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Wiring the Farm: Operational Practices for Sustainable Agriculture

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Since the end of World War II a dominant trend in farming has been to produce a small variety of crops on large parcels of land using a high degree of mechanization and synthetic chemicals. These methods, now standard in conventional agriculture, have resulted in increased crop yields and contributed to the ability of the world to support a growing population.

However, environmental and societal costs are associated with conventional agriculture, triggering interest in sustainable farming. Studies of organic farming, closely related to sustainable farming, have shown a decreased dependence on fossil fuels and synthetic inputs while still maintaining comparable yields. Other research has shown that organic methods support greater biodiversity, better conserve soil fertility and have increased energy efficiency over conventional methods.

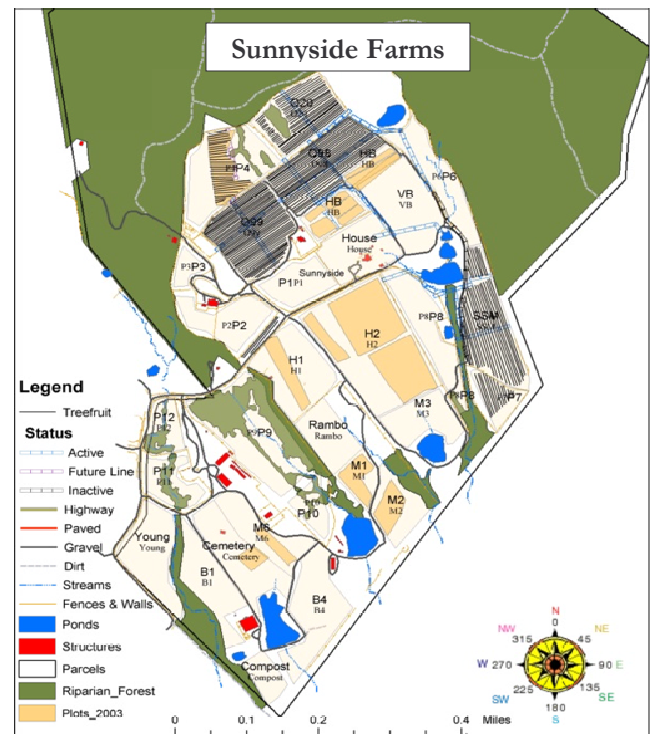


Located in Rappahannock County, Virginia, Sunnyside Farms specializes in sustainable agriculture.

The focus of our project is Sunnyside Farms, an organic farming operation located in Rappahannock County, Virginia. This is the second year that the Farm has been the subject of a Donald Bren School of Environmental Science and Management Group Project. Last year's group provided an overall accounting of the Farm in terms of the three criteria of sustainability: environmental, economic, and social performance. The group concluded that the Farm performed well according to environmental and social measures but was not profitable and therefore could not be considered a sustainable operation.

Project Scope

Our project consists of the design and implementation of an information management system that can help farm managers improve on the previous economic performance of the Farm. Our system can be used to assess the Farm's environmental and economic performance and also provides empirical evidence about the consequences of hypothetical changes in production. The model we have designed is housed in a SQL server database where data collected daily and weekly for labor, harvest and sales are entered and tracked against the forecasted values for each crop. The model provides for the management of a complex system of products, labor allocation and distribution channels. This system of tracking various economic inputs and outputs helps Sunnyside management improve the profitability of the Farm.



During the summer of 2003, two interns worked at the Farm where they designed procedures for data collection by farm employees and gathered data themselves on harvest, labor, and sales activities. Other research included collecting information on historical meteorological conditions and crop yields

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for Rappahannock and neighboring counties. Data were also collected for past national crop yields, as well as pricing for organic and conventional produce at the national level.

During the fall of 2003, the model was developed in the database through SQL queries in order to retrieve and organize the data so as to be useful for interpretation. Additionally, several analyses were performed including: (1) a comparison of key crop metrics against the projections of the model, (2) a statistical analysis to understand the drivers behind the pricing of organic produce, (3) the use of statistical methods to account for uncertainty in crop yield, and (4) an estimation of the energy inputs and the energy outputs of the system at Sunnyside. The results were used to identify gaps and opportunities in terms of operating profits and to make recommendations for more effective processes in terms of data collection, pricing strategy, and crop selection. Further research and analysis were recommended in some cases and transferability of the model to a larger farm operation was also discussed.

Results

The harvest, labor and sales data have been analyzed and organized to compare the actual with the expected values for each crop.

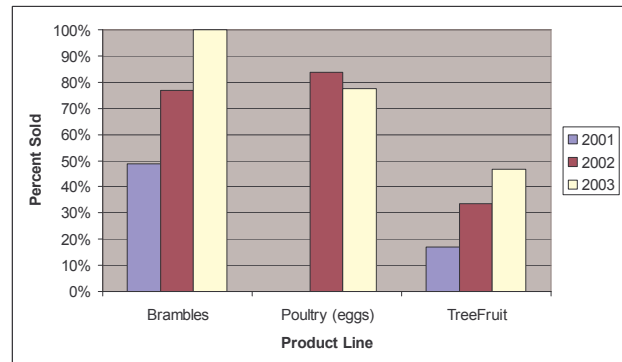
The factor that most influenced crops on the Farm in the summer of 2003 was the unusually large amount of rainfall. The rain was the primary cause of almost all the crops falling short of their harvest expectations. It delayed plantings and increased rots and fungal disease. Of the 19 crops in the model whose season is complete, only basil, peaches, and Asian pears met or exceeded their harvest expectations.

Although their harvests fell short of expected quantities, most crops commanded a higher price in the market, which partially compensated for the lost revenue from the diminished harvest. Of the 22 crops with pricing forecasts, 15 exceeded expectations, many by wide margins. In this regard, the Farm can probably adjust their expected prices upward for several crops for the next fiscal year.

Another factor that helped revenue was that the Farm has improved at selling what it harvests compared to previous years. Of 33 crops, not all of which are in the model, 21 had sales quantities of over 70% of the

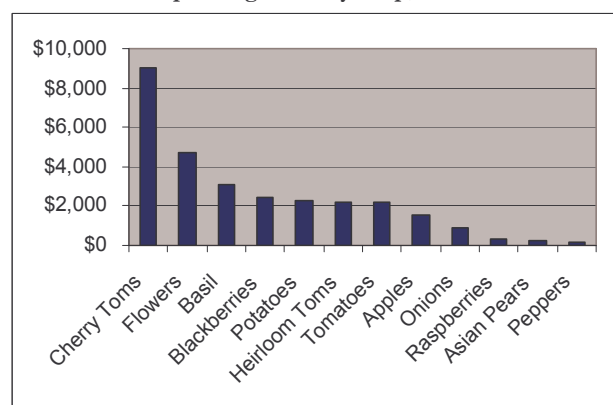
amount harvested. Only 6 crops had sales quantities under 50%. The shortfall between what is harvested and what is sold, as described in last year’s project, has been substantially ameliorated this year.

Percent of Harvest Sold by Product Line, 2001-2003



The Farm’s 2003-2004 fiscal year forecast aimed to break even as the first step in becoming profitable. The actual labor costs, material costs and revenues have been calculated in the model for the crops that have finished producing for the 2003-2004 fiscal year. Operating profits have been calculated considering labor and material costs only. The overall operating profit for these crops is \$20,027, which is about 18% of their combined revenue.

Operating Profit by Crop, 2003.



Out of the 19 crops whose harvest and sales are currently complete, 12 show an operating profit, meaning their revenue was greater than the sum of their labor and material costs. The three most profitable crops were cherry tomatoes, flowers, and basil, while the three crops that took the biggest losses were peaches, black raspberries, and carrots. The operating profit shown above is encouraging, as it marks an improvement. However, the Farm still has a

long way to go to cover the expenses that were not included in the operating profit. The results from next year, assuming that the harvest is closer to average, will give a better idea of the amount of progress that has been made.

An alternative economic performance metric that may be a better measure of individual crop success is profit per acre. The per acre profit ratio is more useful than profit alone because it puts all crops on equal footing by normalizing profit by area. The results are similar to profit alone, except that basil is the top performing crop by this measure, while carrots and eggplant lose the most money per acre.

Harvest Uncertainty

No significant link was found between various meteorological variables and selected crop yields using linear regression. The mean and standard deviation of crop yields reported at the national level were calculated and adjusted to simulate organic yields. The national yields were decreased by 20% of their original value because some research suggests that organic yields are typically about 80% of conventional yields.

Comparison of Yield: Adjusted National and Sunnyside

Crop	Adjusted National Yield (lbs/acre)	Sunnyside Yield (lbs/acre)	Percentage of National Yield
Cherry Tomatoes	20,000	21,728	109%
Bell Peppers	17,000	11,052	65%
Tomatoes	20,000	11,211	56%
Potatoes	21,000	11,632	55%
Onions	30,000	10,515	35%
Melons	15,000	3,399	23%
Red Raspberries	4,000	901	23%
Carrots	19,000	4,192	22%
Blackberries	6,000	1,291	22%
Eggplant	18,000	3,084	17%

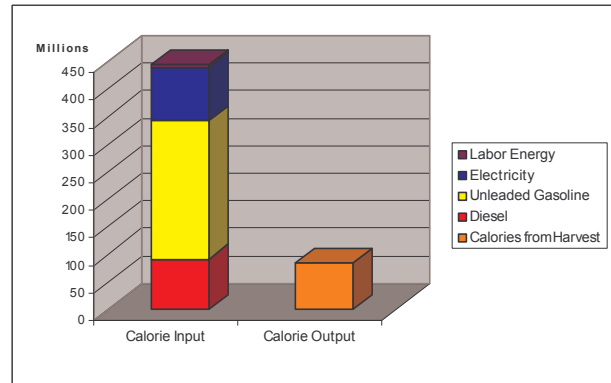
The Farm yield exceeded the adjusted national yield for cherry tomato production but was below the adjusted national averages for all other crops considered in the analysis.

Calorie Analysis

The metric comparing the ratio of the amount of fossil fuel energy used to the amount of food calories produced on the Farm was calculated and compared

to results from previous studies. The input energy measured in the analysis included fuels and electricity,

Energy Inputs and Outputs at Sunnyside



as well as human labor activities. The Farm’s ratio of fossil fuel energy consumption to food energy production was 5:1. This ratio is comparable to other ranges quoted by different authors of 3:1 and 10:1 for conventional methods. It was concluded that the Farm converts between forms of energy well and the use of unleaded gasoline has the greatest impact on the ratio.

Pricing

A regression analysis of conventional and organic produce prices was done to determine if there was a statistically significant relationship between conventional prices and organic prices. This relationship represents the price premium organic goods enjoy over conventional ones. At the farm-gate level, the estimated price premiums exceeded 100% for most the Farm’s crops. In combination with the regression results, the use of several on-going pricing reports on conventional and organic produce is recommended to help the farm managers make timely adjustments to pricing.

Model Discussion

Comparing the expected quantities of harvest, labor and sales with the recorded values for these categories shows that discrepancies exist between them. The differences between expected and actual values for the three categories can be explained in part by the meteorological conditions the Farm experienced in 2003, but improving their accuracy in future years should be a major priority for the Farm.



Adjusted national means of crop yield have been included to help approximate how much yield to expect for many of Sunnyside's crops. The standard deviations of the adjusted means also provide a measure of year to year variability in crop yields and will allow high and low estimates to be created.

As more annual data are collected the possibility exists that specific trends could become evident of crop specific labor activities or labor activities per acre. Currently the distributions of labor are based solely on the data for this fiscal year, a relatively small dataset, making it difficult to account for the effect of extraneous variables on labor versus production related tasks. There is also an absence of outside information detailing expected labor hours per activity or area, so the best estimates of these parameters are still going to come from Farm managers.

Overall the current version of the model is useful as a management tool when considered at the granularity of crop level. Recording activity and harvest data at

the crop level allows for the calculation of per acre profit for all of the Farm crops. Using the per acre profit as one measure of economic performance enables managers to determine those crops that should continue to be grown and those that should be eliminated.



Farm-gate price for organic apples is 2.65 times higher than for conventional apples.

Changes should be made to the model in order to determine the overall economic sustainability of the Farm. Some crops produced on the Farm are not incorporated into the profit calculations, meaning overall operating profits may vary. Additionally, overhead costs are not incorporated into the model, and these must be included in order to determine the overall profitability of the Farm. Accounting for all crops and costs will make the model a more effective tool for management to guide the Farm to becoming truly sustainable.

Results

- Of 19 crops whose season is complete only basil, peaches, and Asian Pears met or exceeded harvest expectations. 12 of these crops show an operating profit.
- Overall operating profits for these crops was \$20,027 in FY 03/04.
- The three most profitable crops were: Cherry Tomatoes, Flowers, and Basil. The three least profitable were: Peaches, Black Raspberries, and Carrots.
- Of 22 crops with pricing forecasts, 15 exceeded expectations, compensating for lost revenue.
- Of 33 crops planted, 21 had sales quantities of over 70% of the amount harvested.