, remove or destroy all infested or diseased plants, as appropriate?	❑	❑
Does your nursery keep records of all treatments that are applied to infested or diseased plants?	❑	❑
Does your nursery refuse return shipments of nursery stock that was delivered to other sites previously?	❑	❑

3.4. Plant propagation

Nurseries use various methods to propagate plants, such as grafting, budding, tissue culture, rooting cuttings, or growing the material from seed. No matter which propagation method is used, however, nurseries can adopt practices that will minimize risks from pests and diseases. Are you following safe propagation practices? Answer these questions and find out.

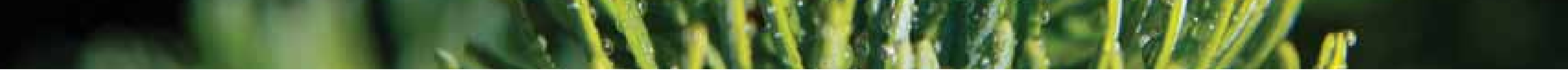
	YES	NO
Does your nursery propagate nursery stock only using materials that were obtained on site from healthy plants?	❑	❑
Does your nursery record the sources of propagative material used at your nursery?	❑	❑
Is your nursery's propagation area isolated from the rest of your production facility?	❑	❑
Does your nursery restrict access to its propagation area so that only necessary personnel are admitted?	❑	❑
Does your nursery make sure that the propagation area is kept free of weeds, moss, liverwort, plant debris and insects?	❑	❑
Are plant propagators at your nursery always required to wear clean clothes, clean footwear, and disposable gloves that are changed between lots?	❑	❑
Does your nursery require that all sorting areas, cutting benches, cutting surfaces and benches are properly disinfested between lots to minimize the introduction or spread of pathogens?	❑	❑
Does your nursery reduce pathogen and pest problems by maintaining proper control of the propagation environment, as outlined below?		
a. Is proper air movement, humidity and temperature always maintained?	❑	❑
b. Is proper irrigation and drainage always maintained?	❑	❑
c. Are periods of leaf wetness minimized?	❑	❑
Are weeds, including moss and algae, removed from propagation trays or beds?	❑	❑
Does your nursery make sure that propagation trays or containers are placed only on clean surfaces, to prevent contamination from soil or old rooting media?	❑	❑
Does your nursery make sure that water used to irrigate propagative material is free from water-borne pathogens?	❑	❑
Does your nursery make sure that watering wands and hose ends never come in contact with the greenhouse floor or any substrate?	❑	❑
Does your nursery make sure that contaminated hose ends and wands are immediately disinfested and properly stored to prevent them from becoming contaminated?	❑	❑
Are the propagation areas at your nursery scouted at least once a week for pests and pathogens, and do you keep records of everything that's observed?	❑	❑
Does your nursery remove or destroy any infested or diseased plants that are found in the propagation area, or treat them as appropriate?	❑	❑
Does your nursery keep records of all treatments undertaken as a result of finding infested or diseased plants in the propagation area?	❑	❑

Are you removing dead leaves and other debris from greenhouses and other production and propagation areas between crops? Dead material can provide a pathway for transmission of certain pathogens.

3.5. Greenhouses

In addition to the areas outlined previously, greenhouses are yet another area of vulnerability where pests and diseases can be introduced to your nursery. Fortunately, there are good sanitation practices that nurseries can follow. Is your nursery following them? Answer the questions below and find out.

	YES	NO
Are the greenhouses at your nursery properly screened to keep insects out?	❑	❑
Do your greenhouses have a double door entry?	❑	❑
Does your nursery have footbaths available in all greenhouses?	❑	❑
For footbaths, are the disinfectant solutions changed frequently, and are treatment times always observed?	❑	❑
Are the greenhouses at your nursery thoroughly cleaned and disinfested between crops?	❑	❑
Are nursery personnel who have been working in the field required to wash hands and change footwear and clothing prior to entering the greenhouses?	❑	❑
Are your greenhouses always kept free of weeds, mosses, liverworts, insects, spilled planting media and plant debris?	❑	❑
Do you make sure that containers are only placed on clean, well draining surfaces, such as raised benches or gravel beds, so as to prevent splash contamination from soil?	❑	❑
Does your nursery make sure that leafy debris is never allowed to build up on the greenhouse floor?	❑	❑
Does your nursery regularly scout its greenhouses for pests and diseases, and do you maintain records of everything observed?	❑	❑
Does your nursery remove or destroy any infested or diseased plants that are found in greenhouses, or treat them as appropriate?	❑	❑
Does your nursery keep records of all treatments that are undertaken as a result of finding infested or diseased plants in greenhouses?	❑	❑



3.6. Field production areas

Does your nursery use pot-in-pot production, or plant material directly in the ground? Field production areas are another location in your nursery where introduced pathogens and pests, left unchecked, can spread quickly to additional plants. Are you following safe practices that will prevent problems from manifesting themselves? If problems develop, does your nursery stop them from becoming more serious?

	YES	NO
Does your nursery keep the soil used for in-field or pot-in-pot propagation free of pests, pathogens and plant-parasitic nematodes?	❑	❑
Does your nursery remove leafy debris from plant production areas between crops?	❑	❑
Does your nursery refill the holes left by removed plants with soil, so that the holes will not retain water?	❑	❑
Does your nursery make sure that field equipment is not moved from infested fields to clean fields?	❑	❑
Does your nursery regularly scout its field production areas and keep records of all significant observations?	❑	❑
Does your nursery remove or destroy any infested or diseased plants that are found in field production areas, or treat them as appropriate?	❑	❑
Does your nursery keep records of all treatments that are undertaken as a result of finding infested or diseased plants in the field?	❑	❑

3.7. Potting media and containers

When it comes to disease prevention, there are certain advantages inherent to producing each plant or tree in its own individual container. However, container production also carries risks that are associated with growing media and with containers. As one might expect, used containers are particularly risky. However, there are easy steps that can be taken to minimize even those risks. Is your container nursery following safe practices?

	YES	NO
Is all the growing media used in your nursery free of pests and pathogens?	❑	❑
Does your nursery either disinfest all used containers and trays before re-use, or use new containers and trays exclusively?	❑	❑
Does your nursery store all planting media and containers in an area that's kept free of potential contamination from dust, soil, weed seeds, water run-off and vehicles?	❑	❑
Does your nursery make sure that equipment used to handle planting media is always kept clean and disinfected?	❑	❑
Does your nursery always clean and disinfect its media bays between lots?	❑	❑

3.8. Container yards

We aren't done talking about disease risks associated with container production. We've discussed the growing media and the containers themselves — now it's time to move out to the can yard and check conditions there. Is your nursery doing what it takes to keep all the plants in your container yard healthy?

	YES	NO
Does your nursery reduce the potential dispersal of pests and pathogens by creating breaks between blocks of plants?	❑	❑
Does your crew regularly remove accumulated leafy debris from production areas between each production cycle?	❑	❑
Does your nursery have a barrier between the soil and your containers, so that potential pathogens on the ground can't be splashed into your containers? *Hint: Sufficient barriers could include raised beds, gravel, or a layer of rock. Mesh is also acceptable, subject to conditions (see next question).*	❑	❑
If your nursery uses a mesh barrier, does your nursery keep the mesh surface free of weeds, soil and leafy debris, and is good drainage always maintained?	❑	❑
Are your container yards scouted regularly for plant health, and does your nursery maintain a record of all significant observations?	❑	❑
Does your nursery treat, remove or destroy any infested or diseased plants that are found in the can yard?	❑	❑
Does your nursery keep records of all treatments that are undertaken as a result of finding infested or diseased plants in container production areas?	❑	❑

3.9. Cull piles

Your nursery has worked hard to earn respect from your customers and the industry as a whole. That respect comes from making sure that only quality products make it off of your loading dock. Unfortunately, not every plant or tree comes out perfect. Some are destined for compost or the burn pile. For these malformed or unhealthy plants, it's the end of the line. But before these plants are disposed of, they can make your life miserable. Are you doing what you can to prevent your cull pile from becoming a source of pests and pathogens? Ask yourself these questions.

	YES	NO
Are the cull piles at your nursery located away from media components, media mixing areas and growing beds? *An ideal location would be at the edge of your property, and downwind from the prevailing storm direction.*	❑	❑
Is the runoff from your cull piles directed away from media components, media mixing areas, growing beds, and waterways?	❑	❑
Does your nursery remove or destroy any infested or diseased plants that are found in field production areas?	❑	❑
Are your cull piles frequently incinerated, buried or properly composted?	❑	❑

3.10. Training

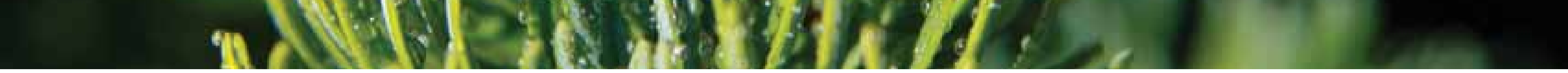
It takes a team effort to run any nursery of significant size. Team members must learn, buy into and follow the nursery's operating procedures, or the operation won't succeed. The same is true of managing risks nurseries might encounter due to pests and pathogens. It does no good to adopt best practices if the employees aren't taught how to follow them. Are you training your employees to look out for your nursery and your plants?

	YES	NO
Have you trained at least two staff members at your nursery in systems approaches, pest management and best management practices? *Hint: Training two employees, rather than one, provides backup when one employee is sick, on vacation or otherwise not available.*	❑	❑
Are your employees trained to implement the best practices that have been adopted at your nursery?	❑	❑
Are your employees trained to implement the pest management plan or standard operating procedures for pest control your nursery has adopted?	❑	❑
Do your employees undergo sufficient training to be able to recognize and report common pests and pathogens, as well as key quarantine pests and pathogens?	❑	❑
Does your nursery submit unusual or unrecognized pests and pathogens to a diagnostic lab for identification?	❑	❑
Are your employees trained to keep records of every time mitigation procedures are used to treat a pest or pathogen problem?	❑	❑

3.11. Scouting

In the above sections we've made reference to the practice of scouting for pests and diseases throughout the grounds of your nursery and along the property line. It's an important practice for preventing the spread of pests and disease from adjacent properties to yours, or from your property to others. Now we will address sound scouting practices for your nursery stock in more detail.

	YES	NO
Are the plants at your nursery inspected for pests and diseases at scheduled intervals frequent enough to prevent or manage outbreaks? *For known pests and pathogens, scouting is scheduled according to predicted emergence dates and/or key life cycle event.*	❑	❑
Does your nursery scout for pests and diseases throughout the year, and more frequently during periods of rapid plant growth?	❑	❑
Does your nursery take corrective action if pests and diseases are found?	❑	❑
Are all inspections and all corrective actions documented?	❑	❑
Are your crew members that are assigned scouting duties trained to recognize and report common pests and pathogens as well as key quarantine pests and pathogens?	❑	❑
Are all unusual or unrecognized pests and diseases submitted to a diagnostic lab for identification?	❑	❑



3.12. Biosecurity

No one likes to think that visitors or employees could unwittingly introduce plant pathogens or pests into your nursery, either on their person or their vehicle. However, the risk does exist, and it's magnified if people behave carelessly. The good news is that any risk to your nursery can be minimized through the use of sound biosecurity policies. Are you taking the necessary steps? Answer these questions and find out.

	YES	NO
Does your nursery require all employees who may have visited areas with pest and disease problems to wash and sanitize their shoes, tools and vehicles before entering the nursery?	❑	❑
Is your property signed and fenced to exclude animals, and are gates regularly locked after hours?	❑	❑
Are visitors required to report directly to your office, sign a log book and be escorted by staff while they are on your property?	❑	❑
Are visitors' shoes cleaned and sanitized, or, absent that, are they given clean boots or shoe covers?	❑	❑
Are visitors asked to park in a cleanable space at the edge of the nursery, and are they prohibited from driving on the property with their own vehicle?	❑	❑
Are your staff members prohibited to return to work the same day after visiting another nursery? *Note: In some nurseries, employees may be permitted to return after washing hands and changing shoes and clothing. Showering provides an additional margin of safety. Some nurseries, however, require a 72-hour interval before a return is permitted.*	❑	❑
Are staff vehicles washed before returning to the nursery from another facility?	❑	❑
Are your staff members required to wear clean clothes each day, and clean their footwear to remove all soil and plant debris?	❑	❑

3.13. Recordkeeping

If there is an outbreak of a serious plant pest or pathogen, it is vital that officials be able to trace the problem so that the damage can be minimized and the pest or disease can be eradicated. Nurseries can help by keeping careful records of all plants through every step in the production process. Are you following sound and thorough recordkeeping practices? The following questions will help you make that determination.

	YES	NO
Can the plants processed or produced at your nursery be traced back and forward through the production process?	❑	❑
Do your records identify the product, source, lot number, when inspected, treatments received and the purchaser?	❑	❑
Are the above records maintained for at least two years?	❑	❑
Does your nursery have a tracking system for the movement of plants within the nursery, starting when plants are bought in or propagated, and ending when the plants are sold and shipped?	❑	❑
Does your nursery have a manual of best practices to be implemented, based on the nursery's specific production systems, location, nursery type, climatic conditions and plants produced? *Hint: The manual should list all standard operating procedures, the responsibilities of staff members, the procedures used for training staff and the documentation of all of these components.*	❑	❑
Does your nursery have a manual of pest management practices to be implemented, based on the nursery's specific production systems, location, nursery type, climatic conditions and plants produced? *Hint: The manual should list all standard operating procedures, the responsibilities of staff members, the procedures used for training staff and the documentation of all of these components.*	❑	❑
Does your nursery keep detailed records of all procedures used during the production process, who conducted the procedures, and when they occurred?	❑	❑
Does your nursery conduct internal audits to ensure that staff members comply with all requirements for scouting, training, treatment and recordkeeping?	❑	❑

Inspection Complete!

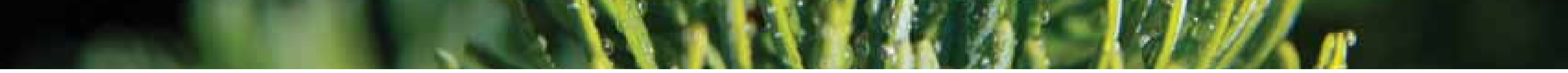
Congratulations are in order. You have completed a rather grueling analysis of your nursery site and processes. You may have learned some things you didn't want to know. Be that as it may, this site and production analysis was an important first step toward adopting a systems approach, and that will save you time, toil and trouble in the long run.

So, what's next? In **Chapters 5–11**, we will go into more detail about each area of production that was covered in your inspection. Each chapter will talk about one aspect of production. For example, **Chapter 5** talks about plant procurement and **Chapter 6** will cover propagation. Subsequent chapters talk about growing media, irrigation, infrastructure, how you identify pests, and how you deal with them when they are found.

In these chapters, we will discuss best practices to make your nursery as safe against pests and diseases as it can be. You may already be following some of the practices listed. Many are just common sense. Other practices may be new to you. Regardless, all of these practices can help you make your nursery safer than it already is. But what if you can't follow every single best practice listed? Don't worry.

> **The goal of a systems approach is not perfection, but significant risk reduction. The idea is to make things better and safer.**

You can experience success in that regard by thinking strategically and choosing the improvements that will make the most difference. That's where the next chapter — **Chapter 4** — comes in. We'll talk about how to prioritize the issues you identified in your site analysis.



Nursery owners can reduce the pest and pathogen risks in their nurseries by deciding which of their identified risks to address first. Such efforts are most likely to succeed when management makes risk reduction a part of the nursery's culture.

Chapter 4: Taking Control

The conversion to a systems approach may seem challenging, but the benefits can be numerous:

- significantly lower risks from pest and pathogen introductions, including quarantine organisms,
- lesser need for chemical control and lower costs,
- fewer losses due to pests and pathogens,
- greater productivity with less down time, and
- better customer confidence in the health of the product.

Taken together, these benefits can contribute significantly to your bottom line.

In the previous chapter, you completed your site analysis and identified areas of risk. Now, you can take rational and deliberate steps towards adopting a systems approach. If your effort is to be successful, **it is vitally important that nursery management make a commitment to this process.**

> **The systems approach is both a philosophy and a set of production and procurement practices. You should make it part of the business culture at your facility.**

Moreover, the management must provide adequate resources and staffing for the program. Depending upon current practices, you might even want to consider amending your mission statement, changing any supporting documents and policies, and/or modifying your business plan.

Will your conversion to a systems approach be easy, or difficult? That depends on many factors. We talked about the **United States Nursery Certification Program (USNCP)** in **Chapter 2**. Some of the first nurseries that pursued certification through this program found that they had to make relatively few changes to the site and operating procedures. Others found that significant changes were necessary.

Nurseries have had to develop an inventory tracking system, and/or hire outside consultants to train staff and help devise a custom system approach manual for their facility. Facilities that have numerous or significant deficiencies may not be able to adopt a systems approach due to a lack of capital.

> **It's essential that nurseries intending to adopt the systems approach either have adequately skilled and trained staff, or be able to hire consultants to provide training.**

Nurseries can be relatively simple operations, or extremely complex entities with multiple types of production, thousands of products, hundreds of employees, and multiple sites. Given this range of complexity, it is not realistic to fashion a single set of priorities. However, some basic priorities do apply to all facilities and are listed below. How one ranks the priorities will be based on the specific nature of the issue and its interaction with other processes and components of the facility.

> **Generally speaking, actions that provide the greatest overall impact in terms of plant health to the largest number of plants should receive high priority.**

Practices that decrease the risk of introducing known quarantine pests and pathogens should also receive high priority.

Priority Areas

Staff training: It will be necessary to have staff trained in systems approaches to carry out the program successfully. Staff members need to understand the overall goal of the program, and they must have sufficient knowledge to perform their respective duties in the program. For example, scouts should be able to recognize and report pests and pathogens, or alert their supervisor if they are unsure. Scouts need to know that they have an important function, and that the program can suffer if they fail to provide due diligence.

> **Ideally, a nursery should designate at least two employees or members of management/ownership to administer its systems approach program.**

The first should be in charge of the overall program. The other should carry out the technical aspects, such as scouting, treatment and training. By having two staff members cross-trained in each other's program duties, the nursery will have back-up for the supervisory and technical functions. This will allow the program to keep going in the event that one of the persons is temporarily or permanently absent due to business travel, vacation, reassignment or other reason.

Siting and infrastructure: The nursery facility needs to have the physical characteristics of proper siting. These include good drainage, adequate biosecurity, proper irrigation systems, and freedom from soil-borne pathogens. Chapter 6, Chapter 7, Chapter 8 and Chapter 9 discuss these elements in detail. For existing facilities, one should prioritize facility maintenance to mitigate issues such as standing water, soil-to-pot contact, soil-to-media contact, sealing roadways and proper storage of inputs, among other site conditions.

Official audits add to the veracity of the systems approach.

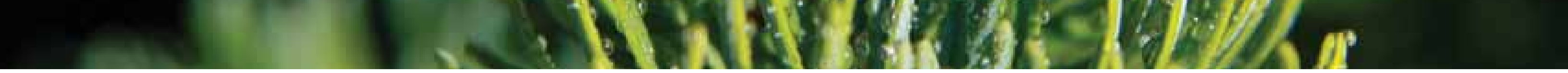
Sourcing material: Nurseries should also prioritize the principle of exclusion, which means "keeping pests out." New buy-in material, as detailed in **Chapter 5**, is a primary way new pests and pathogens could enter your facility. It's becoming more common for nurseries to self-propagate. This is especially true for plants highly susceptible to infection by quarantine organisms, such as *Phytophthora ramorum*.

Critical control points (CCPs): We first discussed critical control points in **Chapter 2**, and there will be further discussion in later chapters.

> **Scientists have only identified a few CCPs to date. Nonetheless, they should be prioritized in any nursery operation.**

This is because CCPs are nursery production steps that must be addressed to exclude or control pests to an acceptable level. For example, nurseries that irrigate from retention ponds must make sure they have an effective water treatment system in place. Further, the treatment equipment must be well maintained and closely monitored. Untreated or poorly treated irrigation water can potentially be large-scale source of infection.

Integrated pest management (IPM): When the mitigation methods that are in place aren't enough to keep out or reduce pests and pathogens, a nursery should keep them under control using an integrated pest management (IPM) program or other similar program. As defined by the U.S. Environmental



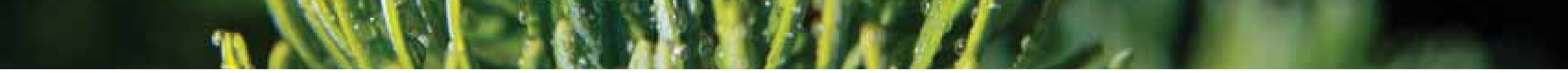
Protection Agency (EPA), IPM taps into knowledge of pests and their life cycles, as well as available control methods, to manage the damage these pests cause at the lowest cost, and with the least hazard to people, property and the environment.

Documentation and recordkeeping: A nursery following the systems approach must properly document all processes and procedures, including inventory tracking, inspections and treatments. This documentation is critical to proper phytosanitary management. Begin by writing down the standard operating procedures that staff must follow. Then, keep careful records showing who did what, when they did it, and where. When and if problems develop, a nursery can then rely on these records to trace what happened and why.

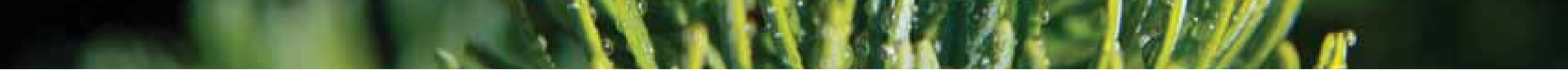
Internal and external audits: A nursery can make its systems approach program more robust, and therefore more reliable, by installing an effective internal auditing system. To make it effective, staff members should not audit areas for which they are directly responsible. Furthermore, the overall program should be audited by a neutral third party.

Conclusion

In **Chapter 3**, we analyzed your nursery and identified any areas of risk that might exist there. Here in **Chapter 4**, we've talked about several priority areas of risk that most nurseries will want to deal with first. Next up, we will explore the various aspects of nursery production, and the best practices nurseries can adopt to lessen their risks or mitigate any problems that become apparent.



Part II: Voluntary Best Practices for Your Nursery



The nursery trade includes a wonderful variety of plant selections found all over the world, such as these Japanese maples. However, one must take precautions when procuring plant material, so new threats are not introduced into the nursery.

Chapter 5: Plant Production: Procurement

As previously discussed, pests and pathogens can make their way into a nursery by riding aboard incoming plant material. To avoid bringing in unwanted problems, nurseries should practice due diligence when they procure plant material.

Generally, the risk associated with bringing in a new pest is proportional to the number of incoming shipments and the volume of material. Certain plant genera are also more prone to infection or contamination by specific pests and pathogens.

To reduce these risks, some growers are propagating more plants on site and greatly limiting new introductions to their facilities. Risks can also be decreased by implementing the best practices listed below.

A Word About 'Best Practices'

From time to time in literature, you may see reference made to **best management practices (BMPs)** or **best plant protection practices (BPPPs)**. There is a difference between the two. BMPs are processes and actions based on the best available science that provide the most cost-effective and efficacious way to address an issue, such as preventing or reducing pest and pathogen problems. By definition, BMPs are always the most cost-effective method available. If the method is not the most cost-effective, or no cost analysis has been done, it is just a best plant protection practice (BPPP).

In this manual, to keep things simple, we will simply use the term "best practices."

We have divided these best practices into sections based on the potential source of the plant material (and of the unwanted regulated organisms that may come along for the ride). These best practices are not necessarily unique to those sections, however. Some of the practices are useful in a broader context. Nurseries that select best practices from different sections may benefit from additional risk reduction. For example, best practices **5.1.3**, **5.2.1**, **5.3.2** and **5.4.4** are broadly applicable, and would provide a very high level of risk reduction.

A Baseline Level of Safety

Before we get started on these best practices, all nurseries should establish a baseline level of safety by following all of the USDA rules on plant importation. Visit the USDA's website, currently:

- **www.aphis.usda.gov/plant_health/permits/plantproducts.shtml**, and
- **www.aphis.usda.gov/import_export/plants/plant_imports/Q37_nappra.shtml**

or contact your local USDA Animal and Plant Health Inspection Service (APHIS) office and talk to Plant Protection and Quarantine (PPQ) program officials.

> **Importers should be aware that at this writing, officials are making major revisions to federal nursery stock importation rules. These revisions could significantly impact the importation of plants.**

Additionally, some states have reporting requirements for growers who bring in plant from other locales. Contact your state nursery inspector for details prior to bringing in material.

5.1. Wild-collected exotic plant material

Nurseries can generate excitement by increasing the spectrum of plants offered. One of the best ways to do that is to introduce exotic plant material that's been collected in the wild. Some growers specialize in this. They travel abroad, looking for new exotic plants that will turn heads and potentially turn a healthy profit.

However, as stated in **Chapter 1** and **Chapter 2**, such new material can serve as a pathway for dangerous plant pests and pathogens. In addition, these plants occasionally can become invasive species themselves when introduced into new environments. Freed from control by their normal competitors and herbivores, they can spread unabated, displacing natives in the process.

While port inspections by the USDA and the U.S. Department of Homeland Security (DHS) can spot many problems on declared material, some problems can go undetected. Plants may be infected by viruses without showing any symptoms. Smaller organisms, such as mites and nematodes, may not be visible, especially if they are present only as eggs. And finally, organisms that are benign in their country of origin can become significant pests or pathogens when introduced to new hosts in the receiving country.

Collectors should avoid importing wild-collected plant material into their operations. Newly acquired non-commercial material should not be brought directly into production in the United States. If possible, that material should be grown-on in the exporting county and inspected and tested by a USDA-approved entity prior to shipment. If such a facility is not available, then the material, if permitted, should be brought to an approved facility in the U.S., grown-on and inspected and tested under the

It's a good idea to report unusual plant symptoms you find to your nursery inspector. Early detection will help you minimize the spread of any pests or pathogens at your facility.

supervision of a USDA-accredited party. Be prepared to lose access to the material if a significant pest or pathogen is found.

BEST PRACTICES:

5.1.1. Use domestic sources first. Find out if the material is already present in the U.S. If it is present and available, it is not necessary to risk another importation. Gaining access to domestic sources can save significant time and money, while reducing risk.

5.1.2. If you must import, grow out the material first. Locate an officially accredited or certified nursery in the exporting country and arrange for a grow-out, inspection and testing evaluation prior to importation. If this is not available, arrange for such an evaluation at an accredited facility in the U.S. prior to plant increase. The imported plant material should be grown out for at least one year or one growing season. Be sure to get and maintain official documentation from the regulatory agency that provided the evaluation. Follow the best practices listed in 5.2 (below).

5.1.3. Consider meristem-tip culture. Use meristem-tip culture (MTC) (see Chapter 6, Page 45) if the plant material can be cultured *in vitro*. This will eliminate pests and greatly reduce any pathogens that are present. This could be a viable alternative to 5.1.2.

5.1.4. Keep thorough records. Be able to identify and track all of this material and any progeny material derived from this material.

5.1.5. Identify and report problems. Make note of any unusual symptoms or potentially exotic pests or pathogens on imported material, and report them to your nursery inspector.

5.2. Foreign-produced plant material

Nursery material produced in other countries can provide access to new cultivars, materials of a size or age not available domestically or material that is less costly than domestic material. Foreign material can be grown safely and protected from unwanted pests and pathogens. There are significant risks, however. Pest interception records indicate that 9.8 percent of all plant shipments imported into the U.S. between 2003–2010 harbored pests or pathogens (K. Britton, U.S. Forest Service, personal communication).

BEST PRACTICES:

5.2.1. Use safer sources. Buy plant material only from nurseries that are officially accredited or certified in their exporting country, and then follow Best Practice 5.1.2 above. If possible, purchase plant material from nurseries that use a systems approach production method, and are accredited by the country of origin's plant protection organization.

5.2.2. Watch for problems. Import a small amount of material and isolate it in a secured facility, such as a restricted-access or self-contained screened greenhouse. Observe the material for a growing season or a year, and make increases from it only if the material remains healthy.

5.2.3. Prevent hitchhikers. If possible, import only material that is leafless, rootless and free of planting media. This will reduce the chance of hitchhikers and soil-borne pests and pathogens. If the material can be cultured in vitro, meristem-tip culture (MTC) will eliminate pests and greatly reduce any pathogens that are present. Thermotherapy and chemotherapy can reduce or eliminate many plant viruses.

5.2.4. Inspect incoming loads. Thoroughly check over any buy-ins upon arrival and before unloading. Reject loads that contain infected or infested plants. Also, inspect the packing material and the inside of the van for hitchhikers such as slugs, snails, ants, and any other pests. Inform your nursery inspector if you detect any hitchhikers.

5.2.5. Keep thorough records. Be able to identify and track all of this material and any progeny material derived from this material.

5.2.6. Identify and report problems. Watch for any unusual symptoms or potentially exotic pests or pathogens on imported material, and report them to your nursery inspector.

5.3. Wild-collected domestic plant material

While not as risky as its exotic counterpart, wild-collected domestic plant material can be a source of new, undescribed pests and pathogens. As these would be domestic-origin organisms, they would not likely trigger a federal reaction. They could, however, cause a regional, state or international quarantine response.

BEST PRACTICES:

5.3.1. Set material aside and observe. Collect a small amount of material and isolate it in a secured facility, such as a restricted-access, self-contained, screened greenhouse. Keep a close watch on the material for a growing season or a year, and make increases from it only if the material remains healthy.

5.3.2. Prevent hitchhikers. If possible, collect only soil-free, root-free and leafless material. This will reduce the chance of pests and pathogens sneaking their way into your nursery in the soil or plant material. If the material can be cultured *in vitro*, meristem-tip culture (MTC) will eliminate pests and greatly reduce any pathogens that might be present.

5.3.3. Keep thorough records. Be able to identify and track all of this material and any progeny material derived from this material.

5.3.4. Identify and report problems. Watch for any unusual symptoms or unknown pests or pathogens, and report them to your nursery inspector.

5.4. Domestically-produced plant material

U.S.-produced nursery material caries a lower risk of exotic pests and pathogens. Nonetheless, this material can be a source of regulated organisms and common nursery pests. Quarantined organisms might even be present. Such organisms can cause significant regulatory actions and disrupt shipments.

BEST PRACTICES:

5.4.1. Watch the source. Purchase plant material only from licensed nurseries. If possible, buy from nurseries that produce material under a systems approach method that is accredited by an independent third party. Buy in only a small amount of material, and make increases from that material to meet needs.

5.4.2. Check it out first. Visit the source nursery and inspect the crop you want to acquire during the growing season before you buy it in. Ask to see any available records of when the material was scouted and what treatments were applied, including their rates and dates of application.

5.4.3. Inspect incoming loads. Thoroughly examine any buy-ins upon arrival and before unloading. Reject loads that contain infected or infested plants. Also, inspect the packing material and the inside of the van for hitchhikers such as slugs, snails, ants or other pests.

5.4.4. Set material aside and observe. Segregate all buy-ins and other new plant material. The segregation period should be at least 60 days during the active growth period. When non-active periods are included, the overall interval could be much longer. The segregation area should be isolated from other plant material. One should choose a location that can be readily sanitized if a problem is found. Runoff from the segregation area should not go to retention ponds or other production areas.

5.4.5. Test a portion without treatments. Set aside at least 10 percent of the buy-in material, and withhold it from pest and pathogen treatments for 60 days during the active growth periods. Scout all of those plants weekly for signs or symptoms of pests and pathogens. This treatment-free period will allow any control chemicals on the material to decompose or fall to below suppression thresholds. As a result, symptoms will have a chance to develop, or pests will be able to resume their life cycles and be detected.

5.4.6. Keep new material separate. Do not co-mingle new buy-ins with existing stock until you are confident the buy-ins are pest-free.

5.4.7. Do not accept unsolicited plant material. This material may "slip though" the normal segregation process and thus pose a high risk to the nursery.

5.4.8. If possible, do not accept plant returns. Returns may have become infected at the customer's nursery or job site. If you must accept the returns, follow the recommendations provided in best practices 5.4.3 through 5.4.5.

Conclusion

Plant procurement from outside sources is a significant avenue of risk for nurseries because it can bring in foreign or quarantine diseases and pathogens. That's true whether the material is collected in the wild, or purchased from another provider, either foreign or domestic.

The best practices outlined above are methods of reducing this risk. However, there's another option nurseries can pursue: propagating their own material. The advantages begin, but don't end, with the fact that growers know more about material they propagated themselves.

Still, self-propagation also has its own risks. We will explore those in **Chapter 6**, along with best practices to help reduce them.

Careful cleaning and handling of all propagation surfaces and implements is vital for preventing the spread of pests and pathogens.

Chapter 6: Plant Production: Propagation

Self-propagation of new plants can be a good strategy to protect the nursery from accidental introductions of new pests or pathogens. It can also afford growers the ability to prevent initial plant infestation or infection. This has several benefits:

- reduced chemical use,
- fewer delays in the production cycle,
- less reduction in plant quality, and
- reduced direct loss of plants.

However, proper hygiene is essential to protect propagants from pests or pathogens that are ubiquitous in the environment or that may have gained a foothold in the nursery.

Improper hygiene can lead to poor establishment and growth, delays in crop maturation, higher costs though chemical treatments, crop loss, and infestation of the growing grounds.

Proper hygiene is necessary in all stages of production. Sound practices should be reviewed and adapted as necessary, and these programs need to be well-documented.

Workers need to be trained to not ignore steps or cut corners. Hygiene standard operating procedures should include thorough recordkeeping that details the what, when, where and who. Furthermore, these records should be audited regularly.

While proper hygiene does add material and labor costs, it typically saves the nursery money in the long run. Proper hygiene helps prevent facility contamination, thereby offsetting other costs which typically reduce profitability. The result?

Most nurseries following proper hygiene will achieve substantially improved performance.

6.1. Sourcing propagation material

The advantage of using your own plant material to propagate is that you know more about that plant material than you would with buy-on material. Therefore, the risk of pests and pathogens is less, but it's not non-existent. Growers can give themselves an additional margin of safety by following the steps below.

BEST PRACTICES:

6.1.1. Start with clean material. Take cuttings or collect seeds only from pest- and disease-free material. Inspect source material regularly and thoroughly, and manage it as necessary to keep it healthy and stress-free. Keep detailed records of the source material for all lots and cultivars collected. For plants that are highly susceptible to ubiquitous pathogens, it may be necessary to source from mother plants that are maintained in a restricted-access greenhouse or other site that prevents contamination.

6.1.2. Avoid heat, moisture and stress. Take cuttings early in the morning to reduce stress to the material. Do not allow material to sit in plastic bags in full sun, as the temperature in the bags quickly elevates. Try to avoid taking cuttings on wet and windy days, as many fungal spores and bacteria travel in such rain events.

It is important to clean and sanitize all propagation and production areas between crops. This means any surface that will come in contact with the plants.

6.1.3. Keep propagation areas and instruments sterile. All surfaces that come into contact with the cuttings or seeds should be clean and as sterile as possible. Collection personnel should wear clean clothes and footwear and should not have worked in a potentially contaminated area earlier in the day. Use new bags, tags and markers for collection and identification. Use disposable nitrile exam gloves and change gloves between each cultivar or lot.

6.2. Propagation

Once you have accessed the plant material you will be using to propagate, that material should be taken to a limited-access area where propagation takes place. It's crucial to take preventive steps to keep pests and pathogens out of the propagation area.

BEST PRACTICES:

6.2.1. Keep it safe and secure. The propagation area should be isolated from the rest of the facility. Access should be limited to essential personnel only. Use footbaths at entrances to the propagation area. Change the solution frequently, following the manufacturer's guidelines, to ensure potency. Prior to and after propagation, clean and then sterilize all work surfaces, including benches, walls, floors, trays, dollies, utensils, utensil holders, squirt bottles and other tools and equipment. Do not contaminate the hormone container. Use disposable trays and aliquot hormone for dipping, and replace trays between lots or cultivars.

Access to propagation areas should be kept restricted and signed to prevent unauthorized access.

6.2.2. Prevent contamination. Ensure that workers are clean and have not worked in a contaminated area earlier in the day. Have workers wear disposable nitrile exam gloves. The workers should change gloves between each cultivar or lot. All implements must be cleaned and sterilized between lots or cultivars. Workers should be on the alert for any off-type material. This includes stunted, malformed, mottled, galled or chimeric material, or any material that appears infected with pathogens or infested with insects. Workers should be encouraged to report such material to their supervisor.

6.2.3. Sterilize properly. Consider using a surface sterilant on the plant material to improve the level of sanitation. Dilute solutions of quaternary ammonia or hydrogen peroxide are effective against many surface contaminants. Follow label directions rigorously, as required by the U.S. Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).

How to correctly sterilze implements between lots

❑ **TIP:** ***Be sure that contact time in the sterilant is sufficient.***
A simple swish in old bleach water may lead to contamination problems. Bleach solutions lose effectiveness quickly. Organic matter will inactivate them, and bleach is unstable in solution. Solutions should be changed out regularly to retain their potency. Don't allow sap or plant residue to build up on implements, as this will decrease the ability to disinfect the implements.

❑ **TIP:** ***Lethal heat is another way to sterilize implements.***
Devices such as a flameless loop sterilizer can be used if electricity is available. This will also prevent issues such as worker exposure to potentially hazardous chemicals and hazardous waste disposal.

6.3. Seedling and cutting establishment

You've gathered your propagation material and established a safe, secure and sterile propagation area. It's now time to pay attention to all of the inputs that are needed to turn your seedlings or cuttings into little plants. All of these inputs unwittingly can be disease vectors unless you take the right precautions.

BEST PRACTICES:

6.3.1. Use clean, preferably new, inputs. Use new, sterile, properly stored inputs in the propagation process, including growing media, containers, trays, flats and labels. Avoid re-using inputs that have not been properly cleaned, sterilized and stored. Such inputs are a significant source of pathogen introduction and should be considered unsafe.

6.3.2. Keep thorough records. Maintain paper or electronic documents that show all lot numbers, and the sources of these inputs. Also, keep plant lots separate and uniquely identifiable. In the event of a contamination problem, it will be easier to identify and isolate the problem.

6.3.3. Watch out for problems. Keep the area as clean as possible to prevent potential contamination. Scout the area frequently and identify any contamination issues. Ensure that insects, pathogens, weeds, mosses, algae and liverworts are controlled.

6.3.4. Monitor conditions and adjust as needed. Manage the environment of the propagation area in a way to reduce potential disease problems. Make sure there is adequate air movement and air humidity is kept in the proper range. Keep the root zone at the proper temperature. Avoid over-watering the plant material, and minimize any leaf wetness if possible.

6.4. Growing on

Once your newly propagated plant material is off and growing, it is far from finished. It's vital to keep an eye on your young plants to protect them — and your business — against possible infection.

BEST PRACTICES:

6.4.1. Use clean, and preferably new, inputs. New, sterile, properly stored inputs should always be used in the production process. This includes growing media, containers, tray, flats, and labels. Avoid re-using inputs that have not been properly cleaned, sterilized and stored. These can be a significant source of pathogen introduction.

6.4.2. Keep thorough records. Maintain accurate written or electronic records of all lot numbers, and the sources of these inputs. Also, keep plant lots separate and uniquely identifiable. In the event of a contamination problem, it will be easier to identify and isolate the problem.

6.4.3. Scout and protect. Keep the area as clean as possible to prevent potential contamination. Scout the area frequently and identify any contamination issues. Insure that insects, pathogens, weeds, mosses, algae and liverworts are controlled.

6.4.4. Keep a watch on conditions. Manage the environment of the production area in a way that will reduce potential disease problems. Make sure there is adequate air movement and maintain relative humidity at proper levels, generally below 75 percent. Keep the root zone at the proper temperature. Avoid over-watering the plant material, and minimize leaf wetness.

6.4.5. Practice safe irrigation. Regularly inspect irrigation wands and hose ends, and clean them as necessary. Keep wands and hose ends off of the floor, and sanitize them if they come in contact with potting media or the ground. Install back-flow preventers to make sure drip emitters do not siphon water back into the feed lines and contaminate the equipment. Back-flow preventers should be tested periodically, following the manufacturer's guidelines. Repair leaky pipes, fittings, valves, sprinklers and emitters to prevent moisture accumulations and issues with algae, gnats and pathogens.

Two sterile propagation methods: MTC and STG

❑ **TIP:** ***Meristem-tip tissue culture (MTC) and shoot-tip grafting (STG) are two methods of generating plant material free of pests and pathogens.*** *Both require excising the meristematic growing point and several leaf primordia under sterile conditions. The size of the meristem tip must be small, from 0.1-0.5 mm in length, to avoid the majority of viruses and similar agents. In the case of MTC, the excised tip or explant is grown on in a sterile, agar-based nutrient medium. In the case of STC, the explant is grafted into a compatible, sterile root stock and can be used when an agar-based medium has not been developed for that cultivar. In some cases, thermal therapy must also be applied to these explants to completely rid them of viruses and other agents.*

Using thermal therapy to control pests and pathogens

❑ **TIP:** ***Heat can control a large range of pests and pathogens.*** *Heat can come in the form of hot air, hot water or aerated steam. It can be applied to seeds, tubers, cuttings or finished plants. The duration and amount of heat applied will determine whether it kills or inactivates the pest or pathogen. Many pests and pathogens are inactivated or killed by 120-130 F for 20 minutes or less (Sadhu, 1989).*

❑ **TIP:** ***Take care when using heat.*** *Some plant species and cultivars, however, may not be able to withstand the temperatures and times required to deactivate unwanted organisms. Further, the heat treatment may change the growth habit, flowering or other horticultural characteristics of the plant. To prevent damage, closely follow tables showing the acceptable temperature and duration of treatment for that cultivar and growth stage. It is crucial to properly calibrate the temperature measuring equipment and treat the plant material uniformly and at the proper temperature.*

❑ **TIP:** ***After treatment is done, initiate a cooling-down period.*** *The plant material generally should undergo a quick cool-down treatment, followed by rapid planting or sticking, to cut down on plant mortality.*

6.5. Mitigating infected material

Even with careful selection of incoming or propagative plant materials, pests and pathogens can still be present. This is more likely if one of the following conditions is present:

- the organism is systemic within the host plant or propagule,
- the organism is small and readily hidden within buds or other structures, or
- the organism is largely asymptomatic in the host plant.

Examples would include organisms and agents such as cyclamen mites, *Thrips*, plant parasitic nematodes, and many plant pathogenic viruses, fungi, bacteria and phytoplasmas.

BEST PRACTICES:

6.5.1. Inspect newly propagated material frequently and thoroughly. Look for unthrifty, sick or dying plants. It is very important to determine the cause of the problem so that it can be corrected quickly and efficiently. It is also important to isolate the problem before it spreads to adjacent plants. Usually, removing the affected plants and sanitizing the containers is an effective way to accomplish this.

6.5.2. Consider using sanitation and environmental control to prevent these problems. These methods are generally effective.

6.5.3. If a pest or pathogen problem occurs, use appropriately labeled products and biological control agents to mitigate it, if possible. A good management resource on these agents is the *Pacific Northwest Insect, Weed and Disease Management Handbook* series (see **http://ipmnet.org/plant-disease/index.cfm** for more information).

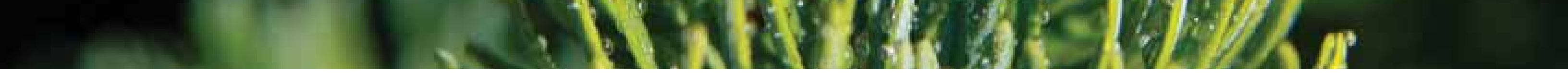
6.5.4. If there are no effective chemical controls for that organism or agent, try other methods. Two prominent mitigation methods are thermal therapy (see sidebar, Page 46) and tissue culture techniques (see sidebar, Page 45).

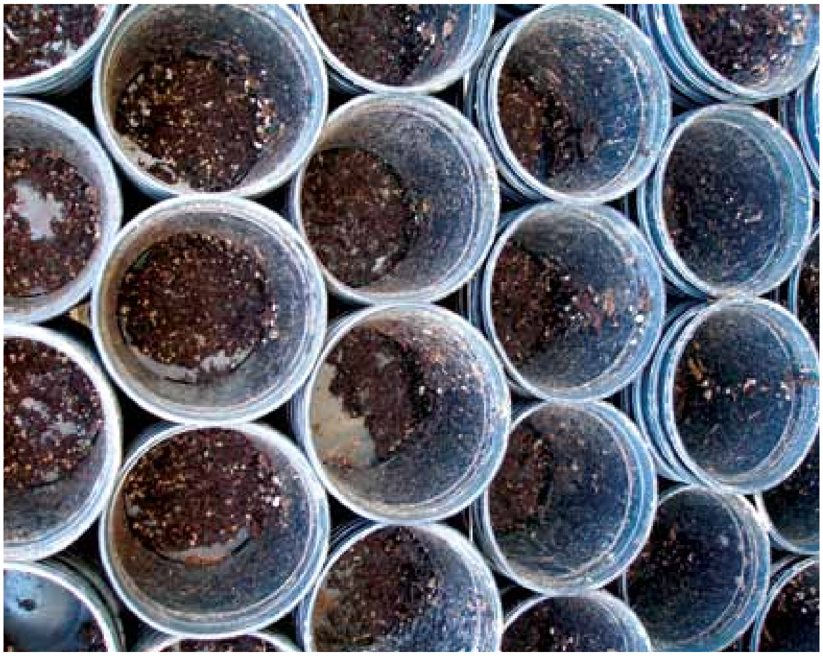
Many other types of tissue culture are employed that do not require small explants excision. These generally rely on bud-on explants that receive some form of pathogen mitigation, such as a sterilant dip and subsequent grow-out to verify treatment efficacy.

Conclusion

In this chapter we have discussed how to protect self-propagated material against infection at all stages of the process, from sourcing, to propagation, to seedling/cutting establishment and finally to growing on. We've also talked about what to do about it when infested material is discovered.

For many nurseries, the next step after propagation is to transplant the material into containers — containers that usually contain a growing media blend that's either created on site, or purchased from a vendor. Like every other stage of nursery production, both the containers and the media can pose pest and pathogen risks. In **Chapter 7**, we'll explore these risks and offer best practices nurseries can use to significantly reduce the risks.





Recycling and reuse are good, but pathogens should not be allowed to come along for the ride. Containers and media used in a growing operation always should be sanitized and disinfested before they are returned to use.

Chapter 7: Plant Production: Containers and Media

When the goal is to produce containerized nursery stock that's free of pests and pathogens, it's important to consider the type and source of growing media and used containers. One should also think about how the containers and media are handled and stored. The safest course is to follow three guiding concepts:

1. **Always procure media and containers that are free from pests and pathogens.**
2. **Always disinfest media and containers before re-using them.**
3. **Avoid contamination of materials during storage and handling.**

These overriding concepts are spelled out in further detail in the following best practices.

7.1. Procure media and containers free from pests and pathogens

Growing media and containers are two pathways by which pests and pathogens gain access to a commercial nursery. Most nurseries either purchase commercially-made growing media, or they blend their own from a variety of constituent ingredients. Each method has its advantages and disadvantages for overall nursery production. That's also the case when it comes to pest and disease vulnerability. Nurseries blending their own media should be especially careful, as they must watch over each of the ingredients in their blend. Finally, each nursery must evaluate its containers and how it sources them.

BEST PRACTICES:

7.1.1. If using commercial potting media, ask if it has been tested for pathogens, pests and weed seeds. Bagged commercial potting media containing peat moss, bark, vermiculite, perlite or compost is generally free from common plant pathogens such as *Pythium*, *Phytophthora*, *Fusarium*, *Rhizoctonia*, and *Thielaviopsis*. It is a good idea, however, to ask your supplier for written assurance that the potting media has been tested for plant pathogens, insect pests and weed seeds. Make sure that the components of the potting media you buy are from an area known to be free from *Phytophthora ramorum* or other quarantine pests and pathogens.

7.1.2. If using sand, take precautions, and disinfest if necessary. Sand frequently contains propagules of plant pathogenic fungi, oomycetes, and nematodes. So-called "river-washed" sand is particularly prone to contamination. One should make sure that sand is obtained from at least 2 meters deep in the soil profile. The sand must not be exposed to surface runoff water. If the sand has been exposed to surface runoff, then it must be disinfested with an approved method before use.

7.1.3. If using bark, make sure it is not from an area infested with *P. ramorum*. Douglas-fir bark and other types of bark used in the nursery industry are essentially free from plant pathogenic fungi and oomycetes. This bark does not need to be treated before use in container media. One should make sure that the bark is not from an area known to be infested with *P. ramorum*.

7.1.4. Rest easy when using perlite and vermiculite. Perlite and horticultural vermiculite are free of pathogens and pests. These components do not require disinfestation before use.

7.1.5. Disinfest peat moss if necessary. Sphagnum peat moss is generally free of pathogens and pests. It does not require disinfestation before use. Other types of peat can harbor soilborne pathogens, however (Mathre, D.E. & Grey, B. 2002). They should be disinfested before use.

7.1.6. If using compost, check with the supplier. Plant material and animal manures that have been properly composted to kill pathogens and weed seeds may be used as a component in potting media. Proper composting requires that a high temperature be maintained for a specific duration of time to kill or inactivate plant pathogens. Temperatures greater than 55 C (131 F) will destroy most (but not all) plant pathogens if the heat is maintained for 15–21 days. It takes temperatures greater than 65 C, for a 21-day interval, to eliminate resistant viruses such as tobacco mosaic virus (Washington Organic Recycling Council 2009). Research indicates that the minimum temperature and time parameters required by federal guidelines for commercial composting will eliminate *Phytophthora ramorum* in infected plant material. (Garbelotto, M., 2003; Swain et al., 2006). However, composting is not currently an APHIS-accepted practice for treatment of quarantined plant materials except in particular composting facilities in California. Certain composts from Pacific Northwest sources have disease suppressive characteristics (Scheuerell et al. 2005). It's a good idea to request written assurance from the supplier to ensure that the compost is free of pest and pathogen contamination, and/or to verify claims of disease suppression.

7.1.7. Take precautions when using containers. New pots, flats, and trays do not need to be treated before use. Pots, flats and trays made from recycled plastic likewise require no treatment. Used containers are a different matter. They must be disinfested before re-use, following procedures outlined in Chapter 7.2., below. Never buy used containers that have not been disinfested. Some nurseries have unwittingly brought *Phytophthora* into their facilities by purchasing used, untreated pots.

7.2. Re-using containers

Re-using nursery containers can be good for the environment and good for business. It reduces costs, saves energy, and keeps waste out of the landfills. There's no doubt about it — recycling is good — but it is very important to not recycle pathogens and weeds. Always disinfest containers before re-use. Several methods are available, but some of them require washing to first remove old potting media and organic debris. This is usually not practical on a large scale. Here are some cleaning methods that have been proven effective if properly followed:

Figure 7.2.1.a — Killing pathogens with heat

Temperatures required to kill various kinds of soil microorganisms based on a 30-minute exposure to moist heat. Modified from Baker, K. F. & Cook, R. J. (1974).

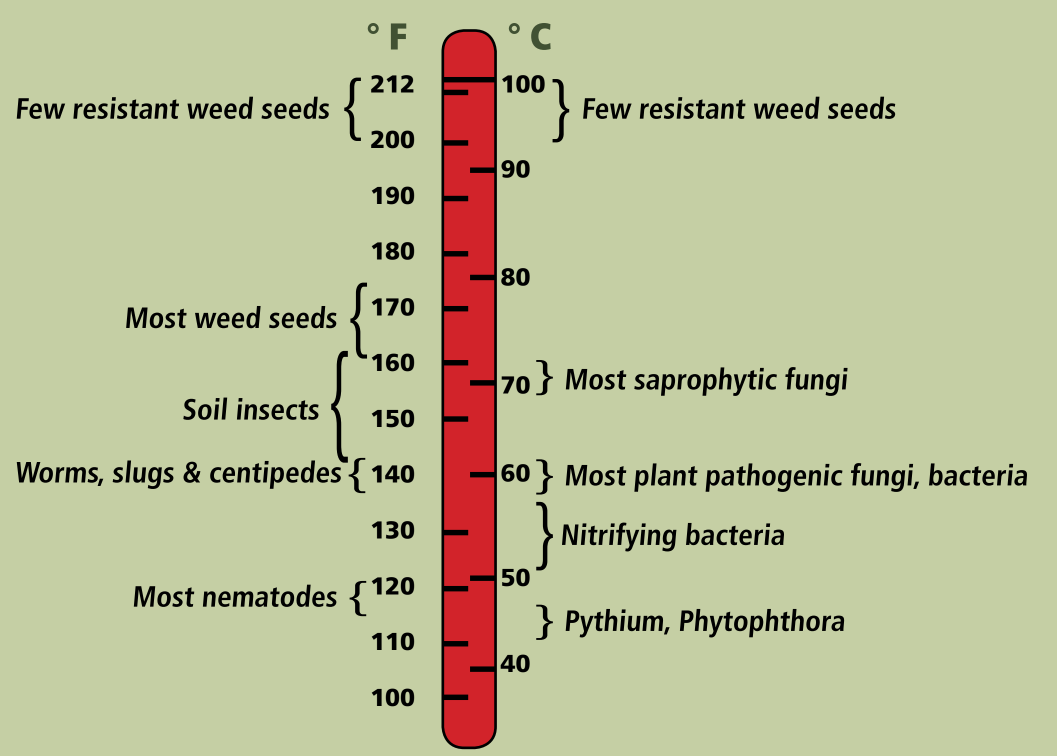


Table 7.2.1 — Disinfesting with aerated steam

❑ **TIP:** ***There are several ways you can steam treat containers on your own.*** *A* ***steam generator*** *(Fig. 7.2.1.b, below) can be connected directly to a container, soil cart, or to an* ***aerator*** *(Fig. 7.2.1.c). An aerator is a device that mixes air with steam to allow the user to achieve the desired temperature of steam at the point of delivery. The steam or steam-air mix is put into a* ***cart or loader covered with a tarp*** *(Fig. 7.2.1.d.), an* ***insulated room adapted for this purpose*** *(Fig. 7.2.1.e), or connected to a stainless steel cabinet.*

❑ **TIP:** ***Monitor temperatures properly.*** *It is important to achieve sufficiently high temperatures even in the center of the stack. Monitor the temperature with a digital probe thermometer or a "button" data logger (such as the WatchDog B-Series Button Logger Model 100, by Spectrum Technologies, Inc.) placed in the center of the stack of containers. Begin timing the 30 minute exposure interval once the temperature read-out from the center of the stack hits 140 F.*

❑ **TIP:** ***If you aren't set up to steam-treat pots yourself, there are several commercial enterprises that will come to your site and do it for you.*** *(See Fig. 7.2.1.f) Although most growers who steam treat their pots do so to get rid of soil-borne pathogens, many growers report an additional benefit. They often realize substantial cost savings due to the excellent weed control achieved with steam treatment of pots. They find themselves spending less money on labor and herbicides.*

Fig. 7.2.1.b — Steam generator

Fig. 7.2.1.c. — Aerator

Fig. 7.2.1.d. — Aerated steam treatment of conatiners in a free-standing loader. Photo courtesy of T. Landis, USFS, www.bugwood.org.

Fig. 7.2.1.e — Insulated shipping container modified as a steam chamber for pasteurizing used containers and propagation flats.

Fig. 7.2.1.f — Mobile steam pasteurization unit for small volume growers.

BEST PRACTICES:

7.2.1. Option: Use aerated steam. Extensive research demonstrates that most plant pathogenic fungi, oomycetes, bacteria, viruses, and nematodes are killed by exposure to aerated steam at 140 F for a minimum of 30 minutes (Fig. 7.2.1.a., Page 51) Higher temperatures are required to kill weed seeds. See **Table 7.2.1** on Page 52 for details.

7.2.2. Option: Use a hot water dip. Some nurseries have the capability to submerge used flats, trays and small containers in large vats of hot water. It takes reatment for 30 min at a temperature of at least 180 F (Baker, K. F. 1957) to kill or inactivate most pathogens.

Fig. 7.2.2. — Apparatus for submerging flats, trays and small containers in hot water.

7.2.3. Option: Soak containers in a disinfectant. Several effective disinfectants are available. They include products with peroxide, quaternary ammonium, sodium hypochlorite (bleach) or potassium peroxymonosulfate bases. You may recognize these products by their trade names, some of which are shown in the table below. However, none of them can do their job effectively unless you wash the pots first to remove potting media and plant debris. The presence of any organic matter in the pots will quickly inactivate these disinfecting ingredients. Exposure time, concentration, and the type of substrate being treated are other factors that can influence the effectiveness of disinfectants (Copes 2004). To improve the effectiveness of the treatment, one should increase the contact time in the disinfectant, and periodically replace the spent disinfectant with fresh chemicals. For best results, follow the instructions on the product label.

Table 7.2.3 — Disinfectants for pots, tools and equipment

The following are chemical and trade names of various effective disinfectants. Follow the instructions on the product label for best results.

Chemical name	Trade names
Peroxide	ZeroTol, OxiDate, TerraCyte
quaternary ammonium	Physan 20, Green-Shield CA
sodium hypochlorite (bleach)	Clorox, Agclor
potassium peroxymonosulfate	Virkon S, Trapall

7.2.4. Option: Disinfest pots using solarization. Some growers are experimenting with solarization to disinfest pots. This method works as follows. First, cover the pallets of pots with clear plastic. Then, leave them in the sun for several weeks during the summer. Alternatively, pallets of pots can be placed inside empty, closed greenhouses for a few weeks during the summer. Sustaining a high temperature is the key to making this process work. One should monitor the temperature with a digital probe thermometer or a "button" data logger such as the WatchDog B-Series Button Logger Model 100 by Spectrum Technologies, Inc. The device should be placed in the center of the stack of containers. The temperatures required to kill pathogens through solarization are the same as those needed for composting,. A sustained temperature greater than 131 F for 15-21 days should be adequate for killing or deactivating most plant pathogens. The problem is that it's hard to sustain a high temperature for that long by using solarization. The temperatures typically fluctuate from a maximum temperature during the afternoon, to a minimum temperature during the night. In light of these day-night fluctuations, the specific requirements for effective solarization treatments are not known.

7.3. Media or media ingredients

If you mix your own potting media and any of the ingredients are potentially contaminated, you must disinfest the ingredients before mixing the media. Two methods are acceptable: treatment with aerated steam, or fumigation with an approved fumigant. It's not recommended that you reuse potting media. However, it may be possible to treat previously-used potting media. Possible means include aerated steam, fumigation, or composting.

BEST PRACTICES:

7.3.1. Option: Treat media or media ingredients using aerated steam. Use a chamber such as a Lindig, or soil steaming cart. Before steaming, mix all ingredients at a moisture content that would be desirable for planting. Fill the chamber with the medium, or fill trays or pots with the medium to be steamed, and place them in the chamber. Place a temperature probe, preferably with a remote read capability, inside the coldest part of the pile. Close the chamber and begin the 30 minute timing once the temperature inside the coldest part of the pile has achieved 140 C. Higher temperatures are required to kill weed seeds. It is not desirable to sterilize the medium, because beneficial microorganisms are also eliminated. Excessive temperatures can also negatively affect potting medium chemical properties. For example, manganese toxicity can develop after high temperature treatment of soils or soilless media that contain high amounts of organic matter.

7.3.2. Option: Fumigate media or media ingredients. Products containing chloropicrin, methyl bromide, and dazomet are effective in killing pathogens, pests, and weed seeds. These materials are very dangerous, however, and there are many label restrictions for their use. Follow all label instructions.

7.3.3. Option: Properly compost of media and plant debris. Composting of used potting media and plant debris can be an effective way to disinfest these materials, but only if done properly (Paul, J. & Geesing, D. 2009). To kill or inactivate plant pathogens, one must compost the materials in a way that maintains a high temperature for a specific duration of time. Temperatures greater than 55 C (131 F) will be effective in destroying most plant pathogens if maintained for 15–21 days. (Washington Organic Recycling Council 2009).

7.4. Storage and handling of media and containers

Potting media components and new or disinfested containers must be stored and handled in such a way that they do not become contaminated before use.

BEST PRACTICES:

7.4.1. Mix media safely. Ensure that media components are mixed and stored on a cement slab, not on soil. Thoroughly clean the slab or media bay between lots.

7.4.2. Keep contaminants away. Prevent runoff water from cull piles, roads, and growing areas from contaminating the stored media.

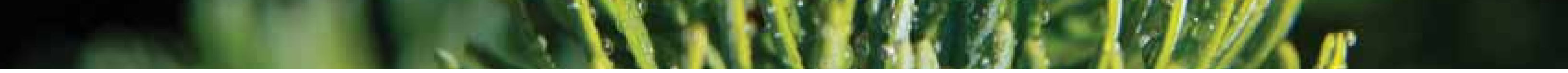
7.4.3. Prevent cross-contamination from vehicles. Regularly clean and treat the vehicles, tools, and equipment that are used to mix potting media. If possible, use dedicated vehicles and equipment for mixing or loading potting media. The vehicles and equipment used in the field operation should not be used to process potting media.

7.4.4. Protect pots from contaminants. Keep all pots off the ground, away from soil and contaminated water, and covered to prevent dust accumulation.

Conclusion

As we have seen, there are many components involved in reduced-risk container production. Sound practices begin with buying or producing containers and growing media that are free of pests and pathogens. If the nursery produces its own growing blend, then it must examine all the components making up that blend, and treat them as needed. From there, it proceeds to many common-sense practices every nursery should be using. For example, if the containers are previously used, then it's imperative to disinfest them before using them again. Finally, the containers and media must be stored in a way that keeps them from becoming infested.

So far we have addressed two of the components making up finished plants — the seedlings or liners themselves, and the containers and media that may be used to grow the plants. The next crucial ingredient needed to grow plants is water, covered in the next chapter.



Nursery operators always must be aware of on-site drainage issues and do their best to avoid standing water. Water that will be reused should be treated using an effective method, so that any risks to plant material are reduced.

Chapter 8: Plant Production: Water Management

Water management is key to managing many pests and diseases in nurseries. Irrigation water can harbor certain plant pathogens, such as water molds.

Poor drainage and standing water can spread certain diseases throughout the entire nursery. Improperly irrigated plants — with too much or too little water — are also more susceptible to certain pests and diseases.

The timing of irrigation is also important, because it affects the length of time leaves remain wet. That is an important variable for some leaf-infecting pathogens. Growers can take several steps to manage water in their nurseries to reduce disease problems.

8.1. A nursery map

When it comes to keeping out pathogens, a diagram of your nursery can be one of the most useful tools in your arsenal. A well-drawn and thorough diagram will make problem areas in your nursery much more apparent. It may also help you consider how you might solve these problems.

BEST PRACTICES:

8.1.1. Map the flow of water throughout your nursery. For an example of how this can be done, go back to Table 3.1 in Chapter 3. Mark surface ditches and subsurface drainage systems. Note any areas that are low-lying or poorly draining. Correct the drainage problem, or avoid using those areas for growing plants that are susceptible to *Pythium* and *Phytophthora* diseases.

8.1.2. In can yards or greenhouses, check the ground surface. Indicate on your map any areas where gravel or crushed rock has sunk into the mud and no longer provides a barrier between containers and the soil. Moss and algae growing on the ground surface indicate that the site is poorly drained. Fabric mesh laid over gravel can become clogged by plant debris, making it impermeable to water.

8.2. Site drainage solutions

Once you have identified drainage issues in best practices 8.1.1 and 8.1.2, the next step is to solve them.

BEST PRACTICE:

8.2.1. Correct drainage problems. Engineer the surface and subsurface drainage systems to move excess water away from the root system and prevent the standing water that favors *Pythium* and *Phytophthora* pathogens. A 2 percent slope is recommended.

8.3. Safe irrigation water

Many plant pathogens are waterborne. This includes the water molds *Pythium* and *Phytophthora*, as well as several fungi, bacteria, viruses, and nematodes (Hong & Moorman 2005). Municipal source water and well water are generally free from plant pathogens. Surface water sources, such as ponds and rivers, are generally contaminated. Although there are many good reasons to recapture irrigation water, this recaptured water often includes *Pythium* and/or *Phytophthora*.

BEST PRACTICES:

8.3.1. Test water for *Phytophthora* spp. The different species of *Phytophthora* make up the most dangerous group of waterborne plant pathogens in nurseries. You can test irrigation water for the presence of *Phytophthora spp.* by baiting the water with a rhododendron leaf for several days. Next, test the leaf with a field diagnostic *Phytophthora* ELISA kit such as the Alert LF™ (Neogen Europe Ltd.) or ImmunoStrip® (Agdia®). Complete directions are available at Oregon State University's Phytophthora Online Course, Module 2 (**http://oregonstate.edu/instruct/dce/phytophthora/module2-3.html**). Be aware, however, that several common species of *Pythium* also cause a positive test result with these kits. The population of waterborne pathogens often fluctuates seasonally, so it is necessary to test your water frequently. Contaminated water should be disinfested before it is used for irrigation.

This nursery has a dedicated shed with chlorination treatment for disinfesting its irrigation water.

Table 8.3.2 — The trouble with turbidity

Turbidity — the total amount of suspended solids — is an important physical factor affecting how easy or difficult it may be to treat irrigation water. These suspended solids can come from silt, or from organic sources, including remnants of potting media, algae and plant debris. Turbidity can be measured in milligrams per liter. A turbidity level of greater than 100 mg/L will hamper your ability to kill pathogens in several ways:

- ***It will deactivate chlorine before the chemical has a chance to kill pathogens;***
- ***It will interfere with ultraviolet (UV) water treatment methods; and***
- ***It will plug emitters, making irrigation itself more difficult.***

To improve the effectiveness of water treatments, and protect your irrigation system, it is best to filter your water prior to treatment. This will remove any solids that interfere with your treatment method. In addition to physical factors, the chemistry of your irrigation water can also influence how well your chosen water treatment methods will kill off pathogens. Here are two examples:

- **Chlorine treatment.** *If you use chlorine to disinfest irrigation water, you will want to monitor the pH level of the water. For water amended with either calcium hypochlorite or sodium hypochlorite, the optimal pH range is between 6.0–7.5. Above pH 7.5, the chlorine would be in the form of hypochlorite, a weak sanitizer. Below pH 7.5, chlorine would be in the form of hypochlorous acid and is 20 to 30 times as effective as hypochlorite.*

- **Copper ionization.** *If you use this treatment method, you'll want to check the electrical conductivity (EC) of the water, which is measured in milliSiemens per centimeter (mS/cm). If EC is low (less than 0.20 mS/cm) then it may be necessary to increase the copper electrode surface area.*

These are two examples of how chemistry can interfere with water treatment methods. Growers should read up on their chosen treatment method and make sure that the conditions for successful water treatment are in place.

8.3.2. Filter contaminated water as needed. If pathogens are found in irrigation water, then the water must be disinfested before it is used for irrigation. In Best Practice 8.3.3, we will address various treatment methods that will kill pathogens. However, several physical and chemical attributes of irrigation water can make these treatment methods less effective. Therefore it may be necessary to first filter water before disinfesting it. See Table 8.3.2 (above) for more on this issue.

8.3.3. Disinfest contaminated water. Several methods are available for effectively disinfesting irrigation water (Fisher 2009). Water treatment systems differ in installation costs, operating costs, mode of action, space requirements, water volume treated, worker safety, and environmental concerns. No single system is best for all nurseries. Each growing operation must select the treatment method that is best for them. Tables 8.3.3a (Pages 60–61) and 8.3.3b (Page 62) provide summaries of some available water treatment methods.

Table 8.3.3a — A summary of treatment options for waterborne pathogens in nursery and greenhouse irrigation systems (Page 1 of 2)

Treatment	Active ingredient	Readily soluble	Injection method	How It Works	Usual range in concentration[1]	Notes
Bromine Example: Agribrom™	1-Bromo-3-chloro-5,5-dimethyl-2,4-imadazolidinedione	No	Tablets or granules are placed in a container with water. The supernatant solution is injected into the irrigation water.	Oxidizing agents listed in this table interact with reactive chemical groups on organic matter. The oxidation of organic matter results in a change in the chemical structure of the organic matter, and death of the pathogen. The oxidizing agent itself is also "used up" during sanitation because the agent changes chemical form as it reacts with organic matter. Plant pathogens vary in their susceptibility to the agents listed in this table. Some plant pathogens and types of resistant inoculum structures may require higher rates of oxidizing agents and/or exposure times than those listed. The material being oxidized can include pathogens, peat, and fertilizer salts. Because all organic matter in the water will absorb and deplete oxidizers, good pre-filtration is essential.	5–35 ppm bromine	Because of low solubility, some time is required for the undissolved tablets or granules to replenish the bromine in the stock solution. Difficult to maintain a constant concentration of bromine over the course of the day, especially with high flow rates. Requires a special injector resistant to corrosive chemicals.
Chlorine gas	Cl^2	Yes	Chlorine gas is bubbled through the water, where it combines with the water to form hypochlorous acid (HOCl) and hydrochloric acid (HCl).		0.5–2 ppm free chlorine. Hypochlorite is a weak acid and can be found in solution in two different forms: OCl- and HOCl. Because the HOCl form is much more effective at disinfecting than the OCl- form, the water pH should be controlled, as sanitizing reactions tend to be slower at higher pH.	Hazardous gas requires special equipment, ventilation, and handling. As with all chlorine application methods, higher than recommended concentrations can be toxic to plants.
Sodium Hypochlorite	NaOCl	Yes	Liquid NaOCl solutions (5–15 percent chlorine) are injected directly into irrigation water.			Requires a special injector that is resistant to very corrosive chemicals and has a very high injection ratio. Has a limited shelf life. Warm temperatures and sunlight speed up breakdown. Never combine with fertilizers or other chemicals containing ammonium.
Calcium Hypochlorite	$Ca(OCl)^2$	Yes	Granules may be dissolved in water, or tablets can be eroded in a flow-through feeder for more automatic chlorination, at chlorine concentrations up to 10,000 ppm, depending on the feeder and operating conditions.			Calcium hypochlorite solutions of up to approximately 21 percent can be prepared, but due to the presence of insoluble materials such as calcium carbonate solutions of above 200 ppm tend to be cloudy. Sediment forms with very concentrated solutions. At less than 100 ppm available chlorine there should be no apparent cloudiness or sediment.
Chlorine Dioxide Examples: Ultra-Shield™, Selectrocide™	ClO^2	Yes	Dry packet or tablets placed in water, ClO^2 solution generated in stock tank.		Injected into irrigation lines. Continuous injection of residual concentration of 0.25 ppm or less. Twice a year shock treatment at 20 to 50 ppm depending on product.	Stock solution should be used within 15 days to minimize loss due to volatilization. Maximum stock concentration of 500 or 3,000 ppm, depending on product.
Ozone	O^3	No	An electrical arc is used to produce the ozone from bottled or atmospheric oxygen. The ozone is then bubbled through the water.		Residual effect from reaction products (peroxides, organic radicals). Breaks up biofilm. 10 grams/hr/m³.	Requires professional design based on water analysis. Proper design prevents ozone from escaping into the atmosphere in hazardous concentrations.
Activated Peroxygen Examples: ZeroTol™, SaniDate™	Hydrogen dioxide/ hydrogen peroxide (H^2O^2) and Peroxyacetic acid/peracetic acid ($CH^3COO-OH$)	Yes	A stabilized H^2O^2 and peracetic/peroxyacetic acid solution that is injected directly into irrigation water. Peroxyacetic acid is a more effective biocide than H^2O^2 alone.		27 to 540 ppm H^2O^2	Requires a special injector that is resistant to very corrosive chemicals and has a very high injection ratio, or the material must be diluted before injection.

Table 8.3.3a — A summary of treatment options for waterborne pathogens in nursery and greenhouse irrigation systems (Page 2 of 2)

Treatment	Active ingredient	Readily soluble	Injection method	How it works	Usual range in concentration[1]	Notes
Ultraviolet (UV) radiation		N/A	Water is exposed to high doses of UV light in tubular chambers. Most common are low pressure mercury vapor lamps with a wave length of 254 nm, close to the optimum range for killing pathogens.	UV radiation disrupts the genetic material in the cell, effectively killing it. Dose, exposure time and turbidity determine effectiveness.	250 mJ/cm^2 eliminates most pathogens. No residual effect on pathogens downstream of treatment.	The effectiveness of the lamp decreases with age. Any particulate matter in the water will disperse the light, making the application of UV radiation less effective. Good pre-filtration is essential. Often used with other disinfecting material to get some residual effect.
Copper ionization	Cu++	Yes	An electrical charge is passed between copper bars or plates, releasing copper ions into the water.	Copper ions are a toxin to most pathogens, including *Pythium*, *Phytophthora*, *Xanthomonas*, and algae. Recent advances in controls produce consistent copper levels and reliable results.	0.5 to 1 ppm Cu for pathogens. 1 to 2 ppm for algae and biofilm.	Less effective if water pH is above 7.5. Choose a system which actively controls copper output according to flow and EC. Applied copper concentrations are within U.S. drinking water standards and a fraction of plant toxicity levels.
Heat treat-ment/pas-teurization		N/A	Water is heated to specific temperature, and waste heat is recovered to pre-heat incoming water.	Pathogen resistance to heat varies. Effect largely independent of water quality.	An example treatment is 203 F for 30 seconds. No residual effect on pathogens downstream of treatment.	High energy use makes it expensive for large flow. To prevent scaling of heat exchangers from hard water, pH needs to be reduced to 4.5, then raised again as needed for irrigation. Best for low-flow, high-sanitation applications.
Slow sand filtration	N/A	Water moves passively through sand bed that supports a biologically active layer (*Schmutzdecke* or biofilm crust) on the filter surface. Clean, filtered water is stored in a covered reservoir until use.	Sand filtration works through a combination of physical removal of particles and biological activity of the biofilm crust. Effective at eliminating *Phytophthora* spp. from water.	An example rate of filtration is 30-90 m^3/hr. A filter bed area of 260 m^2 and 1 m deep can yield approximately 40,000 m^3 filtered water/mo.	While the biofilm crust or *Schmutzdecke* is important for the functioning of the filter, it must be maintained by periodic raking or the filter can become clogged. Slow sand filtration may not be rapid enough to supply the volume of water during periods of peak irrigation demand. Space limitations may also limit the size of the sand filter and the volume of water that can be treated.	

Notes

1. Desired concentration depends on the application (e.g. shock treatment versus continuous treatment of clean water, and the specific pathogens targeted). See product label and manufacturer's instructions for your application.
2. All the methods mentioned above are non-specific and will react with any type of organic matter, whether it is a pathogen, algae, or a particle of peat. In all cases, the cleaner the water is before the application, the more effective the disinfection method is at removing pathogens.
3. Bromine, chlorine products, ozone, peroxyacetic acid, and hydrogen peroxide are strong oxidizing agents. Metal micronutrients (copper, iron, manganese, and zinc) are easily oxidized (particularly iron). It is likely that long-term exposure (greater than 20 minutes) of metal micronutrients to these oxidizing agents will decrease their solubility. Chelated micronutrients should be only slightly less affected than sulfates.
4. Ultraviolet radiation is a photo-oxidizing agent. Research by Cornell University on photo-oxidation of iron in fertilizer solutions indicates that the greater the light exposure, the less iron that will remain in solution.
5. Quaternary ammonium compounds such as Green-Shield®, Physan 20™, or Triathlon™ are listed for disinfection of walkways, benches, tools, flats, etc., but are not for use with irrigation water.
6. Liquid hydrogen peroxide/hydrogen dioxide (H_2O_2) solutions (35–50 percent H_2O_2) are not EPA-registered for water treatment in greenhouses, and are less effective and stable compared with registered activated peroxygen products.

Chemical names and trade names are included in this publication as a convenience to the reader. The use of brand names and any mention or listing of commercial products or services in this publication does not imply ndorsement, nor discrimination against similar products or services not mentioned. Individuals who use chemicals are responsible for ensuring that the intended use complies with current regulations and conforms to the product label. Be sure to obtain current information about usage and examine a current product label before applying any chemical. For assistance, contact your state pesticide regulating authority.

Table modified by J. Parke, Oregon State University, with permission from Fisher, P. (ed.) 2009. *Water Treatment for Pathogens and Algae*. Water Education Alliance for Horticulture. 57 pp.

Table 8.3.3b — Methods of disinfesting contaminated irrigation water

Here is a quick run-down of some available water treatment methods.

- **Oxidizing agents.** *Various oxidizing agents are commonly used to treat water. They include bromine, chlorine gas, sodium hypochlorite, calcium hypoclorite, chlorine dioxide, ozone and activated peroxygen. These agents react with chemical groups on organic matter, including peat, algae, bacteria, plant debris and pathogens. They will also react with any iron or other metals in the water. Given adequate concentration and duration of exposure, oxidizing agents will kill pathogens in the water. However, too much organic matter in the water will deplete the oxidizing agent and make it less effective against pathogens. Consequently, water to be treated with oxidizing agents should first be filtered.*

- **Ultraviolet (UV) radiation.** *With UV treatment, water passes through tubular chambers while it is exposed to UV light. This kills living organisms (including pathogens) by disrupting their DNA. Particulates in the water will disperse the light, reducing the effectiveness of UV radiation. Therefore it is necessary to filter the water prior to UV treatment.*

- **Copper ionization.** *Copper ionization is used in swimming pools, industrial processes and agriculture. It involves releasing charged copper ions into the water by passing an electrical charge between copper plates. Copper ions are toxic to most pathogens and plants, but the levels used to treat water are well below those that cause phytotoxicity.*

- **Heat treatment.** *This treatment kills plant pathogens by raising the temperature of the water to 203 F for at least 30 seconds. The method is energy intensive and considered too costly for treating large volumes.*

- **Slow sand filtration.** *Sand filters are frequently used in municipal, industrial and agricultural water treatment systems. This low-tech water treatment method has been extremely effective in eliminating* ***Phytophthora*** *from recirculating water in commercial nurseries in Germany (Ufer et al. 2008). Sand filters use simple gravity to pass water through a basin of sand from top to bottom, slowly cleaning the water. A biofilm crust, or Schmutzdecke, develops on the surface of the sand filter. While this layer is important for the functioning of the filter, it must be maintained or the filter can become clogged. Slow sand filtration may not be rapid enough to supply the volume of water during periods of peak demand, requiring filtration and then storage of the clean water in a reservoir.*

An excellent source for learning more about water treatment methods is the educational resource section of the Water Education Alliance for Horticulture website (**http://www.watereducationalliance.org/education.asp**) *and the booklet,* Water Treatment for Pathogens and Algae *(Fisher 2009).*

8.4. Improving irrigation conditions

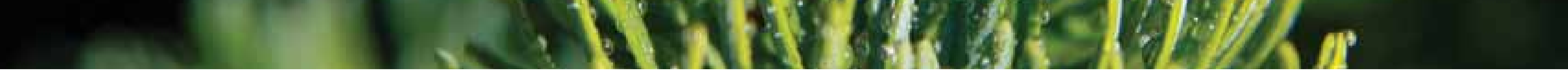
Extended periods of leaf wetness and water-saturated soils and potting media are conducive to many diseases, while some pest problems are more damaging on drought-stressed plants.

BEST PRACTICE:

8.4.1. Manage irrigation to reduce conditions that are favorable for diseases and pests. Apply water evenly to meet, and not exceed, the needs of the crop. Plants with similar water needs should be grouped within the same irrigation zone. It's desirable to reduce run-off and waste by improving water application efficiency. When possible, schedule irrigation in the early morning so that leaves dry quickly. This will create less favorable conditions for foliar diseases. For more detailed information, see the Phytophthora Online Course at **http://oregonstate.edu/instruct/dce/phytophthora/module2-3e.html**.

Conclusion

With the preceding best practices, nurseries can significantly reduce the risk that irrigation water or rainwater will transmit pests or pathogens as it moves through the nursery site. In previous chapters, we addressed plant origins, propagation, containers, and growing media. However, we haven't addressed all the risks associated with the site itself. In the next chapter, we will do that. **Chapter 9** is the last chapter of this section, and covers the remaining voluntary best practices before we move along to certification programs (which are also voluntary, but more stringent). In this next chapter, we will talk about all the components that make up "infrastructure" for our purposes — site selection, sanitation, cull management, composting, equipment and even biosecurity.



Nursery infrastructure includes permanent structures as well as any vehicles, carts, tractors and related equipment. All of these things can unwittingly transmit pests and pathogens. Nurseries should address these risks as best they can.

Chapter 9: Plant Production: Infrastructure

In the preceding three chapters, we have discussed various aspects of how to adopt the systems approach in a production nursery. We have addressed water drainage, soil-to-pot contact, soil-to-media contact, roadway maintenance, propagation and production beds, and the proper storage of inputs. However, we have not discussed the general infrastructure of a nursery. We will do that in this chapter.

To produce healthy nursery stock, one must maintain infrastructure that is clean and free of pathogens and pests.

This includes all permanent structures such as greenhouses and irrigation systems. It also includes mobile structures, such as trucks, carts, tractors and related equipment, among others. Finally, infrastructure also includes less tangible aspects of a nursery, such as site selection, design aspects and biosecurity measures that can affect plant health.

9.1. Site selection and management

Infrastructure management starts with site selection. If the nursery is located in an inappropriate site, it can invite disease and pest problems. Once the site is chosen, one must manage it in a way that does not promote diseases or pests. A well-run nursery using the systems approach will prevent pests and pathogens from entering the site. Further, such nurseries will prevent the movement of any pests or pathogens between different production areas and even between different plants, as outlined in the following best practices.

BEST PRACTICES:

9.1.1. Collect information on the site's history. In selecting a site, collect information on its history. You will want to know about crops previously grown there, the types of herbicides and pesticides that were previously applied, the types of soil on site, the drainage of the site, the location of the water table under the soil, and the availability of clean water. For in-ground nursery sites, one will want to test the soil for pathogens, including *Verticillium* and plant-parasitic nematodes.

9.1.2. Avoid exposure to pests and pathogens. The site should be isolated from known or likely sources of pests and pathogens.

9.1.3. Address site slope and water flow. As detailed in **Chapter 8.1**, one should map the site and make note of all water flow patterns. Ideally, one should choose a site that slopes slightly and offers water drainage to a pond or retention basin for recycling back to the crop. A 2 percent slope is optimal.

9.1.4. Promote good site drainage. If the site is not well drained, install surface and subsurface drainage systems to eliminate saturated soils and standing water as detailed in **Chapter 8.2**.

9.1.5. Prevent contamination from adjacent sites. Soil and water from adjacent properties can bring in pests and diseases, and should not be allowed to spread onto the nursery site.

9.1.6. Control runoff. Nutrients, pollutants and pathogens can be discharged from your site to off-site waters. A well-run nursery will consider the layout of their site and adopt operating procedures and practices to prevent such problems before they occur.

9.1.7. Minimize contact with soil. If plants come in contact with contaminated soil, they could become infested. Nurseries can construct and maintain roadways, receiving, media and container storage, propagation, production, shipping, and parking areas in a way that minimizes contact with soil.

9.1.8. Avoid contamination hazards in nursery layout. Nursery layout is a critical element in the production of healthy plants. For example, media and container storage areas should be isolated to avoid contamination during storage and handling (see **Chapter 7.4**). The receiving, propagation, and production areas should be isolated from each other (see **Chapter 6.2** and **Chapter 6.4**). Access to the propagation and production areas should be restricted to reduce the risk of inadvertent introduction of pests and pathogens.

9.1.9. Protect structures against pest introduction. Structures such as greenhouses and screen houses should be properly screened to prevent insect entry. These structures should be equipped with double entry doors.

9.1.10. Keep air and water systems running properly. A regular schedule of maintenance should be established to ensure proper operation of irrigation, heating, cooling and ventilation systems.

9.2. Sanitation

Keeping the nursery clean is an important step for the prevention of pest and disease problems. Below are a couple of general best practices that at this point should be obvious. See Chapter 6, Chapter 7 and Chapter 8 for best practices that are related, but spelled out in greater detail.

BEST PRACTICES:

9.2.1. Keep infrastructure clean. All infrastructure should be maintained free of dirt and debris.

9.2.2. Avoid standing water. All infrastructure should be drained to avoid standing water.

9.3. Cull management

It's an inevitable fact of nursery production. Not everything produced will be good enough to sell, and not everything that is good enough to sell will be sold. Some plants, trees and shrubs will miss their sales window. Material that doesn't sell or doesn't meet standards must be set aside and destroyed or composted. However, it must be done in a way that doesn't create a phytosanitary hazard. Below are several best practices to help your nursery manage culled material in a way that doesn't endanger saleable stock.

BEST PRACTICES:

9.3.1. Isolate cull piles away from vulnerable material. Cull piles should be situated away from areas used for media and compost storage, media mixing, propagation and production. It may help to place the cull pile at the edge of the property, and downwind of prevailing storms.

9.3.2. Prevent contamination via runoff. Runoff from cull piles should be diverted away from areas used for media and compost storage, media mixing, propagation and production.

9.3.3. Don't let culled material sit for a long time. The materials in cull piles should be incinerated, buried, or properly composted on a frequent basis. If the material sits too long, it can become more vulnerable to pests and pathogens, particularly those that thrive on dead or dying material. More detailed guidelines are included in Best Practice 7.3.3.

Compost piles, as well as burn piles, should be located at the down-wind edge of the nursery, if possible.

9.4. Composting

The use of compost, either made on site or purchased from a vendor, makes sense for most nurseries. However, compost is organic material and therefore can be vulnerable to pests and pathogens. By following sound practices, you can prevent these problems.

BEST PRACTICES:

9.4.1. Purchase compost from reliable sources. Compost that comes from reliable and known sources is less likely to have problems.

9.4.2. If making your own compost, make it safely. Avoid composting diseased material. You should also make sure that compost is properly aerated and reaches desired temperatures to kill pathogens, pests and weeds, following the guidelines in **Best Practice 7.3.3**.

9.4.3. Store compost safely. All compost should be stored in a separate area. Preferably, it should be stored on a cement or asphalt surface that is easy to clean and is not in contact with soil.

9.4.4. Maintain reliable records. Keep records of sources and lot numbers of all purchased composts. Keep compost lots separate and identifiable.

9.4.5. Protect your compost holding area. Make sure that it is free of standing water, insects, pathogens, weeds, mosses and liverworts.

9.4.6. Prevent compost contamination. Clean all trucks, tractors or implements that enter the compost area. Avoid contamination of fresh, clean compost with any materials that could carry pathogens, pests or weeds. Such materials include soil, media, plant debris and water.

9.5. Equipment management

Equipment that enters or leaves your site, or is used at your nursery, can unwittingly serve as a pathway for pests or pathogens in or out of your site, or between different areas of your site. The following best practices can prevent these things from happening.

BEST PRACTICES:

9.5.1. Handle planting media only with clean and disinfected equipment. Follow the best practices outlined in Chapter 7.4, "Storage and handling of media and containers."

9.5.2. Inspect delivery trucks upon arrival. Any trucks or vehicles that are dirty or contaminated should not be allowed entry to the site.

9.5.3. Clean trucks between shipments. Make sure that all nursery delivery trucks are properly cleaned of plant debris between shipments. Any mud and soil should be washed from the truck body as well as the tires.

9.6. Site biosecurity

Sensible biosecurity practices are an effective way to keep pests and diseases from entering your nursery and causing problems. The following best practices should be a part of any nursery's standard operating procedures. This is particularly true for nurseries following the systems approach.

BEST PRACTICES:

9.6.1. Keep a biosecure perimeter around your property. Your nursery property should be signed, fenced to exclude animals, and secured after hours.

9.6.2. Prevent contamination from visitor vehicles. Your nursery should have a designated visitor parking area. The area should be clearly marked, located at the edge of the nursery, and easily cleanable. Visitors should not be allowed to drive on your property with their own vehicle.

9.6.3. Track and escort all visitors. Nurseries should require all visitors to report to your office first, and it should be clearly marked. Nursery visitors should be required to sign a log book, and they should have a staff escort at all times while they are on the property.

9.6.4. Prevent visitor shoe contamination. Shoes may contain soil from other locations, including nurseries that may have pests or pathogens. Visitors' shoes should be cleaned and sanitized, or the visitor should be given clean boots or shoe covers.

9.6.5. Prevent contamination by staff. All members of your staff should be required to wear clean clothes each day. Employees should be required to clean their footwear daily to remove dirt and mud.

9.6.6. Wash up after traveling off site. All staff members who may have visited areas with pest and disease problems, including other nurseries, could unwittingly bring in pests or pathogens. They should be required to wash and sanitize their shoes, tools and vehicles before entering the nursery.

9.6.7. Check all delivery trucks. Arriving delivery trucks should be inspected. They should not be allowed entry to the site if they are dirty or contaminated.

9.6.8. Check arriving plant material. Incoming plant shipments should be inspected and off-loaded to an area that can be cleaned of leafy debris. All buy-in material and other new materials should be segregated on arrival at the nursery, as detailed in Best Practice 5.4.4.

9.6.9. Clean returning delivery trucks. Trucks from your nursery can unwittingly pick up pests or pathogens at the sites they visit. These problems can be brought back to your nursery, unless steps are taken to stop them. All trucks should be properly cleaned of plant debris, including mud and soil from tires and truck body, before returning to the nursery.

Conclusion

Congratulations are in order. We have reached the end of Part II, which explained how to put together a voluntary systems approach program for your nursery. Over the past five chapters, we've covered plant sourcing, propagation, containers, growing media, water management and infrastructure. Remember the checklists back in Chapter 3? These past five chapters have explained how you can reduce the risks that were identified there.

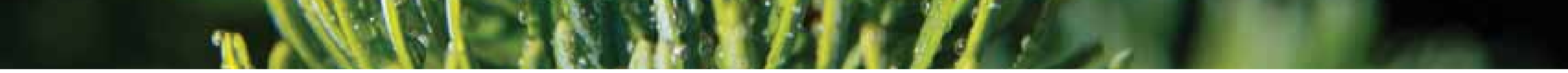
Give yourself a pat on the back — you now have several best practices at your disposal that can help your nursery produce more safely and perhaps more efficiently, too.

But we're not done. Next begins Part III of this systems approach guide. You've adopted the best practices — now do you want the certification to go along with them? There are many advantages to seeking this certification.

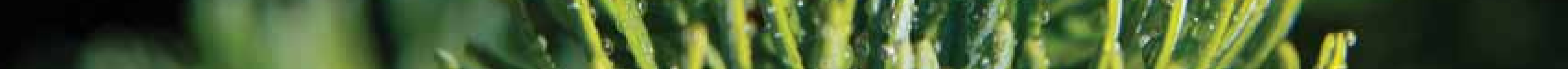
As we have mentioned, certified growers may be able to self-issue their own phytosanitary certificates. Further, certification may become a requirement for shipping to other countries in the near future.

However, it's going to take some significant work to accomplish that. It mostly involves the practices you've already adopted, plus an added layer of self-auditing, disclosure and recordkeeping to demonstrate your nursery has significantly reduced its risks.

Before making a decision, you'll want to read the specifics and see what's really involved.



Part III: The Next Step: Systems Approach Certification



A clean, well-run and well-organized nursery is likely to have fewer risks from pests and diseases. A small number of top nurseries have taken the added step of pursuing certification under the U.S. Nursery Certification Program.

Chapter 10: USNCP Phytosanitary Management System

In **Part II** of this systems approach guide, we discussed voluntary best practices — measures any nursery operation can adopt to promote safe procurement and production of plant material. Here in **Part III**, comprised of **Chapter 10** and **Chapter 11**, we will discuss how nurseries can take the added step of complying with major components of the USDA's system approach nursery program.

At the time of this publication, the **United States Nursery Certification Program (USNCP)** is a pilot accreditation program that uses a systems approach to produce nursery stock as detailed in **Regional Standard for Phytosanitary Measures (RSPM) No. 24.** The North American Plant Protection Organization (NAPPO) developed this regional standard for Canada, Mexico and the United States. The regional standard details how nursery stock is to be grown and traded between these nations using a systems approach.

The USNCP relies on two main management systems to assure a given facility grows and ships product that meets program standards and requirements. They are the phytosanitary management system, and the pest management plan.

The participating nursery must create a document known as an export production manual, or EPM. The manual must describe the phytosanitary management system and the pest management plan the nursery has adopted. This chapter will cover the requirements of the phytosanitary management system detailed in the July 24, 2008 version of the USNCP standards, which are posted on the Internet at:

- **http://www.aphis.usda.gov/plant_health/acns/certification.shtml.**

The next chapter (**Chapter 11**) will talk about the required pest management plan.

The current goal of the USNCP is to ensure that nursery stock shipped from U.S. participants meets all of Canada's requirements for nursery stock produced and certified by USNCP-accredited facilities. Plant material must be:

- free of quarantine pests and other regulated pests,
- essentially free of common, unregulated pests,
- sourced from non-prohibited locations using authorized inputs, and
- tracked from the time it enters the facility (or is produced on-site) until it reaches the receiving customer. This requirement ensures that any problems detected can be traced back to their origins.

The USNCP relies heavily on documentation and auditing to assure compliance. The participant must conduct internal audits of their records and practices. Further, the participant must allow audits by third-party auditors, which normally are a team made up of APHIS and state agriculture officials.

Participants must generate and maintain detailed records and reports to show auditors the source of plant material, the health status of plants, any treatments conducted, and any other actions the nursery takes to comply with the USNCP.

These records must be kept for at least three years, even if the participant withdraws from the program.

10.1. Sourcing plant material

Only plant material of U.S. or Canadian origin is eligible to enter the USNCP. See pp. 14-16 of the USNCP Standards to determine origin. This document also includes other restrictions and qualifications on material.

BEST PRACTICES:

10.1.1. Maintain an up-to-date list of all sources of plant material. This list must include the company or source name, the state/province of origin of the material and source contact information including a telephone number. When your nursery begins working with new sources of material, program contacts must be notified within 48 hours.

10.1.2. Assure that incoming material is free of pests and pathogens of concern. This must be done by using an adequate combination of best practices from **Chapter 5**, including inspection, treatment and isolation procedures. One must then document those procedures.

10.1.3. Obtain and maintain records that can prove the origin of all incoming materials. The nursery must also document how those records will be maintained.

10.1.4. Maintain records that can prove material meets the eligible plant taxa requirements and USNCP certification requirements. For more information, see Sec 2.2 and 2.3 of the USNCP standards.

10.2. Product identity

The USNCP requires that plant material must be traceable at all steps in the procurement and production processes. This allows trace-back and trace-forward investigations in the event of a problem and will also help exclude non-involved stock from regulatory control.

BEST PRACTICES:

10.2.1. Establish procedures and maintain records that track the movement of material. Material must be traceable at every step in the process, from arrival or self-propagation, through the production process and on to the receiving customer.

10.2.2. Describe and document a process that you could use to trace any USNCP-certified material back to its origin or forward to the receiving customer. If a problem occurs, this tracking will allow the problem to be pinpointed and prevent the entire facility from potentially being quarantined or regulated.

10.3. Control of non-conforming product

The USNCP requires that participants have procedures in place to prevent any non-conforming and therefore uncertified product from contaminating other products. In the event that the contaminant is a regulated pest or pathogen, the participant must notify APHIS immediately.

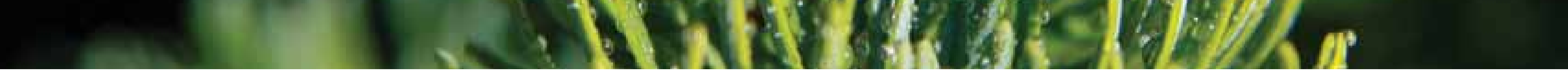
BEST PRACTICES:

10.3.1. Develop, document and train appropriate staff on procedures that provide positive control of non-conforming product. Pest and pathogens must be held below program tolerances and plant material must meet origin and other eligibility requirements.

10.3.2. Require notification. All facility staff must inform the facility's certification manager immediately if any products are not in conformance with the standards.

10.3.3. Investigate any potential problems. The certification manager must investigate any reports received under Best Practice 10.3.2 and determine whether the occurrence rises to the level of a non-conformance. If so, they must issue an internal correction action request (ICAR). The pest control manager must then take expedited action to control the non-conformance and make a recommendation to prevent future occurrences. These actions will be recorded on the appropriate forms.

10.3.4. Notify APHIS of any regulated pests or pathogens. The facility's certification manager or pest control manager must notify APHIS immediately in the event that the contaminant is a regulated pest or pathogen.



10.4. Internal audits

Participants must conduct or designate other parties to conduct at least one complete systems audit annually and four surveillance audits annually using the steps spelled out below in **Best Practice 10.4.2** and **Best Practice 10.4.3**. At least one surveillance audit is to be conducted during the growing season and one during the shipping season. These self-audits are a check to make sure that:

- procedures in the EPM are being followed,
- staff is appropriately trained,
- records are being kept to show compliance with all aspects of the program, and
- product conforms with the USNCP standards.

(Note: APHIS will conduct a parallel series of systems and surveillance audits to assure third-party integrity of the process. It is highly recommended that internal audits precede the corresponding APHIS audits by several weeks.)

BEST PRACTICES:

10.4.1. Designate the certification manager, or a designee, to conduct the audits. The certification manager and crop protection manager may not audit any reports or actions that are part of their regular, USNCP-assigned duties. A detailed audit report must be made available to APHIS and the local regulatory official within two weeks of the audit completion.

10.4.2. Complete a proper systems audit once per year. The annual systems audit must verify the following:

- Processes and procedures meet the requirements of the standards.
- Documentation is current and available to appropriate staff and meets the requirements of the standards.
- The phytosanitary management system is operational and meets specified requirements and that staff are performing program specific duties.
- A corrective action plan has been established and is addressing each non-conformance.

10.4.3. Complete a proper surveillance audit at least four times per year. These surveillance audits must verify the following:

- The pest management plan, as detailed in **Chapter 11**, is effectively preventing the introduction and establishment of pests and pathogens.
- Relevant employees are competent in identifying and controlling pests and pathogens and other duties required by the standards.
- Record-keeping requirements are in compliance with the standards and are sufficient to track plant origin.
- All outstanding non-conformances and corrective action requests are acted upon promptly.

10.5. Internal Corrective Action Requests (ICARs)

The participant should deal with new pest and pathogen problems and other significant non-conformance issues primarily by generating and taking appropriate action on internal corrective action requests (ICARs). An ICAR should be issued anytime a non-conformance is noted during internal audits, or by non-scout staff on the nursery.

BEST PRACTICES:

10.5.1. Issue an ICAR anytime a non-conformance is detected. The ICAR will provide a detailed description of the non-conformance. Each non-conformance must be classified as either critical, major or minor, as defined in Appendices 8 and 9 of the USNCP standards. The ICAR also must instruct staff on how to mitigate and prevent any similar non-conformances in the future. It may be necessary to amend the nursery's export production manual to prevent re-occurrences of some non-conformances.

10.5.2. Notify the proper officials if there is a non-conformance. The certification manager immediately must notify APHIS-PPQ, as well their local regulatory official, of any suspected or verified occurrence of a critical non-conformance on material that is purchased by, produced at or sold by the participant.

10.6. Records management

The participant must keep all records that verify the implementation of the phytosanitary management system and the pest management system as described by the USNCP standards. These records must be maintained for a minimum of three years regardless of the status of the facility. If APHIS or the local regulatory authority requests these records, then they must be made available. Electronic records must have safe and sufficient back-up in case of hard drive or other system failure.

The participant also must maintain up-to-date copies of supporting documents. These documents may include:

- the current version of the USNCP standards,
- CFIA Plant Protection Policy Directives (PPPDs),
- CFIA and USDA regulated pest lists,
- an approved export production manual (EPM) for the facility, and
- pertinent local and federal pest and pathogen regulations.

These documents currently are located at the URLs listed below:

- USNCP standards: **http://www.aphis.usda.gov/plant_health/acns/downloads/USNCP-Standards.pdf** (*Note: Pages 69–77 include a full checklist of the items required in an export production manual.*)
- PPPDs: **http://www.inspection.gc.ca/english/plaveg/protect/dir/directe.shtml**
- Subscribe: **http://www.inspection.gc.ca/english/util/listserv/listbsube.shtml?phpd-dppv**
- CFIA Regulated Pests: **http://www.inspection.gc.ca/english/plaveg/protect/listpespare.shtml**
- USDA Regulated Pests: **http://www.aphis.usda.gov/import_export/plants/plant_imports/downloads/RegulatedPestList.pdf**

BEST PRACTICES:

10.6.1. Maintain all required records. All forms, reports, requests and associated documents related to the USNCP program must be maintained for a minimum of three years, regardless of the accreditation status of the nursery. These records must be available to official auditors upon request.

10.6.2. Limit access to required records. Only the certification manager and the pest control manager should have access to completed records in the USNCP file cabinet.

10.6.3. Create and maintain an export production manual (EPM). An export production manual is a nursery-written set of procedures that show how the nursery will comply with the program standards of the USNCP. The certification manager must make any necessary updates to the manual. All changes must be sent to the USDA for approval within five business days. Approved changes must be documented in the amendment record. Once changes are approved, the certification manager must update all staff copies of the manual within three business days. An original copy of each version must be maintained for records continuity.

10.6.4. Provide staff with all documents as needed. The certification manager must be responsible for providing documents stipulated in the standards to all staff involved with the implementation of the USNCP. These documents will be updated prior to each internal audit, or as detailed above. When possible, a subscription service should be established online so staff members can be updated on any important changes.

Conclusion

We have spent this chapter talking about the phytosanitary management plan that is required for a nursery to gain USNCP certification. We've learned that for successful phytosanitary management, a nursery must:

- keep records of where its plant material came from,
- track that material as it moves through the nursery,
- establish procedures for dealing with non-conforming product,
- perform internal audits to make sure procedures are being followed,
- take proper action when problems are detected and manage records properly.

The phytosanitary management plan is only half the battle, however. The other half of USNCP certification is to create a pest management plan, which documents how you are going to keep pests under control to acceptable levels. We'll discuss the pest management plan in the next chapter.

One component of USNCP participation includes documentation of all procedures in an export production manual. The manual must explain what steps will occur when pests and pathogens are identified in the nursery operation.

Chapter 11: USNCP Pest Management Plan

This chapter will cover the requirements of the pest management plan detailed in the July 24, 2008 version of the USNCP standards at:

- www.aphis.usda.gov/plant_health/acns/certification.shtml

The pest management plan is a collection of documented procedures and processes that the participant uses in controlling pest and pathogens to levels required by the USNCP standards. Specifically, the facility must be free of regulated pests and pathogens (including quarantine and regulated non-quarantine organisms) and practically free of non-regulated organisms. Pest management at the facility must be able to consistently meet this level of control. However, it is largely the participant's choice how this is accomplished.

The pest management plan must be documented in the facility's export production manual (EPM) and it must be approved by APHIS. APHIS may require modifications to the plan to help the participant consistently meet the USNCP standards.

While the pest management plan must cover at least the nine items listed below, most facilities are likely to employ other components of pest management. These additional items and procedures can be documented in Appendix 1 of the EPM. Also, the mission statement of the business can set the tone for the pest management system by striving to produce the highest quality, pest-free product.

11.1. Pest- and commodity-specific requirements

In addition to the basic pest control levels required by the USNCP standards, APHIS or CFIA may require additional examination and/or testing for specific issues. One example is the testing requirement for regulated states for *Phytophthora ramorum*. In cases where additional testing or examinations are required, the pest management plan must describe how that requirement is being met.

BEST PRACTICES:

11.1.1. Maintain pest management documentation. This documentation must be readily available to facility staff involved in implementing the USNCP.

11.1.2. Meet all requirements specific to the commodity or to regulated pests. The certification manager or pest control manager must insure that these requirements are met prior to shipping.

11.1.3. Keep records of laboratories used to meet these requirements. The names and qualifications of any labs used in meeting these specific requirements must be detailed in the nursery's export production manual.

11.2. Maps of the certified facility

The EPM must include a map or maps of the facility that indicate the flow of material through the facility.

BEST PRACTICE:

11.2.1. Maintain facility map(s) that include all relevant areas. The map(s) must show all key areas of the facility that are discussed in the EPM. These areas include receiving areas, shipping areas, the Canada-only shipping area, visitor parking, media storage, propagation areas, burn pile and numbered production beds and structures.

11.3. Incoming plant material

The pest management plan must describe procedures utilized to ensure that stock entering the facility meets the level of pest control required by the USNCP standards. It also must explain how the facility will mitigate the risk of introducing pests and pathogens. New plants must remain physically separated from other plant material and cannot be integrated with existing stock until the material is examined by personnel familiar with regulated pests and is found free from such pests. Non-regulated pests and pathogens must be controlled before the material can be integrated with existing stock, or it should be rejected or destroyed.

Note: As discussed in Chapter 5, visual examination has its limits, especially with cryptic or asymptomatic pests and pathogens. It is prudent to have additional best practices in place to assure consistently meeting the USNCP standards for pest and pathogen levels. Please see that chapter for appropriate best practices.

Additionally, records must be kept that ensure origin of the material and its traceability back to its source. The data that must be captured for incoming stock includes at a minimum:

- Species and variety of material
- Amount of material
- Origin of material (state or country)
- Date of inspection
- Inspector's name and signature
- Pests or diseases observed
- Treatments applied
- Re-inspection to verify control, or re-treat if necessary, or return or destroy

BEST PRACTICES:

11.3.1. Segregate all incoming stock and hold it for inspection. The inspectors must be trained and authorized to inspect the material. They also must be able to recognize regulated organisms, or able to sample and submit to an APHIS-approved lab. If a possible pest or pathogen is detected, the nursery must continue to hold the material in segregation until the organism is identified.

11.3.2. Report all regulated pests to APHIS and the local regulatory official immediately. Non-regulated pests and pathogens must be controlled before the material can be integrated with existing stock, or the stock should be rejected or destroyed.

11.3.3. Keep records of incoming inspections and associated treatments. These records must be generated and held for a minimum of three years. In addition, they must be made available to APHIS or the local regulatory authority upon request. At a minimum, the record must have the bulleted information listed above.

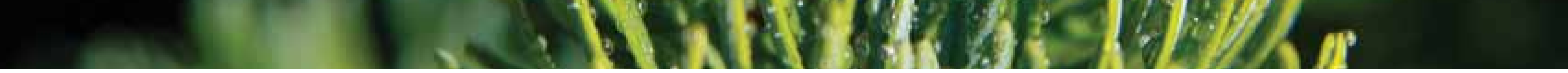
11.4. Examination of production areas

The pest control manager or their trained designee must thoroughly examine all plant material growing in the facility, including all plants for non-Canadian customers. Each block, defined as an area comprised of a unique cultivar, must be examined at the frequency stated in the pest management plan. Suspect plants must be closely examined and pests and pathogens present must be identified, treated or reported, as the standards require.

Records of inspections, treatments, identification samples submitted to outside labs, post-treatment re-inspections and final disposition of the problem must be maintained for a minimum of three years. These records must be made available to APHIS or the local regulatory authority if requested.

BEST PRACTICES:

11.4.1. Conduct regular inspections of all plant material at the facility. The pest control manager or their trained designee must perform these inspections. Frequency of inspections must be timed to prevent the build-up of common pests, and may vary though the year.



11.4.2. Inspect all blocks at the facility. Blocks are defined as an area comprised of a unique cultivar. Symptomatic plants must be closely examined and pests and pathogens present must identified, treated or reported as required by the standards.

11.4.3. Re-inspect treated plants to determine treatment efficacy. If pests or pathogens persist, the plants must be re-treated and re-examined. Failure to control the problem at this stage requires destruction of the material or consultation and treatment with another registered product or effective best practice. Final disposition of the problem must be recorded. An ICAR might also be required, as detailed in **Section 11.9**.

11.4.4. Keep records of production inspections, treatment and final disposition. These records must be held for a minimum of three years. They must be made available to APHIS or the local regulatory authority upon request. At a minimum, such records must have the bulleted information listed below.

- Species and variety of material
- Amount of material
- Origin of material (state or country)
- Location on the farm
- Date of inspection
- Inspector's name and signature
- Pests or diseases observed
- Treatments applied
- Dates when material was re-inspected, re-treated or destroyed

11.5. Examination of shipping areas and export shipments

The participant must make sure that product being shipped under the USNCP does not become contaminated in the staging or shipping areas. Additionally, it is critical that non-eligible cultivars are not shipped under the USNCP. For this reason, it is best to have a "USNCP Canada only" dock or shipping area, so that non-eligible product is not inadvertently loaded.

Each shipment of material certified under the USNCP must be inspected and an inspection record generated for that inspection. Any pest or pathogen discoveries must be described along with the corrective action undertaken. The inspection will include a thorough check of all parts including buds, flowers, foliage, twigs, stems, roots and the growing media and pot and also an inspection of any packing materials, pallets, boxes, and other materials associated with the shipment.

BEST PRACTICES:

11.5.1. Inspect all Canada-bound, USNCP-certified plant material. These inspections shall be made by the pest control manager or their trained designee, and they must occur immediately before shipping. Inspection, treatment and final disposition records must be generated and held for a minimum of three years and made available to APHIS or the local regulatory authority upon request.

11.5.2. Dedicate one dock or area for USNCP-only product. This will prevent inadvertent shipping of non-eligible cultivars. This area must be signed "USNCP-only product." Its location must be indicated on the facility map (see **Section 11.2** of this guide).

11.6. Handling, storage and delivery

The participant must ensure that USNCP-certified product does not become contaminated prior to its receipt by the consignee. Product that been examined and meets pest level standards must be kept separated from non-verified material. This may make sharing a freight load very difficult, unless adequate physical safeguards are in place.

BEST PRACTICES:

11.6.1. Inspect any equipment used to move plants prior to loading. Be sure that the means of conveyance is free from regulated pests and pathogens and practically free of other pests and pathogens.

11.6.2. Do not allow the material to be co-mingled with non-verified material during shipping. If load sharing is unavoidable, there must be adequate physical barriers to assure that contamination cannot take place.

11.7. Pest detection and notification

The participant is required to immediately notify APHIS and the local regulatory official if a pest or pathogen of significance is found. Specifically, this includes:

- the presence of a quarantine or regulated pest or pathogen,
- the detections of a new pest or pathogen at the place of production, and
- any unusual or atypical symptom or plant damage.

BEST PRACTICES:

11.7.1. Make notifications. The certification manager or pest control manager will immediately notify APHIS and the local regulatory official if a pest or pathogen of significance is found.

11.7.2. Keep detection records. The facility must maintain a list of pests and pathogens recorded at the facility and any associated diagnostic or lab reports.

11.8. Pest control

The pest management plan must discuss the strategies employed in meeting the pest control levels required by the USNCP. As we have noted, the requirements are that plant material be free of regulated pests and pathogens, and essentially free of non-regulated pests and pathogens. The strategies used to meet these control levels could include sanitation practices, chemical controls, biological control, weed control, integrated pest management and other practices.

The tolerance for non-regulated pests or pathogens is proportional to the phytosanitary risk they present to USNCP-certified material. Plants that are contaminated by non-regulated pests or pathogens must be treated or culled in an effective manner that mitigates the risk of contamination to other products.

As new regulated pests and pathogens enter the area, new regulations may come into effect that limit shipments or require additional treatments prior to shipping. However, USNCP facilities may add written modules to their EPM, detailing how they will mitigate the risks of these new organisms during receiving, production and shipping. If these measures are approved, the nursery can be exempted from quarantine requirements for the new organism(s).

BEST PRACTICE:

11.8.1. Include, in the export production manual, all strategies used to meet required pest control levels. Be specific. As with all components of the EPM, make sure any action or procedure you list is carried out. Failure to conduct an action that is listed can be considered a non-compliance.

11.9. Control of non-conforming product

The pest management plan must detail how the participant will identify and treat non-conforming product. Generally, non-conformances are recognized during audits, or when staff not associated with the USNCP program finds a problem. The certification manager should then investigate and determine whether the occurrence rises to the level of a non-conformance. If it does, the certification manager must issue an internal correction action request (ICAR). A list of non-conformances can be found in Section 3.4 of the USNCP standards. The pest control manager will take expedited action to control the non-conformance and make a recommendation to prevent future occurrences. It may be necessary to amend the EPM to prevent repeats of some non-conformances.

BEST PRACTICES:

(Note: These best practices are identical to those that were listed in Chapter 10, Section 3.)

11.9.1. Develop, document and train appropriate staff on procedures that provide positive control of non-conforming product. Pest and pathogens must be held below program tolerances and plant material must meet origin and other eligibility requirements.

11.9.2. Require notification. All facility staff must inform the facility's certification manager immediately if any products are not in conformance with the standards.

11.9.3. Investigate any potential problems. The certification manager must investigate any reports received under Best Practice 10.3.2 and determine whether the occurrence rises to the level of a non-conformance. If so, they must issue an internal correction action request (ICAR). The pest control manager must then take expedited action to control the non-conformance and make a recommendation to prevent future occurrences. These actions will be recorded on the appropriate forms.

11.9.4. Notify APHIS of any regulated pests or pathogens. The facility's certification manager or pest control manager must notify APHIS immediately in the event that the contaminant is a regulated pest or pathogen.

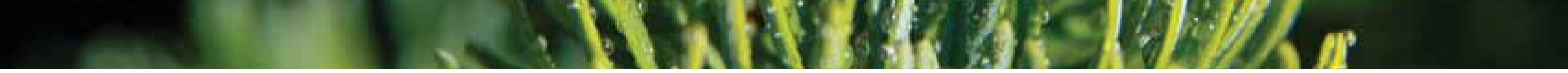
Conclusion

You've reached the end of **Part III**, and seen what's involved in pursuing certification under the U.S. Nursery Certification Program (USNCP). As we explained, a nursery that follows appropriate best practices from **Part II** can likely achieve certification by taking a few extra steps. The added self-auditing, recordkeeping and disclosure are not insignificant, but there are benefits. Certified nurseries can gain an added measure of customer confidence, and may be able to avoid the bother and hassle of end point inspections.

In the end, following proven safe practices is likely to be significantly less burdensome than the old way of ignoring risks and suffering the consequences.

You've seen what it involves. In the end, it's your choice — but one that could have repercussions for your neighboring growers and, for that matter, the entire nursery industry. We urge you to choose wisely and take advantage of the information presented here.

We'll wrap things up in the next chapter, then point to some resources you can consult as you begin your nursery's transformation to a systems approach.



Oregon is known as a state with ideal conditions for producing a wide variety of healthy and vigorous plants. Although all nurseries in all locations face pest and disease threats, new methods of reducing these risks are identified every year and shared by the scientific community.

Chapter 12: Conclusion

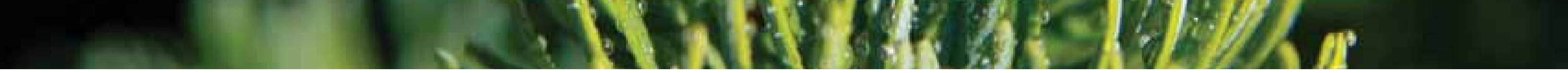
ISPM No. 14, *The Use of Integrated Meausres in a Systems Approach for Pest Risk Management*, was published in 2002 (FAO, Rome). Since that time, the systems approach has been embraced by several countries as a way to reduce the movement of pests and pathogens with nursery stock.

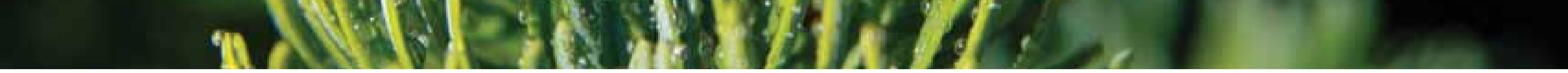
The United States, Canada and Mexico are moving towards adopting a requirement that all nursery stock imported from off-continent sources be produced in approved systems approach programs.

The European Union is also drafting similar requirements and is using the North American systems approach programs as a template.

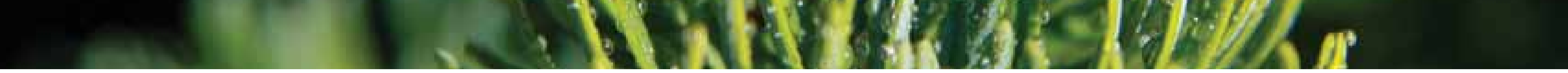
Thus, for the current level of international trade in nursery stock to continue, a significant amount of plant material will need to be grown using an approved systems approach.

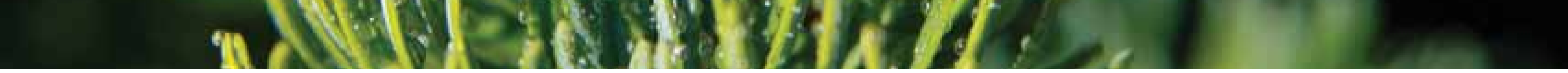
Systems approach programs such as the CNCP and the USNCP are currently in place at only a few nurseries in Canada and the United States. As currently configured, these programs require a great amount of recordkeeping and are expensive to administer. Development, piloting and evaluation of new systems approach programs that focus more on production factors, along with the development of new CCPs and best practices will be needed to help the nursery industry meet increasing international phytosanitary requirements and to produce the healthiest stock possible for their customers.





Appendix





Glossary

APHIS — The **Animal and Plant Health Inspection Service**. The branch of the USDA with a mission area that includes protecting and promoting U.S. agricultural health, regulating genetically engineered organisms, administering the Animal Welfare Act and carrying out wildlife damage management activities.

Audit — An examination of all or a part of a facility, which may include review of documents, plant material, growing inputs and staff interviews to assess conformity to the phytosanitary program.

Best practice — An effective way to address an issue, such as preventing or reducing pest and pathogen problems. This term is related to best management practices (BMPs) and best plant production practices (BPPPs), but it is broader. Consequently it is the term we have used throughout this guide.

BMP — **Best Management Practices.** These are processes and actions based on the best available science that provide the most cost-effective and efficacious way to address an issue, such as preventing or reducing pest and pathogen problems.

BPPP — **Best Plant Protection Practices.** These are processes and actions based on established phytosanitary principles that prevent the introduction and spread of plant pests and pathogens. BPPPs, unlike BMPs, do not consider cost. A BMP must be the most cost-effective solution, but a BPPP need not be. For some of the best practices in this book, cost has been evaluated. For others, it has not. Therefore we have used the broader term “best practices” throughout this guide.

Control point — A step in a system where specific procedures can be applied to achieve a defined effect and can be measured, monitored, controlled and corrected.

Critical control point (CCP) — A step at which control can be applied and which is essential to prevent or eliminate a hazard or reduce it to an acceptable level.

Critical limit — A criterion which separates acceptability from unacceptability.

Certified facility — A status granted to a facility, confirming that the facility has met all the terms and requirements of the phytosanitary program and that it has passed all audits and is in good standing.

CFIA — **Canadian Food and Inspection Agency.** The U.S. equivalent is the USDA.

DHS — The **U.S. Department of Homeland Security.**

EPM — **Export production manual.** This is a nursery-written set of procedures that show how the nursery will comply with the program standards of the U.S. Nursery Certification Program.

FIFRA — **Federal Insecticide, Fungicide and Rodenticide Act of 1972.** This is the basic federal pesticide law of the U.S.

GAIP — The **Grower Assisted Inspection Program.** This is a pilot systems approach program for foliar *Phytophthora* species being conducted in Oregon.

HACCP — **Hazard Analysis of Critical Control Points.** This is a risk management system which identifies, evaluates, and controls hazards in a production system.

ICAR — **Internal Corrective Action Request.** This is a document issued by the nursery staff that identifies a non-conformance with the phytosanitary management program, pest management plan or other program standard. An ICAR also gives guidance on how to effectively correct the non-conformance.

IPPC — **International Plant Protection Convention.** An international agreement on plant health with 173 current signatories, including the United States.

ISPM—**International Standards for Phytosanitary Measures.** These are guidelines designed to achieve international harmonization of phytosanitary actions, to facilitate trade and avoid the use of unjustifiable measures as barriers to trade.

NAPPO — The **North American Plant Protection Organization** is a regional phytosanitary organization that develops agreements on plant health between Mexico, Canada and the United States.

Non-conformance — A non-conformance is said to occur when a certified facility fails to meet the requirements of its phytosanitary management program, pest management plan or other requirement of a systems approach program.

Pest management plan — A written plan that describes processes and procedures designed to consistently meet the level of pest and pathogen control required by the systems approach program.

Phytosanitary — Items or actions pertaining to a commodity and any regulated pests associated with that commodity.

Phytosanitary management system — The systems approach used by the facility to meet all of the requirements of the program's standards.

Plants-for-planting — The accepted phytosanitary term for nursery stock.

PPQ — **Plant Protection and Quarantine.** This is a branch of the USDA Animal and Plant Health Inspection Service. It is responsible for protecting and promoting plants and plant products.

Regulated pest — Pests or pathogens that are restricted in trade including quarantine organisms and regulated non-quarantine organisms (RN-QP).

Quarantine pest — An organism of potential economic impact in the receiving area and not yet present in that area, or not widely present in that area and under official control.

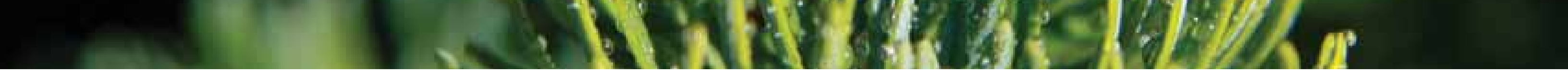
RSPM — **Regional Standards for Phytosanitary Measures.** These are guidelines designed to achieve regional harmonization of phytosanitary actions, facilitate trade, and avoid the use of unjustifiable measures as barriers to trade.

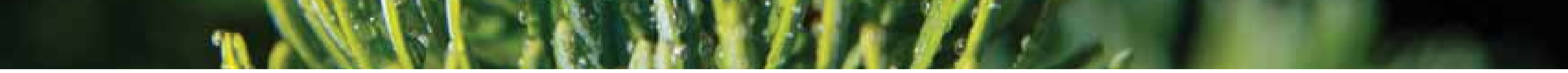
RN-QP — **Regulated Non-Quarantine Pests.** These are pests associated with plants-for-planting that cause unacceptable economic impacts to that plant material and are regulated by the receiving area.

Systems approach — The application of different pest risk management measures, at least two of which act independently but with cumulative effect, to apply the appropriate level of phytosanitary protection.

USDA — **United State Department of Agriculture.** This federal department is responsible for U.S. policy on farming, agriculture and food. Its responsibilities include promoting agricultural trade and production, working to assure food safety and protecting natural resources.

USNCP — **United States Nursery Certification Program.** A pilot accreditation program that uses a systems approach to produce nursery stock as detailed in Regional Standard for Phytosanitary Measures (RSPM) No. 24.





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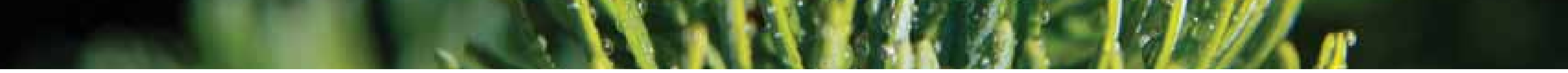

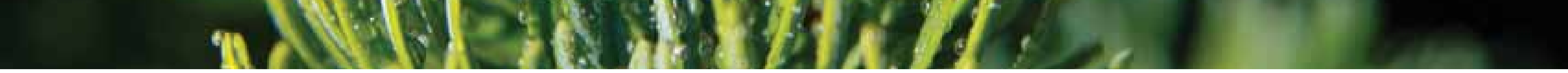

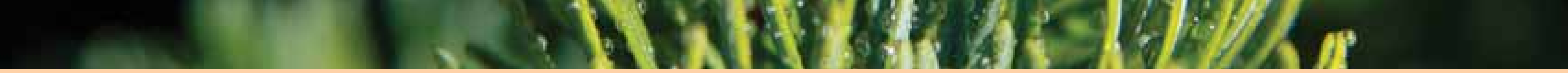

What is the 'systems approach' — and why do I need it?

When it comes to preventing the introduction and spread of plant pests and pathogens, a proactive approach that intelligently targets areas of highest risk is better than reacting to things as they happen. The goal of a systems approach isn't perfection — it's significant risk reduction. By making your nursery less susceptible to the introduction and spread of regulated pests and plant pathogens, you will be able to reduce the risk of quarantines and crop destruction.

(Cover photographs by Curt Kipp, Oregon Association of Nurseries.)

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