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Sustainable Small-scale Nursery Production

Horticulture Systems Guide

Abstract: *This publication focuses on sustainable production of nursery plants, woody and herbaceous, both in the field and in containers. It is not meant as a primer for inexperienced growers, but rather as a complementary piece of information that concentrates on sustainable production techniques. Some of the topics covered include integrated pest management, weed control and alternative fertilizers. Topics related to business management are also introduced.*

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Table of Contents

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NCAT

Introduction

This publication is geared toward small-scale nursery managers who want to use sustainable practices, and larger-scale nursery managers interested in converting from conventional to sustainable practices. (For the purposes of this document, small-scale can be defined as having fewer than five acres in container production and fewer than 15 acres in field production.) It is not meant to include everything one needs to know before going into production. A nursery can be part of a diversification strategy to make a farm more profitable, or it may be the only enterprise. In either case, it is important to start small and expand later.

For general information on standard nursery production, please refer to publications and bulletins published by the Cooperative Extension Service, and common horticultural texts and trade magazines. See the **Resources** section at the end of this document for a listing of nursery literature.

This document discusses sustainable nursery production in general before going on to container and field production techniques. Sustainable nursery practices usually involve reduced levels of synthetic fertilizers and pesticides, use integrated pest management systems to deal with insects, diseases, and weeds, and focus on building the soil to promote plant health.

The nursery industry as a whole has grown 10–20% a year during the past decade. Nursery sales follow the economy in general. When times are tough, people stay home more and garden, but they buy smaller, less expensive plants. When the economy is doing well, homeowners often buy more, larger plants for entire landscaping projects. In general, though, no matter what the state of the economy, it usually takes five to seven years for a beginning nursery business to show a profit.

The most important things to consider before actually beginning production are what crops to grow and how to market them. In today's economy, it is no longer possible to grow crops without first considering how they will be marketed. Here are some facts to keep in mind before starting out.

- Container-grown crops generate about ten times more sales per acre than field crops (1).
- Approximately 80% of a lawn and garden center's customers are drawn from a five- to fifteen-mile radius (2). Over 60% of an average wholesale nursery's sales are within the state. Small nurseries sell about 20% of their plants out-of-state (1).
- Retail garden centers usually want small plants in 1–3 gallon containers. Landscaping firms and landscapers are more often interested in larger container plants (3–5 gallons) and balled and burlapped (B&B) woody plants (1).
- The nursery industry is very dependent on the construction industry and on the rate of unemployment in the vicinity of the nursery.

Marketing

Anyone contemplating entry into the nursery business will need to conduct a market analysis to determine what opportunities exist to sell plant materials in the local area. Most new firms begin with only a few acres of production and initially market primarily within a 50-mile radius, unless growing for mail order or on contract (1). Part of this market analysis includes finding out what crops other nurserymen have grown successfully in the region, and, secondly, what the competition is like.

When considering which market you will serve, bear in mind this advice from Lynn Byczynski, editor of *Growing for Market*, a newsletter geared to small-scale producers: "I feel quite strongly that it is a serious mistake to commit to growing for anyone before you have become extremely confident of your skill as a grower. My recommendation for marketing is

a simple one: Start where no one is depending on you. If you have nothing to sell, no one will have to know" (3). For more in-depth information on marketing, request the ATTRA publication *Direct Marketing*.

Marketing really begins with a decision on what to produce and at what volume. The primary considerations are:

1) deciding who your customers are,
2) determining what type and size of plants these customers want,
3) keeping up with trends in buyers' preferences,
4) knowing what combination of plants will maximize profits (1).

The following paragraphs will address each of these topics.

Who are your potential customers and what plants do they want?

Mass merchandisers usually want large volumes of a few types of the more popular species of plants. Usually, they purchase smaller sizes and may not be particular about the specific plants as long as they are able to obtain a good mix of fast-moving materials. Demand from these customers is very seasonal (1).

There are several disadvantages to dealing with mass merchandisers: they often want instant shipment, they usually pay the lowest price for plants, and they often do not take care of the plants after receiving them, which can reflect poorly on your nursery.

Landscapers look for large high-quality specimens carefully identified by cultivar. Generally, they want to buy plants from a limited number of producers, but they also want to be able to choose among many plants and sizes. Their purchases are more spread out over a year, but there is an emphasis on spring planting (1).

The *lawn and garden center* falls somewhere between the mass merchandiser and the landscaper. Some centers want more variety in plants and sizes, some less.

Other retail outlets include *mail order, web-sites*, and *farmers' markets*. Selling through mail order and websites may involve national advertising, a catalog, and a larger inventory. Sales at farmers' markets will be local, but "local" can mean weekly travel of 200 to 300 miles to a large, metropolitan area.

No matter who your potential customers are, one thing they all have in common is that they need to know they can get uniform, well-grown plants from the producer without having to inspect the crop each time they make a purchase (1).

Keep up with trends in buyers' preferences and watch for service opportunities.

Once the nursery is in operation, constant monitoring of customer characteristics and their purchases should begin. Advertising and promotion are never-ending.

Table 1. Types of Nursery

Type	*Description*
Grower/Retail nursery	Usually a retail outlet with sufficient acreage for growing on-site
Wholesale Nursery	Grows plants for sale to other nurserymen, landscapers, or retailers; may grow plants on a contract basis
Landscape nursery	Provides landscape services and retail sales
Farmers' Market	Sells locally at retail prices
Mail order/Website	Sells at the national level

A survey taken in 1992 analyzed the needs of landscape architects in Georgia and identified the following areas of improvement for growers (4):

- ensure reliable and consistent plant availability
- develop plant varieties for specific needs
- supply plants that meet specified sizes
- recommend plant varieties for specific conditions
- provide photographs of plants
- make presentations to landscape architects

The most common complaints that landscape architects had about growers and nurseries was that the plants provided them were below the specified size and quality.

Know what combination of plants maximizes profits.

Ornamentals fall into general categories: shade trees, conifers, perennials, vines, shrubs, bulbs, and annuals. While most nurseries grow a range of plants, there appears to be a trend toward specialization. For example, growing only native groundcovers, or only daylilies, are viable niche markets. The production of specialty crops (e.g., hardy bamboo, disease-free apple stock, native plants, etc.) and specialization in plants in short supply (e.g., native plants, uncommon plants, very large trees) are niche markets that even small growers can serve.

General Production

There are two types of nursery production: *field* and *container*. Field stock is either direct-seeded or transplanted from seedlings, then lifted as bare-root stock for use as nursery liners, fruit trees, seedlings for Christmas trees, windbreaks, and conservation plantings. Field stock is also grown for balled and burlapped (B&B) landscape or shade trees. Container stock, which is propagated from seed, rooted cuttings, and field-grown seedlings, is common in both forestry and landscape nursery production.

Grower profile
Silver Springs Nursery, Idaho

James Kraemer began growing native groundcovers in 1987. He found customers by advertising in trade publications and attending trade shows. His major customers are larger nurseries that want small plants to grow out into gallon pots. James fulfills their needs by starting native plants from seed—plants like bunchberry dogwood (*Cornus canadensis*), kinnikinnik (*Arctostaphylos uva-ursi*), twinflower, and Oregon grape (*Berberis repens*).

It took time to build the nursery into a business that could support James and his family. For the first three years, Kraemer had a full-time job and worked forty hours a week in the nursery. By the fifth year, however, the nursery was his sole source of income.

All the groundcovers are grown on less than one acre, using four greenhouses and an outdoor holding area for larger plants. He focuses on growing plants in 8-inch-deep tubes, which he sells to other nurseries to grow out.

In 1992, Kraemer contracted with the Soil Conservation Service (now the Natural Resources Conservation Service) to grow native drought-tolerant plants for slope retention. This led to other orders from SCS, and Silver Springs became one of only two nurseries approved in Idaho and Montana as a source of native plant materials (5).

Fifty years ago, most ornamental plants were grown in the field, then dug up for transplanting purposes. Today, 80% of ornamental plants are grown in containers. The switch has occurred for several reasons: container-grown trees have a greater chance for survival and establishment after transplanting than do trees produced in the field; containerized production does not require good soil and takes up less acreage;

and containerized stock enables the grower to extend the planting season. Both container and field production will be discussed separately, but there is some commonality between the two forms of production. For instance, most woody landscape plants are propagated by cuttings (1). Another similarity is that both types of production spend a good percentage of their budgets on farm-type mechanized implements and fertilizers (1).

Five major considerations in determining where to establish a new nursery are soil, climate, water, market, and labor supply. Soil productivity is not as important when growing only containerized products, but relatively level land with good drainage is still necessary. Of concern for the beginner is learning the length of time required to produce saleable crops and how to schedule these so that the proper number of each species is available for the first year of sale and each year thereafter (1).

Irrigation

The two most widely used irrigation systems are overhead and drip (or trickle). Overhead irrigation is designed to cover a large area, and these systems are the least expensive to install. However, this method produces uneven water distribution, which can slow plant growth, encourage disease, and contribute to runoff. Also, a container nursery using overhead irrigation can use from 15,000 to 40,000 gallons of water per acre per day in the summer (6), a reminder that **sufficient water is a prerequisite to nursery production.**

Large containers are usually watered with a drip or trickle system, which uses 60%–70% less water than overhead systems. Drip irrigation systems cost more to install than overhead systems, but have superior application uniformity and efficiency. They are also less affected by wind and crop canopies, and they produce less runoff. Another advantage is that workers can continue working while the plants are being irrigated. The biggest disadvantage to trickle irrigation, besides the initial cost, is keeping the pipes and emitters clean.

A third, less-used type of irrigation system is subirrigation using capillary sandbeds. In this system, water rises into containerized plants through capillary action. Usually, the sandbed is covered with at least one inch of fine sand, and slopes very slightly from one end to the other. Water is released at the high end and slowly percolates to the low end. These systems cost the most to install, but they have no runoff or leaching.

> Sandbeds are normally constructed using wood sidewalks, a plastic bed liner, sand, a small tank, a drainpipe and a float valve. They do not require the use of any electrical parts, and provide a uniform and consistent supply of water without forming a saturated water table at the base of the soil column in the container. In short, you get efficient and uniform crop growth while providing less water, less fertilizer and less pesticide. It also requires less labor, as sprinkler heads, timers, pumps, valves and water-treatment systems don't need to be monitored (6).

The biggest disadvantage of sandbeds is that weeds and containerized plants grow into them. There is a product designed to alleviate this problem: the Agroliner™, a mat that has been treated with Spin Out™, a product that prevents root growth. (For more information on Spin Out™, see the **Container Production** section.) The mat is placed over the sand and under the containers. For distributors of this product, see the **Resources: Suppliers** section. For a list of articles related to sandbeds and subirrigation systems, see **Resources: Publications**.

Regardless of the irrigation system used, it is vital that the plants be watered often, especially during hot, sunny days. A typical nursery plant in a 1-gallon container may consume a pint of water a day, while the growing medium capacity may be only 1½ pints. One important aspect of irrigation management is to group plants according to water requirements.

Table 2. Comparison of Water Systems for Container Nursery Stock (7)			
	Overhead sprinklers	**Drip irrigation/ "spaghetti" tubes**	**Capillary beds**
Installation cost/acre	Moderate	Moderate to high	High
Maintenance	Low	High	High
Durability	Excellent	Low	Moderate
Labor	Low	Moderate-high	Low
Water distribution	Fair	Fair-good*	Good
Water use efficiency	Poor, very wasteful	Good	Good
Pump required	Large, high pressure	Small, low pressure	Small, low pressure
Water volume required	Large	Small	Small
Wind effect on distribution	Serious	None	None
*If ground is level and water quality is good			

Irrigation Runoff

The most important issue in sustainable nursery production, as it relates to irrigation, is the runoff of water, fertilizers, and pesticides. Many states now have regulations limiting runoff and groundwater nitrate levels.

Subirrigation systems are designed for zero runoff, but overhead and drip systems may require special attention. Runoff water can be collected by using ditches (planted with grass to slow down water flow) or tile systems, which direct water to a pond or other holding area.

The water (and some of the fertilizers present) can then be recycled by pumping it back out of the holding tank or pond, after some of the impurities (sand and silt) have settled out. Recycled water has actually been shown to improve plant growth. "In experiments with more than 100 species of ornamentals grown in 2.8 liter containers, the mean relative growth of plants irrigated with continuously recycled water was 103% over that of the control" (8).

Another way to reduce runoff is to use pulse irrigation. In this system, instead of applying one heavy watering daily, a small amount of water is applied five or six times during the day. Very little water escapes from the container or runs off from the field. The production advantage to this is that less fertilizer has to be applied, because there is less leaching. Most nurseries that use this system use a computer to control water flow, since watering plants repeatedly by hand would cause a huge increase in labor expenses.

There are several cultural practices that can reduce runoff:

- Avoid irrigating bare soil
- Have rough soil surfaces to provide surface storage of water
- Use less-porous media that retain moisture and nutrients
- Use slow-release fertilizers instead of liquid fertilizers

Researchers at Ohio State University have been conducting experiments to reduce the amount of pesticides and growth regulators leached from nursery pots and trays. They have had excellent success in mixing chemicals in ordinary latex paint and then painting the interior of the pots. Not only was there less leaching from the pots, but the growth regulator and pesticide they used (Bonzi™ and Marathon™) provided more consistent control. This method also reduced worker re-entry intervals (REIs) into the nursery area, since the chemicals were applied only once, at the beginning of the growth process (9).

A study conducted in the late 1990s found that "growth may be more effectively maximized by reducing moisture stress than by increasing fertilizer concentration" (10). This study, also conducted at Ohio State University, used fertilizer concentrations between 50 and 200 mg/L of nitrogen. The researchers showed that water stress might limit growth more frequently than does limited nutrition under current container production practices, and that ensuring that plants do not wilt is not sufficient. Their recommendation was to use lower amounts of N fertilizer (50 mg/L) and to provide sufficient moisture.

Several Extension bulletins and other publications that deal with irrigation runoff issues are accessible on the Web. See the **Resources: Websites** section for more information.

Integrated Pest Management

"IPM is a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks" (11). An integrated pest management (IPM) program involves using resistant cultivars, building up populations of beneficial organisms, monitoring numbers of pests and developing treatment thresholds, and using spot treatments of pesticides that are least harmful to beneficial organisms and the environment. It is important to identify pests early, so that appropriate measures can be taken quickly.

Again, there are numerous publications available from Extension that deal with integrated pest management for nurseries. See the **Resources** section for more information. A shaded box on this page identifies several related ATTRA publications.

Container Production

A wide selection of ornamentals is produced in containers. Homeowners usually prefer to buy containerized plants because they are easier to transport and transplant than B&B plants. The following section will summarize some important container production practices as well as address sustainable nursery management issues like recycling of plastics, weed control, and fertilization.

ATTRA Publications on Nursery-related Pest Management Topics

Biointensive Integrated Pest Management
Alternative Nematode Control
Use of Baking Soda as a Fungicide
Compost Teas for Plant Disease Control
Disease Suppressive Potting Mixes
Integrated Pest Management for Greenhouse Crops
Greenhouse IPM: Sustainable Aphid Control
Greenhouse IPM: Sustainable Thrips Control
Greenhouse IPM: Sustainable Whitefly Control

The advantages of containerized production include:

- High plant densities
- Use of land unsuited for field production
- Planting times independent of the weather
- Elimination of some operations (like root pruning)
- Lower transportation costs because of lightweight media
- Less root loss and a greater chance of survival than with field-grown trees

The disadvantages are also numerous:

- Small containers need frequent watering
- Nutrients are rapidly depleted
- Plants require winter protection
- Plants easily become root-bound
- Trees are knocked over by wind
- Containers are costly
- Labor costs to pot up plants are high
- Roots are stressed by temperature extremes

Certified organic nursery stock (intended for sale to vineyards, berry farms, and orchards raising organic produce) is a niche market that requires special attention. Restricted products include many of the common ingredients in conventional nursery production, such as chemical fertilizers, wetting agents, herbicides, and synthetic insecticides and fungicides. For more information, refer to ATTRA's publication on organic certification.

Containers

There are several factors to keep in mind when deciding which containers to use: cost, design features that control root growth, how the container affects growing medium moisture content and temperature, availability, how the container suits the particular needs of the nursery, durability, and shipping capacity.

Round black-plastic pots are the norm, but they can cause root constriction, leading to plants with poorly developed root systems. There are other kinds of containers that promote better root systems. For instance, copper-lined, white, and light-colored containers produce more root growth, and square and stair-step pots help keep plants from becoming root-bound (1). Pots and containers designed for enhanced root growth have become such an important feature in containerized nursery production that a few examples are provided below.

Copper

Foresters first discovered that copper could be used to control root growth. Copper kills root tips that come in contact with it; this forces roots to branch within the root ball, instead of circling around it.

Not only are plants grown in copper-treated containers less root-bound, they also are taller, have higher transplant survival rates, and have increased nitrogen recovery (so they require fewer applications of nitrogenous fertilizer). More than 120 species have been shown to perform better in copper-treated containers than in untreated ones. Also, there is very little or no leaching from copper-treated pots into groundwater or soil.

Copper-treated fiber pots, made from recycled paper, are one option. Fiber pots are biodegradable and can even be composted; the main problem with them is that they can degrade too quickly. Research at Ohio State University showed that incorporating copper into fiber pots can increase their longevity (12). Dr. John Ruter at the University of Georgia found that copper-treated fiber pots keep roots cooler in summer, increase root dry weight and shoot dry weight of several species, and can well withstand shipping (13).

Griffin LLC in Valdosta, Georgia, offers a product called Spin Out™, a copper paint registered by the EPA. Root Right™ pots are round black-plastic pots that have been manufactured with Spin Out as a component of the container walls. For more information on Spin Out and Root Right pots, contact the Lerio Corporation (14).

Bottomless Pots

Another way to prevent root circling is to use air root pruning. This works in much the same way as copper: root tips that come in contact with air are killed and the root system branches out within the root ball.

Growing tree seedlings in bottomless milk cartons is one way to use air root pruning. The milk carton, when folded open, creates a long square bottomless container. These containers are placed in a wooden flat with a wire-screen bottom and then filled with a soilless nursery mix. (Another option is to place them in plastic milk crates.) When the seedling germinates, the taproot grows downward and out through the bottom of the container where the root tip is exposed to the air, becomes desiccated, and dies back. Repeated air root pruning stimulates lateral branching and results in a fibrous root system as opposed to a strong taproot system. The benefit to the tree is rapid establishment in the field or landscape with increased scaffold branching and top growth. Nursery stock production by the milk carton method is especially useful for on-farm tree production and can be used in the propagation of a wide range of woody plants, including strong tap-rooted species such as black walnut and pecan, as well as pines for Christmas trees.

There are other types of containers that promote excellent root branching and discourage root circling. One of these products is RootMaker™, developed by Dr. Carl Whitcomb at Lacebark, Inc. (Dr. Whitcomb,

formerly head of the nursery research program at Oklahoma State University, is well known for his numerous innovative approaches to unusual container systems.) RootMaker pots have staggered walls and a staggered bottom, which prevent root circling and direct roots toward the many holes in the walls and bottom of the pots.

Tubes

Growing plants in long bottomless tubes is another production system that uses air root pruning. The tubes are generally made of plastic or styrofoam, and can be single tubes or imbedded in a flat. Tube plants range in size from large plugs (sold as nursery liners) to seedling trees grown in long, narrow pots (sold directly to consumers). Regardless, tubes are popular because massive quantities can be quickly grown in a small area. Tubes are particularly adaptable to small-scale nursery production and to specialized stock like perennials and tree seedlings.

For more information on containers, see *The Container Tree Nursery Manual, Volume 2*, by Landis et al., listed in the **Resources: Publications** section. For suppliers of unusual pots, see the **Resource: Suppliers** section.

Pot-in-Pot System

The pot-in-pot method of production was developed to alleviate some of the problems associated with container production, such as blowover and moisture loss (15). This system involves burying a holder pot, or moat pot, into the ground, and placing a containerized plant inside this pot. The greatest drawback to this system is the high initial cost of the moat pot. But the moat pot is a long-term investment, since it will last for 15 years or more. For more information on pot-in-pot systems, see the articles listed in the **Resources** section.

Recycling Plastic

Most nurseries use lots of plastic, in the form of pots, flats, hanging baskets, and greenhouse

A container system that emphasizes hardy, fibrous roots

Cherry Lake Tree Farm in Groveland, Florida has developed a better way to grow containerized trees (16). Their patented Root-Enhancement System focuses on growing trees with a fibrous, lateral root system. The system has ten main components: Deep Groove Tube cell-pack trays, Tree Band containers, air-pruning benches, Spin Out used on all the containers, 3-gallon container sleeves, 3-gallon grids, 15-gallon container sleeves, Lacebark grow-bags, Root Control grow-bags, and a final Spin Out-treated container.

In the first stage, small liners are raised in Deep Groove Tube cell-pack trays of 38 or 51 cells, available from Growing Systems, Inc. (17). These are cone-shaped and lined with four vertical ridges that guide a plant's roots to the large hole at the bottom. These trays are placed on benches in the greenhouse. Larger liners are planted in Tree Bands, available from Anderson Die and Manufacturing (18). Before planting, all the trays are sprayed with Spin Out.

When the liners are ready to be potted up, they are inspected. Those with weak root systems are culled, and the rest are placed in 1- or 3-gallon containers. These pots contain grids that sit about an inch above the bottom of the pots and cause roots to be air-pruned. Container sleeves are also used to hold the roots. The sleeves are made of a reusable geotextile pruning fabric developed by Cherry Lake and manufactured by Root Control, Inc. in Oklahoma City (19). The fabric lowers root zone temperatures and prunes roots.

After the trees have reached transplantable size, they are either placed into pot-in-pot containers or transplanted into growbags. Finally, the trees are placed into a Spin Out-treated container in preparation for sale.

film. While some of these can be re-used within the nursery, it's important to have a recycling system in place. Buying multi-year, ultraviolet-stabilized greenhouse film will decrease the amount of sheet plastic used each year, but this kind of film is very expensive and not always readily available (20).

Fortunately, there are a number of recyclers around the country who accept nursery plastic. The American Plastics Council website <http://www.plasticsresource.com> provides a wealth of helpful information on recycling of plastics, and maintains the United States & Canada Recycled Plastic Markets Database <http://markets.plasticsresource.com> with contact data for plastic recycling centers on a state-by-state basis.

It Ain't Hay: Recycling Agricultural Film. Resource Recycling, June 1997.
http://www.plasticsresource.com/reading_room/articles/97june_hay.html

Recyclers that accept agricultural plastics often have certain restrictions. They may require that sheet plastic be clean, which often means washing it before storage. It must also be stored properly, indoors. Most hard plastics (plug trays, flats, pots, hanging baskets) are either No. 6 polystyrene or No. 2 high-density polyethylene. This distinction is important to some recyclers (20).

Many recyclers require that a certain amount of plastic be gathered, before it is worth their time to send a truck to pick it up. Smaller nurseries may have trouble storing that amount of plastic. A way to get around this is to combine plastic waste with other growers in the community. Some recyclers will not pay the grower for the plastic, but neither will they charge transportation costs, which are often high.

Weed Control

Weed control is extremely important in container production. Weeds not only compete for water and nutrients, but they can also hinder sales of nursery stock. Weed control efforts should focus on two areas: in the pot and under the pot.

When deciding how to treat a weed problem, the grower should ask herself several questions: Are the weeds mostly annuals or perennials? Are they easy to pull? Does the problem exist only in a small group of plants or is it widespread? Are the weeds monocots (grasses) or dicots (broadleaf)? What time of year is most effective for controlling these weeds?

Sanitation is the least costly and most effective method for controlling weeds. To prevent weed seeds from blowing into pots, attention to a vegetation-free zone—both on and surrounding the production bed—is critical. To keep weeds from growing under the pot, more and more growers are placing the containers on geotextile weed barriers (often called fabric weed barrier or landscape cloth). Modern landscape cloths are durable and long-lasting—they can last for 10 to 12 years in full sun. They do an excellent job of controlling weeds, yet they are permeable to water from irrigation and rainfall, so drainage is not a problem. Although the initial cost is high, the expense can be pro-rated as an annual weed control investment.

Hand weeding is costly, but it may be appropriate in a small nursery setting. Weeds must be removed when they are still small, since large quantities of media are lost when big weeds are pulled out of containers.

Herbicides, on the other hand, are widely used in container nursery production. Even though weed-free media is used to establish nursery plants, wind and birds and surface irrigation

water are sources of weed seeds that get deposited onto the pot surface. Broadleaf and grassy weeds love to get a free ride into the container nursery, because the growing conditions in a media-rich pot are absolutely perfect. Thus, pre- and post-emergent herbicides are commonly used in commercial nursery production to control these free-loaders.

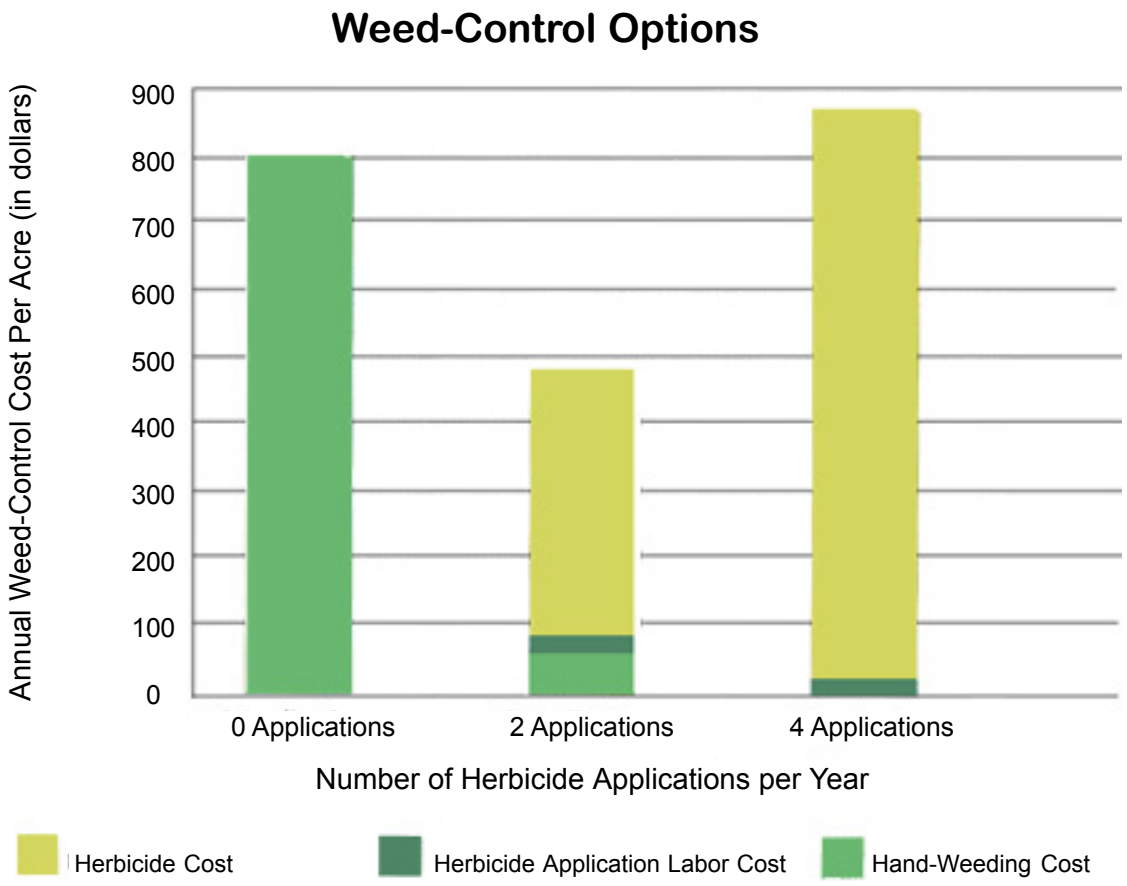
In 1991, Monrovia Nursery compared hand weeding to spraying herbicides and found that a combination of the two was the least costly method (21). (See Figure 1 below.) When they used no pre-emergent herbicides, it took workers 10 hours of hand weeding per acre, performed 10 times a year. By using a pre-emergent once in the spring and once in the fall, the workers were able to perform hand weeding only seven times a year for one hour per acre. Other pertinent information: the workers were paid $8 an hour; the cost of herbicide was $200 per acre per application and it took two hours to apply it.

More information on weed control is presented in the **Field Production** section below.

Alternatives to Herbicides

Fabric weed barrier disks can be used to control weeds in containers. The fabric disks are pre-slitted and fit on top of the pot around the stem. They prevent weeds from growing in the containers by excluding sunlight and inhibiting weed germination. The disks are permeable to air and water but prevent germination of troublesome container-nursery weeds like oxalis. An added benefit of the disks is that they reduce evaporation.

Figure 1. *Courtesy of American Nurseryman (21). Used with permission.*



Tex-R Geodiscs® are fabric disks that have been treated with Spin Out™ and work the same as the disks mentioned above. They prevent weed growth by excluding light and pruning the roots of weed seeds that are blown onto the fabric. They provide effective weed control for up to three years and can be moved from pot to pot. For distributors, contact Texel USA (22).

Professor Bonnie Appleton at Virginia Tech recently conducted research using Geodiscs on container-grown willow oaks (23). The Geodiscs suppressed all weeds completely. Trees grown in the pots with Geodiscs had higher top dry weights and root dry weights than both those grown without any form of weed control and those sprayed with a conventional herbicide.

Bioherbicides

A recently introduced organic weed control is corn gluten meal (CGM), a by-product of corn syrup processing. CGM is a pre-emergent herbicide, applied in early spring. It works best when applied to the top ¼ inch of soil. It has no carry-over into the second year of growth, so it must be applied every year. CGM contains 10% nitrogen and acts as a slow-release fertilizer for the crop. CGM has been patented and is currently being sold as a herbicide (see the **Suppliers** section for sources), but treating a large area can be quite expensive. Wheat gluten meal has many of the same effects as CGM, but it has not been patented and so may be more affordable.

More recent research has revealed that corn gluten hydrosylate (CGH), which is made from corn gluten meal, is more effective than corn gluten meal for controlling weeds (24) and could be applied at less than half the rate for effective weed control. Iowa State University—patent holder of corn gluten meal as a natural herbicide—maintains a web list of licensed suppliers for this product (see **Resources: Suppliers**).

There are some new environmentally friendly contact herbicides that break down quickly and provide options for weed control in container nurseries around irrigation risers and perimeter areas, as well as for general use in field nursery production. One class of products—Weed Eraser™, Scythe™ —is made from pelargonic acid, a fatty acid found in plants and animals. They work by rapidly lowering the pH of any plant sprayed, which weakens the cell walls and kills the weed, usually within two hours. A second class of products—Nature's Glory™, Burnout™, and Bioganic™—contain acetic acid (vinegar), lemon juice, eugengol, thyme oil, orange oil, and other natural ingredients. All of these products work as contact herbicides and control, with varying degrees of success, broadleaf and grassy weeds. Application to nursery plants should be avoided, and several applications may be necessary to kill perennial weeds.

Fertilization

Container nursery production has become a huge success largely due to advances in media and fertilizer combinations. This has resulted from several decades of research collaborations between land-grant universities, commercial nurseries, and the fertilizer industry. Commercial synthetic fertilizers (including slow-release and liquid fertilizers) have played a key role in this picture. Detailed information on commercial nursery mixes and fertilizer systems is widely available through the Cooperative Extension Service.

As organic production becomes standardized under the new federal Rule, more and more nursery growers are looking at organic fertilizers and wondering how they can be used. Unlike synthetic greenhouse fertilizers, organic fertilizers have been given little research to support their use in a nursery mix recipe. Most of the following material will focus on organic fertilizers for container nursery production. Regardless of fertilizer type—whether the source is synyhetic or organic—in sustainable nursery production the emphasis is on zero runoff. Excessive nitrates and phosphorus are the most common problems in runoff water (25).

There are four basic ways to fertilize containerized plants: incorporate, topdress, liquid feed, and foliar feed. In a nursery container, fertilizer incorporation in the mix combined with liquid feeding should provide sufficient nutrition.

Organic fertilizers that can be incorporated to provide nitrogen include alfalfa meal, blood meal, cottonseed meal, feather meal, hoof and horn meal, soybean meal, and animal manures, among others. Materials that provide phosphorus include oak leaves, bone meal, shrimp wastes, residues from raw sugar, and various forms of rock phosphate. Greensand, granite meal, soybean meal, ash from orange and potato skins, unleached wood ashes, K-Mag™, and tobacco (stems, leaves, and stalks) all provide potassium**.** Table 3 is not exhaustive, but it provides analyses of some popular organic and synthetic slow-release fertilizers.

Table 3. Analysis of Organic and Synthetic Slow-release Fertilizers

Organic Fertilizers	**%N**	**%P**	**%K**	**Other nutrients**
Bat guano (fresh)	10	3	1	Calcium
Bat guano (old)	2	8	0	Calcium
Blood meal	10	0	0	
Bone meal (steamed)	1	11	0	Calcium
Cottonseed meal	6	2	1	
Eggshells	1.2	0.4	0.1	Calcium and trace minerals
Fish emulsion	4	1	1	Sulfur
Fish meal	5	3	3	
Greensand	0.0	0.0	7.0	32 trace minerals
Hoof and horn meal	12	2	0	
Kelp meal	1.5	0.5	2.5	Trace minerals
Manure:				
Cow	2	2.3	2.4	
Horse	1.7	0.7	1.8	
Pig	2	1.8	1.8	
Sheep	4	1.4	3.5	
Poultry	4	4	2	
Oak leaves	0.8	9.4	0.1	
Pine needles	0.1	0.0	0.5	
Sawdust, well rotted	0.0	0.2	0.2	
Soybean meal	7.0	0.5	2.3	
Worm castings	0.5	0.5	0.3	11 trace minerals
Slow-release Synthetic Fertilizers				**Effective period**
IBDU	31	0	0	
Lesco™	20	6	12	4-6 months
MagAmp™(also contains 25% magnesium)	8	40	0	100 days
Osmocote™	13-19	6-14	12-14	3-4 or 8-9 months
Precise™	12	6	6	3-4 months
Premix™ (also contains micronutrients)	24	7	8	6-8 weeks
ProKote™	20	3	10	7-9 months
Sta-Green™	12	6	6	6-8 weeks

Table 4. Materials for Organic Fertigation*		
Element	**Material**	**Benefits**
Nitrogen	Liquified fish	Biostimulant, balanced NPK
	Liquid manures	Rapid uptake
	Phytamin 800	Rapid uptake, high solubility
	Sodium nitrate**	Rapid
	Spray-dried fish**	Rapid uptake, biostimulant
Phosphorus	Bat guano**	Rapid uptake
	Micronized rock phosphate**	Biostimulant, 16% P_2O_5
	Seabird guano**	Rapid uptake, 10% P_2O_5
Potassium	Soluble Sul-Po-Mag**	Supplies K, Mg, and S
	Soluble sulfate of potash**	50% K, 18% S
N-P-K combination	Fish products	
	Liquified manures	
	Phytamin 3-2-3	Rapid uptake
	Seabird guano** 12-12-2.5	
Calcium	Solution grade gypsum**	Calcium and sulfur
	Solution grade limestone**	98% $CaCO_3$
Sulfur	Micronized sulfur**	Up to 90% S
	Solution grade gypsum**	
Trace mineral/ Biostimulants	Compost teas	Biostimulant, humic acids
	Kelp extract powders**	Trace minerals, biostimulant
	Kelp extract liquids	Trace minerals, biostimulant
	Liquid humates	Humic acids, biostimulants
	Liquid trace minerals	Various formulations
	Micronized compost**	Biostimulant, humic acids
	Micronized humates**	Humic acids, biostimulant
	Rock dusts**	Trace minerals, biostimulant
*Reprinted with permission from Amigo Cantisano. 2000. Organic growers *can* fertigate! Growing for Market. March. p. 8-9.		
**Dry material: Must be premixed and thoroughly agitated in water prior to and during injection. May be less soluble than liquid formulations.		

Adequate levels of nutrients must be maintained in the container medium for optimum growth of woody ornamentals. The levels of soluble nutrients in containers can be significantly reduced after 3 or 4 irrigations because of limited container volume and frequent application of water. To overcome this problem, two fertilizing systems are used: slow-release and liquid.

Organic or synthetic slow-release fertilizers help cut down levels of nitrates in runoff water (1). Slow-release and controlled-release synthetic fertilizers, such as Nitroform™ and Osmocote™, are becoming more common in container production systems. For best results, they should be incorporated into the growing media, rather than topdressed. Slow-release fertilizers are often used in combination with liquid fertilization.

Nitrogen is the main nutrient supplied through liquid feeding (fertigation). Organic liquid fertilizers include fish emulsion, fish powder, blood meal, bat guano, seabird guano, worm castings, and composted manure teas. Some forms of organic fertilizers are more amenable to low-volume irrigation systems (drip or trickle). A 1992 study found that the spray-dried fertilizers fish protein and poultry protein did not clog drip emitters and microsprinklers (26). Fish protein, blood

protein, poultry protein, and brewers yeast are all available as spray-dried materials. Table 4 was compiled by Amigo Cantisano, an organic agriculture consultant in California (27).

Foliar feeding can be used to supplement soil and liquid fertilization, especially where certain nutrients are deficient and must be incorporated into the plant quickly. Filtered solutions of manure, seaweed, fish powder, and fish emulsion can be used. Seaweed is an excellent foliar material because it contains growth hormones (auxins, gibberellins, and cytokinins) as well as trace elements. Research suggests that foliar feeding programs enhance plant resistance to pest and disease attack. Compost teas are gaining popularity as a foliar feed primarily for their disease-suppressive characteristics. For more information, request the ATTRA publication *Compost Teas for Plant Disease Control*.

For more information on alternative fertilizers, request the ATTRA publications *Alternative Soil Amendments* and *Sources for Organic Fertilizers and Amendments*. Another useful resource is *Fertile Soil* by Robert Parnes (28), an in-depth publication on organic fertilizers. Parnes's book provides detailed tables on the nutrient content of various manures and plant and animal by-products.

Potting Media

Field soil is sometimes used in container mixes (10%–30% by volume), but soil is heavy and requires the additional step of pasteurization to eliminate diseases and weed seeds. The standard replacement for soil is peat moss, but there has been concern over the past few years that peat is a non-renewable resource. Consequently, research is being conducted to determine what materials can be used to replace peat. Most of the products being tested are some form of waste. For example, pine bark (a by-product of the lumber industry) is an excellent medium for containerized plants, once it has been composted. Mixes containing more than 20% composted pine bark support a significant level of suppression of *Pythium* damping-off (30). Other alternatives are coir, spent mushroom compost, paper mill sludge, apple pomace, shredded newspaper, compost, processed alfalfa, processed kenaf, recycled cardboard, and composted municipal yard waste. Most studies have shown that these alternative products should not compose more than 25–50% of the mix. For in-depth information on these topics, ask for ATTRA's publications *Organic Potting Mixes* and *Disease Suppressive Potting Mixes*.

Mycorrhizae are soil fungi that form beneficial associations with plant roots. They enable plant roots to do a better job of gaining nutrients and water. Mycorrhizae can be used

Chris Starbuck, an Extension specialist at the University of Missouri, has developed the Missouri Gravel Bed (MGB) as an alternative growing system for nursery stock (29). The MGB uses a mixture of gravel and sand to get young plants established. The MGB is inexpensive because it uses neither containers nor potting mix, but it produces healthy bare-root plants.

The gravel bed uses ½" or smaller gravel mixed with 10-15% sand, and is 14-18" deep to support 1½" caliper trees. Dormant, bare-root plants are placed in the bed in early spring. Slow-release fertilizers can be applied on top of the gravel. Plants should stay in the bed for at least six weeks, but should be pulled from the bed the same year they are placed into it. Starbuck uses an automatic trickle irrigation system.

Starbuck has helped growers in over 40 states establish gravel beds for their operations. A grower in Iowa has successfully overwintered plants in temperatures as low as -25°F. Apparently, the roots are as protected in gravel as they would be in soil, and are more protected than they would be in containers.

in field or container production; growers have been able to get better stand establishment, cut down on fertilizer, and inoculate bareroot seedlings. There are now commercially available mycorrhizae that stimulate the roots of almost all tree and shrub species. For a listing of suppliers of mycorrhizae, see ATTRA's *Sources for Organic Fertilizers and Amendments*.

Field Production

Until the 1950s, virtually all nursery production was done in the field. Field production is still widely used to produce bare-root seedlings for conservation plantings, fruit trees, and nursery liners. The most profitable product of field nurseries is B&B shade trees for the landscape industry. In-ground production is well adapted to tap-rooted tree species, mass plantings, inexpensive establishment, and large caliper (trunk diameter) size. Disadvantages include a higher percentage of plant loss and longer establishment periods after transplanting.

Field nursery production involves the use of unique soil management practices. Soil-building cover crops and crop rotations are important to maintain good soil structure, fertility, and organic matter. Living mulches are cover crops planted in the aisles to hold the soil, provide traction, increase water infiltration, and suppress weeds. Legume cover crops fix nitrogen and may be used to reduce the amount of nitrogen fertilizer applied each year. See ATTRA's *Overview of Cover Crops and Green Manures* for further information and resources.

Integrating living mulches, cover crops, and the application of high-quality composts into field nursery operations are the quickest ways to improve a nursery soil. For fewer pest problems, a diversity of species should be planted, rather than a large block of a single species followed by a large block of another. Habitat management for beneficial insects can also be practiced in a field situation. For more information on this, see ATTRA's *Farmscaping to Enhance Biological Control.*

Nursery equipment and irrigation systems for field nursery production are unique. Suppliers are listed in the *Nursery Management and Production Buyer's Guide* and in the magazine *American Nurseryman*. See the **Resources** section for contact information.

A recent innovation in field nursery production is the use of in-ground fabric containers, sometimes called *root control bags* or *field grow bags*. These containers were developed in the early 1980s by Dr. Carl Whitcomb at Oklahoma State University. The bags have a fabric or clear polyethylene bottom stitched or glued to walls made of nonwoven fabric, and they come in several sizes (31). In theory, they combine the best qualities of container and field production. The advantages of field grow bags are numerous: they enhance rooting; fewer roots are lost at transplanting (80% of the roots are left intact); harvesting is easier; they save labor and time; no special machinery is needed at harvest; and they can be harvested year-round (B&B are normally harvested only during dormancy) (31). There are also disadvantages: the initial investment in grow bags; more need for staking and water after transplanting; damaged bags cannot be used; mechanical cultivation and precise fertilizer application are difficult; and bag removal can be difficult and time-consuming (31).

At this time, however, perhaps the greatest disadvantage of growing in bags is marketing the plants. Few people know of the advantages of growing in bags and find bagged trees less convenient to handle than containerized trees. One way around this is to grow the plant in a pot for the last year of production.

An important consideration in B&B production is the loss of 200–250 tons of topsoil per acre at each harvest. The digging and removal of topsoil from B&B nursery operations is a practice that can, over the long term, seriously deplete the farm's most important resource. There are two options to fight topsoil depletion: replace it with something else, or have a bare-root operation that does not

require topsoil to leave the farm. Many growers have begun using compost to replace some of the topsoil that is lost, but applying more than 40 tons of compost per acre is not recommended.

Weed Control

Weed control in modern field nursery production is based on the use of herbicides. There are many excellent non-chemical alternatives, however. These include mechanical cultivation, cover crops, living mulches, weeder geese, flame weeding, plastic mulching, fabric weed barriers, and organic mulching.

Cultivation

Bärtschi-Fobro (32) carries Swiss-made nursery equipment, including a brush hoe for mechanical weed control. The brush hoe, geared to precision weeding in multiple-row seedling nursery beds, features stiff brushes attached to multiple heads on a rotating drum. The brush heads—which disturb the soil surface and dislodge weed seedlings as the drum turns—come in a wide range of widths and can be set to varying distances to allow for interrow cultivation.

Flaming

Flame torches, or flamers, may be an option in some nursery situations. Flaming works by searing and disruption of plant cells, not burning of plant tissue. Passing a flamer quickly over a weed is enough to kill the tops of the weeds, but roots can re-sprout new growth. Broadleaf weeds are more susceptible to flaming than grassy weeds. Flaming will need to be repeated every 2–3 weeks to control grasses.

Flame weeders can be used to prepare a *stale seedbed* (by flaming off the first one or two flushes of weeds to emerge after seedbed preparation) and they can be used for post-emergent weed control. To protect young seedlings from injury, flaming shields should be used. However, taller seedlings, and certainly trees with well-developed bark, can withstand directed flaming aimed at weeds growing within and between the rows.

Although there is some criticism that flaming is not a sustainable practice because it uses fossil fuels, much less fossil fuel is needed to flame-kill a nursery bed or field of seedlings than would be used to manufacture, transport, and spray an herbicide for the same job (33). For more information on flaming, contact ATTRA.

Mulches

Mulches are another way to exclude weeds. They keep out weeds by limiting light, and retain moisture in the soil. Organic mulches should be three to four inches thick and will have to be replenished once or twice a year. Millcreek Manufacturing offers a row mulching machine that can apply mulch and compost to field-grown stock (34). The machine costs around $5,000 and can mulch beds from 18″ to 48″ wide, from ½″ to 10″ deep.

Landscape fabric can also be used in field production. A fast way for growers to get into production is to lay cloth in the field, cut or burn holes into it, and then plant the liners or seedlings.

Researchers at Oregon State University found that mulches made of oyster shell, hazelnut shell, and copper-treated geotextile mulches provided good suppression of liverwort, a prevalent weed in many nurseries. These three outperformed mulches of rockwool, peat moss, coarse sand, perlite, and pumice, two herbicides (Ronstar™ and Surflan™), and the fertilizers iron oxide, copper sulfate, and manganese sulfate (35).

Living Mulches

In a study conducted in Minnesota in the early 1990s, researchers compared soil cultivation, herbicides, and three living mulches for weed suppression in a field with six species of ornamental trees (36). The three living

Table 5. Organic Mulches

Type	*Source of Weeds?*	*Comments*
Grass clippings	Yes	Usually free; not very attractive
Newspaper	No	Very effective; inexpensive; not very attractive; can attract slugs
Cocoa hulls	No	Very expensive; adds high amounts of potassium; decomposes in 2–3 years
Cottonseed hulls	No	Expensive; not available everywhere
Pine bark nuggets	No	Chunks are bulky and can wash away; take 2–6 years to decompose
Shredded softwoods (cedar, cypress, etc.)	No	Attractive; price depends on local availability; decomposes in 2–5 years
Hardwood chips	No	Can be quite inexpensive if obtained from chipped shrubs/trees, as from a city facility; decomposes in 1–3 years
Compost	No	Attractive and available
Corn stalks	No	Unattractive; not available everywhere
Wheat straw	Yes	Inexpensive; decomposes rapidly
Hay	Yes	Inexpensive; decomposes rapidly
Rice hulls	Yes	Not available everywhere
Pine straw	Yes	Attractive and inexpensive; decomposes in 1–2 years
Leaves	Yes	Usually free; compost first
Cardboard	No	Lasts a long time; inexpensive
Sawdust	No	Inexpensive; depletes nitrogen; can blow away; better to use aged material

mulches they used were 'Norcen' bird's-foot trefoil, 'Wheeler' winter rye, and a grass sod consisting of 80% 'Eton' perennial ryegrass and 20% 'Ruby' red fescue. The grass sod provided excellent weed control, but it was overly competitive with the trees. The trefoil became infested with weeds. The winter rye, which was killed with herbicides and then acted as a mulch, not only provided good weed control, but also increased water infiltration and soil moisture, evened out soil temperature fluctuations, reduced soil bulk density, improved nutrient cycling, and reduced field maintenance costs. In general, the cover crops tended to reduce annual weeds and favor perennial species. For more information on living mulches, contact ATTRA.

Steam

For years, conventional production systems have used methyl bromide to sterilize the soil before planting into it. One sustainable system that yields the same results uses steam to disinfest beds and greenhouses prior to planting. In a field planting, this system could be used to treat planting beds. Steam is "nontoxic, relatively easy to apply, controls the same spectrum of soil pests as methyl bromide, and can be used in a wide variety of climates and conditions" (37).

For a greenhouse, a small portable boiler is probably the best unit to have. The Sioux Steam Flo, available from Sioux Steam Cleaner Corporation (see **Suppliers** for contact information) will work for greenhouse operations. The Sioux Steam Flo costs about $5,700. For small beds in the field, larger units are available from Saskatoon Boiler Manufacturing in Canada (see **Suppliers**). The important differences in steam machines include how much heat they are putting out, how portable they are, and how far into the

soil the steam penetrates. Although most machines heat only the top 3–6 inches of soil, temperatures are high enough to kill most weed seeds. Machines that heat the soil to 140°F for at least 30 minutes will kill pest fungi, bacteria, nematodes, and weed seeds.

Solarization

Soil solarization is another option for killing pests and can be done before beds are planted to trees, shrubs, or perennials. Again, only the beds where plants are to be placed would be treated. The basic principle of solarization involves stretching sheets of clear plastic across moist ground. Solar radiation heats the soil and kills pests there, including weed seeds and harmful insects. Solarization can kill both annual and perennial weeds, if summer temperatures climb high enough.

Solarization can also be used to disinfest potting media (old media that is to be re-used, or soil-based media). To do this, one must enclose the media in plastic bags and leave them in the sun for two to three weeks. Two layers of plastic kill more pests and work about four times faster than one layer (38). For more information on soil solarization, contact ATTRA.

Harvest and Storage

At some point, field-grown trees and plants must be dug. (See the **Resources** section for manufacturers of tree diggers.) Often, these plants are stored after digging. In conventional production systems, trees are dug in late fall or early winter and stored in warehouses until early spring. During this time, bare-root trees are sprayed with fungicides and bacteristats to keep problems from arising.

Researchers in Rhode Island experimented with *Taxus* B&B stock to see if they could prevent the plants from "rooting out," a condition where the roots grow into the burlap bags. They used Spin Out™ in several different ways (39). Treatments included painting the bottom of the root ball with copper paint, setting the root ball on copper-treated burlap, and rewrapping the root ball with copper-treated burlap before mulching. Although all these treatments provided good control of rooting out after 12 to 16 weeks, the most effective treatments were setting the root ball on copper-treated burlap and leaving it unmulched. The researchers also found that placing the root balls on TexR® Agroliner (a Spin Out™-treated nonwoven fabric) stopped rooting-out completely.

Costs

The costs of nursery production include overhead, direct, and marketing costs. Overhead costs include all the general costs of operating the nursery—such as taxes, depreciation, interest, rent, utilities, insurance, maintenance and repair, new construction, new equipment, supplies, managerial and administrative salaries, and labor wages that cannot be assigned to a particular crop. Direct costs are those that are tied directly to a crop, such as seed, potting media, and fertilizers. Keeping excellent records is the best way to accurately determine true costs.

Prices should reflect the following: 1) exact production costs, including a reasonable profit, for each crop; 2) prices and quantities offered by competitors; 3) supply and demand for the crop, except for very high-quality products and very loyal customers (1).

The British Columbia Ministry of Agriculture, Fisheries and Food has compiled a *Planning for Profit* series that details costs involved in establishing and growing several nursery species. These enterprise budgets provide information on expenses and income for perennial and tree crops, grown in containers and in the field. They should provide a rough idea of how much it costs to get into production and how long it takes to make a profit. See their website at <http://fbminet.ca/bc/pfp/ornament.htm> for more information.

For costs associated with establishing a small perennial nursery, see the handbook *Requirements and Costs of Establishing and Operating a Three-Acre Herbaceous Perennial*

Container Nursery (listed in the **Resources: Perennials** section). See Betrock's hortworld.com <http://www.hortworld.com> for a list of horticultural software that focuses on plant selection and nursery management.

At times, it is possible that the competitive price may fall below the cost of production. In this circumstance, a nursery with a unique advantage, such as closeness to market or a superior product, may be able to maintain a higher price that covers costs, without experiencing a serious drop in the number of plants sold.

Although it is desirable to make a profit on each kind of plant, sometimes it is good marketing strategy to grow some plants that may not be very profitable in order to offer a well-rounded inventory. A small nursery might specialize in a few high-quality plants, or produce some plants not carried by larger nurseries (which probably produce only plants that have high sales volumes).

One way to cut production costs is to grow plants in smaller containers. Although the crop sells for less, the cost of media and containers is reduced, as well as the time needed to produce the crop. Similarly, selling plants at wholesale prices means less money received for each plant, but less money (and time) spent on marketing and advertising.

Summary

Nursery managers can alter their production systems to incorporate products and techniques that will help the nursery meet some attributtes of sustainable agriculture: reduced fertilizer and pesticide runnoff, attention to soil conservation, recycling of plastics, use of organic waste stream products like compost, and so on. Some nursery growers may find certified organic nursery stock or specialty nursery stock to be an economically profitable option. Promotion of healthy plants as a first line of defense against insects and diseases through soil building practices and nursery media modifications plays a central role in sustainable nursery management. The end result—a greener nursery—can be used to build good relations with neighbors and in marketing your nursery plants to the green industry.

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Milwaukee, WI 53212
414-263-3131

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Resources: Publications

For a complete listing of propagation supplies, tree seed, nursery liners, plant materials, nursery supplies, equipment, and services associated with the greenhouse and nursery industries, consider purchasing a copy of the *Nursery Management and Production Buyer's Guide* issue. Single copies are available for $47.50 from:

Nursery Management & Production
Branch-Smith Publishing
P.O. Box 1868
Fort Worth, TX 76101
800-433-5612
http://www.greenbeam.com

An extensive selection of books on nursery management are available through the two trade journals mentioned below, *Nursery Management & Production (NMPro)* and *American Nurseryman* (see **Resources: Trade Magazines**). The American Nursery and Landscape Association also carries a number of titles, and publishes nursery standards and booklets. Contact:

American Nursery and Landscape Association
1250 I Street, NW, Suite 500
Washington, D.C. 20005
202-789-2900
http://www.anla.org

General Production:

Dirr, Michael. 1990. Manual of Woody Landscape Plants. Stipes Publishing Co., Champaign, IL. 1007 p.

Available for $39.80 (softcover) or $49.80 (hardback) from:

Stipes Publishing Co.
10–12 Chester Street
Champaign, IL 61820
217-356-8391

Harlan, Michael and Linda Harlan. 1997. Growing Profits: How to Start and Operate a Backyard Nursery. Moneta Publications, Citrus Heights, CA. 207 p.

This book has some excellent practical information for starting a small-scale nursery. It includes information on starting a nursery, considers the business aspects, and gives down-to-earth facts about production. Available for $18 from:

Moneta Publications
8302 Villa Oak Dr.
Citrus Heights, CA 95610
916-725-6461

Heuser, C.W. and R.F. Stinson (eds.) 1996. Nursery Production. Pennsylvania State University, University Park, PA. 216 p.
Available for $23 from:
Publications Distribution Center
Penn State University
112 Agric. Admn. Bldg.
Univ. Park, PA 16802
814-865-6713

Moorman, Gary. 1994. Scouting and Controlling Woody Ornamental Diseases in Landscapes and Nurseries. Pennsylvania State University, University Park, PA. 90 p.
Available for $7 from Penn State (see address above).

Perry, F. B., Jr., et al. 1990. Establishment and Operation of 20- and 40-acre Container Nurseries in Climatic Zone 9. Southern Cooperative Series Bulletin 341. Dept. of Research Information, Alabama Ag. Expt. Station, Auburn.
Archived in land-grant university libraries; access through Inter-Library Loan.

Rice, Robert P., Jr. 1992. Nursery and Landscape Weed Control Manual, 2nd ed. Thomson Publications, Fresno, CA. 290 p.
Available for $29.95 from:
Thomson Publications
P.O. Box 9335
Fresno, CA 93791
559-435-2163
http://www.agbook.com

Starting A Nursery Business in Virginia (Publication Number 430-015) is an 80-page manual published by the Virginia Cooperative Extension Service that should be helpful to any beginning grower. Access through Inter-Library Loan (ILL).

Whitcomb, Carl E. 1988. Plant Production in Containers. Lacebark Publications, Stillwater, OK. 633 p.
Available for $35 + S&H from:
Lacebark Publications
P.O. Box 2383
Stillwater, OK 74076
405-377-3539

Whitcomb, Carl E. 1989. Production of Landscape Plants. Lacebark Publications, Stillwater, OK.
Available for $35 from Lacebark Publications (see address above).

Propagation:

Dirr, Michael and C.W. Heuser. 1987. The Reference Manual of Woody Plant Propagation. Varsity Press, Inc. Athens, GA. 239 p.
Contains complete propagation techniques for important woody plants. Included is material on plant tissue culture and other specialized techniques. The emphasis is on horticultural plant material. Available for $35 from:
Varsity Press
337 S. Milledge Ave., Suite 119
Athens, GA 30605
706-613-0046

Hartmann, H.T., D.E. Kester, and F.T. Davies, Jr. 1997. Plant Propagation: Principles and Practices, 6th ed. Prentice Hall, London. 912 p.
This is the standard reference on the science and practice of plant propagation. It contains detailed information on propagation from seed or cuttings, and describes and illustrates grafting and budding techniques. Reproduction by grafting or budding is practiced extensively for certain varieties of coniferous landscape trees, fruit trees, and deciduous woody ornamentals. Available for $99 from:
Fertile Ground Books
P.O. Box 2008
Davis, CA 95617
800-540-0170
http://www.agaccess.com

Macdonald, Bruce. 1986. Practical Woody Plant Propagation for Nursery Growers. Timber Press, Portland, OR. 669 p.
Available for $69.95 from:
Timber Press
133 SW Second Ave., Suite 450
Portland, OR 97204
800-327-5680
http://www.timberpress.com

Yerkes, Guy E. 1957. Propagation of Trees and Shrubs. USDA Farmers' Bulletin No. 1567. 54 p.
Published in 1947, this USDA bulletin is a good practical guide to propagation of woody plants by seed and cuttings using on-farm resources. You should be able to obtain a photocopy of this Farmers' Bulletin through a land-grant university library or through Inter-Library Loan.

Young, James A. and Cheryl G. Young. 1992. Seeds of Woody Plants in North America. Dioscorides Press, Portland, OR. 407 p.

Seeds of Woody Plants of North America is a greatly revised edition of the legendary USDA Agriculture Handbook No. 450, Seeds of Woody Plants in the United States. The new edition covers twice the genera of plants, including new material on native plants used in environmental plantings and Asian plant materials of importance. The focus is on propagation from seed; vegetative propagation is not covered. Presentation of material is condensed, however, and access to the USDA handbook may be helpful for literature citations, taxonomic information, tables, and chapters on seed biology, genetics, pollen handling, and harvesting and storage procedures. Available for $49.95 from Timber Press (see address above).

Perennials:

Armitage, Allen. 1997. Herbaceous Perennial Plants. Varsity Press, Athens, GA. 1141 p.

Good book for general knowledge of perennials. Widely available for $57.

Nau, Jim. 1996. Ball Perennial Manual: Propagation and Production. Ball Publishing, Batavia, IL. 487 p.

An excellent resource for perennials. The following information is given for each perennial: description, hardiness, season of bloom, propagation, germination overview, growing techniques, varieties and cultivars, related materials, uses, and tips on how to use in the home garden. Available for $65 from:

Ball Publishing
P.O. Box 9
Batavia, IL 60510
888-888-0013
http://www.growertalks.com

Perry, Leonard P. 1988. Herbaceous Perennials Production: A Guide from Propagation to Marketing. NRAES-93. Northeast Regional Agricultural Engineering Service, Ithaca, NY. 208 p.

Available for $27 from:

NRAES
152 Riley-Robb Hall
Ithaca, NY 14853-5701
607-255-7645
607-254-8770
nraes@cornell.edu
http://www.nraes.org

Taylor, Reed D., et al. 1990. Requirements and Costs of Establishing and Operating a Three-Acre Herbaceous Perennial Container Nursery. Special Circular 136, Ohio Agricultural Research and Development Center, The Ohio State University, Wooster, Ohio. 30 p.

This study identifies the resources and costs associated with an herbaceous three-acre perennial nursery. Calculations are based on 1989 prices. The study calculates total costs per plant, based on how the plant was propagated, with calculations based on 1989 prices. Included in the cost estimates are land improvement, unheated polyhouse, heated polyhouse, cold frame, irrigation, fixed costs, labor, machinery, capital, and variable costs. Archived in land-grant university libraries; access through Inter-Library Loan.

Pests and Diseases:

Dreistadt, Steve H. 1994. Pests of Landscape Trees and Shrubs: An Integrated Pest Management Guide. Publication 3359. University of California, Division of Agriculture and Natural Resources, Oakland, CA. 327 p.

Available for $32 from:

ANR Publications
University of California
6701 San Pablo Ave.
Oakland, CA 94608-1239
800-994-8849
510-642-2431
http://www.danrcs.ucdavis.edu

International Society of Arboriculture. 1997. Plant Health Care for Woody Ornamentals. Printec Press, Champaign, IL. 223 p.

Presents proactive approaches to woody-plant health care in nurseries and landscapes. Focuses on diagnosing and treating diseases, pests, and abiotic disorders. Available for $45 from:

Publications Coordinator
International Society of Arboriculture
P.O. Box GG
Savoy, IL 61874
217-355-9411

Leslie, Anne R. 1994. Handbook of Integrated Pest Management for Turf and Ornamentals. Lewis Publishers/CRC Press, Boca Raton, FL. 660 p.

Gill, Stanton, David L. Clement, and Ethel Dutky. 1999. Pests & Diseases of Herbaceous Perennials: The Biological Approach. Ball Publishing Co., Batavia, IL. 304 p.

Pot-in-pot System:

Brand, Mark H. 1994. Pot-in-pot system—The best of field and container production. Yankee Nursery Quarterly. Spring. p. 1–4.

Haydu, John J. 1997. To bag or to pot? American Nurseryman. April 15. p. 40–42, 44–47.

Ruter, John M. 1997. The practicality of pot-in-pot. American Nurseryman. Jan. 1. p. 32–37.

Ruter, John M. 1995. Effects of pot-in-pot production system on plant growth. American Nurseryman. Feb. 15. p. 66–69.

Capillary Sandbeds and Subirrigation Systems:

Adams, Dave G., Sven E. Svenson, and Robert L. Ticknor. 1997. Making your bed. American Nurseryman. January 15. p. 60–62, 64–67.
Detailed plans for building a sandbed.

Svenson, Sven E., Dave G. Adams, and Robert L. Ticknor. 1997. Slow and steady. American Nurseryman. January 15. p. 50–52, 54–59.

Uva, Wen-Fei, Thomas C. Weiler, and Robert A. Milligan. 1999. Zero the hero. Greenhouse Grower.
January. p. 158, 160.
February. p. 68, 70.
March. p. 44, 47–48, 50.
Three-part series on subirrigation systems.

USDA Publications:

USDA publications—in the Agriculture Handbook, Miscellaneous Publication, and Bulletin series—are a rich source of educational materials on field and container nursery production, seedling propagation and production, species selection, and related topics. Selected titles are listed below.

Landis, T.D., R.W. Tinus, S.E. McDonald, and J.P. Barnett. 1990. The Container Tree Nursery Manual. Volumes 1-7: Agriculture Handbook No. 674-1 through 674-7. USDA Forest Service, Washington, DC.
A thorough treatise on the production of containerized trees; seven volumes altogether. Volume 1–planning, development, and management; Volume 2–containers and growing media; Volume 3–container nursery environment; Volume 4–seedling nutrition and irrigation; Volume 5–pests and mycorrhizae; Volume 6–propagation; Volume 7–processing, storage, and outplanting of seedlings.

The Container Tree Nursery Manual online http://www.rngr.fs.fed.us/nurseries/containermanual.html

Cordell, Charles E. 1989. Forest Nursery Pests. Agriculture Handbook No. 680. Forest Service, USDA. 184 p.

Forest Nursery Pests online http://www.rngr.fs.fed.us/nurseries/nurserypests/nurserypests.html

Peterson, G.W. and R. Smith. 1975. Forest Nursery Diseases in the United States. Agriculture Handbook No. 470. Forest Service, USDA. 125 p.

Hardenburg, R.E. et al. 1986. The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks. USDA Agriculture Handbook No. 66. 130 p.

Carlson, J.R. 1991. Conservation Tree and Shrub Cultivars in the United States. USDA Agriculture Handbook No. 692. 50 p.

Williams, Robert D., and Sidney H Hanks. 1976. Hardwood Nurseryman's Guide. Agriculture Handbook No. 473. Forest Service, USDA. 78 p.

Stoeckler, J.H., and P.E. Slabaugh. 1965. Conifer Nursery Practice in the Prairie-Plains. Agriculture Handbook No. 279. Forest Service, USDA. 96 p.

Stoeckler, J.H., and G.W. Jones. 1957. Forest Nursery Practices in the Lake States. Agriculture Handbook No. 110. Forest Service, USDA. 124 p.

Engstrom, H.E., and J.H. Stoeckler. 1941. Nursery Practices for Trees and Shrubs Suitable for Planting on the Prairie-Plains. USDA. Miscellaneous Publication No. 434. 159 p.

USDA publications are commonly available in land-grant university libraries. Your local librarian can help you borrow agricultural literature through Inter-Library Loan. For-sale publications are available through U.S. Government Bookstores, located in 23 regional locations. The Washington, D.C. bookstore and the Online Bookstore are listed below.

U.S. Government Bookstore
U.S. Government Printing Office
710 No. Capital Street, NW
Washington, D.C. 20401
202-512-0132
202-512-1355 Fax

U.S. Government Online Bookstore
http://bookstore.gpo.gov

University Publications:

Hamm, P.B., S.J. Campbell, E.M. Hansen. 1990. Growing Healthy Seedlings: Identification and Management of Pests in Northwest Forest Nurseries. Forest Research Laboratory, Oregon State University. 110 p.

Growing Healthy Seedlings online
http://www.rngr.fs.fed.us/nurseries/healthyseedlings/healthyseedlings.html

Forest Experiment Station Reports:

Liegel, L.H., and C.R. Venator. 1987. A Technical Guide for Forest Nursery Management in the Caribbean and Latin America. General Technical Report SO-67.

A Technical Guide for Forest Nursery Management in the Caribbean and Latin America online
http://www.srs.fs.fed.us/pubs/viewpub.jsp?index=1409

Numerous bulletins and fact sheets on nursery production are available through the Extension Service, Agricultural Experiment Station, and U.S. Forest Service. For materials available in your region, contact your horticulture and forestry extension specialists.

Resources: Websites

Nursery References & Information

Sources of Information: Nursery Production
Ministry of Agriculture, Food and Industries–British Columbia
http://www.agf.gov.bc.ca/croplive/plant/horticult/nursery/nursourc.pdf

References for Production Nursery Operators
Ron Kujawski, University of Massachusetts
http://www.umassgreeninfo.org/fact_sheets/plant_culture/nursery_references.htm

NurseryWeb
http://www.nursery.umd.edu/
University of Maryland website on nursery production, IPM, and nutrient management. Includes a large collection of horticulural and nursery web links, organized by topic.

PLANT - Purdue Landscape and Nursery Thesaurus
http://bluestem.hort.purdue.edu/plant/
Purdue University collection of web links on landscape and nursery resources, with over 2,300 sites organized by topic.

Nursery-Related Internet Resources
Stuewe and Sons
http://www.stuewe.com/othersites.html

Useful Web Pages for Nursery Operators
Environmental Horticulture, University of Florida
http://hort.ifas.ufl.edu/people/yeagernurseopera.htm

Nursery Production: General, Nutrition, Irrigation, and Water Quality topics

Commerical Nursery Production Information
Ministry of Agriculture, Food and Industries–British Columbia
http://www.agf.gov.bc.ca/croplive/plant/horticult/nursery/nursprod.htm

The Green Beam
http://www.greenbeam.com
Maintained by Branch-Smith Publishing, publisher of NMPro, GMPro, Garden Center Merchandising and Management, and Garden Center Products and Supplies. Site offers articles, industry news, and source lists for products and suppliers.

The Green Beam Cyberconference: Water Quality
http://www.greenbeam.com/cyberconference/cyber-main.html

The Green Beam Cyberconference: Plant Nutrition and Fertilizers
http://www.greenbeam.com/features/cyb011501.stm

Texas: Nursery, Floral and Landscape Network
http://aggie-horticulture.tamu.edu/new//ornweb.html

Texas A&M site with nursery, greenhouse and IPM resources.

Environmental Publications
Texas A&M University, Nursery/Floral Crops
http://extension-horticulture.tamu.edu/greenhouse/ environ/environ.html

- Developing a Management Plan for Irrigation Runoff
- Principles of Irrigation Management
- Developing a Management Plan for Irrigation Runoff
- Monitoring the Quality of Irrigation Water
- Integrated Pest Management for Greenhouse Crops
- Treating and Recycling Irrigation Runoff

Something to Grow On / Nutrient Management: The Key to Growing Healthy Nursery Crops in Containers
http://www.hort.cornell.edu/department/faculty/good/growon/index.html

Cornell University website on nutrient management for field crops, container crops, and container media.

Irrigation Management Practices: Checklist for Oregon
Oregon State University, Bioresource Engineering
http://biosys.bre.orst.edu/bre/docs/irrigation.htm

Best Management Practices for Field Production of Nursery Stock
North Carolina State University
http://www.bae.ncsu.edu/programs/extension/ag-env/nursery/

Using Compost in Landscape Beds and Nursery Substrates
North Carolina State University
http://www.bae.ncsu.edu/bae/programs/extension/publicat/wqwm/ag473_14.html

Pot-In-Pot Production of Nursery Crops and Christmas Trees
Alabama Cooperative Extension System
http://www.aces.edu/department/extcomm/publications/anr/ANR-893/anr893.html

Nursery Crop Science
North Carolina State University
http://www.ces.ncsu.edu/depts/hort/nursery/

- Cultural Practices
- Horticultural Substrates Laboratory
- Container Substrates
- Websites for Nurseries

Ergonomics Papers: Prevention of Worker Injury in Nursery Production
Agricultural Ergonomics Research Center, University of California
http://ag-ergo.ucdavis.edu/papers/

Establishment & Economics of Nursery Production

ORNAMENTALS: Planning for Profit Enterprise Budgets
FBMInet-British Columbia
http://fbminet.ca/bc/pfp/ornament.htm

Enterprise budgets for commercial nursery production in British Columbia

Starting in the Nursery Business
Purdue University, HO-212
http://www.agcom.purdue.edu/AgCom/Pubs/HO/HO-212.pdf

Starting a Wholesale Nursery—Part I
University of Arkansas
http://www.uaex.edu:80/Other_Areas/publications/HTML/FSA-6055.asp

Extension Nursery Publications
Missouri Alternatives Center
http://agebb.missouri.edu/mac/links/linkview2.asp?catnum=160&alpha=N

Integrated Pest Management

Nematodes That Work for Nursery Growers
Stanton Gill, University of Maryland
http://www.agnr.umd.edu/users/ipmnet/nemanurs.htm

Nursery IPM at University of Connecticut
http://www.hort.uconn.edu/ipm/index.html

Forest Insect and Disease Leaflets
USDA Forest Service
http://www.na.fs.fed.us/spfo/pubs/fidl.htm

Nursery Diseases of Western Conifers
Forest Insect & Disease Leaflet 157, USDA Forest Service
http://www.na.fs.fed.us/spfo/pubs/fidls/disease_west/nur_diseases.htm

Corn Gluten Meal Research Site
Iowa State University
http://www.hort.iastate.edu/gluten/

Biological Control of Pests in Forest Nurseries
Don Elliott, page 145-147. In: National Proceedings: Forest and Conservation Nursery Associations—1998
http://www.srs.fs.fed.us/pubs/viewpub.jsp?index=863

Disease-Suppressive Potting Mixes
ATTRA
http://www.attra.org/attra-pub/dspotmix. html

Biointensive Integrated Pest Management
ATTRA
http://www.attra.org/attra-pub/ipm.html

Nursery Associations and Technology Cooperatives

Canadian Nursery Landscape Association
http://www.canadanursery.com
Links to regional associations in Alberta, British Columbia, Saskatchewan, Manitoba, etc.

Nursery Technology Cooperative
Oregon State University
http://www.cof.orst.edu/coops/ntc/ntc.htm

Southern Forest Nursery Management Cooperative
http://www.forestry.auburn.edu/sfnmc/sfnmc.html

Southern Nursery Association
http://www.sna.org
Large site with newsletter archives, publications, conference proceedings, research, news, events.

Forest Conservation Nurseries Associations
http://www.wfcna.net
A special feature is the collection of online conference proceedings and papers.

Directory of Nursery Supplies

The Green Beam
http://www.greenbeam.com
The Green Beam site, maintained by Branch-Smith Publishing—publisher of NMPro, GMPro, Garden Center Merchandising and Management, and Garden Center Products and Supplies—offers extensive lists of products and suppliers.

Pacific Coast Nurseryman: Structures & Equipment Suppliers List
http://www.pacificcoastnurseryman.com/structures.htm

Forest Nursery Resources

***Forest Nursery Notes* (FNN)**
http://www.na.fs.fed.us/spfo/rngr/fnn_list. htm

Archives of *Forest Nursery Notes*
http://www.forestry.auburn.edu/sfnmc/pubs / fnn/fnn.html
FNN is a nursery news and literature service published in January and July of each year, consisting of two sections. The first contains dates and locations of meetings, national issues, cultural articles, equipment and services, nursery networks, and editorials. The second section—New Nursery Literature—contains a numerical list of recently published technical articles.

Forest Nursery Publications Online
Reforestation, Nurseries, and Genetic Resources at USDA Forest Service
http://www.na.fs.fed.us/spfo/rngr/pubs/pubhp.htm

- Forest Nursery Pests
- The Container Tree Nursery Manual
- Forest Nursery Notes
- Tree Planters' Notes
- Bareroot Nursery Equipment Catalog
- Native Plants Journal
- Raising Forest Tree Seedlings at Home

Forest Nursery Information
Reforestation, Nurseries, and Genetic Resources at USDA Forest Service
http://www.rngr.fs.fed.us/nurseries/
- The Container Tree Nursery Manual
- Forest Nursery Pests
- Growing Healthy Seedlings
- Directory of Forest and Conservation Nurseries

Forest Nursery Diagnostic Lab and Seedling Health Monitoring Program
http://www.fs.fed.us/na/morgantown/fhp/nursery/nurse.htm
Especially see the compost amendments and mycorrhizal programs.

Native Plants, Specialty Plants, and Perennials

Native Plants Journal online
http://nativeplants.for.uidaho.edu

Bamboo: A Multipurpose Agroforestry Crop
ATTRA
http://www.attra.org/attra-pub/PDF/bamboo.pdf

Perry's Perennial Pages
Leonard Perry, University of Vermont
http://www.uvm.edu/~pass/perry/

University of Georgia Trial Gardens
Allan Armitage
http://uga.ovationsoftware.com/
- Perennials
- Specialty Annuals
- Genera Trials
- Best of the Best
- Plant Sources

Resources: Organizations

American Nursery & Landscape Association (ANLA)
1250 I Street, NW, Suite 500
Washington, DC 20005-3922
202-789-2900
202-789-1893 Fax
http://www.anla.org
ANLA, a membership organization, publishes key resources for the nursery industry, such as American Standard for Nursery Stock. The Horticultural Research Institute (HRI), a research division of ANLA, sponsors research and publishes Journal of Environmental Horticulture.

International Plant Propagators' Society, Inc.
Center for Urban Horticulture
GF-15, University of Washington
Seattle, WA 98195
206-543-8602
http://www.ipps.org
Publishes the Proceedings of The International Plant Propagators Society.

International Society of Arboriculture
P.O. Box GG
Savoy, IL 61874
217-355-9411
http://www.isa-arbor.com
Publishes Arborist News and Journal of Arboriculture, as well as a catalog of books, educational materials, and software.

Perennial Plant Association
3383 Schirtzinger Road
Hilliard, Ohio 43026
614-771-8431
614-876-5238 Fax
ppa@perennialplant.org
http://www.perennialplant.org
Publishes Perennial Plants Journal and a Newsletter; sponsors an annual symposium with accompanying proceedings. Educational materials include Guide to Herbaceous Perennial Gardens in the United States and Canada, clip art packet for 50 most popular perennials, perennials catalog, and slide sets.

Horticultural Associations and Societies
Betrock's hortworld.com Information Systems
http://www.hortworld.com/associations.htm
Extensive list of regional and statewide nursery associations.

Resources: Trade Magazines

American Nurseryman
American Nurseryman Publishing Co.
77 W. Washington St., Suite 2100
Chicago, IL 60602-2904
800-621-5727
312-782-3232 Fax
http://www.amerinursery.com
$45/year, biweekly. Wide selection of books, videos, CD-Roms, and software.

Branch-Smith Publishing
P.O. Box 1868
Ft. Worth, TX 76101
800-433-5612
http://www.greenbeam.com

- **Nursery Management & Production (NMPro)**
- **Greenhouse Management & Production (GMPro)**
- **Garden Center Merchandising & Management**
- **Garden Center Products & Supplies**

Free to qualified growers, or $96/year for 12 issues with two Buyer's Guide issues.

Pacific Coast Nurseryman and Garden Supply Dealer
Cox Publishing Co.
P.O. Box 1477
Glendora, CA 91740-1477
800-577-5225
626-914-3751 Fax
http://www.pacificcoastnurseryman.com

Nursery Retailer
Brantwood Publications
2310 Northside Drive
Clearwater, FL 33761-2236
888-376-4784
727-786-9771
727-786-9772 Fax
thinkgreen@nurseryretailer.com
http://www.nurseryretailer.com

Horticultural Trade Magazines
Betrock's hortworld.com Information Systems
http://www.hortworld.com/magazines.htm
Extensive list of horticultural trade magazines.

Resources: Suppliers

A Few General Nursery Supplies Mentioned in Text: Root Control Pots, Nursery Equipment, Steam Disinfection

American Horticultural Supply, Inc.
4045 Via Pescador
Camarillo, CA 93012
800-247-1184
http://www.americanhort.com
Unusual pots (square, stair-step, bottomless).

Anderson Die and Manufacturing
2425 SE Moores St.
Portland, OR 97222
503-654-5629
Tree Bands

Bärtschi-Fobro
1715 Airpark Dr.
Grand Haven, MI 49417
616-847-0300
http://www.fobro.com
Nursery equipment: lifter/shakers for digging field stock and brush hoes.

E-Z Implements, Inc.
3311 W. 166th St.
Jordan, MN 55352
800-278-2531
612-492-2867
Tree diggers, tree shears, graders.

Growing Systems, Inc.
2950 N. Weil St.
Milwaukee, WI 53212
414-263-3131
Deep Groove Tube cell-pack trays.

IEM Plastics
606 Walters St.
Reidsville, NC 27320
336-349-9246
Root control bags.

Lacebark, Inc.
P.O. Box 2383
Stillwater, OK 74076
405-377-3539
Root control bags, RootMaker pots.

Root Control, Inc.
7505 N. Broadway
Oklahoma City, OK 73116
800-521-8089
405-848-2302
Root control bags.

RootMaker Products, Inc.
P.O. Box 14553
Huntsville, AL 35815
800-824-3941
256-882-3199
http://www.rootmaker.com
RootMaker pots.

Saskatoon Boiler Manufacturing
2011 Quebec Ave.
Saskatoon, Saskatchewan
CANADA S7K 1W5
306-652-7022
Saskatoon Model 30HP-15 nursery steamer.

Sioux Steam Cleaner Corp.
One Sioux Plaza
Beresford, SD 57004
605-763-3333
Sioux Steam Flo nursery steamer.

Stuewe & Sons, Inc.
2290 SE Kiger Island Drive
Corvallis, OR 97333-9461
800-553-5331
http://www.stuewe.com
Unusual pots (square, stair-step, bottomless).

Texel USA
9987 Winston Dr.
Pinckney, MI 48169
734-878-1814
Agroliners™ and Geodiscs™.

Corn Gluten

Corn Gluten Meal Licensees
Iowa State University
http://www.public.iastate.edu/~isurf/tech/cgmwebsite.html
Iowa State University holds the patent on the use of corn gluten meal as a natural herbicide. Please refer to this website for a list of 16 licensed suppliers of this product.

Resource Directories

For a comprehensive list of products and suppliers that support the nursery and greenhouse industries, see the following two websites.

The Green Beam
http://www.greenbeam.com
The Green Beam site, maintained by Branch-Smith Publishing – publisher of NMPro, GMPro, Garden Center Merchandising and Management, and Garden Center Products and Supplies – offers extensive lists of products and suppliers.

Pacific Coast Nurseryman: Structures & Equipment Suppliers List
http://www.pacificcoastnurseryman.com/structures.htm

By Steve Diver and Lane Greer
NCAT Agriculture Specialists

May 2000
Revised November 2001

The Electronic version of **Sustainable Small-scale Nursery Production** is located at:
HTML
http://www.attra.org/attra-pub/nursery.html
PDF
http://www.attra.org/attra-pub/PDF/nursery.pdf