The F.A.R.M. Food Decision Support Tool
ENEC/SILS 698
Fall 2014 Capstone

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EXECUTIVE SUMMARY

This report addresses the development of a web-based decision support system—called the F.A.R.M. (Fresh, Affordable, Resilient Marketable) Decision Support Tool—that promotes the integration of locally sourced produce into North Carolina community food systems. The system began as a summer 2014 project with the Ecoland Institute (ELI) and has since been developed into a more comprehensive tool. The F.A.R.M. Food Tool aggregates local and regional price, seasonality, nutrition, hydroponic feasibility, and geographic range data for intended use by four user classifications: producers, providers, consumers, and home growers. The user interface is not fully developed, but a demonstrative website and written data aggregation structures have been created to return useful results to all four users groups.

A case study of the tool was performed to assess its function. Carolina Dining Services (CDS), the organization that manages food supply to the University of North Carolina at Chapel Hill campus dining halls, participated in a beta-test to demonstrate a UNC-focused application of the tool. In this case study, local sourcing opportunities were highlighted, crops that could be sourced from a hydroponic facility were identified, and the nutritional composition of CDS’ most highly demanded produce items were explored. The F.A.R.M Food Tool is designed to allow for updates to both data and logic, and it can be customized to meet virtually any client’s needs.

I. HISTORY (PREFACE)

About ECOLAND Institute
ECOLAND Institute (ELI) is a nonprofit organization based in North Carolina. It supports research and development programs in future readiness, timeless communities, critical systems integration, smart cities and extended learning initiatives. ELI’s efforts include design for a timeless community that supports sustainable and resilient practices. Rochelle Blaustein, Director at ELI, served as the representative capstone client.

F.A.R.M. Food Tool Initiation
In summer of 2014, research was conducted under ELI supervision to design a community food system to fit social, economic, and environmental sustainability standards within a resilient community. Questions addressed through the summer research include:

- What produce items should be grown within the community to support a sustainable, healthy, resilient food system, using both indoor and outdoor growing methods?
- How do indoor, specifically hydroponic or aquaponic, growing methods compare to outdoor, traditional growing methods?

Significant research was conducted to determine the criteria of foods that met the standards for ECOLAND Institute’s timeless community. After identifying and collecting related nutritional, economic and environmental data, as well as information for traditional farming methods, the team recommended a list of F.A.R.M. - fresh, affordable, resilient, and marketable - foods that met triple bottom line requirements. Meeting triple bottom lining is achieving economic development, environmental protection and social equity. The list of F.A.R.M foods best suited for traditional farming methods for the current and near future use
by ELI was produced using a rudimentary version of the decision support system tool. F.A.R.M. foods that were suitable for a hydroponic growing method were also indicated.

The summer experience laid the foundation for the fall Capstone project proposal and demonstrated the potential for a functional decision support system tool within the NC food system. Through integration of price, demand, and food producers’ data, the tool could be developed and tuned for many users.

II. INTRODUCTION

Project Overview
With a notable interest in local, sustainable food systems from our client, ELI, and Americans alike, this fall Capstone project developed a decision-making tool that conveniently provides viable and equitable information about produce items to facilitate the integration of locally sourced, sustainable produce into North Carolina community food systems. The decision-making tool, the F.A.R.M. Food Tool, digests aggregated agriculture data and converts such data into useful information. The project caters to four groups of potential users: producers, providers, consumers, and growers. Producers are farmers interested in selling their fruits and vegetables, while providers are food aggregators interested in purchasing locally produced fruits and vegetables to sell to consumers. Consumers are those interested in making informed purchasing decisions, and home gardeners, or small-scale growers, are those interested in learning what to grow. The F.A.R.M. Food Tool was tested in a case study with Carolina Dining Services, which is the on-campus food service provider for the University of North Carolina at Chapel Hill. This tool will be a web-based platform for convenient use and extended access to users.

Report Layout
This report will first explore the need for increased local food consumption, broader access to produce data and the value of spatial presentation in section III. Also in section III, potential applications of the project and user benefits will be extrapolated. The methods used to collect and organize the data and the techniques and technology used to develop the backend of the decision-making tool will be described in section IV. In section V, the results of the CDS case study, example results from hypothetical user inputs, and GIS maps demonstrating geospatial dimensions of the project will be provided. Discussion of the results and limitations found in the project will be given in section VI. Lastly, steps to be taken and considerations by future developers of the F.A.R.M Food Tool will be explored in section VII.

III. BACKGROUND

Overview of Project Significance
The F.A.R.M Food decision support tool, developed during the fall of 2014, was envisioned as a resource for people with interest incorporating local, sustainable foods in North Carolina food systems. Currently, reliable information related to local, sustainable foods is inaccessible or not consolidated for meaningful use. Therefore, determining the viability and equitability of integrating local, sustainable foods for any person, or organization, is largely
The F.A.R.M Food Tool synthesizes affiliated data and information, such as where to buy local foods, where to sell local foods, which foods are best to grow and when to grow them, pricing data and nutritional data, to provide useful, informative results. The F.A.R.M Food Tool is a decision-making tool that presents sensible opportunities for various users to incorporate local, sustainable foods according to a produce item’s suitability for user criteria.

Interest in Local Food
The term “local” has become a buzzword among professionals and consumers alike. Studies have shown that consumers are willing to pay between 5% (Rushing, 2014) and 27% (Carpio, 2008) more for local food. Consumers are willing to pay more due to perceptions that local foods are healthier, fresher, higher quality, support the local economy, and more sustainable than traditional foods (Gracia, 2004). ELI, likewise, demonstrates interest in local, sustainable foods. ELI sees potential in developing a decentralized food production system for sustainability and resiliency among other purposes. Incorporating local food systems into a community’s design ensures self-sufficiency and, therefore, security when traditional food systems are compromised. The F.A.R.M Food Tool generates information for users, like ELI, to name what produce items should be grown, sold, or supported to attend the users preferences of food system criteria like produce price, nutrition, hydroponic capability and seasonality.

Need for Consolidated Food Information
Consolidated information on local North Carolina produce, produce providers and produce sellers is lacking despite the demand. In creating the F.A.R.M Food Tool, this difficulty was seen first hand. The vigor and time allotted to data collection was proof that data and information of this sort is inaccessible and sometimes unavailable. The tool aims to address the demand for centralized, digestible, thorough information by aggregating data for multiple user accessibility. Through the implementation of this tool, users can gain insight on nutritional, economic and social data for a variety of North Carolina produce items, as well as determine which produce items meet particular food system goals.

Importance of Visualization of Data and Information
Users will also be able to view the location of local food producers and providers on a map. GIS mapping of spatial results, such as producer and provider locations, was incorporated into the tool for user-friendliness. Providers include farmers markets, produce stands and retail grocers of varying size and store volume. Producers were highlighted to help users find farms that produce specific crops of interest as well as gain knowledge about what crops grow well in certain regions of the state. In general, visual representations make the flux of information and data digestible for users, creating a user-friendly resource.

Benefits of a Web-Based Application
There are several mediums in which these questions could be addressed, including a yearly PDF, excel zip file, and one-time analysis report. A web-based application was chosen for a number of reasons. First, a web-based application can be easily modified and updated for new data or scaled up to include more data sources. Additionally, it’s more interactive and dynamic in comparison to a paper report format and results of the tool can be customized based on user profile and priorities with. An online tool has the ability to reach a broader audience, provided the user audience has access to an Internet capable device.
Clients and Potential Users of the F.A.R.M Food Tool

The web application’s main user base is segmented into ELI, Producers, Providers, Community and Home Growers, and Supermarket Consumers within North Carolina.

**a. ECOLAND Institute:** Through the implementation of this tool, ELI will be able to gain insight on nutritional, economic and social data on a wide variety of North Carolina produce, as well as utilize the tool to determine which produce items meet food system goals within community development. The tool can be used to examine the economic value of locally versus nationally sourced food through a price comparison and consumer “willingness to pay” price differences. Additionally, ELI can use the tool to assess other considerations for growing produce, such as hydroponic or aquaponic capabilities, nutritional benefit, produce seasonality, shelf life, and, with future developments, the vulnerabilities associated with each produce type. Finally, the tool is scalable to adapt to additional data about NC produce, or to add data from other regions of the world as is available.

The tool provides a systematic method for ELI to categorize relevant information for various produce items. Generated lists of produce from the tool can be adjusted with various filters and user-specific tool variations, eg: produce that meets certain nutritional criteria and has high potential for hydroponic methods. Additionally, due to the array of collected data, ELI can also use the tool to examine produce items from the perspectives of food producers, providers, and consumers.

**b. Producers** can use the tool to determine what produce to grow and where to find a local provider. Producers include farmers and those who grow produce for sale.

**c. Providers** can use the tool to find pricing information about produce and where to find any of the 207 North Carolina local farm producers for which data was collected. Providers include small and large retail grocers as well as local food providers, such as grocery stores and restaurants.

**d. Home and Community Growers** can use the tool to make community and home gardening decisions about what kinds of produce items to plant based on prioritizing many different criteria. Users in this category include community garden organizers, home gardeners, schools, restaurants, and other individuals.

**e. Consumers** can use the tool to make decisions about where to purchase food, as well as learn about nutritional facts for produce. By mapping local food producers, consumers can learn about what kind of food is being grown in their area and how to contact producers. Like home and community growers, consumers can customize their priorities within the tool.

**IV. METHODOLOGY**

**A. Decision-Making Components**

102 crops common to North Carolina--grown in one or more of the three regions of the state annually--, provided by the USDA Census of Agriculture for the state of North Carolina, were
selected to be analyzed for the project. The produce items indicated in CDS records of annual produce demand were also included in this analysis. Data and information was collected for hydroponic potential, nutrition, seasonality, shelf life, color and demand (based on annual order amounts) for each crop on the table. The methods for collecting data and the significance of each component are as follows.

a. Hydroponic Potential
The hydroponic capability of a crop provides valuable information to producers, individual growers and providers about an alternative farming method that can produce crops more quickly and locally. Hydroponic and aquaponic farming methods are highly applicable to many leafy greens, herbs, legumes and tuber vegetables and can be a cost effective and convenient farming method, especially for crops that do not grow as well locally or are out of season.

The purpose of the Hydroponic Potential table is to digest the implementation of on-site produce production into three categories: Easy, Medium, and Hard. Hydroponics is an agricultural technique where plants are grown in water infused with nutrients. The term “Hydroponics” includes many applications and naming conventions, such as aquaponics, which integrates fish culture in a closed system, and aeroponics, where mists or drips of a nutrient solution are applied onto roots. Produce items respond differently to the various techniques, so not all crops are optimally grown in the hydroponic method. According to Howard Resh, “The most important commercial hydroponic crops include tomatoes, cucumbers, peppers, lettuce, and flowers” (Resh, 2012). Although these crops have known commercial value, other considerations like size, time to reach maturity, and pollination play integral roles in choosing which plants to produce given limited space, money, and effort.

**Easy**—Leafy greens and herbs, and to a lesser extent, bulb vegetables and legumes, are the simplest to grow because these plants can be grown in close proximity and have a relatively harvest time. Produce items that CDS orders and fit this criterion include: butter lettuce, Swiss chard, romaine lettuce, and parsley at 500-200 pounds; green onions at 378 pounds; red cabbage, mustard greens, arugula, and baby spinach at less than 200 pounds; finally, basil, chives, rosemary, thyme, mint, dill, sage, and lemongrass all at under 100 pounds.

Legumes and beans possess an autonomous flower structure, allowing them to bear fruit without transfer of pollen from separate gendered plants. To growers considering simplicity, autonomous pollination makes legumes, beans, and bulbs advantageous to fruits and fruiting vegetables. However, some European and hydroponic varieties of cucumber are entirely female and set fruit without pollination.

Mushrooms are not typically raised in greenhouses and require specific accommodations. However, they generate exceptional biomass given marginal time and inputs in hydroponic settings. High quality mushrooms are easy to grow indoors and are not only nutritious, but also an expensive commodity.

**Medium**—The “Medium” classification includes produce items that are economically viable within the confines of an indoor facility, yet require more labor. Fruit vegetables, such as peppers and tomatoes, make for great hydroponic crops, but require greater attention to fruit successfully. These plants mature more gradually than produce classified as “easy” and, therefore, call for adequate spacing for flowering and only bear fruit if, then, pollinated. Pollination is a challenge to hydroponic growers as bees or winds pollinate fruiting vegetables
such as tomatoes, peppers, and eggplants. In greenhouses, however, airflow is insufficient for flowers to pollinate, so producers must also cultivate beehives (~$350/hive/0.5 acres) or tickle the petals manually. Using space and time efficiently is a priority of producers. Heating, cooling, or illuminating greenhouses is an extra difficulty.

**Hard**—Produce items classified as “hard” to grow hydroponically are the least-well suited plants—albeit plants that have had some prior success being cultivated hydroponically. As NASA demonstrated in their effort to grow spuds in space, root and tuber vegetables can be successfully grown in soilless cultures without pollination or a great deal of space (NASA, 2004). However, in light of economic subsidization and mass-production of root and tuber vegetables, they are not recommended for the hydroponic method. Space dedicated to potatoes is less valuable than dedicating the space to more cost-competitive produce items like asparagus or spinach. Space, time, and upfront investment rule out many fruiting plants from traditional hydroponic facilities; however strawberries, grapes, lemons, and some other species of fruits which have higher market value are grown in greenhouses despite requiring more space and infrastructure than leafy greens or herbs.

**N/A**—Unfortunately the additional infrastructure necessary to support a chestnut tree, or apple tree, renders fruiting trees out of reach for most small-scale facilities. The “N/A” category also represents a catchall assignment for all produce items that are simply unrealistic for the average facility to produce. Although few plants cannot be produced hydroponically, some plants are not favorable—like the grains and field crops, for example. Similar to potatoes, grains and field crops such as corn, wheat, barley, and other cereals can be easily, if not more timely, reared in a controlled environment, however the massive scale and subsidy which buttress the expansive production of these crops renders local greenhouse investments very unprofitable; therefore these crops are not recommended for the hydroponic grower.

<table>
<thead>
<tr>
<th>Potential Classification</th>
<th>Produce Category</th>
<th>Prime Examples</th>
<th>Notable Exceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy</td>
<td><em><em>Leafy Greens, Herbs, Legumes, Bulb Vegetables, Mushrooms</em>, Stem Vegetables</em>*</td>
<td>Bibb Lettuce, Arugula, Basil, Snow Peas, Bean Sprouts, Green Onions</td>
<td>Cucumbers</td>
</tr>
<tr>
<td>medium</td>
<td>Fruit Vegetables</td>
<td>Tomatoes, Peppers, Eggplant, Squash</td>
<td>Carrots</td>
</tr>
<tr>
<td>hard</td>
<td>Fruits, Root Vegetables, Tuber Vegetables</td>
<td>Beets, Radishes, Blueberries, Melons</td>
<td>Strawberries</td>
</tr>
<tr>
<td>N/A</td>
<td>Fruits, Tuber Vegetables, some Cereals</td>
<td>Apples, Potatoes, Corn</td>
<td>Barley</td>
</tr>
</tbody>
</table>

Table 1. Table of Hydroponic Classifications
b. Nutrition

The significance of nutrition information varies among users. Individuals would benefit from nutritional information to make informed decisions about what foods to consume and what items to be grown in home gardens. Nutrition and diet is a vital factor in overall public health and wellbeing, as the effects of malnutrition on productivity, development, health and mental wellbeing can be detrimental and, sometimes, long lasting (Burchi, 2011). In providing access and availability to resources to maintain a balanced diet among individuals, a healthy, productive community can be sustained. Improving a community’s diet is important for reducing healthcare costs, avoiding missed workdays and benefiting workplace productivity through disease prevention. By delivering a nutritionally balanced set of foods, healthy lifestyles are promoted, which can reduce the risk of chronic diseases, such as heart disease and cancer. In promoting healthy citizens, a healthy workforce and healthy economy are encouraged. Producers and providers benefit from nutrition information as more nutrient dense foods are in high demand, which affects a consumer’s willingness to pay. Additionally, in providing nutritious food, producers and providers can foster a health-focused reputation encouraging customer loyalty and, again, willingness to pay.

A balanced diet, with a full array of nutrients in the right amounts, is key to disease prevention. To get the complete array of essential nutrients (nutrients that cannot be synthesized in the body and, therefore, need to be incorporated into the diet) in good proportions, consuming quality foods and maintaining a diverse diet is necessary (FAO, 2010). In supporting nutrient dense diets, people can live healthy, fulfilling, and productive lives.

Produce items were ranked for nutritional quality, which was defined by a food item’s density of essential nutrients. The density of essential nutrients in a food item was determined using a tool called the Completeness Score™ from Self Nutrition Data (2014). Self Nutrition Data is a website that provides free nutrition information and was found to be a transparent resource based off the website’s description: “Nutrition Data’s continuing goal is to provide the most accurate and comprehensive nutrition analysis available, and to make it accessible and understandable to all. The information in Nutrition Data's database comes from the USDA's National Nutrient Database for Standard Reference” (Self Nutrition Data, 2014).

The Completeness Score™ is the density of the essential nutrients contained within 1000 calories of a food. Specifically, it incorporates the percentages of FDA Daily Values contained within a 1,000-calorie portion of a food item. The Completeness Score™ reflects how well a food fulfills the need for all of the essential nutrients, including dietary fiber, protein, essential vitamins (Vitamin A, Vitamin C, Vitamin D, Vitamin E, Vitamin K, Thiamin, Riboflavin, Niacin, Vitamin B6, Folate, Vitamin B12, Pantothenic Acid), and essential minerals (Calcium, Iron, Magnesium, Phosphorus, Potassium, Zinc, Copper, Manganese, Selenium). The Completeness Score™ evaluates how a food meets the necessary nutrient array.

The source was checked against raw data from USDA National Nutrient Database by manually calculating nutrient content of items then comparing it to the The Completeness Score™ [Fig. A] from Self Nutrition Data. It was found that the Completeness Score™ was able to interpret relative nutrient content of food items.
The Completeness Score™ for items with a specified attribute that had no results was marked by the most generic produce character affiliated. For example, both “Pink Grapefruit” and “Red Grapefruit” had no score recorded, so both items were recorded with the generic “Grapefruit”, which had a Completeness Score™ result. If neither generic alternatives nor synonym names yielded results, the produce item had no score recorded.

A second data collection for nutrition was performed to obtain more stratified data. A database of nutrient content for each food item pertaining to the F.A.R.M Food Tool was created. Water, protein, total fat, total carbohydrate, total sugar, total dietary fiber, calcium, iron, magnesium, phosphorus, potassium, sodium, zinc, vitamin C, thiamin, riboflavin, niacin, vitamin B-6, vitamin B-12, folate, vitamin A, vitamin E, vitamin K, vitamin D, total saturated fatty acids, total polyunsaturated fatty acids, total monounsaturated fatty acids, cholesterol, and caffeine amounts per 100 grams of a food item were recorded in the database. Data was sourced from the USDA National Nutrient Database for Standard Reference (USDA, nd). A comma-delimited text file of the nutrient information for each item was downloaded, the Value per 100 g data was selected for to have consistency among produce items and all selected data was organized into a table containing the nutrition data for all food items in the tool. Missing data was handled in the same manner as with the Completeness Score™.

The stratified data for each food item would allow for additional data manipulation to lend to more possibilities of information generated in the F.A.R.M Food Tool. Due to scope and time constraints, the more categorized nutrition data collected was not utilized. However, the data holds great potential for the phase two session of tool development (see section VII).

c. Seasonality
The seasonality data for each crop informs producers when the most ideal times to plant and harvest are by traditional, outdoor methods. This can apply to both farmers and community/individual growers. Seasonality data helps providers to know when demand for certain produce will peak, or when they might benefit most from sourcing from a local producer. For example, NC Top Crops, or NC’s most successful crop commodities, grow most successfully and are at a low cost when they are in season. For consumers, seasonality data can inform when certain produce items are going to be in season and can help in consumption decisions on a monthly basis for those who are interested in buying fresh and local produce. The fall and spring plant and harvest dates for each North Carolina crop by region were sourced primarily from North Carolina State University Planting Guides and were supplemented by the Farmer’s Almanac Planting Date Calendars by city. For the purpose of standardizing plant and harvest dates, sources that described dates as being the “first of the month” or “early” were recorded as the first day of the month. “Mid month” was recorded as the 15th day and “end of the month” or “late” was recorded as the 30th day of the month. For produce items that had varying plant or harvest dates for the same region across different sources, the one that was most frequently recorded was used in the data. Additionally, for produce items such as baby spinach, for which there was no seasonality data across any of the sources, the seasonality for plain spinach was used, assuming that the seasonality for the two species would be in sync. For the purpose of this phase of the data aggregation, the results do not heavily rely on regional seasonality. In the future, it is planned to expand on this data to include price variations by season of each crop to help users find the most ideal times to source crops locally.
d. Shelf Life

Shelf Life data helps growers, providers, and consumers alike make decisions about which produce are most practical for them to buy and sell, given their storage capacity and distance from market and demand. Shelf life information is broken down by pantry, refrigerator and freezer lives in order for users to get the most accurate idea of how long their produce will last based on the facilities available to them. All shelf life data was sourced from the Ultimate Guide to Shelf Life at Stilltasty.com. For any produce item in which their shelf life data could not be acquired, estimations were provided based on information obtained for closely related species. For example, the shelf life for Napa cabbage was used to estimate the shelf life of green cabbage. For produce items that did not have a closely related species, they contain no shelf life entries in the database and this is a section of the database that can be expanded upon in the future. This website was the most comprehensive source for shelf life and food storage and contained data on nearly all of the produce items. According to the website, they source their information from food safety research conducted by the USDA, the FDA and the U.S. center for disease control. Their content also incorporates research done by state government agencies (Stilltasty, 2014).

e. Price

The average national pricing data for each produce item was obtained from the USDA website. As an annual average, national pricing did not take into account fluctuations with season. Average price data for Raleigh, North Carolina was also collected to better compare average national and average North Carolina prices. The data was derived from a custom search ran on the USDA Agricultural Marketing Service website, which listed the daily shipping point prices of all food commodities in Raleigh, NC throughout 2013. Additionally, pricing data for North Carolina farmers markets, including statewide farmers markets averages, farmers market averages for Eastern and Western regions separately as well as market averages for Raleigh, NC was provided by the North Carolina Department of Agriculture and Consumer Services. All price data were standardized from produce-specific units, such as bushels, to price per pound using the conversion guide provided by USDA’s Weights, Measures, and Conversion Factors for Agricultural Products and Their Commodities. Storage of this price data allows users to see which products are less expensive when purchased at a local farmers market as opposed to a grocery store, which typically sources produce from farther away.

f. Demand

Demand for produce items was determined using total poundage shipped on an annual basis to the Carolina Dining Services (CDS). As pricing data from CDS was not yet acquired, the best method for indicating demand was to calculate total poundage of each produce purchased by CDS over a year and compared these totals to those of the same produce family to determine which crops are most essential to meet their daily needs. Many of the produce items in the CDS order data were displayed in several different forms and in different units. For example, carrots were reported as “whole carrots”, “baby carrots” and “peeled carrots”, each with specific packaging and poundage measurement. For produce items that were broken down into different forms, but of the same food type, each weight was added together to produce a total annual poundage for that product. Other products were broken down into several different measurement units of weight or volume. For example, Idaho potatoes had one entry in units of pounds and a second entry in units of cartons. As used for price data standardization, Table 6 of the Weights, Measures and Conversions Factors for Agricultural Products and Their Commodities.
Commodities and their Products was used to make conversions between these different units. All units were converted into pounds and then total annual poundage was calculated.

g. Producer and Provider Location
Provider location data was acquired from the Business Listing Files published by Infogroup (Infogroup, 2014). A shapefile of North Carolina food providers was used to produce a map that displayed each of these providers by their total sales volume. North Carolina farmers market name and location data was acquired from the UNC School of Public Health’s Community Transformation Grant project. Producer information was obtained from the North Carolina Department of Agriculture and Consumer Services. Location data was taken from the NCDA&CS directory of farms in the Piedmont NC region found on the NC farm fresh webpage. Kevin Hardison from the NCDA&CS marketing division supplied additional producer data that allowed us to determine what crops certain farms were producing.

h. Vulnerability
The extent to which crops are vulnerable to climate conditions and price inflation is a growing concern for producers, providers, and consumers alike. Assessing the vulnerability of a food shed, or a region that provides a given population with its nutritional demands, involves a national and even global supply chain. Very few populations in the United States have access to local food, which has consequences on food system nutrition, resiliency and security. In fact, centralizing food production about large population centers causes greater risk to food security in the event of a drought or natural disaster. Despite this, policy makers incentivize regions to specialize agricultural practices according to their natural comparative advantage, which advocates for countries and states to produce crops particular to their climate region for economic advantage.

NC was classified into three basic categories—Coastal plains, Piedmont, and Mountains (Blue Ridge)—representative of differing soil types and biomes that are more adequately suited to produce certain crops over others. NC Top Crops were generalized into regional categories. For example, orchards are predominantly grown in the mountains and sweet potatoes associated to the coastal plains. This is important information for ELI and other potential producers if they intend to grow produce in local soils. Different climate regions have a comparative advantage to grow certain foods over others. However, much more data relating crops to soil type and water consumption needs to be collected before this information can be used to make decisions about vulnerability on a local level.

North Carolina residents, as well as the students served by CDS, consume a diverse assortment of produce items from all around the nation and world, so the NC “food shed” cannot be confined to state boundaries. Many produce items are sourced in more regular climates than the seasonal temperate biome, and upon further review it became apparent that for many agricultural products that place is California.

As indicated in the maps above from the USDA Census of Agriculture, lettuce and tomatoes, two crops of particular interest to the commercial hydroponic grower, are predominantly sourced from California. In fact, in 2012 California produced 85% of the nation’s leaf lettuce and 96% of the nation’s processed tomatoes (CDFA, 2013).
According to the US Drought Monitor’s intensity index, an exceptional drought classification describes “water shortages and emergencies” and “widespread crop/pasture loss” (US Drought Monitor, nd). Half of California is in this condition, which creates an exigency to address the most vulnerable crops from California because of their high-risk location. The USDA’s California Drought 2014: Food Prices and Consumers forecasts the drought’s effects inflate fresh fruits and vegetables prices to 3.0 to 4.0 percent and says, “With respect to fruits and vegetables, the immediate concern is the cost and availability of groundwater to supply the crops. Owing to higher production costs, insufficient water, or both, producers may opt to reduce total acreage, driving up prices not just this year but for years to come. At this point, it is too soon to discuss the extent to which this is likely to happen throughout California” (ERS, 2014). This suggests that more fruits and vegetables may become cost-competitive to source from North Carolina. However, North Carolina is not immune to drought, and nowhere is safe from the effects of climate change, so “vulnerability” cannot be complete with an analysis of California’s contribution to the national and local food system. A vulnerability analysis could be a greater asset to the decision-making tool if one evaluated produce items individually for their specific locations, instead of analyzing a high-risk location for its vulnerable crops.

B. Decision-Making Structure Methodology

In selecting which criteria to feature in each of the four user decision support tool specifications (producer, provider, consumer, grower), all possible objectives that each user group might hope to achieve in using the F.A.R.M Food Tool were fitted into the product. The web interface component allows for users to prioritize the criteria to fit their specific goals. Several example criteria for each user were evaluated to assess functionality.

In the provider-specific tool, average price data for produce items for the United States were compared to North Carolina state farmers market price data by region to display the produce, which could be sourced more cheaply if locally grown. Nutrition data was also included for providers interested in learning about nutrition completeness of the products offered, and how overall nutrition of the foods supplied could be improved. The nutrition criteria could be
of interest to providers such as Carolina Dining Services and restaurants. Finally, the hydroponic potential of produce items was included for providers interested in opportunities to grow cost effective products on-site.

Providers would self-select “provider” when accessing the homepage of the web application. It was assumed that across a variety of providers, price was the only parameter that was consistently relevant in deciding whether to source a given produce item locally. All other potential factors that could influence purchasing decisions, including perceived benefits in quality, nutrition, health, local economy, and environmental impact, were difficult to quantify and not equally valued by all providers. The user would input his or her location. The provider-specific tool would compare the average national price from the USDA to the highest resolution average local price available for a given produce item. The F.A.R.M. Food Tool would return produce items highlighted as green whose local prices were less than or equal to national prices. The tool would return produce items highlighted as yellow if the price difference between local and national prices of a produce item was covered by the average customer’s willingness to pay more money for local produce. The tool would return produce items as red if the price difference between local and national prices of a produce item exceeded the willingness to pay adjustment. The tool also would return information for each produce item that providers could use to make their own value judgments, including hydroponic potential, color, nutrition facts, category, and vulnerabilities.

In the producer-specific tool, price criteria was included in order to inform growers of what crops are easily grown in North Carolina and the monetary return to expect from growing and selling a particular crop. Hydroponic potential of produce items was also included for producers interested in learning about what crops could be grown using an alternative hydroponic method. Here nutrition data was also included for producers who prioritize growing nutritious crops.

When accessing the homepage of the web application, producers would self-select “producer”. It was assumed that farmers are mainly interested in crops that can be grown in the soil in their region and also that farmers are interested in growing crops that are in high demand. All other qualities that might influence growing decisions, including price and seasonality, may vary in importance from producer to producer and were therefore not directly included in the tool. The user would input his or her location and application would pull the current month. The tool would return a list of produce items that could be grown in the farmers' region with plant, or harvest, months that would match the current month of the user and be sorted by their relative demand. First, the tool would select the produce items that would be grown within the region corresponding to that location. Next, the tool would sort these results by category, and then by highest annual average price. For example, carrots would be ranked within the root vegetable category, while apples would be ranked within the fruit category. Each produce item on the list would be displayed with its attending data, including its average local price, planting and harvesting dates, seasonality, willingness to pay, hydroponic potential, and North Carolina top crop. When a user would click on a specific produce item, he or she will see a map with farmers market locations that sell that produce item.

For the community and home grower user, only hydroponic potential and nutrition were included as ranking parameters. These criteria were considered to be the primary interest of individuals only growing produce for themselves. This user would key in a zip code and would specify a mile range from zip code to search within. The tool would return a list of produce...
that grows in the specified area. The user would have the option to choose from a range of selectable criteria: produce category, color, seasonality, nutrition, hydroponic capability, or price and can choose up to five selectable criteria. The user would rank selectable criteria in order of subjective importance and the tool would sort the items by each of the criteria. A final, sorted list would be outputted. The seasonality information for each listed produce item would be displayed, including dates for planting and harvesting in spring and fall, if applicable. Produce category, color, seasonality, shelf life, nutritional completeness, hydroponic capability, and price for each produce item could be displayed as well. When clicking on a produce item, the user would see a GIS mapping of producers that grow that item in a specified range.

For the consumer-specific tool, price data was a significant criterion, as the ability to find cheaper local produce options would be a primary concern for a grocery shopper or restaurant goer. Nutrition was also included to give consumers an idea of how they can build a more complete diet through the produce they choose to purchase.

For the consumer-specific tool, the user would be able to key in his or her zip code and would choose important factors from a list of selectable criteria: category, color, seasonality, nutrition, hydroponic capability, and price. The user would be able to choose up to five selectable criteria and then would rank them in order of importance. The tool would sort items by the selected criteria and a final sorted list would be displayed. Again, attending data for each produce item would also be shown, such as category, color, seasonality, shelf life, nutrition, hydroponic capability, and price. When clicking on a produce item, user would be able to see a map of producers that grow that item and providers who sell that item in a specified distance.

The CDS case study did not involve a client using the web application. As a result, the functional requirements were geared towards direct access to the database. CDS-specific produce items were sorted by category, such as tuber and then were sorted by hydroponic potential. Next, the items were sorted by demand, as measured by percentage of the pounds ordered of the item divided by the total pounds of the item’s category. The final, sorted list of produce items was displayed. Attending data for each produce item was also displayed, such as category, hydroponic potential, and amount of production within NC in tons.

While information on seasonality or shelf life was not used in the user-specified variations, this data was intended to be displayed within the web interface to give users more complete information about what produce were going to be most practical for them to grow, sell or consume, given the time of year, the implications this information would have for demand and the degree of ease of storing each crop.

C. Database and Business Requirements Methodology

i. Technology notes
Database version and host box: PostgreSQL 9.3.5 x86_64-unknown-linux-gnu, compiled by gcc (Ubuntu 4.8.2-19ubuntu1) 4.8.2, 64-bit

ii. Overall design methodology
As this project was undertaken with the knowledge that the data collection, database design, and implementation would occur simultaneously, it was elected to pursue a more agile approach to development than the traditional systems development lifecycle. During the initial requirements gathering process, the team mapped out an entity-relationship diagram to identify focus areas for data collection, and began structuring the database itself. As data was collected, it was standardized to match the agreed-upon names and units (e.g. standard produce names, price per pound), and entered into the database. The structure of the database did not undergo any major revisions, but some tables were added, dropped, or combined to fit the structure of the data.

### iii. Data Standardization

To have consistency in identifying data, the tabulated names of produce were altered to match the produce name listed in the CDS data. In order to normalize the original data in the database, the produce nomenclature was normalized across each of the tables as well. Generally, it was attempted to keep produce names consistent with conventional naming so as to minimize future standardization issues as much as possible. Produce was identified as a singular unless food type was commonly seen in groups, such as berries and grapes. Titles had no punctuation and were the adjective followed by the noun (type of produce). For example, “Apple, Granny Smith” would be normalized to “Granny Smith Apple” and “Grape, Red” would be normalized to “Red Grapes”. In the previous examples, each item is normalized to match its commonly pronounced name and is either singular or plural depending on how many servings of the item are usually consumed in a sitting. Standardizing the data in this way will make it easier for users to search and locate the produce items they are curious about learning more about.

Additionally, standardized names for each produce item makes data more convenient to upload. Because the information drawn from the decision support system is only as reliable as the data, data should remain current and easily updatable. The databases are designed to have data easily applied by the tool and add more data to allow for a variety of data sources.

### iv. Tables

The database was designed to be a back-end for the web application commissioned by ELI, the main client. As the data was collected, some tables were added or generated by scripts to facilitate conversion and querying processes on secondary client-specific data, such as the demand data from Carolina Dining Services. These tables are shown in the ER diagram attached (see Fig 3), outlined in dashed lines. Future clients may also require additional personalized tables.

#### a. EcoLand Institute and the four actor profiles

The queries ran from the front-end web application focused on the interests of four main parties: consumers, home and community growers, food providers, and food producers. The queries search information about the produce items themselves, as well as information about producers, providers, and pricing. As such, the produce information is broken down into several tables, which includes information about the produce item’s basic features (e.g. color, category), as well as features that would interest each of the parties above, such as shelf life, planting and harvesting dates for each North Carolina region, nutritional content, nutritional completeness score, and ability to be grown hydroponically. The basic information about the produce item was contained in a single table, with seasonality, nutrition, nutritional completeness score, and hydroponic potential as separate tables linked to the
main table by the unique produce name. The current design allows tables to be added and linked to the main produce table, or rows to be added to the main produce table, without considerable redesign.

Provider information is contained within four main tables, three of which listed the retail grocers, produce stands, and farmers market outlets in North Carolina. A generic provider table was also created, which includes space for the addition of new providers in the future, while also acting as a template for searchable provider information, such as name, address, hours, website, and phone number.

Producer information includes the name, location, and contact information for North Carolina farmers that sell at farmers market outlets. The producers are geocoded to allow for the creation of GIS maps that showed producers within a certain range or mile radius of the zip code that the user entered into the web application. Producer information is also linked to the produce table through a table that listed the different crops that each producer grows. As a result, the maps and text results of queries could be adapted to show producers of a certain produce item, or which items nearby producers grow. Additional producer data showing the most commonly grown crops in North Carolina is contained in another table, and rankings of each of these top crops can be included in queries to show producers, providers, and consumers which crops are likely easiest to buy locally.

Pricing information is contained within a single table, which lists the produce item, its average national price, average price for each region of North Carolina as reported by the USDA, and average local farmers market price for each region of North Carolina.

In order for the database to be able to store archived information, a table was created to list the sources and dates for the data in each table. This table includes the name of each table, the date that it was added to the database, the date range of the data in the table, and the source of the data. Additionally, tables containing time-sensitive data such as pricing, providers, or producers, all include the year of the data in their name. As new time-sensitive data is added to the table in the future, it can be added to new copies of the tables. Older tables can then hold the archive data, and queries can either search across time and compare data from archived and current tables, or only search data in current tables. This table is also shown on the attached entity-relationship diagram, outlined in dotted lines.

b. Carolina Dining Services
Carolina Dining Services acted as a beta test for the back-end database of the web application. Data was provided about the quantities of produce items ordered, and whether these items were sourced locally, over the course of the 2013-2014 school year. The produce names were standardized to match the naming scheme already in place, and used USDA standards to convert the produce from original shipping units to pounds. Both the original data and the standardized, converted data were loaded into the database for storage and analysis, respectively. The standardized data was then processed through scripts, which determined the total quantity of produce ordered in pounds, the demand of each item as a percentage of the total demand, and the total demand for that category (ex. demand of sweet potatoes as a percentage of total demand of all produce, and total demand of all tuber vegetables). These values were entered into another table that showed the produce item, category, whether or not the item was sourced locally, and the percentages of total and category demands. This table allowed for easier querying since the information about the
produce items and demand could be pulled from a single table, and matched with information from other tables, such as hydroponic potential or the top crops grown in North Carolina. The final report to Carolina Dining Services highlighted high-demand items that are not currently sourced locally, but that are easy to grow hydroponically or frequently grown in North Carolina, along with highly nutritious produce items that are not currently ordered in large quantities.

v. User Decision-Making Specificities

The project team designed and tested four main queries to represent the four decision-making schemes used in the web application. The team designed the queries to retrieve a range of results and rankings that would reflect user cases across the three regions of North Carolina. Example queries and a description of each are included below and the coding for the example queries are found in Appendix A.

a. Provider

The provider-specific tool is designed to rank the importance of certain attributes, such as price, and retrieve a list of produce and related information that reflects this ranking. This particular query (see appendix A.a) returns the produce name, seasonality, pricing information, nutritional completeness score, hydroponic potential classification, and top crop ranking, if applicable, for a provider in the coastal region. It sorts produce items by local farmers market prices from lowest to highest, then by the difference between the local price and the national price, where items with the largest price difference favoring local prices are listed first. These results will help providers know which produce items are likely to be cheaper and easier to source from local producers, as well as when these crops are in season locally.

b. Producer

The producer-specific tool is designed to help local farmers determine the hydroponic potential, nutritional content, seasonality, pricing, and demand of crops in North Carolina. This particular example (see appendix A.b) for a farmer in the Mountain region, sorts the crops based on western farmers market prices, then the difference between those prices and the USDA national average price. Eventually, more demand data will allow producers to make planting decisions that will allow them to maximize profitability during each season, by taking advantage of what is in high demand, and what is likely to be purchased more cheaply from local sources.

c. Community and Home Growers

The Community and Home Grower decision-making specification allows home gardeners, restaurants, and other individuals to learn about the nutritional content, seasonality, and hydroponic potential of different crops. They can then make decisions about what to grow in each season in order to supplement their dietary preferences with nutritious food. This particular example (see appendix A.c) is for a home gardener in the Mountain region.

d. Consumer

The consumer-specific tool is designed to help individual food purchasers choose nutritious food that is inexpensive to purchase locally and is in season. This example (see appendix A.d) returns information about the produce item, seasonality, and price for the Piedmont region.
V. RESULTS

Carolina Dining Services Case Study

Carolina Dining Services (CDS) is a major food provider on the University of North Carolina at Chapel Hill campus that runs UNC’s dining halls and on-campus grocery and restaurant services serving over four million students per year. A CDS case study was performed on CDS data to demonstrate the tool’s adaptability to different client cases and to validate its usefulness. The tool was used for CDS to highlight opportunities to purchase more competitively priced local food and to indicate the best foods for potential on-site hydroponic production. The UNC-Chapel Hill case study uses anonymized data from CDS and other local aggregators as “proof-of-concept” for the tool. A query was customized to provide three distinct series of information. This specified query is expanded on in the Carolina Dining Services section of the Database Methods within the Methodology section of this report. CDS was classified as a provider in that it purchases food to serve in the dining halls. Elements of the producer specified tool were incorporated due to CDS’s interest in sourcing food from a
hydroponic greenhouse. This case study demonstrated that the F.A.R.M. Foods Tool was customizable and could deliver meaningful information rather than simple data.

After careful analysis of the tool results, CDS was provided with recommendations for crops that could be sourced from a hydroponic greenhouse, a list of locally-grown produce which may be cheaper than produce grown outside of North Carolina, and nutritional Completeness Scores™ of CDS’s highest demand produce items.

<table>
<thead>
<tr>
<th>Produce Name</th>
<th>Local (Y/N)</th>
<th>Demand in Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet Potato</td>
<td>Y</td>
<td>23.9%</td>
</tr>
<tr>
<td>Purple Sweet Potato</td>
<td>Y</td>
<td>0.1%</td>
</tr>
<tr>
<td>White Sweet Potato</td>
<td>Y</td>
<td>0.1%</td>
</tr>
<tr>
<td>Red Potato</td>
<td>N</td>
<td>33.3%</td>
</tr>
<tr>
<td>Idaho Potato</td>
<td>N</td>
<td>19.5%</td>
</tr>
<tr>
<td>Yukon Gold Potato</td>
<td>N</td>
<td>14.1%</td>
</tr>
<tr>
<td>Fingerling Potato</td>
<td>N</td>
<td>9.0%</td>
</tr>
<tr>
<td>Potato (Unclassified)</td>
<td>N</td>
<td>0.2%</td>
</tr>
<tr>
<td>Jicama</td>
<td>N</td>
<td>0.1%</td>
</tr>
<tr>
<td>Sweet Potato</td>
<td>N</td>
<td>0.01%</td>
</tr>
</tbody>
</table>

Figure 4. Excerpt of CDS report in tabular form

Based on the results of this case study, price, source location, and monthly purchasing data were requested from CDS in order to increase the specificity of the concluded recommendations. It was recommended that CDS decrease the amount of produce it sources from California, add more interactive nutrition information in its displays, and continue to explore a potential partnership with a hydroponic facility operator.

Consumer F.A.R.M. Food Tool Results
The results of the F.A.R.M. Foods decision support tool produce a list of the most affordable and nutritious foods grown in the consumer’s area as well as provide valuable seasonality data for the suggested produce items. For example, when run for the Piedmont NC region, the consumer specified tool found cabbage green, carrot, cucumber and red beet to be the top four most nutritious and affordable foods. Cabbage green was the number one ranked commodity with an average central NC farmers market price of $0.29 per pound and a nutritional completeness score of 81. Carrot was the second with an average price of $0.38 per pound and a nutrition score of 74. Cucumber was third with an average price of $0.50 per pound and a nutrition score of 79, while red beet was the fourth ranked commodity with an average price of $0.66 per pound and a nutritional completeness score of 63. These data accompanied by seasonality information help consumers and home growers to understand which crops will be most beneficial to purchase or grow, as well as when they are in season.

Provider F.A.R.M. Food Tool Results
When run for an eastern NC provider seeking the most cost-efficient produce sources, the F.A.R.M. tool revealed that eggplant, cucumber and green bell pepper were the most profitable commodities to purchase from local providers in their region. Analysis of the results exposed that a pound of eggplant purchased from eastern NC farmers markets was $0.50 cheaper in that region than the average USDA price. Similarly, cucumbers and green bell peppers were significantly cheaper per pound--cucumbers by $0.25 and green bell peppers by $0.17, when purchased from local farmers markets. These results suggest than an eastern NC provider could save 45% on cucumbers, 62% on eggplants and 26% on green bell peppers by purchasing directly from local growers. The retail price difference between locally and nationally sourced produce is expected to carryover into wholesale price comparisons as well.

Producer F.A.R.M. Food Tool Results

When run for an eastern NC producer interested in maximizing profits, the F.A.R.M. tool revealed that asparagus and broccoli are potentially the most lucrative crops to grow, while green bell pepper was most likely the least. At a price of $3.06 per pound, asparagus from eastern NC farmers markets is being sold 67% above the USDA national average of $1.83. Similarly, the results showed that broccoli is purchased from local farmers markets at a price 21% above the national average. The results also show that green bell peppers may not be a profitable crop for eastern NC farmers, as it is being sold at eastern NC farmers markets for 69% less than the national average. By providing a comparison between local farmers market price and average USDA national (or statewide, where applicable) price, the tool allows producers to gauge which foods consumers are currently willing to pay the most to have locally sourced. These results provide eastern NC farmers with information that helps to maximize profits while simultaneously increasing the supply of locally grown produce.
Front-end Website Mock-up

Images of the website are shown below.

**Figure 5. Results page of the F.A.R.M Food Tool**

**Figure 6. The Website features a pop up map for Locations of nearby Producers and Providers**
VI. DISCUSSION

The information outputs of the food decision-making tool are only as good as the data inputs. To provide optimal data resources, issues of data availability, access, and quality are necessary considerations. Data availability is a concern if the agriculture figures of interest are not on record. Availability was particularly an issue with demand and price data. It was difficult to find sources that indicated food prices at regional or state levels. With demand, some food providers neglect to take note of produce item popularity. Data access was another hindrance in the data collection process. For example, in collecting demand data, potential sources were unwilling to lend access to demand quantities and prices. Due to the inclusion of only a few sources, demand data did not have the same level of validity as other decision-making components. Although most data were derived from USDA sources for this project, there is still the question of reliability of sources. Regarding the reliability of the demand data, since the sources are specific to a population and place, data from the sources examined may have tacit geographical and cultural biases.

Data collection and the database design were performed simultaneously. Ideally, data collection would happen before database design, to minimize extensive modifications to the database when the format of the data is different than expected. Although the current database is very functional for analyses of the data provided from CDS, and was designed so that it can be extended to fit new demand data from other providers, additional tables and relationships may need to be added to meet the requirements of future clients, and hold new time-sensitive data such as price. The addition of many new tables may result in inefficient use of space, inelegant design, or slower querying. With additional metadata allowing for more conversions between units and other standardizations, additional scripts could be written to fit future data into a single, more standardized format. This would allow the database’s design to remain more stable, even with the addition of new data.

Because data must be manually input into the tool, the process of running the decision-tool with updated data is inefficient. Largely, this issue could be resolved if an expert could link the back-end of the tool to an updated USDA source, for instance. Both technical abilities and time constraints have limited the current version of the decision-making tool. Similarly, time and group-skillset limitations have prevented the creation of a connection between the back-end database and the web-based user interface. Connecting the tool’s back-end to the front-end is doable and recommended in future developments of the F.A.R.M. Food Tool.

VII. NEXT STEPS

This capstone project holds numerous further research applications. The immediate future of this capstone project will primarily concern the development of the web-based application, the continuation of ELI’s food system project, and the further engagement of Carolina Dining Services regarding food provision on campus.

Website Development

The design of the web-based tool is currently a ‘mock-output’ and has yet to be launched into a functional website. Functionality would require the user-input food website to connect with
the back-end of the F.A.R.M Food decision support tool. Even with connection, constructing an online tool involves further development of the provider, producer, and DIY tool specifications to better address the needs of potential users. To most accurately express the resulting F.A.R.M foods, a more comprehensive—updated, reliable and thorough—dataset must be sought. Another feature that should be addressed is linking synonymous produce names, such as Chinese cabbage and Bok Choy, to encourage the tool’s flexibility to user inputs.

The web-based interface is expected to become more robust, interactive, and helpful to potential users. An example of further developing the visual aspect of the information includes an online mapping portion, where users can access the GIS potential within the database. Another possibility is the generation of visuals such as tables and calendars, in a way that automatically provides regional- and season-specific data. The web-based application contains immense visual and spatial potential, so its final form depends on the storytellers who continue its mission.

Data Improvement and Extension

The extent to which the fall F.A.R.M. Food Tool evolves into a North Carolina agriculture information hub on its own will be limited without future collaboration. The requests of the client, ELI, align with the food decision support tool endeavor and inspired the many questions that this Fall Capstone sought to answer. How to provide a population with a sustainable, nutritionally complete, and cost-effective food system is not fully addressed in this report, but that is a central question to ECOLAND’s proposed community. North Carolina’s top crops, or what ELI can grow well in NC soil, were indicated, but there was no evaluation of food production within a given context of available time, space, or financial resources. Another area of interest for ELI is vulnerabilities within the agricultural system. Quantifying risks such as high water dependency, susceptibility to diseases, pests, and chemicals would be a substantial project that could be integrated into the F.A.R.M. tool or used in other decision-making applications.

ELI Collaboration

In addition to a capstone, another option for expanding the scope of the project would be through ELI’s summer “Rising Experts” Program. Future collaboration with ELI should manifest in a follow-up capstone or summer internship to develop the work toward a more sustainable food system.

ELI and CDS Hydroponic Facilities

Another interest of both ELI and CDS is on-site hydroponic production. The hydroponic potential table of results represents extensive research into the feasibility of applying the hydroponic method to the list of produce items. However, the true potential of indoor agriculture is not encapsulated in this study, and further research about implementing a hydroponic facility is in the interest of many stakeholders. The extent to which the clients’ food demand can be met from a hydroponic facility requires continued cost-benefit analysis. CDS has expressed interest in continuing to work with capstones, so a future capstone project could focus on creating a proposal for a potential onsite hydroponic facility.

GIS Potential Areas for Hydroponic Facilities

Lastly, one of the extensions for this project will begin in the spring of 2015 with an independent study to evaluate the food production potential of UNC’s campus. This GIS-based study will include the possibility of a hydroponic greenhouse, and with the data gathered in
this capstone project, the team member performing the independent study will be able to
tell CDS with greater certainty where such a greenhouse might best be located and which
crops it could produce.
APPENDIX A

a. Provider
SELECT p.produce_name, p.produce_color, pr.price_easternnc, pr.price_easternfarmnc,
pr.price_statenc, pr.price_usda, pr.price_easternfarmnc-pr.price_usda AS price_difference,
n.produce_nutritionalcompleteness, h.hydroponic_potential, nc.rank_topcrop, (SELECT count(g.produce_name) AS farmers_growing FROM grows g WHERE
g.produce_name=p.produce_name GROUP BY g.produce_name),
s.produce_springplant1, s.produce_springplant2, s.produce_springharvest1,
s.produce_springharvest2, s.produce_fallplant1, s.produce_fallplant2, s.produce_fallharvest1,
s.produce_fallharvest2
FROM produce p
INNER JOIN price_2014 pr ON p.produce_name=pr.produce_name
INNER JOIN seasonality s ON p.produce_name=s.produce_name AND s.produce_region='Coast'
INNER JOIN nutritional_completeness n ON p.produce_name=n.produce_name
INNER JOIN hydroponic_potential h ON p.produce_name=h.produce_name
LEFT OUTER JOIN nc_top_crop_2013 nc on p.produce_name=nc.produce_name
ORDER BY pr.price_easternfarmnc ASC, price_difference ASC, h.hydroponic_potentialscore ASC, n.produce_nutritionalcompleteness DESC;

b. Producer
SELECT p.produce_name, p.produce_color, pr.price_westernfarmnc, price_westernnc, pr.price_statenc, pr.price_usda, pr.price_westernfarmnc-pr.price_usda AS price_difference,
n.produce_nutritionalcompleteness, h.hydroponic_potential, s.produce_springplant1,
s.produce_springplant2, s.produce_springharvest1, s.produce_springharvest2, s.produce_fallplant1, s.produce_fallplant2, s.produce_fallharvest1, s.produce_fallharvest2
FROM seasonality s, price_2014 pr, nutritional_completeness n, hydroponic_potential h,
produce p
WHERE s.produce_region='Mountain' AND p.produce_name=s.produce_name AND s.produce_name=pr.produce_name AND s.produce_name=n.produce_name AND s.produce_name=h.produce_name
ORDER BY pr.price_westernfarmnc ASC, price_difference ASC, h.hydroponic_potentialscore ASC, n.produce_nutritionalcompleteness DESC;

c. Community and Home Grower
SELECT p.produce_name, p.produce_color, n.produce_nutritionalcompleteness,
h.hydroponic_potential, s.produce_springplant1, s.produce_springplant2,
s.produce_springharvest1, s.produce_springharvest2, s.produce_fallplant1, s.produce_fallplant2, s.produce_fallharvest1, s.produce_fallharvest2
FROM seasonality s, nutritional_completeness n, hydroponic_potential h, produce p
WHERE s.produce_region='Mountain' AND p.produce_name=s.produce_name AND s.produce_name=n.produce_name AND s.produce_name=h.produce_name
ORDER BY n.produce_nutritionalcompleteness DESC, hydroponic_potentialscore ASC;

d. Consumer
SELECT p.produce_name, p.produce_color, pr.price_centrefarmnc, pr.price_statenc, pr.price_usda,
n.produce_nutritionalcompleteness, s.produce_springplant1, s.produce_springplant2, s.produce_springharvest1, s.produce_springharvest2, s.produce_fallplant1, s.produce_fallplant2, s.produce_fallharvest1, s.produce_fallharvest2
FROM seasonality s, price_2014 pr, nutritional_completeness n, produce p
WHERE s.produce_region='Piedmont' AND p.produce_name=s.produce_name AND s.produce_name=pr.produce_name AND s.produce_name=n.produce_name
ORDER BY pr.price_centralfarmnc ASC, n.produce_nutritionalcompleteness DESC;
Appendix B: Local Producer Location Maps

Map 1. Displays producer locations and farm names within the Triangle region.

Map 2. Simulates the ability of the F.A.R.M. Food Tool to specify producer locations within a desired radius of home zip code.
Map 3. Simulates ability to search for producer location for a specific produce item within North Carolina.
BIBLIOGRAPHY


