Engineering, Economics Structures and Innovations

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Economic Impacts of Construction on the Nursery/ Greenhouse and Landscape Services Sectors in Tennessee

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Index Words: Economic Impacts, Construction, Nursery/Greenhouse, and Landscape Services

Nature of Work: The study of economic impacts of construction on the nursery/greenhouse and landscape services sectors is of particular interest due to recent momentum in construction markets and results from aggregate market studies suggesting positive linkages between the nursery/greenhouse sector and construction activity. The objective of this study is to examine economic impacts the construction sector has on the nursery/greenhouse and landscape services sectors in Tennessee. This study employs input-output analysis for five regions within the state to derive the economic relationships and linkages between construction and the nursery/ greenhouse and landscape services sectors. Direct, indirect and induced effects are analyzed for total industry output, employment, and added value.

Results and Discussion: Tennessee's nursery greenhouse industry ranks 14th in the U.S. (1997 Census of Agriculture). In 1997, both the nursery/greenhouse and landscape services sectors generated over $574 million in direct economic activity (1997 IMPLAN data). Construction, in particular, new housing and residential improvements, influences the nursery/greenhouse sector. Results from past studies suggest positive relationships between the sales of nursery/greenhouse products and the level of residential construction and home renovations at an aggregate market level (Johnson and Jensen). New construction generates demand for landscape services and landscape materials, including nursery/ greenhouse products. Past research also suggests that as homeowners improve their homes, they also spend money to improve the landscaping around their homes. Since the early 1990's, real growth in the value of new residential buildings averaged 7 percent for the U.S. and 11 percent for Tennessee (Census Bureau). This study examines how the value of construction impacts the landscape services and nursery/greenhouse sectors using an input-output model. The study also examines how growth in construction could impact the nursery/greenhouse and landscape services sectors.

Economic Impacts of the Nursery/Greenhouse and Landscape Services Sectors: In 1997, the estimated total industrial output from the nursery/greenhouse industry is $213.36 million for Tennessee (Table 1). Over 5,300 jobs are generated directly from the nursery/greenhouse industry and $72.80 million is generated in value-added. When the indirect and induced effects from the nursery/greenhouse industry are considered, the total estimated effects are $430.32 million, 8,556 jobs, and $192.95 million in value-added.

Statewide, the landscape services industry provides an estimated $361.10 million in total industry output directly, and $707.98 million when indirect and induced effects are also considered. An estimated 15,973 persons are employed directly by landscape services, while an additional 5,282 jobs are created through indirect and induced effects.

Table 1. Estimated Effects of Nursery/Greenhouse and Landscape Services Sectors in Tennessee.

	Direct Effects			Total Effects		
	TIO* ($ Millions)	Employ-ment	VA** ($ Millions)	TIO ($ Millions)	Employ-ment	VA** ($ Millions)
Nursery/Greenhouse	213.36	5,353	72.79	430.32	8,556	192.95
Landscape Services	361.09	15,973	271.37	707.98	21,255	472.22
Total	574.45	21,326	344.16	1,138.30	29,811	665.17

*TIO=Total Industry Output
**VA-Value-Added

Impacts of Construction on the Nursery/Greenhouse and Landscape Services Sectors: Estimates of the direct effects of total industrial output from three types of private construction -- new residential, residential maintenance and repairs, and new industrial and commercial construction - are generated. The statewide total industry output from new residential construction is around $3.52 billion, while total industrial output from residential maintenance and repairs is about $1.28 billion. Total industry output from new commercial and industrial construction is $4.73 billion.

The greatest impacts of a $1 million increase in total industry output from construction on the nursery/greenhouse and landscape services industries results from an increase in residential maintenance and repairs, followed by new residential construction, and finally by new commercial and industrial construction(Table 2). This pattern holds for total industry output, employment, and value-added.

Table 2. Total Impacts of Construction on Nursery/Greenhouse and Landscape Services Sectors.

Sector	Total Impacts (Indirect and Induced) Total Industry Output (Dollars)	Employment (Jobs)	Value Added (Dollars)
	$1 Million in New Residential Construction		
Nursery/Greenhouse	22,815	.5724	7,784
Landscape Services	15,524	.6866	11,667
	$1 Million in Residential Maintenance and Repair		
Nursery/Greenhouse	25,385	.6368	8,661
Landscape Services	16,033	.7092	12,049
	$1 Million in New Industrial and Commercial Buildings		
Nursery/Greenhouse	3,873	.0971	1,321
Landscape Services	10,949	.4545	8,228

Impacts of Growth in Construction: Tennessee experienced just over 11 percent real growth in new residential construction during the 1990's. Examining the impacts relative to the actual magnitudes of these industries would also be useful. If 10 percent growth is assumed for each of the types of construction, the overall magnitudes of the impacts on the industries of interest can be projected. A 10% increase from the 1997 Total Industry Output estimates for new residential construction implies a $352 million increase. As a result, over $1.6 million in impacts on the total industry output from the nursery/greenhouse industry and nearly $1.1 million on the landscape services industry are estimated. Over 85 new jobs in these industries are added. Increases in value-added are in excess of $1.3 million.

A 10% increase in residential maintenance and repairs ($129 million) increases total industry output by over $.6 million for the nursery/greenhouse industry and over $.4 million for the landscape services industry. An increase of 34 new jobs occurs. Value-added increases by over $.5 million.

A 10% increase in new commercial and industrial construction is $473 million and positively impacts total industry output from the nursery/greenhouse industry by nearly $.4 million and the landscape services by over $1.0 million. The majority of the jobs added occur in the landscape services industry, with 46 jobs added. Value-added from the nursery/greenhouse and landscape services industries increases by over $.9 million.

A 10% increase in each of the types of construction results in a 1.2% increase in nursery/greenhouse total industry output and a 0.7% increase in landscape services total industry output. These combined construction activities constitute 12.3% of the final demand for nursery/greenhouse industry output and 7.0% of the final demand for the landscape services total industry output.

Significance to the Industry: The results from this study suggest that construction activity is important to the nursery/greenhouse and landscape services industries in Tennessee. As with findings from past aggregate level studies, the greatest impacts are from home renovations, repairs, and related activity.

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Economic Viability of Using Wood Residues as a Heating Source for Greenhouse Operations in Tennessee

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Index Words: Greenhouse Heating, Wood Residues, Energy Costs, and Net Present Value

Nature of Work: Wood residue combustion systems can provide an alternative source for heating greenhouse operations in Tennessee. The purpose of this study is to examine the economic feasibility of heating greenhouses with hardwood residue chips. This study examines the potential costs of heating a 2,000 square foot greenhouse, estimates the potential savings per BTU from using wood as an energy source, and evaluates whether investing in wood as an energy source is financially feasible.

Results and Discussion: According to the 1998 USDA Census of Horticultural Specialties for Tennessee, 340 operations had a total area of 11,306,000 square feet under cover, representing an average under cover area of 33,253 square feet per operation. The most commonly used greenhouse covering material was plastic film. Estimated energy costs for horticultural operations in Tennessee were $10,650,000 across a total of 603 operations or $17,662 per operation per year. Tennessee is also a major hardwood lumber and wood products producing state, providing a potentially readily available source of residues for heating. In general, it is not considered economically feasible to transport residues more than 50 miles. Counties with greater than $4 million in nursery/ greenhouse sales, which are also in close proximity to hardwood residues, include Warren, Shelby, Franklin, Sumner, Blount, Grundy, and Coffee. Furthermore, Davidson, DeKalb, and Knox Counties have green hardwood residue counties nearby.

In evaluating the costs of various energy sources for greenhouse heating, BTU requirements must be calculated. Energy requirements are, in part, based on heat loss. There are two components of heat loss: heat conduction loss and air exchange filtration heat loss (Texas A&M University). Heat conduction loss is calculated as:

$$Heat\ Conduction\ Loss\ Factor = TSA*T*HLV$$

where TSA = Total Surface Area Exposed on the Greenhouse, T = Maximum Temperature Inside minus Minimum Temperature Outside, and HLV = Heat Loss Value for the Covering. Using the example of an even span structure that is 100 feet long, 20 feet wide, and 10 feet tall. A maximum inside temperature of 80˚F/26.7˚C with a minimum outside temperature of 15˚F/-9.4˚C, and a heat loss value of 4-mm polycarbonate at .70 Btu/h x ft^2 x˚F (heat loss in Btu's per hour per square foot per degree in Fahrenheit), the Heat Conduction Loss Factor would be 3571*65*.70 or 162,481 BTU's per hour. An estimate of air exchange infiltration heat loss would be:

*Air Exchange Filtration Heat Loss = .22*T*V*Air Exchanges per Hour*

An estimate of the air exchanges per hour for a plastic covered greenhouse is .75 exchanges per hour. The volume of the greenhouse is represented by V. The air exchange filtration loss is 160,875 BTU's. The total loss would then be 162,481+160,875 or 323,356 BTU's. Prices on 350,000 BTU output-heating units (conventional fuels, such as gas or fuel oil) ranged from $1,300 to $3,000 per unit depending on the type.

A comparison of BTU energy equivalents are provided in Table 1. Burner efficiencies are assumed at 80% for electricity and fuel oil, and 75% for natural gas and liquid propane. (Prices, Department of Energy)

Table 1. BTU Equivalents for Various Energy Sources, Unit Price, and Cost/BTU.

Fuel Type	1 BTU Equivalent		Unit Price	Cost/BTU
Electricity	1/2730	KWh	$.03	$.0000110
Natural Gas	1/75,000	Therms	$.68	$.0000091
Liquid Propane	1/67,500	Gallons	$1.32	$.0000196
Fuel Oil	1/112,000	Gallons	$1.29	$.0000115

Wood Residues as an Energy Source, Costs Comparisons, and Investment Decision. The following example assumes a burner efficiency of 70% and wood moisture content of 40%. For hardwood residues, BTU's per pound is estimated at 4,007.14, and for softwood residues 4,242.85. According to Panshin and Zeeuw, the BTU's generated by wood vary with moisture content as:

*BTULB = [H * (100-MC/7)/(100+MC)] * EFFIC*

where H is the BTU's per pound produced by bone dry wood, about 8,500 for hardwood and 9,000 for softwood, MC is the moisture content percentage, and EFFIC is the burner system's efficiency (expressed as a percent). Converting this to tons gives 8.01 MM BTU's per ton for hardwood and 8.49 MM BTU's per ton for softwood. Given the example greenhouse, which required 366,761 BTU's per hour, residue requirements would be estimated at .04576 tons of hardwood and .04321 tons of softwood. Values for wood residue prices are based on a 2,000 survey of wood products producers. Undelivered price estimates from the survey results were $16.37 per ton for green hardwood coarse residues, $7.36 per ton for green hardwood sawdust residues, and $7.97 per ton for green hardwood bark residues. Using Warren County as a destination county and the surrounding counties having available coarse hardwood residues, an average delivered hardwood residue (coarse) price of $23 is estimated (English, Jensen, Menard, Park, and Wilson). The hardwood residue requirements to obtain a BTU of heat are about 1.2478 $x10^{-7}$ tons, giving an energy cost of about $2.87 $x10^{-6}$ per BTU. Comparing wood with fuels (Table 1) shows an average 76% saving in energy costs.

The question of how much the producer could afford to invest in a wood burning system arises. An estimate of the dollars per square foot under cover based on the energy bill of nursery/greenhouse operations in Tennessee was calculated at $0.94 per square foot of greenhouse space. Adjusting this for 6% inflation from the 1998 costs raises the price to $1.00 per square foot. For the example 2,000 square foot greenhouse, the estimated energy costs would be $2,000 per year. Using 76% as an average value for savings, these costs (not including investment in facilities and equipment) could be reduced to $480 if wood were used as fuel.

A Net Present Value criterion can be used to assess the financial feasibility of investing in a wood burning system.

$$NPV = - I + \sum_{i=1}^{n} \frac{CF_i}{(1 + r)^i}$$

where I is the initial investment, CF_i is the expected net cash flow in year i, r is the discount rate, and n is the time horizon of the project. The CF for each year is the savings from using wood or $1,520 less the additional costs of operating the wood unit (estimated at 10% of $1,520), which equals $1,368. With a discount rate of 9%, and an expected life of the unit of 12 years, then to make the investment in the wood-burning unit financially viable, the unit must cost less than $10,685 to install. The costs of installing a wood burning furnace system would include the furnace (and building if not self contained), digging a trench, piping, and plumbing costs into an existing heat distribution system are estimated to be about $7,940. The costs of operating the wood furnace would include labor involved in loading and cleaning out the furnace. Estimates are based on commercial sources and a study by Girourd, Lowe, and Samson.

Significance to the Industry: The economic viability of heating a greenhouse with wood residues, such as wood chips, depends on the level of capital required to purchase and install the wood fuel heating system and accessibility of low cost sources of wood residues. The results from this study suggest that wood heating can be a viable economic alternative to other sources.

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Production Cost Estimates for Selected Field Grown Nursery Stock

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Index Words: Cost of Production, *Quercus palustris*, Pin Oak, *Pyrus Calleryana,* 'Bradford' Pear, *Ilex x attenuata 'Fosteri'*, Foster's Holly

Nature of Work: As the nursery industry grows, there is an increased demand for cost of production information for potential growers to make more informed decisions about entering the industry or for experienced growers to expand their current operation. The objective of this study was to develop enterprise budgets to estimate the costs associated with growing and harvesting five-acre field plantings of Pin Oak, Bradford Pear, and Fosters Holly. Cost estimates for this study were developed using production coefficients and labor records of several North Carolina nurserymen. Growth rates and losses were estimates for drip irrigated crops.

Results and Discussion: The primary focus of this study was to estimate the variable and fixed costs associated with growing and harvesting trees. Machinery cost estimates includes depreciation, interests, taxes and insurance as well as the cost of fuel and lubricants. Labor cost estimates include required payroll expenses, such as OASDI and hospitalization insurance, unemployment insurance, workman's compensation and housing expenses and were adjusted for the annual number of hours allocated for vacation and sick leave. Both machinery and labor costs were allocated to each enterprise based on the hours of actual use.

The total cost of growing and harvesting a five-acre planting of Pin Oaks was estimated to be $127,212 over a five-year production period (Table 1). This was an average expense of $37.97 per tree for the 3,350 marketable trees, however, the actual cost per tree ranged from $34.96 to $38.21 depending on the size and month of the year when the tree was harvested (Table 2). Overall, the loss rate for Pin Oaks was 16.25%, 650 of 4,000 trees. The total cost to grow and harvest 3,800 marketable Bradford Pears was estimated to be $107,396 over a four-year production cycle, for an average cost of $28.26 per tree (Table 3). The average cost per tree ranged from $26.74 to $29.99 per tree (Table 4). The aggregate loss rate was 5%. Ilex Foster production cycle took seven years to grow 5,675 marketable plants and cost an estimated $111,750, or an average of $19.69 per tree with an aggregate loss rate of 8.47% (Table 5). However, the actual cost per plant ranged from $15.11 to $26.89 depending on the market size and when the tree was harvested (Table 6).

Growers also incur additional overhead costs that were not incorporated in this study, but should be included when pricing their plants. These costs include advertising expenses, bad checks, building repairs and maintenance, rent and property taxes. Unfortunately, many growers ignore or overlook these additional costs, which were estimated to range from 17.8% to 21.4% of a nursery's annual net sales, Table 7.

Significance to Industry: These cost estimates will provide a basis for decision making for those evaluating the profitability of establishing a new nursery or expanding current production. A shortcoming of this analysis is that markets were assumed to be present and available as the plants were harvested. If this situation is not the case, the actual cost per plant will increase as the number of plants that the grower can not sell increases. The actual cost per tree will also increase if the actual loss rates are greater than the estimated rates used in this study. Since every nursery situation is different, it is highly recommended that each grower estimate their individual costs-of-production based on their own production cycles and growing techniques.

Table 1. Estimated Annual Cost for Pin Oak, Five Acre Planting

	Year 1	Year 2	Year 3	Year 4	Year 5
Land Preparation	$ 3,626	0	0	0	0
Planting Trees	$64,929	0	0	0	0
Maintenance	$10,426	$4,031	$3,904	$ 3,614	$ 43
Harvest					
2 ½ - 3" Trees	0	0	$7,393	$19,660	$4,370
3 - 3 ½" Trees	0	0	0	0	$5,216
Trees Planted & Sold	4,000[i]	0	692[ii]	1840[ii]	818[ii]
Loss Rate[iii]	10%	5%	1%	1%	1%

Table 2. Estimated Cumulative Cost per Harvested Pin Oak

	Number of Trees	Cost per Tree
Year 3: 2 ½ - 3"	692	$ 34.96
Year 4: 2 ½ - 3"	1,840	$ 36.31
Year 5:		
2 ½ - 3"	409	$ 36.36
3 – 3 ½"	409	$ 38.43

Table 3. Estimated Annual Cost for Bradford Pear, Five Acre Planting

	Year 1	Year 2	Year 3	Year 4
Land Preparation	$ 3,626	0	0	0
Planting Trees	$42,249	0	0	0
Maintenance	$10,427	$4,556	$ 4,534	$ 214
Harvest:				
Spring: 2 ½ - 3" Trees	0	0	$20,306	$6,092
Fall: 2 ½ - 3" Trees	0	0	$ 8,123	0
Spring: 3 – 3 ½" Trees	0	0	0	$7,269
Trees Planted & Sold	4,000[i]	0	2,660[ii]	1,140[ii]
Loss Rate [iii]	4%	1%	0%	0%

Table 4. Estimated Cumulative Cost per Harvested Bradford Pear Tree

	Number of Trees	Cost per Tree
Year 3		
Spring (2 ½ - 3")	1,900	$26.74
Fall (2 ½ - 3")	760	$27.74
Year 4		
Spring (2 ½ - 3")	570	$27.93
Spring (3 - 3 ½ ")	570	$29.99

Table 5. Estimated Annual Cost for Ilex Foster, Five Acres Planting

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Land Preparation	$ 3,626	0	0	0	0	0	0
Planting	9,349	0	0	0	0	0	0
Maintenance	2,933	$5,142	$5,142	$5,142	$ 5,142	$ 4,327	$2,793
Harvest							
22" B&B	0	0	0	0	$12,508	$12,508	$9,317
28" B&B	0	0	0	0	$12,295	$12,295	$9,231
Trees Planted & Sold	6,200[i]	0	0	0	2,066[ii]	2,066[ii]	1,543[ii]
Loss Rate [iii]	2%	1%	0.5%	0%	0%	0%	0%

Table 6. Estimated Cost per Harvested Ilex Foster

	Number of Trees	Cost per Tree
Year 5:		
22" Ball	1,380	$15.11
28" Ball	686	$23.97
Year 6:		
22" Ball	1,380	$16.22
28" Ball	686	$25.08
Year 7:		
22" Ball	1,028	$18.03
28" Ball	515	$26.89

Table 7. Overhead Costs as a Percentage of Net Annual Sales

Category	Low	High
Advertising	2.84 %	3.58 %
Bad Checks	1.00 %	2.00 %
Building Maintenance and Utilities	2.17 %	2.25 %
Property Taxes	0.24 %	0.41 %
Rent	1.98 %	3.07 %
Other Overhead Expenses	9.54 %	10.05 %
Total	17.77 %	21.36 %

[i] Number of plants that were planted.
[ii] Number of plants sold.

[iii] The aggregate loss rate was based on the total plants planted compared to the total plants harvested, while the annual number of plants lost was based on the annual loss rate and the number of plants that survived and were not harvested during that year.

Economic Evaluations of Structure and Technology Adoption

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Index Words: capital budgeting, discounted cash flow, benefit cost ratio, net present value, internal rate of return

Nature of Work: The chief determinant of what a company will become is the investments it makes today. The generation and evaluation of creative investment proposals is the ongoing responsibility of all managers throughout a nursery's organization. In well-managed companies, the process starts at a strategic level with management specifying the activities or functions in which the company will compete and determining the means of competition. These strategic goals are then translated into concrete action plans involving specific investment proposals. A key aspect of this process is the financial evaluation of investment proposals, or what is frequently called capital budgeting. The achievement of an objective requires an outlay of money today in expectation of increased future benefits. It is necessary to decide, first, whether the anticipated benefits are large enough, given the risks, to justify the current expenditure, and second, whether the proposed investment is the most cost-effective way to achieve the objective.

Cash flow is viewed a critical in day-to-day or short term operations as cash flow is the timing of inflows and outflows of dollars. Simply put, this is a firm's ability to meet its financial obligations using the sales or revenue dollars generated. Viewed broadly, however, the discounted cash flow techniques are relevant whenever a company contemplates an action entailing costs or benefits that extend beyond the current period, or are long term. This covers a lot of ground, including analyzing equipment or facility acquisitions, choosing among competing production technologies, deciding whether to launch a new product mix or series of plant varieties, valuing the company or part of it for purchase or sale, and even assessing marketing campaigns and propagation programs in a nursery. It is not an exaggeration to say that discounted cash flow analysis is a backbone of financial decision making in any business, including nurseries and greenhouses.

The financial evaluation of any investment opportunity involves three discrete steps: (1) estimate the relevant cash flows; (2) calculate a figure of merit (economic worth, rate of return) for the investment; and (3) compare the figure of merit to an acceptance criterion or standard of comparison. The basic premise or question in any financial evaluation becomes whether the anticipated benefits from a purchase justify the cost, and a proper answer must reflect the time value of money. There are, however, two commonly used, back-of-the-envelope techniques that, despite their popularity, suffer some glaring weaknesses because they do not consider the time value of money. [The time value of money can be summarized as "a nearby penny is worth a distant dollar" (Anonymous), or that a dollar today is worth more than a dollar in the future.] These two figures of merit calculations are the payback period (equal to the investment divided by the annual cash flow, and shows how long the company will have to wait to recoup its original investment, but is insensitive to all cash flows occurring beyond the payback date) and the accounting rate of return (equal to the annual average cash inflow divided by the total cash outflow, but is insensitive to the timing of cash flows).

Financial texts suggest that more appropriate investment evaluation techniques include the net present value (NPV), the benefit-cost ratio (BCR), and the internal rate of return (IRR). So what are they, how are they calculated, how are they interpreted, and how can they be used to evaluate a structure or technology purchase in a nursery? A capital budgeting decision tree will be used to sequence the investment evaluation techniques and their relevance to the decision at hand. Calculations of the NPV, BCR, and IRR of a nursery's investment in a technology, such as computerized irrigation systems, and a structure, such as a greenhouse, will be performed and applied to the capital budgeting decision tree, as example applications of the process.

Results and Discussion: Today's computers and calculators readily adjust investment cash flows using compounding and discounting values. There are still tables in financial reference texts to extract a value if neither a business calculator or computer spreadsheet is trusted. For definition purposes, compounding is the process of determining the future value of a present sum, while discounting is the process of finding the present value of a future sum. But what about the NPV, the BCR, and the IRR?

The net present value (NPV) of an investment or purchase is determined by deducting the present value of cash outflows from the present value of cash inflows to estimate the amount of value created from the investment. Embrace or accept positive NPV activities — the higher the NPV, the better — and avoid or reject negative NPV activities. Zero NPV activities are marginal because they neither create nor destroy wealth. NPV calculations require using present value tables which present coefficients for the present value of $1 in year "n", discounted at a discount rate "k." If the annual cash flows (inflows and outflows) are constant across time, then the present value of an annuity table can similarly be used.

A second time-adjusted investment analysis technique popular in management and government agency circles is the benefit-cost ratio (BCR), defined as the present value of cash inflows divided by the present value of cash outflows. Obviously, an investment is attractive when its BCR exceeds 1.0, and is unattractive when its BCR is less than 1.0.

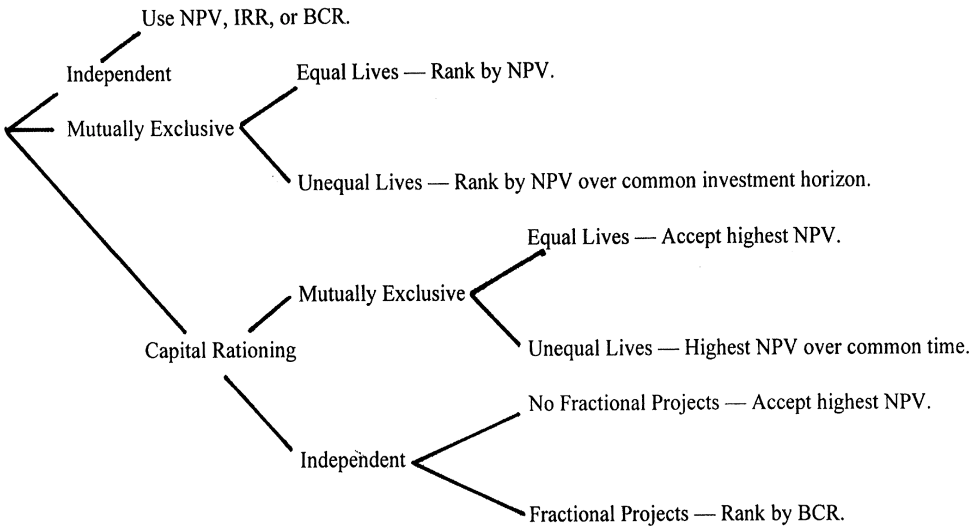
Without doubt the most popular investment analysis tool is the investment's internal rate of return, or IRR. The relationship of NPV to

IRR can be summarized in the thought process that as the NPV changes from positive to negative, i.e., the investment changes from acceptable to unacceptable, the critical discount rate at which the change occurs in the investment's IRR. Formally, an investment's IRR is defined as the discount rate at which the investment's NPV equals zero. If the IRR is greater than this discount rate, accept the investment; reject if less than the rate; and the investment is marginal if IRR equals the discount rate. The IRR of an investment can be compared directly to the annual percentage cost of the capital to be invested.

Three more brief points to mention are that financial investment decisions can be independent (where each opportunity can be analyzed on its own without regard to other investments), mutually exclusive (whereby accepting one investment precludes further consideration of the other, and that money is readily available at a cost equal to the discount rate), and capital rationing (whereby the nursery has a fixed investment budget which it may not exceed, which requires ranking investments rather than simply accepting or rejecting them).

To provide a summary and an overview, a capital budgeting decision tree is presented. It indicates the tools for analysis that are appropriate under the various conditions described earlier. For example, following the lowest branch in the tree, it can be seen that when evaluating investments under capital rationing (maximum investment budget stated) that are independent and can be acquired fractionally (purchasing irrigation for part of a greenhouse as opposed to purchasing an entire greenhouse), ranking by the BCR is the appropriate technique.

The capital budgeting decision tree for fixed or long-term investments in structures or technologies:



Consider the example of comparing manual watering in a 30' x 100' quonset with installing drip irrigation. Using annual savings as the economic criteria, under discrete assumptions and budgeted costs for both methods, investment analysis results favor the investment in the drip irrigation system are reflected in the following evaluations: payback period = 1.26 years; return on investment = 77.7%; net present value = $ 22,542; internal rate of return = 65%; and the benefit cost ratio = 5.7.

Significance to Industry: In using discounted cash flow techniques in investment appraisal by a nursery manager, the first step in the evaluation, estimating the relevant cash flows, is the hardest in practice. Money has a time value because risk customarily increases with the futurity of events, because inflation reduces the purchasing power of future cash flows, and because waiting for future cash flows involves a lost opportunity to make interim investments. Therefore analyzing a purchase or investment that has both an income stream and a cash outflow stream needs to account for the time value of money. The NPV, the BCR, and the IRR are three acceptable techniques. The guiding principles in deciding what cash flows are relevant for an investment decision are the with-without principle and the cash flow principle. Recurring problems in determining relevant cash flows involve depreciation, working-capital changes, allocated costs, sunk costs, temporary excess capacity, and financing costs. The decision tree aids in determining which technique is most appropriate for specified circumstances.

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Retractable Shading Influences Growth of *Vaccinium*

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Index Words: blueberry, container nursery production, retractable roof systems

Nature of Work: Compared to production under stationary or no shading, container grown nursery crops grown under retractable shading often show improved growth (Svenson et al. 1992, 2000; Svenson, 1998). The objective of this study was to determine the growth response of *Vaccinium* to a retractable shading system.

Potted liners (2-in) of *Vaccinium* 'Darrow' were potted 16 June 2000 into trade 1-gal containers filled with unamended Douglas-fir bark. Plants were placed under no shading, under 30 X 96-ft hoop structures covered with 30% knitted black shade cloth, or under retractable roof structures using white woven poly-film (50% shade) as the glazing. Plants were top-dressed with Apex 20-10-10 controlled release fertilizer at a rate supplying 2.25 lbs. N per cubic yard of substrate. Plants were irrigated as needed (unfiltered well water). Leachate pH ranged from 6.2 to 6.8 during the study.

The retractable roof system was operated using a photosensor to extend the poly-film shade (80% closed position) whenever natural sunlight exceeded 1100 PPF (about 5700 ft-c) for 20 minutes, and to retract the poly-film whenever sunlight remained below 1100 PPF for more than 30 minutes. The system required 4 minutes to place the roof in the designated position.

On 15 October, plant shoot height and size were recorded and four plants from each of the three growing environments were harvested to determine shoot dry weight. The study was a split-block treatment arrangement in a randomized complete block design, with 55 plants representing each treatment. Data were analyzed for significant differences to shading environment using SAS ANOVA.

Results and Discussion: *Vaccinium* were taller when grown under stationary or retractable shading compared to no shading, but had more shoot size when grown under retractable shading (Table 1). Shoot dry weight response was similar to shoot size (data not shown). The results are consistent with earlier reports for *Schefflera, Coreopsis* and *Forsythia* (Svenson et al., 1992; 2000). Cooler substrate temperatures that prevent damage to root systems may partially explain the increased growth of some nursery crops when produced under retractable shading systems using poly-film for the glazing. Containers growing under white woven poly-film providing 50% shading had cooler substrate temperatures compared to containers under black woven shade cloth providing 63% shade (Svenson et al., 2000). Exposure to more light on cloudy days and during early morning and late afternoon hours may also contribute to increased shoot growth when plants are produced in retractable roof structures.

Significance to Industry: Container grown *Vaccinium* had more shoot size and dry weight when grown under retractable shading compared to no shading or stationary shading. While not all taxa may exhibit increase growth when produced under properly managed retractable roof structures, this study suggests that *Vaccinium* may benefit when produced under a retractable shading system.

Literature Cited:

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Table 1. Shoot height and shoot size of *Vaccinium* ‘Darrow’ grown in trade 1-gal containers under no shading, stationary shading (30% shade from woven black shade cloth) or retractable shading (50% shade from woven white poly-film).

Type of shading	Shoot height (cm)	Shoot size (cm)
no shading	17.8 b[1]	18.6 b
stationary	20.2 a	18.8 b
retractable	20.7 a	20.1 a

[1] Means in columns followed by the same letter are not significantly different using Fisher’s Protected Least Significant Difference (P<0.05).