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Hudson River Foodway Corridor Study

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NOTICE

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Executive summary

Farmland in New York State, especially in the Hudson Valley, is fast disappearing as development pressure mounts. However, with the emergence of the local food movement, there exist opportunities for farmers in New York State to capture the market in New York City. Supermarkets and retailers in New York City now use "local" as a marketing technique and the city passed a law that led to the development of local and regional food procurement guidelines for city agencies. At the state level, the Governor announced the establishment of three food hubs in the state as a way to ensure a sustainable future for the state's agricultural sector.

The local food movement is a welcome shift in the public's attitude. However, little attention has been paid to the impact on the food distribution system for the region. New York City is home to more than eight million residents and receives more than 50 million visitors annually. In Manhattan, whose resident population is 1.6 million, the number of people more than doubles to nearly 4 million during the work day. These numbers present enormous market opportunities, yet, at the same time also challenges. Streets and highways in the metropolitan New York region already suffer from congestion and poor air quality. In moving toward a more local food system, transportation of food requires careful planning.

The Lower Hudson Long Island Resource Conservation and Development Council has put forth a concept of barge transport as an alternative to trucking agricultural products as a way to enhance the economic viability of farms in New York State, to meet the demands of consumers in New York City, and to reduce the environmental impact of the regional food distribution system. The concept is for agricultural areas both in the Hudson Valley and Long Island, although the Council has narrowed its focus on the Hudson Valley as the initial phase. In partnership with the New York State Energy Research and Development Authority, the Council undertook this study to evaluate the feasibility of transporting agricultural products on a barge.

The study was divided into three components: transportation logistics, agricultural production assessment, and transportation mode comparison. The component studies were conducted by consultants with expertise in each topic area. Sustainable Ports conducted the transportation logistics, which examined the feasibility of barge transport from the infrastructure and logistics perspective. Karp Resources was responsible for developing an agricultural production inventory and surveying the producers. Finally using data and findings from the first two components, New West Technologies analyzed the travel time, fuel consumption and costs, and emissions for barge vs. truck transport.

The study initially considered two models of transportation: value-added and produce market models. In the value added model, producers deliver their products to an aggregator, which will then deliver the aggregated products to the port. In the produce market model, producers deliver directly to the port and products are aggregated and sorted at the market in New York City. Several cold or refrigerated storage facilities were identified in the proximity of the Hudson River, however, most appeared to be affiliated with a private farm. They seemed unlikely to have the capacity to serve as a regional aggregator. Thus the study focused on the produce-to-market model.

Four potential ports were identified along the Hudson River. However, two of them were eliminated from further consideration due to 1) the lack of infrastructure and 2) proximity to the city, making truck transport more efficient for producers. The remaining two, the Port of Albany and the Port of Coeymans, are both currently operating ports. The Port of Albany is a container port and is unsuitable for truck-on-barge (Roll On Roll Off or RoRo) transport. The Port of Coeymans is a privately owned container port and has the capacity for RoRo ramps. It was determined that a distance of approximately 150 miles from the city would be a minimum for the location of the port since farmers closer to the city would find it easier to drive to the city to sell directly to consumers.

Assessment of farms in the Hudson Valley showed that the farms in the Hudson Valley tend to be small and that the producers have a better opportunity with direct sales through farmers' market or Community Supported Agriculture programs especially given the proximity to the city. Thus, the catchment area was expanded to central New York State where farms tend to be larger with the capacity for higher volume production. Products that are durable, non-perishable and available year round are the best candidates for barge transport. However, they tend to be lower value products. While higher market prices are desirable, high value products tend to be fragile, perishable, and seasonal (e.g., strawberries). Because ensuring adequate volumes was critical to the viability of barge transport, three products – cabbage, squash and apples – were selected as potential candidates. These products are produced in high volumes (NYS is the second largest producers of both cabbage and apples), relatively durable and available ten months out of the year.

Producers, distributors, aggregators and others in the related industry were interviewed to assess their attitude toward a new mode of transporting food. About half of them indicated an interest in exploring barge transport if costs, logistics and the controlling entity were satisfactory. Producers were first and foremost concerned about the costs of shipping and the price for their products. However, many are equally concerned about the logistics of the alternative transport mode: who will be responsible for the products at the port, on the barge and at the market in New York City and how their products will be insured were major issues.

To conduct the mode comparison between trucks and barges, the Port of Albany was selected as the origin port and the Hunts Point Produce Market and the Red Hook Container Terminal as our destination ports. Pomona Packing in Wolcott, New York, was selected as the origin farm because of the volume of apples aggregated at the facility. Travel time, fuel consumption in gallons of diesel fuel, costs of fuel and emissions for CO, NO_x, particulate matter and CO_2 were estimated. For all parameters analyzed, truck mode was better than the barge: travel time, fuel consumption, and fuel costs were higher for the tug/barge approximately by a factor of two over those for trucks alone. Emissions for trucks were also lower, as they are related to fuel consumption. The destinations (Hunts Point vs. Red Hook), and cargo types (container vs. trailer) for the tug/barge did not result in significant differences for any of the factors analyzed.

Two factors were found to be important in accruing benefits for the barge: a minimum number of containers and the geometry of the transport route. Because the energy required to power tug boats does not increase proportionately with the number of containers or trailers, tug/barge transport is more efficient than trucks at higher volumes of cargo. A preliminary analysis shows a minimum of 35 containers are required to realize an advantage for tug/barge transport. The location of the origin farm or aggregator also affects the efficiency. The origin must be in the proximity of the port or the port must lie along the straight line between the origin and New York City. By moving further west to central NYS the geometry of the system gave trucking an advantage because of the roadway system that cuts across diagonally connecting the origin directly to the city.

The results of this study suggest further research be focused on aggregation of products (both infrastructure and operation), supply chain logistics (who will assume responsibility for products?), mid-size farms as the target producer, and other product types such as wine, dairy products and wood products. Furthermore suitable backhaul and development of a market in New York City, whether at an existing facility or a new site, also need to be researched.

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Introduction

The Hudson River Foodway Corridor Project envisions a food distribution system that connects agricultural producers of New York State with the consumers of New York City through the use of the region's waterways. Such a regional food distribution system will ensure that 1) farming remains economically viable in New York State, 2) City residents have access to fresh local food, and 3) increased demand for local food will not be met by more trucks on the road.

Developing a new food distribution system, particularly one which employs a "novel" mode of transportation, is a long process, which requires multiple stakeholders and partners. As an initial step to developing such a food system, the Lower Hudson Long Island Resource Development & Conservation Council (the Council), in partnership with the New York State Energy Research and Development Authority (NYSERDA), conducted a research study that evaluated the following:

1) Transportation logistics for barge transport on the Hudson River
2) Mode comparison between truck and barge transport of agricultural products
3) Agricultural inventory in central New York and producer attitude on barge transportation

The region's food distribution system is very complex, involving producers from many agricultural regions of the country and the world as well as New York State and the tri-state region. Creating a food distribution system envisioned by the Hudson River Foodway Corridor Project will require many years and broad coalition of stakeholders. This study is a small but a significant first step, which not only assesses the feasibility of barge transport but also initiates a dialog among producers and brings together stakeholders.

Background

New York State is home to some of the nation's most productive yet endangered farmland. Admired for having good soils and a long growing season, our farms produce a bounty of products for the State residents and beyond. According to the USDA Economic Research Service, New York State farm related economic output totaled $5 billion in 2010[1]. About 24 percent of the State's land area, or 7.1 million acres, are used by a little over 36,000 farms to produce a very diverse array of food products. Even in the region with some of the densest development, such as the Hudson Valley, 17% of its land area is still farmland. Although New York does not rank high in terms of overall agricultural sales, its apple production ranked second in the nation and milk and dairy products as well as grape production were the third largest in the country in 2007[2]. However, these seemingly impressive figures are daunted by crippling economic factors facing our farms. An American Farmland Trust study found many parts of New York State as high quality farm land under high development pressure[3]. A steady decline in farming in New York has been exacerbated by a combination of factors including a subsidy system that favors commodity production, industrialization of food production, a global market place that offers cheap food year round, and increased costs of production.

New York State is also home to the nation's largest city with more than eight million residents and over half a million commuters daily and fifty million tourists annually, as well as a large number of restaurants, hospitals and educational institutions forming a huge market. The Hunts Point Terminal Market, located in the City, supplies food to 22 million people living within 50 miles of the market with estimated annual sales of $2 billion. The demand for locally grown food has also increased in recent

[1] United States Department of Agriculture, Economic Research Service. *State Fact Sheets: New York*. Retrieved Spring 2010 from http://www.ers.usda.gov/statefacts/NY.HTM

[2] DiNapoli, T.P. (2010, February). *The Role of Agriculture in the New York State Economy: Report 21-2010* [PDF].

[3] American Farmland Trust. *Farming on the Edge: New York State Map*. Retrieved in Spring 2010 from http://www.farmland.org/resources/fote/states/map_newyork.asp

years according to a 2005 study by Karp Resources[4], which cited there is an unmet demand for over $860 million of locally grown products in New York City alone. At the same time, reducing the impacts of food distribution has also caught the attention of policy makers and is one of the initiatives added to the 2011 update of the City's sustainability plan, PlaNYC 2030[5]. Despite the growth in demand for local produce, there are only about a dozen farmers from the region who sell at the Wholesale Farmers Market at Hunts Point and a casual inspection of produce available at the Hunts Point Produce Market reveals that produce available there is generally not from New York State. Recognizing this gap in supply and demand, a report by the City Council of the City of New York proposed building a wholesale farmers market as one of many ways to improve our food system[6].

In order to ensure agriculture remains viable in the State, a broad range of stakeholders must begin building a regional food system by developing distribution infrastructure that meets the needs of the producers and facilitates a cost-effective distribution system. The time is right for such a shift in the region's food system. The term, "local food," has entered our daily vocabulary and the reduction of greenhouse gas emissions is widely supported by the public. However, while the idea of creating a wholesale market in the City for NYS agricultural products has garnered substantial support from both the public and private sectors, it is assumed that the added volume of food will travel by conventional means. This is particularly ironic given the fact that the location of the existing wholesale greenmarket for small to mid-size farmers of the region is located on the waterfront of Hunts Point in the Bronx. With the increasing fuel costs and the environmental and public health costs of trucking, using the State's waterways, once the equivalent of interstate highways, should be an important part of the planning process for the growth of the wholesale market for the State's agricultural products.

Currently agricultural product distribution is dominated by trucking, with the flow of product hinging more on access to – and the cost of – transportation to market than any other single factor. The region's consumer demand for food generates a substantial amount of land-based traffic exacerbating the already congested transportation system. This region boasts the nation's largest food market, the Hunts Point Food Distribution Center. Unfortunately the Hunts Point Peninsula and surrounding coastal islands of Manhattan, Long Island (Brooklyn and Queens) and Staten Island have limited or no intermodal food distribution facilities. Less than 3% of what is transported to the Hunts Point Food Distribution Center arrives by rail and the remaining 97% of shipments are delivered to the market by approximately 16,500 mostly refrigerated trucks per day. Nothing, including fish for the fish market, arrives via water even though the market is located on a waterfront property. This staggering amount of commerce and food distribution certainly warrants further investigation of commercialized alternatives to overland trucking and the energy used in the distribution chain.

In August 2010, the Hudson River Foodway Corridor Project was designated as one of only six *America's Marine Highway Initiatives* by the US Dept. of Transportation, Maritime Administration. The Foodway Corridor Project has been endorsed by the U.S. Dept. of Agriculture, NYS Dept. of Agriculture and Markets, the NYC Mayor's Office, Bronx and Manhattan Borough Presidents, and several non-governmental organizations.

Study Goal and Objectives

The long-term vision for this project is a sustainable, regional food distribution system that empowers the farming industry of New York State, provides high quality food to the urban residents, and revitalizes the

[4] Karp Resources (2005). *A Study on Development of a NYC Wholesale Farmer's Markets: Executive Summary*[PDF]. Retrieved Spring 2011 from http://karp.dev.1over0.com/wp-content/uploads/2011/09/Phase1NYCWFMExecutiveSummary.pdf. (p.8, Rep.).

[5] The City of New York (2011). *PlaNYC 2030* [PDF]. Retrieved Spring 2011 from http://nytelecom.vo.llnwd.net/o15/agencies/planyc2030/pdf/planyc_2011_food.pdf

[6] Brannen, S. (2010). *Food Works: A Vision to Improve NYC's Food System*.

region's waterways as the transportation corridor. The project is loosely organized in four parts: supply (produce and agricultural products), transportation, demand (consumer markets), and backhaul.

The goal of this study was to assess the feasibility of transporting NYS agricultural products to New York City using the Hudson River as a transportation corridor. In this study, the focus was on the transportation and supply, with the understanding that all the parts interrelate and need to be evaluated with respect to each other. The specific objectives for this study included:

1) analyze transportation logistics,
2) survey producers to assess their needs and interest in an alternative food distribution system,
3) compile an inventory of potential agricultural products that are suitable for waterborne transportation, and
4) compare costs, emission, and energy consumption for a select commodity between conventional and waterborne transportation.

Project Management

The project was managed by the Lower Hudson Long Island Resource Conservation & Development Council's Foodway Corridor Committee, which consists of volunteers with expertise in natural resources management and conservation. In addition to the Committee, a Technical Advisory Committee was established specifically to guide the project. Representatives with expertise in the transportation and agriculture sectors were asked to participate. The members represented: US Dept of Transportation, NYS Dept of Transportation, NYS Dept of Agriculture and Markets, NYSERDA, NYS Canal Corporation, NYC Economic Development Corporation, Cornell Cooperative Extension, Northeast Organic Farming Association NY, Apple Growers Association, and Working Harbor Committee. The Technical Advisory Committee was convened as needed to provide feedback and guidance for the three component studies. The list of members is provided as Appendix A.

The research was conducted in three sections: 1) transportation logistics, 2) agricultural assessment (inventory and survey), and 3) transportation mode comparison. A consultancy was retained to conduct the research for each of the three sections, resulting in three separate reports.

Methodology and assumptions

Detailed methodology and assumptions can be found in each component report (see appendices) with summaries presented below.

Transportation logistics

The goal of the transportation logistics section was to develop a model for barge transportation and identify potential loading sites based on the chosen model. The results from this section were utilized in the analyses for the remaining two sections.

Two models for maritime transport were considered: produce market model and value added model. In the produce market model, produce will move from the producer to the barge to the market, while in the value added model produce will go to an aggregation facility, where it is packaged before moving on the barge to the market.

To identify potential ports in the Hudson Valley, the following criteria were used:

- Adequate depth at berth and channel
- Adequate dockage and land (i.e., staging area)

- Highway access
- Port costs
- Nautical distance to the Battery

Google Maps and Google Earth were utilized to evaluate the landside facilities while nautical maps were used to determine the depth. For some sites, operators were also contacted to obtain information.

Agricultural assessment

Products to study were selected based on a combination of factors: durability, perishability, production volume and seasonality. The United States Department of Agriculture (USDA) data and USDA National Agricultural Statistics Service were the primary sources of data on acreage, yield, and market value of a range of products.

Although the original scope of the study focused on the Hudson Valley as the production area, the geographical area was expanded based on the following preliminary findings:

1. Producers in the areas in the proximity of the city (i.e., less than 150 miles) will opt for the conventional truck transport,
2. Farms in central and western New York State are larger with the potential to produce volumes more appropriate for barge transportation, and
3. Access to New York City market might be more appealing to farms in central and western New York State because many of them currently do not sell to New York City due to distance.

The inventory data were mapped using GIS to create maps of production volume for select products and sales of two categories of products (vegetables and fruit & tree nuts).

In-depth interviews with producers, producer associations, cooperatives, aggregators, distributors, and production/marketing advisors were conducted to gather data on the current production and distribution of NYS agricultural products. Results of the in-depth interviews were used to develop the producer survey to collect current production volume, sales, marketing, and transportation and producers' attitudes toward an alternative mode of transportation.

The producer survey was conducted via an online survey web site. Solicitations for survey participation were distributed via web site postings, e-mail blasts, meetings, and postcards. In addition, several surveys were completed through a telephone conversation with producers.

Transportation mode comparison

Based on the findings of the transportation logistics and agricultural assessment components, Pomona Packing in Wolcott, NY, was selected as the origin point. For the destination, Hunts Point Produce Market and Red Hook Container Terminal were selected as the two possible points. For the barge transport, the Port of Albany, with truck transport from Wolcott to Albany, was designated as the origin port.

Transport time, gallons of fuel, transport cost (for fuel only) and emissions for CO, NO_x, Particulate Matter (PM) and CO_2 were estimated. The metrics were calculated for diesel-powered Transport Refrigerated Unit (TRU) and hybrid electric TRU (eTRU).

For the truck-only mode, the route was divided into segments with different vehicle speeds (mph) depending on the type of roadway and likely congestion. Miles per hour ranged from less than 10 mph within the city to 60 mph on the highway. Fuel consumption in gallons per mile was calculated based on

operational percentage with respect to ambient temperature using historical, published data, multiplied by fuel rate for diesel (in gallon per hour) and electric operation (in kW) and travel time.

For the barge mode, a similar analysis was conducted for the segment between Wolcott to Port of Albany. For the barge transport, speed of 8 knots was used to calculate the travel time. The fuel consumption rate of 45 gallons per hour (2 gallons per hour for idling) was used based on the particular tug examined for the study. Idling fuel consumption was an important consideration given the fact that a barge would require a substantial loading/unloading time. The metrics were developed in consultation with operators at the Port of Albany. Analyses were conducted for ten 48' trailers and 20 Trailer Equivalent Units (TEUs) on a barge.

Findings

Detailed findings can be found in individual component reports in the Appendix section. Below is a summary of the findings from the component reports.

Transportation logistics

1. Value added vs. produce market models

Transportation logistics encompasses three distinct but connected segments: farm to port (landside), port to market (maritime), and market to retailers (landside within New York City). This study evaluated the first two segments.

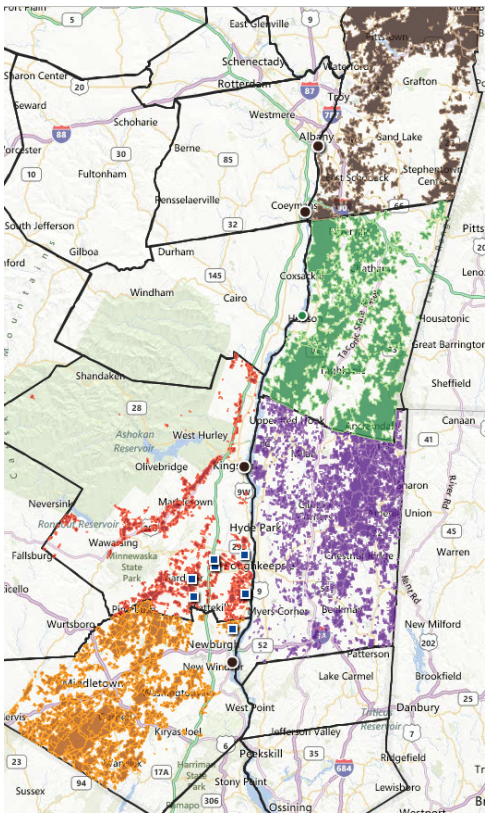

Figure 1. Agricultural districts and cold storage facilities in the Hudson Valley
Map created by Sustainable Ports

For the farm to port segment, two different business models were evaluated: value added and produce market models. In the former, trucks will go to an aggregation and sorting facility, likely involving a cold or refrigerated storage. In the latter, trucks go directly to the port and products are aggregated and sorted at the unloading site in New York City.

Value added model

The value added model requires a geographical convergence of farms, aggregation facility and the port. The location and size of farms within a reasonable radius is important in generating the volume necessary for the barge; existence of a facility for aggregation and sorting ensures products are market-ready. These two factors must further converge with a suitable waterfront site in proximity of the aggregation site.

Existing facilities were inventoried in the Hudson Valley using the North American International Association of Refrigerated Warehouses and Manta, a search engine for commercial businesses. The search was focused on facilities in the proximity of the Hudson River. In addition, agricultural districts in the Hudson Valley as an indicator of agricultural production (i.e., proxy for production volume, Figure 1.) were researched. Nine facilities were identified within 10 miles of the waterfront in the Hudson Valley. These facilities are

associated with specific farms and are most likely unavailable to serve as an aggregation center for other producers. In addition, many of the facilities are within a few hours by truck to the city. However, the aggregation and sorting add value and open a new market for the producers, even those who are already selling to the city through direct marketing.

Produce market model
The most common form of the produce to market model is the NYC Green Market and community supported agriculture where producers sell directly to the consumers. For the barge transport, however, it is unlikely that diverse producers already participating in a green market or a community supported agriculture program will alter their mode of transportation, which will require producers to arrive at the same port on the same day of the week. Thus the produce to market model for barge transport would likely require a wholesale market (i.e., Hunts Point Produce Market), a supermarket chain (i.e., Whole Foods) or a distributor as the customer.

The port will need to have a staging area that can accommodate multiple trucks. It may also need to have infrastructure (e.g, loading cranes). There are major challenges associated with the produce market model including, but not limited to, what entity handles the products at the port in the absence of an aggregator, whether trucks go directly on the barge ("Roll On Roll Off" or RoRo) or only trailers are loaded (requiring a crane), and how drivers travel if trucks go on the barge. Coast Guard regulations require barges transporting any passenger, even if one person, be considered passenger ferries, which must comply with a more stringent set of regulations different from those governing vessels without passengers.

2. Riverfront infrastructure in the Hudson Valley

Identifying ports was necessary, even if the existing infrastructure does not support barge transport of agricultural products, so that the mode analysis, which requires an origin port, can be conducted. For this analysis the search was not restricted to a particular infrastructure configuration (i.e., RoRo vs. container). Although several ports on the east side of the Hudson River were identified, these ports would most likely only serve Dutchess and Columbia Counties. For this reason, the analysis was limited to the ports on the west side of the Hudson River.

Four ports were identified: Port of Albany, Port of Coeymans, Kingston and Newburgh. The former two are currently operating ports while the latter two have the appropriate conditions without port facilities.

The Port of Albany
The Port of Albany is a container port operated by the Albany Port District Commission. The port has operated container-on-barge transport of goods from ports in the New York Harbor to Albany in the Port Inland Distribution Network program of the Port Authority. However this port is unsuitable for truck-on-barge transport due to the geometry of the dock and the width of the river.

The port is 150 miles from the Battery or approximately 3 hours by truck from the city.

The Port of Coeymans
The Port of Coeymans is a privately owned non-union port currently operating container barges. The port can also handle RoRo barges. The port is 136 miles from the Battery.

Ports of Kingston and Newburgh
Without an aggregation and sorting facility, there is no added value to using marine transport for producers who are within a 2-hour drive of New York City. Kingston and Newburgh are 82 and 52 nautical miles from the Battery respectively. Furthermore, these sites would require significant

infrastructure investment for barge transport since neither site currently operates commercial shipping by barge. Therefore sites at Kingston and Newburgh were eliminated from further examination.

3. New York City marine terminals

Several New York City sites were evaluated for capability (RoRo vs. container) and their potential for food related operations and backhaul. This assessment is not a comprehensive in-depth study but a quick evaluation of existing sites.

Of the six sites identified, Hunts Point Produce Market and the Red Hook Container Terminal emerged as the sites with the greatest potential.

Hunts Point Produce Market is the highest volume produce market in the country, generating more than $2 billion in sales annually. Located on the Hunts Point peninsula in the Bronx, the waterfront market has the appropriate conditions (e.g., water depth) to receive shipments via barges, even though currently there is no infrastructure for handling either RoRo or containers.

Red Hook Container Terminal is a container terminal operated by the Port Authority of NY/NJ in Brooklyn. There is adequate space to establish a RoRo ramp at this site. The port handles imports of furniture, apparel and beverages, the last of which may be good products as backhaul.

4. Preliminary cost estimates for marine transport

The summary of preliminary costs for barge transport is shown below. For the container transport model, estimates were based on 100 containers, stacked four high on a 180' x 43' barge. This size was selected to maximize the 4-hour minimum labor at the port. For the RoRo model, the same size barge (180' x 43') was used to carry between 9 to 12 trucks. For simplicity the cost calculations are based on 10 trucks.

In addition to these costs, there are port fees, such as tariffs, security (if port usage is during non-business hours) and dockage. However, these costs do not add substantially to the overall costs. Transportation cost components are shown in Table 1.

Component	**Containers (Albany to Red Hook)**	**RoRo (Coeymans to Red Hook)**	**Notes**
Barge (lease cost)	$2,375	$2,375	$9,500/month for a lease >3 mos., 4 trips/mo
Tug with crew & fuel	$7,200	$6,400	$400/hr as quoted by a vendor
Truck to barge		$2,000	Loading and unloading
Container to barge	$40,000		Loading and unloading
# of containers/trucks	100	10	
Cost one way	$56,775	$17,175	
Round trip cost	$111,175	$31,175	Without backhaul
Per container/truck	$1,112	$3,118	

Table 1. Transportation cost estimates for trailers vs. containers

Clearly, more energy efficient tugs, more frequent service, availability of backhaul and multiple barge tows can all reduce costs. Furthermore a high speed truck ferry capable of holding 40 trucks is being developed by a passenger ferry operator in New York. While the fuel costs for high speed vessels are

generally higher, the time to travel between Albany and New York City will be reduced by 60% to 7 hours.

Fuel costs and energy consumption are more fully analyzed in the transportation mode comparison section below.

Agricultural assessment

1. Catchment area for agricultural products

The project set out to define a catchment area that would allow a focus on producers in a confined geographical area. Defining a catchment area was also necessary for the transportation mode comparison section. Originally the project was to focus on the Hudson Valley producers, because of 1) the Lower Hudson Long Island Resource Conservation & Development Council's mission; 2) the immense development pressure in the Hudson Valley; and 3) the proximity to the country's largest metropolitan area. However, for barge transport to be viable, the following factors must work together to create optimal conditions:

- Distance to the city from the port
- Distance to the port
- Production volume

Distance to the city from the port
Lacking any facilities that can add value to the products, a minimum distance that would render barge transportation more efficient with respect to transport time was estimated to be about 2.5 hours by truck (or a round trip of 5 hours). This transport time was then converted to 150 miles using an average of 60 miles per hour. Thus the Port of Albany was selected as the origin port even though it cannot accommodate RoRo.

Distance to the port
For barge transport to be meaningful, clearly the distance to the port from the farm must be significantly shorter than the distance from the farm directly to the city. However, this requirement poses a challenge for a port located 150 miles from the Battery, since the counties surrounding Albany are not the highest agricultural producers (see figure 2). Furthermore, the geography of the state and its highway system are such that the distances to the Port of Albany and to New York City from parts of western NYS are not significantly different. In other words, the time it takes for western NYS producers to reach Albany may not be significantly shorter than for them to reach New York City. This factor must be carefully considered in selecting the area of the state where producers can take advantage of barge transport from the Port of Albany.

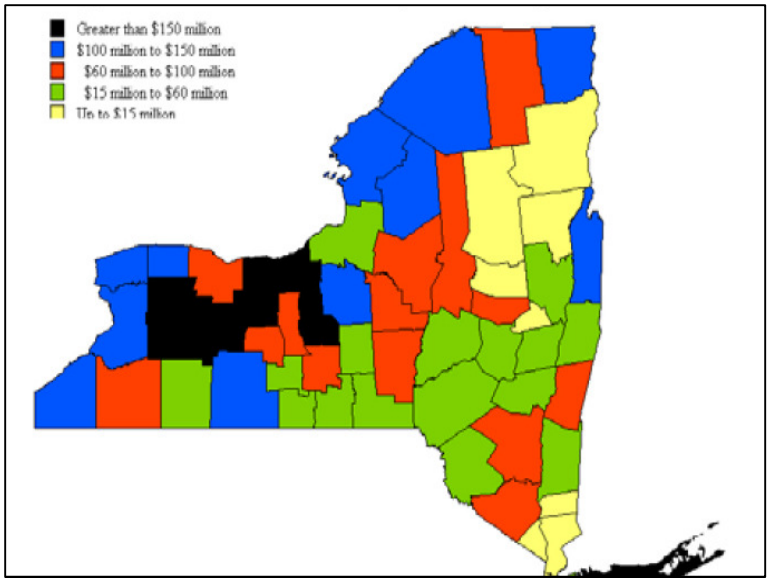

Figure 2. Agricultural sales value by county in 2007.
Source: The role of agriculture in the New York State economy, the NYS Comptroller

Production volume
One of the advantages of barge transport is its capacity to carry large volumes. However, farms in the Hudson Valley tend to be smaller (more than 50% of farms in the southeast region of NYS are under 100 acres, while the average farm size statewide is nearly 200 acres[7]) making the volume requirement a potential challenge. On the other hand, farms in central and western NYS are larger and are better able to meet the volume requirement for barge transport. In addition, many of these farms currently do not have access to the market in New York City due to their distance from the city.

Evaluation of these factors led the study to expand the potential catchment area from the Hudson Valley to central NYS. The Hudson Valley catchment area included 12 counties bordering the river from Putnam/Rockland to Saratoga/Washington and 4 adjacent counties of Delaware, Schenectady, Schoharie and Sullivan. The central-western NYS catchment included 11 counties of Cayuga, Genesee, Livingston, Monroe, Onondaga, Ontario, Orleans, Oswego, Seneca, Wayne and Wyoming.

2. High potential products

Barge transport from Albany to the Battery is approximately 17 hours. Although products from the west coast travel longer (three days), California production optimizes for long haul distribution, making it possible for perishable products to be shipped across the continent without compromising quality. Unfortunately NY production is not tailored to withstand long travel. Thus, products that are best suited for barge transport are those that are durable and non-perishable. However, products with higher value tend to be non-durable and perishable (e.g., strawberries). For example, in 2011, the average price per hundred weight (cwt) for tomatoes in NY was $84.80 while cabbage, a durable, less perishable product, sold for $20.00. Seasonality of products is also an important factor for barge transportation. Many of the high value products are available for only a brief period of the year (some as short as six weeks), while lower value products are often available for a longer period.

Apples, cabbage and winter squash were selected for further analysis. These are storage crops that are available near year-round, are durable and produced in high volume. However, these were not the only products considered for the producer attitude survey, which included a wider range of products for consideration.

3. Agricultural product inventory

New York State agricultural production overview
New York State was ranked 5th in the nation for area harvested and value of vegetables grown in 2011. During the same year, NY was home to 36,000 farms on 7 million acres. Table 2 shows 2011 statistics for vegetable production in NYS. Same statistics for the three potential candidate products are shown in table 3.

Types of products	**Volume produced**	**Total sales (in millions)**	**Acres harvested**
Vegetables grown for fresh market sales	11.3 million cwt	$329	58,500
Vegetables for processing	113, 000 tons	$27	23,400
Total vegetable production	13,56 million cwt	$356	81,900

Table 2. Vegetable production in NYS in 2011

[7] 2007 Census of Agriculture. http://www.agcensus.usda.gov/Publications/2007/Full_Report/Census_by_State/New_York/index.asp

Product	Volume (cwt)	Value ($/cwt)	Total sales (in millions)	Acres
Cabbage	4,708	$20.00	$86.6	10,700
Squash	836	$51.30	$42.9	4,400
Apples	12,000	N/A	$251.0	42,000

Table 3. Production of cabbage, squash, and apples in NYS in 2011.

Production of cabbage and apples are ranked 2nd in the nation. New York State was also the fourth largest milk producer in the nation in 2010. Dairy is the largest sector in the agriculture in NYS with $2.7 billion in sales in 2011 representing more than half of the total agricultural sales in the state. However, due to the complexity of dairy sales in NYS with numerous milk cooperatives and well established existing distribution system, dairy products were not considered further in this study.

Catchment area production overview

For the inventory in the barge transport catchment area, 16 counties in the Hudson Valley (Albany, Columbian, Delaware, Dutchess, Greene, Orange, Putnam, Rensselaer, Rockland, Saratoga, Schenectady, Schoharie, Sullivan, Ulster, Washington and Westchester) and 11 counties in central NYS (Cayuga, Genesee, Livingston, Monroe, Onondaga, Ontario, Orleans, Oswego, Wayne and Wyoming) were considered.

Hudson Valley farms account for 16 percent of the state's farmland and 14.7 percent of the total value for the State. As a region, 21 percent of farms sold over $50,000 of product in 2007. Farms with sales less than $50,000 are considered "small farms" which are less likely to sell in quantities necessary for barge transport.

Farms in central NYS account for more than a quarter of the state's farmland and capture 34.7 percent of the value of the state's agricultural sales. These farms are also larger than their counterparts in the Hudson Valley with an average of 30 percent of farms selling over $50,000 of product in 2007 (see table 4).

	Hudson Valley	Central NYS
Number of farms	7,116	7,820
Value of products (in million dollars)	$646	$1,530
Acres of farms (in million acres)	1.2	1.9
Percent of the total value of NY agricultural products	14.6%	34.7%
Types of products	Poultry/livestock (61%) Crop (39%)	Poultry/livestock (60%) Crop (40%)
Cabbage production volume (in cwt)	52	4,433
Squash production volume (in cwt)	52	133
Apple production volume (in cwt)	3,124	8,259

Table 4. Characteristics of production in the two catchment areas in 2007.

Aggregation points

For the transportation mode comparison component of the study, it was necessary to identify a single origin point. Three aggregation facilities, one for each potential product, were evaluated.

For the cabbage, My-T-Acres in Batavia, Genesee County, was evaluated. It grows cabbage for fresh and processing markets and has the capacity to produce 20 million pounds of cabbage per year. At the

maximum production of 20 million pounds, My-T-Acres would require 500 truck loads (at 40,000 pounds per truck) between September and June with a slight seasonal variation in the number of truckloads.

Del Mar Farms in Batavia, Genesee County, has the capacity to distribute 10 million pounds of butternut squash for both fresh and processing markets between September and January. The maximum production would require 250 truckloads.

Pomona Packing in Wolcott, Wayne County, is an aggregator, which ships 16 million pounds, or 400 truckloads, between September and June. There are a few other apple aggregators in the proximity of Pomona Packing. One handles twice the volume while another has a similar size operation. Pomona Packing currently ships to mainstream supermarket distribution centers along the eastern seaboard. Very little of the product is currently bound for New York City.

For the transportation mode comparison, Pomona Packing was selected for its high volume and long period of product availability.

4. Producer attitudes

Thirty interviews involving more than 100 individuals representing a broad range of businesses in the agricultural sector in the state were conducted. The individuals represented farmers, producer associations, cooperatives, aggregators, and distributors as well as a spirits manufacturer, a co-packer of value added products, a cheese producer and the Cooperative Extension.

Costs and logistics of transport

Financial viability is an important factor across all types of respondents. Distribution costs and prices paid by the buyer are highly critical in determining whether to use barge transport. Many respondents reported that they pay more to truck products to New York City than to equidistant locations elsewhere and are interested in reducing the transportation costs. Ten respondents stated that their interest in barge transport would increase if the total cost of shipping by barge, from farm to NYC end buyer, remained the same, while comparable costs would not increase the interest level in five respondents. One farmer commented barge transportation becomes more appealing as the distance to the port or aggregation facilities decreases.

About half of the producers interviewed or surveyed would be interested in accessing the New York City market if the right price (both transportation costs and price paid by the buyer), smooth logistics, and trusted distributors were available. Respondents stated low prices, complicated logistics and distribution constraints make selling in New York City unpalatable and many consider the Hunts Point Produce Market a market of last resort.

Many respondents wanted to understand how the products would be aggregated and how the barge operator would work with a network of aggregators. Barge transport was also imagined as adding a leg to the truck travel because products must still travel to the port by truck. Respondents were concerned not only about the logistics of adding another leg to the distribution but also the inefficiencies of multiple loadings and unloadings of products. Respondents further equated longer travel time and more handling to increased risk for error.

Travel duration

The respondents viewed the duration of the transport (approximately 17 hours from Albany to the city) counter to the consumer demand for freshness. The longer transport time, even if predictable and dependable, was a perceived barrier. However, producers of shelf-stable, value-added products and less perishable products were less resistant to the long transport time.

Production volume
Many producers interviewed had concerns that the volume required for barge transport was not attainable except by large scale growers already selling by the tractor trailer load. They felt barge transport would only be viable with new customers and higher prices, conditions which often necessitate direct retail.

Controlling entity
Brokering or sales service tied to the barge operation would increase the level of interest among the respondents. In other words, the barge operator or a broker would take ownership of the products at the port so that the producers are not responsible for the products in transit and for the sale in New York City. The chain of produce ownership and insurance from the farm to the end buyer is thus an important factor that requires careful planning for barge transport to be viable. While these are concerns for any mode of transportation, they are deterrents to an untested mode of transport. The product needs to be sold to an entity and out of the hands of the producers before it is loaded onto a barge.

Beyond taking ownership of the products, respondents were concerned about who would identify new customers in New York City, handle the transactions, and manage the relationships with the buyers as well as producers. Establishing a brokerage service that handles aggregation, transportation, and sales, manages marketing of products, and builds relationships with buyers and growers would address many of the concerns raised by the respondents.

Transportation mode comparison

Travel time, fuel consumption, energy costs and emissions for two different routes for six vehicle/vessel configurations were analyzed. Truck routes were broken down into segments based on the severity of congestion. Speed limits and fuel efficiencies were adjusted accordingly for each segment.

Routes analyzed were:
- Pomona Packing in Wolcott to Hunts Point Produce Market
- Pomona Packing in Wolcott to Red Hook Container Terminal

Analyses were conducted for the following configurations of vehicles/vessels:
- Tug/Barge with electric Transport Refrigeration Unit (eTRU) containers
- Tug/Barge with conventional TRU containers
- Tug/Barge with eTRU trailers
- Tug/Barge with conventional TRU trailers
- Truck with eTRU
- Truck

Travel time
For this analysis, only three configurations were considered: tug/barge with containers, tug/barge with trailers, and truck. Hours for loading, waiting, unloading, truck transit (to the port for tug/barge) and barge transit were estimated. Available information only enabled estimating the time required by each mode for a single container or trailer rather than for a full barge. To estimate time of travel for a full barge requires information on the dynamics of transportation between farms and the port (e.g., trucks delivering to the port all at once, one truck per day, etc.).

Travel time for both destinations was similar for a given mode but significantly different between the modes: trucks would take approximately 15 hours while barges would take between 34 to 37 hours. The two configurations for tug/barge (containers vs. trailers) did not result in significantly different transport

time. Not surprisingly the largest component of barge transport was the barge transit time (more than 15 hours). The waiting time for tug/barge was also longer than for trucks.

The Federal Motor Carrier Safety Administration's Hours of Service rule requires a ten-hour rest period following eleven hours of driving. It is worth noting that the actual *roundtrip* driving time from Wolcott to New York City will exceed eleven hours, necessitating a 10-hour rest or an additional driver for this mode.

Energy consumption
There are two primary energy consumers: the prime mover (tractor or tug) and the Transport Refrigeration Unit (TRU)/electric Transport Refrigeration Unit (eTRU) operation. The prime mover is fueled by diesel. Conventional TRUs are powered by diesel while eTRUs are partially powered by electricity when they can be plugged into the grid.

The analysis was broken down into 1) TRU fuel consumption, 2) eTRU electricity usage, 3) truck fuel consumption and 4) tug fuel consumption. For the truck transport, the full power fuel rate for diesel operation of 1.7 gallons per hour was utilized. For the eTRU 10.1 kW was used. The rate of 45 gallons per hour was used for the tug transport.

Both routes would require approximately 60 gallons of fuel for trucks and between 50 and 55 gallons for trucks with eTRUs. The tug/barge with trailers configuration consumes the most fuel (more than 120 gallons and slightly less than 120 gallons for Hunts Point and Red Hook respectively) while the tug/barge with eTRU containers consumes slightly less (approximately 110 gallons and 100 gallons for Hunts Point and Red Hook respectively). Under this analysis, tug/barge configurations consume nearly twice as much fuel as the truck mode.

Cost considerations
Only the costs associated with fuel consumption are compared. The costs for both routes varied from slightly over $200 for the truck with eTRU to more than $400 for the tug/barge with trailers. The truck mode for both routes for either configurations costs between $200 and $230. The tug/barge configurations for Hunts Point cost less than those destined for Red Hook by about $50. The tug/barge with eTRU for Hunts Point costs the least (approximately $330) while the tug/barge with trailers for Red Hook costs the highest at about $425.

Emissions
Emissions of CO, NO_x, particulate matter and CO_2 were estimated for all configurations and routes. Because emissions are related to fuel consumption, estimated emissions for all pollutants followed the same pattern as the fuel consumption: a tug/barge with trailers emits the greatest amount for all pollutants while a truck with eTRU has the lowest emissions.

Barge vs. trucks
Two factors emerged as critical in realizing the benefits of barge transport. These factors directly affect the fuel consumption and the associated emissions. The first is the distance from the origin to the port versus the distance from the origin to the market in the city. If the port lies between the origin and the city (e.g., the origin is just west or north of Albany), then the use of the barge can result in better fuel consumption and reduction in emissions. However, as the case of Wolcott, NY, when the origin is located in an area that has diagonal road access to the city bypassing the port, barge transport benefits cannot be realized.

The second factor is the volume to be transported. Tugboats typically consume fuel at a relatively fixed rate, largely unaffected by small variations in cargo size. The difference in fuel consumption of a tug

carrying between 10 trailers and 50 trailers is not significant. In other words, the fuel consumption by a tugboat does not increase proportionately with the increase in cargo size. An analysis of fuel savings by barge transport and the number of trailers per barge show that a minimum of 35 trailers per trip is needed to accrue fuel savings over trucking.

Conclusion and future research

There are many factors that must coalesce and align for the barge transport to accrue benefits, both environmentally and economically. From the transportation perspective, a minimum volume of containers or trailers is needed as well as a particular geographical relationship of the origin (whether a farm or an aggregator), the port and the market in New York City. The origin must be in the proximity of the port or the port must be located along a "straight line" between the origin and the city. Furthermore a particular type of port – a container port with lift on lift off facilities or a port with roll on roll off ramps – will affect the location of the port as well as how products will be aggregated and delivered to the port. Whether the port is union operated will also affect not only the costs but the entire operation (if one port is union, the other must also be union operated).

From the operations perspective, how products are aggregated to create the volume needed; who will aggregate the products and deliver them to the port; whether value-added processing beyond aggregation is available; who controls the products at the port, on the barge and in the city; and how new markets in the city are created and products are promoted are just some of the questions that need to be addressed.

Producers' primary concerns were costs and logistics. Reducing the costs, thereby increasing profits for producers, may not be enough of an incentive unless accompanied by seamless logistics that reduce uncertainty for producers. Minimizing the number of product handling "nodes" – farm to aggregator to port to barge to port to buyer – is also an important factor for many producers.

Although in this study we focused on larger farms to ensure adequate volumes of products, it is the mid-sized farms (earning between $50,000 and $499,999 annually) that would most benefit from new market opportunities in New York City. Twenty percent of New York State farms are mid-size, but account for one-third (2.37 million acres) of the state's farmland. Many of these are family farms. Mid-size farms in New York State are too small to access the commodity supply chains but too large for direct sales through farmers' markets or Community Supported Agriculture programs. These farms produce adequate volume for large institutions, such as school districts and universities, but a supply chain does not exist for them.

Future research

Further research should focus on mid-size farms as potential beneficiaries of this project. A business model for product aggregation is a key question in moving forward. Mid-size farms will not be able to take advantage of potential new market opportunities without aggregation and/or value-added processing. The recent announcement by Governor Cuomo to create three food hubs in the state, one in the Hudson Valley, presents an opportunity for this project.

Further research is also warranted on other product types, including but not limited to dairy products (e.g., yogurt, cheese), livestock products, wine, beer, spirits, and wood products. With the proliferation of microbreweries in the city, hops may present an opportunity, especially if the beer can be shipped as backhaul.

While it was outside the scope of this study, availability of backhaul would significantly alter the economics of barge transportation. New York Harbor is the third largest port in the nation and the largest on the eastern seaboard. More than two and a half million Trailer Equivalent Units (TEUs) came through the ports as import in 2011. Due to the lack of rail facilities, these containers move within and out of the

region primarily on trucks. The ports in the region continue to grow, accommodating bigger ships carrying more containers. Unless alternative means of shipping the goods within and out of the region is developed, more trucks on the road will be an inevitable consequence. While improvements are made on trucks to reduce their environmental impacts, more research and resources should be directed to finding alternative transport of goods coming into our ports.

In fact the Port Authority of New York New Jersey ran a pilot program, Port Inland Distribution Network (PIDN), using barges to distribute goods from the New York ports to Albany. Unfortunately PIDN ceased operation when the subsidies expired. Lack of backhaul was cited as one of the reasons for its failure to become sustainable. Reviving PIDN in conjunction with this project warrants further consideration.

Appendices

Appendix A. List of Technical Advisory Committee members

Appendix B. Hudson River Foodway Logistics Analysis by Sustainable Ports

Appendix C. Hudson River Foodway Corridor Project by Karp Resources

Appendix D. Hudson River Foodway Transportation Analysis by New West Technologies

Appendix A. List of Technical Advisory Committee members

First	Last	Organization
Jan	Blaire	LH-LI RC&D Council
John	Brennan	NYS Ag & Markets
John	Callaghan	NYS Canal Corporation
Mark	Christian	NYS Department of Transportation
Carrie	Davis	LH-LI RC&D Council / Watershed Agricultural Council
Steve	Delmonaco	NYSERDA
John	Doswell	Working Harbor Committee
Christopher	Eachus	LH-LI RC&D Council / Orange Co. Legislature
Jeff	Flumignan	US DOT Maritime Highway
Andrew	Genn	NYC EDC
Steve	Hadcock	Cornell Cooperative Extension
Laura	O'Donohue	Northeast Organic Farming Association, NY
Randall	Pratt	Apple Growers Association
Ron	Rausch	NYS Ag & Markets
Brian	Stratton	NYS Canal Corporation
Shino	Tanikawa	LH-LI RC&D Council / NYC Soil & Water Conservation District
Joseph	Tario	NYSERDA
Brian	Zimmerman	LH-LI RC&D Council / Nassau Co. Soil & Water Conservation District