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Buyer and grower perceptions of liner quality and associated production costs of nursery liner stock

Andrew H. Jeffers

University of Tennessee - Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by Andrew H. Jeffers entitled "Buyer and grower perceptions of liner quality and associated production costs of nursery liner stock." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Plant Sciences.

William E. Klingeman, Major Professor

We have read this thesis and recommend its acceptance:

Dean A. Kopsell, David S. Buckley

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Vice Chancellor and
Dean of Graduate Studies

Buyer and grower perceptions of liner quality and associated production costs of nursery liner stock

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Andrew Hamilton Jeffers

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Dedication

This thesis is dedicated to my parents, Dennis and Patsy Jeffers, my grandparents, Don Jones, and Claude and Iris Jeffers, my friends, family, and most of all God. Thank you for your prayers, love, guidance, support, and encouragement. I could not have achieved my goal of obtaining a Master's Degree without you. Special thanks to my major professor, Dr. Bill Klingeman.

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Abstract

Liner production is a key segment in the nursery industry. Due to a lack of specific of quality standards by governing industry organizations as well as a lack of general consensus among growers of perceived liner quality, a conjoint analysis study was developed to determine buyer and grower preferences for nursery liner product features during point-of-purchase decisions. The study used a visual survey using six variables (first order lateral roots (FOLR), price, region of production, and height, canopy density and caliper uniformity) with varying levels yielding a 3 x 3 x 3 x 2 x 2 x 2 factorial design. Surveys were administered at tradeshows and events around the southeastern United States. Results indicated that a high FOLR, a uniform canopy density and height were most important to purchasing decisions of nursery liner buyers, while liner price and region of production were found not to be important. From the experimental model, utility values for each product feature were derived and can be inserted into an equation to determine a hypothetical quality rating. Growers can use this formula to determine hypothetical quality ratings for their products and serve as a marketing tool for growers.

To determine if the production of premium quality liners is economically feasible and help aid growers to take advantage of niche opportunities we investigated production costs of growing ornamental nursery liners in a USDA Plant Hardiness Zone 6b to 7a nursery. We used three contemporary nursery liner production systems: a field-groundbed system, a polyhouse-covered groundbed, and a polyhouse covered container system. We estimated capital requirements, fixed costs and variable costs for each

system. We also compared production costs of a deciduous plant, a broadleaf evergreen, and a needle leaf evergreen to allow inferences about the widest variety of nursery liner crops.

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Chapter 1

Literature Review

Introduction

Liner production is a key economic segment of the nursery industry. Although production methods have changed with time, the concepts and goals have not. Liner production starts when a seed, rooted cutting, or tissue culture plantlet is planted in a ground bed or pot. These plants will usually be grown for one year, in which the primary emphasis is placed on promoting the root system. Seedlings will typically be undercut once they have emerged to promote lateral root growth (Garber et al., 1999). Seedlings will be lifted in the spring and graded, and either sold or transplanted into the field to be grown further. Liners can also be grown in plug trays or containers, for example, a 1 gallon container (3.78L) or 4" (798 cm^3) rose pot. Container-grown liners are a growing trend in today's nursery industry, especially in containerized finished tree operations (personal conversation with Gene Griffith, Wilkerson Mill Nursery, 01/04/2007).

The next stage of ornamental tree production is "whip" production. During this stage, liners will be placed in very tightly spaced rows to promote stem height. Typically, plants are grown for one year and then cut off at the root collar. Multiple shoots emerge from the cut and the straightest shoot is chosen and staked for best quality. After a second year of growth, the whip is lifted and sold or transplanted to the field for final production. During whip production, plants may be undercut to aid in root growth, but the primary emphasis is development of a straight stem (Garber et al., 1999). At this point in the production process, the plant will either be sold and/or transplanted into a field for "finished" tree production.

The definition of a liner is often misunderstood. One grower may consider a three-foot tall tree whip a liner, while another grower will consider it to be a small seedling. An explanation for this confusion is that two of the three stages of the production process are combined. Some southeast growers will tend to grow a seedling to the whip status and sell the "whip" as a liner (personal conversation with Mark Halcomb, University of Tennessee Extension, 8/16/2006). This confusing language has possibly led to lost market opportunities for Southeastern U.S. growers (personal conversation with Gene Griffith, Wilkerson Mill Nursery, 1/04/2007). Since liner sales are often focused on root systems, it is possible that a majority of a grower's emphasis might be on the roots. We are interested in quality parameters of the root system, as well as other characteristics that buyers assess when making purchasing decisions. Other characteristics of liners may relate to market demands. Many nursery industry buyers tend to want a more uniform product, whether their focus is on caliper, height, or canopy uniformity. Liner characteristics are all relatively controllable from a grower's perspective. Caliper and canopy uniformity can be influenced by bed planting density, or the number of stems grown per square meter. Height is typically controlled in the nursery, not necessarily for uniformity, but mainly for shipping issues, as well as to promote root growth (personal conversation with Mark Halcomb, University of Tennessee Extension, 10/16/2007).

For the purpose of this study, we define a liner as a seedling, rooted cutting, or tissue culture plantlet that has been grown for 1 year either in a seedbed or in a pot, then used for nursery planting stock (Garber et al., 1999). The primary focus of this study emphasizes the liner production phase and parameters of quality perceived by growers. In today's competitive nursery industry, a grower must find ways to increase quality standards of the end product. If the nursery stock or liner is of poor quality, it increases the chance that finished plants will also be poor quality. Liner quality plays a role in out-planting survivability.

A majority of tree liners are produced on the west coast. There has been some debate about whether a liner grown in the southeast could compete with a liner grown in the Pacific Northwest. A commonly stated belief among growers is that high quality liners come only from specific areas of the country, with key regions including the pacific northwest (primarily Oregon), lower southern states (primarily Florida), and northern Midwest states such as Michigan and Ohio (personal conversation with Don Shadow, Shadow Nurseries, 02/16/2007).

Currently there are no actual quality standards set down by the American Nursery and Landscape Association (ANLA). Current ANLA standards only govern minimum caliper requirements of flowering and shade tree liners (Table 1-1, see end of chapter appendix). Due to the lack of well-defined industry-wide standards for liners, various regions of the country have different perceptions of quality.

Perception of quality is a multidimensional concept. Various aspects and different methodologies have been introduced to the industry. Many liner growers and buyers seem to have their own methodologies for assessing the quality of nursery stock. Seedling quality can be assessed using either physiological or morphological approaches.

Physiological Measurements of Transplant Success

Physiological evaluations of hardwoods usually deal with seedling vigor. The objective is to predict seedling survivability when specific physiological stresses are imposed. There are several common methods of assessing physiological quality. Physiological quality tests have included root growth potential (RGP), root-electrolyte leakage (REL), shoot water potential (WP), and root moisture content (RMC) (Wilson and Jacobs, 2006).

Physiological measurements are often time consuming and expensive, which is primarily the reason these are often performed destructively on a proportion of seedlings grown for the forestry and paper industries or specialized crops (Wilson and Jacobs, 2006). A much more rapid and non-destructive method would be more logical for nursery growers primarily producing an ornamental crop. Measurements that examine the morphological characteristics focus on visible characteristics that can be rapidly identified by trained employees.

Morphological Assessments of Quality

Most nursery grading practices rely on rapid assessments of plant morphological characteristics. Like physiological attribute measurements, morphological measurements are usually linked to field survivability and overall seedling health (Kormanik et al., 1998; Clark et al., 2000; Wilson and Jacobs, 2006). Measurements such as these are rather subjective and standard parameters have not been widely accepted by the industry. Grading criterion usually differ depending on the grower, and on the plant species being produced. Some growers may simply set grading standards based on height and root length of the seedlings, choosing the largest and culling smaller seedlings (Clark et al., 2000), believing the larger the seedling has a greater chance of survivability. Most of the visual grading done in the liner industry is a visual grade of the root system itself.

First Order Lateral Roots

One major morphological plant characteristic attributed with transplant success is number and size of first order lateral roots (FOLR), or side roots arising from a taproot that are greater than 1 mm in diameter 30 mm below the root collar (Kormanik et al., 1998; Clark et al., 2000). First order lateral roots provide the structural framework of the root system as well as sites for root initiation, and water and nutrient uptake for the plant (Dey and Parker, 1997). Although FOLR counts are not a measure of root density they have been shown to be a good indicator for root system quality, field survivability, and predict seedling performance (Schultz and Thompson, 1996; Kormanik et al., 1998; Jacobs et al., 2005). Many growers would benefit from the FOLR evaluation method because it is quick, relatively easy, and non-destructive to the stock (Jacobs et al., 2005). Measurements of FOLR allow a grower to have a quantitative assessment of the root system, which may be more important in studies of out-planting success (Kormanik et al., 1998).

Cultural practices such as bed density and undercutting may influence FOLR. Liner bed planting density can influence production of fibrous roots, quantity of FOLR and overall root density. A grower must be able to grow enough liners to cover production costs, but problems can develop if the liners are grown too close together. Crowding seedlings does not allow for adequate root development, which could affect root quality (Schultz and Thompson, 1996; Jacobs et al., 2006; Cicek et al., 2007). Northern red oak and black walnut seedlings produced more number of FOLR and fibrous roots when grown at 64 stems per m^2 when compared to those grown at 128 stems per m^2, even when compared to non-undercut treatments (Schultz and Thompson, 1996; Jacobs et al., 2006; Cicek et al., 2007). However, the number of FOLR was significantly greater when seedlings were grown at 32 stems per m^2. By simply lowering bed planting densities, a grower can significantly improve root density, fibrous root production, and number of FOLR (Schultz and Thompson, 1996). Undercutting does not just generate FOLR; however, it can stimulate fine root production, especially when depth of cut is considered. When the tap root of English oak (*Q. robur* L.) was cut 18 cm below the root collar, production of fine roots declined compared with fine roots on liners cut 33 cm below the root collar (Harmer and Walder, 1994; Schultz and Thompson, 1996). Since shoots grow at expense of roots, it is conceivable that undercutting would have an adverse effect on plant shoots. Undercutting seedlings reduced root to shoot dry weight ratio and reduced height of sessile oak, *Q. petraea* (Mattusch.) Liebl., compared to non-undercut control seedlings (Andersen, 2004).

Though FOLR can be used to predict first year out-planting success, it is just one considerable characteristic. Assessments of FOLR characteristics do not provide a grower any additional information about the canopy or height, nor does it tell anything about the caliper development of the plant. Grading criteria based on root characters are relatively easy to evaluate in 1+0 bareroot seedlings. In the production of container grown liners, evaluations of the root systems are limited, and the root architecture is not visible. Fibrous roots may be present in plug liners but, simultaneously, girdling of the roots may be occurring. In containerized liner production systems other visible characteristics must be taken into account. Growers may grade plug liners based on height uniformity while simultaneously checking for presence of disease (personal conversation with Jeremy Depey, Spring Meadow Nursery, 01/04/2007). Most growers tend to check for good roots on the outside of the root ball and compare that information to the relative height of the plant (personal conversation with Stacy Moore, Oak View Liners, 02/16/2007).

Root Collar Diameter

Root collar diameter (RCD) is another morphological measurement used to predict field survival. Root collar diameter can also be an indicator of a quality product. Root collar diameter has been linked to long-term field survival and stem development. There were positive correlations between RCD and FOLR in northern red oak when comparing “premium” and “good” liner grades (Clark et al., 2000).

Caliper Uniformity

A majority of growers advertise using caliper and not RCD. While RCD is an important measure of quality in liner stock, we used caliper because many growers will identify with caliper more readily than RCD. Though the ANLA does give some general guidelines on what caliper measurements are acceptable, many growers have expressed concerns with caliper uniformity (personal conversation with Jeremy Depey, Spring Meadow Nursery, 01/04/2007). A possible explanation is that caliper measurements will vary among species and could vary with the needs of the grower. With a wide diversity of needs from buyers the industry is becoming more and more responsive to the demands of the final consumers (homeowners, landscapers, etc) of having a relatively uniform plant crop to sell.

Region of Production

A nursery's reputation is often key to identifying quality characteristics of a product with its consumer. The nursery industry in the United States is regionalized and each region tends to be known for a particular or unique growing method or crop. A majority of liners bought in the southeastern U. S. are purchased from the Pacific Northwest. Growers are now assuming that if the nursery liner stock is produced in the Pacific Northwest then the stock should be of high quality. This perception can be partially attributed to the region's mild wet climate and sandy loam soils in which liners are grown, particularly for Oregon (personal conversation with Trudie Hayes, Hayes Nursery Enterprises, 02/16/2007), which also allows for a shorter production period than Tennessee growers.

Multi-functional liners

Southeastern growers are able to compete by adapting to market trends. One trend is production of container-grown liners. The on-going debate about the merits of plug liners versus groundbed grown liners has raised several issues. Initial equipment costs are not as high for container and plug-grown liners, but production time to sale lengths are increased. An advantage of container-grown liners is that these plants can be harvested and shipped independent of unfavorable weather conditions. Container-grown liners also fill a niche as being multifunctional customer options. Although container-grown liners have their place in the industry, these plants have some limitations. For example, if plants are kept in the containers too long, roots will become pot-bound and could potentially damage the plant. Another limitation is there is not an effective method to evaluate the root system. If these pot-bound liners are sold, shipped and transplanted to the field, roots have potential to girdle the liner causing injury to the plant.

A multifunctional liner could be used for container, field, or other production types. Most Tennessee liners are grown in ground-beds as whips and are not multifunctional; meaning the stock usually meets few customer needs. Multi-functional liners are plants that can be marketed to a variety of customers. For example, a liner grown in a plug tray can be marketed to a variety of customers including mail-order nurseries, retail nurseries that do not have a great amount of production space, and field nurseries. A mail-order nursery could not use whips because the height of the product would make it difficult to ship.

Perceived Quality

From a grower's perspective, perceived liner quality characteristics can be somewhat vague. People often say one thing and do another when making point-of-purchase decisions. The grower's true perception of what makes a high quality liner is the main focus of this study. Quality perception to a grower might entail packaging, the root system, stem uniformity, etc. In a majority of cases, price might dictate the decision-making. However, some growers might be willing to pay more for a higher quality liner even if the low quality product is of the same species and significantly lower in price. Because of quality perception some southeastern growers are already willing to pay the shipping costs for west coast liners to be able to advertise that their starter material comes from the west coast (personal conversation with Trudie Hayes, Hayes Nursery Enterprises, 02/16/2007).

Conjoint Analysis

Liner quality is a multi-dimensional concept (Palma, 2002; Wirth et al., 2007). Several attributes come together to make up the overall conceptual view of quality. We know that FOLR number, height, caliper, and canopy density (mostly in evergreen and plug liners, but can be considered branching in deciduous species) seem to be the most prevalent. Other characteristics such as region of production may also have an influence during the point-of-purchase.

Conjoint analysis, sometimes called tradeoff analysis, or more generally choice experiments is a statistical method in which a respondent's preference for a product are broken down to determine the respondent's inferred utility function for each attribute of an item and the relative importance of each attribute of an item (Wally et al., 1999; Palma, 2002; Wirth et al., 2007). Conjoint analysis is based on the assumption that people make purchase decisions based on multiple variables. This allows respondents to choose an item (make a purchase) by forcing them to make trade-offs of one or more characteristics for others. If a respondent were to simply rank the characteristics from least desirable to most desirable based on one characteristic alone, the data will reveal nothing of how different characteristics interact (Curry, 1996). By forcing respondents to consider purchase preferences based simultaneously on multiple attributes, we can determine the relative importance of each characteristic of a product and the trade-offs for others features. The test procedure may be a ranking of most preferred to least preferred, but the difference is that as the respondent places characteristics in rankings, more and more difficult decisions must be made by the respondent by trading off different characteristics for others (Wally et al., 1999).

Conjoint analysis, unlike focus and market research groups, allows the study to be less biased (Mason et al., 2008). The most common type of conjoint model is a factorial design. Studies are usually conducted through written surveys with written descriptions of the product features. Survey respondents are usually asked to rate the products on a numeric scale (Palma, 2002; Wirth et al., 2007). Conjoint models then estimate utility values for each product attribute selected in the study.

Conjoint studies also include products that are referred to as holdouts. Holdouts are used in conjoint studies to examine the effectiveness of the model's ability to predict the utility value of a product by comparing the model's predicted values with actual survey respondent's average. (Palma, 2002; Wirth et al., 2007). For example, a 1999 study examining the consumer preferences for Geranium (*Pelargonium* sp.) characteristics used a blue flower color geranium as one of the holdout products (Behe et al., 1999). While blue flower color in geraniums does not exist in the marketplace and researchers predicted that it would do well as a "new" product, results showed that respondents did not prefer a blue flowered geranium (Behe et al., 1999).

Economics of Perceived Quality

Liner Production costs:

The Tennessee nursery industry of today has very few liner producers as defined by this project. Accordingly, there may be an opportunity for a new grower, or even a current grower to enter this segment of the industry. There is a need and opportunity for high quality liners produced in the southeast, in part because shipping costs for transporting liners from the west coast to the southeast are high (personal conversation with Don Shadow, Shadow Nurseries, 02/16/2007).

One of the major concerns of a nursery's transition to liner production is the initial investment costs, as well as operating costs for the business. In 1983, an economic study investigated three types of production systems for rooted cuttings: 1) outdoor propagation beds, 2) Quonset poly houses, and 3) both poly house and outdoor beds (Dickerson et al., 1983). The study examined costs incurred during rooted cutting production. Formulae for computing costs were developed to help growers make sound financial decisions.

Capital costs:

Whether building a new operation or expanding an existing nursery operation, significant capital investments are required. There are three primary cost categories to be considered when determining the amount of capital needed: land, buildings, and equipment. Land costs usually represent a significant portion of the initial cost. The land area required for liner production is not as large as needed for a full-scale "finished" tree and shrub nursery. However, actual acreage cost is not the only land cost; to consider. Land improvements such as grading, graveling of roads, pond construction, etc., can also be costly. Both of these costs usually vary depending on the region of the country. Another benefit of owning the land is that it appreciates in value over time.

The *buildings* line item in the capital requirements includes buildings and structures built and used for the nursery operation. Building costs vary by type of production system used, as well as the specific operational needs. While equipment costs are a significant expense to liner producers, growers often save money by purchasing used equipment.

Fixed Costs:

Fixed costs are costs that do not vary with the level of production (Badenhop, 1985). Fixed costs usually include: depreciation, interest, rent, taxes, insurance and general overhead. Depreciation is considered an expense, but it is not technically "paid", unless a business is sold (Badenhop, 1985; Scarborough and Zimmerer, 2006). There are several methodologies for calculating depreciation costs. Most common are straight-line, sum-of-the-years digits, and double declining balance. A nursery owner should consult their accountant or tax preparer to determine which method is appropriate. Interest is simply any interest that is accumulated from loans outstanding, of which rates can vary. Taxes usually vary from state to state, and a nursery owner should consult with a tax preparer or accountant to determine all taxes and fees that might be applicable in their area. General overhead includes items such as workmen's compensation insurance, utilities, unemployment insurance premiums, etc.

Even though these costs are considered fixed, they can increase or decrease as the number of production unit changes. In other words, if a grower produces more plants, fixed costs are distributed over a wider range of salable product, thus decreasing the individual costs attributed to each plant. In 1985, Badenhop compared incurred fixed costs between a large and small nursery. A small nursery was defined as 16.2 hectares (40 acres) of growing space with 4 hectares (10 acres) of production facilities. A large nursery was defined as 34.4 hectares (85 acres) of growing space with 6.1 hectares (15 acres) of production facilities (Badenhop, 1985). Five groups of woody ornamentals were examined: Euonymus (*Euonymus* spp.), Junipers (*Juniperus* spp.), Forsythia (*Forsythia* spp.), Maple (*Acer* spp.), and Dogwood (*Cornus* spp.).

Variable Costs:

Variable costs are the most prevalent, and often most recognizable expenses considered when estimating production costs. Unlike fixed costs, variable costs such as chemical applications, irrigation, harvesting, etc., change with the production needs of the firm (Scarborough and Zimmerer, 2006). A major portion of the firm's variable costs usually deal with labor expenses. Because of the large impact of variable costs on a firm's profit margin, variable costs should be among the first line items to be inspected when trying to cut costs. Variable costs fluctuate depending upon the production system being utilized, as well as what cultural practices (e.g. pesticide application, top growth trimming, bed planting density, etc.) the nursery utilizes. Every time a cultural practice or other step of production is performed on a crop, the cost of production is incurred by that crop. For example, if a nursery were to experience a drought, such as the one of the summer of 2007, more frequent irrigation would be needed just to keep the crop alive. Even if the nursery is operating on well water, incurred costs include the gas or electricity used to pump the water from the well and can have a significant impact on the overall operating expenses. Heat and drought also induce other problems like reduced plant growth, susceptibility to pathogens, and insect pests. When a nursery sprays a pesticide, the total cost to perform that operation include: the depreciation on the equipment used, the fuel to get to the field and perform the task, the chemical itself, the cost(s) of the water to mix with the chemical, as well as the labor cost for the applicator (Hall et al., 1987; Hinson et al., 2007). To be successful and profitable, a grower must take into account exactly what it costs to produce a crop.

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Chapter 1 Appendix

Table 1-1: Minimum Caliper, Height, and Root Lengths for Deciduous and Coniferous Evergreen Tree Seedlings [Z].

	Min. Caliper[Y] mm (in)	**Min. Height** mm (in)	**Min. Root Length** mm (in)
Deciduous Seedlings			
	1.6 (1/16)	76 (3)	101 (4)
	2.4 (3/32)	76 (3)	127 (5)
	3.2 (1/8)	152 (6)	152 (6)
	4.8 (3/16)	304 (12)	203 (8)
	6.4 (1/4)	457 (18)	254 (10)
	9.5 (3/8)	609 (24)	304 (12)
Coniferous Evergreen Seedlings			
	1.6 (1/16)	152 (6)	*NS*[X]
	2.4 (1/8)	228 (9)	*NS*
	3.2 (3/16)	304 (12)	*NS*

[Z] Table adapted from American Standards for Nursery Stock by American Nursery and Landscape Association (ANLA)

[Y] Caliper shall be taken at the ground-line just above the root collar (ANLA)

[X] Root length, *NS* = not-specified.

Chapter 2

Quality Assessment and Purchasing Decisions of Nursery Liner Buyers: A Conjoint Analysis

Abstract

Liner production is an important segment of the nursery industry. Many different parameters can be used to describe liner quality. Due to a lack of specific quality standards by governing industry organizations and a general consensus of perceived liner quality, a conjoint analysis study was developed to determine nursery liner buyer preferences for product features during point-of-purchase decisions. A visual survey was developed using six attributes (number of first order lateral roots (FOLR), price, production region, height, canopy density and caliper uniformity) with varying attribute levels yielding a 3 x 3 x 3 x 2 x 2 x 2 factorial design, and was administered at tradeshows and events around the southeastern U. S. Results indicated that high FOLR was the most important attribute during buyer purchasing decisions, along with height and canopy density uniformity. Price and region of production were found not to be critically important to purchasing decisions. From the experimental model, utility values were calculated for each feature level. From these values, growers will be able to estimate product ratings for various nursery liner products. This tool will be able to aid growers in emphasizing characteristics that buyers evaluate during purchasing decisions, as well as the development of marketing strategies for southeastern U.S. markets.

Chapter 2

Quality Assessment and Purchasing Decisions of Nursery Liner Buyers: A Conjoint Analysis

Introduction

Liner production is a key economic segment of the nursery industry. Although production methods have changed over time, the general concepts and goals have not. Liner production starts when a seed, rooted cutting, or tissue culture plantlet is planted in a ground bed or pot, and grown for one year, in which the primary emphasis is placed on promoting the root system. These plants will be sold and/or transplanted as either field or container stock to become a finished product. As with most products, nursery liner buyers are in constant pursuit of high quality liners for nursery stock. The term “quality liner” is not necessarily defined by growers, but rather described with many different parameters. For the purpose of this study we define a liner as a seedling, rooted cutting, or tissue cultured plantlet that has been grown for one year either in a seedbed or in a pot, and then used for nursery planting stock (Garber et al., 1999).

Growers often use morphological characteristics as grading criteria for liner stock due to previous research linking these characteristics to field survivability and vigor. Morphological characteristics are easily identified and require minimal time and employee training to be adequately assessed. Some morphological characters include: the number of first order lateral roots (FOLR) or roots greater than 1mm in diameter that are 30mm below the root collar (Kormanik et al., 1998), root collar diameter (RCD), caliper measurements, height, etc. While many different morphological characteristics can be indicators of “quality”, buyer preference and perceived quality is of most importance (Clark et al., 2000).

Perception of quality has been recently applied to production regions, especially the Pacific Northwest region of the United States. These quality perceptions also seem to vary among liner buyers. Due to lack of previous research on perceived liner quality, we surveyed various growers and asked their opinion about what constitutes a “quality” liner. Some growers simply evaluate the overall appearance, checking only for signs of disease or insect damage (personal conversation with G. Griffith, Wilkerson Mill Nurseries, 1/04/2007), while others stated that uniformity was very important (personal conversation with D. Shadow, Shadow Nurseries, 2/16/2007). Many different characteristics seem to impact overall buyer perceptions of nursery liner quality during purchasing decisions.

To better assess nursery liner buyer perceptions of quality and purchasing decisions, we adapted a survey technique that allows multiple product attributes and attribute levels to be analyzed simultaneously, and forces liner buyers to trade-off certain liner characteristics for others. Conjoint analysis, sometimes called tradeoff analysis, is a statistical method in which a respondent’s preferences for different product choice options are broken down to determine the respondents’ inferred utility function and relative importance of each attribute of a product (Curry, 1996; Walley et al., 1999; Wirth et al., 2007). Unlike focus and market research groups, conjoint analysis techniques, most often conducted through written surveys, allow studies to be less biased (Mason et al., 2008). After ranking each product with varying attributes, conjoint statistical analyses produce utility values for each product attribute, thereby allowing researchers to make inferences about effects of interactions of attributes on respondent product rating (Curry, 1996; Wirth et al., 2007). In conjoint studies, holdout products are also used to measure predictability of the experimental model by comparing the model's predicted utility values with the actual survey respondent's average (Behe et al., 1999; Palma, 2002; Wirth et al., 2007).

Though we can describe what attributes constitute a high quality liner, we are more interested in which attributes liner buyers gauge when assessing bareroot nursery liner stock. Based on a review of the literature and informal phone interviews with retail and wholesale nursery liner buyers, we identified six key attributes that influence buyer preferences for liners: price, region of production, root appearance (FOLR number) and uniformity of liner height, canopy density, and caliper. By using conjoint analysis, we will be able to more accurately determine the relative importance that buyers place on nursery liner product attributes when evaluating nursery liner stock and making point-of-purchase decisions.

Materials and Methods

Most conjoint studies utilize a written survey to obtain data. Surveys usually contain only descriptions of the products being tested with respondents rating each profile on a numeric scale. Our study utilized a visual survey with sets of images that portrayed nursery liner products with different product attribute combinations. By conducting the survey in this manner, we were able to more closely mimic nursery liner buyer point-of-purchase decision processes. Product images contained 1+0 Nuttall oak (*Quercus nuttallii* Palmer) bareroot liners, which were chosen because their root and shoot appearance during dormancy are representative of a wide variety of plant species. Variables were defined as the quality parameters (features) identified both from informal grower surveys and the literature: FOLR number, price, region of production and caliper, canopy density, and height uniformity (Table 2-1, see end of chapter appendix).

The combination of these attributes and their respective feature levels yields a 2 x 2 x 2 x 3 x 3 x 3 factorial model. Conjoint Designer software was used to generate a fractional factorial design (Bretton-Clark, 1987), which provided an orthogonal subset of 16 feature levels needed to generate digital images of tree liner product attribute combinations (Table 2-2 and Figure 2-1). To obtain the nursery liner product images, we used Nuttall oak liners from a local nursery (Tennessee Forestry Nursery). Liners were first divided into short, medium, and tall height groups; then subdivided with height grades into 3 FOLR grades: low = 4 or 5 FOLR, mid = 6 or 7 FOLR, and high = 8 or 9 FOLR after previous studies (Kormanik et al., 1998). Once segregated these liner pools were used to select combinations of either multiple branched or un-branched specimens or either thin = 1- 3 mm in diameter or thick = 5 - 7 mm stem caliper at about 1 cm above the root collar. Products were photographed using a digital camera mounted about one meter above the table. As needed images were either digitally altered using Adobe Photoshop to emphasize variations in product characteristics based on criteria for product profiles as prescribed by the Conjoint Designer Software output (Table 2-2 and Figure 2-1).

In addition to the 16 nursery liner products, the survey also includes two “holdout” products. The first holdout product (HO1) was constructed as the hypothesized “ideal” product feature combination: a high FOLR count (8 or 9 roots), uniformity among the height, canopy density and caliper among the liners in the bundle, grown in the southeastern U.S. region, and with a mid-range price of a $1.60 per liner. The second holdout product (HO2) has a low FOLR count (4 or 5 roots), no uniformity of height, canopy density and caliper among the liners in the bundle, grown in a unspecified U.S. region, and with a high price of a $1.90 per liner (Table 2-2 and Figure 2-1).

Surveys were administered to liner buyers and growers at the 2007 Southern Nursery Association Trade Show, the Tennessee Green Industry Field Day, and Smoky Mountain Nursery Tour and at the 2008 Mid-States Horticultural Exposition. Respondents first provided demographic information, such as primary operating location of the business; whether respondents grow, buy, or sell liners; approximately how many acres they have in total production, and approximately what percentage of that acerage is used for liner production; the company's gross sales and what percentage of those gross sales are obtained from liner sales; the respondent's gender and years of experience in the green industry, as well as the number of suppliers from whom liners are purchased; and the types of liner stock preferred by the respondents from the choices of: bareroot, cellpack (plug grown), 3" (414 cm^3) air root prune container, 4" (798 cm^3) rose or band container, 1 gallon (3.78 L) air root prune container, or a 1 gallon (3.78 L) trade-standard container (Appendix 2-A).

To obtain self-stated preferences that buyers expressed for each of our variables, respondents were asked to rank each variable (root number, region of production, price, and height canopy and caliper uniformity) on a self-stated Likert scale, where "1" is not very important through "5" being very important, when making their nursery liner purchasing decisions. For the visual portion of the survey, respondents rated each of the

18 nursery liner product images, which depicted variable characteristics as dictated by the Conjoint Designer model (Table 2-2 and Figure 2-1), using a 1 to 10 Likert scale where "1" signified low personal preference and "10" high personal preference for the different liner product feature combinations.

Data were analyzed using Time Series Processor (TSP) econometric modeling software (TSP International, Palo Alto, CA). Effects coding was used and dummy variables were created such that the $k^{'th}$ base level in the model to -1 instead of 0, which allowed us to constrain the level of each feature to sum to 0 (Palma, 2002).

The preference utility model for the conjoint analysis can be expressed as follows:

Liner rating = f (FOLR number, height uniformity, caliper uniformity, uniformity of canopy density, region of production, price per liner and other) [1]

Where:

Rating = preference rating given to hypothetical nursery liner stock

FOLR number = the number of roots greater than 1mm in diam.: low FOLR = 4 or 5, mid FOLR = 6 or 7, or high FOLR = 8 or 9.

Region of production = region of the country where liners were produced: Southeastern U.S., Northwestern U.S., or unspecified U.S. region.

Price per liner = cost per plant of the nursery liner bundle: Low price = $1.30 per plant, midrange price = $1.60 per plant, or high price = $1.90 per plant.

Liner height uniformity = average height of the plants in the liner bundle is relatively the same: uniform, not uniform

Liner caliper uniformity = average caliper of the plants in the liner bundle is relatively the same: uniform, not uniform.

Liner canopy density uniformity = average canopy density of the plants in the liner bundle is relatively the same: uniform, not uniform.

Other = other relevant demographic variables expected to influence consumer preference including whether the respondent grows, buy or sells plant liners, annual gross sales, volume of annual liner purchases, type of liner stock preferred, gender and years of green industry career experience

Within the conjoint model, the intercept (β0) represents the mean preference rating, and coefficients of dummy variables calculated for each liner attribute (e.g., β1 through β8) measure the deviation from the mean rating (Palma, 2002). Precision of the conjoint model can be further enhanced by integrating other important variables that influence preference and key demographic characteristics identified with liner consumers, including respondent's production, purchasing and sales experience with nursery liners, as well as the volume of liner purchased annually, volume of annual sales, gender, and years of experience the respondent has in the green industry. When these variables are pooled to become β9 'Consumer Demographics' and included in a modified conjoint preference model, the equation is expressed as:

$$Liner\ Rating = \beta 0 + \beta 1FOLR2 + \beta 2FOLR3 + \beta 3Height + \beta 4Caliper + \beta 5Canopy\ Density + \beta 6SEUS\ Region + \beta 7NWUS\ Region + \beta 8Price + \beta 9Consumer\ Demographics + Vi \quad [2]$$

Where V_i = the error term.

We used a two-limit Tobit model to account for the truncation residuals of the rating scale and to eliminate bias from estimating bounded ratings from an ordinary least squares (OLS) model (Palma, 2002). Our rating scale established lower and upper limits of 1 to 10. The two-limit Tobit model estimates part worth values and allows any values lower than one to automatically be tallied as one, which is the lower tail censoring value (Palma, 2002). Values greater than 10 are counted as 10 (Palma, 2002). Parameters of the two-limit Tobit regression model are obtained by computing the Maximum Likelihood Estimates (MLE) (Palma, 2002). The log likelihood for the censored regression model can be expressed as follows (Greene, 1990):

$$In\ L = \sum_{Yi\ .0} \quad -\frac{1}{2}\left[\ 1n(2\pi) + 1n\ \sigma 2 + \frac{(Yi - \beta\ Xi)2}{\sigma 2}\right] + \sum_{Yi=0} \quad \left[1 - \ \sigma\left(\frac{B\ Xi}{\sigma}\right)\right] \quad [3]$$

Results

Respondent Demographics

Respondents returned a total of 248 completed surveys from all venues for a total of 3,968 observations that were used to conduct the conjoint experiment. Consistent with the locations where surveys were conducted, survey respondents were mostly from southern states. Respondents were primarily male (76%) and more than half of all respondents had greater than 12 years experience in the green industry. Of respondents who answered related questions, about 85% had either bought, sold, or grew nursery liners with about half of the respondents reported purchasing 5,000 or more liners per year (Table 2-3). Approximately half of respondents that answered the question reported that they produced liners on 20 or more acres (8.1 ha) of land, which corresponded to about 6% of the total production operation (data not shown). For ease of analysis, acreage devoted to liner production, percentage of total production area available, and range data on liner purchase quantities were classified into six categories (Table 2-3). Relatively few suppliers provided the liners purchased by respondents who averaged just 2 to 4 sources for their nursery liner stock needs (Table 2-3). Half of respondents reported making less than $250,000 per year, while about 39% worked for firms earning in excess of $1 million, of which only a relatively small proportion was attributed to sales of liner stock, with less than 20% of respondents reporting proportional earnings of greater than 25% attributed to liners. Only about 4% reported total annual sales volume resulted from nursery liner stock sales (Table 2-3).

Self-Stated Attribute Importance Ratings

Mean attribute scores revealed FOLR to be the most important consideration when making purchasing decisions (4.22), with liner height uniformity being the second most important (3.87). As identified by the respondents, price per liner ranked third in importance of making purchasing decisions (3.86). Surprisingly, region of production was stated as least important to decisions about liner purchasing (3.03) (Figures 2-2).

Estimated Conjoint Preference Model

The conjoint preference model was estimated using a two-limit Tobit model. Independent variables were the nursery liner attributes and other variables that influence preference for liners such as whether the respondent grew, bought, or sold liner stock; their volume of sales, volume of stock purchase annually; respondent gender; and years of experience the respondent has in the green industry. The model separates and estimates the contribution of each variable to the respondent's preference rating for each of the products (Wirth et al., 2007). Within the model, the intercept term (ß0 = 6.86) represents the mean preference rating combined among all respondents for all variables. Parameter estimates for tested variables and other data reported by respondents that were expected to influence consumer preferences for nursery liner stock were used to calculate the 'Consumer Demographics' value (ß9 = -0.92) (Tables 2-4, 2-5, and 2-6). Our estimated model yielded a log-likelihood of -2331.7.

The model assumes values for the dependant variable (preference rating) in a scale of 1-10 (Wirth et al., 2007). Three key liner attribute conditions, including high FOLR (t = 17.2, $P \leq 0.0001$), height uniformity (t = 4.5, $P \leq 0.0001$), and canopy density uniformity (t = 6.4, $P \leq 0.0001$), significantly influenced buyer hypothetical purchasing decisions (Table 2-4). Consistent with previous research, all levels of parameter estimates for price, including the lowest price or $1.30 per plant received negative valuation (-0.13) (Table 2-6), and decreased linearly with rising price (Table 2-4) (Wirth et al., 2007). Regardless, within our model, the price attribute did not affect buyer decisions regarding hypothetical liner purchases (t = -0.8; $P = 0.42$) (Table 2-4). A non-significant coefficient is an indication that the parameter had no effect on the preference rating (Wirth et al., 2007). As with price, neither region of production (t = 0.24 to -0.48; P = 0.81 to 0.63) nor caliper uniformity (t = -1.26; P = 0.21), nor mid FOLR grade (t = -1.69; P = 0.92) influenced buyer preference for nursery liner feature levels (Table 2-4).

Using the model parameter estimates, quality ratings were derived for each nursery liner product (Table 2-7), and were consistent with mean preference ratings given by respondents (Figure 2-3). The nursery liner product with overall highest estimated preference among respondents is a liner with a high FOLR number, a uniform height, uniform canopy density, a uniform caliper, from an unspecified U.S. region, and with the lowest price. When consumer demographics are included, the summed utility value for this product is: ß0 6.86 + 1.49 + 0.25 + 0.07 + 0.35 + 0.02 – 0.28 – 0.92 = 7.84 (Table 2-6 and 2-7). The rest of the variables were estimated at their mean values and represent values characteristic of a typical liner buyer. Ratings of holdout products were statistically compared to actual product ratings to demonstrate the model's validity (Wirth et al., 2007). The actual mean rating for the first holdout product (HO1) was 7.26 (± 0.19) versus the model's estimated rating of 7.64. The mean rating for the second holdout product (HO2) was 3.43 (± 0.22) versus the estimated rating of 3.86 (Table 2-7 and Figure 2-3). Thus, the model appears to have good predictive reliability.

Relative Importance of Attributes

Relative importance weights of attributes, expressed as percentages, are another method of analyzing conjoint results (Wirth et al., 2007). Relative importance weights are calculated by first summing the minimum and maximum utility values for each attribute to determine a range for each of the six attributes. All six attribute ranges are then summed together. The relative importance weight of an attribute is the percentage of its range to the total sum of all six attribute ranges. Results of the attribute importance weight calculations were consistent with other results from the study. First order lateral root number was the most important feature and was responsible for 65.4 percent of buyer's purchasing decisions. Canopy density and height uniformity were important features at 16.15% and 11.29%, respectively. Region of production and price were not important to purchasing decisions at 1.52% and 2.44%, respectively (Table 2-8).

Discussion

Results from both the self-stated importance ratings and the visual survey portion was consistent with the FOLR feature being the most important product attribute buyers assess when making nursery liner purchasing decisions. The observation that high FOLR counts are important as a grading criterion is consistent with previous research. In previous studies, FOLR number has been a reliable grading criterion (Clark et al., 2000) and is a reliable indicator of out-planting success (Thompson and Schultz, 1995; Kormanik et al., 1998; Clark et al., 2000; Dumroese et al., 2005; Jacobs et al., 2005; Wilson and Jacobs, 2006).

From preliminary surveys, we identified product uniformity as an important characteristic to liner buyers. In the direct-reported importance ratings, liner height uniformity was the second highest preferred product feature. Though it ranked third in relative importance to the purchasing decision during the conjoint analysis, liner height uniformity still seemed to play an important role in buyer preference. The same was true of uniform canopy density. A possible explanation for liner canopy density uniformity being more important during buyer purchasing decisions than liner height uniformity is the belief about future growth of the plant. Initial branching structure might trigger a perception in the buyers mind that the crop would have a good, uniform branching structure during the finishing stage of production. While later branching would be controlled through pruning, initial branch structure forms the base architecture of the plant. If branch structure of the crop has an overall uniformity, a potential buyer might anticipate good canopy architecture in the finished crop with less pruning effort.

Surprisingly, caliper uniformity was not very important to buyer purchasing decisions. A possible explanation could be the method in which the survey was given. Though photographs displayed visual characteristics of the products, respective feature levels were also printed on the product image. Even though liner caliper uniformity or non-uniformity were clearly stated, it might have been difficult for respondents to visualize differences in caliper size among the pictured liner products. Future survey efforts might benefit from hands-on examinations of carefully selected live plant material. Respondents would then be able to gauge differences in caliper more accurately and be able to make more discriminatory decisions.

Contrary to pre-study hypotheses, production region was relatively unimportant to buyer purchasing decisions. Both the southeastern and Pacific Northwest U.S. regions yielded a negative impact on buyer utility. We interpret that an unspecified region of production might be more acceptable to a nursery liner buyer due to pre-conceived notions about certain U.S. regions. For example, if a buyer is evaluating a liner bundle from the Pacific Northwest, that buyer might make the assumption that incurred shipping costs would be too high to positively influence the buyer to make the purchase.

Respondent preference ratings indicate that price was important to nursery liner buyers when making purchasing decisions. Results from conjoint analysis however, indicate that the price range used contributed just 2.4% to the buyer's overall hypothetical purchasing decisions. This contradiction may be partly explained by the similarity between our hypothetical price ranges and those encountered by nursery liner buyers. While the midlevel price of $1.60 per liner was consistent with 2006 nursery catalog listings for many 1-0 Nuttall oak (*Q. nuttallii* Palmer) liner species, our high and low values were set at just 15% above and below contemporary costs. If the low and high price were set to extreme differences, price per liner might have been perceived to be of greater importance to purchasing decisions. Other relevant demographic variables, for example whether or not a respondent grows, buys or sells liners as well as years of experience in the green industry, are expected to influence consumer preferences for nursery plant liners. We can increase the explanatory power of simulation analysis models by including key demographic variables in calculations of an aggregate average for typical consumers in a surveyed region (β9). In turn, calculated utility values for each product more accurately predict potential product acceptance in different markets.

Growers will be able to take immediate advantage of the results of this study. Because we have adequate predictability with our model, nursery liner growers can compare nursery liner buyer utilities, and evaluate their field-dug liners to estimate buyer acceptance ratings for their products. A grower has to simply examine the analysis of the holdout products to know that a product with a high FOLR count, overall product uniformity of liner height and canopy density, and a relatively low to midrange price per plant for the species will be desirable to nursery liner buyers. Also, because we did not specify the plant species during the survey, the utility of this model should apply across several deciduous tree species, which can be used by liner growers to judge a variety of different crops. Buyer utility is calculated by adding the sum of selected liner product attribute utility values to the model intercept, and the aggregate average for the demographic mean values, which describes the mean utility value (Wirth et al., 2007). The premium first choice product would be the product with the highest utility, a liner with a high FOLR number, a uniform canopy density and height, from an unspecified region, and a low price. Sub-grades could then be determined based on buyer utilities of sub-premium products. By allowing growers to establish baseline parameters for grading purposes, they will also be able to modify production and grading techniques, such as undercutting or altering bed planting densities (Thompson and Schultz, 1995; Kormanik et al., 1999; Clark et al., 2000; Dumroese et al., 2005; Jacobs et al., 2005; Wilson and Jacobs, 2006) that emphasize desirable product features.

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Chapter 2 Appendices

Table 2-1: Parameters of 1+0 bare-root liner attribute levels visually tested using conjoint survey analyses to quantify relative importance of each character to hypothetical point-of-purchase acceptance by respondents (as "buyers").

Attribute	**Attribute level**
First Order Lateral Roots (FOLR) (FOLR = side roots ≥ 1mm diam)	4 or 5 roots 6 or 7 roots 8 or 9 roots
Liner height uniformity	Non-uniform Height Uniform Height
Liner caliper uniformity	Non-uniform Caliper Uniform Caliper
Liner canopy density uniformity	Non-uniform Canopy Density Uniform Canopy Density
Region of production	Southeastern U.S. Northwestern U.S. Non-specified U.S.
Price per liner	Low = $1.30 per liner Mid = $1.60 per liner High = $1.90 per liner

Table 2-2. Conjoint analysis visual survey nursery liner product profiles rated by respondents.

Product	First Order Lateral Root Number (FOLR)	Liner height uniformity	Liner caliper uniformity	Liner canopy density uniformity	Price per liner	U.S. Region of production	Position in display
1	4 to 5 roots	Mixed	Mixed	Mixed	$1.30	Unspecified	10
2	4 to 5 roots	Mixed	Mixed	Uniform	$1.30	Northwestern	5
3	4 to 5 roots	Mixed	Uniform	Mixed	$1.60	Northwestern	11
4	4 to 5 roots	Mixed	Uniform	Uniform	$1.60	Southeastern	1
5	4 to 5 roots	Uniform	Mixed	Mixed	$1.90	Northwestern	4
6	4 to 5 roots	Uniform	Mixed	Uniform	$1.90	Southeastern	3
7	4 to 5 roots	Uniform	Uniform	Mixed	$1.30	Unspecified	17
8	4 to 5 roots	Uniform	Uniform	Uniform	$1.30	Northwestern	2
9	6 to 7 roots	Mixed	Mixed	Uniform	$1.30	Northwestern	6
10	6 to 7 roots	Mixed	Uniform	Uniform	$1.90	Unspecified	8
11	6 to 7 roots	Uniform	Mixed	Uniform	$1.60	Northwestern	13
12	6 to 7 roots	Uniform	Uniform	Mixed	$1.30	Southeastern	15
13	8 to 9 roots	Mixed	Mixed	Mixed	$1.30	Southeastern	9
14	8 to 9 roots	Mixed	Uniform	Mixed	$1.90	Northwestern	16
15	8 to 9 roots	Uniform	Mixed	Uniform	$1.60	Unspecified	12
16	8 to 9 roots	Uniform	Uniform	Uniform	$1.30	Northwestern	7
HO 1	8 to 9 roots	Uniform	Uniform	Uniform	$1.60	Southeastern	14
HO 2	4 to 5 roots	Mixed	Mixed	Mixed	$1.30	Unspecified	18

Table 2-3. Demographic information provided by survey respondents

Item:	Number of respondents (%)
State of operation:	
Alabama	13 (5.6)
Arkansas	1 (0.4)
Florida	18 (7.8)
Georgia	25 (10.8)
Illinois	2 (0.9)
Indiana	14 (6.1)
Kentucky	40 (17.3)
Michigan	4 (1.7)
Mississippi	6 (2.6)
North Carolina	8 (3.5)
Ohio	3 (1.3)
Oklahoma	1 (0.4)
Oregon	1 (0.4)
South Carolina	10 (4.3)
Tennessee	79 (34.2)
Texas	4 (1.7)
Virginia	1 (0.4)
Whole East Coast	1 (0.4)
Respondent gender:	
Male	130 (76.0)
Female	41 (24.0)
Whether respondent grows/buys/sells liners [*respondents could check more than one*]:	
Grow liners (n=324 responses)	126 (56.0)
Buy liners (n=324 responses)	126 (56.0)
Sell liners (n=225 responses)	46 (20.0)
Do not grow, buy, or sell liners (n=203 responses)	31 (15.0)
Total number of acres of operation:	
No acres	33 (22.9)
0.01 to 0.5	24 (15.3)
0.51 to 5.0	48 (33.3)
5.1 to 25	15 (10.4)
25.1 to 100	17 (11.9)

≥ 100 acres	10	(6.9)
Percentage of production acreage dedicated to liner production:		
None	37	(24.8)
1 to 10% of production acreage	57	(38.3)
11 to 25% of production acreage	20	(13.4)
26 to 50% of production acreage	18	(12.1)
51 to 75% of production acreage	3	(2.0)
76 to 100% of production acreage	14	(9.4)
Total number of liners purchased by respondent per year:		
0 to 100 liners	10	(7.8)
101 to 1,000 liners	26	(20.2)
1,001 to 5,000 liners	38	(30.0)
5,001 to 25,000 liners	31	(24.0)
25,001 to 100,000 liners	16	(12.4)
100,001 to ≥ 1 million liners	8	(6.2)
Number of suppliers from whom respondents purchase liners:		
Do not buy liners	3	(2.2)
1 to 5 suppliers	87	(64.4)
6 to 10 suppliers	29	(22.0)
11 to 25 suppliers	13	(9.6)
≥ 26 suppliers	3	(2.2)
Total gross sales for respondents' firm		
< $50,000 per year	37	(19.3)
$50,001 to $100,000 per year	19	(9.9)
$100,001 to $250,000 per year	22	(11.4)
$250,001 to $500,000 per year	19	(9.9)
$500,001 to $750,000 per year	11	(5.7)
$750,001 to $ 1 million per year	10	(5.2)
Over $ 1 million per year	34	(17.7)
Over $ 3 million per year	40	(20.8)
Percentage of total sales obtained by respondents' firm from liner sales:		
Sales proportion not stated	80	(42.5)
1 to 10% of sales	55	(29.3)
11 to 25% of sales	16	(8.5)

26 to 50% of sales	15	(8.0)
51 to 75% of sales	8	(4.3)
76 to 99% of sales	6	(3.2)
100 % of sales	8	(4.3)
Number of years of green industry experience held by respondents:		
No years of experience	3	(2.6)
< 1 to 5 years of experience	27	(23.5)
6 to 10 years of experience	23	(20.0)
11 to 25 years of experience	43	(37.4)
≥ 26 years of experience	19	(16.5)
Type of Stock preferred by survey respondents [*respondents could check more than one*]:		
Bareroot		
Preferred	108	(50.7)
Not listed as a preference	105	(49.3)
Cell pack (plug grown)		
Preferred	99	(46.5)
Not listed as a preference	114	(53.5)
3” (414 cm^3) air root prune container		
Preferred	42	(19.7)
Not listed as a preference	171	(80.3)
4” rose (798 cm^3) (band pot) container		
Preferred	20	(9.4)
Not listed as a preference	193	(90.6)
1 gal (3.78L) air root prune container		
Preferred	35	(16.4)
Not listed as a preference	178	(83.6)
1 gal (3.78L) trade standard container		
Preferred	69	(67.6)
Not listed as a preference	144	(32.4)

Table 2-4. Parameter estimates of nursery liner product preference ratings

Variable	**Coefficient**	**Standard error**	**t–value**	***P*–value**
Intercept				
*ß*0	6.865	0.40	17.19	≤ 0.0001
Nursery liner attributes				
Low FOLR	-1.347			
Mid FOLR	-0.144	0.09	-1.69	0.092
High FOLR	1.492	0.09	17.39	≤ 0.0001
Uniform height	0.245	0.05	4.47	≤ 0.0001
Mixed height	-0.245			
Uniform caliper	-0.069	0.05	-1.26	0.209
Mixed caliper	0.069			
Uniform canopy density	0.350	0.05	6.40	≤ 0.0001
Mixed canopy density	-0.350			
Northwest U.S. region	-0.017	0.07	0.24	0.814
Southeast U.S. region	-0.041	0.09	- 0.48	0.630
Unspecified U.S. region	0.024			
Price	-0.176	0.22	- 0.80	0.423
Consumer demographic attributes				
Grew plant liners	-0.365	0.12	-3.01	0.003
Bought plant liners	-0.162	0.14	-1.19	0.232
Sold plant liners	0.081	0.14	0.57	0.567
Annual liner purchase volume	0.023	0.04	0.59	0.555
Annual liner sales	-0.036	0.02	-1.58	0.115
Preference for bare-root liners	-0.015	0.13	0.11	0.911
Gender	-0.330	0.14	-2.34	0.019
Green industry experience (years)	-0.018	0.01	-3.11	0.002

Table 2-5. Respondent means, parameter estimates and calculated utility of demographic variables

Variable	Respondent mean	Parameter estimate	Calculated utility
Grew plant liners	0.635	-0.365	-0.231
Bought plant liners	0.676	-0.162	-0.110
Sold plant liners	0.243	0.081	0.020
Annual liner purchase volume	2.270[Z]	0.023	0.051
Annual liner sales	4.014[Y]	-0.036	-0.145
Preference for bare-root liners	0.662	-0.015	-0.010
Gender	0.757	-0.330	-0.250
Green industry experience (years)	15.104	-0.018	-0.264
β9 'Consumer Demographics'			∑= *-0.919*

[Z] Value represents ranked mean from total annual liner purchase volumes where 1 = '0 to 100 liners' and 6 = '100,001 to + 1 million liners' purchased per year

[Y] Value represents ranked mean from total gross sales values of firms where 1 = '< $50,000 per year' and 8 = 'Over $ 3 million per year'

Table 2-6. Utility of nursery stock feature levels as described by survey respondents.

Feature	Feature level	Utility
FOLR number	Low FOLR (4 or 5)	-1.35
	Mid FOLR (6 or 7)	-0.14
	High FOLR (8 or 9)	1.49
Height uniformity	Uniform	0.25
	Non-uniform	-0.25
Caliper uniformity	Uniform	-0.07
	Non-uniform	0.07
Canopy density uniformity	Uniform	0.35
	Non-uniform	-0.35
Region of production	Pacific Northwest U.S.	-0.02
	Southeast U.S.	-0.04
	Unspecified U.S.	0.02
Price (per liner)	$1.30 per liner	-0.23
	$1.60 per liner	-0.28
	$1.90 per liner	-0.33

Table 2-7. Estimated ratings for nursery liner products produced from nursery liner product feature attribute level utility values [*Ratings were ranked in order of highest to lowest for comparison purposes*].

Product (image)	FOLR number	Liner height uniformity	Liner caliper uniformity	Liner canopy uniformity	Region of production	Liner price	Intercept	Consumer demographics	Estimated rating
15 (12)	1.49	0.25	0.07	0.35	0.02	-0.28	6.86	-0.92	7.84
16 (7)	1.49	0.25	-0.07	0.35	0.02	-0.23	6.86	-0.92	7.75
13 (9)	1.49	-0.25	0.07	-0.35	-0.04	-0.23	6.86	-0.92	6.63
14 (16)	1.49	-0.25	-0.07	-0.35	-0.04	-0.23	6.86	-0.92	6.49
11 (13)	-0.14	0.25	0.07	0.35	0.02	-0.28	6.86	-0.92	6.21
9 (6)	-0.14	-0.25	0.07	0.35	0.02	-0.23	6.86	-0.92	5.76
10 (8)	-0.14	-0.25	-0.07	0.35	0.02	-0.33	6.86	-0.92	5.52
12 (15)	-0.14	0.25	-0.07	-0.35	-0.04	-0.23	6.86	-0.92	5.36
8 (2)	-1.35	0.25	-0.07	0.35	0.02	-0.23	6.86	-0.92	4.88
6 (3)	-1.35	0.25	0.07	0.35	-0.04	-0.33	6.86	-0.92	4.86
2 (5)	-1.35	-0.25	0.07	0.35	0.02	-0.23	6.86	-0.92	4.52
5 (4)	-1.35	0.25	0.07	-0.35	0.02	-0.33	6.86	-0.92	4.22
7 (17)	-1.35	0.25	-0.07	-0.35	0.02	-0.23	6.86	-0.92	4.18
1 (10)	-1.35	-0.25	0.07	-0.35	0.02	-0.33	6.86	-0.92	3.72
4 (1)	-1.35	-0.25	0.07	-0.35	-0.04	-0.28	6.86	-0.92	3.71
3 (11)	-1.35	-0.25	-0.07	-0.35	0.02	-0.28	6.86	-0.92	3.63
HO1 (14)	1.49	0.25	-0.07	0.35	-0.04	-0.28	6.86	-0.92	7.64
HO2 (18)	-1.35	-0.25	-0.07	0.35	-0.04	-0.28	6.86	-0.92	4.27

Table 2-8. Relative importance of nursery liner attributes in effecting consumer acceptance

Feature	Utility range	Relative importance (%)
FOLR number	2.84	65.43
Canopy density uniformity	0.70	16.15
Height uniformity	0.49	11.29
Caliper uniformity	0.14	3.17
Price	0.11	2.44
Region of production	0.07	1.52

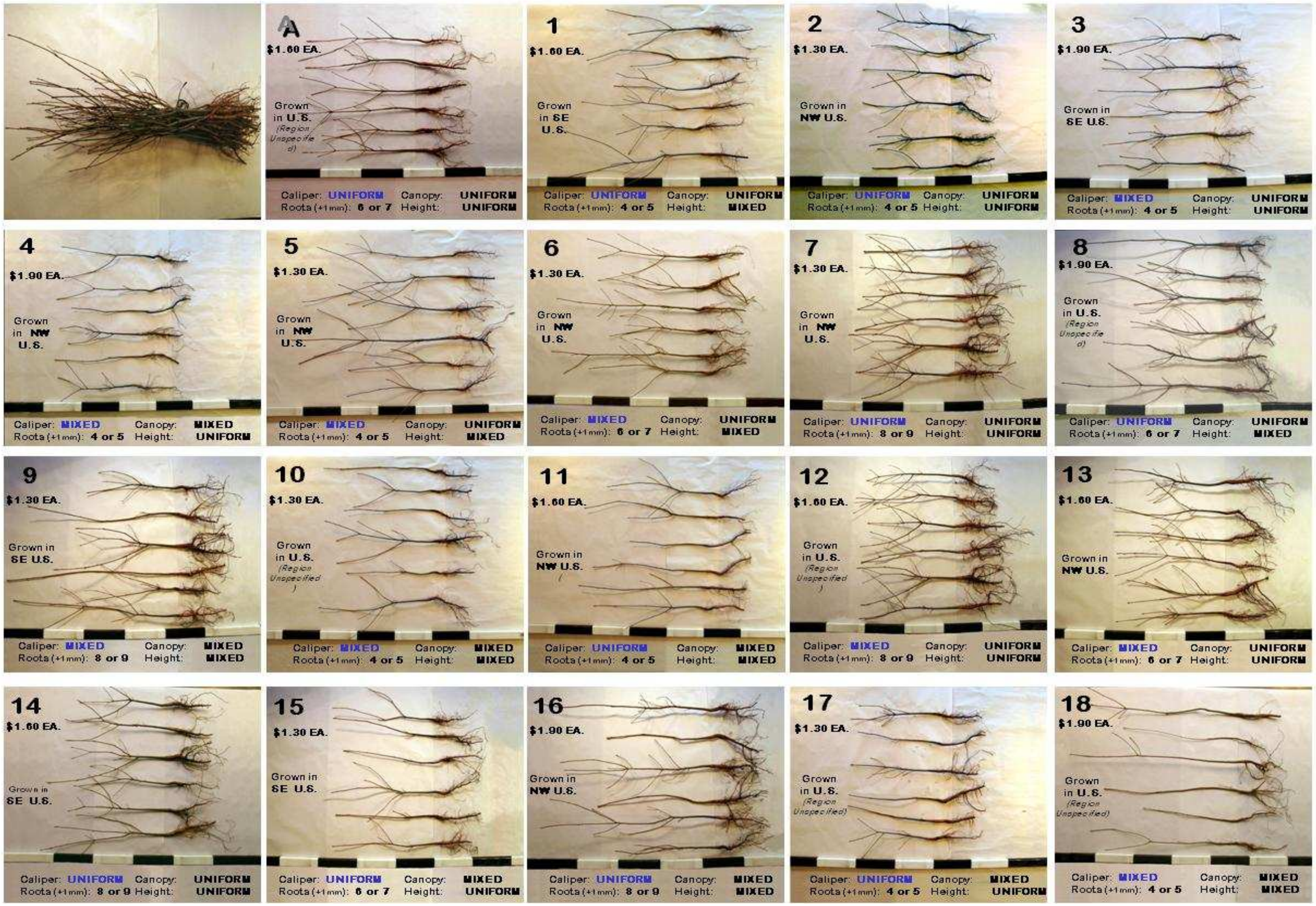

Figure 2-1. Scaled down representation of the visual survey nursery liner product images rated by respondents.

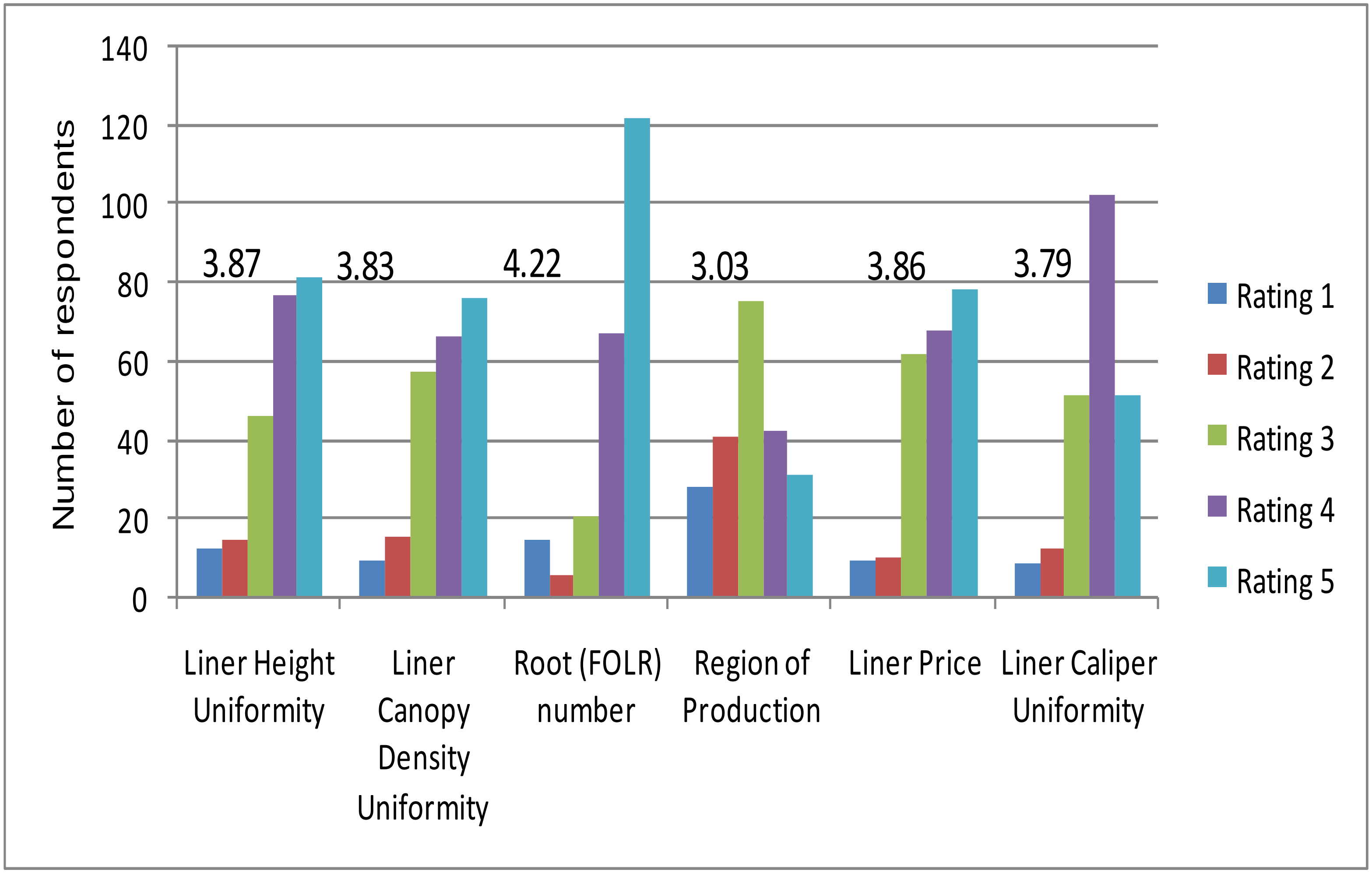

Figure 2-2. Summary of directly reported preference ratings for nursery liner quality characteristics (average ratings are listed above the respective characteristic).

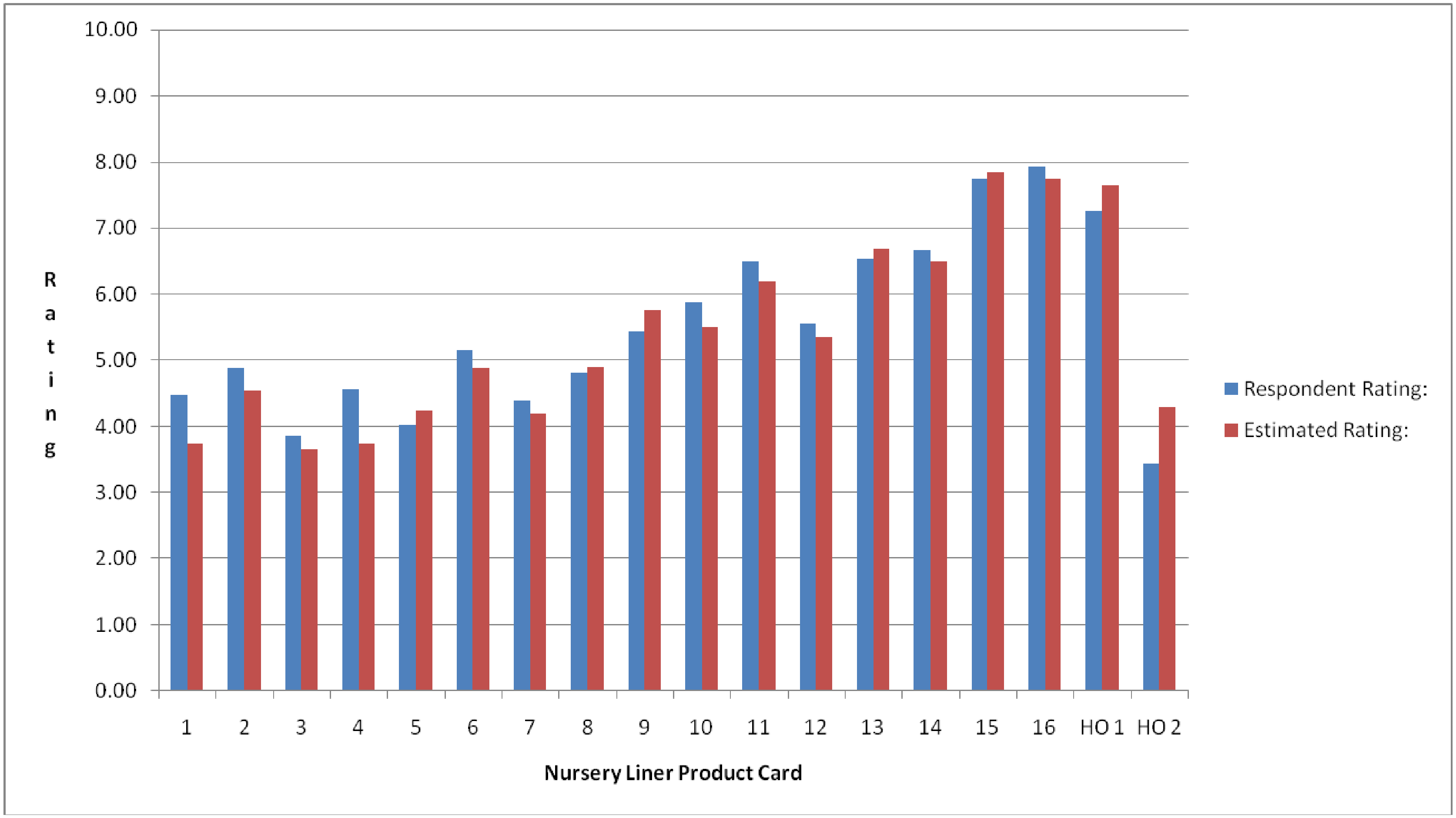

Figure 2-3. Comparison of estimated ratings to average respondent ratings of tested nursery liner products.

Appendix 2-A

University of Tennessee
Department of Plant Sciences
Liner Production Research Project

For your assessment, we've defined nursery liner stock as:
Liner: *a 1-year-old seedling or rooted cutting*

1.) *In which state* is your company's primary operation located? ________________

2). Do you ___ GROW, ___BUY, or ___ SELL liners?

3.) About *how many acres* does your business have *in* total production? ____________ Ac.

3b.) What acreage (or *percent of total*) is *in liner production*? ______ Ac. OR (__ %)

4.) Does your company *buy* nursery liner stock? ___ Yes ___ No
If 'YES', above:

4b). *About how many* liners does your company buy each year? __________________

4c). From *about how many* suppliers does your company buy liners? ______________

5.) About what percent of your company's annual sales volume would you guess is *made from liner sales*?

__ 0% __ 1–10% __ 11–25% __ 26–50% __ 51–75% __ 75–99% __ 100%

6.) Please estimate the *annual gross sales* for your company:

__ < $50,000 __ $50,001 - $100,000 __ $100,001 - $250,000 __ $250,001 - $500,000
__ $500,001 - $750,000 __ $750,001 - $1 Million __ + $1 Million __ +$3 Million

7.) What *type* of nursery stock liner(s) would YOU prefer to purchase? (*check all that apply*)

___ bareroot ___ 3" air-root pruning pot ___ 1 gal. air-root pruning pot

___ cell pack (plug grown) ___ 4" rose or band pot ___ 1 gal. standard container

8.) In YOUR opinion, how important are the following characteristics to decisions about buying high-quality liners.

	Very unimportant				*Very important*
___ Height uniformity	1	2	3	4	5
___ Canopy uniformity	1	2	3	4	5
___ Root number	1	2	3	4	5
___ Where liners were grown	1	2	3	4	5
___ Price	1	2	3	4	5
___ Caliper uniformity	1	2	3	4	5
___ Other: ______________________	1	2	3	4	5

Liners in Bundles

Rating

	Low				Average					High
EXAMPLE A	1	2	3	4	5	6	7	8	9	10
Bundle 1	1	2	3	4	5	6	7	8	9	10
Bundle 2	1	2	3	4	5	6	7	8	9	10
Bundle 3	1	2	3	4	5	6	7	8	9	10
Bundle 4	1	2	3	4	5	6	7	8	9	10
Bundle 5	1	2	3	4	5	6	7	8	9	10
Bundle 6	1	2	3	4	5	6	7	8	9	10
Bundle 7	1	2	3	4	5	6	7	8	9	10
Bundle 8	1	2	3	4	5	6	7	8	9	10
Bundle 9	1	2	3	4	5	6	7	8	9	10
Bundle 10	1	2	3	4	5	6	7	8	9	10
Bundle 11	1	2	3	4	5	6	7	8	9	10
Bundle 12	1	2	3	4	5	6	7	8	9	10
Bundle 13	1	2	3	4	5	6	7	8	9	10
Bundle 14	1	2	3	4	5	6	7	8	9	10
Bundle 15	1	2	3	4	5	6	7	8	9	10
Bundle 16	1	2	3	4	5	6	7	8	9	10
Bundle 17	1	2	3	4	5	6	7	8	9	10
Bundle 18	1	2	3	4	5	6	7	8	9	10

Chapter 3

Estimated Costs of Growing Three Species of Nursery Liner Stock in USDA Plant Hardiness Zone 6b to7a

Abstract

To compete in today's nursery industry, a grower must be able to take advantage of niche opportunities. In this study, we investigate production costs of growing ornamental nursery liners in a USDA Plant Hardiness Zone 6b to 7a ornamental plant nursery. We examined three contemporary nursery liner production systems: a field-groundbed system, a polyhouse covered groundbed system, and a polyhouse covered container system. We estimated capital requirements, fixed costs and variable costs for each system. We also compared production costs for a deciduous plant, a broadleaf evergreen, and a needleleaf evergreen to allow inferences about the widest variety of nursery liner crops.

Chapter 3

Estimated Costs of Growing Three Species of Nursery Liner Stock in USDA Plant Hardiness Zone 6b to7a

Introduction

Tennessee nursery growers may gain a competitive advantage if they can economically produce, rather than outsource, their own nursery liner stock plants. In part, these advantages accrue if growers can achieve better control over plant quality, convenience, and customer savings on high shipping costs of liners purchased from extra-regional producers or markets (personal conversation with Mark Halcomb, University of Tennessee Extension, 10/16/2007). Some percentage of on-site grown liners may also be sold for profit. Growing liners on site may also present new market opportunities for nursery growers. To compete with larger producers, a grower must be able to take advantage of niche opportunities, for example, production and marketing of a premium quality liner. Marketability is not the only question that a grower must consider. Other factors include initial investment costs of starting a new business, or costs associated with adapting or expanding a previous one.

In 1983, Dickerson, Badenhop and Day investigated the costs for production of liners of three common nursery crop liners from rooted cuttings (Dickerson et al., 1983). While formulae developed in the study remain beneficial to the industry, the actual costs generated by the formulae as well as the production systems described, are no longer current with today's industry trends. There is a need to update and modify these formulae to not only estimate current production costs, but to also make them available for growers to utilize quickly and effectively. These formulae could be adapted to a spreadsheet program so growers can adapt cost figures to their particular production situation.

The production of a premium quality southeastern liner depends on factors including economic feasibility, methodology for producing high quality stock, and ability to compete with west coast and high volume liner producers. A premium quality liner grown in the southeast could potentially be very profitable for a new producer or existing grower considering expansion, particularly if reduced shipping costs for regional growers yield additional incentives for attracting new customers to the firm. The objectives of this study were to determine production cost estimates for liner growing systems by comparing three contemporary growing systems.

Materials and Methods

The model nursery was set on 10-acres (4 ha) with 1.5 acre (0.16 ha) set aside for facilities and the other 8.5 acres (3.4 ha) used for production, which would probably be considered a medium to large nursery liner production operation. Our baseline nursery employs ten people including 4 salaried employees: a manager, an assistant manager, a propagator and a secretary, plus 6 hourly workers. To better represent variability that might occur between different methodologies of liner production, we used three production systems within the nursery: a field-groundbed system, a polyhouse covered groundbed system, and a polyhouse covered container system. Production areas within each system were established using a 2,000 (20' x 100') ft^2 block (186 m^{-2}). Each of the three systems was also compared among key species by assessing the costs of three different plants: the deciduous tree species red maple, (*Acer rubrum* L.), the broadleaf evergreen species Foster holly, (*Ilex* X *attenuata* Ashe. 'Fosteri'), and giant (or western) arborvitae (*Thuja plicata* D. Don 'Green Giant'), a needle leaf evergreen species.

Growing system descriptions:

Within the 20' X 100' field-groundbed system are three 567 ft^2 (5.67' x 100') (53 m^{-2}) growing areas, with a 1.5' (0.3 m^{-2}) wide path between each growing area, yielding an actual growing area of 1,701 ft^2 (158 m^{-2}) (Figures 3-1 and 3-2 at end of chapter appendices).

The polyhouse covered groundbed system is a 20' wide, 100' long growing block covered by a cold-frame polyhouse. The block is split into two 693 (7' x 99') ft^2 (64 m^{-2}) areas by a 5' (1.5 m) wide path. A 0.5' (0.15 m) buffer strip extends around the perimeter of the growing area to provide adequate light for the plants. The two 693 ft^2 (64 m^{-2}) growing areas yield a total growing area of 1,386 ft^2 (129 m^{-2}) (Figures 3-3 and 3-4).

The polyhouse covered container system is a 20' wide, 100' long growing block covered by a cold-frame polyhouse. The block is split into two 693 (7' x 99') ft^2 (64 m^{-2}) areas by a 5' (1.5 m) wide path. A 0.5' (0.15 m) buffer strip extends around the perimeter of the growing area to provide adequate light for the plants. The two 693 ft^2 (64 m^{-2}) growing areas yield a total growing area of 1,386 ft^2 (129 m^{-2}) (Figures 3-5 and 3-6).

Determination of capital requirements:

Capital inputs (including costs of land, improvements, buildings, equipment) for each growing system were determined by using the consumer price index (CPI) (United Stated Department of Labor: Beaureau of Labor Statistics <http://bls.gov>) to deflate older cost estimates to current day costs to account for inflation. Equipment costs were determined using the CPI adjustments and a modified Delphi method (Table 3-1).[1]

Determination of fixed costs:

Fixed costs are expenses that do not vary with the level of production. Fixed costs usually include: depreciation, interest, rent, insurance, taxes, and general overhead. Depreciation is a non-cash cost that is determined formulaically by using the straight-line method[2] based on salvage value of mechanical equipment (Badenhop, 1985). General overhead and rent were estimated using the CPI to adjust costs in 1980, to current cost estimates. Insurance and taxes were assessed by taking 20 percent of the original cost of the item. Interest expenses were estimated by taking 7% of the average value based on initial cost and salvage value[3] (Badenhop, 1985). Once the total fixed costs were determined, the cost was divided by 8.5 acres (3.4 ha) (370,260 ft^2, 34,398 m^{-2}) to determine the cost per square foot. We were able to calculate the cost per growing area by multiplying the cost per square foot by the actual amount of growing space available in the production system. The total amount of fixed costs per growing area was then divided by the number of plants capable of being produced in the growing area[4].

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[1] Delphi method is accomplished by taking an average of the costs of line items and comparing them to actual numbers generated by firms.

[2] Straight-line depreciation = $\frac{\text{original cost} - \text{salvage value}}{\text{useful life (in years)}}$

[3] Interest calculated by ((initial + salvage value) /2) x 0.07)

[4] Depending on the bed planting density.

Determination of variable costs:

Variable costs for production inputs (e.g., chemical and fertilizer applications, planting, harvesting etc.) were computed using a modified Delphi method. Variable costs were determined for one growing area per system per year. While the actual actions performed differed among growing systems and by plant species, costs were grouped in this same general manner (e.g., preparation of growing area/medium, planting and rooting, chemical applications, misting and irrigating, overwintering, root pruning, harvesting, and storage). Costs were calculated on an annual basis for one 20' x 100' growing area for each of the three systems (adapted from Hall et al., 1987; and Hinson et al., 2007).

Typical payroll costs were approximated after assessing wage and salary survey data and U.S. census data (American Nurserymen Staff Report 2001-2008). The hourly wage rate was also adjusted to account for future changes in U.S. wage rates. All payroll withholdings and taxes were determined by using rates of the U.S. Internal Revenue Service. Federal Insurance Contribution Act (FICA) taxes were determined by multiplying employee gross pay by 6.2%. Medicare taxes were determined by multiplying employee gross pay by 1.45%. Federal income taxes were determined by multiplying employee gross pay by 14% (<http://www.dol.gov>).

Nursery equipment operating costs were divided into three categories: fuel driven equipment, non-powered equipment, and electricity-driven equipment. The fuel driven equipment operating cost per hour was determined by summing together the fuel cost per hour, the lubrication cost per hour, and the labor (maintenance) cost per hour. The fuel cost per hour is determined by taking the current fuel price per gallon and multiplying it by the maximum power take off (PTO) horsepower of the machine, and then multiplying by a factor of 0.044 for diesel engines or 0.06 for gasoline engines. The lubrication cost was determined by taking the fuel cost per hour and multiplying it by 0.15. The labor cost was determined by multiplying the hourly labor wage rate by 1.1 to account for equipment travel and setup. These figures were then summed to give the total equipment operating cost per hour for fuel driven equipment. Equipment cost per hour was then multiplied by the number of hours of annual use to determine total annual operating cost.

Non-powered equipment operating costs per hour was determined by taking the new cost of the equipment and dividing it by the product of the number of hours of annual use and the number of years of useful life. Equipment cost per hour was then multiplied by the number of hours of annual use to determine total annual operating cost.

Electricity-driven equipment operating cost per hour was determined by taking the number of kilowatt hours the equipment used, by the cost per kilowatt hour. Kilowatt hours were determined by taking the horse power of the equipment and multiplying it by 0.746 kilowatts[5]. Equipment cost per hour was then multiplied by the number of hours of annual use to determine total annual operating cost.

Total cost determination:

Total annual production costs were determined by summing together the total annual fixed costs per growing area and the total annual variable costs. After determining the total annual cost per 20’ X 100’ growing area, that figure was then divided by the

[5] 1 hour of electricity = 0.746 kilowatts

number of actual useable square feet in the growing system to achieve the cost per square foot.

Cost per plant determination:

To determine the total cost per plant, the total cost per square foot was divided by the number of plants per square foot as specified by the planting density. The polyhouse covered container system is different. To achieve the cost per plant in this system, we summed the total annual production cost of the growing area and divided it by the total number of plants that could be grown within the model's 1,386 ft^2 (129 m^{-2}) area.

Results and Discussion

Capital requirements

Initial land investment costs for each of the three growing systems were just over $375,000 and comprised approximately 42% of the total investment costs. Buildings and facilities cost between 26 and 30 percent of the investment for all growing systems. The polyhouse covered groundbed system required the most capital for buildings and facilities ($286,840.34), followed by a difference of less than $2,000 by the field-groundbed system ($284,710.50). In all, the field-groundbed system was the most costly to establish with a total cost exceeding $900,000. Costs of the polyhouse covered groundbed and container of both above $870,000 and differed by only about $5,000 (Figure 3-7, Tables 3-2, 3-3, 3-4). However, the variance between the polyhouse covered groundbed and container system is somewhat offset by combined costs of the media mixer, hopper, and flat filler for the container system.

Capital investments would vary if nurseries that wish to expand their current operations were to explore other sources of revenue. Investment costs would also be different for growers purchasing used equipment. A nursery owner, or investor should consider consulting with their tax preparer or accountant to ascertain what potential tax credits or penalties may be incurred from purchasing used equipment.

Fixed costs:

Total annual depreciation expenses for each of the three growing systems were more than $50,000 and made up about 15% of the total annual fixed costs. Though depreciation is a non-cash expense, it is still recognized as a line item expense (Scarborough and Zimmerer, 2006, Badenhop, 1985) (Figure 3-8, Tables 3-5, 3-6, 3-7, and 3-8). Both the field-groundbed and the polyhouse covered groundbed systems had the highest depreciation cost due to the quantity and the initial cost of the equipment and facilities. Most common methods include straight-line, double-declining balance or sum-of-the-years digits. Different states usually require different methodologies for determining depreciation costs and offer options for which method is acceptable, based on the item. Growers should consult a tax preparer or an accountant to determine what method of depreciation is acceptable.

Total interest expenses for each of the three growing systems cost exceeded $30,000 and comprised around 10% of the total annual fixed costs. Interest expense in this study was calculated by adapting formulae from previous research by adjusting the interest rate formula input to a concurrent level (Badenhop, 1985) (Figure 3-8, Tables 3-

5, 3-6, 3-7, and 3-8). Most interest rates will vary depending on economic conditions, market of the business, and other economic factors.

Insurance and tax expenses for each of the three growing systems only comprised about 5% of the total annual fixed costs. Both the polyhouse covered groundbed and container system had insurance and tax expenses of about \$17,000, while the field-groundbed system was the most expensive at just above \$18,000 (Figure 3-8, Tables 3-5, 3-6, 3-7, and 3-8). While this line item in the study was computed by adapted formulae (Badenhop, 1985), more likely the scenario would be different. Different states maintain different tax codes and insurance policies vary by company. The insurance line item in this study is primarily concerning insurance coverage on buildings and equipment. Insurance coverage policies vary by company and growers would have many options of coverage from which to choose.

General overhead comprised the largest percentage (around 69%) of the total annual fixed costs for each of the three growing systems, totaling \$236,027.78 (Figure 3-8, Tables 3-5, 3-6, 3-7, and 3-8), due in large part that general overhead includes a number of line items such as administrative pay, utilities, advertising, etc. General overhead would also include any additional insurance policies and benefits packages.

To allocate total annual fixed costs to the actual growing areas, totals for each system were divided into amount of square feet in production (8.5 acres, or 370,260 ft^2, or 3.4 ha, 34,398 m^{-2}) yielding fixed costs per square foot. Fixed cost per square foot was then multiplied by square footage within a growing area, 1,701 ft^2 (158 $m^{-2)}$ for the field-groundbed system, and 1,386 ft^2 (129 m^{-2}) for both the polyhouse covered groundbed and container system, to obtain total fixed cost per growing area. The field-groundbed system had the highest fixed cost per growing area, $1,500, while the cost per growing area for the polyhouse covered groundbed and container systems was more than $1,200 but differed by only about $30.00 (Figure 3-8, Tables 3-5, 3-6, 3-7, and 3-8).

Payroll costs:

Payroll costs did not vary among the respective growing systems. Total monthly payroll cost (including withholdings and taxes) for all of the nursery's employees was $27,277.65 or $327,331.79 annually. Our base hourly wage pay was set at $8.50 per hour, which was actually lower than the Tennessee Adverse Effect Wage Rate (AEWR) of $9.15(< http://foreignlaborcert.doleta.gov/adverse.cfm>), which must be paid if employing workers on H2A and H2B Visas. The total hourly labor cost, including all taxes and withholdings paid by the nursery was $9.15 per hour (Table 3-9). It should be noted that wage rates do vary by region, and from state to state. Though data from the American Nurserymen Wage 2000 - 2007 surveys were used, it may not necessarily be representative of the wages and salaries being paid to employees in certain regions of the country. The hourly wage of $8.50 per hour was chosen to account for future adjustments in hourly rate increases to account for inflation. Additionally, we used the same hourly wage rate for all of the hourly employees. In doing so, we were able to keep the labor rate constant when calculating equipment operating costs and other variable costs. This would not be the case in a real business setting since owners often pay different hourly wage rates to employees.

Total monthly FICA costs for all employees were $3,142.06. The total monthly Medicare taxes were $734.84, and the total monthly income tax withholdings were

$3,547.49. Total monthly withholdings and taxes were $7,424.39. When determining Medicare and FICA withholdings, the employer is not only responsible for the percentage that is withheld from the employee, but also responsible for matching that figure. For example, in all three growing systems the total monthly gross pay for one hourly worker is $1,360. The amount withheld from the employee's check for FICA and Medicare would be $84.32, and $19.72 respectively, totaling $104.04. The employer has to match that $104.04, making the total cost of those two withholdings $208.08, for FICA and Medicare, but is not responsible for matching the federal income tax. These payroll costs do not include any state income taxes or withholdings. Currently, the state of Tennessee does not have an income tax, except on dividends and interest, but other states do. State income taxes will need to be considered by growers, as well as any other withholdings that may be applicable to their state.

Equipment operating costs:

Total annual fuel-driven equipment costs for the field-groundbed system had the highest expense at $66,253.43. Fuel-driven equipment costs for the polyhouse covered groundbed and container systems did not differ (both at $56,184.26) (Tables 3-10, 3-11, 3-12, and 3-13). Current fuel prices, gasoline and diesel, are fluctuating drastically. Our costs are based on a fuel price set in May of 2008 at $3.59 for regular unleaded gasoline and $4.09 for diesel.

The field-groundbed and polyhouse covered groundbed systems incurred more than $3,000 in total non-powered equipment operating costs, and differed slightly by $400. The polyhouse-covered container totaled just about $2,700 (Tables 3-10, 3-11, 3-

12, and 3-13). Differences occurred due to the amount of equipment needed for each system. Both the field-groundbed and polyhouse covered groundbed contained items in this category that would not be necessary in the container system, such as a fertilizer spreader, u-blade, etc.

Both the field-groundbed and polyhouse covered groundbed systems had the same electric-powered equipment operating costs, exceeding $4,000 (Tables 3-10, 3-11, 3-12, and 3-13). The polyhouse covered container system was the most expensive with a cost of $6,400, due to the media mixer, hopper, and flat/pot filler (Tables 3-10, 3-11, 3-12, and 3-13). With fluctuating energy prices, business owners must be able to take note of equipment operating costs. Electric-powered equipment costs in this study were calculated using an average kilowatt hour cost for the southeastern United States. (<http://www.eia.doe.gov/neic/brochure/electricity/electricity.html>).

In all, the field-groundbed system had the highest annual equipment operating costs at more than $74,000 (Tables 3-10, 3-11, 3-12, and 3-13). Slightly less than $1,000 differentiated polyhouse-covered groundbed and container systems at $64,780.72 and $65,348.22, respectively (Tables 3-10, 3-11, 3-12, and 3-13).

Total variable costs:

To evaluate costs over a wide variety of crops, we selected representative species for production in each of the three production systems: a deciduous plant (red maple), a broadleaf evergreen plant (Foster holly), and a needle leaf evergreen plant (giant arborvitae). While fixed costs for each growing system were the same for each species, variable costs differed based on crop needs, production techniques, etc. Variable costs were evaluated on an annual basis for growers producing within a 2,000 ft^2 (186 m^{-2}) area.

In the field-groundbed system the red maple species had the least expensive total annual variable costs at almost $14,000 (Figure 3-9 and Table 3-14). The Foster holly and arborvitae had total variable costs exceeding $28,000 and differed by less than $100 (Figure 3-9 and Table 3-14). Principal differences between systems included stratification, rooting, and planting. The red maple was propagated by seed and stratification costs were determined for roughly two and half weeks of stratification. Foster holly and arborvitae were propagated by cuttings from established stock blocks. The cost of rooting was determined by grouping the hormone cost and labor necessary to treat 20,000 cuttings for both the Foster holly and arborvitae. Planting costs were similar for the Foster holly and arborvitae, but differed for the red maple. Chemical application costs for the red maple and Foster holly were similar, but differed from the arborvitae only in the type of pesticide treatment. While the same fungicide (Subdue MAXX) was used for general application on all crops, the insecticide was different. Merit was used for both the maple and Foster, and Avid was used for the arborvitae species. Applications were calculated based on chemical rates, crop, and amount of square feet to which the chemical was applied (1,701 ft^2, or 158 m^{-2}).

Red maple was the least costly crop for the polyhouse covered groundbed system at almost $13,000, while the Foster holly and arborvitae costs were greater than $18,000 and differed by a margin of less than $100 (Figure 3-9 and Table 3-15). Differences in individual variable cost line items were similar to the field-groundbed system. Costs of rooting and sticking made up the largest differences as well as chemical applications.

Applications in the field-groundbed system were based on 1,701 ft^2 (158 m^{-2}) of actual growing area, while both polyhouse-covered systems applications were based on 1,386 ft^2 (129 m^{-2}) within a 2,000 ft^2 (186 m^{-2}) block.

Trends in overall variable costs were consistent with the polyhouse covered container system as well. Red maple was the least costly at just over $18,000 and Foster holly and arborvitae costs exceeded $21,000 and differed by less than $100 (Figure 3-9 and Table 3-16). There were differences in the individual variable cost line items. Media preparation was the same for all three crops and included the initial cost of substrate, fertilizers, fire ant treatments, labor, and operating cost of the mixer. Planting of red maple was done by hand similar to other growing systems. Planting and sticking for the Foster holly and arborvitae cuttings also included the cost of rooting (similar formula to previous growing systems) as well as the labor cost needed to stick the cuttings. Chemical application trends were also similar, in terms of marginal differences, between growing systems on average. Application cost of the insecticide Avid to arborvitae was on average $40 more than for red maple and Foster holly (Figure 3-9 and Table 3-16).

Total production costs:

Trends in total annual production costs were similar to variable cost trends. Red maple was least expensive to produce at around $15,000. Foster holly and arborvitae cost about $30,000 and differed by less $100 (Figure 3-10 and Tables 3-14, 3-17). Similar trends were found in the polyhouse covered groundbed system. Red maple was the least costly to produce at just above $14,000. Foster holly and arborvitae costs both exceeded $19,000, but differed by less than $100 (Figure 3-10 and Tables 3-15, 3-17). In the polyhouse covered container system total cost of red maple was over $19,000 and Foster holly and arborvitae cost over $22,000, yet differed by a margin of about $70 (Figure 3-10 and Tables 3-16, 3-17).

Cost per plant:

Planting density is important for the production of first order lateral roots (FOLR), which was found to be important in the quality survey (Chapter 2). In 1996, Schultz and Thompson found that by growing seedlings and 32 stems per m^{-2} (3.2 stems per ft^2) rather than 128 stems per m^{-2} (12.8 stems per ft^2), the number of FOLR produced was doubled. To compare cost per plant, we compared three bed planting densities: 12.8, 6.4, and 3.2 stems per ft^2 (128, 64, and 32 stems per m^{-2}) (Schultz and Thompson, 1996) to a typical commercial nursery liner bed planting density of about 36 stems per ft^2 (360 stems per m^{-2}). Trends have shown that lowering bed densities typically result in higher quality root structure and development (Schultz and Thompson, 1996). Cost per plant was dependent on the planting density for both the field-groundbed system, and the polyhouse covered groundbed. A potential downside to decreasing bed density is the corresponding decrease in the number of salable plants. There was a linear relationship between bed planting density and cost per plant, which was consistent throughout the results, and showed that for every decrease in bed planting density there is a corresponding increase in the cost per plant.

At the typical commercial planting density of 36 stems per ft^2 (360 stems per m^{-2}), red maple had the least cost per plant for both the field-groundbed and the polyhouse covered groundbed system at $0.25 and $0.28, respectively. Foster holly and arborvitae cost more per plant to produce but did not differ from each other at $0.49 per liner for the field-groundbed and $0.38 per liner for the polyhouse covered groundbed (Table 3-18). The highest planting density offers the most salable plants per growing area (over 61,000 for the field-groundbed, and over 49,000 for the polyhouse covered groundbed), but plants may not have room to develop adequate root architecture.

A planting density of 12.8 stems per ft^2 (128 stems per m^{-2}) yielded a $0.60 difference per plant between red maple versus Foster holly and arborvitae (Table 3-21) for both the field and polyhouse covered groundbed systems. Similar trends were seen for the two systems at densities of 6.4 and 3.2 stems per ft^2 (64 and 32 stems per m^{-2}) (Table 3-18). With each decrease in bed planting density, there was also a decrease in the number of salable plants causing an increase in the cost per plant (Table 3-18). For example, changing the bed planting density from 36 stems per ft2 (360 stems per m-2) to 12.8 stems per ft2 (128 stems per m-2) resulted in a reduction of salable plants by almost 50% and almost a $0.50 cost per plant increase across all plant types.

The polyhouse covered container was not dependant on bed planting density. Cost per plant was determined based on plants grown in 4" (798 cm^3) rose (band) pots. Similar to the other growing systems, red maple was the least costly, $1.50 per plant (Table 3-21). There was no difference in the cost per plant for Foster holly and arborvitae, at $1.72 each (Table 3-18).

When examining production costs by species within the field-groundbed system, the Foster holly and giant arborvitae were most expensive to grow, most likely due to the amount of equipment required for the field-groundbed system. However, red maple in the polyhouse covered container system was the most expensive of the three crops. Despite the actual cost per growing area, costs were higher for the red maple in the polyhouse covered container system. While this study used a field-groundbed type growing system that mimicked the type of field systems used in the Pacific northwest, not all growers are alike. Some growers use railroad ties to line propagation beds in order to build up their own soil mix and to reduce the amount of equipment needed (personal conversation with Dr. Charles Hall, Texas A&M University, and personal conversation Mark Halcomb, University of Tennessee Extension) (Table 3-18). Costs associated with the polyhouse covered groundbed differed from the field-groundbed system, primarily as a result of the amount of actual growing space available to produce plants. Equipment for the polyhouse-covered groundbed and the field-groundbed were similar, but the amount of space lost from the 5ft (1.5 m) aisle and the buffer strips on the sides of the growing area reduced the actual amount of growing space available within the 2,000 ft^2 (186 m^{-2}) block. Overall, red maple was least costly when examining the variable costs. The polyhouse covered groundbed system was the least expensive of all three growing systems and species for red maple in terms of variable costs, for Foster holly and giant arborvitae in the polyhouse covered groundbed and container, relatively the same (Figure 3-10 and Table 3-17). It should be noted that even though these systems are different, growers have adapted them to meet different needs. These separate growing systems have independent advantages.

The field-groundbed system, despite needing more equipment, has the easiest facilities to set-up. Field-groundbed systems also allow for the greatest number of plants to be produced per square foot, so that costs of production can be distributed over a larger number of salable products. The disadvantage of the field-groundbed system is that if fields are too wet from rainfall, harvesting can be difficult to nearly impossible.

The polyhouse covered groundbed offers advantages similar to the field-groundbed system, with added overwintering protection beneath a polyhouse cover. The major disadvantage of this system is reduction in actual production space. For highest efficiency, the center aisle must be large enough for tractors and other equipment to pass through the house. Reduced growing space limits the number of plants that can be produced. Both the polyhouse covered groundbed and the field-groundbed system are also dependent on bed planting density. Bed planting density can have a dramatic effect on the price per plant and the company's profit margin.

The polyhouse covered container system is not necessarily dependant on bed density, but rather dependant on the size and style of container in which plants are being grown. Cost variation is also dependant on whether the grower stacks containers "pot tight" and for how long during the production cycle. It is conceivable that a grower will probably not use one particular growing system. They might use one or the other based on needs of the crop and in which system the crop performs best. It is likely that a grower will use two or more systems simultaneously.

When considering the overall costs of each system, a grower must also consider changes in crop physiology that occur within each system. The polyhouse-covered groundbed offers the benefits of a groundbed environment to allow for adequate root development, but also a controlled environment for potentially more rapid growth. In theory a grower would be able to turnover a "1 year" crop in less time than in a crop grown in a field-groundbed system. Also, in this study we only assume that one crop is planted, grown and harvested. A more practical scenario, especially when the initial crop is seed-propagated, cuttings would be taken from the crop to produce more plants and therefore more salable crops within a one year growing cycle.

Conclusions

Though the field-groundbed system was the most expensive in total capital requirements, it is also one of the easiest systems to establish. The field-groundbed also offers the greatest flexibility in terms of growing densities and amount of usable square feet. Whichever growing system nursery owners choose, they will have to be mindful of not just variable costs, but also the incurred fixed costs. Choosing a bed planting density will also be important to a grower when planning production schedules. Though a lower bed density offers fewer plants, the possible trade-off of a higher quality product for a slightly higher production and sales costs might be palatable to a buyer who focuses on value and quality of their purchases. Growers will also have to take advantage of unique marketing methods to be able to sell their plants at a competitive price, especially if plants must be priced higher to reflect both greater production costs and availability fewer liners per area.

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Chapter 3 Appendix

Table 3-1. Sources of data input for cost calculations for nursery liner production (Items that were taken from literature were adjusted using Southeastern United States Consumer Price Index (SEUS CPI).

Item	Description	Sources
Land		
Unimproved land		Taylor et al. 1990
		Taylor et al. 1986 "Calculating bottom line for a small container nursery"
		Taylor et al. 1986 "Calculating field nursery costs"
Land improvements	grading, tilling, graveling, pond	Taylor et al. 1990
		Taylor et al. 1986 "Calculating bottom line for a small container nursery"
		Taylor et al. 1986 "Calculating field nursery costs"
Buildings		
Office and Restrooms	20' X 40'	Taylor et al. 1986 "Costs of establishing and operating field nurseries…"
		Taylor et al. 1986 "Calculating bottom line for a small container nursery"
		Hall et al. 1987
Storage Cooler	40' X 50' X 20'	BARR inc.<http://www.barrinc.com>
Machine Storage Shop	40' X 100'	Taylor et al. 1986 "Costs of establishing and operating field nurseries…"
		Hall et al. 1987
		Taylor et al. 1986 "Calculating field nursery costs"
Packing & Shipping Facility	50' X 75'	Taylor et al. 1990
		Coartney et al. 1988
Polyhouse Structure	20' X 100'	Taylor et al. 1990
		International Greenhouse Supply http://www.igcusa.com
Equipment		
Large Tractor	50hp tractor	<www.johndeere.com> (JD4120)
		Case IH D45 www.Case.com
		Tyler Brothers Farm Equip.
Small Tractor	< 50hp tractor	<www.johndeere.com> (JD3520)
		Case IH DX40 <http://www.Case.com>
		Tyler Brothers Farm Equip.
ATV	Utility Vehicle	Kawasaki Mule<http://www.Kawasaki.com>
		JD Gator HPX <http://www.johndeere.com>
		<www.cubcadet.com>
Trailers	6' X 12'	John Smiths & Sons inc.
		Ellis Products
		Nursery Carts Mobile Serv. & Repair
Water System	Well and Pump	Taylor et al. 1990
Irrigation System	Complete (other than misting)	Taylor et al. 1990
		Taylor et al. 1986 "Calculating bottom line for a small container nursery"
		Taylor et al. 1986 "Calculating field nursery costs"
Backpack Sprayers	3 gal	Tennessee Farmers Cooperative
		A.M. Leonard 2007 Catalog
		Gempler's Supply 2007 Fall Master Catalog
Pickup Truck	½ ton	Chevy Silverado 1500 <http:// www.cheverolet.com>

Table 3-1 (continued)

Item	Description	Sources
Pickup truck(cont)	Ford F-150	<http://www.ford.com>
		Toyota Tundra <http://www.toyota.com>
Hand Tools	Miscellaneous	Taylor et al. 1986 “Costs of establishing and operating field nurseries…”
		Taylor et al. 1986 “Calculating bottom line for a small container nursery”
Mist System	Complete misting	Taylor et al. 1990
		Taylor et al. 1986 “Calculating bottom line for a small container nursery”
		Taylor et al. 1986 “Costs of establishing and operating field nurseries…”
Tank Sprayer	25 gal tank	Gempler’s Supply 2007 Fall Master Catalog
		FIMCO Industries < http://www.fimcoindustries.com/>
		Northern Tool <http://www.northerntool.com>
Boom kit	7 nozzle (100” boom)	Gempler’s Supply 2007 Fall Master Catalog
		FIMCO Industries < http://www.fimcoindustries.com/>
Skid Loader	forklift (46hp)	Bobcat Equip. <http://www.bobcat.com>
		Northern Tool <http://www.northerntool.com>
		Knox Rental and Sales, Knoxville TN
Undercutter-bed	50” lift tines	Taylor et al. 1986 “Calculating field nursery costs”
		Taylor et al. 1986 “Costs of establishing and operating field nurseries…”
Fertilizer spreader	500# capacity broadcast spreader	<http://www.tractorsupply.com>
		Ritchie Tractors
Bed Shaper / Tiller	machine driven (70” wide)	Ferguson Tillovator (RT 700) <http://www.agrisupply.com>
		Pro HD bed shaper, Buckeye Tractors <http://www.buctraco.com>
Rotary Mower	5’ tractor mounted	Johndeere MX 5 rotary mower <http://www.johndeere.com>
		Bushhog RZ60R , Bishop Tractor and Equipment Ltd.
		Landpride RCR 18, <http://www.landpride.com>
U Blade	lifting blade	Taylor et al. 1986 “Costs of establishing and operating field nurseries…”
		Taylor et al. 1986 “Calculating field nursery costs”
		Diversified Products Marketing inc. http://www.diversifiedmktg.com
Pot / Flat Filler	Flat Filler with Hopper	Pack Manufacturing inc.
		Classic 2000, Gleason Equipment http://www.gleasonequipment.com
Media Mixer	4 yrd cu capacity	Pack Manufacturing inc.
		Classic 2000, Gleason Equipment http://www.gleasonequipment.com
Conveyor	Feed from mixer to hopper	Pack Manufacturing inc.
		Classic 2000, Gleason Equipment http://www.gleasonequipment.com
General Overhead		
Utilities	telephone, gas, electric etc.	Badenhop 1985
		Taylor et al. 1986 “Calculating field nursery costs”
		Taylor et al. 1986 “Calculating bottom line for a small container nursery”
General Repairs & Maintenance	buildings and grounds	Badenhop 1985
		Taylor et al. 1986 “Calculating field nursery costs”
		Taylor et al. 1986 “Calculating bottom line for a small container nursery”
Licensing and bonds		Badenhop 1985
		Taylor et al. 1986 “Calculating field nursery costs”

Table 3-1 continued.

Item	Description	Sources
		Taylor et al. 1986 "Calculating bottom line for a small container nursery"
Advertising and Printing		Badenhop 1985
		Taylor et al. 1986 "Calculating field nursery costs"
		Taylor et al. 1986 "Calculating bottom line for a small container nursery"
Travel and Professional Fees		Taylor et al. 1990
		Taylor et al. 1986 "Costs of establishing and operating field nurseries…"
		Taylor et al. 1986 "Calculating field nursery costs"
Administrative & Management		Calculated from combined salaried employees
Miscellaneous		Badenhop 1985
		Taylor et al. 1986 "Calculating field nursery costs"
		Taylor et al. 1986 "Calculating bottom line for a small container nursery"
Production Inputs		
Pre plant herbicide	Paraquat (2.5 gal)	Knoxseed and Greenhouse Supply
		Tennessee Farmers Cooperative
Post-emergent herbicide	41% glyphosate (2.5 gal)	A.M. Leonard 2007 Catalog
		Tennessee Farmers Cooperative
Fungicide	Subdue MAXX	American Horticultural Supply
		Tennessee Farmers Cooperative
Insecticide	Merit 4 (4lb bottle)	Hummert International Supply 2006/2007 Catalog
		Knoxseed and Greenhouse Supply
	Avid (1 quart)	Hummert International Supply 2006/2007 Catalog
		BFG Supply <http://www.bfgsupply.com>
Fire-ant Control	Talstar (1qrt)	Hummert International Supply 2006/2007 Catalog
		BFG Supply <http://www.bfgsupply.com>
Rooting Hormone	Dip-N-Grow (16oz)	A.M. Leonard 2007 Catalog
Fertilizer	15-15-15 bulk	Tennessee Farmers Cooperative
Slow release fertilizer	14-14-14 Osmocote with Micro(50lb bag)	Tennessee Farmers Cooperative
		Hummert International Supply 2006/2007 Catalog
Seed		Red Maple <http://www.seedsandsuch.com>
		Lawyer Nursery Seed Price Catalog 2007/2008
Polyplastic	Overwintering plastic (8' X 100' roll)	A.M. Leonard 2008 catalog
		BWI Companies <http://www.bwicompanies.com>
Overwintering plastic supports	concrete wire (6' X 100' roll)	Home Depot www.homedepot.com
Growing Medium	Promix PG (2.8 Cu ft)	Hummert International Supply 2006/2007 catalog
		The Greenhouse Mega Store http://www.greenhousemegastore.com

Table 3-2. Capital Requirements for a 10-acre (4 ha) liner nursery using a field-groundbed type growing system.

Item	Description	Unit	Useful Life (yrs)	Price per Unit	Quantity	Total
Land						
Unimproved land		acre		$8,942.00	10	$89,420.00
Land improvements	grading, graveling, pond	acre	20	$286,665.67	1	$286,665.67
Total						*$376,085.67*
Buildings						
Office and Restrooms	20' X 40'	sq ft	20	$53.81	800	$43,048.00
Cooler	40' X 50' X 20'	each	20	$53,845.00	1	$53,845.00
Machine Storage Shop	40' X 100'	sq ft	10	$27.67	4000	$110,680.00
Packing & Shipping Facility	50' X 75'	sq ft	10	$20.57	3750	$77,137.50
Total						*$284,710.50*
Equipment						
Large tractor	50 hp tractor	each	10	$23,423.67	1	$23,423.67
Small Tractor	< 50 hp tractor	each	10	$21,448.33	2	$42,896.66
ATV	Utility Vehicle	each	10	$9,486.33	1	$9,486.33
Trailers	6' X 12'	each	10	$1,881.67	2	$3,763.34
Irrigation System	Complete (other than misting)	system	20	$49,889.13	1	$49,889.13
Backpack Sprayers	3 gallon capacity	each	10	$93.31	3	$279.93
Pickup Truck	½ ton	each	10	$26,942.67	1	$26,942.67
Hand Tools	Miscellaneous	sets	5	$7,959.00	1	$7,959.00
Misting System	Compete	system	10	$1,518.34	1	$1,518.34
Tank Sprayer	25 gallon tank	each	10	$310.33	1	$310.33
Boom Kit	7 nozzle (100" boom)	each	10	$221.25	1	$221.25
Skid Loader	Forklift (46 hp)	each	10	$22,520.00	1	$22,520.00
Undercutter-bed	50" blade lift tines	each	7	$528.00	2	$1,056.00
Fertilizer Spreader	500# capacity broadcast	each	7	$540.00	1	$540.00
Bed Shaper/Tiller	machine driven (70" wide)	each	7	$3,105.00	1	$3,105.00
Rotary Mower	5' tractor mounted	each	10	$1,303.00	1	$1,303.00
Water Delivery System	Well and Pump	system	20	$43,781.41	1	$43,781.41
U Blade	lifting blade	each	5	$712.67	2	$1,425.34
Total						*$240,421.40*
Grand Total						**$901,217.57**

Table 3-3. Capital requirements for a 10-acre (4 ha) liner nursery using a polyhouse covered groundbed growing system.

Item	Description	Unit	Useful Life (yrs)	Price per Unit	Quantity	Total
Land						
Unimproved land		acre		$8,942.00	10	$89,420.00
Land improvements	grading, graveling, pond	acre	20	$286,665.67	1	$286,665.67
Total						*$376,085.67*
Buildings						
Office and Restrooms	20' X 40'	sq ft	20	$53.81	800	$43,048.00
Cooler	40' X 50' X 20'	each	20	$53,845.00	1	$53,845.00
Machine Storage Shop	40' X 100'	sq ft	10	$27.67	4000	$110,680.00
Polyhouse Structures	20' X 100'	each	10	$2,129.84	1	$2,129.84
Packing & Shipping Facility	50' X 75'	sq ft	10	$20.57	3750	$77,137.50
Total						*$286,840.34*
Equipment						
Small Tractor	< 50 hp tractor	each	10	$21,448.33	2	$42,896.66
ATV	Utility Vehicle	each	10	$9,486.33	1	$9,486.33
Trailers	6' X 12'	each	10	$1,881.67	2	$3,763.34
Irrigation System	Complete (other than misting)	system	20	$49,889.13	1	$49,889.13
Backpack Sprayers	3 gallon capacity	each	10	$93.31	3	$279.93
Pickup Truck	½ ton	each	10	$26,942.67	1	$26,942.67
Hand Tools	Miscellaneous	sets	5	$7,959.00	1	$7,959.00
Misting System	Compete	system	10	$1,518.34	1	$1,518.34
Tank Sprayer	25 gallon tank	each	10	$310.33	1	$310.33
Boom Kit	7 nozzle (100" boom)	each	10	$221.25	1	$221.25
Skid Loader	Forklift (46 hp)	each	10	$22,520.00	1	$22,520.00
Undercutter-bed	50" blade lift tines	each	7	$528.00	1	$528.00
Fertilizer Spreader	500# capacity broadcast	each	7	$540.00	1	$540.00
Bed Shaper/Tiller	machine driven (70" wide)	each	7	$3,105.00	1	$3,105.00
Rotary Mower	5' tractor mounted	each	10	$1,303.00	1	$1,303.00
Water Delivery System	Well and Pump	system	20	$43,781.41	1	$43,781.41
U Blade	lifting blade	each	5	$712.67		$712.67
Total						*$215,757.06*
Grand Total						**$878,683.07**

Table 3-4. Capital Requirements for a 10-acre (4 ha) liner nursery using a polyhouse covered container type growing system.

Item	Description	Unit	Useful Life (yrs)	Price per Unit	Quantity	Total
Land						
Unimproved land		acre		$8,942.00	10	$89,420.00
Land improvements	grading, graveling, pond	acre	20	$286,665.67	1	$286,665.67
Total						*$376,085.67*
Buildings						
Office and Restrooms	20' X 40'	sq ft	20	$53.81	800	$43,048.00
Machine Storage Shop	40' X 100'	sq ft	10	$27.67	4000	$110,680.00
Polyhouse Structures	20' X 100'	each	10	$2,129.84	1	$2,129.84
Packing & Shipping Facility	50' X 75'	sq ft	10	$20.57	3750	$77,137.50
Total						*$232,995.34*
Equipment						
Small Tractor	< 50 hp tractor	each	10	$21,448.33	2	$42,896.66
ATV	Utility Vehicle	each	10	$9,486.33	1	$9,486.33
Trailers	6' X 12'	each	10	$1,881.67	2	$3,763.34
Irrigation System	Complete (other than misting)	system	20	$49,889.13	1	$49,889.13
Backpack Sprayers	3 gallon capacity	each	10	$93.31	3	$279.93
Pickup Truck	½ ton	each	10	$26,942.67	1	$26,942.67
Hand Tools	Miscellaneous	sets	5	$7,959.00	1	$7,959.00
Misting System	Compete	system	10	$1,518.34	1	$1,518.34
Tank Sprayer	25 gallon tank	each	10	$310.33	1	$310.33
Boom Kit	7 nozzle (100" boom)	each	10	$221.25	1	$221.25
Skid Loader	Forklift (46 hp)	each	10	$22,520.00	1	$22,520.00
Rotary Mower	5' tractor mounted	each	10	$1,303.00	1	$1,303.00
Water Delivery System	Well and Pump	system	20	$43,781.41	1	$43,781.41
Pot/Flat Filler	Flat filler with conveyor	each	15	$24,412.50	1	$24,412.50
Hopper	4 cubic yard capacity	each	15	$21,925.00	1	$21,925.00
Media Mixer	3 cubic yard capacity	each	15	$6,798.50	1	$6,798.50
Total						*$264,007.39*
Grand Total						**$873,088.40**

Table 3-5. Comparison of the cost per ft^2 and cost per growing area of three liner growing systems

Growing System	Total Fixed Cost	Actual Growing Space	Cost per sq ft[z]	Cost per Growing Area[x]
Field Groundbed:				
Land & Improvements	$34,588.00	1701 sq ft	$0.09	$158.90
Buildings	$37,919.32	1701 sq ft	$0.10	$174.20
Equipment	$32,513.32	1701 sq ft	$0.09	$149.37
General Overhead	$236,027.78	1701 sq ft	$0.64	$1,084.33
Total	$341,048.42	1701 sq ft	$0.92	$1,566.80
Polyhouse Covered Groundbed				
Land & Improvements	$34,588.00	1386 sq ft	$0.09	$129.47
Buildings	$38,235.61	1386 sq ft	$0.10	$143.13
Equipment	$28,766.16	1386 sq ft	$0.08	$107.68
General Overhead	$236,027.78	1386 sq ft	$0.64	$883.53
Total	$337,617.54	1386 sq ft	$0.91	$1,263.81
Polyhouse Covered Container				
Land & Improvements	$34,588.00	1386 sq ft	$0.09	$129.47
Buildings	$32,662.65	1386 sq ft	$0.09	$122.27
Equipment	$34,112.15	1386 sq ft	$0.09	$127.69
General Overhead	$236,027.78	1386 sq ft	$0.62	$855.52
Total	$329,908.47	1386 sq ft	$0.91	$1,262.96

[Z.] Cost per sq ft was computed by taking the total fixed cost / by the number of total sq ft in the nursery (8.5 acres * 43560 sq ft).
[Y.] Cost per growing area was computed by taking the cost per sq ft multiplied by the amount of actual growing space in the system

Table 3-6. Annual fixed costs of a 10-acre (4 ha) liner nursery using the field-groundbed type growing system.

Item	Salvage Value [Z]	Depreciation	Interest	Insurance & Taxes	Total
Land					
Unimproved land			$3,129.70	$1,788.40	$4,918.10
Land Improvements	$28,666.57	$12,899.96	$11,036.63	$5,733.31	$29,669.90
					$34,588.00
Buildings					
Office and Restrooms	$4,304.80	$1,937.16	$1,657.35	$860.96	$4,455.47
Cooler	$5,384.50	$2,423.03	$2,073.03	$1,076.90	$5,572.96
Machine Storage Shop	$11,068.00	$9,961.20	$4,261.18	$2,213.60	$16,435.98
Packing and Shipping Facility	$7,713.75	$6,942.38	$2,969.79	$1,542.75	$11,454.92
					$37,919.32
Equipment					
Large Tractor	$2,342.37	$2,108.13	$901.81	$468.47	$3,478.41
Small Tractor	$4,289.67	$3,860.70	$1,651.52	$857.93	$6,370.15
ATV	$948.63	$853.77	$365.22	$189.73	$1,408.72
Trailers	$376.33	$338.70	$144.89	$75.27	$558.86
Irrigation System	$4,988.91	$2,245.01	$1,920.73	$997.78	$5,163.52
Backpack Sprayer	$27.99	$25.19	$10.78	$5.60	$41.57
Pickup truck	$2,694.27	$2,424.84	$1,037.29	$538.85	$4,000.99
Hand Tools	$795.90	$1,432.62	$306.42	$159.18	$1,898.22
Mist System	$151.83	$136.65	$58.46	$30.37	$225.47
Tank Sprayer	$31.03	$27.93	$11.95	$6.21	$46.08
Boom Kit	$22.13	$19.91	$8.52	$4.43	$32.86
Skid Loader	$2,252.00	$2,026.80	$867.02	$450.40	$3,344.22
Undercutter-bed	$105.60	$135.77	$40.66	$21.12	$197.55
Fertilizer Spreader	$54.00	$69.43	$20.79	$10.80	$101.02
Bed Shaper/Tiller	$310.50	$399.21	$119.54	$62.10	$580.86
Rotary Mower	$130.30	$117.27	$50.17	$26.06	$193.50
Water Delivery System	$4,378.14	$1,970.16	$1,685.58	$875.63	$4,531.38
U Blade	$142.53	$256.56	$54.88	$28.51	$339.94
Total					*$32,513.32*
Total Depreciation, Insurance, Taxes, and Interest:					**$105,020.64**
General Overhead					
Utilities					$11,628.00
General Repairs and Maintenance					$10,268.00
Licenses and bonds					$4,362.67
Advertising and printing					$2,511.67
Travel and Professional Fees					$3,379.00
Unemployment Insurance Premiums					$2,450.00
Workmen's Compensation Insurance					$36,452.00
Administrative and Management					$162,498.11
Miscellaneous					$2,478.33
					$236,027.78
				TOTAL ANNUAL FIXED COSTS:	**$341,048.42**

[Z.] Assumed as 10% of the initial investment cost. Salvage value was only used to calculate depreciation, and was not used tot calculate total annual fixed costs

Table 3-7. Annual fixed costs of a 10-acre (4 ha) liner nursery using the polyhouse covered groundbed type growing system.

Item:	**Salvage Value [A]**	**Depreciation**	**Interest**	**Insurance & Taxes**	**Total**
Land					
Unimproved land			$3,129.70	$1,788.40	$4,918.10
Land Improvements	$28,666.57	$12,899.96	$11,036.63	$5,733.31	$29,669.90
					$34,588.00
Buildings					
Office and Restrooms	$4,304.80	$1,937.16	$1,657.35	$860.96	$4,455.47
Cooler	$5,384.50	$2,423.03	$2,073.03	$1,076.90	$5,572.96
Machine Storage Shop	$11,068.0	$9,961.20	$4,261.18	$2,213.60	$16,435.98
Polyhouse Structures	$212.98	$191.69	$82.00	$42.00	$316.28
Packing and Shipping Facility	$7,713.75	$6,942.38	$2,969.79	$1,542.75	$11,454.92
					$38,235.61
Equipment					
Small Tractor	$4,289.67	$3,860.70	$1,651.52	$857.93	$6,370.15
Trailers	$376.33	$338.70	$144.89	$75.27	$558.86
Backpack Sprayers	$27.99	$25.19	$10.78	$5.60	$41.57
Tank Sprayer	$31.03	$27.93	$11.95	$6.21	$46.08
Boom Kit	$22.13	$19.91	$8.52	$4.43	$32.86
Pickup truck	$2,694.27	$2,424.84	$1,037.29	$538.85	$4,000.99
Irrigation System	$4,988.91	$2,245.01	$1,920.73	$997.78	$5,163.52
Bed Shaper/Tiller	$310.50	$399.21	$119.54	$62.10	$580.86
Hand Tools	$795.90	$1,432.62	$306.42	$159.18	$1,898.22
Mist System	$151.83	$136.65	$58.46	$30.37	$225.47
Skid loader	$2,252.00	$2,026.80	$867.02	$450.40	$3,344.22
ATV	$948.63	$853.77	$365.22	$189.73	$1,408.72
Fertilizer Spreader	$54.00	$69.43	$20.79	$10.80	$101.02
Undercutter-bed	$52.80	$67.89	$20.33	$14.25	$98.77
U Blade	$71.27	$128.28	$27.44	$14.25	$169.97
Water Delivery System	$4,378.14	$1,970.16	$1,685.58	$875.63	$4,531.38
Rotary Mower	$130.30	$117.27	$50.17	$26.06	$193.50
					$28,766.16
Total Depreciation, Insurance, Taxes, and Interest:					**$101,589.16**
General Overhead					
Utilities					$11,628.00
General Repairs and Maintenance					$10,268.00
Licenses and bonds					$4,362.67
Advertising and printing					$2,511.67
Travel and Professional Fees					$3,379.00
Unemployment Insurance Premiums					$2,450.00
Workmen's Compensation Insurance					$36,452.00
Administrative and Management					$162,498.11
Miscellaneous					$2,478.33
					$236,027.78
TOTAL ANNUAL FIXED COSTS					**$337,617.54**

A. Assumed as 10% of the initial investment cost. Salvage value was only used to calculate depreciation, and was not used tot calculate total annual fixed costs

Table 3-8. Annual fixed costs of a 10-acre (4 ha) liner nursery using the polyhouse covered container type growing system.

Item:	Salvage Value [A]	Depreciation	Interest	Insurance & Taxes	Total
Land					
Unimproved land			$3,129.70	$1,788.40	$4,918.10
Land Improvements	$28,666.57	$12,899.96	$11,036.63	$5,733.31	$29,669.90
					$34,588.00
Buildings					
Office and Restrooms	$4,304.80	$1,937.16	$1,657.35	$860.96	$4,455.47
Machine Storage Shop	$11,068.00	$9,961.20	$4,261.18	$2,213.60	$16,435.98
Polyhouse Structures	$212.98	$191.69	$82.00	$42.00	$316.28
Packing and Shipping Facility	$7,713.75	$6,942.38	$2,969.79	$1,542.75	$11,454.92
					$32,662.65
Equipment					
Small Tractor	$4,289.67	$3,860.70	$1,651.52	$857.93	$6,370.15
Trailers	$376.33	$338.70	$144.89	$75.27	$558.86
Backpack Sprayers	$27.99	$25.19	$10.78	$5.60	$41.57
Tank Sprayer	$31.03	$27.93	$11.95	$6.21	$46.08
Boom Kit	$22.13	$19.91	$8.52	$4.43	$32.86
Pickup truck	$2,694.27	$2,424.84	$1,037.29	$538.85	$4,000.99
Irrigation System	$4,988.91	$2,245.01	$1,920.73	$997.78	$5,163.52
Hand Tools	$795.90	$1,432.62	$306.42	$159.18	$1,898.22
Mist System	$151.83	$136.65	$58.46	$30.37	$225.47
Skid loader	$2,252.00	$2,026.80	$867.02	$450.40	$3,344.22
ATV	$948.63	$853.77	$365.22	$189.73	$1,408.72
Water Delivery System	$4,378.14	$1,970.16	$1,685.58	$875.63	$4,531.38
Rotary Mower	$130.30	$117.27	$50.17	$26.06	$193.50
Pot/Flat Filler	$2,441.25	$1,464.75	$939.88	$488.25	$2,892.88
Hopper	$2,192.50	$1,315.50	$844.11	$438.50	$2,598.11
Media Mixer	$679.85	$407.91	$261.74	$135.97	$805.62
					$34,112.15
Total Depreciation, Insurance, Taxes, and Interest:					**$101,362.80**
General Overhead					
Utilities					$11,628.00
General Repairs and Maintenance					$10,268.00
Licenses and bonds					$4,362.67
Advertising and printing					$2,511.67
Travel and Professional Fees					$3,379.00
Unemployment Insurance Premiums					$2,450.00
Workmen's Compensation Insurance					$36,452.00
Administrative and Management					$162.498.11
Miscellaneous					$2,478.33
					$236,027.78
			TOTAL ANNUAL FIXED COSTS:		**$329,908.47**

[Z.] Assumed as 10% of the initial investment cost. Salvage value was only used to calculate depreciation, and was not used to calculate total annual fixed costs.

Table 3-9. Annual payroll and withholding costs of a 10-acre (4 ha) liner nursery with four salaried employees and six hourly workers [z].

Position	Gross Pay (Hourly)	Gross Pay (Monthly)	FICA	Medicare	Income Tax	Total Monthly Payroll Costs	Total Annual Payroll Costs
Manager	Salary	$5,200	$644.80	$150.80	$728.00	$5,597.80	$67,173.60
Assistant Mgr	Salary	$4,800	$595.20	$139.20	$672.00	$5,167.20	$62,006.40
Propagator	Salary	$4,600	$570.40	$133.40	$644.00	$4,951.90	$59,422.80
Admin Assist.	Salary	$2,579	$319.82	$74.80	$361.09	$2,776.51	$33,318.11
Worker	$8.50	$1,360	$168.64	$39.44	$190.40	$1,464.04	$17,568.48
Worker	$8.50	$1,360	$168.64	$39.44	$190.40	$1,464.04	$17,568.48
Worker	$8.50	$1,360	$168.64	$39.44	$190.40	$1,464.04	$17,568.48
Worker	$8.50	$1,360	$168.64	$39.44	$190.40	$1,464.04	$17,568.48
Worker	$8.50	$1,360	$168.64	$39.44	$190.40	$1,464.04	$17,568.48
Worker	$8.50	$1,360	$168.64	$39.44	$190.40	$1,464.04	$17,568.48
Total		**$25,339.20**	**$3,142.06**	**$734.84**	**$3,547.49**	**$27,277.65**	**$327,331.79**

[z.] The above payroll costs were used for all three nursery liner stock growing system

Table 3-10. Annual equipment operating costs of a 10-acre (4 ha) liner nursery using the field-groundbed type growing system.

Item:	Expected Life (years)	Annual Use (hours)	Fuel Cost per hr[Z]	Labor Cost [Y] (travel & maintenance)	Lubrication Cost [W]	Total Cost per hr	Total Annual Cost:
Fuel Driven [W]							
Large Tractor	10	400	$9.00	$10.07	$1.35	$20.41	$8,165.19
Small Tractor	10	600	$6.84	$10.07	$1.03	$17.93	$10,757.72
ATV	10	250	$2.15	$10.07	$0.32	$12.54	$3,135.59
Pickup Truck	10	540	$42.00	$10.07	$6.30	$58.37	$31,519.59
Skid Loader	10	550	$11.29	$10.07	$1.69	$23.05	$12,675.81
Non-Power							
Trailers	10	520	NA	NA	$0.07	$0.07	$36.40
Irrigation System	20	3000	NA	NA	NA	$0.83	$2,494.46
Backpack Sprayer	10	60	NA	NA	NA	$0.16	$9.33
Tank Sprayer	10	150	NA	NA	NA	$0.21	$31.03
Boom Kit	10	150	NA	NA	NA	$0.15	$22.13
Undercutter-bed	7	250	NA	NA	NA	$0.30	$75.43
Fertilizer Spreader	7	200	NA	NA	NA	$0.39	$77.14
Bed Shaper/Tiller	7	250	NA	NA	NA	$1.77	$443.57
U Blade	5	350	NA	NA	NA	$0.41	$142.53
Mist System	10	500	NA	NA	NA	$0.30	$151.83
Electricity Driven			Kilowatt hr (KwH)	Cost per KwH			
Water Delivery System	20	3500	14.90	$0.0689		$1.03	$3,593.14
Cooler	20	3000	5.60	$0.0689		$0.39	$1,157.52
Total Annual Equipment Operating Costs							**$74,487.94**

[Z.] Fuel cost per hour = maximum PTO horsepower X current fuel cost per gallon X 0.06 (gasoline) or Fuel cost per hour = maximum PTO horsepower X current cost of fuel per gallon 0.044 (diesel)
[Y.] Labor (travel and maintenance) = hourly rate X 1.1
[X.] Lubrication cost = 0.15 X fuel cost per hour
[W.] *Note: Diesel fuel price per gallon as of 5-5-2008 = $4.09 and gasoline price per gallon as of 5-5-2008 = $3.59

Table 3-11. Annual equipment operating costs for a 10-acre (4 ha) liner nursery using the polyhouse covered groundbed type growing system.

Item:	Expected Life (years)	Annual Use: (hours)	Fuel Cost per hr[Z]	Labor Cost[Y] (travel & maintenance)	Lubrication Cost [X]	Total Cost per hr	Total Annual Cost
Fuel Driven [X]							
Small Tractor	10	600	$6.84	$10.07	$1.03	$17.93	$10,757.72
ATV	10	250	$2.15	$10.07	$0.32	$12.54	$3,135.59
Pickup Truck	10	540	$42.00	$10.07	$6.30	$58.37	$31,519.11
Skid Loader	10	550	$8.28	$10.07	$1.24	$19.59	$10,771.84
Non-Power							
Trailers	10	520	NA	NA	$0.07	$0.07	$36.40
Irrigation System	20	3000	NA	NA	NA	$0.83	$2,494.46
Backpack Sprayer	10	60	NA	NA	NA	$0.16	$9.33
Tank Sprayer	10	150	NA	NA	NA	$0.21	$31.03
Boom Kit	10	150	NA	NA	NA	$0.15	$22.13
Undercutter-bed	7	250	NA	NA	NA	$0.30	$75.43
Fertilizer Spreader	7	200	NA	NA	NA	$0.39	$77.14
Bed Shaper/Tiller	7	250	NA	NA	NA	$1.77	$443.57
U Blade	5	350	NA	NA	NA	$0.41	$142.53
Mist System	10	500	NA	NA	NA	$0.30	$151.83
Electricity Driven		Kilowatt hr (KwH)	Cost per KwH				
Water Delivery System	20	3500	14.90	$0.0689		$1.03	$3,593.14
Cooler	20	3000	5.60	$0.0689		$0.39	$1,157.52
Total Annual Equipment Operating Costs							**$64,780.72**

[Z.] Fuel cost per hour = maximum PTO horsepower X current fuel cost per gallon X 0.06 (gasoline) or Fuel cost per hour = maximum PTO horsepower X current cost of fuel per gallon 0.044 (diesel)

[Y] Labor (travel and maintenance) = hourly rate X 1.1

[X] Lubrication cost = 0.15 X fuel cost per hour

[X] Note: Diesel fuel price per gallon as of 5-5-2008 = $4.09 and gasoline price per gallon as of 5-5-2008 = $3.59

Table 3-12. Annual equipment operating costs for a 10-acre (4 ha) liner nursery using the polyhouse covered container type growing system

Item	Expected Life (years)	Annual Use (hours)	Fuel Cost per hr [Z]	Labor Cost [Y] (travel and maintenance)	Lubrication Cost [X]	Total Cost per hr	Total Annual Cost
Fuel Driven [W]							
Small Tractor	10	600	$6.84	$10.07	$1.03	$17.93	$10,757.72
ATV	10	250	$2.15	$10.07	$0.32	$12.54	$3,135.59
Pickup Truck	10	540	$42.00	$10.07	$6.30	$58.37	$31,519.11
Skid Loader	10	550	$8.28	$10.07	$1.24	$19.59	$10,771.84
Non-Power							
Trailers	10	520	NA	NA	$0.07	$0.07	$36.40
Irrigation System	20	3000	NA	NA	NA	$0.83	$2,494.46
Backpack Sprayer	10	60	NA	NA	NA	$0.47	$27.99
Tank Sprayer	10	150	NA	NA	NA	$0.21	$31.03
Boom Kit	10	150	NA	NA	NA	$0.15	$22.13
Mist System	10	500	NA	NA	NA	$0.30	$151.83
Electricity Driven			Kilowatt hr (KwH)	Cost per KwH			
Water Delivery System	20	3500	14.90	$0.0689		$1.03	$3,593.14
Pot / Flat Filler	15	2800	5.97	$0.0689		$0.41	$1,151.73
Hopper	15	2800	1.12	$0.0689		$0.08	$216.07
Media Mixer	15	2800	7.46	$0.0689		$0.51	$1,439.18
Total Annual Equipment Operating Costs							**$65,348.22**

[Z.] Fuel cost per hour = maximum PTO horsepower X current fuel cost per gallon X 0.06 (gasoline) or Fuel cost per hour = maximum PTO horsepower X current cost of fuel per gallon 0.044 (diesel)
[Y] Labor (travel and maintenance) = hourly rate X 1.1
[X] Lubrication cost = 0.15 X fuel cost per hour
[W] *Note: Diesel fuel price per gallon as of 5-5-2008 = $4.09 and gasoline price per gallon as of 5-5-2008 = $3.59

Table 3-13. Summary and comparison of equipment operating costs of three 10-acre (4 ha) nursery liner growing systems

Growing System	Fuel Driven Equipment	Non-Power Equipment	Electricity Driven Equipment	Total:
Field Groundbed				
Total Operating Cost per hr	$132.30	$4.58	$1.41	$138.29
Total Annual Operating Cost	$66,253.43	$3,483.86	$4,750.66	$74,487.95
Percent of total	88.95%	4.68%	6.38%	100%
Polyhouse Covered Groundbed				
Total Operating Cost per hr	$108.42	$6.57	$1.41	$116.40
Total Annual Operating Cost	$56,184.26	$3,845.80	$4,750.66	$64,780.72
Percent of total	86.73%	5.94%	7.33%	100%
Polyhouse Covered Container				
Total Operating Cost per hr	$108.43	$2.03	$2.03	$112.49
Total Annual Operating Cost	$56,184.26	$2,763.84	$6,400.12	$65,348.22
Percent of total	85.98%	4.23%	9.79%	100%

Table 3-14. Summary of the total annual production costs of a 10-acre (4 ha) liner nursery using the field-groundbed type growing system for one 20' X 100' growing area with 1,701 ft^2 (158 m^{-2}) of actual growing space.

Item:	**Red Maple**	**Foster Holly**	**Giant Arborvitae**
Fixed Costs:			
Total annual cost	$341,048.42	$341,048.42	$341,048.42
Fixed cost per sq ft	$0.92	$0.92	$0.92
Total cost per growing area	**$1,566.80**	**$1,566.80**	**$1,566.80**
Variable Costs [z.]			
Pre-plant herbicide application	$33.44	$33.44	$33.44
Tillage	$62.68	$62.68	$62.68
Fertilizer Application	$25.24	$25.24	$25.24
Stratification	$416.96	--	--
Cost of rooting	--	$12,233.95	$12,233.95
Planting / Sticking	$13.73	$2,611.99	$2,661.99
Post-emergent herbicide application	$914.29	$914.29	$914.29
Insecticide application	$249.33	$249.33	$289.43
Fungicide application	$317.46	$317.46	$317.46
Misting	$1,178.44	$1,178.44	$1178.44
Irrigation	$8,654.12	$8,654.12	$8,654.12
Overwintering	$661.70	$661.70	$661.70
Undercutting	$82.14	$82.14	$82.14
Harvesting	$109.71	$109.71	$109.71
Cooler Storage	$1,216.08	$1,216.08	$1,216.08
Total variable cost	**$13,935.31**	**$28,350.57**	**$28,440.67**
Total production cost per growing area:	**$15,502.11**	**$29,917.37**	**$30,007.47**

[z.] Derived from Delphi method, CPI, and formulaic methods. Adapted from Hinson et al. 2007 and Hall et al. 1987

Table 3-15. Summary of the total annual production costs of a 10-acre (4 ha) liner nursery using the polyhouse covered groundbed type growing system for one 20' X 100' growing area with 1,386 ft^2 (129 m^{-2}) of actual growing space.

Item:	Red Maple	Foster Holly	Giant Arborvitae
Fixed Costs:			
Total annual cost	$337,617.54	$337,617.54	$337,617.54
Fixed cost per sq ft	$0.91	$0.91	$0.91
Total cost per growing area	**$1,263.81**	**$1,236.81**	**$1,26.81**
Variable Costs [Z]:			
Pre-plant herbicide application	$33.39	$33.39	$33.39
Tillage	$57.71	$57.71	$57.51
Fertilizer Application	$24.31	$24.31	$24.31
Stratification	$368.43	--	--
Planting / Sticking	$36.60	$1,879.97	$1,929.97
Cost of Rooting	--	$3,727.34	$3,727.34
Post-emergent herbicide application	$914.29	$914.29	$914.29
Insecticide application	$249.33	$249.33	$289.43
Fungicide Application	$306.88	$306.88	$306.88
Misting	$767.80	$767.80	$767.80
Irrigation	$8,654.12	$8,654.12	$8,654.12
Undercutting	$82.14	$82.14	$82.14
Harvesting	$109.71	$109.71	$109.71
Cooler Storage	$1,205.70	$1,205.70	$1,205.70
Total variable cost	**$12,810.41**	**$18,012.70**	**$18,102.80**
Total production cost per growing area:	**$14,074.22**	**$19,276.50**	**$19,366.61**

[Z.] Derived from Delphi method, CPI, and formulaic methods. Adapted from Hinson et al. 2007 and Hall et al. 1987

Table 3-16. Summary of the total annual production costs of a 10-acre (4 ha) liner nursery using the polyhouse covered container type growing system for one 20' X 100' growing area with 1,386 ft^2 (129 m^{-2}) of actual growing space.

Item:	**Red Maple**	**Foster Holly**	**Giant Arborvitae**
Fixed Costs:			
Total annual cost	$337,390.57	$337,390.57	$337,390.57
Fixed cost per sq ft	$0.91	$0.91	$0.91
Total cost per growing area	**$1,262.96**	**$1,262.96**	**$1,262.96**
Variable Costs [z]:			
Media Preparation	$5,997.13	$5,997.13	$5,997.13
Filling Containers	$808.49	$808.49	$799.38
Planting / Sticking	$220.40	$3,151.53	$3,189.03
Post Emergent herbicide application	$914.29	$914.29	$914.29
Insecticide application	$249.33	$249.33	$289.43
Fungicide application	$306.88	$306.88	$306.88
Misting	$1,178.44	$1,178.44	$1,178.44
Irrigation	$8,654.12	$8,654.12	$8,654.12
Harvesting	$286.13	$286.13	$286.13
Total variable cost	**$18,615.21**	**$21,546.34**	**$21,614.84**
Total production cost per growing area:	**$19,878.17**	**$22,809.30**	**$22,877.80**

[z.] Derived from Delphi method, CPI, and formulaic methods. Adapted from Hinson et al. 2007 and Hall et al. 1987

Table 3-17. Summary of production costs for all three liner growing systems. All growing systems were assumed to be on a separate 10-acre (4 ha) liner nursery. (Italicized figures denote differences)

Growing System	Red Maple	Foster Holly	Giant Arborvitae
Field Groundbed [Z]			
Total annual fixed cost	$341,048.42	$341,048.42	$341,048.42
Fixed cost per sq ft[Y]	$0.92	$0.92	$0.92
Fixed cost per growing area [X]	$1,566.80	$1,566.80	$1,566.80
Total variable cost	*$13,935.31*	*$28,350.57*	*$28,440.67*
Total cost per growing area	*$15,502.11*	*$29,917.37*	*$30,007.47*
Polyhouse Covered Groundbed [W]			
Total annual fixed cost	$337,617.54	$337,617.54	$337,617.54
Fixed cost per sq ft	$0.91	$0.91	$0.91
Fixed cost per growing area	$1,263.81	$1,263.81	$1,263.81
Total variable cost	*$12,810.41*	*$18,012.70*	*$18,102.80*
Total cost per growing area	*$14,074.22*	*$19,276.51*	*$19,366.61*
Polyhouse Covered Container [V]			
Total annual fixed cost	$337,390.57	$337,390.57	$337,390.57
Fixed cost per sq ft	$0.91	$0.91	$0.91
Fixed cost per growing area	$1,262.96	$1,262.96	$1,262.96
Total variable cost	*$18,615.21*	*$21,546.34*	*$21,614.84*
Total cost per growing area	*$19,878.17*	*$22,809.30*	*$22,877.80*

Z. Total growing area within the 2,000 ft^2 (186 m^{-2}) block is 1,701 ft^2 (158 m^{-2})

Y. Total fixed cost per sq ft is computed by taking the total annual fixed cost and dividing it by the number of acres in production converted into ft^2 (8.5 acres X 43,560 ft^2) e.g. $333,566.31 / (8.5 acres*43,560 ft^2) = $0.9009

X. Fixed cost per growing area = fixed cost per sq ft X the number actual sq ft within the particular growing system (Field groundbed contains 1701 sq ft and both polyhouse covered groundbed and container has 1,386 ft^2 (129 m^{-2}) within the 2,000 ft^2 or 186 m^{-2}, block).

W. Total growing area within the 2,000 ft^2 (186 m^{-2}) block is 1,3861 ft^2 (129 m^{-2})

V. Total growing area within the 2,000 ft^2 (186 m^{-2}) block is 1,3861 ft^2 (129 m^{-2})

Table 3-18. Summary of the cost per plant of three different 10-acre (4 ha) nursery liner growing systems.

Growing System / Plant Type	Cost per plant @ 36 per sf[Z]	Number of plants	Cost per plant @ 12.8 per sf[Y]	Number of plants	Cost per plant @ 6.4 per sf[X]	Number of plants	Cost per plant @ 3.2per sf[W]	Number of plants
Field Groundbed [V]								
Maple	$0.2532	61,236	$0.71	21,772	$1.42	10,886	$2.85	5,443
Foster	$0.4886	61,236	$1.37	21,772	$2.75	10,886	$5.50	5,443
Arborvitae	$0.4900	61,236	$1.38	21,772	$2.76	10,886	$5.51	5,443
Polyhouse Covered Groundbed [U]								
Maple	$0.2821	49,890	$0.79	17,740	$1.59	8,870	$3.17	4,435
Foster	$0.3863	49,890	$1.09	17,740	$2.17	8,870	$4.35	4,435
Arborvitae	$0.3881	49,890	$1.09	17,740	$2.18	8,870	$4.37	4,435
Polyhouse Covered Container [T]								
Maple	$1.4984	28,067	$1.4984	28,067	$1.4984	28,067	$1.4984	28,067
Foster	$1.7194	28,067	$1.7194	28,067	$1.7194	28,067	$1.7194	28,067
Arborvitae	$1.7245	28,067	$1.7245	28,067	$1.7245	28,067	$1.7245	28,067

Z. Typical commercial nursery liner planting density at approximately 360 stems per m^{-2}
Y. Equal to 128 stems per m^{-2} (Schultz and Thompson 1996)
X. Equal to 64 stems per m^{-2} (Schultz and Thompson 1996)
W. Equal to 32 stems per m^{-2} (Schultz and Thompson 1996)
V. 1701 ft^2 (158 m^{-2}) of growing space within 2,000 ft^2 (186m^{-2}) block
U. 1386 ft^2 (129 m^{-2}) of growing space within 2,000 ft^2 (186m^{-2}) block
T. 1386 ft^2 (129 m^{-2}) of growing space within 2,000 ft^2 (186m^{-2}) block

Figure 3-1. Field-groundbed system (photo courtesy of Dr. Charles Hall)

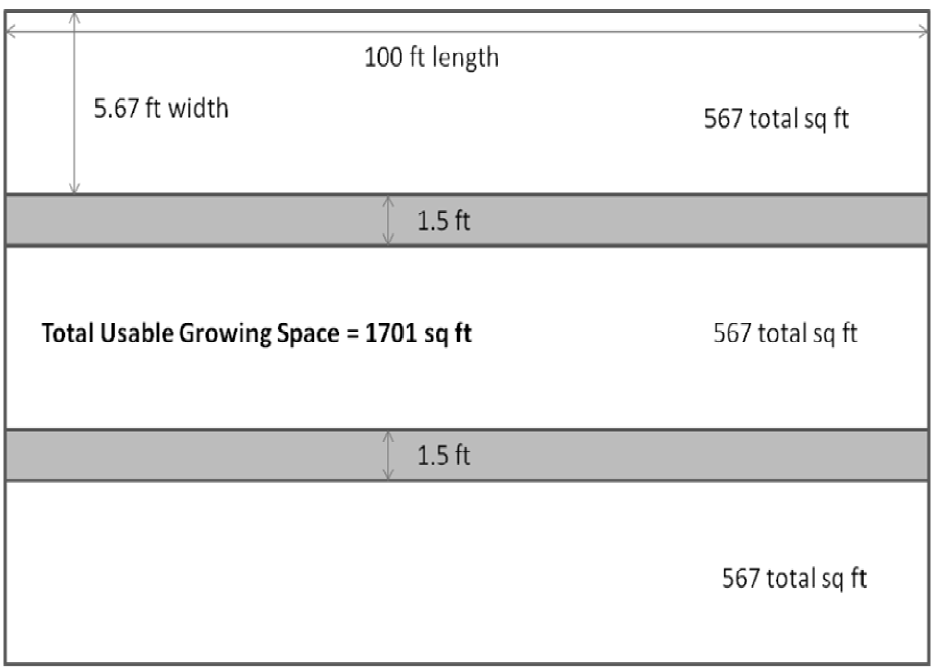

Figure 3-2. Arial view of field-groundbed growing system with 1,701 ft^2 (158 m^{-2}) of growing space with a 2,000 ft^2 (186 m^{-2}) growing block.

Figure 3-3. Polyhouse covered groundbed system (photo courtesy of Dr. Charles Hall)

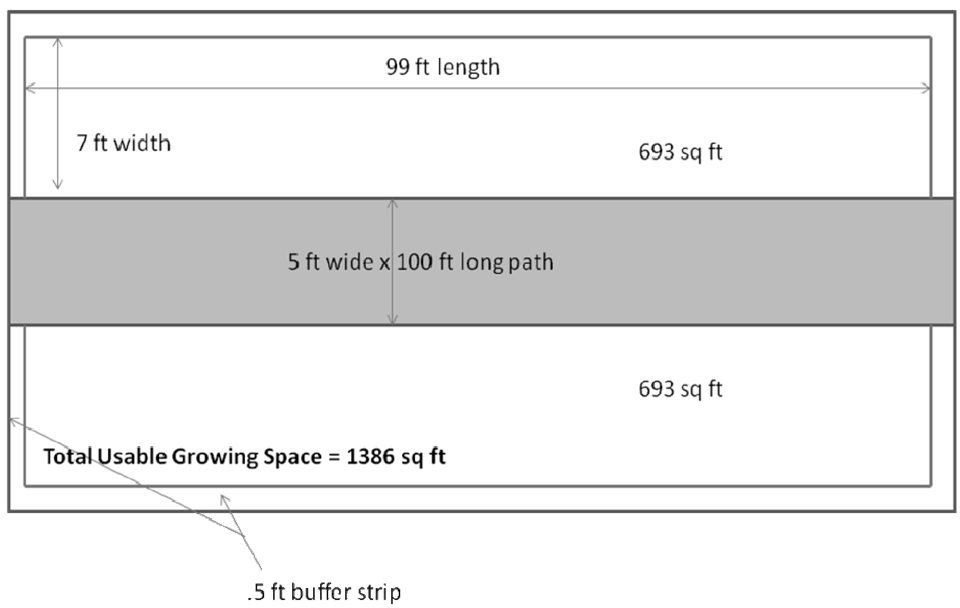

Figure 3-4. Arial view of polyhouse covered groundbed system with 1,386 ft^2 (129 m^{-2}) of growing space with a 2,000 ft^2 (186 m^{-2}) growing block.

Figure 3-5. Polyhouse covered container system (photo courtesy of Dr. Charles Hall)

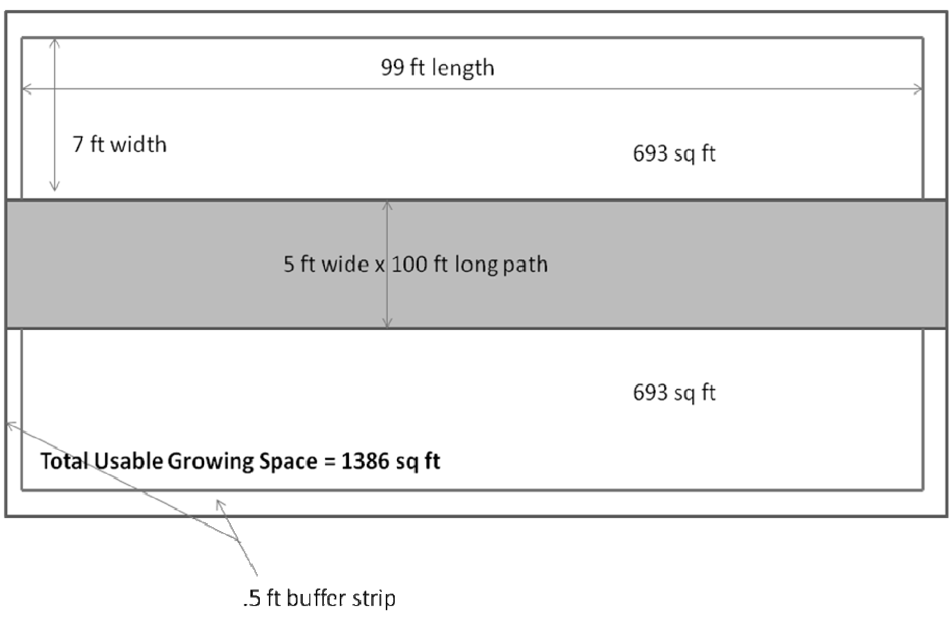

Figure 3-6. Arial view of polyhouse covered container system with 1,386 ft^2 (129 m^{-2}) of growing space with a 2,000 ft^2 (186 m^{-2}) growing block.

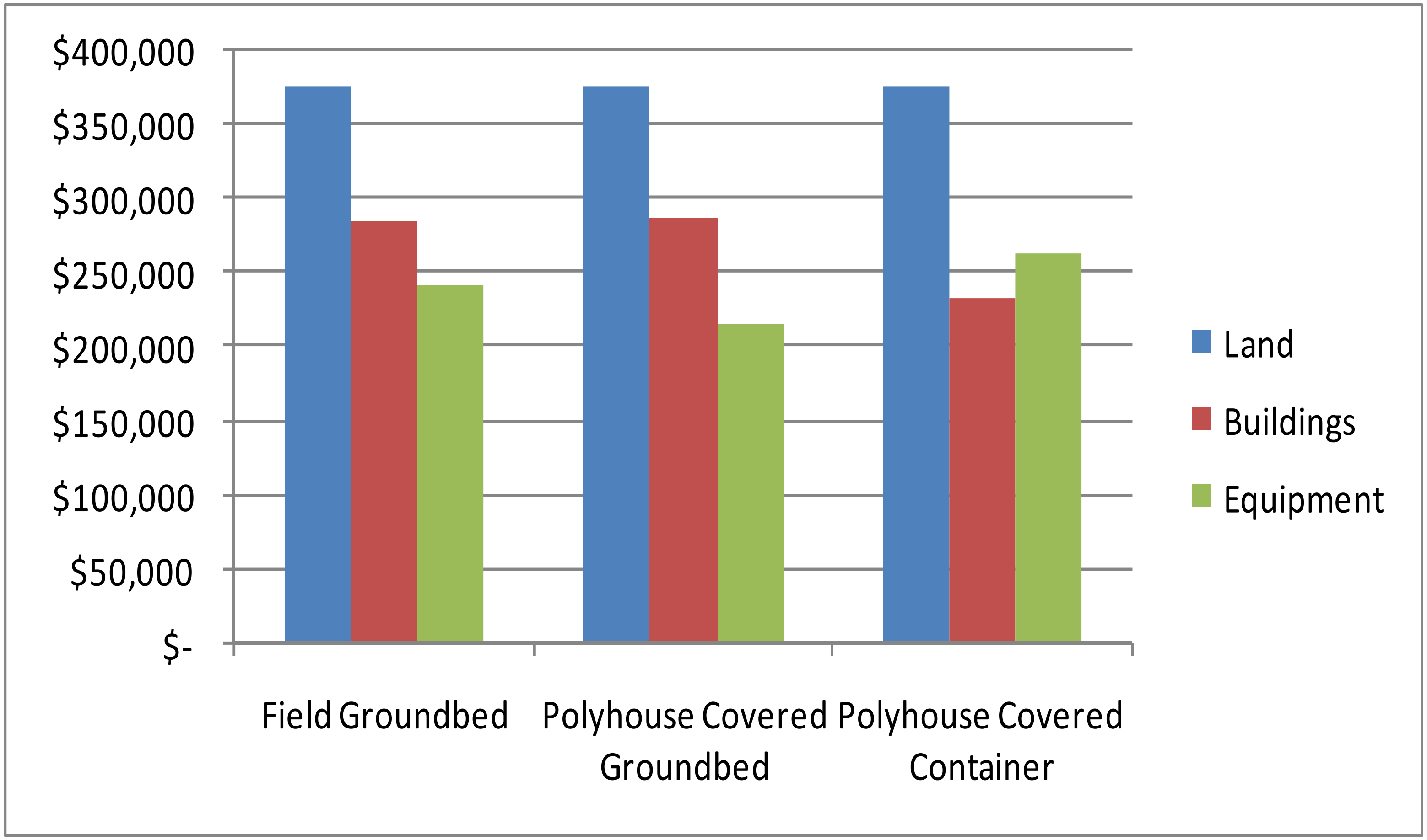

Figure 3-7. Comparison of the land, buildings, and equipment capital requirements for three nursery liner growing systems situated on 10 acres (4 ha) (1.5 acres, 0.6 ha, set aside for buildings and facilities).

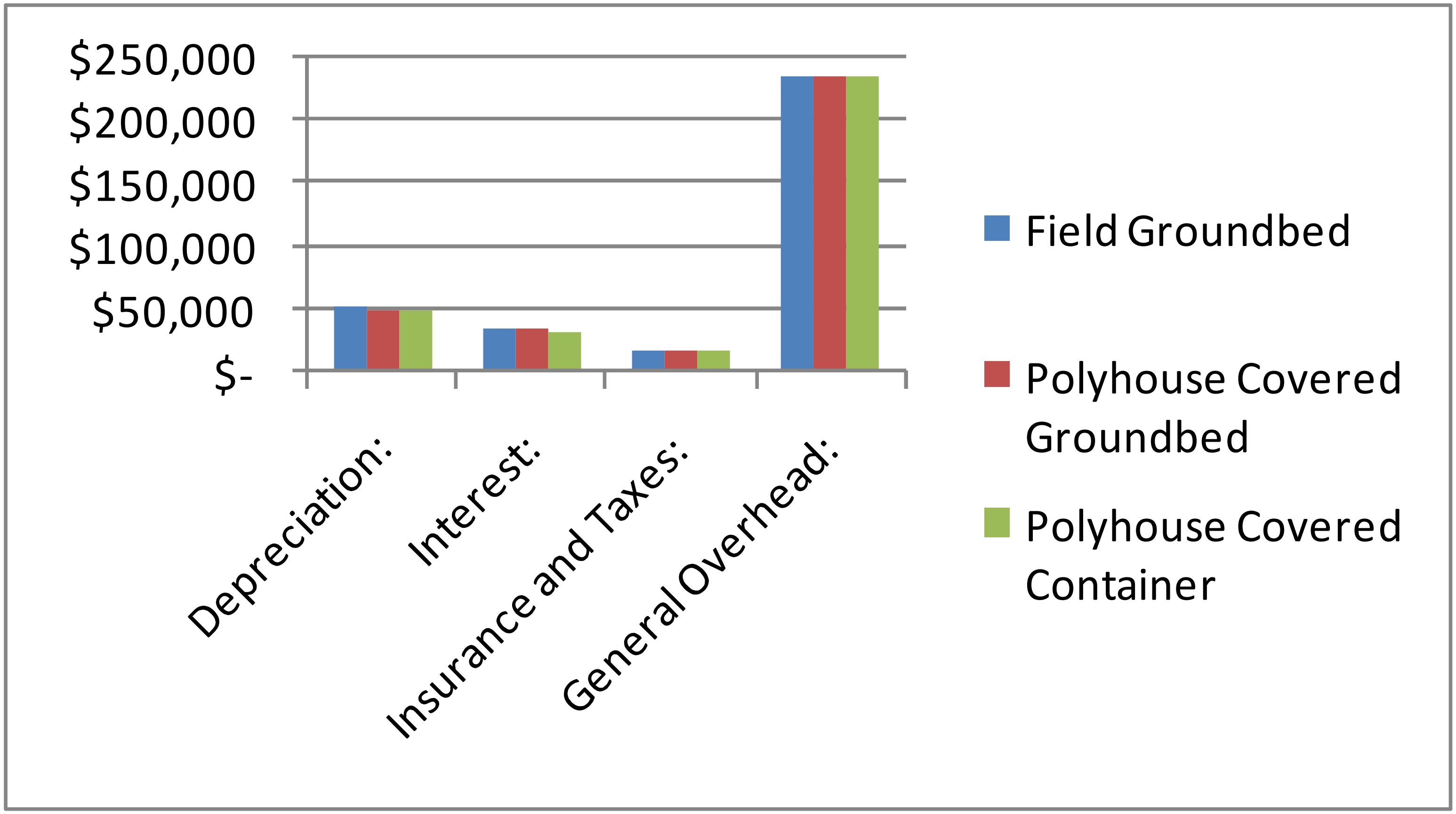

Figure 3-8. Comparison of the depreciation, interest, insurance and taxes, and general overhead costs for three 10-acre (4 ha) nursery liner growing systems.

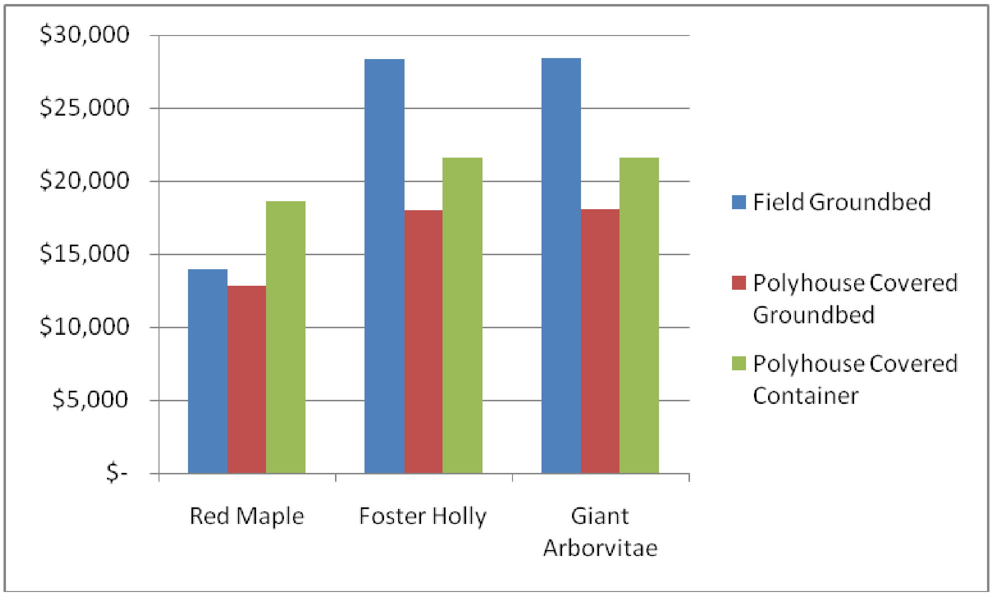

Figure 3-9. Comparison of the total variable costs for three 10-acre (4 ha) nursery liner growing systems with three species of plant material

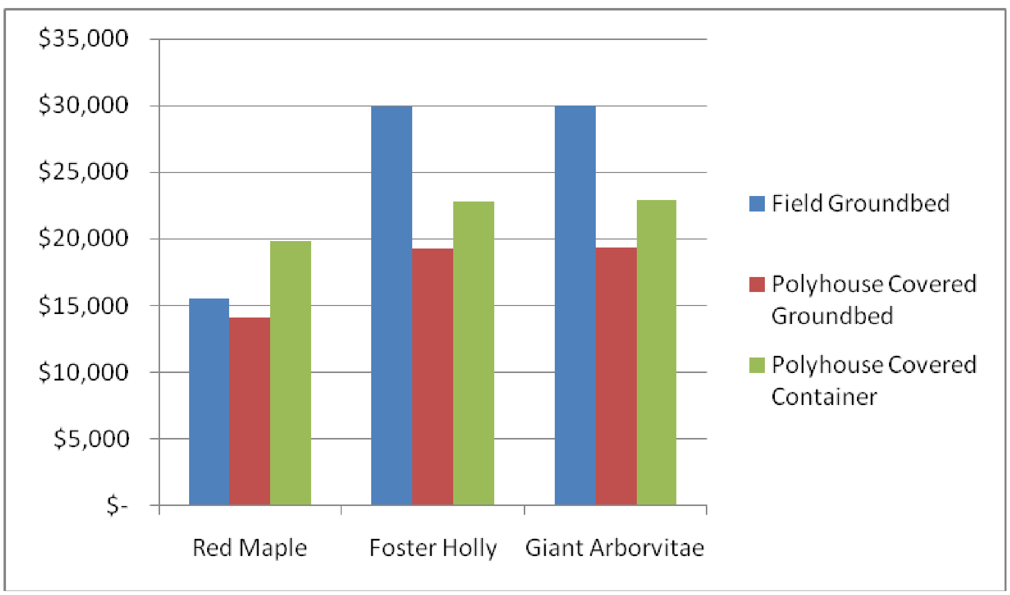

Figure 3-10. Comparison of total annual production costs for three 10-acre (4 ha) nursery liner growing systems with three species.

Chapter 4

Summary and Conclusions

Chapter 4

Summary and Conclusions

Introduction

When examining liner quality and production through basic economics, we must consider supply and demand functions. Evaluation of supply and demand is beneficial to developing business models for a new liner operation or expansion of an existing nursery. In the quality assessment survey, we examined quality characteristics that liner buyers focus on during point-of-purchase, or the demand side of the economic equation. In the nursery liner production cost estimation study, we examined the supply side of the economic equation by providing production costs estimates with a comparison of three nursery liner growing systems.

Nursery Liner Product Quality Survey

A market survey was developed and conducted to ascertain liner buyer perceptions of premium quality when making purchasing decisions. We tested six variables: first order lateral root (FOLR) number, region of production, price, and uniformity of height, canopy density, and caliper. Surveys were conducted at nursery trade shows, and respondents were asked to provide general information as well as specific quality preference characteristics made during purchasing decisions. Conjoint analysis techniques were used in the evaluation of this survey. Principles of conjoint analysis are based on assumptions that buyers ascertain utility of a product based on utility of each individual product attribute (Garcia, 2002).

Results from the self-stated importance ratings coincided with what we predicted. First order lateral root number was found to be the most important characteristic to nursery liner buyer purchasing decisions, followed by price per liner and height uniformity. Yet, results from the visual survey partially contradicted the self-stated importance ratings. While FOLR and uniformity of height and canopy density were the most important liner attributes affecting buyer purchasing decisions, region of production and price per liner were relatively unimportant. An unspecified U.S. region was preferred, which may be explained due to preconceived notions about liners grown in Pacific Northwest and southeast U.S. regions. For example, a grower deciding on purchasing liners from the Pacific Northwest might expect high value and quality to the crop, but have negative perceptions about anticipated shipping costs associated with purchases from that region.

By using the conjoint model to calculate nursery liner attribute utility values, growers can predict buyer utility and valuation of different attribute compositions. Growers will be able to evaluate and estimate nursery liner quality by assessing their crop's attributes, and summing the respective utility values and the intercept to determine an estimated quality rating for their crop. Estimating quality ratings can allow growers to establish various grades of their nursery liner products and emphasize those characteristics in marketing strategies.

Indeed, nursery liner growers should have no problem adapting their production systems and techniques to help emphasize and promote desirable product features. The characteristics that were identified through this survey as important to buyer purchasing decisions can, in part, be controlled culturally by liner growers.

Most morphological characteristics are influenced by cultural practices such as bed planting density and undercutting. Undercutting uses a machine-driven blade to prune seedling roots. In a study using northern red oak (*Quercus rubra L.*) and black walnut (*Juglans nigra* L.), undercut seedlings had more FOLR than non-undercut seedlings (Schultz and Thompson, 1996). Undercutting does not just generate FOLR; it also provides stimulation for fine root production, especially when depth of cut is considered. When the taproot of English oak (*Q. robur* L.) was cut 18 cm below the root collar, production of fine roots declined compared with fine roots on liners with taproots cut 33 cm below the root collar (Harmer and Walder, 1994). With respect to the plant canopy, since shoots grow at the expense of roots, it is conceivable that undercutting would have an adverse affect on plant shoots. In fact, undercutting seedlings reduced root to shoot dry weight and reduced height of sessile oak (*Q. petraea*) compared to non-undercut control seedlings (Schultz and Thompson, 1996; Andersen, 2004).

Liner bed planting density (sowing density) has also been shown to impact not only the production of fibrous roots, but also the quality of FOLR and overall root density (Schultz and Thompson, 1996; Tomlinson et al.; 1996, Cicek et al., 2007). A grower using a lower bed density could in theory, improve seedling quality. Northern red oak and black walnut seedlings produced more number of FOLR and fibrous roots when grown at 64 stems per m^{-2} when compared to those grown at 128 stems per m^{-2}, even when compared to the non-undercut treatments (Schultz and Thompson, 1996). The number of

FOLR was significantly greater, however, when seedlings were grown at 32 stems per m^{-2}. Lower bed density has also increased plant height and root collar diameter in northern red oak as well as coniferous seedlings (Tomlinson et. al., 1996).

While crowding seedlings at a high planting density has been shown to have a negative impact on seedling quality (Schultz and Thompson, 1996; Cicek et al., 2007), a grower still has to produce an adequate number of seedlings to be profitable. Growing liners at a lower bed density also requires more land acreage for production, which incurs more cost per plant than for liners being grown at a higher density and using less acreage. The positive side of this relationship is that even if a grower has fewer seedlings to distribute production costs over, the grower could charge a premium price for the crops premium quality.

The quality survey had some limitations. We primarily received responses from southeast growers. Future quality surveys such as these should be conducted in each major nursery production region, Pacific Northwest markets, west coast markets, as well as New England markets. Conducting surveys in each of the major markets would yield a larger sample size, and growers would be able to make inferences about other potential markets other than the southeast. Other limitations include variables within the study. Price per liner was determined using representative prices for Nuttall oak (*Q. nuttallii* P.) in nursery catalogs. Variances among the three price levels were only ± $0.30, thus were relatively close to one another. Future studies might include levels of price with more "shock value", meaning that the price per liner variable might be set at $0.50 intervals or more. Results in the importance of price per liner to purchasing decisions are likely to have been different if the price levels were set at greater intervals. Uniformity of caliper among liners was also not found to be very important to buyer purchasing decisions in the survey, which contradicted pre-study informal surveys and phone calls. Actual differences in liner caliper were difficult to discern in the photographs. For this reason, variances in liner characteristics were stated in text form within each image. Future studies might include an interactive survey with live plants. Although actual completion time would be extended, respondents would be able to better assess variances in nursery liner characteristics. Future studies might also be conducted solely on plug liners. Our study looked at bareroot liners, but a comparison between desirable characteristics for both plug and bareroot liners could be potentially beneficial to nursery liner stock growers.

Production Cost Estimation Study

To examine the supply side of the economic equation, a model was examined to ascertain production cost estimates of three common nursery liner products. On a 10-acre (4 ha) model nursery, we evaluated three different production systems within a 2,000 ft^2 (186 m^{-2}) growing area utilizing a field-groundbed system, a polyhouse covered groundbed system, and a polyhouse-covered container system. Within these systems were three representative nursery liner products including red maple (a deciduous species), Foster holly (broadleaf evergreen), and giant arborvitae (needle leaf evergreen). Capital requirements, fixed, and variable costs were determined using a modified Delphi method and the Southeastern United States Consumer Price Index (SEUS CPI). All costs in this study were assumed as a new business venture.

The field-groundbed system required the largest amount of start-up capital totaling over $900,000. The polyhouse covered groundbed and container systems totaled $875,000 and differed only slightly. The field-groundbed system had more capital requirements due to initial investment costs and amount of equipment needed. Results of total production cost estimations indicated that Foster holly and giant arborvitae cost more to produce than red maple in all three production systems. In all, the field-groundbed system was the most expensive to operate in terms of total production costs for Foster holly and arborvitae.

When examining cost per plant at a typical commercial nursery liner growing density, the red maple in the field groundbed had a lower cost per plant than Foster holly and arborvitae. A similar trend held true for the polyhouse covered groundbed, however, the cost per plant for all plant types was lower than the field-groundbed system due to differences in the amount of growing space (ft^2) in the two systems, the number of salable plants able to be produced, and the amount of costs being distributed over that number of plants. There was a linear relationship between cost per plant and bed planting density. As densities of plantings in beds were lowered (thereby the number of salable plants) there was a corresponding increase in cost per plant. Bed planting density is important for the production FOLR, which was found to be important in the quality survey.

Root formation on liners grown using the polyhouse-covered container system are not dependant on bed density. Four inch (798 cm^3) rose (band) containers were used in this system, and the trend of the maple being the least expensive compared to the Foster holly and arborvitae, were similar to the compared densities in the other two systems.

Changes in cost per plant and number of salable plants in the growing space are expected to change with type and size of container being utilized by growers.

In the production cost study, we made the assumption of new land, buildings, and equipment, as well as the operation itself, was a new purchase consequently revealing higher production costs. A more likely scenario is that new business owners or business desiring expansion would choose to purchase used equipment and might possibly even rent the land acreage. Future studies should include options for substituting new equipment for used, and possibly a scenario where the land is rented. Comparisons could then be made between the two different scenarios.

Marketing

We have seen from the quality survey that a majority of respondents claimed only to use between 2 to 3 liner suppliers. To compete with larger, already established liner production facilities, newcomers who wish to grow and sell good liners will have to employ unique marketing strategies in order to establish a niche market for their products. Growers could use the knowledge that purchasers of nursery liner stock are tending to focus on product uniformity as well as FOLR characteristics, and emphasize those characteristics when developing their marketing plan.

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Vita

Andrew H. Jeffers was born in Knoxville, Tennessee, March 23, 1983, and raised in Oneida, Tennessee. He attended schools in the Oneida Special School District, and graduated from Oneida High School in May 2002. He graduated from with a Bachelor of Science in Agriculture with an emphasis in plant and soil science, from the University of Tennessee-Martin in 2006. In August of that same year, he began a Master of Science in plant science at the University of Tennessee-Knoxville, which he completed in December 2008. Currently he plans to pursue a career in the nursery industry.