Field Production

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Incidence and Severity of Buprestid Infestation in Field-Grown *Acer platanoides* Related to Cardinal Orientation of Understock Bud Union

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Index Words: integrated pest management, scouting, monitoring, cultural practices, beetle

Significance to Industry: Flatheaded Buprestid borers attacked field-grown trees of 'Royal Red' Norway maple (*Acer platanoides* L.) only at the stubbed portion of the bud union where the understock and cultivar were joined. Trees with this stubbed area of the understock facing a northerly direction were approximately 40% less likely to be attacked by borers than trees with this area facing a southerly direction. The simple cultural practice of orienting the bud union facing north could reduce flatheaded appletree borer infestation in other field planted liners of shade and flowering trees.

Introduction: Borers were ranked by growers in the southeastern U.S. as one of the most damaging and difficult pests to control (Fulcher et al. 2012). Borers are most damaging because one larvae of flatheaded appletree borer (FAB) (*Chrysobothris femorata* Olivier) (Coleoptera: Buprestidae) can render a tree unmarketable (Adkins et al. 2010). FAB adults emerge in late spring or early summer, mate, and then lay eggs on target hosts. Larvae hatch, feed all summer under the bark, pupate sometime in winter, and emerge as adults in spring just as the cracked bark and cambial tissue damage becomes evident from feeding the previous summer (Adkins et al. 2010). The separation of life stages that are trapped during monitoring methods (adult beetles) and those that do the actual damage (larvae) makes the process even more complicated. Simply waiting for the damage to be evident before intervention is taken is too late to prevent economic or aesthetic loss.

Most shade and flowering trees are propagated vegetatively by budding to increase growth and decrease production time at liner producers. One- to three-year-old understock is field planted in spring or early summer in nurseries to obtain an established root system. In late summer, buds of desired cultivars are affixed just under the bark of the understock using various budding techniques (Garner 2003). The following winter, just as the new bud is beginning growth, the understock is pruned off and its resources are channeled through the single cultivar bud, thus producing tremendous growth of the desired cultivar in one year. When plants reach the desired height for liner production, they are dug dormant and field planted elsewhere. During the budding process, stubbing-off the understock leaves a scar at the plant base that is essentially a wound until it calluses completely in two to three years prior to final sale. The practice of budding is not detrimental to plant growth, and has been used successfully with many cultivars and hundreds of thousands of plants transplanted into the landscape. The objective of this observational study was to determine if the cardinal direction of the stubbed portion of the bud union affected infestation of FAB after liners were field planted into a nursery.

In February 2009, 200 32 mm (1.25 inch) caliper 'Royal Red' Norway maples were planted as branched liners in a field along the Johns River in Caldwell County, NC. Trees were planted randomly, thus cardinal orientation was randomized by the transplant crew without regard to future observation. Trees received standard cultural practices for the area and nutrient additions according to soil tests using NC State University recommendations (Bilderback et al. 2013).

Following grower notification of a severe pest infestation in summer 2012, the production field was scouted August 2012, during which time the authors made observations on natural levels of pest infestation. Flatheaded appletree borer attacks on infested trees were restricted to the stubbed portion of the bud union only and not any other portion of the trunk. For example, if the stubbed portion was oriented north and the tree was attacked, the damage would be constrained to the cut-stub area that was oriented north and not on the southwest side of the trunk as expected based on previous observations in the literature (Oliver et al. 2002; Seagraves et al. 2012). Thus, the treatment variable, cardinal direction of cut stub, was established *ex post facto* by categorizing cut stub orientation of each tree into either north, northeast, east, southeast, south, southwest, west, or northwest direction. After designating cardinal direction of the cut-stub area, it was next noted whether the tree was currently or had been infested previously by FAB at those stubbed areas.

The experimental design was considered completely randomized since the planting crew planted trees without regard for future experimentation. The eight stub orientation categories were replicated unevenly by single tree plots. PROC GLIMMIX (SAS v. 9.4) (SAS Institute, Inc., Cary, NC) was used for analysis of variance using a binomial distribution and the default logit link. To adjust for unbalanced data when comparing means, least squares means (LSMEANS) were separated using Tukey's HSD using adjusted P values with a probability of finding a greater F value set at 0.05 (data not shown). A separate contrast statement using pooled variances was used to compare the combined probability of being attacked in categories "Southeast-South-Southwest" to "Northwest-North-Northeast."

Results and Discussion: By August 2012, about 3 years after transplanting, approximately 183 trees were alive (92%), yet, of those, 44.8% had been or were infested by FAB. The combined overall probability for larval damage of the Southeast, South, and Southwest directions was approximately 64%. Trees facing Northwest, North or Northeast had a 21% probability of attack. Troxclair (2005) noted the same propensity for FAB to infest the same stubbed area on field-transplanted apple trees that were grafted previously. According to Seagraves et al. (2012), FAB attacks are more common on the lower southwest side of tree trunks, and the observations from the present study support greater frequency of attacks if the southwestern side contains a wounded area such as a cut-stub from the understock.

Operationally, field crews planting tree liners may not be precise in their efforts to orient stubbed areas of trees facing due north or northeast. Therefore, a contrast statement was created to compare planting trees facing a northerly direction (Northwest-North-Northeast) to trees facing a more southerly direction (Southeast-South-Southwest). The significant outcome ($P<0.01$) (data not presented) of the contrast allows for error in placement when planting trees with the stubbed bud union facing a northerly direction. Based on the observations of this study, planting trees with the stubbed portion of the bud union facing a northerly direction is a simple cultural practice that can decrease the probability of FAB infestation by as much as 40%. Additionally, summer field scouting protocols should now include inspection of the stubbed area of cultivars that were budded or grafted to determine if FAB is present. Focusing solely on this area, especially when it is facing a southerly direction, might increase the chances of detecting the presence of FAB while decreasing the actual time spent scouting for the pest.

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Economic Impact of Recapturing and Recycling Irrigation Techniques on Horticulture Nurseries

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Index Words: Agricultural Economics, Partial Budgets, Nursery, Recapture, Recycle, Irrigation Water, Horticulture

Significance to Industry: The recapture and recycling of irrigation water in horticulture nurseries is a technique which could have significant savings for the operation. These savings may also require substantial risk and capital cost outlays. The risk of increased disease becomes more prevalent in nurseries which implement recapturing and recycling methods. These added costs must be taken into account in assessing the feasibility of recapture and recycle when comparing to alternative sources of water, such as municipal or well water. This study employed use of partial budgeting techniques to compare between the recapture and recycling irrigation option, with pathogen mitigation techniques, and the most feasible alternative. On-site visits were used to inform the costs associated with the partial budgets and clarified the decision making process for individual nurseries. The partial budgets were also informed by sensitivity analysis with regard to the extraction cost of water and opportunity cost of land. The results indicated that most nurseries visited exhibit savings from recapturing and recycling techniques, compared to a feasible alternative source. These savings could be used to motivate further water conservation within the horticulture industry.

Nature of Work: Due to the fact that water is a widely used input in nursery production, it may be the case that recapturing is a more viable economic option than irrigating with municipal water and well water. The recapture and recycling of water could allow for a nursery to be self-sufficient rather than to rely on other water sources, which may experience price shocks. Recapture is also versatile and can work as a complement to an existing water source, such as rainfall and well water supply. The implementation and use of recaptured water for irrigation does not come without upfront and ongoing management and operational costs. Recapturing used irrigation water for recycling purposes can increase the possible risk of pathogen contamination through the nursery operation. There are possible ways to mitigate risks such as pathogens. These pathogens can live in the recycled water, thus causing re-infection of plants each time the water is recycled through the irrigation system [1]. There are many best management practices (BMPs) that attempt to mitigate that risk, but have large costs associated with implementation. BMPs include a variety of options that help effluent mitigation or control pollutants such as "…activities, prohibition of practices, maintenance procedures, or other management practices" [2] Oftentimes, land must be contoured to recapture the most water possible to an irrigation, sedimentation, or storage pond, which may replace production from profitable plant growing areas. Therefore, nurseries face the choice of regrading the land for recapturing and recycling water, while implementing pathogen mitigation procedures; or of using an alternate source of water.

An analysis of recycling costs in comparison to other water sources will assist in a nursery's decision to recycle. The analysis is designed to provide information on the lowest cost of collecting water and irrigating plants. This information is of interest to growers and farmers who may be unsure of the cost efficiency of their current water irrigation methods. Policy analysts and decision makers, especially in water conservation, are interested in the implications of water recycling and its relative costs to other alternatives. Recycling of irrigation water is viewed as a potential conservation practice to assist in mitigating water issues. The Chesapeake Bay Monitoring, a function of the state of Maryland, analyzes pollutants, water quality, habitat, and living recourses; which are affected by runoff from nurseries within the study area [3]. Businesses that provide services for recycling can learn about the feasibility of incorporating new customer bases to their existing clientele, whereas some industries that exploit conventional water services might see more profitable alternatives or existing options as future competition to their current technologies.

The objectives of this study are as follows: 1) to estimate the cost of a recapturing and recycling program for a horticulture operation; 2) to compare such costs against the next best water source alternative; and 3) to conduct a sensitivity analysis to determine how changes in key factors affect recycling costs compared with competing water uses.

In order to meet these objectives case studies using partial budgets are developed to analyze nurseries of differing sizes and locations. Partial budget analysis is used to evaluate costs and benefits of recycling versus use of alternate water sources and is applied to nursery case studies. The nursery case studies are compiled through on-site visits to each operation to document the costs associated with recapturing and recycling of water, as well as other factors influencing decision making. In person visits offered an examination of the costs connected with regrading the land, recapture ponds, and pathogen mitigation techniques. For costs that nurseries could not provide, professional secondary cost sources were consulted. The partial budgets compared the costs associated with recapturing and recycling water to the next best water source alternative.

Eight nurseries, which recycle irrigation water, were visited to gather data on the ways in which they handle recapturing and recycling of irrigation water. Selected nurseries in Pennsylvania, Maryland, and Virginia were all visited during the summer of 2014 through the winter of 2015. The visits were used to assess the physical characteristics of the nursery and to learn about what steps have or have not been taken to recycle water. The visits were also an opportunity to learn what factors led to the nursery deciding to recycle. The nurseries not only differed in physical characteristics but also in the size and scope of products offered for sale, as well method of sale (wholesale, retail, re-wholesale, or combinations thereof). Some nurseries were small family operations that focused on the on-farm or local retail store. Conversely, others were large scale businesses that have dozens of workers and specialize in wholesale or re-wholesale markets. Each of the nurseries were different, but patterns emerged pertaining to the factors that influenced their production decision to begin recycling in their operations.

From the physical visits and questions asked, it became apparent that every nursery is engaged in similar practices to capture and recycle water but those practices differ depending on the location and resource allotment of the operation. The individual problems and goals of each nursery are very similar but the way in which they cope with these demands of a reliable and safe source of water depends on their location. Each nursery finds a different way to address problems of acquiring water and pathogen risk based on their resources. The case studies and subsequent discussions outline these concerns and costs.

The partial budget analysis is an important tool that is implemented to evaluate a defender, or current technology, versus the challenger, or viable alternative. A partial budget only deals with those characteristics or factors that affect the defender and challenger options; nothing else is included in the budget as per a *ceteris paribus* assumption. The defender portion for this study is divided into two sections, one including additional costs and the other being reduced returns. The challenger is characterized by the sections of reduced costs and additional returns.

Rutgers Cooperative Extension (2014) outlined the four components to a Partial Budget in *Partial Budgeting: A Financial Management Tool*. Additional costs are costs associated with the current practice (defender). Reduced returns are the profits, or returns, forgone when using the defender. The additional returns are new profits originating from the new alternative option (challenger). The reduced costs are distinguished by the outlays that would not be sustained if the challenger were selected (p.8). [4] These four estimates are the foundation of the partial budget and influence way that alternative water sources are evaluated from a nursery operation perspective.

Due to the large cost differences in the nurseries, assumptions are made to allow for comparison between diverse operations. All cost numbers are before-tax measures and the same interest rates will be used for calculations involving for capital outlays and the amortization schedule. The choice for before tax accounting limits the amount of variables in the calculations as well as reduces any confounding issues in assessing profitability across nurseries, as taxes are operation-specific. Before tax metrics allow for a better understanding of the measurements that are at work in the partial budgeting process.

Results: The cost matrix is shown below, which was constructed to summarize the costs for each nursery for the defender and challenger options. The item, in the cost matrix, is listed on the left hand side while the cost and percent of total costs is listed in the columns corresponding to each nursery.

Error! Reference source not found. is composed of the visited nursery with consideration to the defender being the recapturing and recycling option. The percentages with regard to the nurseries are relative to the overall amount spent for each individual operation. The percentages are an optimal way to assess the trends in costs between nurseries of differing sizes.

The largest outlays for the defender option are split between the regrading of the surrounding area and the opportunity cost of land for the capture pond. Of the four nurseries who would need regrading, the amount of total cost was between the range of 43% and 54%, with an average at 50% between the four. In seven of the eight nurseries, digging of pond ranks as the highest or second highest expense of the defender option. Two nurseries (E and H) incur more than 70% of the total cost for the recapture and recycle option for recapture ponds. Chlorine systems and chlorine gas amounted to an average to 0.019% and 3.78%, respectfully. There are other miscellaneous costs associated with each individual nursery; however, for the majority of nurseries and the scope of the project regrading, opportunity cost for land devoted to the pond, digging of the pond, chlorine, and chlorine systems were the most important items, as indicated by the cost matrix.

The challenger option has some decidedly different outcomes. The largest outlays for rate of city water, engineering, fees, and permits, and finally the opportunity cost of a buffer pond. The rate for city water is used for five of the eight visited nurseries as an alternative option. The nurseries alternative budget for city water ranged from 8% to 87% with the average between the five nurseries at 52% of the hypothetical budget. The engineering, fees, and permits were anticipated when a nursery had to pump in water from a far away source. These were important outlays for planning and implementing an alternative option to recapturing and recycling. The engineering, fees, and permits were used in three nursery alternatives and average 65% of the overall budget between operations. The final major outlay was filling of the buffer pond to accommodate more growing space for the business. This was a major expense in both materials and labor. Seven of the eight nurseries would experience the opportunity cost of creating buffer ponds ranging from 0.28% to 35% of their overall budget, with the average being 23%.

The Cost Matrix for Synthetic Nurseries is composed of the two synthetic, or theoretical, nurseries which form a defender option relating to well water drilling in Maryland. The defender incurs two main items, the cost and installation of well pumps and the digging of wells. Together, these two items account for more than 90% of the overall costs. The electricity for the wells is negligible, much like the actual nurseries on-site visited.

Of the two synthetic nurseries, the largest outlays for the challenger is regrading followed by dredging and the opportunity costs of the pond. The relative cost of chlorine and the chlorination system are minimal, which is similar to the visited nursery budgets. The regrading numbers are functions of the amount of soil moved, which are diverse for the small and large nurseries as the acreages are vastly different. The same calculation was used for the nurseries previously stated. The amount of soil moved is directly related to the nurseries responses from a previous study conducted by the same research team, Cultice (2013)[5].

The cost matrix figures illustrate that well water would be an advisable option for the nurseries given the basic assumptions used in the case study. However, the question remains as to how robust the results are given possible changes in water extraction costs and the opportunity cost of land. A sensitivity analysis was conducted to mitigate these concerns.

The sensitivity analysis was conducted on the cost of water extraction and the opportunity cost of land. The analysis was affected by the magnitude of the costs associated with the individual item. Water extraction was based upon the costs associated with municipal water and electricity to run well pumps. Data from previous time periods were used to forecast future prices, which were then added to the partial budgets. The opportunity cost of land was shown by the operating profit per acre for the nursery, extrapolated from the Cultice (2013) [5] survey data. Finding from the sensitivity analysis proved to be robust as there were limited changes to the overall partial budgets for the nurseries.

The Option and Totals Table below shows the nursery and most profitable option for the business. The difference in the options is show as it can be seen as savings a nursery can experience. Defender to challenger ratio measures the differences in the totals; closer to one would indicate that totals are more similar while farther from 1 would specify the totals are disparate. This table shows that from the visited nurseries six of the eight nurseries would be more profitable using recapture and recycle techniques. The two visited nurseries which would not be more profitable exhibit large ratios well above any other option.

Discussion and Conclusion: The economic impact of a recapturing and recycling program in a nursery is shown through various factors that are compared against feasible alternatives. The use of partial budgets allowed for a concise registering of the way mitigation techniques can be incorporated. The budgets synthesize the way the nurseries deal with water conservation practices and the consequences, such as pathogen contamination, that accompany them.

Visits to nurseries proved to be a rich source of information as they assessed the potential structure, implementation and costs of such conservation practices. The partial budget constructed from those case studies showed how significant outlays in capital were used in different categories across nurseries. The results indicate that remodeling of the land to encompass water recapture is the highest barrier to implementing a recycling irrigation system. The opportunity cost of the pond represents a large forgone revenue opportunity in terms of possible growing area. The utilization of pathogen mitigation technology was not of significant value when assessing the cost matrix above. Most recapture and recycle in the nurseries which use mitigation techniques were found to be more profitable than their feasible alternative. A consequence to draw from these numbers is that the reason which these nurseries have engaged in recapture and recycling is that the alternative is entirely infeasible due to location or resource constraints. The partial budgets were assumed to be under static conditions that do not allow for fluctuations of future prices.

The overall objective of the sensitivity analysis was to show how future fluctuations in either the operating profit per acre or the rate of extraction of water would affect the overall bottom line of the partial budget. The findings indicate that the water and land costs depend on the amount to which these items are factored into in the overall cost matrix. The magnitude with which the item is used would dictate how much of an effect it would have on the budget. It should be noted that the nurseries visited have been adaptive and creative; therefore, nurseries would probably find new solutions if these two inputs became too much of a burden on the bottom line of the business.

The budgets and sensitivity analysis show that changes in the water price may be a costly factor, depending on the amount of water needed for the nursery. A nursery that does not use copious amounts of water will see much less effect than a nursery using hundreds of thousands of gallons daily. It should also be noted that the cost of well extraction is far cheaper than purchasing water from a municipal source, given the factors listed within the study. The discounted cost of using well water should be tempered by possible future regulations on groundwater extraction. These regulations could be imposed due to situations germane to long term drought, contamination of the water table, or excess of extraction by increased sources dependent on the water table.

If future regulations, regarding water extraction limits, do come to pass, many nursery growers may be more inclined to focus on a recapturing and recycling irrigation path to either replace or supplement their current system. A possible program could be enacted to mitigate the costs associated with recontouring the farms through the federal government. If it can be viewed that recontouring and digging of recapture ponds is an improvement to the land, such costs could be mitigated. Such improvements would be priceless in terms of water access and availability. The continuation of these land manipulations would result in increased savings for the grower and decreased depletion of their water table. Due to the necessity of water in the horticulture business, all efforts should be made to conserve water as there is an impact on the bottom line of the operation.

The problem of pathogen mitigation is a relatively small outlay for nurseries as evidenced through cost matrix tables. However, it was assumed in the project that chlorine was predominantly used in these situations. The costs associated with chlorine may fluctuate in the future as possible regulations may become stricter and some states attempt to ban its use. These situations would cause an increase in grower's costs in fighting pathogen outbreaks. The increases to mitigation costs are not projected to be similar to the massive outlays for regrading and remodeling to incorporate recapturing and recycling in the operation. The ability to get water and/or recontour the land to accommodate water conservation are main determinants in the direction of the nurseries visited and analyzed. The costs of mitigation techniques are key to a healthy operation, and for most operations, it is still profitable for them recapture and recycle, even with increased mitigation costs.

The limitations of the project begin with the lack of a budget pertaining to the visited nurseries which do not recapture and recycle irrigation water. A synthetic nature of the solution to this limitation was achieved; however, an on-site visit would have allowed for a more accurate accounting of the costs associated with such a decision. Another limitation was the lack of inclusion of nurseries which recycle because of the necessity of the business to survive, as no other feasible alternative is possible. Thus, the selection to look at such nurseries would show that they are indeed more profitable, using water conservation techniques, due to the high relative costs of alternatives. This assumption would be supported by the high costs associated with feasible alternatives from partial budgets. However, regardless of these assumptions or alternatives, it should still be noted that mitigation and filtration technology encompass a small portion of the budget and are feasible methods that many nurseries can incorporate into their business.

The purpose of this project was to assess the way in which nurseries handle with the recycling of water. There have been a variety of factors nurseries have indicated as to why they recapture and recycle water; from ethical environmental choices, to concern about future regulations, and finally to outright survival as a nursery. The costs as they relate to decisions to recycle can be delineated using the partial budget techniques found within this study. While recycling of water can present some risks, the benefits monetarily outweigh the costs in some situations.

The method of recapturing and recycling irrigation water, even when including pathogen mitigation techniques, has proved to be profitable for nurseries. Recapture and recycle methods are important because they reduce costs for the nursery from the next best alternative as well as conserve and supply water to a business where water is tantamount to survival. As water scarcity persists around the world, it will be important for businesses, especially in the horticulture industry, to be adaptable to changing cost of water extraction.

It can be seen through the case studies that the profitability associated with recapture and recycling of irrigation water can be characterized by the overall physical location of the nursery. The physical location of the nursery is a substantial variable in the decisions to implement the recycling of irrigation water as it informs the proximity to other water sources as well as the available maximum recapture the site could retrieve. The budgets provide an in-depth analysis of the costs associated with a nursery that recaptures and recycles. Of the eight visited nurseries, it was shown that six were more profitable with the addition of recapturing and recycling water for irrigation.

An interesting byproduct of this paper is the opportunity cost and filling of the pond, which may act as a proxy for the answers to water and land resources. Some nurseries were already remodeled to where recapture ponds were already situated and able to achieve the maximum amount of retention. The opportunity costs of the pond can act as the amount of forgone profit to some, but can be seen as the cost for water security by others. In many of these nurseries there is no other alternative for irrigation water, therefore, the forgone profit may be an easy decision to make based on recapture.

It should be noted that the visits to each nursery were vastly different from each other. Each one had its own strengths and weaknesses as it attempted to implement recapture techniques and technology. The breakdown of budgets, tables, and sensitivity analysis proved to be well adept at working through each individual case. The use of these tools was paramount in allowing for a flexible analysis of each nursery that could be, partially compared to the others. However, the results from such tools should be assessed by the data incorporated for each situation.

Future studies could be conducted with regard to the breakeven point of loses while keeping in mind mitigation techniques constrained by the overall revenue incurred in partial budgets. Other studies could be focused on the differences of nurseries in various regions of the county or world, such as comparing the nurseries on the east coast of the United States, where water is cheaper and more plentiful to those located in either California or Australia. Additional research should investigate the way that savings or losses incurred from recapture and recycling affect the overall economy.

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Cost Matrix 1

Defender																
	Nursery	%	Nursery	%	Nursery	%	Nursery	%	Nursery	%	Nursery	%	Nursery	%	Nursery	%
Item	*A*	*A*	*B*	*B*	*C*	*C*	*D*	*D*	*E*	*E*	*F*	*F*	*G*	*G*	*H*	*H*
Regrading	$ 3,101	51.68%	$ 157,312	54.00%	$ 315,833	43.27%					$ 91,330	51.35%				
Extra Stone	$ 125	2.09%														
Excavation 2 Gas Tanks	$ 92	1.54%														
Chlorine System			$ 179	0.06%	$ 1,822	0.25%			$ 848	0.53%	$ 179	0.10%				
Smart Valve											$ 670	0.38%				
Cost of Chlorine			$ 28,000	9.61%	$ 16,800	2.30%	$ 70	2.45%	$ 2,240	1.39%	$ 5,600	3.15%				
Dredging			$ 20,882	7.17%	$ 179	0.02%	$ 64	2.22%	$ 1,187	0.74%	$ 9,588	5.39%	$ 9,476	17.15%		
Coppers			$ 661	0.23%					$ 2,000	1.24%	$ 587	0.33%				
Gas Tank	$ 2,682	44.69%														
Opp Cost of Recapture Pond			$ 24,597	8.44%	$ 115,058	15.76%	$ 600	20.96%	$ 40,726	25.25%	$ 39,293	22.09%	$ 11,162	20.20%	$ 10,648	23.44%
Low Fountain					$ 234	0.03%										
Bubbler					$ 854	0.12%			$ 747	0.46%	$ 107	0.06%				
Filter							$ 155	5.42%								
Fill in Upper Plot							$	-								
Labor Moving Soil							$ 444	15.52%								
Digging of Pond			$ 59,692	20.49%	$ 279,165	38.24%	$ 1,466	51.24%	$ 113,057	70.09%	$ 29,516	16.59%	$ 31,622	57.24%	$ 34,275	75.44%
Irrigation Pipes and Drains							$ 63	2.19%								
Herbicides									$ 500	0.31%						
Bromide Tablets											$ 1,000	0.56%				
Algaecide													$ 1,527	2.76%		
Coloring													$ 1,457	2.64%		
Dye															$ 511	1.13%
TOTALS	$ 6,001	100.00%	$ 291,322	100.00%	$ 729,945	100.00%	$ 2,861	100.00%	$ 161,306	100.00%	$177,870	100.00%	$ 55,243	100.00%	$ 45,435	100.00%

Challenger																
	Nursery	%	Nursery	%	Nursery	%	Nursery	%	Nursery	%	Nursery	%	Nursery	%	Nursery	%
Item	*A*	*A*	*B*	*B*	*C*	*C*	*D*	*D*	*E*	*E*	*F*	*F*	*G*	*G*	*H*	*H*
Water Availability Fee	$ 133	2.19%	$ 38,841	2.59%					$ 1,293	0.46%						
Rate for City Water	$ 4,084	66.89%	$ 1,311,497	87.40%	$ 652,550	52.45%			$ 23,236	8.19%					$ 10,444	40.73%
Gas Tanks	$ 518	8.48%														
Meter Install					$ 7,143	0.57%			$ 376	0.13%						
Water Hook Up Fee	$ 470	7.70%	$ 155	0.01%	$ 2,381	0.19%										
Meter Service Charge	$ 900	14.74%	$ 731	0.05%												
Selling off Soil			$ 94,387	6.29%	$ 252,667	20.31%										
Opp Cost Buffer Pond			$ 15,382	1.03%	$ 8,790	0.71%	$ 4,922	48.23%	$ 976	0.34%	$ 4,816	52.81%	$ 984	1.76%	$ 7,969	31.07%
Digging of Buffer Pond			$ 37,322	2.49%	$ 11,059	0.89%	$ 3,564	34.92%	$ 804	0.28%	$ 1,073	11.77%	$ 828	1.48%	$ 7,232	28.20%
Treatment of City Water			$ 2,233	0.15%												
Installation of Water Pipes					$ 61,400	4.94%			$ 8,848	3.12%			$ 1,394	2.50%		
Engineering, Fee, Permits					$ 248,140	19.94%			$ 248,140	87.47%			$ 49,628	88.89%		
Digging of Extra Wells							$ 829	8.12%			$ 829	9.09%	$ 613	1.10%		
State Permits							$ 71	0.69%			$ 71	0.78%				
Cost and Install of Well Pumps							$ 430	4.21%			$ 1,767	19.38%	$ 1,351	2.42%		
Electricity for Pumps							$ 389	3.82%			$ 564	6.18%	$ 145	0.26%		
Wire For Wells													$ 241	0.43%		
Install of Outlets													$ 646	1.16%		
TOTALS	$ 6,105	100.00%	$ 1,500,548	100.00%	$ 1,244,130	100.00%	$ 10,205	100.00%	$ 283,673	100.00%	$ 9,120	100.00%	$ 55,831	100.00%	$ 25,644	100.00%

Cost Matrix 2

Cost Matrix for Synthetic Nurseries				
Defender				
	Nursery	%	Nursery	%
Item	***Synthetic Small***	***S. Small***	***Synthetic Large***	***S. Large***
Buffer Pond	$ 993	3.71%	$ 4,764	4.24%
Digging of Extra Wells	$ 8,290	30.92%	$ 34,542	30.76%
State Permits	$ 120	0.45%	$ 429	0.38%
Cost and Install of Well Pumps	$ 16,568	61.79%	$ 69,035	61.49%
Electricity for Pumps	$ 842	3.14%	$ 3,508	3.12%
TOTALS	$ 26,814	100.00%	$ 112,278	100.00%
Challenger				
	Nursery	%	Nursery	%
Item	***Synthetic Small***	***S. Small***	***Synthetic Large***	***S. Large***
Regrading	$ 20,785	43.77%	$ 135,776	37.74%
Chlorine System	$ 179	0.38%	$ 179	0.05%
Smart Valve	$ 670	1.41%	$ 670	0.19%
Cost of Chlorine	$ 1,540	3.24%	$ 6,497	1.81%
Dredging	$ 5,178	10.90%	$ 42,865	11.91%
Digging of Pond	$ 13,771	29.00%	$ 123,328	34.28%
Opp Cost of Pond	$ 5,368	11.30%	$ 50,491	14.03%
TOTALS	$ 47,491	100.00%	$ 359,807	100.00%

Table A

Option and Totals Table for each Nursery			
Nursery	**More Profitable Option**	**Difference in Option from Alternative**	**Defender/ Challenger Ratio**
A	Recapture/Recycle	$105	0.98
B	Recapture/Recycle	$1,209,226	0.19
C	Recapture/Recycle	$514,185	0.59
D	Recapture/Recycle	$5,672	0.44
E	Recapture/Recycle	$122,367	0.57
F	Well Water	$168,750	19.50
G	Recapture/Recycle	$588	0.99
H	Municipal Water	$28,306	2.54
Synthetic Small	Well Water	$19,859	0.58
Synthetic Large	Well Water	$244,080	0.32