WASHINGTON STATE UNIVERSITY EXTENSION

RAISING AND SELLING ORNAMENTAL NURSERY STOCK IN WASHINGTON STATE

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RAISING AND SELLING ORNAMENTAL NURSERY STOCK IN WASHINGTON STATE

Table of Contents

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Abstract

This publication covers the steps required to successfully grow and market a wide array of ornamentals in Washington State. It provides innovative suggestions for summer irrigation of nursery stock when available water sources may be limited. It provides a very extensive list of references cited for further study.

Raising and Selling Ornamental Nursery Stock in Washington State

Introduction

The Pacific Northwest is known as a key player in the national production and sale of woody ornamentals. Washington and Oregon growers produce a range of deciduous flowering trees, broadleaf evergreens, coniferous evergreens, and fruit and nut plants (Figure 1). Oregon is the second largest nursery grower behind California when it comes to the sale of woody ornamentals.

The bulk of nursery stock grown in Washington State is utilized for sale within the state to local landscaping firms and independent garden centers. The majority of the industry is located in western Washington (Table 1), with the exception of Grant County, on the east side, where fruit tree and wine grape nursery stock is produced. In 2012, Washington State ranked 11th in the nation for the sale of nursery stock.

Oregon leads the nation in the production of deciduous shade trees (USDA 2007, Oregon Business Council 2011), producing 26% of the deciduous shade tree stock sold in the trade. Oregon also leads the nation in the production of ornamental conifers.

Oregon growers have benefited from strict land use planning, which has protected valuable farm ground near population centers and interstate highways. Nurseries are located on approximately 54,000 acres of farmland, largely situated on rich alluvial floodplains of the rivers coming off of the Cascade Mountains. These rivers flow to the Willamette River, which flows north toward Portland, Oregon.

The bulk of the production (86%) of ornamentals comes from the northern end of the Willamette River basin. The top five highest-producing counties are Marion, Washington, Clackamas, Yamhill, and Multnomah (OR Ag Stats 2014). All of these counties are close to major freeways, as well as population centers. The Oregon Association of Nurseries is one of the largest in the nation, with over 1,800 nursery/greenhouse operations.

Table 1. Top seven Washington counties for the production of nursery, greenhouse, floriculture, and sod[a]

Figure 1. Northwest growers can supply a wide array of nursery stock.

Value of the Washington and the Oregon Ornamental Industry

Table 2. Value of the nursery industry in the Pacific Northwest, in millions of dollars.

The production and marketing of ornamental nursery stock is significant in both Washington and Oregon. Table 2 shows the value of production over the course of 2005-2011. The United States economic downturn, which first started in 2008, has had an effect on the economic viability of the entire Pacific Northwest. In Washington State, the value of nursery stock has stayed relatively constant over the period of 2005-2011, where a greater percentage of the sale of nursery stock is through the retail trade. During this time span, the sale of nursery stock consistently ranked 7th or 8th out of all agricultural sales.

The Oregon industry, however, suffered to a larger extent with the onset of the 2008 recession. A greater percentage of the Oregon nursery stock is destined for the wholesale market. The downturn in the housing market across the United States presented a significant challenge in the demand for landscape trees and shrubs. More than 65% of all the stock produced in Oregon is shipped out of the state. In terms of sales, 45% of the Oregon nursery stock was sold in containers, 19% was sold as bare root, 17% was sold as greenhouse material, 14% was sold as balled and burlap (***B&B***) material, with the remaining 6% sold as other. Washington does not track this data.

Washington State nursery and garden center owners benefit from the proximity to Oregon, as they can source and receive a wide array of plant material within a very short time period.

Pacific Northwest Climate

Nursery growers capitalize on the maritime climate with the prevailing on-shore flows coming off of the Pacific Ocean (Figure 2). The moist air coming off the sea moderates winter temperatures and keeps the summers relatively warm but dry with a low relative humidity. Nearly all of the nursery growing districts are in the USDA Hardiness Zone 8. The lower end of the scale is 8a, which would have a mid-winter temperature that does not drop below 10–15°F. The upper end of the scale is 8b, which would have winter temperatures that don’t drop below 15–20°F.

Figure 2. USDA Plant Hardiness Zone map for Washington State (USDA Hardiness Zone 2015).

Growing season

The bulk of the nursery industry in Washington State is located in western Washington, where the growing season is long (200–250 days). A longer growing season contributes to the growth of larger plants over a shorter time period. The mild winter weather often keeps the soil from freezing during the winter.

When it comes to digging bare root plant material in the winter, nurserymen in Oregon and Washington have a distinct advantage over those in the mid-west or the east coast. Northwest growers can dig up, grade, and ship their stock to East Coast garden centers for spring sales when eastern growers are still experiencing inclement weather, including snow and potentially frozen ground (Figure 3).

Figure 3. Harvesting and moving balled and burlap conifers in February for shipments to East Coast markets for the start of the garden center and home building season.

Moisture patterns

The Washington State nursery industry is primarily located in a maritime climate where there is considerable rain (more than 150 days/year in Puget Sound), extending from late October through the end of March. The long period of rain (5-6 months) reduces the need for supplemental irrigation in the late fall and spring.

In-ground tree growers with established shade trees often don't have to consider irrigation until the latter half of June. The high amount of winter rainfall (more than 4 ft typically) will usually fill irrigation ponds during the winter months. The lack of summer rainfall from mid-June through early October does challenge container stock producers, who have to rely on supplemental irrigation to keep their plants thriving.

Marketing Alternatives

Retail Nurseries

Growers interested in primarily raising their own nursery stock and selling it directly to consumers should consider establishing a ***retail nursery***. The retail nursery manager can determine the product mix, the intended market segment, and the range of plant sizes which will be offered (Figure 4).

Figure 4. The owner of this retail nursery sells ornamental native grasses that she has raised.

In relation to wholesale nurseries, a retail nursery generally carries a smaller number of plants but a much wider array of cultivars. Retail growers will purchase plants from wholesalers, but they will also propagate some of their own plants. There are tax advantages to selling one's own plants.

A retail nursery grows the majority of its own plants, where an independent garden center operation buys in all of the plants (Avent 2003). The profits from a retail nursery are classified as agricultural and are often lower than those for garden centers, where all of the plants have been purchased from others.

Larger Plants Sizes

A retail nursery can offer an entire range of plant sizes in order to appeal to a wide segment of the population. Larger plant material is especially attractive to well established homeowners with a desire for more immediate gratification. Middle-aged shoppers generally have the money needed to buy the larger plants and to have a landscaper install them.

Trees in 15 gallon pot sizes, or larger, are heavy to pick up and load into vehicles. There is more profit potential from the sale of larger plant material. As a value added product, retail nurseries will deliver and install trees and shrubs. Conversely, first time homebuyers often prefer the smaller sizes and lower prices that come with a plant at a big box store.

Independent Garden Centers

In the nursery trade an ***independent garden center*** (IGC) is one that is managed by an owner that purchases nearly all their plants from others and then simply resells them. An independent retailer can specialize in a whole host of unique cultivars, which have been bred and developed to survive well in their specific region of the Pacific Northwest (Figure 5).

IGC owners will order plants from their vendors for the next 3-12 months of sales without changing or altering the original container. Independents will make it a point not to always carry the same product as would be stocked by a mass merchandiser. If they do, however, they often stock a wider array of sizes. Independents will often carry hard goods as well.

Figure 5. A high-end garden center combines eye-catching plants, displays, and structures.

Location

IGC owners generally find a ready supply of customers in the Pacific Northwest, where home gardening is very popular. When located near a major metropolitan area, trade can be brisk from February through October. Shoppers at IGCs value the range in plant sizes and services offered, two characteristics which are generally not associated with a mass merchandiser. While a mass merchandiser may carry half a dozen different types of Japanese maples, generally all in smaller container sizes, an IGC may stock more than two dozen types in all shapes, sizes, and colors.

Size and Location

IGC operations often have less than five acres of total land as nearly all the plants and accessories have been purchased on the wholesale market. Sites with high road traffic nearby will experience the highest number of drop-by customers. A visible location on a major highway, where there is enough time to slow down and turn, is highly desirable.

Customer Service

The three most relevant traits of any IGC operation are service, selection, and quality. Gardeners will greatly appreciate visiting garden centers that offer courteous, knowledgeable sales staff, a feature that is often lacking at mass merchandisers (Hodges, 2008).

Staff should know where each of the various types of plants are displayed. They should understand their eventual size, flowering characteristics, and pest and disease susceptibility. Customers appreciate having the same product in different sizes. Discerning customers are attracted to nurseries featuring an eclectic collection of specialty plants (Figure 6).

IGC owners understand that 80% of their sales are to 20% of their customers. Unlike the traditional farmer, growing a commodity item, an astute IGC owner is a price "setter," rather than a price "taker." There is often a 100% markup or more going from wholesale to retail. A complete guide to establishing a retail garden center, "Establishing and Operating a Garden Center: Requirements and Costs," authored by university faculty from the northeast portion of the United States, is available from Plant and Life Sciences Publishing (Barton, 2002).

Figure 6. A plethora of dwarf conifers in larger container sizes sets this operation apart from other IGC's.

Wholesale Nurseries

The term ***wholesale nursery*** refers to a business that sells nursery crops to independent garden centers, mass merchandisers, landscape contractors, other growers, or brokers. In general wholesalers don't sell directly to the public.

The largest wholesalers in Oregon and Washington grow commodity crops, which are defined as crops that are commonly sourced by builders or developers. Examples include deciduous shade trees (Figure 7), hedging cedars (Figure 8), deciduous and evergreen shrubs, groundcovers, vines, herbaceous perennials, and bedding plants. This material is shipped all over the United States.

Sales of these crops prosper when the economy is doing well and homes are being constructed. When the housing market softens, it is hard to compete on pricing for commodity nursery stock. During these times, competing on price alone is not a guarantee of success. The most successful owners set their operations apart by focusing on the perceived value of their product (Robbins 2010a). There are guides to the layout and design of wholesale nurseries (Yeager 2010; Robbins 2010b).

Figure 7. Shade trees make up a large percentage of the commodity crops sold to landscape contractors.

Niche marketing

Finding a niche in the nursery industry is probably the most important decision a prospective manager must make early on, even before the first plant is raised (Knox 2011). A niche is defined as a specific situation that is suited to one's character or abilities.

There is wide range in specialization in the Northwest nursery industry. An example of a niche market is found within the shade tree industry. There are markets for a whole host of different attributes, including foliage color, leaf texture, plant size and shape, distinctive bark, season of bloom, and winter interest.

A strong passion for marketing must be a key part of the mission statement for a grower that specializes. Many buyers will have seen the limited selection of choices from a ***mass merchandiser,*** which often carry a generic array of plants, along with building supplies. Having an enthusiastic sales pitch and colorful sales literature can lead to both initial and continued return purchases. A manager planning to delve into specialization will have to generally attend industry trade shows, and tour nurseries, arboretums, and display gardens that feature different cultivars to keep abreast of industry trends.

Figure 8. Eastern arborvitae *(Thuja occidentalis)* is the most widely grown hedge plant in the Pacific Northwest.

Herbaceous perennials

There are a number of growers in the Pacific Northwest that specialize in the production of ***herbaceous perennials***, including hostas (Figure 9), day lilies, ornamental grasses, succulents, and peonies. Consumers greatly enjoy the year-to-year longevity of perennials over seasonal annuals. Once established in the landscape, the majority of perennials are drought tolerant and pest free. Herbaceous perennials can bring a better return on investment, as they grow quickly and are relatively easy to propagate. During slow economic times, their sales often hold better than for trees and shrubs.

Figure 9. Hostas come in plethora of different colors, and sizes.

Conifers

Ornamental conifer production is a key element of the Northwest's nursery industry. Growers can capitalize on the mild, maritime climate and acidic soils found west of the Cascade Mountains that encourages plant growth. There are also growers that specialize in sculptured conifers (Figure 10) that appeal to discriminating shoppers looking for a unique plant for their landscape. These types of plants do very well for local landscape trade. There are also dwarf conifers that come in a wide array of colors and textures. The smaller stature plants lend themselves well to the retailer who is looking to specialize. Conifers sell well during the winter months in western Washington at IGCs. They are ideally suited to the region's cool, damp weather and acidic soils west of the Cascade Mountains.

Figure 10. These Austrian pines *(Pinus nigra)* have been sculptured into shapes known as "pom poms" for the upscale landscape market.

Japanese maples

There are over 150 different cultivars of Japanese maples in the nursery trade, though roughly half a dozen are commonly sold in the retail trade. As with conifers, there are many unique growth habits: prostrate, pendulous, globose, cascading, and weeping. Within these categories, foliage color varies widely: rose, burgundy, yellow orange, orange, red, variegated green and white, and green.

There are northwest wholesale growers that specialize in just raising Japanese maples for the retail trade. Retail garden centers in Washington have found that shoppers are highly attracted to a range of Japanese maples in a host of different container sizes, from 5-15 gallons. There is a market for even larger sized plant material (25 gallon and larger), especially for the landscape contractors seeking out larger material for the upscale homeowner (Figure 11). The larger Japanese maples have a higher perceived value once they have started to develop an interesting framework of limbs.

Annuals

Spring sales of bedding plants and vegetable starts are key parts of ornamental industry. Each year, the flower and vegetable seed industry introduces new, improved cultivars to the retail trade. During the months of April-June, garden centers can do a brisk business selling tray packs of impatiens, geraniums, petunias, pansies, marigolds, and other colorful annuals (Figure 12). Sold in the trade for their instant color, these plants encourage consumers to work in their yards. With their lower initial costs, bedding plant sales can work for all income levels. Bedding plants can be raised for all segments of the green industry, including landscape contractors, garden centers, home centers, supermarkets, and IGCs.

Figure 11. Growing the highly popular Bloodgood Japanese maple in larger sizes can be a lucrative niche in an upscale nursery market.

Unique selection

Smaller nurseries (under five acres) can take advantage of consumer individuality, and their need for detailed attention. Smaller operations can cater to landscape contractors and designers, who are always looking for larger plant material for the upscale homes. IGC's will sell some of the larger plant sizes, but rarely a big enough size. Mass merchandizers generally don't stock larger plant material for landscape contractors. Smaller operations require more skills in customer service and marketing. Nurseries don't have to be large in order to be profitable. Growers that raise ***liner material*** (propagation stock) don't need the acreage that the container or in-ground field requires (Knox 2011).

Figure 12. Primroses are widely sold in the garden center trade beginning in February. They are sold as annuals, even though they are classified as perennials.

Value added

Nursery growers can specialize in larger plant material to meet the needs of the more affluent buyer. Setting the price for these large plants (Figure 13) is often determined by assessing their perceived value. ***Image pricing*** can be utilized for a particular plant or landscape service when a manager adds value from marketing or differentiation.

A nursery owner will often have to invite ***landscape designers*** and ***landscape contractors*** (design and install), to their fields and container yards for tours to highlight the unique features of the plants that they have for sale. Summer tours are organized by the Washington State Nursery and Landscape Association (WSNLA 2015) in different regions of the state. Landscapers can attend new home tours during the summer to view custom designed homes and grounds that surround them.

Figure 13. Setting the price for larger plant material is subjective.

Re-wholesaling

A potentially lucrative small scale business can be built on purchasing wholesale stock for later sale to landscape contractors (Dunwell 2012). Owners with excellent marketing skills will find the local trade to be very receptive to a broker that can gather stock as needed to supply local home builders and landscape maintenance contractors.

Re-wholesalers order in a large array of plant material, thus starting their own nursery. For deciduous shade trees, re-wholesalers sell primarily 2 in. caliper stock. A tree like this would be 12-14 ft tall, and would come in a 20-40 gallon pot, or as B&B plant with a 24 in. inch diameter root ball (American Hort 2015). This size tree is often utilized by developers looking to install boulevard planting areas. Landscape contractors are often looking for even larger plant material. A three inch ***caliper*** shade tree would be sold in a 45-95 gallon pot, or as a B&B plant with 32 in. diameter root ball. Re-wholesalers often arrange for delivery to job site.

A large inventory of plants does not have to be stored for this service to be successful, but it does require access to a number of wholesale nurseries from which to source product. Re-wholesalers in Washington frequently purchase plants from Oregon and British Columbia. Re-wholesalers will need to have a Nursery License, as issued by the Washington State Department of Agriculture Plant Services Program (WSDA 2015 plant services).

Internet Sales

Computer savvy shoppers can now turn to the Internet to source smaller plant material. There are a number of firms in the Northwest that can supply shoppers with live plants in containers nearly all year long. One gallon containers (Figure 14), or even 4 in. pots or tubes predominate, in order to reduce shipping charges. There are packaging suppliers who can provide tall and narrow cardboard boxes for shipping.

For this type of business to succeed, the owner needs to be able to design a very user friendly website with plenty of pictures of plants being sold. It takes very little land to start this type of nursery as many plants can be raised in the smaller containers. A whole host of different cultivars can be raised for the Internet or mail order trade. Larger Internet distributors can go beyond the smaller plant sizes by shipping larger material to IGCs.

Figure 14. Dwarf Hinoki cypress *(Chamaecyparis obtusa),* in one gallon pots, for the mail order sales.

Site Selection

Before starting into the nursery business, managers should fully consider all their site selection options. These include: zoning, soils, parcel size, proximity to customers and services, access to roads, and availability of water.

Parcel Size

Ornamental nursery operations vary in size from 1-2 acres for an IGC selling specialty plants, all the way up to large wholesale operations with hundreds of acres. In the Pacific Northwest, some of the most profitable nurseries are near major urban centers where a large population base supports year-long retail sales.

Smaller operations

For a single owner operation with less than half a dozen employees, 5 acres of land can serve as an adequate base from which to operate either a full or part-time operation (Schnelle 2009). Specialty garden centers don't generally require more than 2-3 acres of land. Smaller operations are often characterized by a greater reliance on ***container nursery stock***, and more direct sales (Figure 15).

These intensively managed operations often rely on a heavy utilization of ***grafted plants*** purchased from wholesale producers. By sourcing plants and supplies from a wide array of sources, the astute direct marketer can create a specialized business that does not require extensive acreage. Smaller operations can be irrigated with a combination of ground water, rainwater collection, and/or municipal water if it is available.

Figure 15. Smaller operations are best suited to urban areas with a high population base, municipal water, and highly visible road access.

Larger operations

Wholesale operators typically own a minimum of 10-20 acres (Figure 16) of ground, and often lease additional acreage as needed (Robbins 2010a,b). Wholesale operations are often based on growing and selling large quantities of plants.

In order to be efficient, wholesalers often specialize in one type of crop, whether it is shade trees, conifers, shrubs, or herbaceous perennials, as each of these crops have their own unique production requirements.

Figure 16. This large wholesale nursery specializes primarily in unique conifers destined for sale as B&B stock to east coast buyers.

Any property chosen for a larger operation will need to come with a valid water right permit as issued by the Washington State Department of Ecology (WA Ecology 2015a). Larger wholesale operations often rent farm ground that is zoned agricultural, as it considered a wise business strategy where land prices are very high. Larger operations require more labor, mechanization, and access to capital (Ingram and Vanek 2013).

Location

Selecting a nursery site is largely influenced by the type of operation that is planned. If there are any plans to sell finished plants to a local clientele base, every effort should be made to find land near population centers.

Direct sales

IGC's and landscape contractors do best when they are within 20 miles of their intended customers. Specialty garden centers don't generally require more than 2-3 acres of land. Larger plant material for the landscaping trade can be very heavy and awkward to ship a long distance. High-end garden centers require close access to affluent populations in order to construct expensive buildings, greenhouses, parking lots, and demonstration beds.

The high cost of establishing a store in an urban area is more than made up for by the greater economic return of a nearby large population (Figure 17, Knox 2011). Parcels located near population centers may come with access to the municipal water supply, thus reducing concerns over the availability of supplemental water.

Large county planning departments offer Geographical Information Services (GIS) that provide data on land classification, including the tax base, access to services, soils type, proximity to flood plains, etc. Upscale retail nurseries often do best when they are located near mass merchandisers. The lack of service and selection at the discount stores encourages gardeners to seek out the customer service and selection at an IGC.

Figure 17. Garden centers near urban centers can capitalize on the sale of trees in decorative boxes, which can be set out on patios and decks.

Wholesale

If plants are to be shipped over long distances or sold via the Internet, the parcel selected does not need to be located near a major population center. They do however require access to major state and interstate highways, as essentially all of their stock is shipped out on over-the-road trailers. Wholesale operators typically select land that is zoned for agriculture and has access to the legal use of groundwater (Ingram and Vanek 2013).

Topography

The term "topography" refers to the slope and aspect of a potential site. Level to gently rolling sites are preferred as they allow easy tillage, and ease of moving plants, equipment, and supplies.

Field grown stock

Field stock growers generally look to establish their crops on gently rolling pastureland (Figure 18) near river bottom lands. Plants can be safely raised on ground with up to 10% slope, where mechanical equipment is used for cultivation and harvesting. When slopes exceed 10%, the risk of tractor rollover increases greatly. On sloping ground, growers prefer to plant with the contour of the land in order to reduce soil erosion.

Figure 18. These Japanese maples *(Acer palmatum)* have been grown on sloping ground that exceeds 10%.

Field growers may have to dig B&B plants (trees and shrubs) by hand on steeper slopes. On most sites, some slope is beneficial in that it allows for better soil drainage and air circulation. Growers should consider using permanent cover crops (LeBude et al. 2007), such as mixtures of perennial ryegrass and creeping fescue, on steeper ground in order to reduce soil erosion during the winter rainy season. A good stand of ryegrass and fescue will help keep the surface from becoming deeply rutted from the use of tractors (Halcomb 2010, Halcomb 2002).

Container nursery stock

Container yard operations, also called ***can yards***, are typically situated on land with 5% or less slope (Yeager 2010, Figure 19). The run-off from a container operation is easier to capture when there is a slight slope to the can yard. Container-grown plants can take on a lean if they are set on sloping ground. Buyers prefer to have trees that grow straight up in the container in which they were raised.

Figure 19. These Tanyosho pines *(Pinus umbraculifera)* are in 10-gallon pots set on a slightly sloping, graded piece of ground. A layer of crushed rock keeps the surface dry.

When there is slope to the can yard, water can be drained to a retention pond via surface flow, where it can be treated (White et. al. 2011) and re-used to provide irrigation water back to the nursery. When there is not enough slope, sub-surface tiles can be trenched in around the raised container yard beds to direct the flow of water to a retention pond.

Pot-in-Pot production

If the native ground is too steep for a container yard, a grower can adopt the ***Pot-in-Pot*** (PnP) production system, which is adapted to steeper slopes. After using an auger to dig the holes for the socket pots, workers should use a handheld level to ensure that their top edges have been set level to the slope (Figure 20).

Greenhouse operations

Container growers often utilize greenhouses for propagation or overwintering structures. If plants will be raised in greenhouses, the nursery manger will need to find the flattest area on the property. Larger engineered greenhouses have to be built on graded pads that have been leveled in order to ensure that doors and benches open and move smoothly, and that concrete walkways can be leveled. Simple cold frames can be erected on sloping ground (less than 5% is preferred).

Figure 20. Pot-in-pot operations can utilize sloping ground as long as the socket pots are leveled after they have been installed.

Soil Type

Consider the soil type when first assessing a prospective parcel for a nursery, whether for in-ground or above-ground production. Review a soils map to determine the soil texture classification. The online application, SoilWeb, determines soil pH, soil type, soil chemical properties, and soil depth (Green 2015). This application works on desktop computers, tablets, and smartphones.

Field grown operations

When plants are to be raised in the ground one must look for a site with ***well-drained soil*** (LeBude and Bilderback 2008). A prospective site should have a ***sandy loam*** or loamy sand soil texture. Ideally, the site should have good drainage to a depth of 4 ft (Figure 21). Well-drained ground can be tilled during the wetter months of the year, an especially important point in areas west of the Cascade Mountains.

Figure 21. In-ground growers need well-drained sites in order to utilize harvesting machinery during the winter months.

Drainage can be checked by digging a 1 ft hole with a shovel or post-hole digger. Fill the hole with water and let it drain away. This will saturate the site. After the water has had a chance to drain away, fill the hole once again with water. If the water has not drained away after 24 hours, the site is considered poorly drained. Plants will growly poorly on wet sites, or suffer from root rot.

Knowing the soil texture for a potential in-ground nursery is very important if plants will be dug and sold as ***bare root*** in the winter months. Sites classified as sandy loam are best in that they reduce the amount of soil that clings to the root systems when the stock is dug. If a handful of moist soil does not ball (form a clump when squeezed in one's hand) it should serve well for the bare root producer. Conversely, if the field stock will be dug and sold as B&B, it is advisable to select a site with soils that do ball when squeezed.

Heavy clay sites should not be used for B&B operations, as their very fine texture will result in a heavier product. Sites with an excess of stones are also more problematic, as the rocks interfere with tillage and digging bare root stock.

Container operations

Container yards can be situated on ground with less than perfect drainage by properly utilizing drain tiles and crushed gravel. However a prospective site exhibiting standing water may require too much time and money in modifications to make it a suitable nursery site. As nearly a third to one-half of the site will be devoted to roads, buildings, greenhouses, or a pond, the better draining areas can be devoted to the container yards.

Pot-in-Pot operations

Growers contemplating a future PnP production nursery must know the site's soil drainage capacity before they decide to purchase or rent the land. On sites with poor soil texture and drainage, the socket pots will flood (Figure 22) during the winter months, thus impacting the growth of the plants in the liner pot (Halcomb 2009). One of the biggest expenses of establishing a PnP nursery involves having to install agricultural drain tiles under every row of socket pots (Dunwell 2013).

Figure 22. Flooded socket pots are the nemesis for PnP growers.

Existing Vegetation

When reviewing a new piece of ground for a potential in-ground nursery, look at the amount of existing vegetation, including trees, brush, and perennial weeds on the site. All of the existing vegetation will need to be removed in a systematic process that often takes 2 years to complete.

During the first year, the trees and brush will need to be cut or mowed down and the stumps either pushed out or ground up. During the second year, a cover crop of grain (oats, rye, barley, etc.) will need to be planted in order to rebuild the ***soil tilth***.

When clearing land, use caution not to disturbing the native topsoil. Making significant grade changes often results in mixing sub-soil with topsoil, thus leading to problems with soil drainage. When field-grown stock is ready for sale, buyers will expect it to be completely clean of any weed growth. Unless the future planting site has been properly prepared, it will be very difficult to achieve a weed-free harvest of plants, with or without soil surrounding their root systems.

Container operations

Can yard crop growers can utilize parcels of land that have a scattering of mature trees (Figure 23). If the goal is to grow shade-loving plants, then a lightly wooded lot can be utilized. This will reduce the need to build shade structures. Be sure to address the health of the existing shade trees, however. If a large tree blows over it, will take time and effort to cut up and haul off the limbs and trunk. Container stock near the downed tree will often be impacted as well. Shade intolerant nursery stock generally needs open ground.

Figure 23. Western red cedar *(Thuja plicata)* can be raised in containers under the shade of native trees.

Land Use Zoning

Nurseries, greenhouses, and retail garden centers are all heavily impacted by land use planning and protection efforts in Washington State. Zoning laws set the standards for farming practices, building projects, and marketing regulations. Growers need to be assured that their agriculturally zoned land will allow them to maintain their normal farming practices of planting, harvesting, pest control, irrigation, and marketing (Figure 24).

In Washington State, the Growth Management Act was adopted by the State Legislature in 1990 in order to ensure an adequate supply of agricultural land by protecting critical areas and natural resource lands (WA State Growth Management Act 2015). The act also requires cities to designate urban growth areas around major population centers, thus setting the standards for zoning.

Figure 24. Farmers enjoy land use planning that helps preserve their farm ground in the face of urban encroachment.

When land has been placed in the Resource and Rural zoning classification, it can be used for commercial nurseries growing and marketing locally produced plants and associated landscaping materials, have accessory buildings and greenhouses, and can have housing for agricultural employees. Land zoned in Commercial Districts can be used for agricultural practices, as well for the sale of nursery stock at retail garden centers.

Water Utilization

Prospective nursery owners have to understand the need for supplemental irrigation before establishing any sites in the Pacific Northwest. Even in the higher rainfall districts of western Washington, there will be very little rain from mid-June through early September. In eastern Washington, where there can be as little as 10 inches of annual precipitation, the lack of access to irrigation water will preclude establishing a nursery. Prospective nursery owners must develop a thorough understanding of the different avenues for obtaining legal water as set forth by the Washington State Department of Ecology (Figure 25) (WA Ecology 2015a).

Legal water rights

All too often, new landowners assume that ownership entitles them the use of surface and ground water (WA Ecology 2009). Land ownership is not the same as having the right to use water. According to the Landowner's Guide to Washington Water Rights, water right is defined as the "right to a beneficial use of a reasonable quantity of public water for beneficial purpose during a certain period of time occurring at a certain place," (WA Ecology 2015a).

Figure 25. Legal irrigation of nursery stock involves thorough regulatory consideration.

Before considering using water from surface or ground water sources, producers must first determine if the site they have selected has a valid water right on file with the Washington State Department of Ecology (DOE). A ***Certificate of Water Right*** is the legal record of the water right, and is recorded at the county's auditor's office. When DOE issues a certificate, it becomes attached to the land on which the water will be used.

If the water right use is still under permit and has not moved to certification, the permit is considered personal property and does not automatically transfer with the sale of the land. The new landowner must make sure that the permit is reassigned from the previous landowner (s). This is done by the seller completing an Assignment of Application or Permit to Appropriate or Store Water form, which is filed with the DOE along with the appropriate fee.

There are many competing uses for water in Washington and much of the ground water supplies have already been claimed. DOE suggests that growers interested in a new water right first attend a pre-application consultation with DOE regulators to determine the opportunities and alternatives for obtaining a legal water right.

Table 3. Cost of purchasing 1 in. of irrigation water (27,000 gallons/acre) for overhead irrigation on container ornamental nursery stock.

Municipal water supply

Lacking legal water rights, nursery operators can draw their irrigation water from a ***municipal water*** system if it is available. Municipal water rates for commercial enterprises vary in price across the state, depending upon the proximity to urban centers (Table 3). The costs associated with public water will probably preclude its use for container operations exceeding five acres, where water is supplied via overhead impact sprinklers (Schnelle 2009). Garden center operators often use public water sources for their nursery stock, as their facilities are frequently located in urban areas where water supply lines are available.

Groundwater exemption

In the absence of a valid Water Right Permit or Certificate, a landowner may be able to use Washington's groundwater permit exemption (WA Ecology 2015b). This provision states that a landowner can withdraw up to 5,000 gallons of groundwater per day for industrial purposes, including irrigation. One industrial use of the exemption is allowed for any one project, regardless of the size.

Although ***permit-exempt ground water*** users do not require a permit they are still required to follow state water laws. There are watersheds in Washington where there is little to no available water (WA Ecology 2015c). Growers interested in using a permit-exempt well should consult with WA Ecology to ensure that the groundwater permit exemption is not restricted in their area.

Rainwater collection

WA Ecology allows ***rainwater harvesting*** (RWH) from rooftops. The practice of RWH can be legally conducted without applying for a water right permit (WA Ecology 2015d). As long as the cumulative impact of RWH does not affect in-stream flows or existing ground water supplies Ecology does not require water users to make an application for their water use under RCW 90.03 (Washington State legislature 2015a) or RCW 90.44 (Washington State legislature 2015b).

To qualify as rooftop collected rainwater, the roof collecting the rainwater must be part of a fixed structure above the ground with a primary purpose other than the collection of rainwater for beneficial use. Ecology requires that the water collected from an outbuilding roof must be used on the same parcel. Once collected there are no limits on how the water can be used. The RWH storage system can be used to store permit-exempt groundwater collected in the winter for use the following summer.

To calculate the amount of water that can be collected from a given amount of roof surface, first measure the width and length of roof surface (Mangiafico 2011). Multiply the square footage of roof surface by 0.62 to calculate the gallons of water that could be collected from one inch of rainfall.

If nursery managers utilize water pumped from the ground or collected by RWH to irrigate their crops, there should be very little need to test the water for pathogens, excess nutrients, pesticides, or turbidity. Water withdrawn from the ground or captured from RWH is considered pure and will not contain dissolved salts.

Water silos

Nursery owners can purchase corrugated metal water catchment silos that range in size from 5,000–15,000 gallons for pre-assembled systems, up to 150,000 gallons for field erected tanks (Mangiafico 2011; Figure 26). Due to the limited amount of rain received during the summer months and the expense of rain collection tanks, it is probably not realistic to consider that RWH systems will do more than supplant water derived from ground water.

Figure 26. Rain water harvesting storage silo.

Irrigation reservoir ponds

Ecology states that landowners can construct a lined ***reservoir pond*** on their property without obtaining a Water Right Permit to store water from RWH. The liner will prevent the pond from leaking. Ponds that exceed 10 acre-feet of storage above natural ground level require a Dam Safety permit (WA Ecology 2015e).

Building a reservoir that would store 10 acre- feet of water would require digging a pond with 1 acre of surface area (equivalent to a square 208 ft on a side, to a depth of 10 ft), or a pond with two acres of surface area (equivalent to a square 295 ft on a side, to a depth of 5 ft). It would require moving 432,260 cubic feet of soil (208 ft x 208 ft x 10 ft) or 16,023 cubic yards (at 27 cubic feet/cubic yard). A reservoir of this size could hold 3,244,800 gallons of water (at 7.5 gallons of water per cubic feet) but would be expensive to excavate and permit.

Large container nurseries (more than 10 acres) often use ***one acre ponds*** to store and filter runoff from their production beds. For smaller nurseries (less than five acres), a one acre pond (10 acre-feet of water) would take a large amount of land out of production. To avoid this loss of production, the pond can be reduced in size. Building a pond of .3 acres (116 ft on a side, 10 ft in depth) would only involve moving 4,983 cubic yards of soil. County public works departments often impose fees on projects moving more than 5,000 cubic yards of earth. A lined reservoir of this size would still supply one million gallons of water at the start of the irrigation season.

Types of ponds

There are three different types of ponds: embankment, dug, and levee.

An ***embankment pond*** (Figure 27) consists of a low area at the base of a slope where water collects. A dam or embankment is constructed in a depression between two hills, thus serving to impound water on the upstream side of the dam. This may be the least expensive type of pond to construct as it involves the least amount of soil to be moved, although the soil for the embankment must be properly placed and compacted in order to hold water. Design and construction of the embankment must be supervised by a licensed Professional Engineer.

Figure 27. This embankment pond captures nursery run-off and serves as an irrigation supply source.

The second type of pond is known as an excavated or ***dug pond*** (Figure 28). In this type of pond, soil is removed from below the original grade level. As it requires a relatively large amount of earth-moving equipment to construct this type of pond, they are typically less than half an acre in size.

Figure 28. An excavated pond is dug into flat ground.

The third type of pond is known as a ***levee pond***. In this type of construction, flat or nearly flat ground is selected (Figure 29). Earth from what is to become the basin is excavated (no deeper than 10 ft) and placed on the boundary of the pond to form a levee, thus impounding the water that collects within. The water level of the levee pond will be higher than the surrounding ground level. The soil for the levee embankment must be properly placed and compacted in order to hold water. Design and construction of the levee embankment must be supervised by a licensed Professional Engineer. Levee ponds may be expensive to construct.

Figure 29. This levee pond stores water captured from the roof of the adjacent greenhouse.

For either a levee or embankment pond, a civil engineer should be consulted prior to considering this type of pond. For a complete guide to different types of ponds refer to the Natural Resources Conservation Service Ag Handbook 590 (NRCS 2000).

Ponds serve as wetlands

Nursery crop producers utilize pesticides and fertilizers to help grow their crops quickly and efficiently. However the excess nutrients, pesticides, and a number of potential plant pathogens can leave the fields or container yards during high rain events or through irrigation. This polluted water should not be allowed to leave the fields onto adjacent properties. Ideally, nurseries should capture the first inch of a rainfall event (Johnson 2009).

Irrigation ponds can serve as constructed wetlands (White et.al 2011) to help to filter excessive levels of phosphorous and nitrogen that have clearly been found to be environmental hazards (Southern Nursery Association 2013). The water collected from a ***constructed wetland*** can serve as a valuable source of water for re-use back in the nursery. Depending upon the type of irrigation system, it will probably need to be treated before it is re-used (Haver 2014).

Constructed wetlands can harbor the pathogens (*Phytophthora spp.*) responsible for Sudden Oak Death (Greisbach at al. 2012). Water that has been sent through a sand filter will have reduced levels of solids (lower turbidity) and thus will not clog drip emitters (Bilderback 2008a). Sand filtration has been very effective in treating ponds harboring water borne pathogens (Chastagner 2015). Pond water should be checked for pH and alkalinity (Halcomb and Fare 2010). Commercial soil testing labs can perform this service. Irrigation water can be treated with sulfuric acid (Bailey and Bilderback 1997) to lower the pH, and chlorine can be used to reduce algae and pathogens. Consult with an engineer at an irrigation supply firm.

Overhead irrigation

Nurseries have widely used ***impact sprinklers*** to supply supplemental irrigation during the summer months when rainfall is scarce (Figure 30). These systems can throw water over a large area, and are relatively inexpensive to install. Impact sprinklers often produce uneven water distribution, which can slow plant growth. By wetting the foliage, foliar diseases can develop. They also tend to be inefficient (30% loss due to wind drift and evaporation), especially under hot, windy conditions. On sloping ground, there can be a greater chance of erosion with overhead irrigation.

Figure 30. Overhead irrigation with impact sprinklers delivered through portable aluminum pipe.

Drip irrigation

With the strict regulations concerning ground water withdrawals, Washington State nursery owners will need to utilize drip irrigation as opposed to overhead irrigation whenever possible.

The primary advantages of drip irrigation include the precision and control of applying the appropriate amount of water to each individual plant as needed during the growing season (Figure 31). There is practically no water lost due to run-off, percolation, or evaporation, or watering the space between containers. Drip systems don’t apply water to the crop leaves, stems, or fruit, thus reducing incidence of diseases (Keskula 2005). A large portion of the soil surface always stays dry between the rows for in-ground stock, thus reducing weed pressure.

Figure 31. The use of large containers and drip irrigation helps conserve water.

Drip systems can be controlled with microprocessor controllers and computers, thus reducing the need to physically move sprinkler pipes or traveling guns. Table 4 outlines the number of acres of nursery stock that could be raised with one million gallons of water at the beginning of the irrigation season.

Stretching irrigation water supply

Prospective nursery owners who have seen large wholesale operations using overhead irrigation often question how they can succeed, given the limited availability of ground water and the price of municipal water. In practice however, there are many well managed, small scale nurseries that have learned how to adapt water conserving strategies. Table 5 outlines the number of acres of field-grown stock that could be raised with one million gallons of water at the beginning of the irrigation season.

Irrigation—best management practices

In Washington State, it can be difficult to find land with a valid water right permit. Nursery owners will need to adopt a series of water conserving practices in order to build a reliable supply of irrigation water for the dry summer months. A number of alternative production practices are described in Table 6.

Table 4. Container nursery stock irrigation, based on 1 million gallons of stored water from RWH.

Table 5. Field nursery stock production based on 1 million gallons of stored water from RWH

Table 6. Best management practices for farms lacking a valid water right permit from the Washington State Department of Ecology.

Production Options

Potential crops that could be grown include: trees, shrubs, evergreens, groundcovers, native, and/or herbaceous perennials. Initially, the grower will start with liner stock, also called ***liner material***. In the trade, liners refer to young, immature plants that will be grown into a saleable product.

In-Ground Field Production

Raising plants in the ground (Figure 32) has traditionally been one of the most widely utilized nursery production techniques. Trees, shrubs, groundcovers, bulbs, and herbaceous perennials are simply planted in the ground and left to grow on their own until they reached the desirable stage of maturity (Halcomb 2009).

Advantages

There are numerous advantages to raising plants in the ground. Field grown plants are inherently more forgiving than container raised plants (Eaton 2009). Plants grown in the ground will develop an extensive root system, making them more resilient to drought. There are a number of wholesale shade tree and conifer plantations in the Northwest that receive very little supplement irrigation during the summer months**.**

Figure 32. Specialty conifers are (*Chamaecyparis lawsoniana* "Minima Aurea") typically grown in the ground until they are ready for harvest.

Pest management is easier for field stock in general, as the plants are often grown in rows that allow for access to tractors, all-terrain vehicles, and sprayers. On heavier (higher clay content) soils there may be less need for supplemental fertilization, as the soil will supply the basic nutrients. Winter injury is less of a problem as root temperatures are buffered by the soil. Plants don't blow over do plants in containers. When market conditions slow down, field-grown trees and shrubs can be left to grow to larger sizes. Landscape contractors often prefer the larger plant material, which is dug B&B, when they don't have to travel far to secure it.

Disadvantages

The major challenges to raising nursery stock in the ground arise upon harvesting it. As the majority of buyers are looking to buy nursery stock in the spring, the digging and shipping season must take place in a relatively short time frame, from February through April. Inclement weather and wet field conditions can make digging difficult, more so if the soil does not drain well. While smaller plant material can be dug by hand and carried out of the field, it can be challenging to dig larger stock on soft, poorly drained ground.

Pre-plant plowing

Field stock growers must prepare their sites thoroughly by deep plowing the ground prior to disking (Figure 33). In the nursery industry, it is important to produce a substantial 360° root system while it is in the ground. Tree roots will spread out well if they are planted in well mixed soil. Deep plowing followed by disking the soil to break up clods enables roots to spread out. A chisel plow is the preferred implement (LeBude and Bilderback 2008). Moldboard plows can be used on deep, sandy loam soils. However, they are not as preferable on sites with marked contrasts in texture in the top two feet of soil, as they tend to deposit the better, surface soil deeper.

Figure 33. Disking prepares the field for planting.

Pre-plant fertilization

There is a shortage of information in the Northwest concerning fertility recommendations for woody plant material. It is best to study a soils survey map of the prospective planting site to ascertain the native soil type and texture, ***pH***, organic matter, ***cation-exchange capacity*** and ***exchangeable base saturation*** of the soil in question. Some of this information is available online from the SoilWeb application (Green 2015). Previous cropping patterns may have changed the soil properties, so don't rely solely on maps. Soil chemistry data can be determined by submitting a soil test to a reputable soil testing lab (Daniels 2005).

Prior to planting, a soil test should be performed to determine the native levels of phosphorus (P), potassium (K), and resident pH. In general, most woody plants raised on mineral sols will do best at pH of 5.0 to 7.0. If the soil test shows that P and K levels are low, or if the soil pH is less than 5.0, the nursery manager will need to apply the needed amounts of P, K, and calcium carbonate (agricultural lime) and work it into the top 10 in. of the soil profile (Figure 34).

P, K, and calcium carbonate are considered immobile elements. Depending upon the soil pH, anywhere from 2-4 tons of lime will be needed per acre prior to planting. For soil pH, the suggested range is 5.5- 6.5. With low levels of P and K, a manager may need to add 125 pounds each of actual P and K per acre (Owen et al. 2010). Pre-plant amendments are applied across the entire field a year ahead of planting, and incorporated by disking.

Figure 34. Lime and pre-plant fertilizers will need to be worked into the top foot of soil.

Nitrogen (N) is a mobile element and would not be incorporated prior to planting. In Oregon, in-ground tree growers typically incorporate 120 pounds of N/acre in the spring in split applications of no more than 60 pounds of N/acre applied at any one time. The first application should go on in late winter (February to April), while the second one should be applied in the spring (May). To increase the rate of N efficiency (defined as reducing the over-all amounts), growers are advised to band the N on either side of the row, using hopper spreaders.

There is no reason to apply mobile elements to the alleyway between the rows. Testing for available soil nitrate nitrogen is imprecise (Horneck et al. 2011). There are no guidelines for in-ground nursery stock (Owen et al. 2010).

In the eastern part of Washington, there may be fields that need to be acidified. Elemental sulfur can be applied as needed, prior to planting (Locke at al. 2006). It can take more than a year to lower soil pH levels with sulfur additions.

Pre-plant use of cover crops

Field crop growers often plant summer cover crops prior to planting their fields. Sorgum-sudan grass (Figure 35) can be used to stabilize open and bare soil to reduce erosion (Bilderback 2008a). While cover crops can help increase organic matter levels, their greatest benefit comes from increasing soil aggregate particle size thus improving aeration and percolation (McGuire 2003).

Figure 35. Sudangrass is often used as a summer cover crop prior to planting field stock.

Bare root growers need to have a loose, friable soil that does not stick to the roots during winter digging. Sudan grass is planted in the late spring at 25 pounds/acre, while soil moisture is still present. In the fall, dwarf barley works best when planted in mid to late September (LeBude and Bilderback 2008).

Slope and soils considerations

Field grown nursery stock is best situated on gently rolling land for good water drainage and air circulation. It can be challenging to work on slopes over 10%. If plants are to be harvested bare root, be sure to select a sandy loam soil type. This will greatly reduce the amount of soil that will need to be washed from the roots after harvesting by machine or by hand. Conversely for trees and shrubs that will be dug B&B, select a site with a silty-clay loam, as the soil holds together better, thus reducing root breakage during harvest.

Liners

Field stock growers have a series of options for when and how they will harvest their stock. Young deciduous trees, shrubs, and berry plants are often dug in the winter as either ***liners*** or ***whips*** when they are they still dormant. In the nursery industry, growers use the term "liner" to designate seedlings started from cuttings or tissue culture plantlets, which are grown for one year. A liner grower is looking to grow a root system on plants.

For shade trees, the term "liner" refers to a plant that grew from a seed. Mature seed is often collected from trees in the fall. Workers either pick the seed pods from the trees or shrubs by hand or allow them to drop to a tarp placed beneath the plants. Freshly harvested seed from woody plants can be sown into prepared seed beds in the field (Figure 36). At the end of one year of growth, the term 1-0 refers to a seedling that was grown for one year in the ground in a row without being transplanted. Nursery catalogs often refer to liners as "seedlings."

Figure 36. Sugar maple seed beds have been hand seeded and then mulched.

Graded seedlings will be lined out in the row to become "whips" which are discussed below. Germination requirements vary among different genera (Wray 1998, Dirr and Heuser 2006). In the case of oaks, young trees are started from acorns (which consists of the seed). After the acorn has been cold stratified for 2-3 months at 40°F, they can be sown into shallow nursery flats in the greenhouse (Figure 37). From here they will be lined out in the field.

Liners produced in the Northwest are generally grown in the ground and dug up during the winter, before being transplanted or sold the following spring. Deciduous tree and shrub liner stock has to be harvested after all of the foliage has dropped. Any green leaves on the plant material will decay during transit, thus spoiling it.

Figure 37. Rooted oak seedlings, termed "liners" in the nursery trade. They will be lined out in the field to become whips.

Bare root conifers

In the Northwest, conifers for the timber companies, Christmas tree growers, or the nursery trade are raised from seed in the ground or container-grown for 1-2 years before being sold as planting stock (Duryea 1984). Seedlings that are grown for 1 year are referred to as 1-0, defined as 1 year in the same bed without any additional years in a transplant bed (Figure 38). Ornamental conifers are typically grown as 2-0 before they are dug up, trimmed (both shoots and roots), and then replanted for another 1-2 years. The resulting plants are referred to as 2-1 or 2-2 liners. As long as all the harvesting, trimming, and replanting occurs during the dormant season, field survival rates for new planted stock is generally quite good.

Figure 38. Direct seeded Norway spruce seedlings (1-0) will be dug up as liners before they are replanted back into the field and grown on to become finished trees.

Whips

The second stage of woody plant production involves the production of whips, which are defined as plants consisting of straight stems with few branches. The first step in raising whips involves planting liners out in rows in the ground and allowing them to grow for one year.

Row spacing

Shade trees are commonly grown 12-15 in. apart within the row, with rows set 48 in. apart (Figure 39). At the whip nursery, the goal is to raise a straight, upright plant with minimal branching and few lower limbs. Bamboo or metal stakes and some variation of plastic tape will be used every 6-12 in. to keep the main trunk straight and tight alongside of the stake. Shrubs are often set at wider in-row distances, but at similar between-row spacing, because they can grow wider than trees.

Figure 39. Grafted 6 ft tall red maple whips in mid-summer. Digging, grading, and sale will begin 3-4 months later.

Seedling whips

In the case of deciduous trees grown from seed, liners will be planted in the spring and allowed to grow for a year. At the beginning of the second year, they will first be cut back to the ground. When a new shoots arises, one will be selected and allowed to grow for one year. All other shots will are removed.

At harvest, this plant is referred to as a “one-year whip,” indicating one year of growth after cut-back but two years of growth after transplant. Upon harvest, whips will be graded by caliper (stem diameter 6 in. above the ground; Table 7). It can take 1-4 years to raise a whip, depending upon the desired caliper at harvest.

Table 7. Height and caliper for shade trees.[1]

Budded whips

If the whip will become a grafted cultivar, as is the case for the common deciduous shade tree cultivars, budding will take place in the late summer (August) of the first year of liner growth. During the following spring, the plant will be cut off just above the bud union. A shoot stemming from a grafted bud (Figure 40) will be grown for an additional year, before the finished whip is dug up and sold. As with seedling whips described previously, the goal is to produce an 8-10 ft tall single stem whip or lightly branched tree of ¾- 2 in. caliper size.

Staking

It is very important that shade trees (both deciduous and coniferous) are grown with a single central leader, free from competing stems (referred to as co-dominant) or other upright branches that would compete with the central leader (Gilman 2009). Double stem trees lack the strength and form of single leader trees.

Shade trees and conifers will have to be staked during the second year of the two-year whip cycle (Bilderback 2008c). As a result of rapid growth, staked and close spaced whips don’t have the strength to stand straight without diligent taping to some type of a thin diameter pole. To calculate the length of pole needed, a grower can refer to Table 7 to determine the mature height of the finished whip at harvest. For example, a commonly sold 1.5 in. caliper shade tree whip will need a 14 ft. stake during its growth period.

Figure 40. A budded whip, Snowdrift crabapple, grafted onto seedling apple rootstock.

Growers often use plastic tape held in a Max-Tapener dispenser to apply stretchable plastic tape to secure the main stem to a bamboo, steel, or fiberglass stake (Figure 41) that is set right next to the first year whip (Figure 42). Metal stakes (5/16 in. galvanized) are often used, as they will last many years, but they have a high purchase price.

Staking maintenance

It is essential for workers to periodically check to make sure that the tape, which has some stretch, is not girdling the trunk. The goal is to keep the tree tight against the pole. Once the stem has grown to the top of the stake, the stake should be removed. If the tree is allowed to out-grow the height of the stake, the top can start to bend, and that can cause a permanent bow or even break (Figure 43).

Whips that don't make a desirable grade will often have to be rejected, or left in the ground longer with a stake extender or a new, taller stake. In conifers, the loss of a central leader makes the whip unmarketable. A short stake can be used to tie up a lateral shoot to form a new leader. Taller conifers (over 6 ft) typically don't require staking, as they typically retain a pyramidal shape on their own.

Figure 41. Plastic tape is used to secure stems to the stakes for this Golden Showers Lawson cypress.

Harvesting whips

The larger wholesale nurseries will dig their whips with a mechanical digger (Figure 44) that straddles the row, and lifts the entire tree up and out of the soil where workers load them onto carts for transport back to the grading shed. Whips will be graded based on their height, caliper, root structure, and branch structure or tree form. There are always a number of whips that don't make the grade for any of the desirable characteristics, and are chipped.

Figure 42. The field manager of this nursery is using long-lived fiberglass stakes to keep the trees perfectly straight.

Marketing whips

Whips can be sold bare root to municipalities for use in urban tree planting programs (Figure 45). As long as they are planted when they are still dormant, and care is taken to water them the first year, field survival can be very good. They are considerably less expensive than container or B&B stock, thus making them attractive to the urban tree professional charged with the task of increasing over-all canopy coverage. Whips are also sold to conventional container, PnP, and fabric bag growers, who will set them in pots or bags for further growth. They will also need staking when they are grown in a container.

Finished Trees and Shrubs

The final stage of nursery stock production is aimed at producing a finished tree or shrub that can be sold to a landscape contractor or garden center. The starter material typically is a 1-1.5 in. caliper whip for deciduous shade trees, a 2-0 conifer seedling, or a well branched shrub. For finished shade trees (1.5- 3 in. caliper), it may take 2-3 years before the initial whip has grown large enough to achieve the desirable stem diameter and height.

Figure 43. These whips have grown past the top of the stake.

Figure 44. An over-the-row mechanical digger is used to lift bare root deciduous trees and shrubs (whips) in the winter months.

Figure 45. Dormant 1- 1.25 in. caliper whips (8 to 10 ft tall) have been temporarily heeled into the ground.

Row spacing

For shade tree production, whips are set out at an in-row spacing of 5-7 ft, with a between-row spacing of 12 ft (Figure 46). As a rule of thumb, plant shade trees 3 ft apart in the row for every inch of anticipated trunk diameter (LeBude 2008). The wider row spacing is suggested where the trees will be dug up with a mechanical tree spade. It takes more room to maneuver when heavy equipment is used.

Some trees will develop a wider canopy. Rather than having aligned on a square both within the row and between rows, a manager can offset adjacent rows. The in-row spacing of 6 ft would stay the same, but the trees would be off-set 3 ft, thus making them lined up on the diagonal.

Figure 46. With an in-row spacing of 7 ft and a between-row spacing of 12 ft, these shade trees will be allowed to grow to 1.5 in. to 2.0 in. caliper.

Pruning

Raising finished shade trees requires the use of straight, un-branched whips. The goal is to produce single leader trees with full crowns, and no signs of un-thrifty foliage (Bilderback 2008c). There should be no side branches coming off the main stem with narrow crotch angles, or co-dominate stems (two equally sized stems competing with each other). The lower limbs should be removed to a height of 3 ft for a tree sold to retail customers, and 5-6 ft for street trees sold to landscape contractors. If the tree has lost its terminal leader, a side shoot can be bent up and taped to a bamboo stake to help encourage the formation of a new central leader (Figure 47, Gilman and Kempf 2009).

For conifers, pruning may be required frequently (3-6 times over their lives) in order to keep the canopy from developing open spaces. Typically only 3 in. of new growth is removed at any time. Whenever new growth is pruned back, side shoots develop, which over time helps ensure a dense, full canopy (French and Appleton 2009). Ornamental conifers lend themselves to a multitude of different decorative forms (Figure 48, Gooch and Cregg 2009).

Figure 47. Side shoots can be bent up and tied or taped to stakes to help create new central leaders.

Japanese maples

Western Washington and Oregon are key growing regions for Japanese maples. While they take longer to attain a saleable size, they have a high demand and price structure. The upright Palmatum types produce approximately 1 ft of new growth each year (Figure 49). A field grower starting with budded liners could expect to sell a 4-5 ft tall finished tree after 4-5 years of production in the ground or in a container (including fabric bag, plastic pot, or tree box).

Conifers

The rotation for conifers varies widely depending upon the species. The commonly raised hedging species (Arborvitae, Rocky Mountain juniper, Leyland cypress) can all put on 12 in. of new growth per year. Hedging conifers are very popular in the ornamental trade, as customers seek out screening plant material (Brun and Dinius 2015). Dwarf conifers will grow slower (1-6 in. per year) depending upon the species.

Conifers are typically raised in the ground and then dug up and sold as B&B stock. For the garden center trade, B&B conifers are typically put into a container or wooden box and allowed to grow before they are shipped out.

Figure 48. Shearing Alberta spruce *(Picea glauca)* into a conical spiral form.

Supplemental irrigation

Raising nursery stock trees in the ground, as opposed to in containers above ground, requires less supplemental irrigation during the summer. On sites with adequate silt and clay, which naturally holds water and nutrients, in-ground shade tree growers in western Washington may only need to irrigate during the first year of establishment.

For boulevard shade trees, which may reach finished caliper in 2-3 years, water should be applied twice a week during the first year and once per week during the second and third years during the dry summer months. Withholding water during the final year of tree growth is considered a best management practice as it discourages excessive shoot growth. The trees will still put on good root and caliper growth.

Figure 49. These well-staked Coral Bark Japanese maples (*Acer palmatum* "Sango-kaku") have had their lower limbs removed, and have been pruned every year.

Drip tape

Field growers use both buried and surface drip tape systems (Bilderback 2008b).

Drip tape is merely thin-walled drip tubing that lays flat when there is no pressure on it. Tape is usually less expensive that tubing. By using drip tape, nursery managers can stretch limited irrigation supplies, thus allowing successful field stock production (Table 8).

Table 8. Drip irrigation considerations for in-ground field nursery stock with limited irrigation water available.

Drip tape dimensions

Tape typically comes in diameters of 5/8 in, ¾ in, and 7/8 in. Within these diameters, the tape can have a wall thickness ranging from 5 to 10 millimeters (Table 9). The standard 8 mil tape will last more than one season. Growers will select the 5 and 6 mil tape where the soil is free from rocks and low cost is important. This tape can be used either above ground or buried alongside the row. For maximum life span, in-ground tree growers will opt for the thicker 10-15 mil tape, as it is best suited to crops left in the ground for multiple years.

Depending upon the manufacturer, drip tape comes with built-in emitters with common spacings of 8 in, 12 in, 16 in, 24 in, 30 in, 36 in, and 48 in. Closer spacing ensures better water distribution in lighter soils. Growers will select tape with wider emitter spacing (>24 in) on heavier soils. Wider emitter spacing and lower built-in flow rates will ensure better infiltration on heavier soils. If the field is hilly, growers should select tape with built-in pressure compensating emitters to ensure a constant flow rate over the entire length of the field.

Table 9. Drip tape specifications[1]

Above-ground tape

Field crop growers typically prefer above-ground tape (Figure 50) when their stock is destined to be dug up by hand or with a tree spade and sold as B&B stock. In these types of plantations, plants are rarely removed all at the same time. By having the drip tape visible, a manger can move it as needed in order to keep a close watch on its integrity.

A stronger piece of drip tape pays off in the long run, as it can be re-used and resists damage by animals. Managers will run the irrigation system until the soil in plants' root zone (top 1-2 ft) soil is wet. This can be checked by using a shovel. By concentrating the water only in the root zone with drip irrigation, a greater percentage of roots will be available at harvest, compared with over-head irrigation which encourages much wider root spreads.

Figure 50. Heavy wall drip tape (10 mil) with 16 in. emitter spacing on lighter soil.

Below-ground tape

Shade tree growers growing whips should consider trenching in their drip tape prior to planting their liners. At the end of the 2 year cycle, the entire row of whips will be dug up along with the tape. During the digging process, the tape will be broken and should be collected for recycling.

Balled and Burlap

When trees and shrubs are dug up and their intact roots systems covered with burlap, the term B&B is used. B&B can be considered the next step up from harvesting plants bare root. This practice can be used for both deciduous trees, as well as conifers.

Advantages

B&B is widely used in the Pacific Northwest for the larger caliper stock destined for sale to the landscaping trade (Figure 51). When compared to trees which are dug bare- root, difficult to transplant species (primarily tap roots) will often perform better if they have been dug with their root systems covered in soil. In the case of conifers, only seedling sized trees can be dug up bare root.

Figure 51. B&B nursery stock being transported to the landscape job site.

Larger conifers have to be produced as B&B stock, as the roots would break off if they were dug bare root. In relationship to container grown trees, the B&B grower produces a tree that develops a fuller root system and a better developed canopy. Landscapers state that they get better transplant success by moving trees grown in soil as opposed to trees grown in soil-less substrate (fir bark). Large caliper B&B shade trees (2 in. caliper) are often specified by landscape developers for a public construction project.

Some growers will ***root prune*** their B&B stock each year, well before eventual harvest. Methods for root pruning vary. In this process, workers will use a spade to cut through the existing roots, making a circular cut all the way around the plant (Tripepi 2009). The edge of this cut should be just inside the edge of the future root ball. Table 10 lists the appropriate root ball diameter for different sized trees.

Table 10. Physical characteristics of B&B nursery stock.

Disadvantages

There are disadvantages of harvesting B&B trees. Over time there can be a lot of field soil removal with a B&B operation. By digging up the tree with native soil, the manger has to understand the weight of his products. A 2 in. caliper B&B dug tree can have a root ball that can weigh 300-350 pounds. Heavier planting stock will require the use of larger tractors with nursery jaws, and larger trucks or trailers to move the trees to the intended planting site. If the stock is sold to landscape contractors, they will require similar equipment to move and plant the trees.

Dormant season harvest

In general B&B harvest occurs during the dormant season, from early November to mid-March. During the Northwest's winter months (November through March), seasonal rainfall will ensure that the ground is soft, thus making digging easier.

Growers have found that they can keep their B&B stock out of the ground for 2-3 years if they care for the trees (Figure 52). Often the root balls will be set into sawdust beds where workers will cover the root balls. Supplemental water will be applied during the summer as needed to keep the trees from drying out.

Figure 52. Sawdust holding bed for B&B deciduous shade trees.

Hand dug B&B

Traditionally smaller field grown stock will be dug by workers using spades (Figure 53). After shaping the root ball a piece of burlap will be dragged under the root ball and then secured with plastic twine. Experienced workers can hand dig 10-15 B&B (1.5 in. caliper) trees per day. Weight certainly becomes a factor when digging and moving stock larger than 1.25-1.5 in. in caliper. Very little B&B stock is sold to retail outlets because even the smallest 1.5 in. caliper trees can weigh 250 pounds, which is too much for retail customers to handle.

B&B into containers

To extend the life span of the B&B stock, growers will transplant them into pots, tubs, and tree boxes. It will take six months for roots to grow out through the sides of the burlap. There are customers who prefer the ease of handling of these larger containers where a forklift can be utilized to move the product. The root system of B&B stock may respond better to the rigors of shipping if they are in a container.

Figure 53. Wrapping the root ball of a hand dug Colorado blue spruce with burlap.

Mechanical tree spades

Once a tree has surpassed a caliper of more than 2 in., the weight of the large root ball makes hand digging too difficult. Mechanical digging is a great deal more efficient than hand digging (Figure 54). With a tractor-mounted mechanized tree spade, a crew of 3-4 workers can dig 400 trees per day, if working with straight rows.

Because this work is done during the winter months, it is imperative that the site drains well. Even so, the fields often become very rutted after harvest and will need to be periodically re-plowed and leveled. If the trees will be harvested with a mechanical tree spade, the between-row spacing will need to be increased to 10-12 ft to allow access for large equipment. The suggested in-row spacing for 2 in. caliper shade trees is 6 ft.

Container Production

Figure 54. Mechanical tree spades can take the place of hand digging B&B stock.

Of all the different types of nursery stock produced in the Northwest, container sales generally comprise 40-50% of the total. The majority of trees and shrubs are now sold in containers, both to wholesale landscapers, as well as retail garden centers (Figure 55).

Customers like to buy trees anytime during the year. Container plants come with a full complement of roots when they are sold, thus minimizing transplant stress. Conversely, when field stock is dug, whether it is bare root or B&B, many of the fine roots are lost. These roots are responsible for both water and nutrient uptake. In the Northwest there are numerous examples of plants that have been grown their entire lives in a container, including grafted Japanese maples, dwarf conifers, and many of the herbaceous perennials.

Figure 55. A wholesale container nursery requires strict attention to detail on a concentrated piece of ground.

Acreage

In comparison to a field production nursery, a container nursery will need considerably less ground in order to support the business (Dunwell 2009). With the use of small containers, a vast number of plants can be raised on an acre of ground. A small operation may consist of 5-10 acres (Adam 2009). The return on investment can be considerably higher with container stock and plants can be produced twice as fast as ones in the ground. Plants such as annuals, perennials, and small shrubs can be ready for sale in only 6-12 months.

Land that is not suited to in-ground production can often support a container operation (Halcomb and Fare 2010). In general, at least a third to half of the property will need to be devoted to roads, loading areas, and buildings (Table 11). Container nurseries can be very labor intensive. Pots will need to be weeded, set back up after they have blown over, re-potted enough to discourage root circling, and checked each day to ensure that they are receiving irrigation water. As a rule of thumb, most nursery managers allocate one worker per acre of container stock, versus one worker for 5-20 acres of field grown stock (Neuman 2014). There are now robots being utilized in container operations that can be programmed to move plants from one part of the nursery to another
(Figure 56).

Figure 56. Robot moving 3 gallon azaleas.

Table 11. Container yard specifications.

Container sizes

The nursery industry relies on a series of different sized containers in which to grow plants. Nursery owners select a pot size to match height and width of the plant at sale time. At the big box stores, trees are typically sold in 10 gallon pots. At the retail garden center, larger containers are often used. For shade trees, customers will generally find that 15 gallon pots predominate. Landscape contractors prefer shade trees in 25 gallon pots. Refer to the American Standards for Nursery Stock (AmericanHort 2015) for the suggested container sizes for all the different types of trees, shrubs, and conifers sold in the trade.

Container media

Nursery owners shy away from using native soil in their containers, as it is too heavy, lacks adequate drainage, lacks consistency, and frequently has weed seeds and/or disease organisms. Outdoor container growers in the Pacific Northwest generally prefer a well-drained media for their woody ornamentals.

A standard nursery media would consist of 70% medium bark (Douglas fir), 20% yard debris compost, and 10% pumice (Robbins and Evans 2013; Figure 57). Pumice is a key inorganic component in growing media, used to increase aeration, porosity, drainage, and reduce weight. Bark retains water, has excellent drainage, and is typically pest free. It decays slowly over time. It is also lighter in weight than native soil thus making it easier for workers and shippers that handle the containers. A 15 gallon container with a 1-2 in. caliper shade tree will weigh 75 lb, while a comparable caliper B&B tree will weigh 260 pounds.

Container nutrition

The media used for woody plant container mixtures has a low ***cation-exchange capacity***, which is defined as the ability to hold nutrients. Growers will need to provide supplemental nutrients in order to encourage plant growth (Zinati 2005). The limited size of the container and the frequent irrigation levels will contribute to nutrient leaching as well.

Figure 57. Container growers will use a mix of compost (left), and bark (right) for their woody outdoor ornamentals.

Fertilizer manufacturers have developed a wide range of ***controlled release fertilizers*** (CRF) which can be incorporated into the soil-less media to provide season-long nutrients (Cabrera 2004) for plant growth (Figure 58). Manufacturers use a polyurethane resin coating which coats the major and minor element granules, forming a small ***prill***. The nutrient release of the fertilizer is not affected by excess moisture, microbial activity, substrate component composition, or pH. The various CRF's are designed to release nutrients over a period of time based upon the thickness of resin coating and the soil temperature (Merhaut 2012).

Incorporating the CRF prills into the substrate can be an advantage to top-dressing (applying substrate to the surface) because if the pot was to tip over, the prills would be lost (Cabrera 2004). Growers will often use a small mechanical cement mixer (1-3 cubic yards capacity) to blend their own media. It is best to add the CRF's at the end the process to avoid damaging the prills. Once damaged, the prills will release the nutrients too quickly, thus potentially burning the roots of young plants (Halcomb and Fare 2010).

Figure 58. Controlled release fertilizers come in a range of formulations depending upon the nutrient release times.

There are often three different application rates listed on the CRF label: low, medium, and high. Growers will need to consult with fertilizer sales representatives or university extension faculty with responsibilities over ornamentals, and experiment on their own to determine the optimum rate (Figure 59).

Container irrigation

Figure 59. Adding controlled release fertilizer (CRF) to the bark mixture.

Of all the different methods of growing plants, above-ground container production will use more water per acre than any other practice. Because containers can dry out quickly on a hot summer day, the nursery manager has to be prepared with a reliable source of water to last through the largely dry Pacific Northwest summer. Plants grown in smaller containers have relatively small root systems in relation to their foliage sizes, and will need to be watered more frequently. In general, 1-3 gallon containers are irrigated with overhead impact sprinklers (Bailey et al. 1999). While a trickle system would be more efficient in theory, the number of spray sticks and length of tubing needed for the thousands of pots per acre would make this technique nearly impractical. The principal disadvantage of impact sprinklers is their inefficiency in applying water. Typically 35% is lost due to evaporation.

Water quantity

Irrigation design engineers working with container crop growers suggest a minimum of one acre-inch (approximately 27,000 gallons) of water availability per day for every acre of nursery stock (Bailey et al. 1999). Over the 4.5 months of summer in the Pacific Northwest where growers irrigate, this would amount to 3,645,000 gallons of water. In the absence of a lined, water reservoir, and strict limits on the amount of ground water that one can use in Washington, container growers will need to select larger pot sizes to stretch their water resources.

Utilize drip irrigation

Figure 60. This 15 gallon pot has one spray stake which is enough to adequately apply summer irrigation during the heat of summer.

Container nursery owners that don't have a Certificate of Water Right associated with their property, or lack a large RWH catchment pond, will need to consider drip or ebb and flow irrigation as their principal technique (Schmal et al. 2011). Water application efficiency can be as high as 95% with drip irrigation. When water is applied to the soil in the pot, it won't be deflected by the plant's leaves (Figure 60).

Table 12. Drip irrigation considerations for above-ground container nursery stock.

If applied properly, the amount of water delivered to the container will meet the daily needs of the plant, with little lost due to runoff. The most commonly used spray stakes have application rates of 5-15 gallons per hour. These are considered medium to high flow rate stakes. Mini-flow spray stakes won't be able to supply water fast enough to replenish water use in a larger container on a hot summer day. Drip irrigation practices are outlined in Table 12.

Potting and shifting up

When plants are raised in hard-sided pots, there is a very strong tendency for their roots to start circling as the plant grows (Figure 61). If the plant is not repotted into a larger container, the solid mass of circling roots can severely stunt the plant when it is installed in the landscape.

Pruning, which is shaving off the shell of roots on the periphery and bottom of the root ball, will remove most of the defects (Gilman 2009). Plants in smaller containers can be moved into larger containers as they grow, a process termed "shifting-up" or "bumping-up." Shrubs in 1 gallon pots are often stepped up to 3 gallon pots, while 3 gallon pots will go to either 7 or 10 gallon pots. Trees in 3 gallon pots will be shifted up to either 10 or 15 gallon pots depending up the growth rate.

Figure 61. A solid mass of circling roots is a key sign that the plant needs to be re-potted to a larger pot.

The final container size is typically set by the intended market (Figure 62). It becomes very difficult to lift and transport fifteen gallon and larger plants by hand. Landscapers will use mechanical forklifts and loaders for the larger trees and shrubs, to meet the needs of clientele wanting larger plants.

Air pots

In order to minimize the need to shift plants into larger containers, manufacturers have developed plastic pots with many holes in the sides and bottom. So called ***air root pruning*** (ARP) reduces circling of roots, though does not completely eliminate it. When the developing roots encounter the holes in the side walls, the root tips are killed. The resulting plant develops a dense mass of fibrous roots, thus ensuring good field establishment.

Figure 62. Arborvitae shrubs ready for shipping after being grown in successively larger containers.

ARP containers come in various sizes and shapes (Figure 63). The smaller sizes can be utilized in the succession process of growing larger plants. Extra attention will be needed to provide adequate supplemental irrigation. Wholesale nurseries will use these to start plants, but will often shift them up to hard-sided pots prior to sale.

Larger boxes

Although most nurseries have gone to using plastic pots or fabric bags, there are still growers who prefer using wooden boxes (Figure 64) or collapsible plastic boxes (Figure 13). While these are more expensive, they do offer the landscape nursery grower the option of keeping the trees in the box until they are ready for installation.

After digging a big hole at the installation site, workers will first attach slings to the stem of the tree and then un-bolt the sides and base of the plastic box before the lowering the root ball into the hole. For wooden boxes, the base will be left under

the tree. The trees must be completely ***rooted out*** before they are moved or there may be damage to the root ball during transport and installation.

Over-wintering containers

When plants are raised in smaller containers (1-3 gallons) above ground, their roots are susceptible to cold damage (Johnson 2015). Root hardiness is the primary factor influencing the winter survival of container grown ornamentals. Shoots and stems acclimate to colder temperatures, which is initiated by shorter days in the fall, followed by cooling temperatures. Roots however, simply don't acclimate well. Freeze damage can occur in the spring, when new spring growth collapses, followed by marginal leaf necrosis, stem dieback, and bark splitting (Dunwell 2005).

Figure 63. Air root pots keep roots from circling. The 2 in. by 2 in. piece of wood over the top of the pots is bolted to stakes driven into the ground to prevent the pots from blowing over.

Cold frames

Growers in the Pacific Northwest typically use cold frames to help protect their smaller containers (less than 3 gallons) from winter freeze damage. Often these structures resemble Quonset greenhouses. Growers often fashion their own bows by bending 1 in. heavy walled electrical conduit into a half circle. The ends of the pipe are set over steel posts, which have been driven into the ground.

Figure 64. These 3 in. caliper Giant Sequoias can be kept for up to 5 years in these 36 in. square wooden boxes before becoming too large to manage.

These low-cost cold frames (Figure 65) come in various widths (16 ft and 20 ft are most common). They are generally 7 ft tall. In areas that receive snow, the narrower width will shed snow buildup better. In addition, the bows can be set closer together (4 ft as opposed to 6 ft) and the end walls can be braced to keep the structures from collapsing under snow. A semi-gable cold frame is considered stronger than a Quonset frame against snow loads. Cold frames are often 96 ft in length, but they can be ordered in shorter sizes, by utilizing fewer uprights.

Figure 65. Uncovered, over-wintering cold frame will serve to protect 1-3 gallon plants during the winter.

Cold frames can be covered with clear, white (4-mil and 6-mil), or double polyethylene clear plastic. The white poly film (Figure 66) is preferred, as it lets in less light during the winter, thus reducing heat buildup. Clear poly covering is not recommended unless it can be vented, as it can lead to dramatic swings in day/night temperature which can ultimately harm the plants by forcing them out of dormancy.

It is not uncommon to find air temperatures rise to 70°F by midday on a sunny day when the outside temperatures are 30°F (Green and Fuchigami 1985). The highest level of winter protection would come from the use of a double poly structure with a small fan that is used to inflate the space between the two layers of plastic.

Figure 66. Quonset style cold frames covered with white 6 mil poly.

Cold frame usage

Growers will typically incorporate cold frames into their container yards. Growers should ensure that their plants are well watered before they go into the winter to reduce injury from winter desiccation. When faced with a choice, growers should position cold frames in a north/south orientation. In a north/south layout, the air inside the cold frame will stay cooler during the midday (Smith 2015). Plants should be set close together within the confines of the cold frame. Delay covering the cold frames until early to mid-November (25ºF at night) to ensure the plants enter dormancy (LeBude 2012).

The better equipped cold frames will be built with ventilation fans installed on the downwind end of the house, and intake shutters on the windward ends. A powered thermostat can be used to open and close the fan and vents as appropriate. Manual ventilation can be provided by opening and closing the doors on either ends of the cold frame. In late winter, growers will have to learn from experience when to remove the poly covering. The goal is to obtain a compromise between late winter cold protection and premature shoot growth.

At the first sign of bud swell, growers will need to consider either opening the ends, cutting openings in the poly, or removing the plastic entirely (Johnson 2015). The doors will most certainly need to be opened when the interior temperature of the cold frame approaches 45-50°F. It is better to err on the side of caution and leave the plants in the cold frame during late winter when outside temperatures can fluctuate widely.

Two-piece doors that allow the operator to open the upper half are ideal because this does not expose the plants to cold, drying air currents seeping in and damaging the plants at ground level.

In-Ground Fabric Bags

In the early 1980’s, nursery supply companies introduced ***fabric bags*** as an alternative container in which to raise nursery stock (Figure 67). Utilizing porous synthetic materials (typically polypropylene), fabric containers were manufactured in various sizes for both in and above the ground applications. Fabric bags work on the principal of stopping root growth as they extend to the edges of the bag, thus preventing circling as would be the case in a hard-sided container. As the roots encounter the sides of the fabric they start to branch. At harvest time, a dense mass of fine roots develop inside of the bag (Figure 68).

Figure 67. This 1.5 in. caliper Himalayan birch is being raised in a 12 in. diameter fabric bag.

Advantages

Growers like fabric bags, as they reduce the need for specialized equipment to dig the trees out of the ground at maturity (Cole et al.1998). Landscapers have found that trees grown in root control bags have better survival rates and more vigorous growth during their initial year of establishment when compared to bare root trees. In relation to B&B production, the fabric bag trees have a much smaller root mass that can easily be handled without the need for large equipment (Gilman 2015). While a wholesale tree will cost more when it is sold in a fabric bag versus bare root, the faster establishment rate makes them very competitive.

Moisture requirements

As the root system is approximately one-half the size of comparably grown B&B trees, there will be less water storage capacity in the fabric grown root ball. If there is delay in either shipping or planting the freshly harvested trees, they will have to be irrigated to prevent desiccation.

Once installed in the landscape, these trees will need irrigation immediately. Staking will be required as the size and weight of the root ball will be considerably less than that of the B&B tree. When sold to landscapers, fabric bag growers must instruct their workers to remove the bag prior to installing the tree or shrub at the job site. In addition, care should be taken not to drop the fabric bag tree that has yet to achieve a fully developed root system. Some growers will remove the fabric bag at the nursery and then have their crews wrap the root system in burlap (as in B&B) or pot them into hard-sided containers. This practice ensures that an un-trained planting crew will not make the mistake of leaving the fabric bag on at the job site.

Figure 68. Fabric bags keep tree roots from circling and girdling the tree.

Planting practice

Nursery operators will auger a hole which equals the diameter of the fabric bag. Next, a stiff plastic insert is placed into the hole (Figure 69), thus keeping the sides intact before placing the fabric bag into the hole. It is best to keep 2 in. of the bag above the native grade in order to prevent roots growing out over the top of the bags. The liner tree or shrub is placed into the fabric bag and native soil is used to fill the remaining space.

As the developing roots fill out inside the fabric bag, they reach the sides of the fabric. When the developing root tips encounter the porous sides of the bag, they are choked or girdled by the fabric. As the fabric bag is porous, both water and nutrients can be absorbed by the root tips. If fabric bag-raised trees are harvested at the appropriate age, root circling or girdling can be reduced. Results vary depending upon the species grown (Cole et al.1998).

Figure 69. Plastic insert allows for fabric bag installation.

Bag sizes

Growers will select a fabric bag size based upon the desired tree caliper that they wish to achieve (Table 13). Growers are advised to select a larger root control bag if there is concern over not being able to sell a tree in a timely fashion.

Harvesting

Upon maturity it is relatively easy to dig the fabric bags out of the soil by using a shovel on either side of the bag to help lever it out of the ground. Occasionally a few minor roots will have escaped out of the base of the fabric bag. Two workers can dig a 2 in. caliper shade tree grown in one-fourth the time of a conventional B&B tree. In contrast to traditional B&B harvest, no specialized labor is required to handle burlap, wire baskets, or mechanical tree spades.

Post-harvest

When the tree is ready to be planted, the fabric bag has to be cut away and discarded. Trials have found that over 80% of the tree's roots are retained in the root ball. Upon planting, fabric bag trees typically grow very quickly in the landscape. For retail sales, growers will remove the fabric bags and containerize the stock into either conventional plastic or wooden tree boxes. Removing the fabric bag at the nursery prevents the installers from inadvertently leaving the tree in the bag in the landscape. The dense rooting pattern of the fabric bag trees will quickly fill out the container they are planted into.

Growers use both tape and hose systems for in-ground fabric bags. With hard hose tubing and individual emitters, water will only be applied to the trees themselves (Figure 70). For smaller bag-grown plants, it would be easier to use tape with evenly spaced emitters (Figure 71).

Above-Ground Fabric Bags

The Pacific Northwest nursery industry has the option of using above-ground fabric bags (Figure 72). A broad range of bag sizes are available, from 15 gallon up to 200 gallon. The fabric used in these bags allows for the passage of air and water while still impeding the passage of roots. Problems with root girdling, as found with hard-sided plastic containers, are reduced significantly.

As with other container nurseries, growers can utilize above-ground fabric bags on ground that would not be appropriate for in-ground shade tree production. As the bags will be set out on landscape fabric, weed growth competition is less. As with hard-sided containers, a wide array of media can be used in the bags, including aged bark, peat, yard debris compost, and possibly sand. The heavier sand in the mixture will help protect the plants from blowing over.

Table 13. Fabric bag sizes for various tree calipers[1]

Figure 70. This fabric bag tree grower is using a hard hose and individual emitters for each tree. These 18 in. diameter bags will grow landscape ready 2.5 in. caliper shade trees.

Figure 71. Liner stock oaks being raised in 10 in. diameter fabric bags can be shipped all season.

Figure 72. Japanese maples being raised in 20 gallon above-ground porous fabric bags.

Bags can be ordered in white, black (Figure 73), or green. They come in different sizes as well (up to 30 gallons), with the largest size appropriate for larger caliper (2 in) shade trees, and the smallest are best suited for shrubs and small caliper trees. They can also be manufactured with carrying handles. The lighter color fabric has been found to maintain root system temperatures 20°F-25°F cooler than traditional black plastic pots. Some fabric bags allow a few roots to pass through the base of the bags. These will help keep the tree anchored to the ground.

When growers use bags that don't allow roots to pass through the base, they will need to consider the prevailing winds and the potential for blow-over. On windy sites, a post and cable system can be installed so that the trees can be loosely tied to keep them upright. There is typically some adhesion to the landscape fabric upon which the bags should be set upon, thus reducing problems.

Figure 73. Arborvitaes being raised in above-ground plastic fabric bags.

Water use

Northwest growers and university researchers report less supplemental water is needed for above-ground fabric bag-grown trees as opposed to hard-sided containers (Gilman 2015). Soil temperatures will be lower in the above-ground bags, especially if the bags are white in color. Irrigation spray stakes or drip emitters can be placed on the surface of the container mix in order to keep the root system in the bag moist. As with in-ground bags, the fabric bag will need to be removed prior to planting. End-users will need to be reminded to remove the fabric bag prior to planting.

Pot in Pot production

The Pot in Pot (PnP) system combines traits of in-ground field and above-ground container production. In the Pacific Northwest, there are shade tree, shrub, and conifer growers who have adopted the PnP system to produce plants for both the wholesale and retail garden center trade (Halcomb 2009). Field crop growers can relate better to PnP production, as row spacing, weed control, and drip irrigation is similar to the practices of raising plants in the ground.

Field establishment

A PnP operation involves two containers that fit together (Figure 74). A strong, injection-molded socket container is set into an augured hole in the ground, leaving 3-4 in. of its lip exposed. This pot will stay in the ground over the course of perhaps 10 years. It has sufficient strength to withstand soil compression, thus it won't pinch the space for the liner pot. It is important that the workers installing the socket pots level them with portable levels to keep the tree or shrub raised in the liner pot completely upright.

Double pots

Next, a slightly smaller "insert pot" is placed within the socket pot. The insert pot is often blow molded, and less expensive than the socket pot. The liner pot will serve as the container for the plant being sold. This container will be filled with soilless growing media, the plant, and a spray nozzle from a drip irrigation system. The dual pot combinations range in size from 7-45 gallons (Table 14).

Figure 74. A 25 gallon liner pot with tree is set into a matching socket pot buried into the soil.

Shrub growers prefer the smaller, 7-10 gallon systems, while tree growers gravitate to the larger sizes. Garden center owners prefer the 15 and 25 gallon insert pot plants, while landscapers look for the larger, 45 gallon plants. Table 14 describes the size and field spacing of PnP operations.

Table 14. Recommended container size and field spacing for Pot in Pot nurseries[1]

The most widely used combination PnP is 15 gallon, with 25 gallon being second. In a 5 gallon PnP nursery, growers prefer to have 4-6 rows separated by a roadway for access. In a 10 gallon nursery, there are typically 6-8 rows. For shade tree growers using 15 gallon sockets, there will be 1,452 plants per acre. If 25 gallon sockets were used, the plant population is reduced to 1,210 plants per acre.

As for media, the PnP manager will select a porous mixture that drains well. In Oregon, it is not un-common to find a media consisting of 90% bark and 10% pumice. As this media has limited available nutrients, controlled release fertilizers will be needed to keep the plants thriving.

Advantages

There are multiple advantages to raising nursery stock in a PnP arrangement (Figure 75). PnP operators enjoy not having to worry about containers blowing over on windy sites. They don't have to worry about the roots freezing in their plants because the ground insulates the containers from low air temperatures. They don't need to erect greenhouse structures typically used by container crop growers for winter protection (Mathers 2003). PnP nursery crops can be quickly harvested all year long (Dunwell 2013).

Figure 75. Coral Bark Japanese maples *(Acer palmatum* "Sango-kaku") are thriving at this 15 gallon PnP nursery.

When it comes to selling plants, workers can easily lift the liner pots out of the socket pots (Figure 76). Socket pots can be spaced closely together, thus concentrating plant production on less land. Setting up a drip irrigation system with a PnP nursery is facilitated by having the socket pots lined out in straight rows with uniform plant spacing.

Disadvantages

The high cost of initial establishment is the biggest disadvantage to this production technique. The producer needs to purchase two pots per plant. Once the socket pots are installed into the ground, a compatible liner pot has to be used. One must plan carefully for larger pot sizes if there is delay in harvesting the plants, such as periods of slow sales. While the establishment costs are higher, a manager must balance them with costs of building and moving above-ground pots into over-wintering structures.

Figure 76. Otto Luyken English laurel *(Prunus laurocerasus* "Otto Luyken") being raised in a 10 gallon PnP nursery.

Soil drainage

PnP nursery production is ideally suited to sandy soils that drain very well. However, in many situations growers have found that even with sandy loam sites there will be concerns over water collecting in the socket pots. Unless the soil is very well drained, growers have found that they need to install a row of agricultural drain tile (Figure 77) under every row of socket pots, which is an additional cost.

On less than perfectly drained sites, the socket pots will fill with water, which can harm the roots in the liner pot. The trench for drain tile is relatively shallow (18 in), in relation to depth for conventional field drainage (3-4 ft). In a PnP nursery, the bottom of the socket pot should touch the top of the plastic tile line. Growers that have not installed drain tile may revert to installing inserts into their socket pots (Figure 78) to help keep the liner pots out of standing water. The insert also helps keep the liner and socket pots from sticking together.

Row middles

Growers have a number of options for managing the area between the socket pots. A manager can select bare ground, grass middles (Figure 79), crushed rock (Figure 80), or geotextile fabric. The weed fabric may last 6 years if it is shaded by the plants.

Figure 77. Perforated drain tile lines (4 in. diameter) will need to be considered in a PnP nursery. The white fabric sleeve covers the tile lines, reducing plugging.

After leveling the surface and installing the socket pots, a grower can spread out the weed barrier over the top of the socket pots. Cut an "X" in the fabric and fold the edges back. The four corners fall into the socket pot and will be held in place by the inserted liner pot. As for machinery and trailers, the industry utilizes three-foot wide tractors and custom designed, narrow width trailers to tend to the crop.

Cooler roots

The temperature of the root system is 23-34°F cooler in the ground than in a comparable pot above ground, thus reducing plant transpiration (Halcomb et al. 2009). The roots in above-ground pots can heat up excessively. The roots on the southwest side of an above-ground pot can be killed on a hot summer day as the temperature can exceed 120°F. A healthy functioning root system is the leading factor in above-ground shoot growth. At harvest time there will be a greater number of roots near the walls of the liner pot in a PnP system.

Figure 78. An insert for the socket pot will help elevate the liner pot from any water that collects. Hard hose tubing and spray sticks are used for supplemental irrigation.

Supplemental irrigation

For farms that have a limited source of irrigation water, the PnP system greatly expands the options for container crop growers. When compared to above-ground containers plants, Pacific Northwest tree and shrub producers have found that their PnP nurseries use less water. A 15 gallon socket pot with a 1.5 in.caliper shade tree typically uses only one gallon of water per day, half the amount of water required for an above-ground container. A 25 gallon socket pot will typically require 2 gallons of water per day. These numbers are less than those reported for east coast nurseries, where evapotranspiration rates are often considerably higher during the summer months.

Figure 79. This PnP owner (25 gallon pots) is using residual herbicides around the sockets and a grassed alleyway between the rows.

A manager can usually lift the tree out of the liner pot to examine it and to check the media for even moisture distribution (Figure 81). There should be some water lost through the liner pot into the socket pot. Strive for 10% of the applied water to be leached through container media into the socket pot (defined as the leaching fraction). Table 15 describes the technique for determining the leaching fraction.

Figure 80. Crushed rock serves well in a PnP nursery to keep the weeds in check. Workers can use non-selective herbicides to spot spray the few weeds that emerge.

The best technique for supplying summer irrigation to the PnP nursery involves the use of drip irrigation in the form of spray stakes or individual emitters (Figure 82) connected by mainlines. Spray stakes are best for the larger containers (10 gallon and larger).

Table 15. Determining irrigation and leaching fraction for PnP nurseries[1]

Figure 82. This shade tree is in a 25 gallon liner pot in a PnP nursery. Only one spray stake is required for this setup.

Figure 81. Worker checking the roots for even soil moisture distribution with this 2 in. caliper, heavily root bound shade tree.

Business Planning

Planning for a successful nursery starts with a thorough review of the all the steps required to form a new company, registering it, obtaining the required licenses, obtaining loans and grants, learning how to hire labor, and learning how to pay taxes. The United States Small Business Administration has a complete website (SBA 2015) addressing all of these topics, and does have local offices for personal assistance. Before any time is spent in working directly with plants, a new grower needs to consult with business advisors.

Required Licenses

Master Business License

Nursery owners that gross more than $100 per year are required to obtain a Master Business License, issued by the Washington State Department of Revenue (WSDR 2015). The one-time fee for a new Master Business License is $19. Once a Business License has been obtained an owner will be assigned a Unified Business Identifier (UBI), better known as a Tax Registration Number. A Business License must be posted at each location where the licensee operates. A Master Business License is also required for any business that needs a specialty license, even if the owner does not achieve the $100 per year gross return.

Nursery license

Table 16. Businesses required to hold a Nursery License[1]

The specialty license that nursery owners must obtain is called the nursery license. Table 16 outlines the businesses that are required to obtain the nursery license. Business owners that handle or sell more than $100/year of horticultural plants are considered nursery dealers, and must have a license for each place of business where plants are sold. Anyone that sells more than $15,000 worth of plants per year (retail or wholesale) must pay the nursery license fee ($218.40) each year. The fees are lower when sales do not exceed $15,000/year.

There are civil penalties for not having the nursery license. The Washington State Department of Revenue is responsible for issuing nursery licenses in conjunction with their Master Business License Program. In Washington State, there are over 40 locations where nursery license applications can be obtained. Nursery license fees are collected by the Plants Services Program at the Washington State Department of Agriculture in Olympia (Washington State University Department of Agriculture 2015 Nursery Inspections).

The nursery license program provides funding for staff to inspect over 6,000 licensed retail and wholesale nurseries across the state. This ensures that consumers and the nursery industry are sold healthy, pest and disease free plant material. Inspectors are also required to enforce quarantines to help protect against pest introductions, thus ensuring insect and disease-free planting stock.

Pesticide license

The Washington State Department of Agriculture requires that a nursery owner who applies restricted use pesticides on his/her property for the purpose of producing an agricultural commodity be licensed as a Private Applicator and hold the appropriate endorsements (e.g., insect and disease, weed, etc.) (Washington State Department of Agriculture 2015 pesticide management). This license would also pertain to owners that supervise employees that apply pesticides.

There is a fee-based exam for this license, consisting of a 75-question multiple choice test. Washington State University county Extension offices across the state offer the Private Applicator and endorsement exams. A 70% or higher score is needed to pass. If the license is renewed each year, the exam is good for 5 years. If the license holder obtains 20 re-certification credit hours during the course of the 5-year period, there will be no need to re-test. Once a five-year recertification cycle has been completed, a new one begins. Re-certification courses are sponsored by a variety of businesses, agencies, and organizations, including land-grant universities, many of which are listed on WSDA's free database. Depending on the course and sponsor, there may be a fee required for attendance.

Interstate Plant Shipments

Notification rule and hold requirement

The vast majority of plant material sold in Washington State has been grown outside of the state. With the introduction of ***Sudden Oak Death*** (SOD), concern rose over the importation and shipment of contaminated nursery stock all over the United States. While SOD can infect a large number of plants, the most commonly affected plants include rhododendrons (Figure 83), viburnum, camellia, kalmia, and pieris (Chastagner 2015).

In order to safeguard Washington nurseries, the WSDA Nursery Inspection program developed a new ruling in 2005 known as the Notification Rule and Hold Requirement (WSDA Nursery Inspection 2015). Under this program, a nursery owner is required to notify WSDA within 48 hours of receiving trees and shrubs from outside Washington State. The rule applies to woody nursery stock, including woody forest and ornamental trees, shrubs, and vines kept or grown for propagation, distribution or sale. This ruling pertains to landscape contractors as well. Seeds and tissue-cultured plants are excluded. After notifying the WSDA (by phone or fax), a nursery owner is required to hold all woody plants coming into Washington State for 24 hours, to give inspectors time to look at the plants.

Figure 83. Growers that bring in rhododendrons from outside Washington must hold them for inspection prior to sale.

In addition, nurseries are asked to keep records of all incoming and outgoing shipments of SOD hosts for 24 months. Using these records can enable inspectors to perform both trace-back and trace-forward investigations if SOD is detected. For a complete guide to managing SOD refer to Greisbach, 2012.

Plant quarantine

Nursery owners need to take great care that they don't introduce or spread invasive pests, including insects, diseases such as ***sudden oak death*** (SOD), mollusks, weeds, and parasites into the United States. At the federal level, Animal Plant Health Inspection Service (APHIS 2015) helps protect both nurseries and consumers from the spread of deleterious plants and animals. WSDA staff from the Plant Services Department can provide the export certification inspection required by APHIS, when growers chose to send their plants to other states or countries.

A phytosanitary permit states that the plants are free from injurious pests, diseases, and noxious weeds. A complete list of all the plant quarantines is available, see Washington State Department of Agriculture 2015 Plant Quarantines. Quarantine inspection fees are based on both an hourly rate and mileage to the shipping location, no matter how many plants will be shipped out of state. Other states that ship nursery stock into Washington have similar programs. Plant Services staff work with the National Plant Board, which publishes a list of all the Plant Protection Laws and Regulations that govern quarantines in all the 50 states.

Farm Construction

Building permits

Building permits are generally not required for accessory buildings associated with agricultural operations, including nurseries and production greenhouses. Accessory buildings (often referred to as agricultural buildings) refer to structures such as pole barns, or sheds where equipment is stored or serviced, or greenhouses where plants are raised but are not open to the public (University of Massachusetts Extension 2015). It is advisable to check with the local planning department first, before building any accessory buildings.

Retail greenhouse

The International Building Code does apply to retail greenhouses, where the public is invited inside for retail shopping. Refer to the National Greenhouse Manufacturers Association 2015, under Design Manuals for the design specifications.

Labor

Managing labor at nurseries can be a challenge. For each new hire, employers need to have employees complete an Employment Eligibility Verification-Form I-9, from the U.S. Citizenship and Immigration Services, of the Department of Homeland Security. Employees must also complete an IRS Employees Withholding Allowance Certificate\. Employers must collect these, and keep them in each employee's file. The Washington State Department of Agriculture lists labor regulations in the Handbook for Small and Direct Marketing Farms.

Pacific Northwest Nursery Trade Associations

Washington State Nursery and Landscape Association (WSNLA)
34400 Pacific Hwy South, Ste 2
Federal Way, WA 98003
253-661-6055 800-672-7711
http://www.wsnla.org/

Washington Association of Landscape Professionals (WALP)
23607 Highway 99, Suite 2C
Edmonds, WA 98026
425- 967-0729, 800- 833-2186
Http://www.walp.org

Oregon Association of Nurseries (OAN)
29751 SW Town Center Loop W.
Wilsonville, OR 97070
503-682-5089, 888-283-7219
Http://www.oan.org

Pacific Northwest Christmas Tree Association (PNWCTA)
P.O. Box 3366, Salem, Oregon 97302
503-364-2942
http://www.nwchristmastrees.org/

Idaho Nursery and landscape Association
P.O. Box 2065
Idaho Falls, ID 83403
208-681-4769
http://www.inlagrow.org

Glossary

***air pots*.** Nursery containers with vented sidewalls which discourage root circling, known as air root pruning (ARP).

bare root. A plant that is sold with its roots exposed rather than in soil. Commonly used for roses, small deciduous trees and shrubs, Christmas tree seedlings, deciduous berry plants, small ground covers, herbaceous perennials, and ornamental bulbs.

***balled and burlapped plant* (B&B).** Evergreen or deciduous tree sold with the soil mass attached. The root system and soil is covered with heavy burlap, and often a wire basket, in order to keep the root system intact.

***caliper*.** For bare root shade trees, the caliper is defined as the stem diameter 6 in. above the root flare. Stems are rarely perfectly round. Take the average of the smallest and largest diameters. Refer to AmericanHort 2015.

***can yard*.** An area devoted to the production of container nursery stock.

***cation exchange capacity* (CEC).** The ability of soil to bind or hold exchangeable cations, including calcium, magnesium, and potassium. Soils with a higher organic matter level have a higher cation exchange capacity.

***certificate of water right*.** The legal record of a water right issued by the Washington State Department of Ecology.

***cold frame*.** An un-heated, plastic covered greenhouse used to overwinter container nursery stock.

***container nursery stock*.** Plants sold in rigid plastic pots. Can also refer to the sale of plants in wooden boxes.

***controlled-release fertilizer* (**CRF**).** A granular fertilizer that slowly releases nutrients through a porous coating.

***constructed wetland*.** An artificial marsh or swamp for treating run-off from nurseries. Often serves as a reservoir pond for irrigation storage, as long as the water is treated before it is re-used.

***cyclic irrigation*.** The practice of applying water in a series of cycles, including rest intervals.

***dug pond*.** A pond that has been built by excavating soil from below the original soil grade.

embankment pond. A pond built at the base of a slope, where water collects. A liner may be needed to keep the captured water from seeping into the ground.

exchangeable base saturation. Defined as the fraction of negative binding sites occupied by base cations (calcium, magnesium, potassium, and sodium). Total base saturation is equal to the sum of the number of cations divided by the cation exchange capacity.

***fabric bags*.** Bags consisting of non-woven fabric with straight sides sewn to round bases. The fabric allows water and nutrients to get through, but prevents roots from penetrating.

***field stock*.** Nursery plants grown in outdoor settings from seeds or transplants, and then dug up by hand or machine.

***grafted plants*.** The horticultural process of combining a desirable root system (understock) with a shoot system (scion) to create a superior, uniform plant. The seeds of many woody ornamentals don't yield tree-to-type upon germination. In addition many woody ornamentals root poorly. Grafted plants are sold as clones, which is important in terms of flowering, fruiting, height control, and adaptation to different soil types.

***herbaceous perennials*.** Plants with leaves and stem that die to the soil level at the end of the season. They have no woody stems. They have perennial root systems that send up new shoots the following year.

image pricing: A marketing strategy where the prices of goods are set higher than normal, as lower prices will hurt rather than help sales.

***impact sprinkler*.** A rotating sprinkler with a weighted arm that drives the emitter to move in a circle.

independent garden center (IGC). A privately held business that sells regionally produced plants.

***landscape contractor*.** Business that installs plants, decks, paths, water features, maintains lawns, and applies appropriate pesticides.

landscape designer: A person who understands the art of arranging or modifying the features of yards or urban areas for aesthetic or practical purposes.

***levee pond*.** A pond built above the surrounding grade by construction of berms.

***liner material*.** Smaller plant material that originated from tissue culture, seeds, nuts, or cuttings.

***mass merchandiser*.** A company that sells a large volume of affordably priced plants, hardware, and building supplies (often highly discounted) to a large number of shoppers.

municipal water. A public water system providing water for human consumption and use through pipes or other constructed conveyances

one acre pond. A pond encompassing 43,560 square ft of area (a rectangle of ground 208 ft on a side). Ten acre-ft of water would be contained in a one acre pond that is dug to 10 ft in depth.

permit-exempt ground water. The Washington State Department of Ecology allows the use of up to 5,000 gallons of water per day from dug wells (RCW 90.44.050) where municipal water is not available.

pH. The logarithmic of the hydrogen ion concentration in the soil. A pH of 7 is considered neutral. Soil pH can be altered with the additions of lime (calcium carbonate) to raise the pH, or elemental sulphur to lower the pH.

pot-in-pot. This nursery technique describes a nursery production system that uses two containers to raise trees and shrubs. Sockets pots are permanently buried with their rims extending above ground. Production pots (referred to as liner pots) containing the tree or shrub grown in customized soilless media are set into the socket pots and watered using drip irrigation. The pot-in-pot system is used for raising caliper-sized shade trees, flowering trees, and large shrubs.

prilled fertilizers: The use of sulfur or polymers to coat nutrients in order to ensure their slow dissolution throughout the root zone of the plant.

prills. A granule form of solidified fertilizer.

rainwater harvesting. The Washington State Department of Ecology allows landowners to capture rainfall from onsite rooftop/guzzlers and use it for irrigation. The on-site storage and/or beneficial use of this water is not subject to the permit process of RCW 90.03, the state's Water Right permit.

reservoir ponds. The Washington State Department of Ecology allows rural landowners to build ponds on their property to store water from RWH and use it for irrigation and frost control. Ponds that exceed 10 acre-ft or have dams taller than 10 ft in height will require a dam safety permit.

retail nursery. An operation that grows some of the plants that it sells. Different than an IGC in that it purchases all the plants that are sold to the public.

re-wholesaler. Businesses that exist to transfer plants from one location to another, all the while continuing in wholesale trade only.

rooted out. A term used in the container industry to describe a plant that has developed a full root system that remains intact during handling.

sandy loam. A soil with equal portions of silt, sand, and clay particles.

soil tilth. The physical condition of soil as it relates to the planting of a crop. Determined by the aggregation of soil particles, moisture content, degree of aeration, rate of water infiltration, and soil drainage.

***sudden oak death* (SOD).** The term used to describe the death of thousands of live oaks, tanoaks, and related oaks-species in central California in the mid-1900s. Caused by the pathogen *Phytophthora ramorum*. The disease was first found in 1993, and most commonly infects rhododendrons, viburnum, camellia, kalmia, and pieris.

well-drained soil. Well-drained soil is one which allows water to percolate through it reasonably quickly and not pool on soil surface.

whips. young tree liner with a central stem and little or no side branching.

wholesale nursery. Business that raises and sells plants to IGC's, mass merchandisers, re-wholesalers, or landscape contractors, but not directly to the general public.

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