USING GIS TECHNOLOGY TO EVALUATE TRANSPORTATION OF ORNAMENTAL CROPS IN GEORGIA

by

JAVIER MANTILLA COMPTE

(Under the Direction of Paul Thomas)

ABSTRACT

In the agricultural industry, the importance of transportation costs is considerably heightened as fuel and labor costs rise. Logistic cooperation is an important strategic alternative to reduce transportation costs and increase efficiencies. Georgia's ornamental industry is characterized by producers that share clients, routes and origins; however, each producer has an independent transportation system. This paper analyzes a case study to determine if a transportation alliance through a horizontal cooperation and routing junction among ornamental producers in Georgia would reduce shipping costs, increase distribution efficiencies and reduce carbon dioxide emissions. Results showed that, with the use of the GIS ArcLogistics 9.3 software, transportation alliances in the ornamental industry are profitable in terms of transport efficiencies and internal and external costs. Total cost savings per shipping cycle ranged from 1.0% to 13.2%, total miles driven savings from 1.1% to 13.6%, total number of trucks savings from 2.5% to 10.0% and driving hours savings from 1.0% to 18.4%. CO_2 emissions savings were also achieved, ranging from 1.2% to 8.4% per shipping cycle.

INDEX WORDS: Logistic cooperation; transportation costs; ornamentals; routing; distribution efficiencies; carbon dioxide emissions.

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TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Throughout the last five years a combination of economic, social and climate factors have negatively affected the ornamental industry in Georgia. A severe drought, the economic crisis at home and abroad, the instability of oil prices and the increase of other production costs have encouraged the industry to become more efficient and productive.

Costs have risen dramatically and the market has become more complex and dynamic. This trend has been more persistent in terms of one specific factor; transportation. Transportation has become the major determining factor of success of most ornamental operations. How, when and with whom growers do their shipping thus determines how efficient and productive an operation becomes.

Ornamental growers have started to realize the importance of operating a more cost efficient logistic operation by minimizing the costs of miles driven, fleet ownership, and labor. Many ornamental operations, however, do not have the resources to determine how much downsizing is necessary or appropriate for them, but they are interested in knowing available alternatives that could help them increase their success.

In the ongoing globalization process, large international freight forwarding companies are more competitive than small companies, largely due to their wider portfolio of disposable resources and a higher ranking in the market power structure. "The remedy for the medium and small sized carrier businesses is to establish coalitions in order to extend their resource portfolio and reinforce their market position" (Krajewska and Kopfer, 2006).

1.1 Background, the Green Industry

The U.S. Ornamental Industry, also known more broadly as the Green Industry, encompasses a variety of businesses involved in production, distribution and services associated with ornamental plants, landscape and garden supplies and equipment. The structure of the industry includes, but is not limited to, input suppliers, production firms, wholesale distribution firms, horticultural services firms, and retail operations.

Input supply firms are businesses that provide inputs to ornamental production firms, landscape services, and retail sales. Production firms are businesses engaged in ornamental plant production, such as floriculture crops, nursery crops, and turf grass sod. Jerardo (2004), defines floriculture crops as “ornamental plants without woody stems, including annual and perennial bedding and garden plants, cut flowers, cut cultivated greens, potted flowering plants, indoor foliage plants, and unfinished propagative material”. All other ornamental plants are classified as nursery crops. Nursery crops are defined as “woody perennial plants usually grown in containers or in the ground including ornamental trees and shrubs, fruit and nut trees, vines and ground covers” (Hall et al., 2006). Turf grass sod farms are nurseries specialized in the production of a specific group of turf grass for a particular region; working through one or more marketing channels. Wholesale distribution is an integral part of the supply chain. Intermediaries, such as brokers and importers, play a major role in this segment. Horticultural services are businesses that provide service and maintenance, such as design and installation. Retail operations is the last segment of the supply chain, and it includes garden retail centers, florists, home centers, mass merchandisers and other chain stores. According to the Southern Cooperative Bulletin (2005), the weighted average percentage of sales to retail operations in the U.S. in 2003 attributed 34-

percent to landscapers, 26-percent to re-wholesalers, 16-percent to single garden centers, 11-percent to home centers, 8-percent to mass merchandising and 5-percent to multiple location garden centers (Brooker et al., 2005).

The green industry has been characterized as one of the fastest growing segments of the U.S. agricultural economy, even during recession periods. Hall et al. (2006) estimated that the economic impact of the U.S. green industry was $147.8 billion in output, 1,964,339 jobs, $95.1 billion in value added, $64.3 billion in labor income, and $6.9 billion in indirect business taxes. From 1960 to 1998, the industry grew an average of 8-percent annually. This growth has varied considerably between decades. For instance, the 1960's averaged 3.8-percent annual growth, while the 1970's averaged 13.6-percent; the 1980's averaged 9.8-percent, while the 1990's averaged just over 4.2-percent. The green industry grew from $661 million in 1960 grower cash receipts to $12.11 billion in 1998 (Brooker et al., 2000). In 2006, the continuous percentage increase in sales came to a halt, while still averaging a $52 million increase from 2005, and a marginal gain of over $17 million in gross receipts (Jerardo, 2006; Jerardo, 2007). Of the estimated $50 billion sales in U.S. horticulture in 2005, greenhouse and nursery crops contributed approximately $16 billion (Hall et al., 2006).

Georgia's green industry is ranked as the 5th most valued agricultural commodity behind poultry and eggs, forage crops, livestock and aquaculture, and vegetables. Its total sales represent $770,185,915 (Boatright and McKissick, 2008). Georgia has become the 10th largest ornamental producer in the nation; its overall economic impact is $4.7 billion in revenue while providing a total of 62,493 jobs. The Georgia industry attributes 34.9-percent of its total value to greenhouse production, 21.3-percent to turf grass, 27.9-percent to container nursery production, 13.1-percent to field nursery production and 2.8-percent to miscellaneous ornamental (Hall et al., 2006).

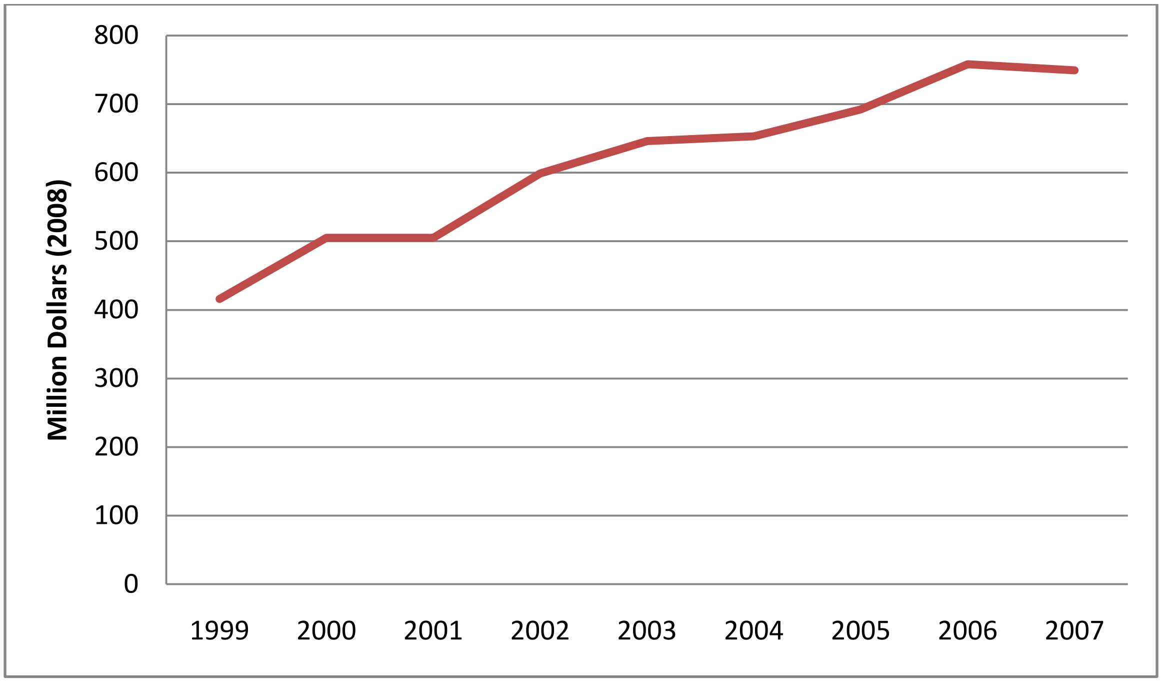

Figure 1.1 Georgia's Ornamental Industry Value from 1999 to 2007

(Boatright and McKissick, 2008)

The biggest supplier of seedlings, whips, grafts, and liners for the ornamental industry in Georgia is Georgia itself, providing 54.9-percent of the resources; the other five biggest suppliers are Alabama (6.3-percent), Florida (14.3-percent), Oregon (7.4-percent), Tennessee (6.7-percent) and Texas (1.7-percent) (Brooker et al., 2005). Georgia's ornamental industry accounts 93.8-percent of its total annual sales to wholesale and 6.2-percent to retail. The distribution of annual wholesale sales goes as follows: 6.8-percent to mass merchandisers, 32.3-percent to home centers, 16.4-percent to garden centers, 25.6-percent to landscape firms and 18.8-percent to re-wholesalers. Total sales destinations for Georgia firms are mainly distributed among six states:

Alabama (1.8-percent), Florida (4.0-percent), Georgia (78.7-percent), North Carolina (4.6-percent), South Carolina (3.7-percent) and Tennessee (2.3-percent) (Brooker et al., 2005).

1.2 Problem Statement

Georgia's ornamental industry mirrors similar national economic decline. The ornamental horticulture commodity group production value rose only slightly from 2006; increasing 9.4 percent in 2006, and increasing fractionally by 0.007 percent in 2007; with total sales of $770 million. Georgia's gains in container nursery and miscellaneous ornamental horticulture were offset by declines of $4 million in turf grass (-2-percent), $4 million in field nursery (-4-percent), and $6 million in greenhouse (-2-percent), industries most affected by the drought (Boatright and McKissick, 2008).

The increase of energy and gasoline prices, the worldwide financial recession characterized by the weakening of the U.S. dollar and the reduction in personal income are all factors expected to reduce the consumption of discretionary agricultural products such as ornamental crops. This trend keep businesses concerned about the economic stability of their businesses and encourages them to be more competitive. A study on U.S. Energy Policy and Transportation, released in May by Rice University's Baker Institute for Public Policy, shows that demand for freight transportation is increasing in the United States, an astonishing fact given that the U.S. already accounts for a third of the transportation fuel used worldwide, and that it imports more than half of the petroleum it consumes. The study calls for efforts to curb demand as well as an increase in energy production, not just from oil, but also from other sources such as wind, solar and bio-fuels (Beaubouef, 2008).

The ornamental industry faces hard economic and climatic changes, given that sales have decreased, production costs increased, and the market has become more dynamic and competitive. Hodges and Haydu (2005) ranked as the most important factors for price determination the costs of production, grade of plants and market demand. In 2007, the Floriculture and Nursery Crop Yearbook highlighted competition from imports of unrooted cuttings from out seas as an important factor in sales reduction; however, it attributed higher energy and food prices as the main causes of reduction in overall consumer demand. Climate has played an intrinsic role in Georgia's green industry economic woes. Boatright and MacKissick (2008) see the drought and its water use policies as a relevant factor that caused sales reductions in the turf grass, field nursery and greenhouse industries.

Thus all segments of the industry need to work on alternatives to keep themselves competitive and accessible to the new challenges they are facing and will continue to face. Among all the factors that affect the expansion of nurseries, production, marketing, personnel and transportation are considered the most relevant (Hodges and Haydu, 2005). In the 2003 Southern Cooperative Bulletin Survey, nurseries ranked transportation as an important factor of concern for expansion of trading, ranking it above debt capital, equity capital, marketing and below personnel and production (Brooker et al., 2005).

Truck transportation accounts for $127.6 billion, encompassing 31-percent of the entire transportation services in the U.S. in 2007 (Bureau of Transportation Statistics, 2009). The significant importance of transportation costs has remained consistent during the last ten years, turning it into an enormous strategic factor that must be accounted for economic growth and social change to occur. Transportation that is readily available and has a low cost makes raw materials accessible to the costumer at the quantity desired when and where they are needed. However, in recent years, transportation costs have increased steadily, forcing businesses to give up a higher percentage of income to transportation costs. The 2008 3rd quarter USDA report stated that average truck cost rates have increased to $2.67 per mile, 13-percent higher than in the 2nd quarter and 23-percent higher than the same quarter the year before (Transportation Services Division, 2008). Gasoline and energy sources will continue to decline in importance and transportation will eventually become one of the highest, if not the highest, determining factor of success for any business; especially those in agriculture. Figure 1.2 shows the fluctuation of diesel and gasoline prices in the last nine years, largely skewed by climatic disasters that affected local oil production.

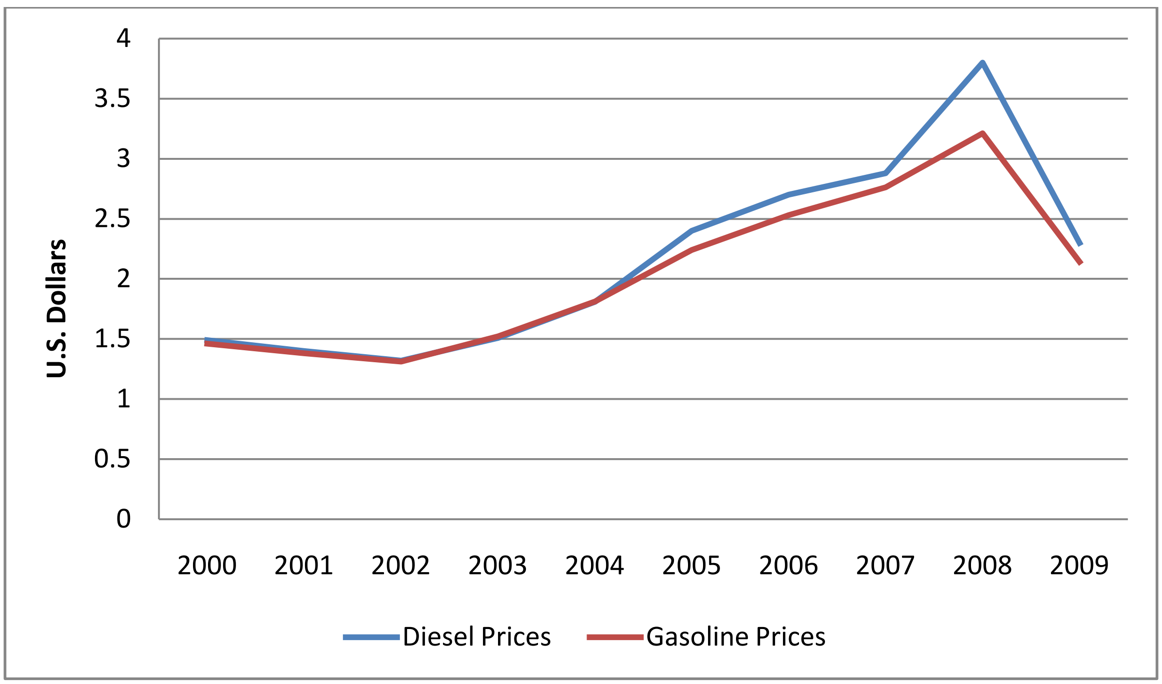

Figure 1.2 Retail Price of Diesel and Regular Gasoline from 2000 to 2009

(Energy and Information Administration, 2009)

In the agricultural industry, the importance of transportation costs is quite high, as evidenced by the fact that transportation accounts for over 8-percent of the wholesale value of total farm shipments (Nichols Jr, 1969). Logistic cooperation is an important strategic alternative to reduce costs and increase efficiency in the agricultural sector. The remedy for the medium and small-sized carrier businesses is to establish coalitions in order to extend their resource portfolio and reinforce their market position (Krajewska and Kopfer, 2006). In the case of Georgia's ornamental industry, we can find producers that share clients, routes and origins; however, each producer has an independent transportation system or ships using a third party. 85.8-percent of the total annual sales of Georgia's nursery industry have repeat customers, making it the third highest ranked state with the most repeat costumers (Brooker et al., 2005). The study, published in May 2008 by the Canadian Investment Bank CIBC World Markets, calculated that the recent surge in shipping costs is on average the equivalent of a 9-percent tariff on trade. The report concluded that "the cost of moving goods, not the cost of tariffs, is the largest barrier to trade today," effectively offsetting all trade liberalization efforts over the last three decades (Rohter, 2008).

Due to the aforementioned reasons, efficient fleet management is a growing concern of businesses and local governments as they seek to optimize the performance of vehicle operations to save fuel, reduce labor and maintenance costs, and operate in a more sustainable manner.

1.3. Objectives

The overall objective of this study was to determine if transportation alliances through horizontal cooperation and routing junction would reduce shipping costs, increase distribution efficiencies and reduce CO_2 emissions among ornamental producers in Georgia. The specific objectives of this research are as follows:

(i) Conduct a survey of medium and small nurseries/greenhouses in Georgia to gather data regarding shipping costs, orders and fleet management.

(ii) Construct a simple unit cost model to determine internal and external transportation costs in a per mile, per hour and per day basis.

(iii) Develop routing plan analysis to participant nurseries and potential alliances with the use of GIS software ArcLogistics 9.3.

(iv) Develop sensitivity analysis for each constraint to show cost-saving opportunities.

1.4 Organization of the Study

This thesis is divided into five chapters. Chapter 1 consists of an introduction that reviews the ornamental industry and the importance of transportation in agriculture. Chapter 2 provides a literature review on the establishment of a strategic transportation alliance, horizontal cooperation in logistics, joint routes planning and order sharing, GIS software (ArcLogistics 9.3) and a cost allocation unit model. Chapter 3 explains the data and methodology used in this study. Chapter 4 reports the results and analysis. Chapter 5 provides a summary and discussion of conclusions.

CHAPTER 2

LITERATURE REVIEW

This chapter reviews the literature on (1) strategic alliance objectives and dimensions in logistic management; (2) horizontal logistic cooperation components, opportunities and case studies; (3) benefits of joint route planning in transportation with case studies as examples; (4) the use of information technology and the application of the GIS software ArcLogistic 9.3 to solve routing and scheduling problems; and finally (5) a description of a fully cost allocation process using a unit model.

2.1 Strategic Alliance in Logistics

"Like romances, alliances are built on hopes and dreams, what might happen if certain opportunities are pursed" (Kanter, 1994).

Strategic alliances are gaining importance in current management practices. Alliances between companies, whether they are from different regions of the world or different ends of the supply chain, are a fact of business today (Kanter, 1994). More than 20,000 corporate alliances have been formed worldwide over the past years, and the number of alliances in the U.S. have grown by 25-percent each year since 1987 (Farris, 1999). Contractor and Lorange (2002) defined an alliance as "any interfirm cooperation that falls between the extremes of discrete, short term contracts and the complete merger of two or more organizations". Businesses that share complementary strengths and opportunities take advantage and form synergies among them to reduce operating costs, improve efficiency and seek competitive advantages.

Strategic alliances use a different legal structure than cooperatives. Alliances structure is based on equity investments with stock shares as consideration for entering into the alliance (Fogler and Reichert, 2002). There are a variety of economic reasons for the formation of such alliances. An alliance can be formed to share the costs of large investments, pool and spread risk, and/or gain access to complementary resources (Gugler and Dunning, 1993). Additionally, collaborative relationships can increase the return on investment by geographically widening the marketplace for a firm's products and services (Esper and Williams, 2003).

Companies can participate simultaneously in many kinds of relationships, and alliances can take many forms. One form of strategic alliance that is becoming increasingly popular in business to business markets is the logistics-based strategic alliance (Bowersox, 1990). However, compared to other types of strategic alliances, lateral or internal, logistics-based alliances have not received much conceptual or empirical attention in the literature (Zineldin and Bredenlow, 2003)

Logistic-based strategic alliances deliver a wide variety of service combinations; therefore, they have been classified on two general simple dimensions: scope and intensity. Zinn and Parasuraman (2007) defined scope as “the range of services to be included in the alliance and intensity as the extent involvement between partners”. These arrangements are combined to define the classification of logistic based alliances in a broad or narrow scope and in a high or low intensity as follows: focused, integrated, extensive and/or limited alliance. For the purpose of this study, the analysis is directed to evaluate a focused alliance where companies would benefit from the cost efficiencies of intense relationships with their logistics partners but, for competitive or strategic reasons, keep certain delicate information confidential (Zinn and Parasuraman, 1997).

2.2 Horizontal Cooperation

Competition in global markets, the heightened expectations of customers and the introduction of products with shorter life cycles have forced shippers to invest in stronger and mutual relationships between each other (Cruijssen et al., 2007b). The most fundamental choices that logistic companies face is whether to outsource, keep logistics in house, or seek cooperation with other companies to exploit synergies (Razzaque and Sheng, 1998). The Wine and Spirits Shippers Association (WSSA) in Reston, Virginia, is a specialized cooperative that serves about 450 member companies in the alcoholic beverages trade market. "The weak link in the chain is the small guy, and his main recourse is to join an association," says Geoff Giovanetti, managing director of WSSA. Most of WSSA's members are small or medium sized enterprises (Cottril, 1998). Customers' demands have increased; they expect fresher products, in perfect condition, at the right place, at the right time and at lowest costs. Oftentimes companies experience difficulties satisfying individual customer demands, forcing them to unify synergies and seek to work in cooperation with other firms. Whether companies choose to form an alliance or not, cooperation between one another can occur in myriad ways.

Cooperative arrangements between companies vary from weak and distant to strong and close. Kanter (1994) established three main arrangements: 1) mutual service consortia, similar companies in similar industries that pool their resources to gain benefits difficult to acquire by themselves, for example access to technology; 2) joint ventures, companies that pursue an opportunity that requires a capability from each of them, for example the technology from one company and the market share from the other; and 3) value chain partnerships, such as companies in different industries with different but complementary attributes join their capabilities to pursue value for ultimate use.

Cooperatives in the supply chain are classified based on their structure as either vertical, horizontal or lateral (Simatupang and Sridharan, 2002). Simchi-Levi (2005) defined vertical cooperation "as the set of approaches to efficiently integrate suppliers, manufacturers, warehouses and stores so that merchandise is produced and distributed in the right quantities at the right locations and at the right time in order to minimize system wide costs while satisfying service level requirements". Vertical cooperatives have been studied in depth; the most common and best studied type is when shippers hire a third party to perform all or a part of their distribution. Horizontal cooperatives consist of organizations in the same industry, whose main purpose is to coordinate skills and functions that contribute to the production or service of a certain resource (Elg and Johansson, 1996). Horizontal relationships can take place between competing or unrelated companies and occurs when companies at the same market level coordinate practices such as facilities, information, or resources to reduce costs or improve efficiency (Cruijssen et al., 2007b). Lateral cooperations combine vertical and horizontal cooperation by synchronizing shipping of multiple companies and logistics service providers in an effective logistics network (Simatupang and Sridharan, 2002).

Whereas a fair amount of literature has focused in vertical cooperation in supply chains and lateral cooperation in supply networks, the literature in horizontal cooperation in transport and logistics is fairly limited, especially where operational consequences are concerned (Cruijssen et al., 2007b). Nevertheless, this type of cooperation is becoming more and more relevant in practice; as Cruijssen et al. (2006) pointed out, horizontal cooperation is an important alternative to decrease costs, gain market position and improve service.

Cruijssen et al. (2007b) divided horizontal cooperation into three categories: Type I, consists of partners that coordinate through a limited time period and focus on a single activity; Type II, is a cooperation in which participants not only coordinate but integrate on the business of their partners through a long time period; and Type III, is referred as a horizontal strategic alliance. Burgers et al. (1993) defined horizontal strategic alliance as "a long term contractual agreement pertaining to an exchange or combination of some, but not all of firm's resources with one or more competitors".

The concept of horizontal cooperation has become extensively common in airline transportation and maritime shipping, while land transportation has not yet adopted horizontal cooperation on a large scale. In the airline industry, this concept of cooperation plays a dominant role. Airlines have strong incentives to operate in cooperatives to expand their network internationally. Some examples of major alliances are Skytema (nine airlines), Star Alliance (sixteen airlines), Qualifier (eleven airlines) and One World (eight airlines) (Cruijssen et al., 2007b). Oum et al. (2004) revealed that airline horizontal alliances formed between 1986 and 1995 made a significant contribution to productivity and profitability gains. In maritime shipping, horizontal alliances have become such common practice that it has lead to the creation of a new concept of cooperation known as conferences. Conferences consist of multiple ocean carriers that focus on a specific route gaining rate stability and service improvement. For example: Transpacific Westbound Freight Agreement operates on the route from the U.S. to the Far East and the Indian subcontinent (Sjostrom, 2002). A majority of shippers oppose conferences due to the fact that carriers' ability to compete has greatly diminished (Clarke, 1997).

Even though horizontal cooperation in land transportation is quite scarce (Cruijssen et al., 2007c), in recent years a considerable number of order-sharing initiatives have been launched in Europe (Cruijssen et al., 2006). Caputo and Mininno (1996) analyzed horizontal integration of logistic functions in the Italian grocery store industry, where transportation costs encompass about 50-percent of total cost. The study points that the aim of cooperation is not only to reduce the incidence of these interface costs but above all to improve the level of service. Horizontal integration was suggested for the aggregation of suppliers to a common courier so coordinated multi pick up deliveries can be achieved.

Hageback and Segerstedt (2004) discuss the need of co-distribution for companies in Pajala, Sweden. Companies in Pajala receive and distribute goods with a low frequency and carry loads are often loaded to less than 50-percent of capacity. The authors implied that to lower transportation costs and increase delivery services, a joint distribution through horizontal cooperation is necessary. They concluded that volume of trips to Pajala and transportation costs would be reduced by one third while still increasing the frequency of deliveries. They also stated that the same results could be achieved in other municipalities of rural areas in Sweden besides Pajala.

Elg and Johansson (1996) also discuss the horizontal oriented alliance between Skånemejerier, Sweden's largest dairy producer, and the Danish dairy company Klöver and MD Foods. The main purpose of the alliance was to gain distribution efficiency and market penetration. Klöver and MD Foods, while cooperating, were able to internationalize their market to Sweden due to Skånemejerier's extensive direct store delivery system, gaining access to superior distribution. On the other hand Skånemejerier was able to utilize distribution channels in Denmark and Germany, increasing the control of its marketing environment and limiting the opportunities to its major competitor ARLA, to squeeze its market position. The study suggests that horizontal cooperatives are expected to have an enormous future impact and will become more complex in the internalization process.

Cruijssen et al. (2006) evaluated a simulation of horizontal cooperation through order sharing to reduce transportation costs at the Dutch flower auction. The authors compared how two transportation companies could share clients' orders at the auction and determined the savings of such an operation. The study found that due to economies of scale, more efficient routes could be constructed, leading to both a smaller number of trucks needed and a reduction in kilometers driven. The results show that order sharing and joint route planning can lead to general cost savings of 5 to 15-percent and sometimes even higher. They also claim that order sharing is especially applicable for the transportation of low value goods, since transportation makes up a high percentage of the total cost price of such goods. Studies are suggested to evaluate how order sharing may reduce costs when multiple factors such as time windows, multiple depots, periodicity and/or pick up delivery are introduced into the analysis.

Krajewska et al. (2007) studied a medium sized freight forwarding company that uses its own vehicles and subcontractors for its operations in several German regions. The company consists of several autonomous profit centers which operate as independent freight carriers. Thus, the mentioned profit centers treat each other like any other competitor on the market. The study analyzed whether a horizontal collaboration between the profit centers could reduce the number of empty truck movements and consequently cost reduction. Results found that by using a cooperative game theory between the three profit centers, savings between 10 to 20-percent could be achieved.

2.3 Joint route planning

Through cooperation partnering, companies seek to increase the competitiveness of their logistic networks by saving in storage costs, in core activities and purchasing costs (Cruijssen et al., 2007a). These types of costs can be estimated by a simple cost allocation model or a basic cost calculation. However, distribution costs are more complex and they require a joint route plan analysis. For example, logistic horizontal cooperatives, where distribution channels are unified to improve services, efficiencies and costs are associated with transportation and delivery processes by achieving economies of scale (Esper and Williams, 2003). Joint route planning considers a set of multiple companies with separate distribution orders. These orders are delivered from a single distribution center to specific drop off locations, in most cases retailers (Cruijssen et al., 2007a). Unification of routes is achieved when distribution centers and drop off locations are located close to each other forming a similar distribution network among multiple companies.

The effectiveness of joining routes and order sharing is measured by the synergy value. This value represents the percentage difference of distribution costs between the original situation where companies perform their orders individually versus collecting all shipping orders together and setting up routes simultaneously. Questions still remain as to how the costs savings could be allocated. Game theory models in a variety of industries (Cachon and Lariviere, 1999; Yang and Bell, 1998) have defined how to take into account each player's impact in a cooperation group and produce compromise allocations based on clear and fair properties (Krajewska et al., 2007).

The design of distribution networks is determined by two factors: structure and process. To establish the structural design, decisions need to be taken regarding the number of different steps through a network from production to retail and the number of hubs used per step (Bahrami, 2002). The process determines the type of transportation mode used and the transportation process taken. Bahrami (2002) defined two transportation processes in fast moving goods: 1) Two-stage delivery, distribution from production site to distribution center and then directly to retailer and; 2) Three-stage delivery, distribution that includes a transshipment point between distribution center and retailer and serves as a consolidation group. The study concluded that transporting goods in a two-stage delivery produces higher savings. A distribution network's design can determine how a transportation system will function and how efficiently joint route planning and order sharing can be achieved.

Literature discusses several joint route planning case studies. Cruijssen et al. (2007) evaluated three Dutch companies that produce frozen products. Given that such type of products require temperature controlled trucks, transportation costs play a significant role in product pricing. Driven by a 68-percent overlap between customers, companies decided to evaluate a joint route distribution for their products. The study found 50-percent reduction in terms of kilometers driven. One of the main reasons for the savings besides the fewer kilometers driven was the increase in load factors, over 95-percent. Baharami (2002) described how Henkel and Schwarzkopf merged distribution networks. Due to the light weight and homogeneity of their products, and the proximity of their production plants, 85-percent are located in Germany, joining routes was a viable alternative to reduce transportation costs. However, savings in overall distribution costs only fell by 2.4-percent through process and 9.8-percent through structure optimization. Cruijssen et al. (2005) also talk about a Dutch logistic service provider (third party), which acquired four grocery retailers as costumers. The study evaluates the cost savings of joining routes for their frozen goods to local supermarkets. A 20-percent savings was achieved. The authors suggested a third party to control the distribution of goods, because it makes horizontal cooperation possible without the difficulties arising from the sharing of sensitive information.

Bahrami (2002) suggested a three-phased model for the analysis of a logistic cooperation between producers and consumer of goods. The first phase consists of the selection of suitable partners; the second phase consists of the estimation of savings on transportation due to cooperation and joint route planning and the third phase consists of developing an algorithm that gives an allocation of the synergy benefits among the partners. This study focuses on the first and second phase of Bahrami's model and then it applies an established algorithm to evaluate synergy values.

2.4 Review of GIS Software: ArcLogistics 9.3

Transportation has evolved considerably from a passive cost to a primary one by encompassing a functional and supportive role (Lai et al., 2006). The market has become electronically connected and dynamic in nature. Companies are seeking to improve their agility levels with the objective of being flexible and responsive to the market. In an effort to achieve these goals, companies have highlighted the importance of technology advantage and information in the supply chain distribution (Gunasekaran and Ngai, 2004). Developments in telecommunications and information technology have created many opportunities to increase cooperation among entities operating logistic chains (Krajewska et al., 2007). Many studies have suggested that information technology increases logistic competitiveness, helping companies focus on strategic issues and core competencies (Boudreau et al., 1998; Closs and Xu, 2000; Ross et al., 1995). Information technology is one of the few tools that can increase capabilities and decrease costs of distribution simultaneously (Closs et al., 1997).

Mintsis et al. (2004) highlighted that the future challenge for the transportation sector is its ability to take advantage and implement global positioning system (GPS) and geographical information system (GIS) technologies. Thus far, the experience gained from the wide range of applications of GPS and GIS technology in the transportation sector shows an ample array of applicable benefits. Mennecke et al. (1995) defined GIS as "a computer based information system that provides tools to collect, integrate, manage, analyze, model and display data that is referenced to an accurate cartographic representation of objects in space". GIS possesses several characteristics that distinguishes it from the other information systems (Mennecke and Crossland, 1996). GIS is designed to support the production of maps, collect and manage spatially defined data, display spatial data and elaborate spatial and what if analysis. GIS is a powerful decision tool, allowing users to not only manage attribute data, but also to capture, manage and incorporate spatial data in their analyses (Mennecke and Crossland, 1996).

GIS's uses are widely spread from surveying and mapping, facility management, market analysis and logistics and transportation. Weigel and Cao (1999) studied how Sears, Roebuck and Company uses GIS to run the delivery and home service fleets more efficiently. GIS made the system quite efficient, improving the Sears technician dispatching and home delivery businesses resulting in over $9 million savings. Based on experience gained from Sears logistic and production services, the Environmental Services Institute Inc. (ESRI) developed an algorithm that can solve larger logistic problems, called ArcLogistics Route (Prasertsri and Kilmer, 2004). The algorithm considers a “cluster first, route second” method, with two steps (Weigel and Cao, 1999): 1) the resource assignment algorithm that assigns stops to vehicles and 2) the sequence and route improvement algorithm that orders the route sequence within the allocated vehicles (Prasertsri and Kilmer, 2004). The algorithm was modeled as a vehicle routing problem with time windows considering relevant constraints. The vehicle routing problem with time windows is well known among researchers for its complexity, making it quite difficult and almost impossible to solve (Solomon, 1987).

Aiming to provide a solution with significant usability enhancements and new capabilities to help organizations optimize their fleet operations, ESRI developed a new version of the ArcLogistics Route, named ArcLogistics 9.3, based on the ArcGIS platform. ArcLogistics Route software was developed in the late 1990s, its users consistently reported operational cost savings of 15 to 20-percent (ESRI, 2008). The earlier ArcLogistics Route was an effective operational tool for all fleet sizes that took into account real street network and driving attributes. The new version, ArcLogistics 9.3 maintains these attributes while incorporating new advantages that make it an even more valuable analytic tool.

ArcLogistics 9.3 helps users improve their daily fleet operations to achieve an optimum level of performance, resulting in less fuel consumed and a reduction in their carbon footprint. The software allows organizations to build more efficient routes and schedules in a multistep or multivehicle environment, service more customers maintaining the same fleet, improve customer service satisfaction by offering a specific time window for each delivery, achieve pick up and drop off deliveries simultaneously and respond to same day orders (ESRI, 2008). Operating efficiencies are also increased by considering additional factors while solving the routing problem such as customer time windows, vehicle capacities, and driver specialties (work skills or language spoken), as well as organizational factors like workday start times.

Morey's Seafood International LLC is one of the biggest fresh fish and seafood distributors in the United States. In fall 2000, Morey's began using ArcLogistics software to improve the delivery of its products in the Detroit area, one of the firm's primary markets. In the first six months of using ArcLogistics, they managed to increase the average load per vehicle by more than 30-percent, from nine orders per route to more than twelve orders. Morey's also reduced its local delivery fleet from 28 trucks to 23 trucks, an 18-percent decrease. Loading fewer trucks in a more efficient manner led Morey's Seafood International LLC to achieve a significant reduction in transportation costs (ESRI, 2009).

Ivan Smith Furniture is a third generation family owned furniture retailer that owns 48 stores in Louisiana, Arkansas, and Texas and runs up to 23 delivery routes per day out of seven locations. Ivan Smith Furniture implemented ESRI's software ArcLogistics to identify and implement a routing and scheduling solution that could give the company the confidence to build up optimal routes to reduce miles driven and fuel consumption. The company decided to implement ArcLogistics desktop application, because it was a low cost solution that worked outside the box while still including highly sophisticated route solving algorithms. Ivan Smith Furniture was able to solve routing and scheduling problems at the lowest cost while considering factors such as truck capacities, delivery windows, length of workday, and driving times. "We are working more efficiently and saving time. Our local delivery drivers are back one to two hours earlier each day," Trey Smith (Operations Manager) said. "Our initial estimates are that we are saving $1,000 to $2,000 each week" (ESRI, 2009).

The MMC is a milk marketing cooperative created by Florida dairy farmers to link the primary supply of fluid milk with processors in a vertical market. A relevant economic and operational factor for the MMC is to optimize the operation of the fluid milk hauling system to reduce milk routing and scheduling costs, subject to farm and plant schedules. The MMC found that the standard operating procedures of the processors and farmers were inhibiting the cooperative from becoming more efficient. For example, instead of receiving the same number of loads of milk each day of the week, processors order a different number of loads of milk each day and sometimes cancel orders the day before the delivery. Therefore, Prasertsri and Kilmer (2004) conducted a study to determine if it is economically feasible to implement more efficient routing and scheduling milk collection from farm to plant using the ArcLogistics Route 2.0 software. Results yielded a reduction in the total average weekly route mileage of 5,726 miles, a 3.39-percent reduction, equaling $7,387.26 in total savings.

2.5 Cost allocation process: one unit model

Transportation is a vital factor in the economy of a country, region and/or city. Low costs provide businesses with a competitive advantage (Sahin et al., 2009). Therefore, it is imperative to calculate all transportation costs accurately and to try to minimize them to accomplish an economically savvy transportation system. Abundant literature has been dedicated to determine the transportation cost of a unit of cargo or passenger per route length, considering it a relevant economic indicator. For example, Burns et al. (1985) developed an analytic method for minimizing the cost of distributing freight by truck from a supplier to various customers. The study compares two distribution strategies: shipping separate loads to each customer and shipping loads in the same truck to more than one customer. McCann (2001) analyzed the optimum size of a vehicle and the structure of transport costs with respect to haulage distance. The study concluded that under very general conditions the optimum size of a vehicle or ship increases with the haulage distance and haulage weight. Hu et al. (2002) formulated a cost minimization model for a multi-time step, multi-type hazardous waste reverse logistics system. By using the proposed model coupled with operational strategies, the total reverse logistics costs for the applications cases can be reduced by more than 49-percent. Ravn and Mazzenga (2004) evaluated the quantitative effects of introducing transportation costs into an international trade model. The model was constructed via the introduction of the international transportation services sector. Dullaert et al. (2005) suggested a new methodology for determining the optimal mixture of transport alternatives to minimize total logistics costs when goods are shipped from a supplier to a receiver.

The total costs of producing a product or providing a service includes the market value of all the resources used in its production and/or delivery (Schiller, 2008). For a better economic evaluation, costs are classified and segmented as internal costs, also known as user or private costs; and external costs, also known as social costs or externalities (Litman, 1996). Internal costs are costs incurred directly by the good's consumer, and external costs are costs incurred by others. Some costs, such as carbon dioxide emissions and accident risks, are external to individual users but largely influenced by the group of users. Studies debate whether these costs should be considered external costs and subsidized by the public at large, or whether they should be considered internal costs subsidized by the good's consumer/producer.

Internal costs are the resource costs incurred by a specific producer or service provider; in the case of transportation, they are the direct expenses assumed by providers of freight transportation (Schiller, 2008). Such costs consist of operating costs, as well as investments in capital assets and stock material, which eventually runs out and must be replaced (Forkenbrock, 1999). Operating costs are those closely linked to the amount of service provided, such as: fuel, maintenance, user charges, depreciation, wages and insurance. Internal costs are subdivided amid fixed and variable costs depending on the perspective and time horizon (Litman, 1996). Variable costs are costs of production that change when the rate of output or service is altered; for example, the amount a vehicle is used affects costs such as: fuel, emissions, travel time and accident risk. In comparison, fixed costs are costs of production that do not change when the rate of output or service is altered; for example, insurance, depreciation, taxes and registration costs are not affected by the amount of miles driven by vehicles (Schiller, 2008).

External costs are all the costs of a market activity borne by a third party, that is, by someone other than the immediate freight provider (Schiller, 2008). External costs are influenced by the result of day to day operations. Forkenbrock (1999) classified four general types of external costs for intercity freight trucking to be compared with the private costs incurred by carriers: 1) accidents (fatalities, injuries, and property damage); 2) emissions (air pollution and greenhouse gases); 3) noise; and 4) unrecovered costs associated with the provision, operation, and maintenance of public facilities. For full cost pricing of transportation services to occur, the magnitude of social costs must be projected as accurately as possible by estimating the amount of economic damages produced by the externality, rather than the cost of preventing that damage in the first place (Levinson and Gillen, 1998).

Most economic studies analyze interactions through the effect on prices and not on externalities. However, in practice this theory is flawed due to the fact that few external costs can be assigned dollar amounts akin to private costs. Truck transportation has experienced an increase in external costs, yet few estimates actually calculate them since they are not always taken into account when production and consumption decisions are made. For example, Forkenbrock (1999) revealed that external costs are equal to 13.2-percent of private costs and user fees need to be increased about threefold to internalize these external costs. Some economists believe that external benefits can arise from improvements to transportation systems. An improvement may reduce the costs of transportation operations, thus contributing to increased competitiveness and higher output (Greene and Jones, 1997).

A range of literature describes the effects of internal and external costs in road transportation. Levingston and Gillen (1998) developed a full cost model which identifies the key cost components and then estimates costs component by component: user costs, infrastructure costs, time and congestion costs, noise costs, accident costs, and pollution costs. The total long run average cost found was $0.34 per vehicle/kilometer traveled, making travel time the single largest cost category. While the marginal cost of infrastructure was higher than its average cost, this just indicates that new construction is increasingly more expensive. On the other hand the marginal cost of driving (including fixed and variable costs) was less than its average cost, indicating that by increasing travel, the user can spread his vehicle's fixed cost over more trips without penalty.

Zegras (1998) conducted a cost analysis of the transportation system of Santiago de Chile. The paper presented a summary of the total magnitude of costs, a differentiation of internal and external costs, and a cost comparison according to various travel modes. Results accounted transportation costs of Santiago de Chile to be approximately $5.7 billion, 27.5-percent of the Gross Regional Product, where 74-percent of transportation costs are paid by system users in the form of personal expenditures and the other 26-percent of costs, amounting to approximately $1.5 billion in external costs, paid by society. Jakob et al. (2006) estimated the value of external and internal costs for private and public transport using a case study for Auckland, New Zealand. The study concluded that private transport generates 28 times more external cost than public transport. The internal cost assessment showed that total revenues collected did not even cover 50-percent of the total transport cost. The research has shown that not only is the external cost of vehicle transport high, but that contrary to popular belief the total cost of private transport is subsidized by public transport users. Janic (2007) developed a model to calculate combined internal and external costs of intermodal and road freight transport networks. The model simplifies configurations of both networks using the inputs from the European freight transport system. Results show that the full costs of both networks decrease more than proportionally as door to door distance increases, suggesting economies of distance. In intermodal transport network, average full costs decline at a decreasing rate as the quantity of loads rises indicating economies of scale, while in road transport network they remain constant. Full and internal costs decrease more rapidly with increasing distance in the intermodal case compared to the road transport network.

Taken together, private operating costs and external costs can give both shippers and carriers signals regarding the true (full) cost of a unit of service. In turn, the amount of service demanded at this cost will define the appropriate level of capital investment. Estimating the full cost of a road transportation network involves indentifying the appropriate cost allocation model, collecting data and implementing the model (Levinson and Gillen, 1998). The principle underlying fully allocated costing analysis is that the total cost incurred in producing a specific product or delivering a specific service should be attributed to that product or to that service. The fully allocated costing analysis recognizes that both fixed and variable costs are incurred in the delivery of any specific service of transit service; therefore, it represents a complete accounting of all the capital, labor and resources used in the delivery.

By contrast, a marginal cost analysis recognizes only the variable costs of any specific segment of service (Pshyk et al., 1987). For the purpose of this study, the cost allocation process used to estimate the full cost is a unit cost mode. This model indentifies all the resources used in the production of a good or service, determines its value, calculates its unitary cost, and then adds up everything. The diagram below explains the steps required to adopt a unit cost model.

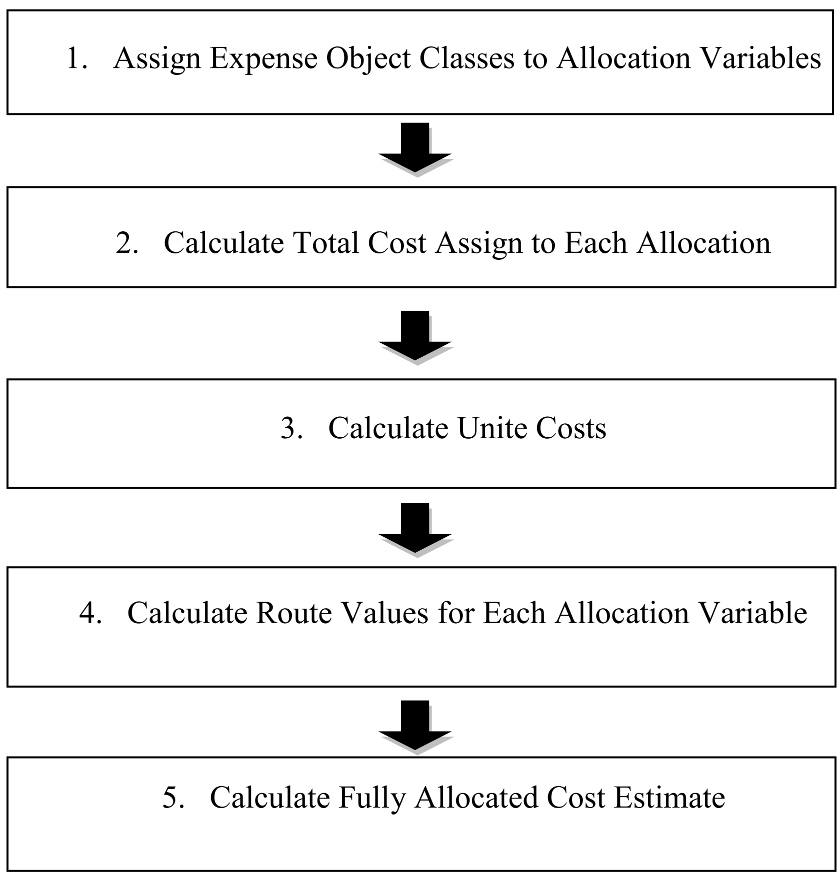

Figure 2.1 Cost Allocation Process Using a Unit Cost Model (Pshyk et al., 1987).

CHAPTER 3

METHODOLOGY

This chapter includes a description of the data and the methodology used. Three step by step methods were conducted: 1. Selection of participants and data collection through a survey; 2. Full and unitary cost analysis on a per truck, per mile, per hour and per day basis; 3. Routing plan analysis of all transportation operations and alliances among with a "what if" analysis for four different constraint scenarios.

3.1 Selection of Participants and Data Collection

This study focuses in evaluating the transportation decisions of ornamental producers located in the state of Georgia, disregarding their size of operation, market share, volumes or product constraints. The selection process was accomplished at an annual conference of the green industry, where ornamental growers were randomly provided with a sales proposal (Appendix B) and a detailed survey (Appendix C).

The aim of the sales proposal was to provide enough information to growers to understand how and why transportation alliances could help ornamental growers achieve more competitive shipping rates, price advantages in comparison to imported plant materials, reductions in carbon footprint and decrease overall truck traffic. The survey included several questions related to their shipping *modus operandi*, shipping costs, routing procedures and client locations. A total of ten growers responded the questionnaire positively and they were considered as the participant group for the research.

3.2 Cost Analysis

Cost control is an essential tool for economic survival, yet ornamental producers have less knowledge of the full cost of their shipping operation than shippers, larger trucking companies, and logistics firms. Ornamental producers need accurate, reliable estimates of owner and operator costs. This may supply revenue adequacy, without sacrificing distribution efficiency and marketing goals. Current cost estimates are also important to determine the appropriate mode of transportation.

Developing transportation costs requires the use of a variety of data sources. Data gathered from the survey were used as primary source and data from previous studies were used as secondary sources. A spreadsheet model was developed to link relevant truck costs to performance measures. Extensive literature describes that cost measurements, or performance measures, are limited to cost per ton, cost per mile, or per ton-mile (Barnes and Langworthy, 2004; Berwick and Dooley, 1997). Different cost measurements are important for the different entities using truck costs or transportation assessment. Alternative performance measures may react differently to changes in truck and product characteristics, or input price changes. The model developed in this study measures costs in a per truck, per mile, per hour and per day basis. The flexibility of the model allows for changes in performance measurements to fit individual needs.

The total cost of a shipping operation or of an individual truck is affected by a wide variety and level of circumstances. Costing models analyze each feature separately from each other;

consequently, finding an established model to determine transportation costs of ornamentals was not suitable. In the transportation of ornamentals, as not with other agricultural commodities, several factors affect the overall operation efficiency, making it complex to estimate full unitary costs. First, there is wide variety of plants, with different sizes, formats and requirements; second, loading and unloading procedures are unique to each operation; and third, there is lack of primary data. All these factors are major reasons why little research has been performed in this field.

Because of time constraints of the study and lack of previous information and data, it was assumed that all producers would ship plants with similar characteristics regarding their size and space in truck; loading and unloading times; and temperature and humidity requirements. These factors must be considered in real modeling, but since there is an enormous variation between each shipping operation, it was assumed that all operations ship the same products with the same approach. Second, due to the strong dependence of a cost model to its particular functionality the study analysis was developed on "average" costs based on data from the survey and from literature. For example; bigger trucks consume more fuel than smaller trucks, as other costs also vary widely. The purpose of this study is to provide primary data and develop routing models that would allow in the future identifying and evaluating more variables that increase transportation efficiencies.

The study employs a simple unit costs model that accounts for external and private costs. Private costs, also known as internal costs, are the direct expenses assumed by providers of truck transportation, in this case by the participants. Such costs consist of investment in capital and operating costs and are divided into fixed and variable costs. Capital investment must be renewed eventually, once the stock is empty or useless. Operating costs are the most appropriate basis for comparison with external costs, because external and operating costs are the result of day to day operations (Forkenbrock, 1999). Whereas, external costs are the expenses paid by the society and the environment as a whole (Jakob et al., 2006).

The following chapters of the study address the calculations and estimates of the fixed costs (depreciation, insurance, overhead expenses, taxes and registration fees, and return on investment), variable costs (fuel, repair and maintenance, tires, and labor), and external costs (accident costs and carbon dioxide emissions) used for the routing analysis.

Table 3.1 Literature Review Truck Costs Summary (cents per mile)

Source	Total Cost	Fuel	Maint./Repair	Tires	Labor	Tax/Regist.	Insurance	Overhead
Berwick, 2003	1.31	32.2	9.6	6.2	39	1.7	7.2	10.7
Barnes, 2003	1.30	21.4	10.5	3.5	50	-	-	-
LSBI, 2005	1.24	22.3	8.7	3.5	44.6	3.7	3.7	17.4
ATRI, 2009	1.73	63.4	9.2	3.0	60.3	6.2	2.4	6.0
USDA, 2009	1.98	-	-	-	-	-	-	-

Fixed Costs

Truck Values

As mentioned in previous chapters, there are many different, models, sizes and kinds of trucks that increase the variability of the total cost of a shipping operation. In this study we estimate a single average truck value that accounts for all trucks values. This was done for two reasons: first, most of the growers surveyed didn't have a detailed accounting of their costs incurred by each truck model, and second, with the aim to evaluate a successful comparison and sensitivity analysis between the transportation alliance and a single unit transportation operation, the study required standardized data for better analysis. So to be more conservative it was used as an adjustment factor the same average truck value of $25,000 for all truck models. This value came from averaging all the truck values referenced from The Truck Blue Book 2009 January Edition (Stephens, 2009).

Depreciation

Depreciation is defined as the cost of using capital assets. It is considered as the portion of useful life that an item has during its accounting period. In shipping operations depreciation is referred in most cases as the main capital investment. Thus, by allocating depreciation over the useful life of the investment, a manager can measure the economic contribution of the investment (Newkirk and Casavant, 1990). In this study, trucks and trailers were depreciated on the straight line basis correspondingly as Berwick and Dooley (1997). Depreciation was calculated by subtracting the salvage value from the purchase price and dividing this figure by the estimated useful life (Newkirk and Casavant, 1990).

Salvage values are difficult to determine and primarily depend on the mileage and condition of the truck. Newkirk and Cassavant (1990) used a salvage value equal to 30-percent of the truck total value, as did Berwick et al. (2003). Other studies in the truck industry have estimated salvage values of 5 years for trucks and 10 years for trailers (Berwick and Dooley, 1997). Barnes and Langworthy (2004) determined a fixed depreciation rate of 0.008 cents per mile per truck. This value assumed that 70-percent of mileage is driven by trucks less than 5 years old, and 30-percent by trucks 5 years old and more. For the purpose of this research the following formula was used to calculate depreciation.

Depreciation= (Purchase Price – Salvage Value) / Years of Service

Insurance

Insurance rates are the most variable cost and represent a significant portion of total fixed costs. Many personal, geographic and political factors determine the exact insurance premium, making it hard to measure (Wurster, 2002). Therefore, this study averaged the insurance costs from data gathered in the survey and used that value for all the insurance costs for all trucks. The average insurance value used was $0.047 per mile. The review of the American Transportation Research Institute in 2009 to motor carriers of different sizes and regions attributes that the straight truck insurance premium cost averages $0.06 per mile. This value indicates that there is no considerable difference from our estimates and literature.

Overhead Expenses

Literature describes overhead costs as short run fixed costs not directly attributable to a unit of output (Newkirk and Casavant, 1990). Overhead expenses consider costs such as management and administration staff, advertising and communications equipment, office space, and office equipment. For some, ornamental producer management and overhead costs may be minimal because the driver may be the manager or owner; also, other costs such as administration staff may not be applicable. Additional costs included in overhead are sales, management, and accounting.

Berwick and Farooq (2003) estimated that overhead expenses represent $10,721 annually. Our survey data averaged $3,000 annually. This significant difference of $7,721 can be attributed to advances in technology that have lowered communication and accounting costs. Cell phones can reduce the time spent in search for loads and dispatch, while computers and electronic data can reduce time spent on the accounting process. Overhead expenses can be acquired by calculating total short-run fixed costs and annual mileage (Newkirk and Casavant, 1990). Overhead expenses in this study represented a lower value than Newkirk and Casavant estimates, due to the fact that trucks in the ornamental industry have a reduced annual mileage of 16,000 miles, if compared to trucks used in grain transportation.

Total Short Run Fixed Costs = Sum of Short Run Fixed Costs / Annual Mileage

Taxes and Registration Fees

Taxes and registration fees costs are directly related to the total miles driven, weight of load and truck, and type of product delivered. Both have a character of variable costs, but generally are treated as fixed costs (Newkirk and Casavant, 1990). Their value varies on a per state basis. Intellichoice in 2002 published that the average sales tax of a small truck in the United States is 5.28-percent, title fees in the state Georgia average $18 and registration and license fees average $20. The Georgia Motor Association estimated that in 2006 each truck owner in the states of Georgia pays $8,959 annually in federal taxes and fees for a typical five-axle tractor, semi-trailer combination. This annual charge comes from federal heavy vehicle use tax that averages $550 per truck annually; federal excise fuel tax that averages a total of $5,092 annually; and the annual license plate and weight based registration fees that average $737 (Georgia Motor Trucking Association, 2006). The Transportation Research Institute in 2009 valued licensing and overweight oversize permits at $0.024 per mile, analogous to Berwick et al. (2003) estimates of $0.017 per mile for license and registration fees. Due to the elasticity of taxes and registration fees in the different regions and between the different types of trucks, literature data showed inconsistency. Therefore, in this study not only literature was taken into account, but also survey results that averaged a tax fee of 5-percent of the truck's value and license and fee cost of $0.02 per mile.

Return on Investment

Return to Investment is considered to be either the interest on debt capital or the return on equity investment. It basically represents a charge for the capital invested on trucks, refrigeration systems and/or loading and unloading equipment. The interest rate used varies in the case of lease versus purchase, depending on the market rates and the risk factor foreseen by the lender. The following formula was used to calculate the return on investment for the study, based on the weekly federal reserve interest rate for auto loans (Newkirk and Casavant, 1990).

Return on Investment = (Purchase price + Salvage Value / 2) x Interest Rate

Variable Costs

Fuel Costs

Truck costs are very sensitive to fuel prices that fluctuate considerably over time. A small movement in price greatly impacts total costs and reduces margins for owners and operators. For example, a 10-percent change in fuel price changes total cost by 1.85-percent and a 10-percent increase in speed over 55 miles per hour results in a 2.3-percent increase in total costs (Barnes and Langworthy, 2004).

There are two factors that need to be taken into account when calculating fuel costs, the expected consumption of fuel by a given model of truck and the price of fuel. This study addresses these two separately, so different models of trucks and changes in fuel prices can be modified. One should also consider that fuel economy is a factor of weight and speed. Trip speed is affected by traffic, weather, road construction, and road conditions, but it can be regulated and monitored by determining how long a delivery must take and how much time should the driver should work. In this study, the tool used to estimate the total fuel economy was the ArcLogistics 9.3 software, which allowed us to control and regulate speed, weight, miles driven and more constraints that affect the total fuel economy.

To estimate the truck fuel mileage, the study referenced Barnes and Langworthy (2004) research, who projected, based on the standard economy data generated by the Environmental Protection Agency, that an industrial or construction truck averages a fuel mileage of 5 mpg, a semi truck averages a fuel mileage of 6.5 to 7 mpg and straight truck or pick up delivery van averages 8 to 9 mpg. Since most of trucks used by participants fit into the semi truck category, we fixed the fuel mileage at 7 mpg for all trucks. However this value can be modified in the future if new trucks become more fuel efficient. USDA published that in the second quarter of 2009 diesel fuel prices averaged $2.34 or 7-percent higher than the first quarter of 2009 and 44-percent below the same quarter last year. Because fuel prices vary greatly from year to year, making it complicated to develop a clear price trend or price pattern, the study referenced the daily diesel prices given in the website of the U.S. Energy Information Association (2009). Only diesel was used as the fuel source, given that the majority of participant's trucks work with diesel.

Repair and Maintenance

Most of literature estimates repair and maintenance costs simultaneously. Most studies refer maintenance costs to the costs incurred in oil changes, oil filters, fuel filters, corrosive resistance elements, and normal preventive inspections, while repair costs are referred to the costs incurred to keep the truck engine and the chassis in proper conditions. Barnes et al. (2003) and Berwick et al. (2005) state that maintenance and repair costs had declined over the last 15 years and estimated that these costs range between \$0.07 and \$0.15 per mile; these data corroborate the 2009 report of the American Transportation Research Institute that estimated repair and maintenance costs at \$0.092 per mile. Even thought repair and maintenance costs appear to have declined in the last few years, this study assumed an inflated value of \$0.12 per mile to be more cautious (Barnes and Langworthy, 2004). The stabilization of prices in the past years appears to be due to deregulation and competition in the industry.

Tire Costs

Tire costs are made up of the combination of tire price and tire wear. These costs also vary between truck model, annual mileage, weight of truck, and owner preferences; these variables also affect directly the tire's life. Barnes et al. (2003) based on multiplying the average tire costs of cars by three, estimated that tire costs per truck ranges between $0.021 and $0.04 per mile. Berwick (2005) estimated that a tractor or trailer averages a tire cost of $0.0615 per mile; Victoria Transport Policy Institute (2009) accurately estimated that a semi truck averages tire costs of $0.0294 per mile, while the American Transportation Research Institute (2009) estimated tire costs of $0.03 per mile for trucks of different sizes located different regions.

Literature reveals that tire costs had remained stable through the last decade. IntelliChoice reported a study in 2002 that brought the attention that small car tire costs have not had any significant inflation for the last 20 years (Wurster, 2002). Most researchers have estimated tire cost values that range between $0.021 and $0.04 per mile, corroborating Barnes et al. statement in 2003. For that main reason, this study considered only literature data to determine tire costs. The study used as reference was published by ATRI in 2009 that estimated a tire cost of 3 cents per mile for medium and large trucks.

Labor Costs

In May 2006, 69.4-percent of employment in transportation operations belonged to transportation and material moving occupations, 4-percent to management operations, 2-percent to sales occupations and 17-percent to administrative support. Transportation labor rates are a readily known variable for paid drivers. In the model established in the study, labor rates are accounted in a per hour basis, not in per mile basis as many studies do. Workers in the truck transportation industry average 40.9 hours of work per week, compared with an average of 37.9 hours of work per week in the warehousing and storage industry and 33.9 hours of work per week in the private industry.

The hourly income per truck driver of light volumes or delivery services averages $14.43, including fringe benefits (Bureau of Labor Statistics, 2009). ATRI in 2009 estimated that the average truck drivers pay is $16.59 per hour excluding fringe benefits. This reflects that wages have increased over the last few years; however, data gathered from the survey averaged a considerably low hourly income per truck driver of $9 without fringe benefits. Hence, to be more accurate with such imperative cost; the study considered literature data and established an hourly driver pay of $16 including fringe benefits.

External Costs

To estimate the total cost of transport, it is necessary to look at private and external costs simultaneously. External costs added to private costs give us total social costs. Most economic studies analyze interactions through the effect on prices and not on externalities. However, the difficulty is that only a few external costs can be assigned dollar amounts like private costs do. External costs are not borne by the public and private transport use; they are paid by others; generally by the society as a whole, but also by the environment itself (Jakob et al., 2006). External costs have continuously increased as the overall number of trucks running has also gone up. Only a few studies estimate them, because they are not always taken into account when production and consumption decisions are made. These costs mainly comprise, external accident, air pollution, climate change, external parking, congestion costs and others (Victoria Transport Policy Institute, 2009). Of all transport-related external costs evaluated in the literature, accident cost, air pollution and climate change are the three largest, comprising 77-percent of the overall costs (Jakob et al., 2006). With the principle to be more conservative and precise when determining the exact dollar value of external costs, this study focused only on two of the costs mentioned above: accident costs and emissions costs. Some economists believe that external benefits can arise from improvements to transportation systems. An improvement may reduce the costs of transportation operations, thus contributing to increased competitiveness and higher output (Greene and Jones, 1997).

It is important to point out that the degree of confidence among external costs varies considerably. Whereas accident costs, like truck damage, can be calculated quite precisely, emissions costs are much less certain. For this reason, a very conservative approach has been applied to this study. Literature suggests several techniques to quantify and monetize external effects of motor vehicle transport, such as the damage cost method, prevention cost method, and contingent valuation method (Bruce et al., 1996; Jakob et al., 2006; Victoria Transport Policy Institute, 2009). Nevertheless, all these methods are quite uncertain.

Accident Cost

The cost of a particular type of accident refers to the monetary amount that people would pay to reduce the risk of the accident occurring. Accident cost analysis involves two steps: first, quantify physical impacts such as the number of crashes that occur, the number and severity of vehicle damages, human injuries, disabilities and deaths. Second, monetize these impacts. It is relatively easy to monetize accident costs, such as vehicle damages, medical expenses and disability compensation.

Truck transportation accounted for a 2.64-percent mortality rate in 2007; 538 fatalities of 2’036,000 people employed (Bostwick et al., 1996). Forkenbrock (1999) estimated the compensation paid per truckload in shipments in rural areas accounts 4.2-percent of the total amount paid in salaries. Meyer (2008) found that crash costs average more than twice congestion costs. Urban crash costs are estimated to average \$0.25 to \$0.41 per vehicle mile. This study examined the whole comprehensive cost of crashes, and therefore reports higher values than literature that covers either internal or external accident costs. The Victoria Transport Policy Institute (2009) estimated that the internal and external accident costs for average automobiles and vans are \$0.083 passenger per mile and \$0.22 vehicle per mile total crash costs, respectively. Diesel Buses received a value of \$0.04 passenger per mile and \$0.264 vehicle per mile, respectively.

Emission Cost

Emission cost refers to motor vehicle air pollution damages, including human health, ecological and landscape degradation (Victoria Transport Policy Institute, 2009). From all air emissions, carbon dioxide (CO_2) is by far the most prominent greenhouse gas released by human activity, accounting for about 85-percent of total emissions weighted by global warming potential (Bureau of Transportation Statistics, 2009). Control technologies have substantially reduced emission rates, but this success has been limited because emission tests often underestimate actual emission rates, emission control systems sometimes fail, and reduced emission rates have been partly offset by increased travel (Victoria Transport Policy Institute, 2009). The harmful impacts of some emissions, such as air toxics, have only recently been recognized and so have minimal control strategies. Despite all the challenges to reduce emissions, mobile emission reduction efforts can be considered a success.

Determining a value on greenhouse gases emissions is difficult, due to uncertainty and differences in human values concerning ecological damages and impacts on future generations. In addition, climate change impacts are not necessarily linear; many scientists believe that there may be thresholds beyond which warming and damage costs could be disastrous. Although uncertainty exists as to the consequences of greenhouse gases on climatic changes, the role of the transportation sector in the production of greenhouse gases is a fact. Vehicle air pollution costs vary depending on vehicle, fuel and travel conditions. The amount of CO_2 released per unit of transportation service, or per ton per mile, is directly related to the energy consumption of the mode providing the service. Larger, older and diesel vehicles, and those with ineffective emission controls have higher emission costs. Emissions rates tend to be higher for shorter trips; thus urban driving entails greater air pollution costs than rural driving. The U.S. Environmental Protection Agency (2005) determined that a gallon of diesel produces 10.1 kilograms or 22.2 pounds of CO2. This value assumes that the carbon content of a gallon of diesel weighs 2.77 kg.

To estimate the cost of emissions on a per mile basis, this study alludes to relevant literature. Small and Kazimi (1995) provided a widely cited emission cost analysis, in which they estimate that in Southern California heavy truck emissions costs represent \$0.53 per mile. In other urban regions, costs reflected a third of what they estimated. The study states that by the year 2000, 50 percent of emissions should decline because of improved emissions controls. Forkenbrock (1999), with a fuel efficiency of 5.2 miles per gallon and an average payload of 14.80 tons per vehicle per mile, estimated the cost to society of CO_2 emissions per ton per mile shipped by truck \$0.15 (Forkenbrock, 1999). Berechman (2009) modeled estimates of private and social costs of truck traffic in the cities of New York and New Jersey. Air pollution costs per truck were priced at \$0.114 per mile. Victoria Transport Policy Institute (2009) reported that greenhouse gas emissions costs represent \$0.04 per mile for an average car, \$0.071 per mile for light trucks, and \$0.129 for a diesel bus. Air emission costs estimates tend to increase with time and are largely dependent on the conditions and assumptions perceived in each scenario. In this study primary data came from ornamental producers located in rural areas, with trucks largely diesel fuel based, and assuming with trucks no older than ten years. With such conditions an average emissions cost per truck of $0.12 per mile was used.

3.3 Routing Analysis

The routing analysis was accomplished using the ArcLogistics 9.3 ESRI software, which contains many enhancements that makes it a more functional software, simple to use and easier for commercial growers and distributors to localize. The routing simulation considered a transportation system with multiple clients (deliveries) and with multiple ornamental transportation operations (depots). The clients place the orders and next these orders are shipped from a single distribution center to its respective client location. The client locations were obtained from the survey. It was assumed that no depot pickups were taking place; meaning that all orders are direct deliveries from the distribution center to the client locations. It was also considered that all ornamental producers own the trucks and that the employees to carry out the orders. More details of the routing simulation are described in Table 4.3.

The purpose of the routing simulation is to compare a traditional ornamental transportation operation without order sharing with an ornamental transportation alliance with order sharing. To acquire a more robust analysis, four different constraints scenarios were introduced into the study:

1) Order sharing

2) Location clusters

3) Time Windows

4) Optimal number of orders

For all constraint scenarios, a sensitivity analysis was developed for total costs, total miles driven, total number of trucks, driving hours and total CO_2 emissions. Sensitivity analyses are used to determine how changing variables in the model affect total costs, providing a decision maker tool that allows ornamental producers to understand how different variables affect different costs. Understanding cost relationships helps managers minimize costs (Berwick, 1997).

CHAPTER 4

RESULTS AND IMPLICATIONS

This chapter reports a detailed routing cost analysis of the simulation of different case scenarios in the transportation of ornamental products in the state of Georgia. This study demonstrates the total cost and total miles savings gained by joining routes through horizontal cooperation. The results of external cost minimization are also presented for every scenario. The overall simulation is discussed in detail with its respective sensitivity analysis.

4.1 Survey Results

Survey results revealed that the majority of participants consider that transportation is a key limiting factor for economic growth in ornamental production; 80% of respondents stated that their transportation costs have increased in the last year at an average rate of 21% and transportation accounted for approximately 10% of total cost of production. Results corroborate existing literature. Brooker et al. (2005) as well ranked transportation as an important factor of concern for expansion of trading. Hodges and Haydu (2005) also estimated that transportation is one of the most restrictive factors of nurseries expansion. USDA Transportation Service Division (2008) similarly found that transportation costs have increased 23% from 2007 to 2008.

4.2 Base Case Scenario

This study developed a case scenario that was used as a template for the other routing scenarios. The intention was to reduce error and variability between simulations. The average truck variables used for analysis are set in table 4.1, the average truck costs are set in table 4.2 and the characterization of the all simulations is described in table 4.3. This data served also as a starting point for the sensitivity analysis.

Table 4.1 Truck Variables for Base Case Scenario

Variable	Average simulation values
Annual Mileage	16,000
Model Year	2002
Price	14,711

Table 4.2 Average Costs for Base Case Scenario

Fixed	Variable	Internal	External	Total Cost/ mile	Total Cost/hour
0.619	1.361	1.598	0.37	1.98	14.531

Table 4.3 Characterization of Simulation Analysis

Item	Sub item	Definition and assumptions
Distribution network	Components	Consist of multiple nodes where each node represents a single client location (delivery location). In addition there is one mode that represents the distribution center where the client orders are picked up. The set of lines between the distribution center and the client locations represent the road network.
Clients	Number	The number of clients varied between 18 and 21 for a single distribution center.
	Location	The location was provided in the survey with a different level of clusteredness between each distribution center.
Orders	Number	The number of orders varied between simulations 1 order to 5 orders per route.
Transportation companies	Number	8.
	Location	All trucks start and end their shipping at the distribution center.
	Number of trucks	Unlimited depending on the maximum number of orders per simulation.
	Truck capacities	Not considered due to high variability between ornamental products.
	Fixed costs	Based on a per mile basis.
	Variable costs	Based on a per mile basis.
	Working day hours	8 to 12 hours per day. Over time was considered over 8 hours.
	Time windows	Base case scenario used a time window of 60 minutes to load and 60 to unload the trucks. In one simulation, time windows changed to 30 and 90 minutes.
	Number of routes	Unlimited, depending on the number of orders.

4.3 Order Sharing

The first case scenario evaluated was order sharing. Eight different ornamental distribution centers and one central point location alliance were routed with a total of 45 simulation runs with 1 (Figure 4.6), 2 (Figure 4.7), 3 (Figure 4.8), 4 (Figure 4.9) and 5 order sharing (Figure 4.10). Time windows consisted of 60 minutes per pickup and 60 minutes per delivery. The maximum number of orders strictly depends on the volume delivered to each client. Since this value varies significantly among ornamental producers, because of seasonality and market conditions, the analysis was limited to a range of 1 to 5 orders per route. Volume delivered was considered as a constant for all orders. The depot locations represented in the routing figures with a number 2, 3 or 4, correspond to the total number of producers that share same depot location; while the different colors of the routes do not stand for any value or particularity.

The routing simulation determined that by joining routes and sharing orders, total costs decreased by 2% to 9%, total miles driven decreased by 1% to 10%, service time decreased by 2% to 11% and the number of trucks used decreased by 1% to 6%. Cruijssen and Salomon (2004), in a case study on the transport of flowers in The Netherlands, found cost reductions of 12.3% with order sharing when compared to the traditional situation of transportation without order sharing. They also found order sharing results in a shorter total distance driven by 11.9%. Krajewska et al. (2007) studied a medium sized freight forwarding company that transported a variety of products in several German regions. Results of the routing simulation found that horizontal collaboration can achieve savings between 10 to 20%.

The cost savings with order sharing is a result of better coordination between demand and supply. Because of the larger customer base and economies of scale, routes can be constructed so that truck space is used more efficiently. Consequently, the number of used trucks, the total miles driven and the cost of performing the transportation orders decreases. Because CO_2 emissions are directly related to the total miles driven, the amount of CO_2 emissions also decreases by 1% to 10%. Since variable cost are calculated in a per mile basis, these costs decrease at the same rate as total costs.

Table 4.4 Average Routing Results (5 orders max.)

	No order sharing	Order sharing	Change (%)
Total Cost ($)	18851	17231	9
Number of Miles	10247	9415	8
Number of Trucks	25	23	8
Driving Time (hours)	203	173	15
CO_2 emissions (kg)	14785	13585	8

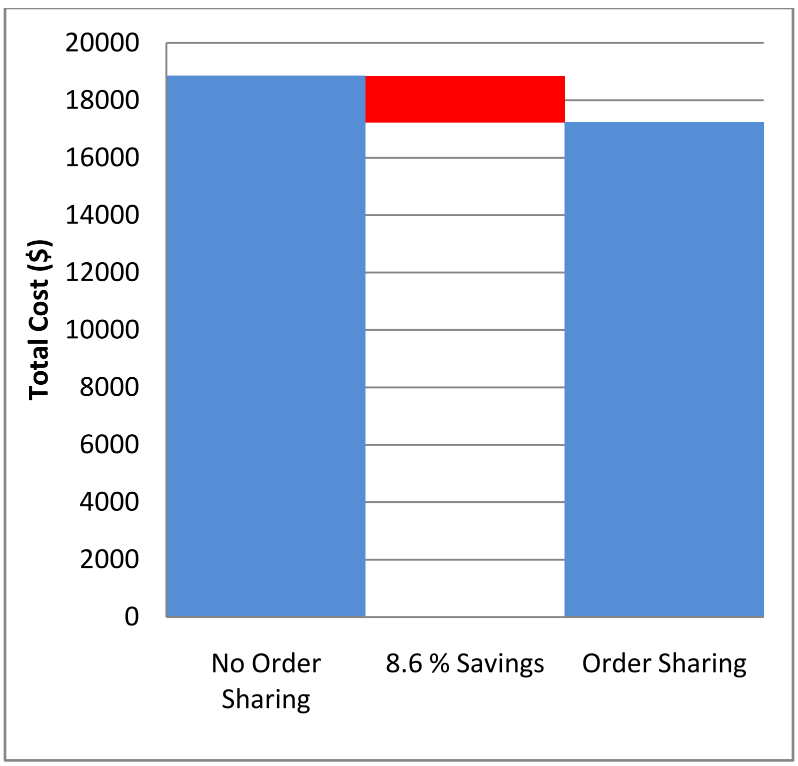

Figure 4.1 Average Savings with 5 Order Sharing

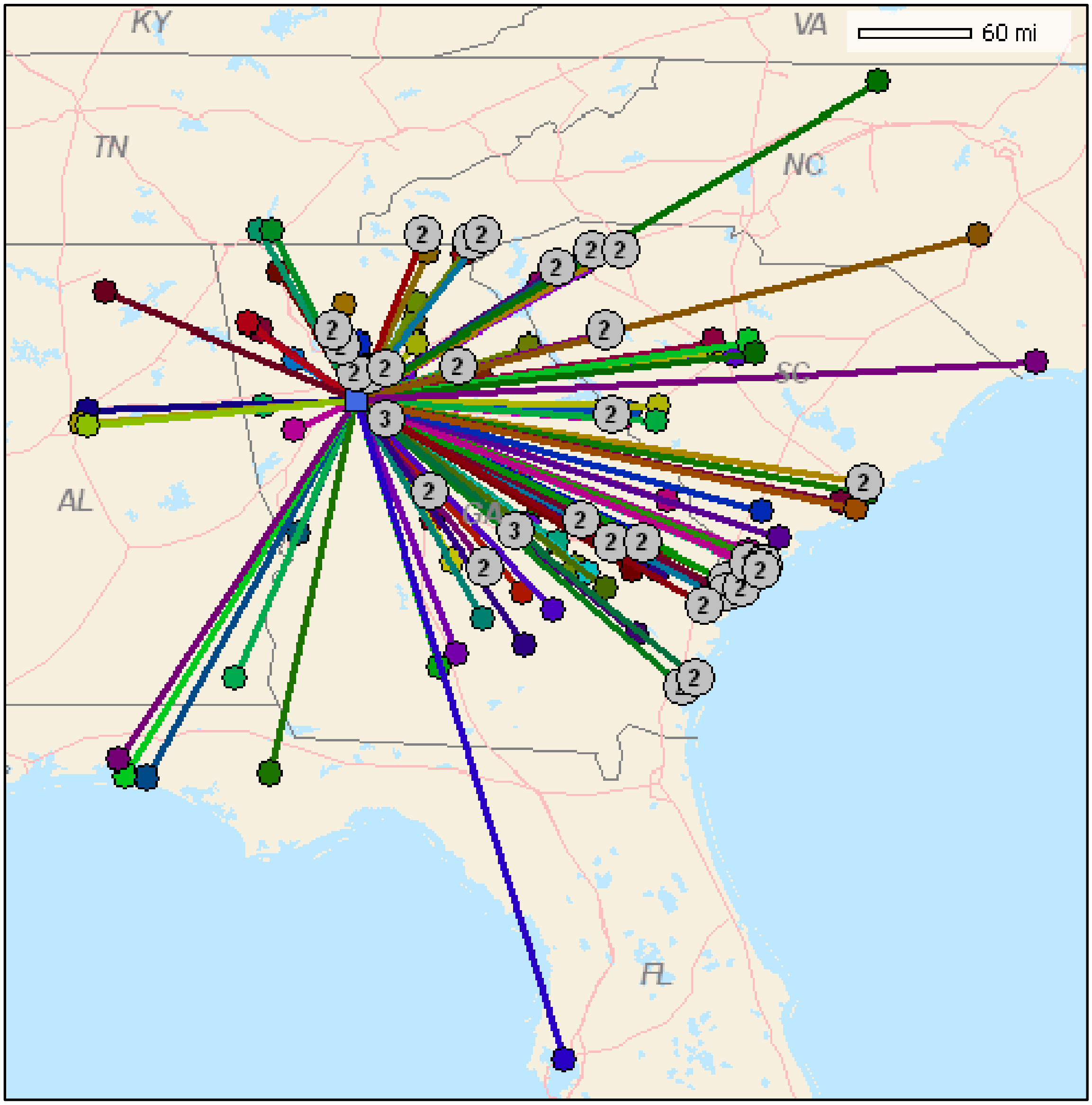

Figure 4.2 Alliance Routing Plan with 1 Order Sharing

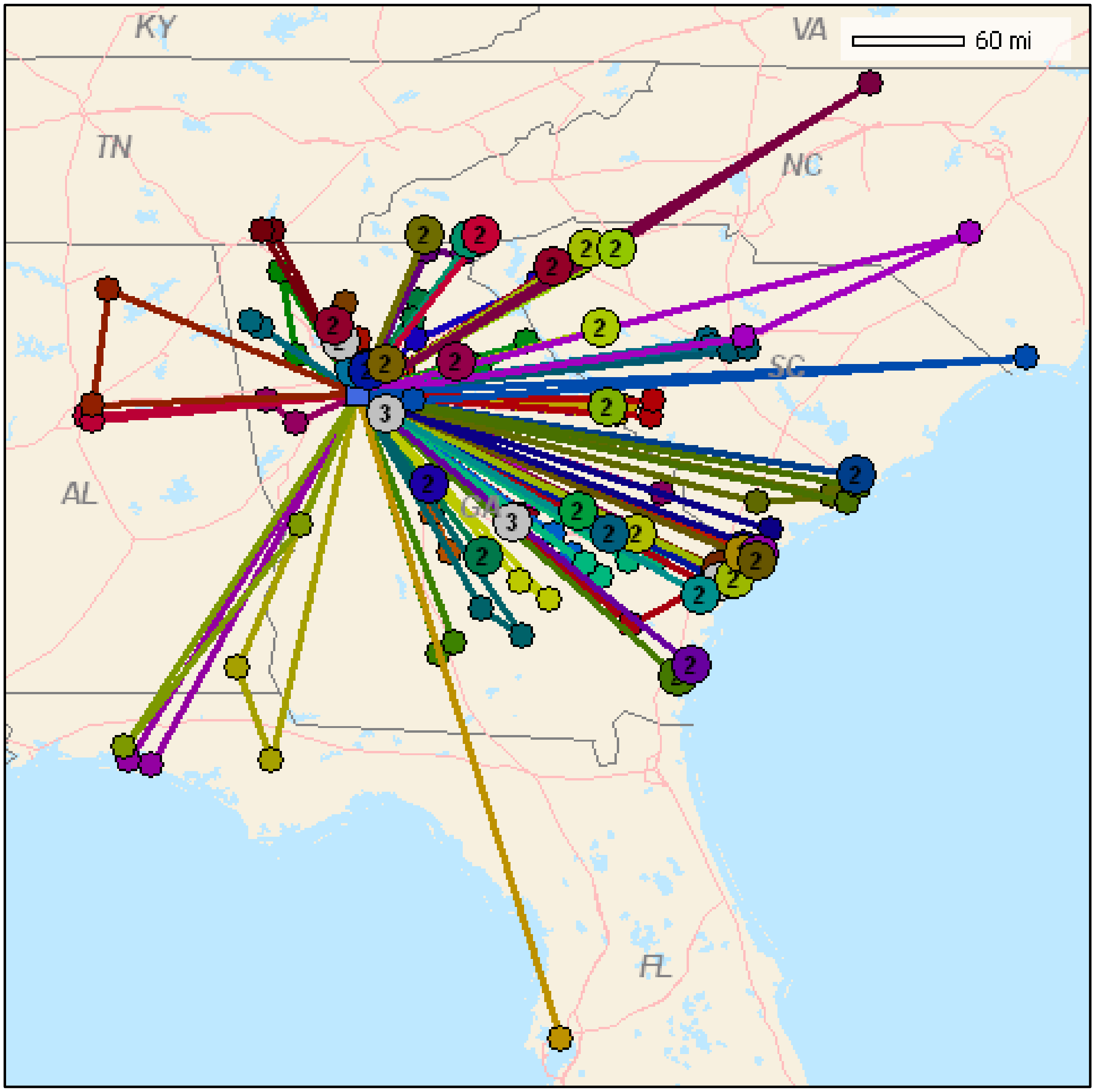

Figure 4.3 Alliance Routing Plan with 2 Order Sharing

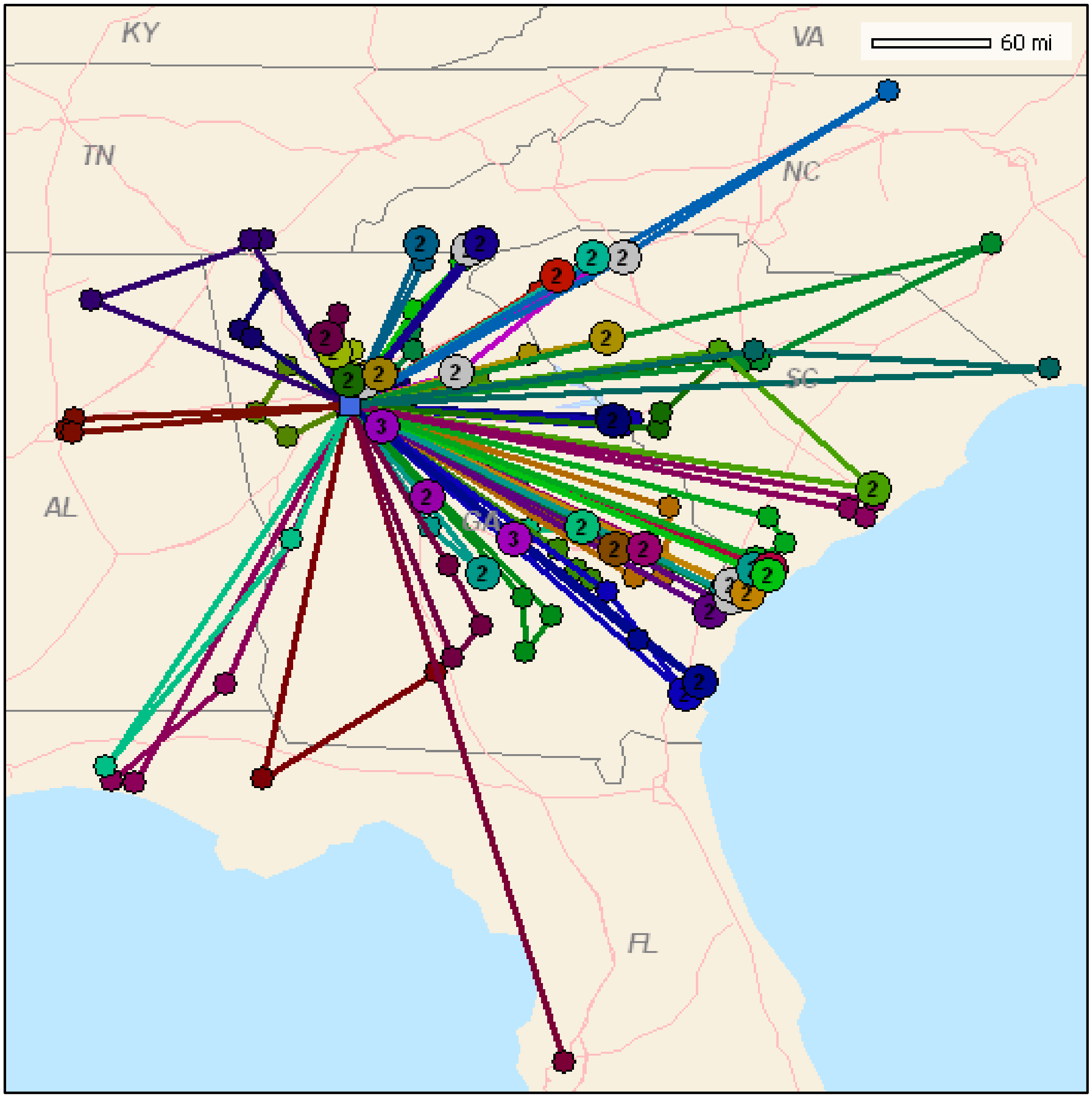

Figure 4.4 Alliance Routing Plan with 3 Order Sharing

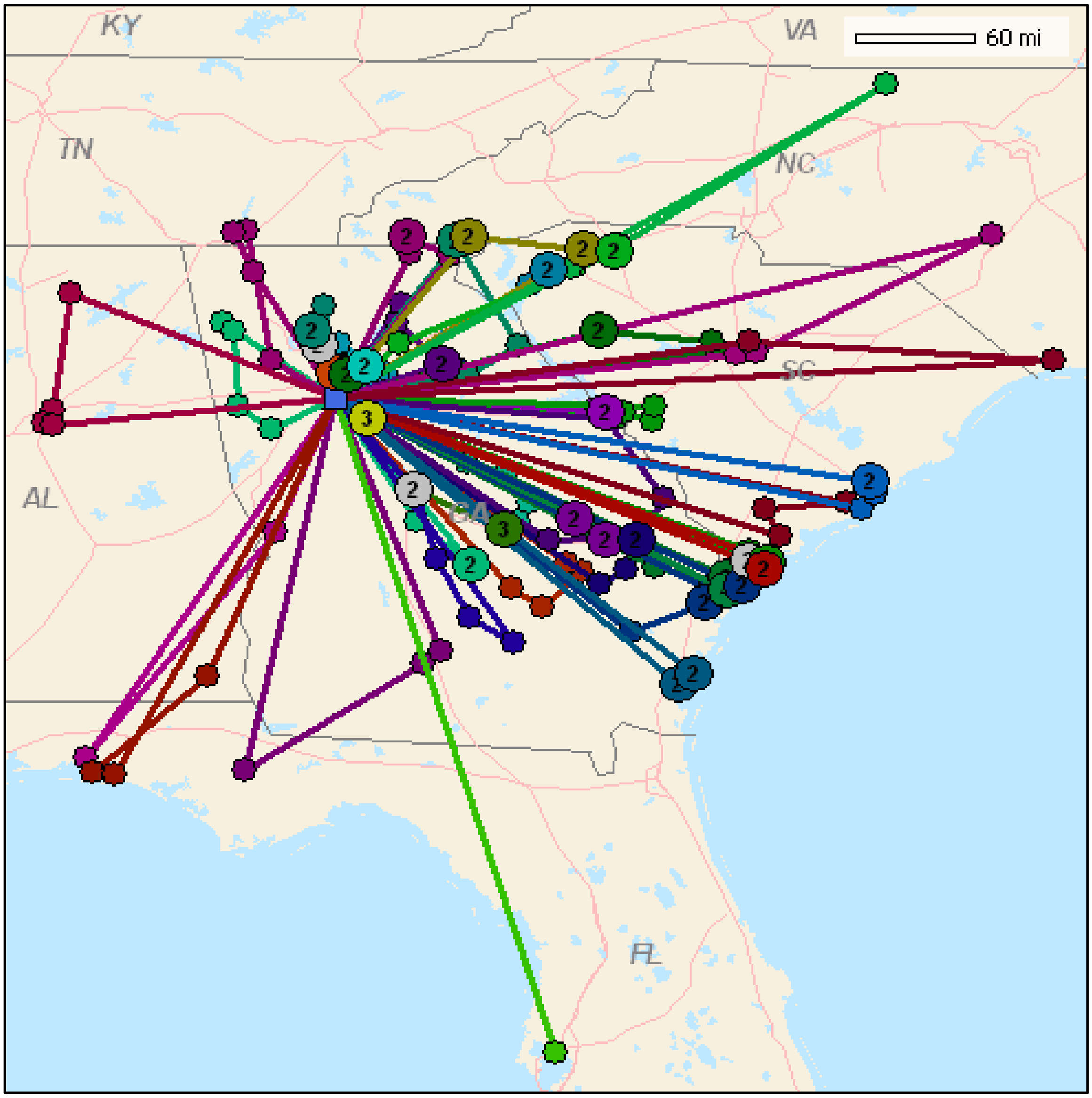

Figure 4.5 Alliance Routing Plan with 4 Order Sharing

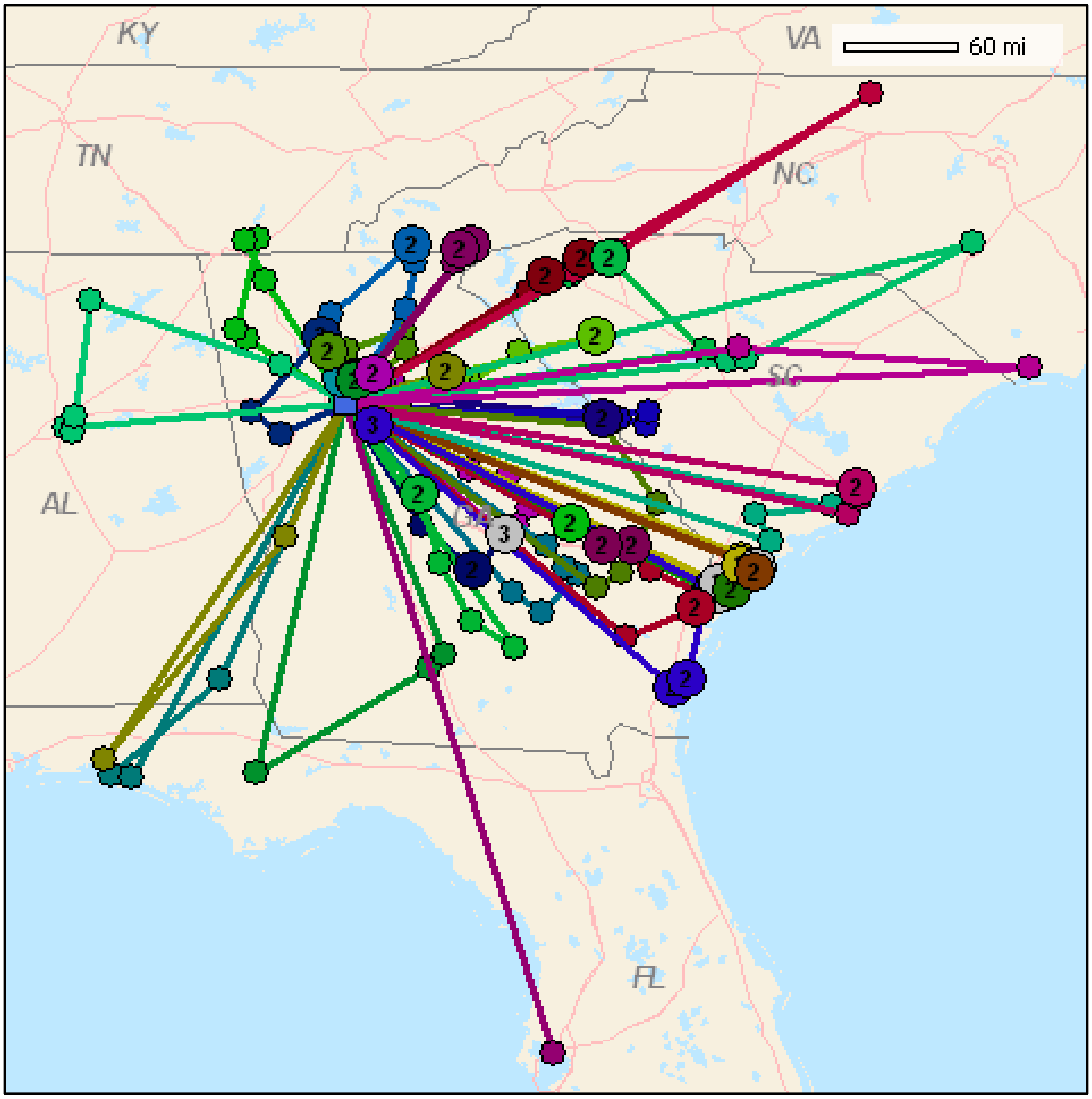

Figure 4.6 Alliance Routing Plan with 5 Order Sharing

Figure 4.11 illustrates the total savings by sharing orders starting at 1 order and increasing to 5 orders per route. Without performing a routing alliance, the total costs of 1 order to 5 order sharing per route decreased at an average rate of 17%, with a total cost reduction of

56%; while by performing a routing alliance, total costs from 1 order to 5 order sharing per route decreased at an average rate of 21%, with a total cost reduction of 64%. The cost slope rate stopped decreasing at 3 orders per route. The biggest cost reduction was attained from 1 order to 2 order sharing per route, with an average decrease in cost of 39%. Figure 4.12 illustrates the total savings by sharing orders, starting at 1 order up to 5 orders per route.

Two sensitivity analyses were conducted to illustrate the total cost change of a transportation alliance of 157 orders, with respect to labor and fuel price changes. Fuel and labor represent the two major variable costs in a truck operation. These' have largely increased in the last few years (Table 3.1). Figure 4.9 illustrates that as labor costs per hour rise by $4, from $8 to $24 per hour, total costs of the entire operation increase linearly at an average rate of 6.3%. Similarly, figure 4.10 shows that as fuel prices, in this case diesel price per gallon, rise by $1, from $1 to $5 per gallon, total cost rise linearly at an average rate of 9.0%.

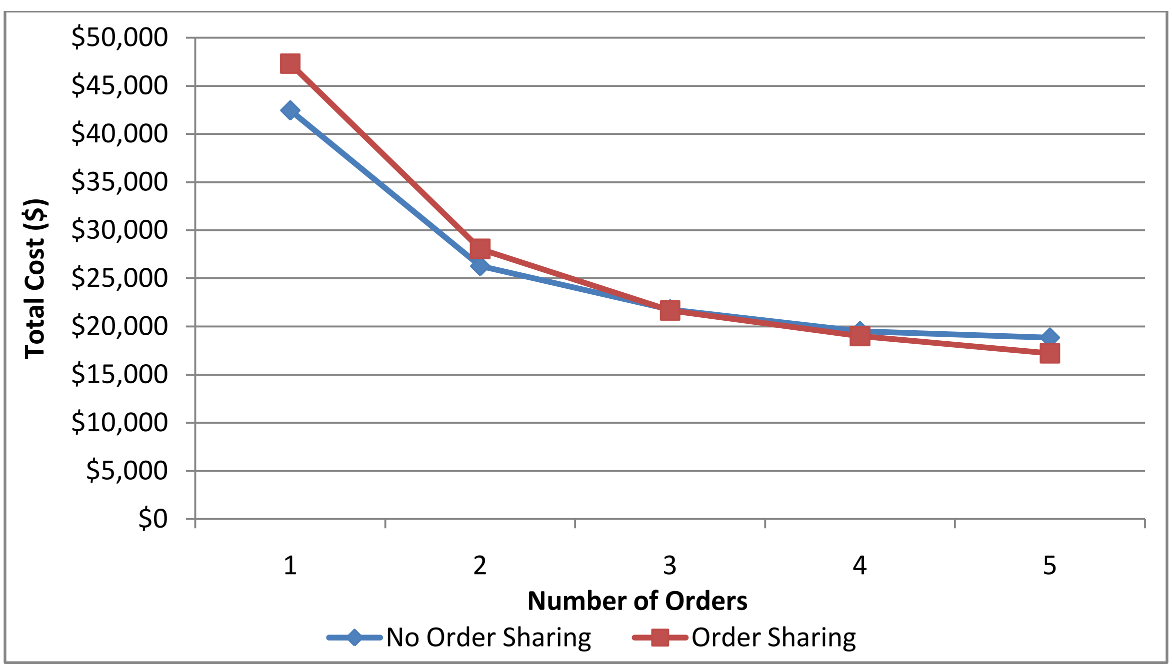

Figure 4.7 Average Cost Savings from 1 to 5 Order Sharing per Route

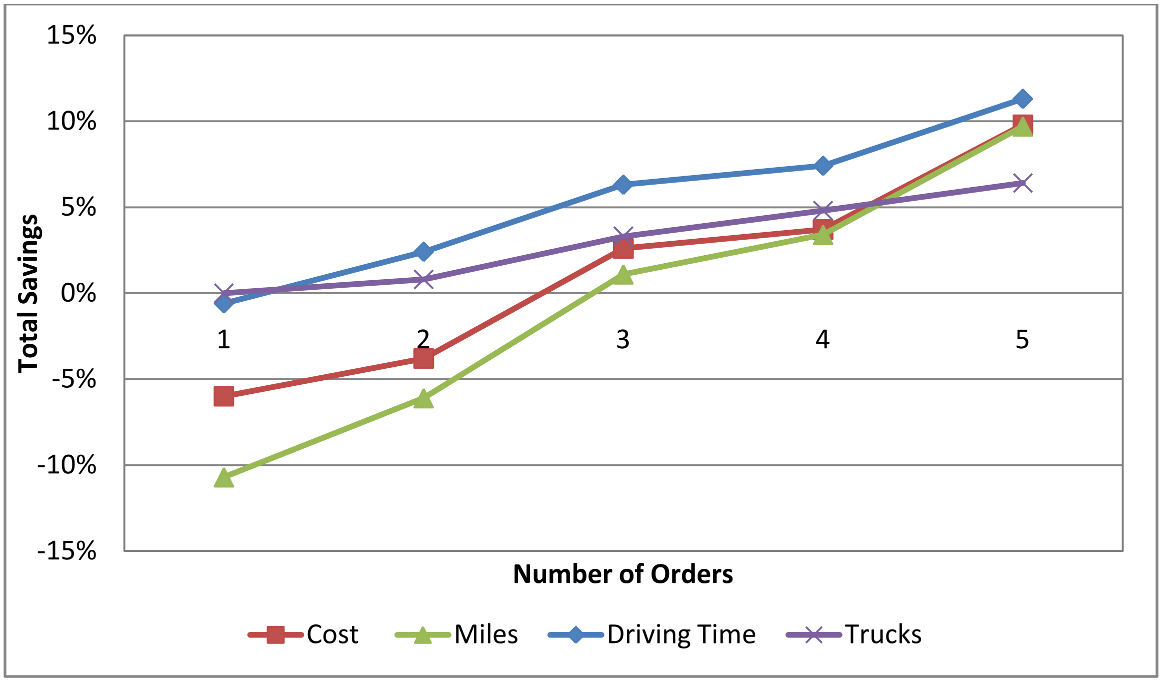

Figure 4.8 Total Savings with 1, 2, 3, 4 and 5 Order Sharing

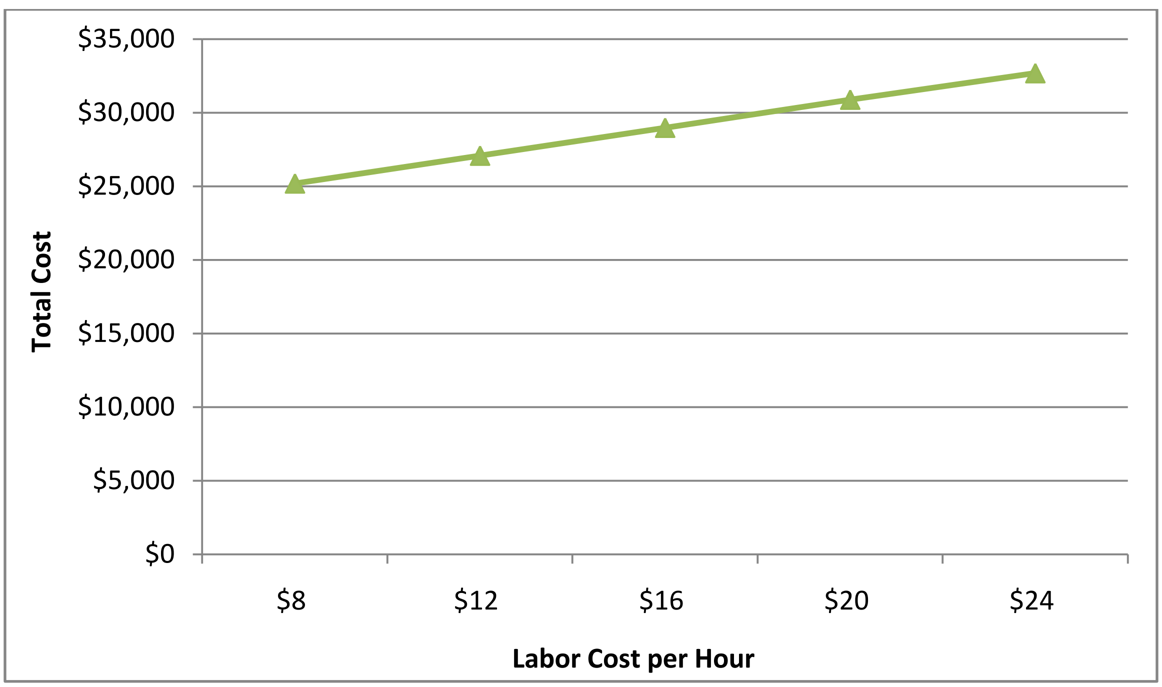

Figure 4.9 Sensitivity of Total Cost with respect to Labor Cost

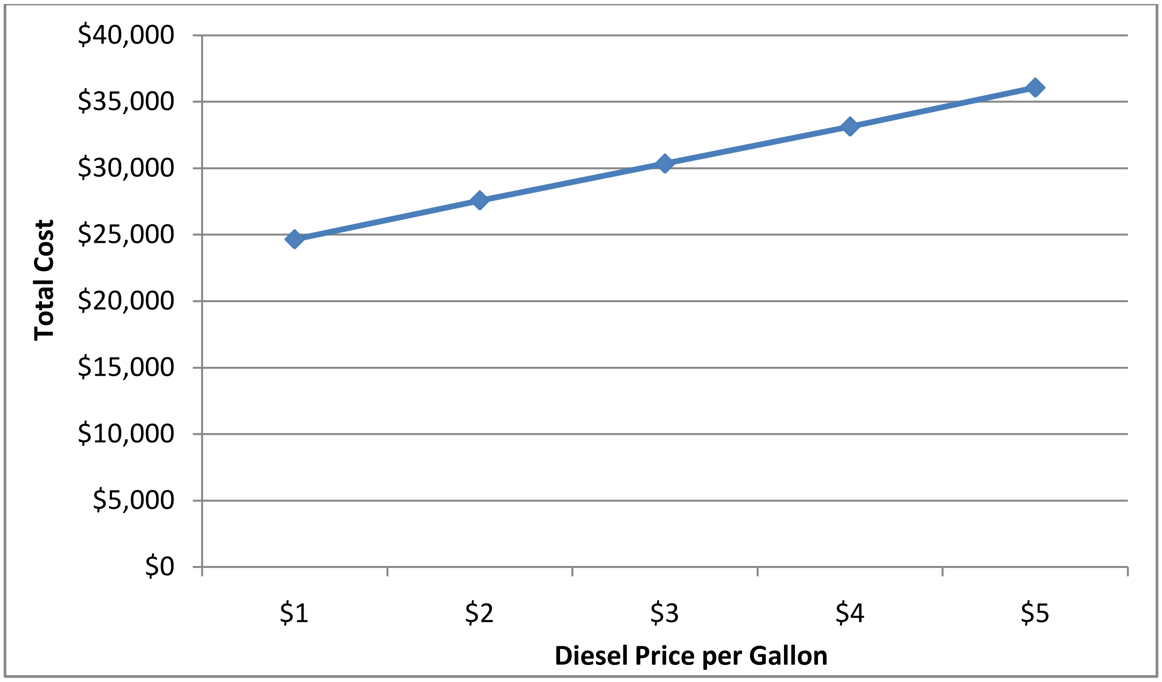

Figure 4.10 Sensitivity of Total Cost with respect to Fuel Price

4.4 Location Clusters

The second case scenario evaluated the effects of client clusters on the transportation of ornamentals. The level of clusteredness or proximity of client clusters is defined as an indicator of the number of different clusters in which client locations arise. The main purpose was to determine if, by locating the distribution center of the transportation alliance based on client clusters, the total savings of the alliance would increase and become significantly higher than the saving achieved in the original central location.

The study developed a total of 30 routing simulation runs; subsequently, the simulation results were submitted into a comparison analysis with the central location alliance of section 4.2. Client location clusteredness maps suggested that the original central location of the alliance should be divided in a north and south location (Figures 4.13 and 4.14). Within these 3 different alliances, the study evaluated two more variables, a central location and a major highway location. The central location was selected to be the central location between all distribution centers within the alliance, and the major avenue location was selected to be the closest location to the center of the alliance while providing direct access to a major avenue or highway. The purpose was to determine if the location of the distribution center may achieve even higher savings by locating it at a central location or at a major avenue or highway location.

In the routing simulation, the north location alliance (Figure 4.15) consisted of 3 depots and 57 orders in total; the central location alliance (Figure 4.16) consisted of 8 depots and 157 orders in total; and the south location alliance (Figure 4.17) consisted of 3 depots and 81 orders in total. Results from all simulations are illustrated in figures 4.11 and 4.12. Time windows consisted of 60 minutes per pickup and 60 minutes per delivery. Volume delivered was considered as a constant for all orders.

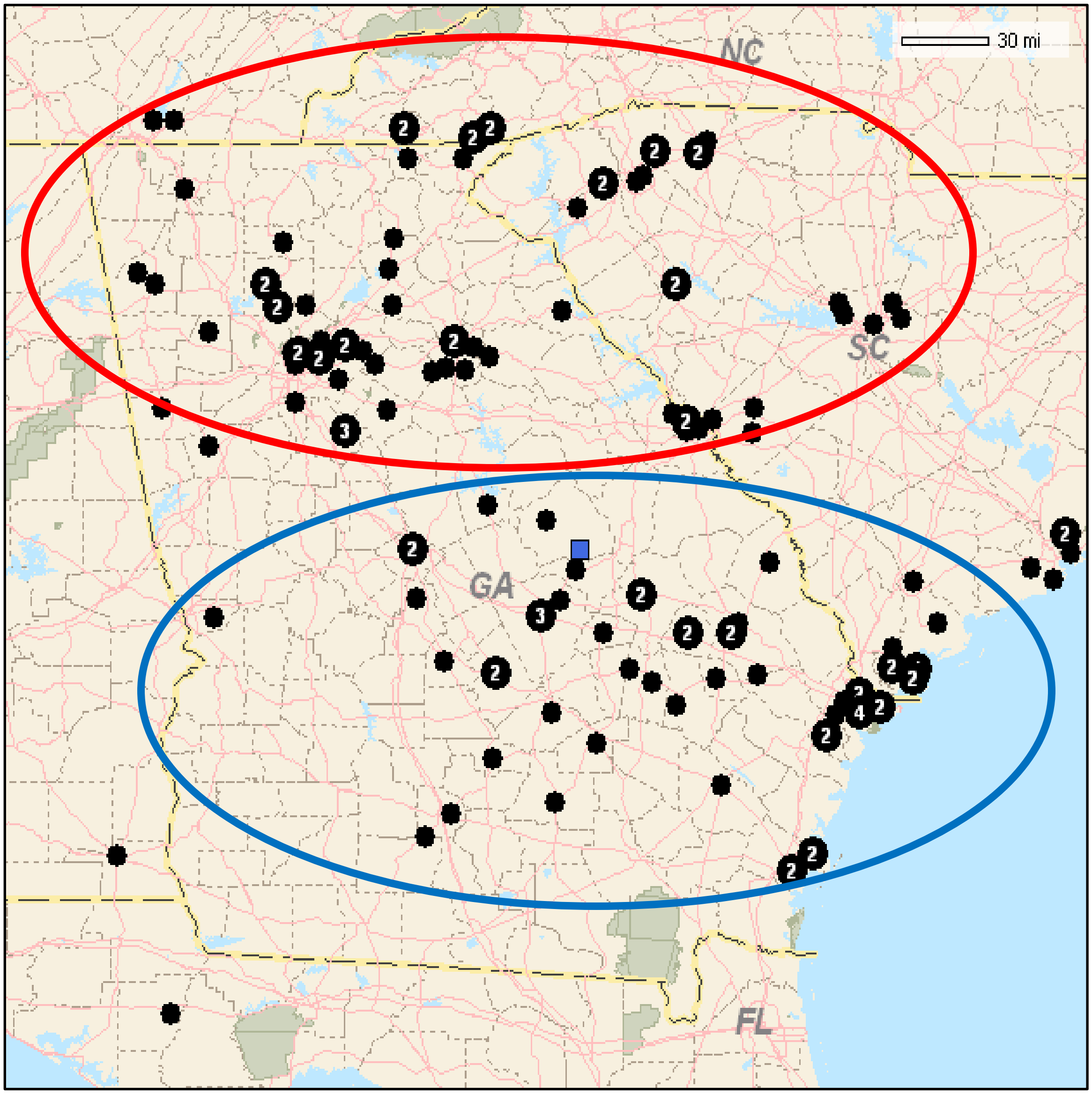

Figure 4.11 North and South Client Location Clusters

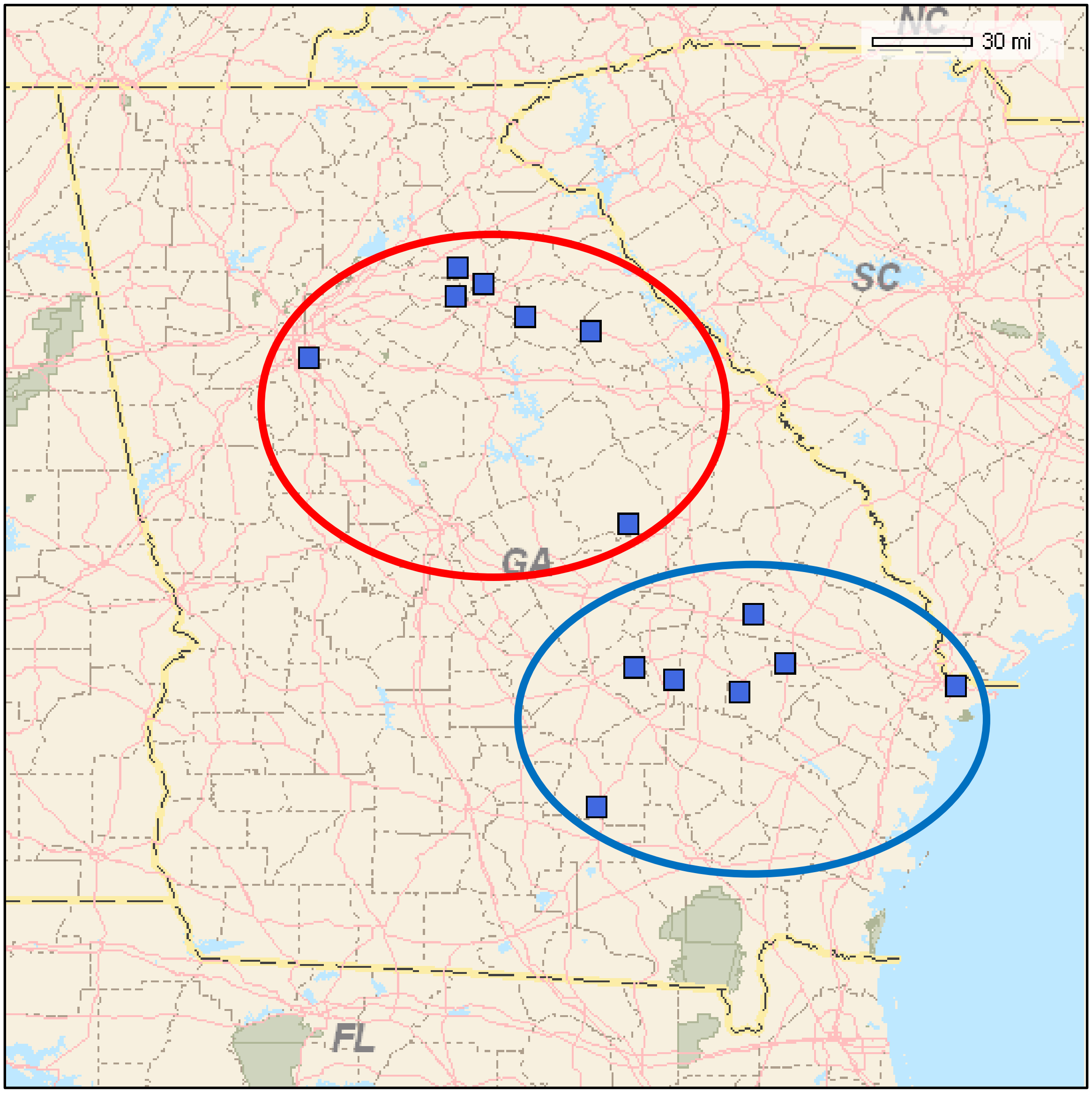

Figure 4.12 North and South Distribution Location Clusters

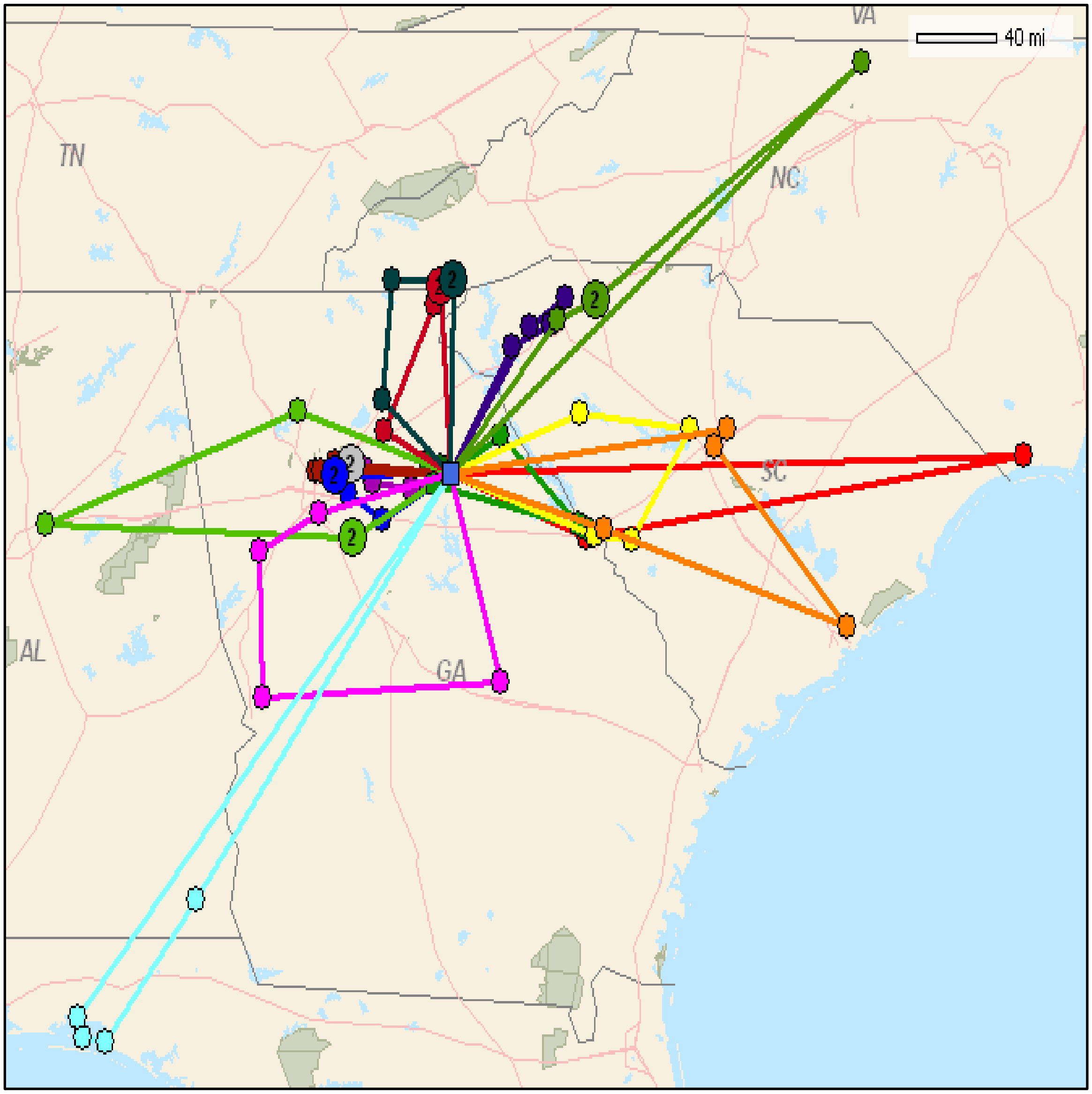

Figure 4.13 Routing Plan North Alliance

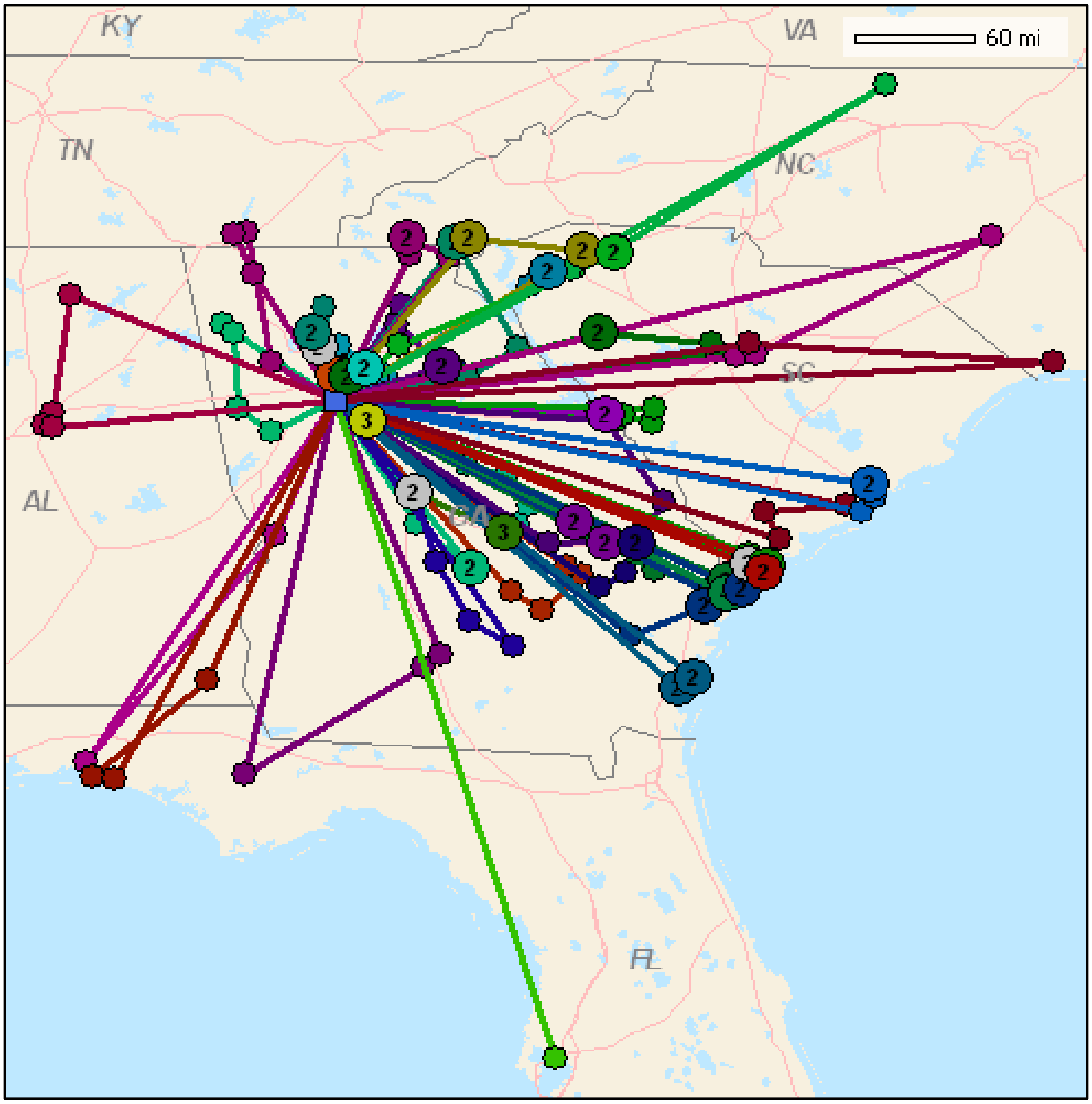

Figure 4.14 Routing Plan Central Alliance

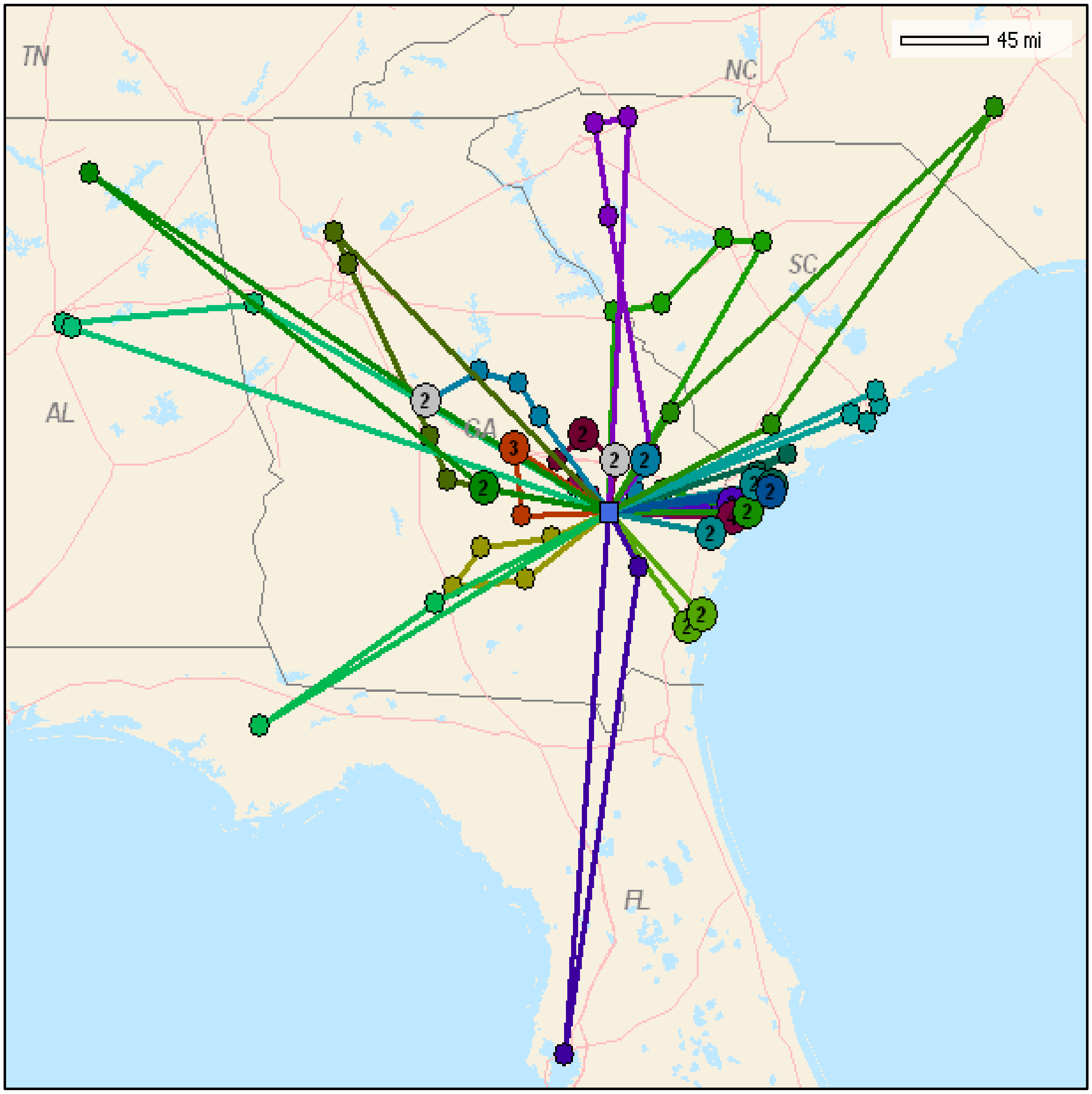

Figure 4.15 Routing Plan South Alliance

Results of the routing study demonstrate that by establishing the location of distribution centers based on client location clusters, transportation alliances increase cost savings. The south alliance showed the higher average costs savings of 5.2% to 6.9%; the north alliance showed the second highest cost savings of -0.8% to 6.0%, and the central alliance showed the lowest average cost savings of -0.3% to 0.7%. Major depot highway location alliances showed greater and faster cost reductions than central depot location alliances in all three case scenarios. The north alliance showed total cost reductions starting at 1 order per route, the south alliance at 3 orders per route, and the central alliance at 4 orders per route. The greatest cost savings accomplished was 13.2% by the major avenue south alliance with 5 orders per route and the lower cost savings was -21.3% by the central location central alliance with 1 order per route. The major avenue north alliance, with 5 orders sharing, also showed considerably higher costs savings of 10.7%. In all scenarios, the total costs decreased by adding more orders per route to a maximum of 5 orders per route, corroborating order sharing results in chapter 4.3.

The sensitivity analysis demonstrates that total cost savings are related to the number of miles driven. The highest cost savings scenarios show also the lowest miles driven; however, these two factors are not directly related. For example, the north major avenue alliance achieved the highest miles driven savings but did not achieve the highest cost savings. The same trend is observed with the maximum number of trucks and total driving time. These disproportional interactions can be attributed to the overtime factor that increases total costs due to the fact that labor costs double each hour of overtime. Figure 4.21 describes the average cost savings of major avenue locations in the north, central and south alliance and Figures 4.22, 4.23 and 4.24 show the total cost, number of miles, number of trucks, driven hours and CO_2 emissions savings in the three different alliances.

Table 4.5 Routing Average Results, North Georgia Alliances

Variable	No order sharing	Central Location	Change (%)	Major Ave.	Change (%)
Total Cost ($)	15035	15154	-0.8	14131	6.0
Number of Miles	6254	6228	0.4	5727	8.4
Number of Trucks	16	16	0.0	16	0.0
Driving Hours	124	124	0.0	109	12.1
CO_2 emissions (kg)	9024	8986	0.4	8263	8.4

Table 4.6 Routing Average Results, Central Georgia Alliances

Variable	No order sharing	Central Location	Change (%)	Major Ave.	Change (%)
Total Cost ($)	32977	33068	-0.3	32761	0.7
Number of Miles	18117	17902	1.2	18349	-1.3
Number of Trucks	48	44	8.3	44	8.3
Driving Hours	356	372	-4.5	325	8.7
CO_2 emissions (kg)	26140	25830	1.2	26475	-1.3

Table 4.7 Routing Average Results, South Georgia Alliances

Variable	No order sharing	Central Location	Change (%)	Major Ave.	Change (%)
Total Cost ($)	15773	14954	5.2	14679	6.9
Number of Miles	8599	8097	5.8	8046	6.4
Number of Trucks	25	21	16.0	24	4.0
Driving Hours	171	163	4.7	150	12.3
CO_2 emissions (kg)	12407	11683	5.8	11609	6.4

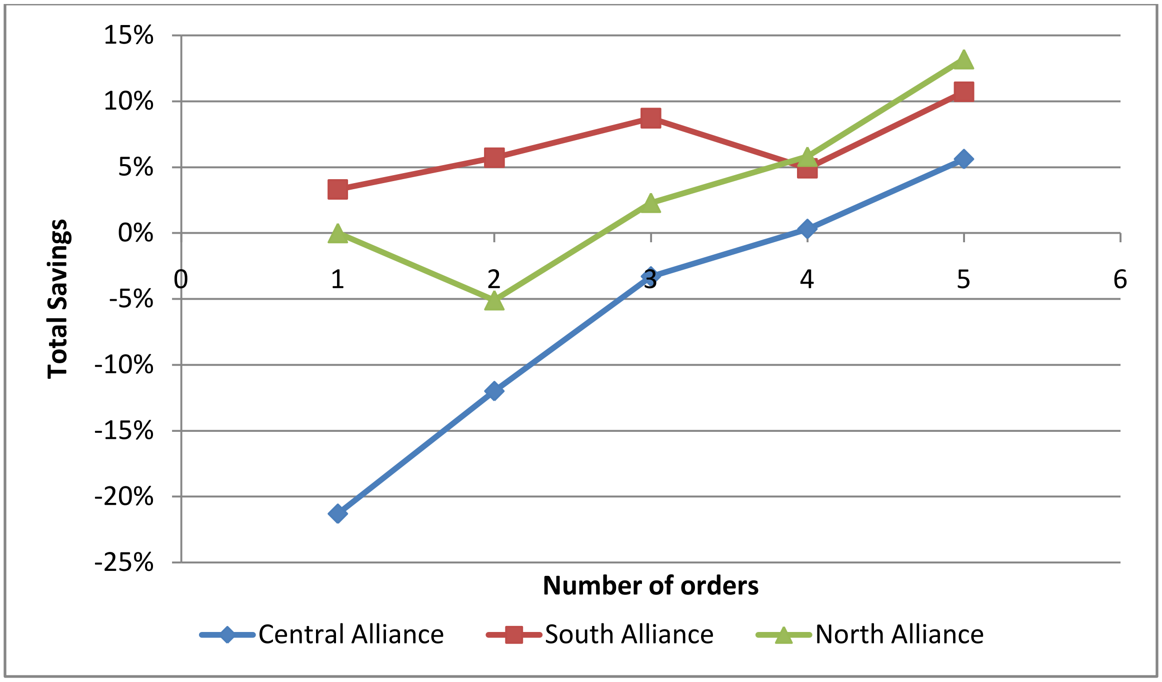

Figure 4.16 Average Cost Savings in Central, South and North Alliance

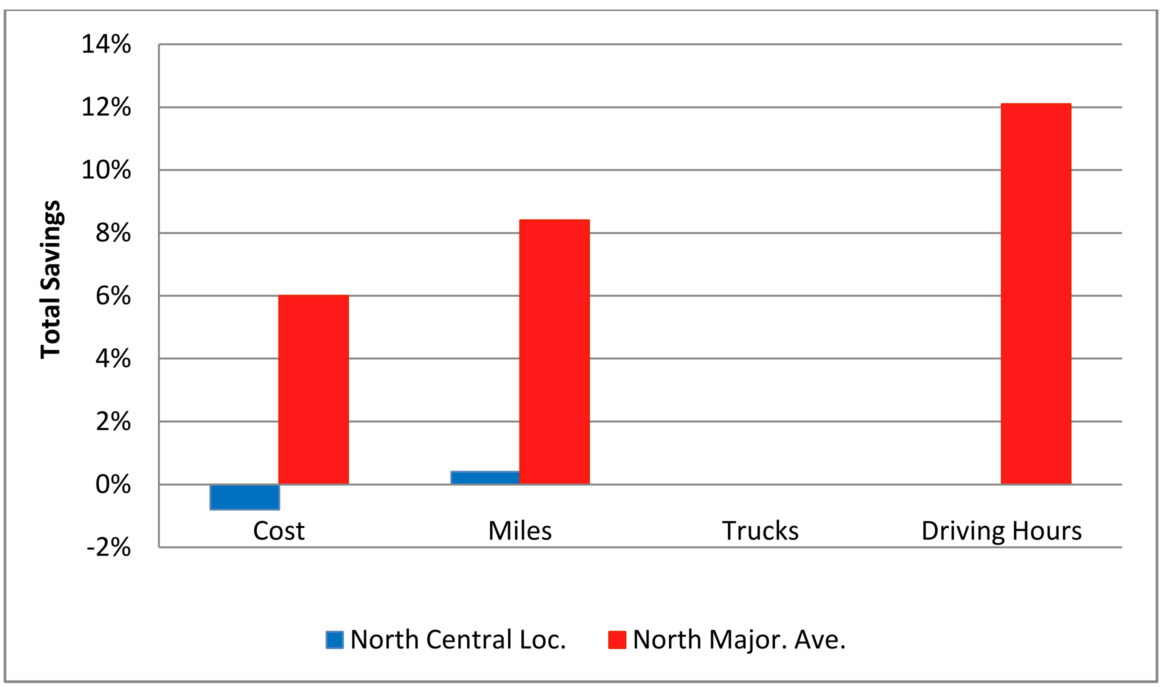

Figure 4.17 Total Savings North Alliance at a Central Location and a Major Avenue Location

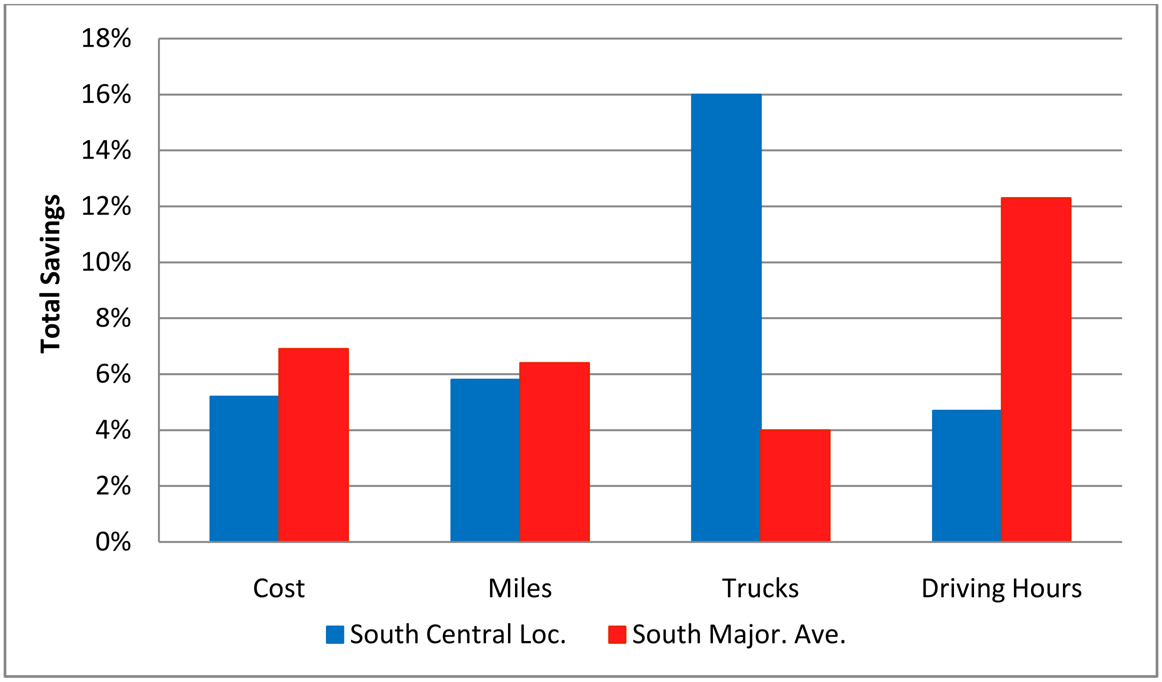

Figure 4.18 Total Savings South Alliance at a Central Location and a Major Avenue Location

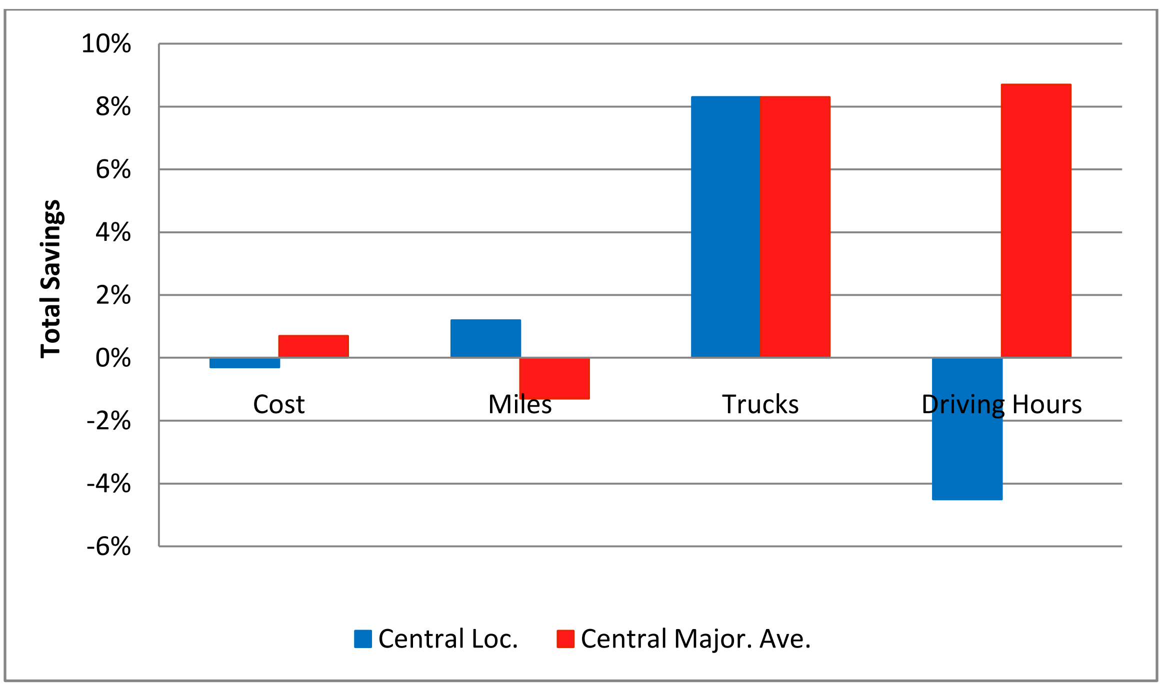

Figure 4.19 Total Savings Central Alliance at a Central Location and a Major Avenue Location

4.5 Time Windows

The third scenario assessed in this study was determination of the consequences of increasing or reducing time windows, which represents the time in minutes required to unload and load a truck in a delivery process. This value varies greatly among ornamental producers for several reasons: 1) the use of different equipment to load and unload the truck, 2) the different types and sizes of plants delivered, and 3) the use of time windows in additional market and specifically with mixed product loads. For the aforementioned reasons, the control in the preceeding scenario and the fixed time window in all previous routing simulations was 60 minutes. This value came from averaging the time window values given by the participants in the survey. Hence, with the aim of determining what percentage of costs and total savings can be reduced in a transportation alliance by becoming more efficient in managing the time windows; the study evaluated three different time windows scenarios: a 30 minutes time window, a 60 minute time window and a 90 minute time window. The three case scenarios were analyzed starting at 3 orders up to 5 orders per route (maximum), with order sharing and without order sharing. A total of 81 routing simulations were performed, 27 for each time window scenario. Average values were used to develop the sensibility analysis in Figure 4.29.

Results in Table 4.28 show that when time windows decrease, total savings increase. Time windows of 30 minutes achieved cost savings of 9% on average, while 90 minute time windows only achieved cost savings of 5% on average. Results provide enough information to conclude that for every 10 minute reduction in time window, total costs savings increase 0.66%. Number of miles, number of trucks and driving hours savings correlated with total cost savings. For every 10 minute reduction in time windows; miles driven declined approximately 0.66%, the number trucks used declined 0.33% and driving hours declined 0.33%. Total cost decreased almost linearly as the number of trucks and driving time decreased, whereas the number of miles stopped decreasing at a 60 minute time window. The maximum savings were gained in the total number of trucks at 30 minute time windows, with a total savings increase of 15%, and the lowest savings were gained in the total miles driven at 90 minute time windows with a 4% savings increase.

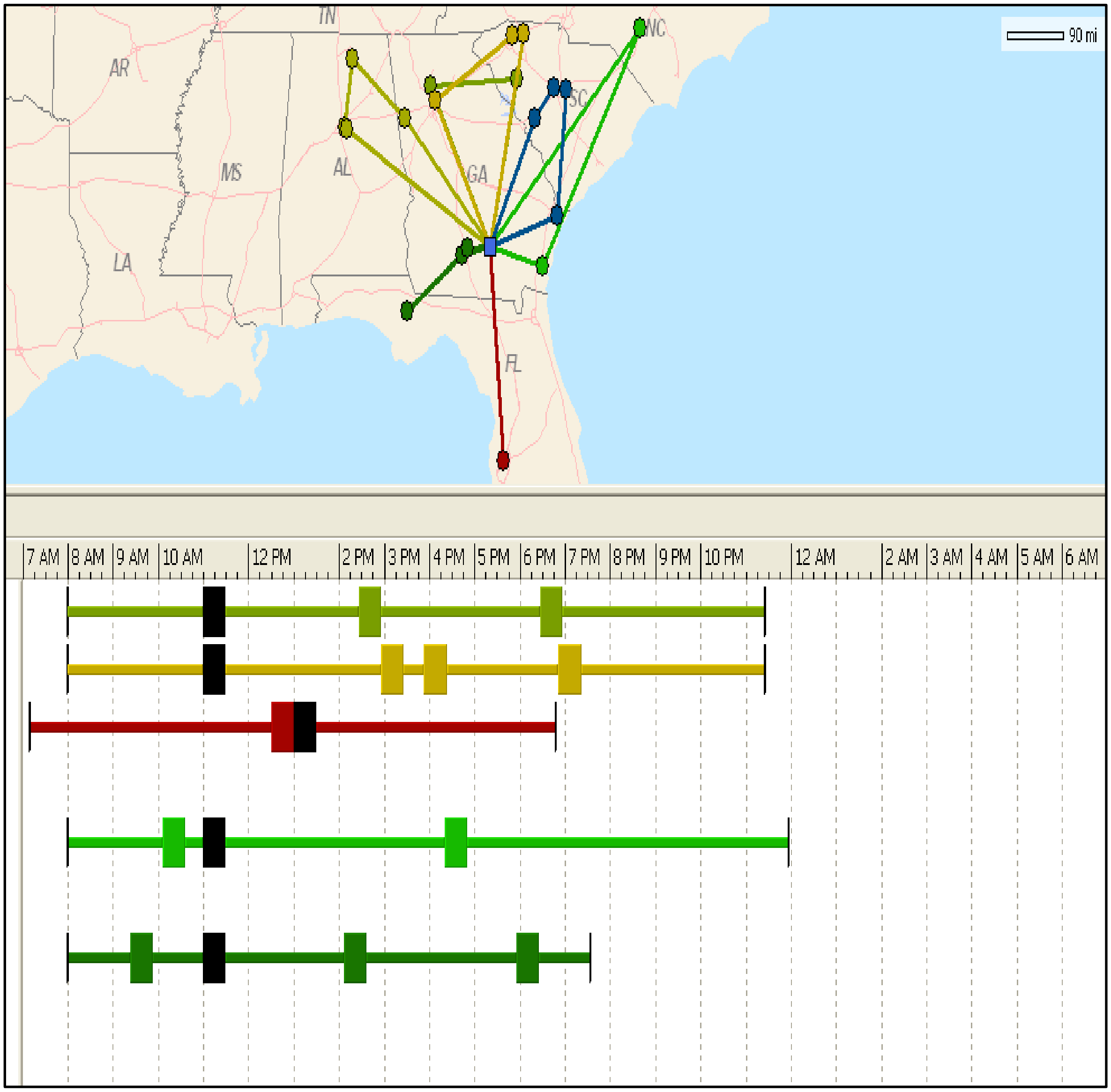

Figure 4.20 Routing Plan 30 Minutes Time Windows

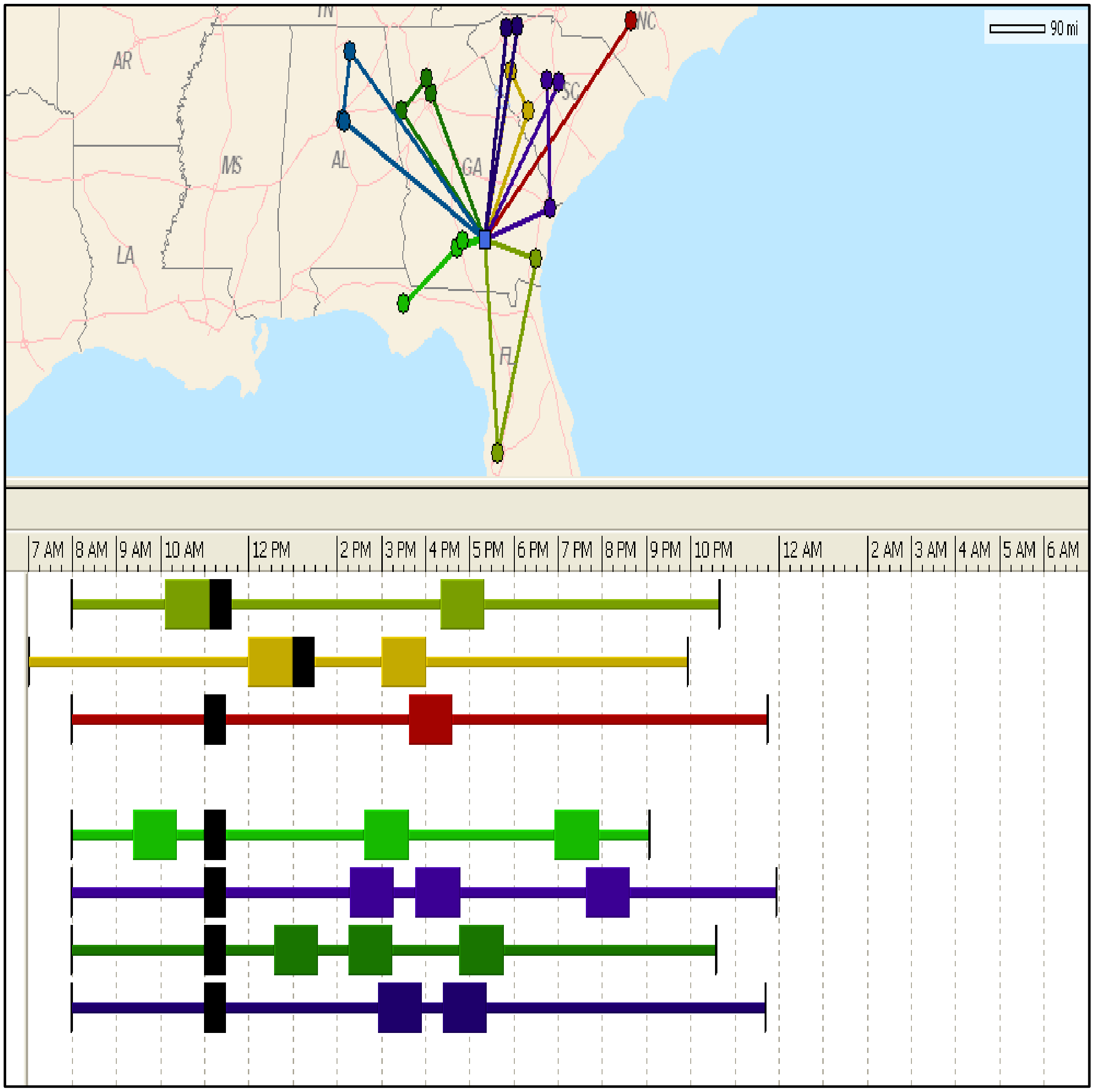

Figure 4.21 Routing Plan 60 Minutes Time Windows

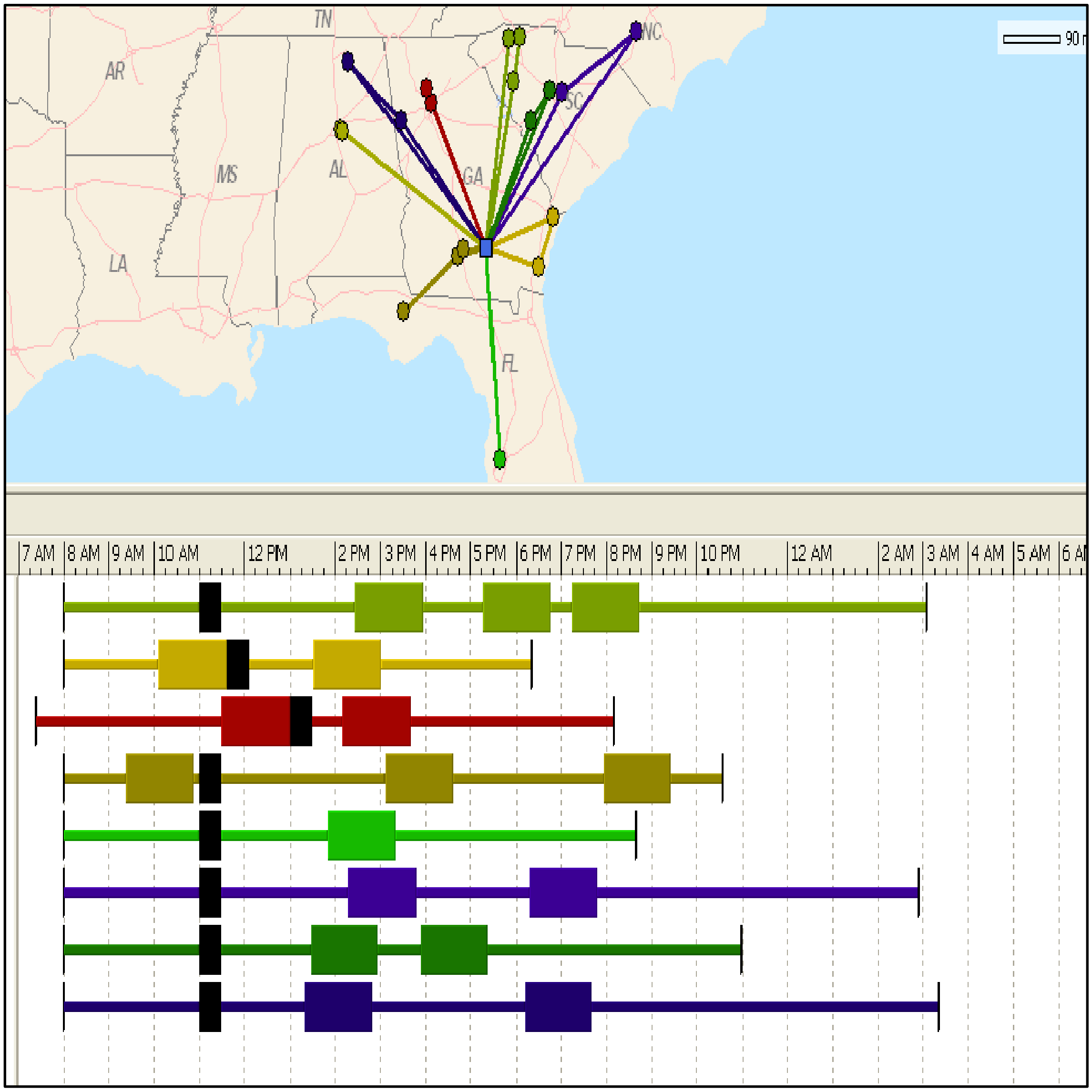

Figure 4.22 Routing Plan 90 Minutes Time Windows

Table 4.8 Time Windows Routing Results

	30 minutes	60 minutes	90 minutes
Total Cost ($)	18415	20791	21564
Number of Miles	10633	10725	11578
Number of Trucks	28	28	30
Driving Time (hours)	195	207	2011
CO_2 emissions (kg)	15342	15475	16705

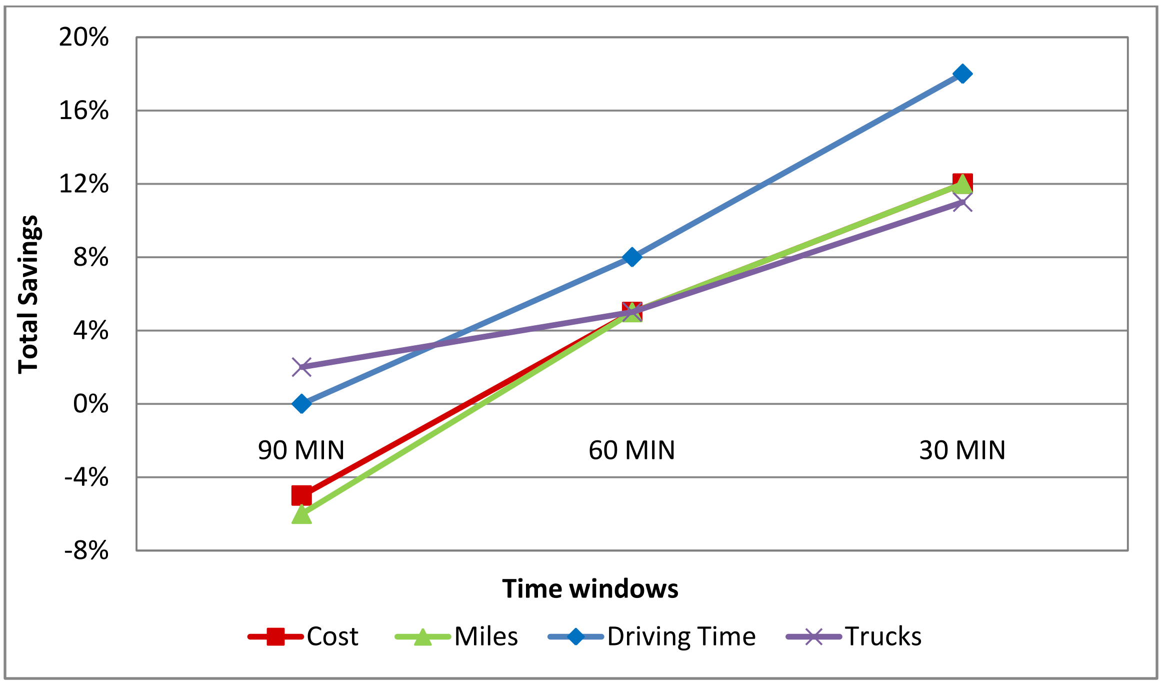

Figure 4.23 Alliance Average Cost Savings with 90 Minutes, 60 Minutes and 30 Minutes Time Windows

4.6 Optimal Number of Orders

The fourth scenario evaluated in the study was to determine the optimal number of orders per shipping cycle and the calculated percent change in total savings when the number of orders increases or decreases. The analysis included 3 different scenarios: 50 orders maximum (Figure 4.30), 100 orders maximum (Figure 4.31) and 150 orders maximum (Figure 4.32). Time windows consisted of 60 minutes per pickup and 60 minutes per delivery. Volume delivered was considered as a constant for all orders.

Sensitivity analysis (Table 4.33) results show that as more orders are added to a transportation alliance, costs increase. Nevertheless, the percent savings varies between the optimal number of orders. Total costs increased from 50 orders to 100 orders at a rate of 43%, and from 100 to 150 orders, costs increased at a rate of 38%. Similarly, the total numbers of miles driven increased 42% from 50 to 100 orders and 39% from 100 to 150 orders. Total number of trucks increased 50% from 50 orders to 100 orders and 37% from 100 to 150 orders. Driving hours increased 2% from 50 to 100 orders and 33% from 100 to 150 orders. The rate of total savings was higher when orders increased from 50 to 100 orders per shipping cycle, except for total driving time, whereby savings were higher when orders increased from 100 to 150.

Results in Figure 4.34 show the average savings of 3, 4 and 5 order sharing with 50, 100 and 150 orders maximum. The graph shows that cost savings decrease linearly by adding orders, reaching its peak at 50 orders. However, total miles driven, number of trucks and number of miles driven savings are higher at 100 orders max. Since all transportation companies have almost equal market shares, a larger total number of orders imply that the order set of every individual company increases. As a result, each individual company itself has better economies of scale and is able to carry out more efficient routes.

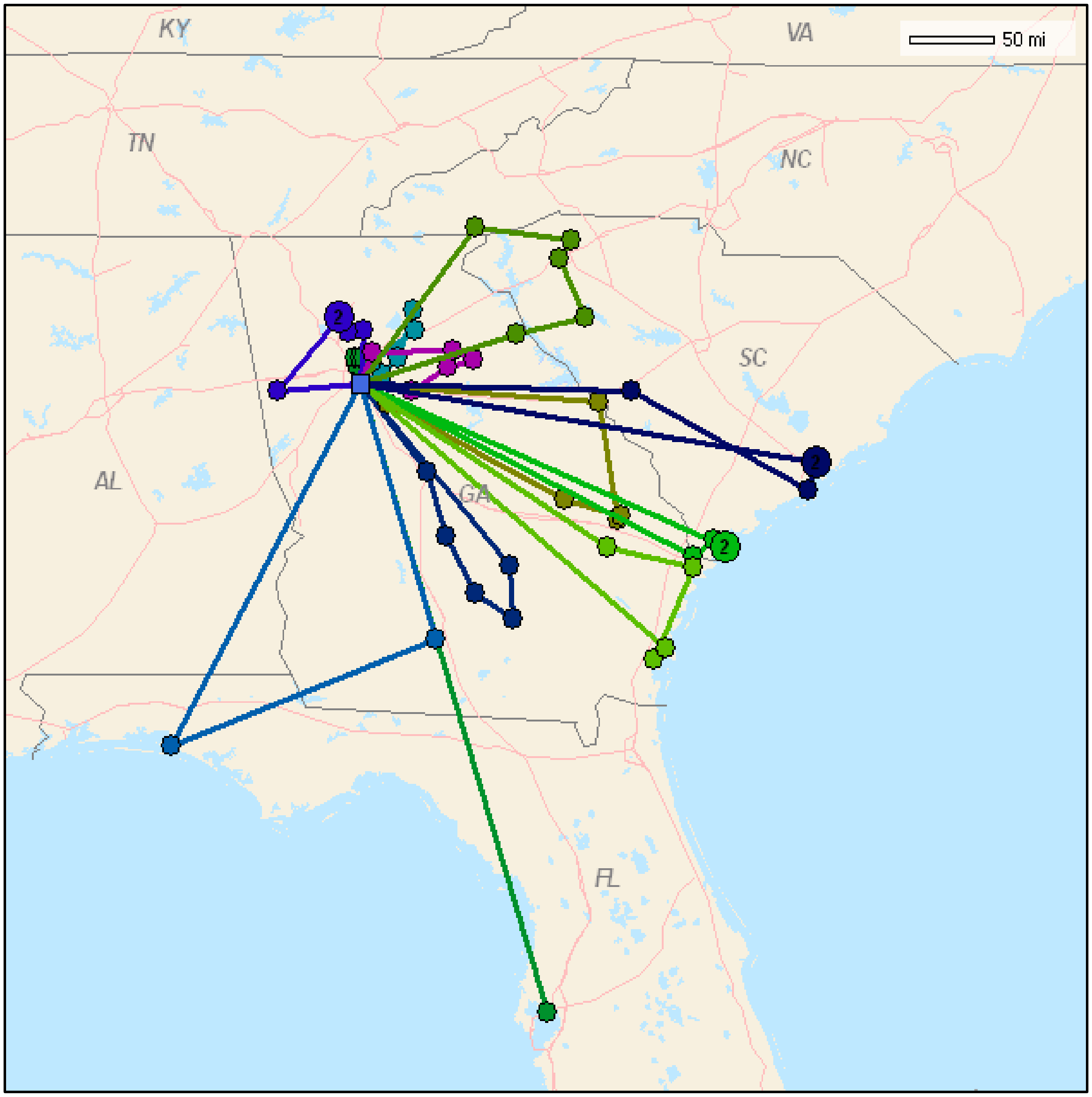

Figure 4.24 Central Alliance Routing Plan with 50 Orders Max.

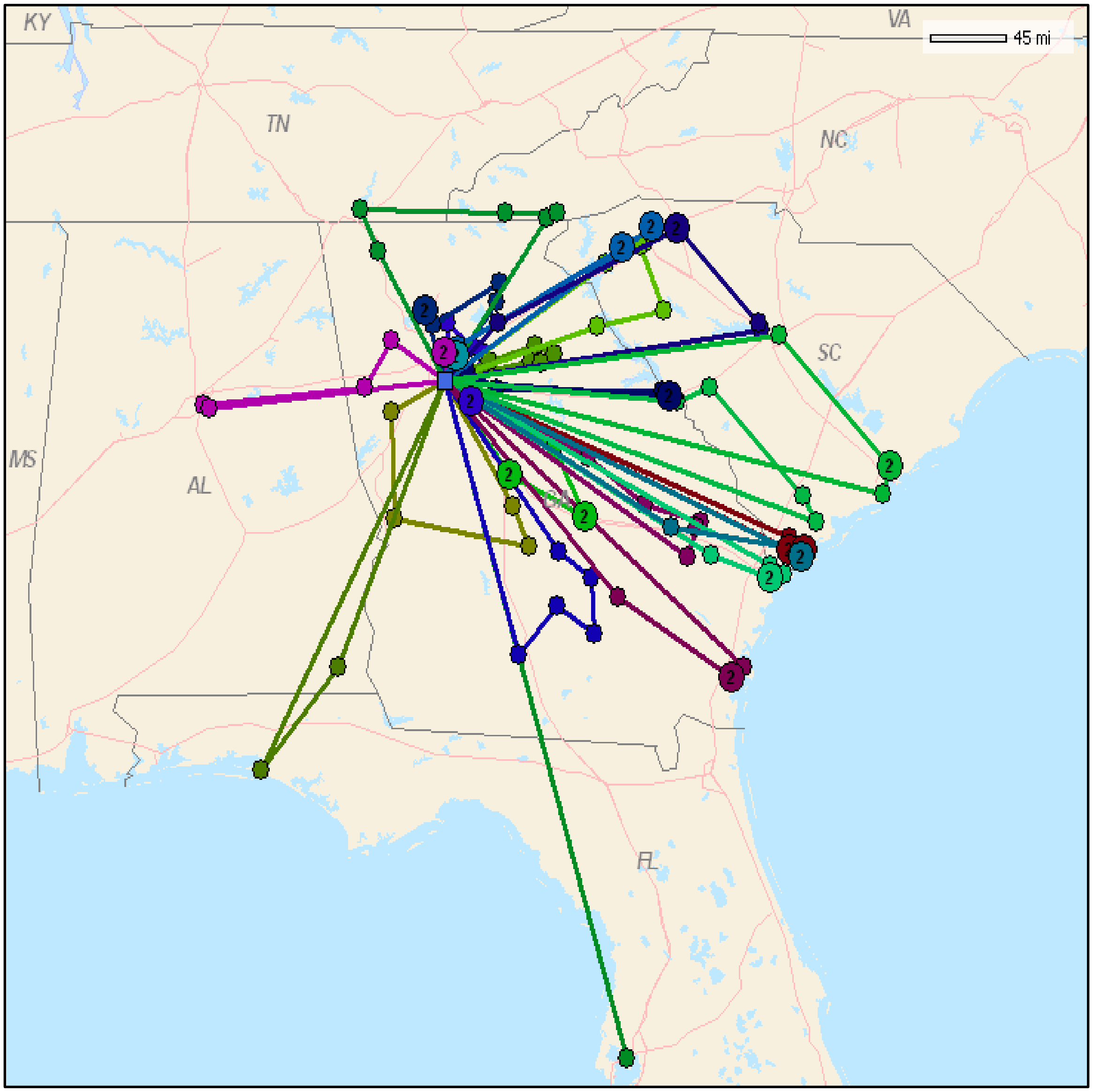

Figure 4.25 Central Alliance Routing Plan with 100 Orders Max.

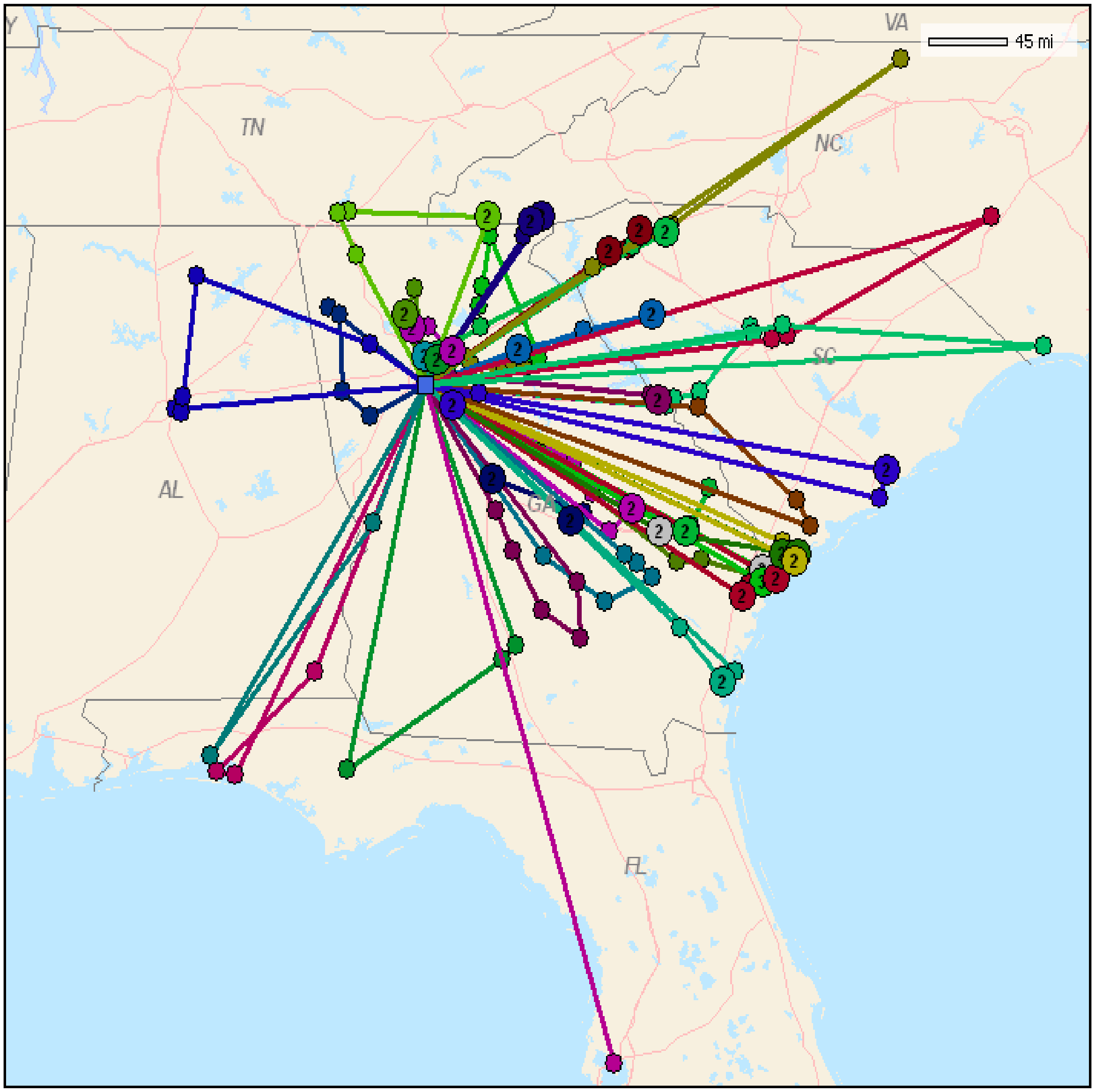

Figure 4.26 Central Alliance Routing Plan with 150 Orders Max.

Table 4.9 Optimal Number of Orders Routing Results

	50 orders	100 orders	150 orders
Total Cost ($)	9952	17443	28302
Number of Miles	5525	9537	15633
Number of Trucks	11	22	35
Driving Time (hours)	99	101	150
CO2 emissions (kg)	7972	13761	22556

Figure 4.27 Average Cost Savings in Central, South and North Alliance

CHAPTER 5

SUMMARY AND CONCLUSIONS

5.1 Summary

The increase of energy and gasoline prices, the worldwide financial recession characterized by the weakening of the U.S. dollar and the reduction in personal income are all factors expected to reduce the consumption of discretionary agricultural products such as ornamental crops. The ornamental industry faces hard economic and climatic times given that sales have decreased, production costs increased and the market has become more dynamic and competitive. In 2007, the Floriculture and Nursery Crop Yearbook highlighted competition from imports of unrooted cuttings from overseas as an important factor in sales reduction; however, it attributed higher energy and food prices as the main causes of reduction in overall consumers demand.

Among all the factors that affect the expansion of nurseries and greenhouses, production, marketing, personnel and transportation are considered the most relevant (Hodges and Haydu, 2005). In the 2003 Southern Cooperative Bulletin Survey, nurseries ranked transportation as an important factor of concern for expansion of trading, ranking it above debt capital, equity capital, marketing and below personnel and production (Brooker et al., 2005). The significant importance of transportation costs has remained consistent during the last ten years, turning it into an enormous strategic factor that must be accounted for economic growth and social change to occur. However, in recent years, transportation costs have increased steadily, forcing businesses to give up a higher percentage of sales revenue to transportation costs. The 2008 3rd quarter report from the USDA stated that average truck cost rates have increased to $2.67 per mile, 13% higher than in the 2nd quarter and 23% higher than the same quarter the year before (Transportation Services Division, 2008). Gasoline and energy sources will continue to decline and transportation will eventually become one of the highest, if not the highest, determining factor of success for any business, especially those in agriculture.

In the agricultural industry, the importance of transportation costs is heightened, as evidenced by the fact that transportation accounts for over eight percent of the wholesale value of total farm shipments (Nichols Jr, 1969). Logistic cooperation is an important strategic alternative to reduce costs and increase efficiency in the agricultural sector. The remedy for the medium and small sized carrier businesses is to establish coalitions or alliances in order to extend their resource portfolio and reinforce their market position (Krajewska and Kopfer, 2006). In the case of Georgia's ornamental industry, producers may share clients, routes and origins; still, each producer has an independent transportation system. 85.8% of the total annual sales of Georgia's nursery industry have repeated customers, making it the third highest ranked state with most repeated customers.

Therefore, the main objective of this study was to determine if a transportation alliance through horizontal cooperation and routing junction would reduce shipping costs and increase distribution efficiency among ornamental producers in Georgia. A convenience sample of 10 medium and small nurseries/greenhouses in Georgia were surveyed from March through September, 2009. The costs gathered were tabulated and evaluated with recent research in the transportation industry for data validation. Using the GIS software ArcLogistics 9.3 various routing plan analyses were conducted to evaluate different constraints, such as: depot locations, number of services, and order sharing. The routing analysis considered the 20 most relevant location deliveries per participant. Subsequent sensitivity analysis was constructed for all constraints.

5.2 Conclusions

This study suggests that transportation alliances, through horizontal cooperation and routing junction, reduce shipping costs and increase distribution efficiencies among ornamental producers in Georgia. Results show that with the use of the ArcGIS software ArcLogistics 9.3, transportation alliances in the ornamental industry are potentially profitable and reduce external costs such as CO_2 emissions. Total cost savings per shipping cycle ranged from 1.0% to 13.2%, with an average savings of 9%. Total miles driven savings ranged from 1.1% to 13.6%, with an average of 8%. Total number of trucks savings ranged from 2.5% to 10.0%, with an average savings of 8%. Driving hour's savings ranged from 1.0% to 18.4%, with average savings of 15%. Finally, CO_2 emission savings ranged from 1.2% to 8.4%, with an average savings of 8%. Sensitivity analysis showed that transportation costs increase at a rate of 6.3% when labor costs per hour increases $4 and at rates of 9.0% if diesel prices per gallon increases $1.

The four base case scenarios evaluated in the study demonstrate that: 1) order sharing reduces costs and increases transportation efficiencies, 2) by locating distribution centers based on client clusteredness, costs savings increase; in addition alliances that operate close to a major highway compared to a alliances located at central location achieve higher total savings, 3) reducing time windows to 30 minutes reaches higher total savings compared to 60 and 90 minute time windows and, 4) by adding orders from 50 to 100 and 100 to 150, cost savings decrease;

however, the total miles, the number of trucks and driving hour savings are higher at 100 orders maximum compared to 50 and 150 orders maximum.

This study concludes that in order to significantly reduce internal and external costs in the transportation of ornamentals, producers should explore forming transportation alliances that allow order sharing until a level of economies of scale is achieved and transportation efficiencies reach their peak. It is imperative to indicate that order sharing must be encouraged at all times; location of distribution centers must be established based on client location clusters and close to a major highway; time windows must be managed efficiently in order to achieve higher savings and the optimal number of orders must be defined with a previous sensitivity analysis that determines the maximum and minimum orders allowed to route efficiently.

Clearly, additional insights could be gained from additional case studies. Future research is encouraged to evaluate the impacts of transportation alliances in more complex transportation systems with more variables in the analysis. For instance, future research could focus on evaluating factors including market seasonality, product volumes, product perishability, total market share, loading/unloading processes, and quality of service. To attain a more thorough and rich comparison between our results and conclusions, a study that compares transportation alliance savings in practice is fully encouraged.

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APPENDICES

APPENDIX A

TRUCK UNIT COST MODEL EXCEL SPREADSHEET

Cost of Truck Operation					
(based on survey and literature review data)				Adjustment Values Non Adjustment Values	
Model / Year	**Hino 2002**				
Total Miles Driven Annually	**16,000**				
Truck Payment	**$14,711.00**				
Years Old	**8**				
FIXED COSTS	**ANNUAL COSTS**	**MONTHLY COSTS**	**PER HOUR**	**CENTS PER MILE**	**%**
Depreciation	$2,059.54	$171.63	$0.98	0.129	7
Insurance	$1,392.00	$116.00	$0.66	0.087	5
Overhead Expenses	$3,000.00	$250.00	$1.42	0.188	10
Taxes and Registration Fees	$1,120.00	$93.33	$0.53	0.070	4
Return on Investment	$747.76	$62.31	$0.35	0.047	3
Total Fixed Costs:	**$8,327.30**	**$693.94**	**$3.94**	**0.520**	**28**
VARIABLE COSTS					
Fuel	$5,901.71	$491.81	$2.79	0.369	20
Tires	$1,050.00	$87.50	$0.50	0.066	4
Repair and Mantenance	$1,920.00	$160.00	$0.91	0.120	6
Labor	$6,473.60	$539.47	$3.07	0.405	22
Loading/Unloading Charges	$0.00	$0.00	$0.00	0.000	0
Miscellaneous Expenses	$0.00	$0.00	$0.00	0.000	0
Total Internal Costs:	**$23,673**	**$1,972.72**	**$11.21**	**1.480**	**80**
EXTERNAL COSTS					
Air Pollution	$1,920.00	$160.00	$0.91	2.568	6
Accident	$4,000.00	$333.33	$1.89	5.349	14
Other	$0.00	$0.00	$0.00	0.000	0
Total External Costs:	**$5,920**	**$493.33**	**$2.80**	**0.370**	**20**
Total Variable Costs:	**$21,265**	**$1,772.11**	**$10.07**	**1.329**	**72**
Total Vehicle Costs:	**$29,593**	**$2,466.05**	**$14.01**	**1.850**	**100**

APPENDIX B

SALES PROPOSAL

Dear Mr. / Miss…

As you may know, the increase in fuel and energy costs is reducing the efficiency and competitiveness of ornamental producers and it is becoming an immense concern among Georgia's Green Industry. On behalf of the Department of Horticulture at the University of Georgia, I would like to inform you that I will be conducting my Masters Degree Research on analyzing the actual transportation costs and methods used by ornamental growers and assess whether there is any feasibility in developing a transportation alliance. The study would require transportation information such as costs and operational details from several growers.

The purpose of this research is to provide us with an opportunity to closely assess your needs and present recommendations which could then be easily implemented. I hope that this outline has helped to get you interested in participating in the study and to collaborate with my research.

I would like to thank you for your time and future cooperation. If you have any questions, whatsoever, please do not hesitate to contact me.

Sincerely,

Javier Mantilla Compte

Current Situation

Higher energy and gasoline prices, slow economic growth, the reduction in personal income expected to reduce the consumption of discretionary agricultural products such as ornamental crops and the introduction of more imported cut flowers and cultivated greens pushed by the weakening of the US dollar is causing tremendous concerns for Georgia's Green Industry future. Georgia's Green Industry was valued at $3.02 billion in 2004 dollars which is 0.95% of the state's $318,276 billion total gross state product. Transportation has become a big expenditure; the 2008 3rd quarter report from the USDA reported that average truck cost rates have increased to $2.67 per mile, 13% higher than in the 2nd quarter and 23% higher than the same quarter the year before. These trends are pushing growers to become more efficient especially when it comes to their transportation operations. The study, published in May 2008 by the Canadian Investment Bank CIBC World Markets, calculated that the recent surge in shipping costs is on average the equivalent of a 9 percent tariff on trade. "The cost of moving goods, not the cost of tariffs, is the largest barrier to trade today," the report concluded, and as a result "has effectively offset all the trade liberalization efforts of the last three decades."

Objectives

The objectives are to develop a technically feasible analysis of a transportation alliance between ornamental growers in Georgia that participate in the study. The analysis would provide enough information to proof that their transportation costs could be reduced and profit margin increased by working together with growers located in determinate areas. Further objectives include the development of useful tools such as route planning and excel spread sheets for future alliances.

Approach

As the objectives highlighted, the research would analyze the actual transportation costs and systems used by the participant growers. With that information recorded a hypothetical alliance would be created between specific growers that provide cost and route planning reductions. Using GPS Satellite programs such as ArcGIS, Arc Logistics 9.3 and Google Earth, more variables would be analyzed and further accuracy obtained from the data.

The study would be complemented with a what-if and feasibility analysis that encourages producers to work in an alliance or cooperation.

Deliverable

The research would be published and guided as an Official Graduate Student Thesis of the Horticulture Department from the University of Georgia. To process the current research we would need specific information described in list below:

1. Complete description of your shipping and transportation costs
    A) Maintenance costs
    B) Drivers salaries
    C) Drivers working hours
    D) Insurance costs
    E) Fuel costs
2. Description of your modus operandi used in your shipping system
3. List of Cliental
4. List of your competition

5. Frequency of delivery dates
6. Schedule of deliveries
7. Back haul deliveries
8. Age of vehicles used
9. Capacity of Vehicles
10. Dollar value that clients pay for your products

Benefits

A thorough analysis of transportation alliances in the ornamental industry will provide enough tools and incentives for growers to form the aforementioned alliances. The alliances will provide more competitive shipping rates, reduction in the carbon footprint, reduction in overall truck traffic and a more competitive product against imported plant materials. The study would also provide useful information for the growers that participate as:

1. Tangible spreadsheets to determine your shipping costs.
2. Analysis of the Arc Logistics 3.0 software to be used in future transportation alliances.
3. Deep evaluation of your actual shipping system
4. Recommendations of the studied alliance.

Closing

Despite the bad weather and higher fuel and energy costs, ornamental crops' sales are still stable throughout the region, with a 1.5% sales growth. To further increase that rate and become more competitive, the industry needs research and tangible tools for their producers to procure new alternatives to solve the economic and energy crisis.

Wine and Spirits Shippers Association (WSSA) in Reston, Va., is a specialized cooperative that serves about 450 member companies in the alcoholic-beverages trade market. "The weak link in the chain is the small guy, and his main recourse is to join an association," says Geoff Giovanetti, managing director of WSSA. Most of WSSA's members are small or medium-sized enterprises, he says.

I would like to thank you once again for your consideration as well as for your future cooperation. If you have any questions, whatsoever, please feel free to contact me javiermc@uga.edu

APPENDIX C

QUESTIONNAIRE

I. GENERAL INFORMATION

1. Nursery's Name:____

2. Address: ____

3. Do you maintain records of your transportation costs?

   Yes: _____No: _____

4. How have your transportation costs behaved in the past 5 years?

   Decreased: ________Stayed the same: ________Increased: ________

5. What percentage of your costs do you attribute to transportation?

   _______ %

6. Have you considered the use of a third party to deliver you products?

   Yes: _____No: _____

7. What percentage of your total sales do you deliver in 1 – 3 gallon containers?

   _______ %

8. What are the three main products delivered in 1 – 3 gallon containers?

   ____

II. VEHICLES

1. Fill the following table based on each vehicle used in your operation:

Vehicle	**Brand**	**Model**	**Year**	**Purchase Price $**

#1				
#2				
#3				
#4				
#5				
#6				
#7				
#8				
#9				
#10				

2. Fill the following table based on each vehicle. (Please follow same order as in the previous table)

Vehicle	**Volume**	**Weight**	**Attainable miles per hour**
#1			
#2			
#3			
#4			
#5			
#6			
#7			
#8			

#9			
#10			

3. What is the total cost of your License fees?

____

4. What are your total Insurance Costs?

____

5. What are your total Management Expenses (including but not limited to administration staff, communication equipment, housing costs, garage facilities and/or utility bills)?

____

6. How much do you pay in taxes for the entire operation?

____

7. Total cost (year 2008):
   - Tires: ____________________
   - Fuel: ______________________
   - Maintenance: _______________
   - Repairs: ___________________
8. Driving labor:
   - Number of Drivers: ________________________
   - Average salary paid per Driver: _______________
   - Average working hours per Driver: ____________

III. LOCATIONS

1. Fill the following list of clientele (Exclusively for 1 – 3 Gallon Containers):

Clients	Name	Address	Zip Code
#1			
#2			
#3			
#4			
#5			
#6			
#7			
#8			
#9			
#10			

2. Please mark the day that deliveries are done per client? If a specific time for the delivery is required please include it? (Please follow same order as in the previous list).

Client	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
#1						
#2						
#3						
#4						

#5						
#6						
#7						
#8						
#9						
#10						

3. How frequently do you deliver 1 – 3 gallon containers to each client in a month? (Please follow same order as in the previous list)

Client	**Frequency of deliveries per month**
#1	
#2	
#3	
#4	
#5	

#6	
#7	
#8	
#9	
#10	

IV. ORDERS

1. What type of products do you deliver in 1-3 containers? What is their average weight?

Type: ____

Average Weight: ____

2. What is the average time it takes to load and unload a Full loaded delivery? A Half loaded one?

Full Loaded: ____

Half Loaded: ____

APPENDIX D

ARCLOGISTICS ROUTING MAPS

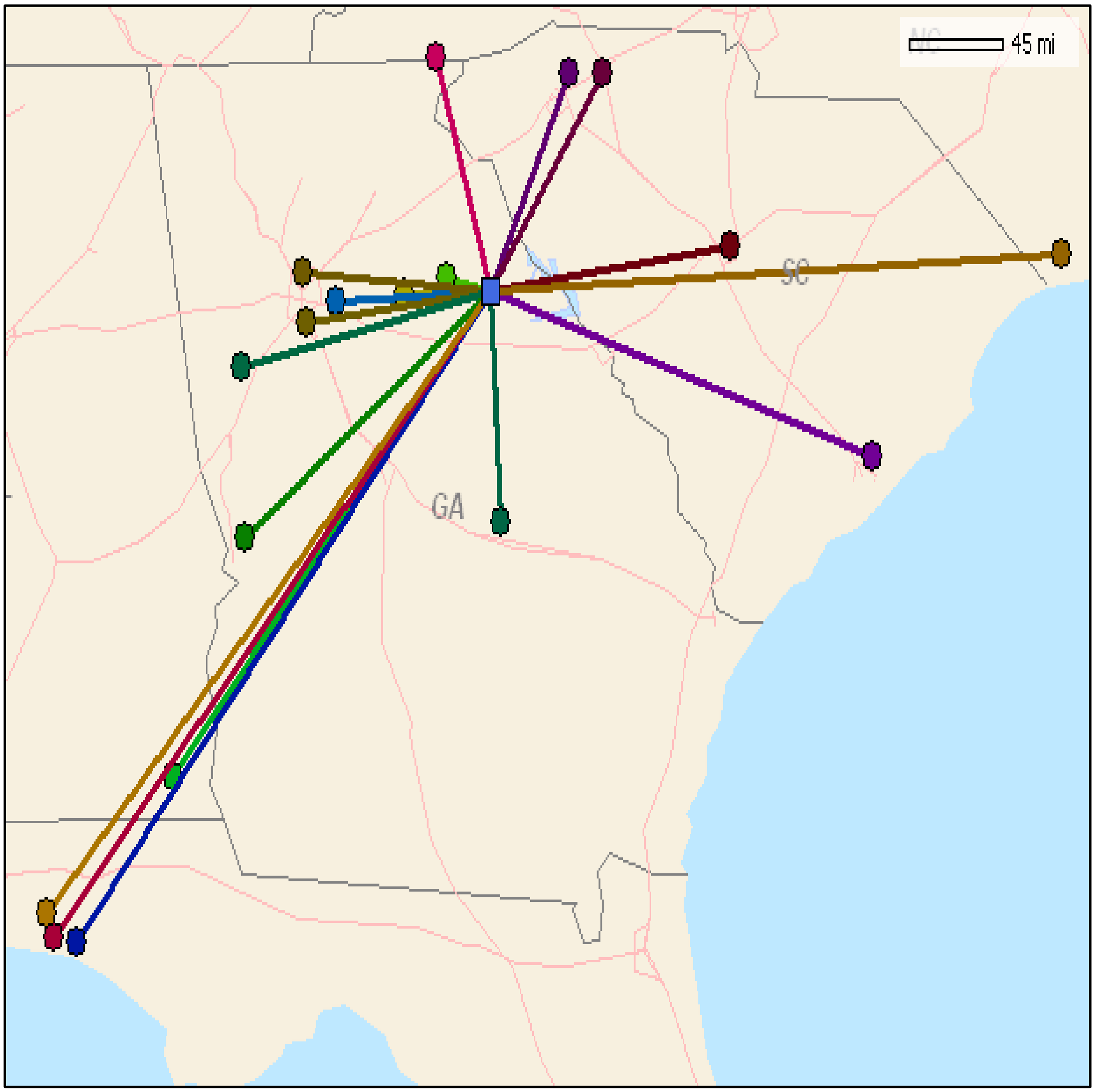

Figure C.1 Routing Plan A

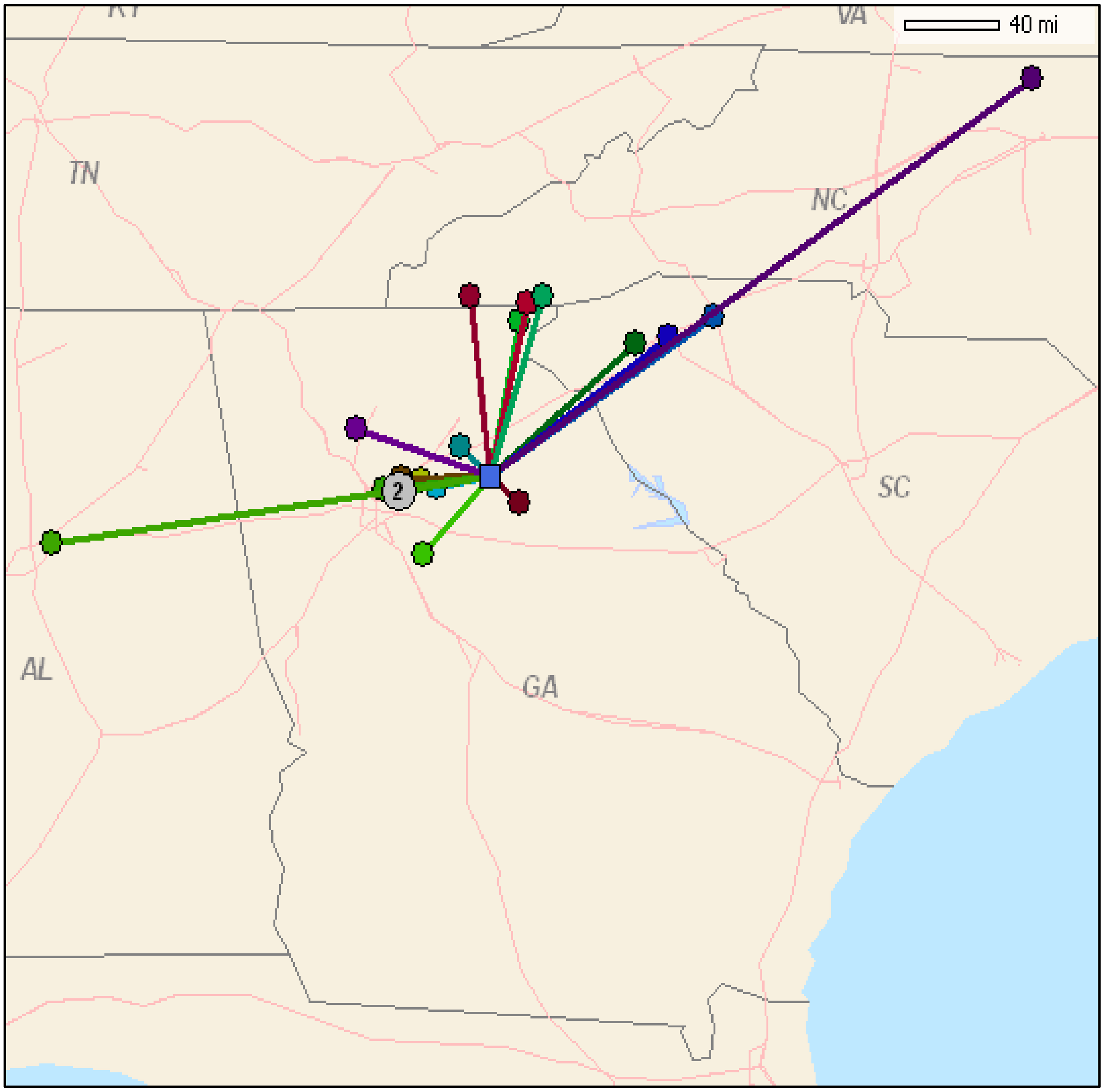

Figure C.2 Routing Plan B

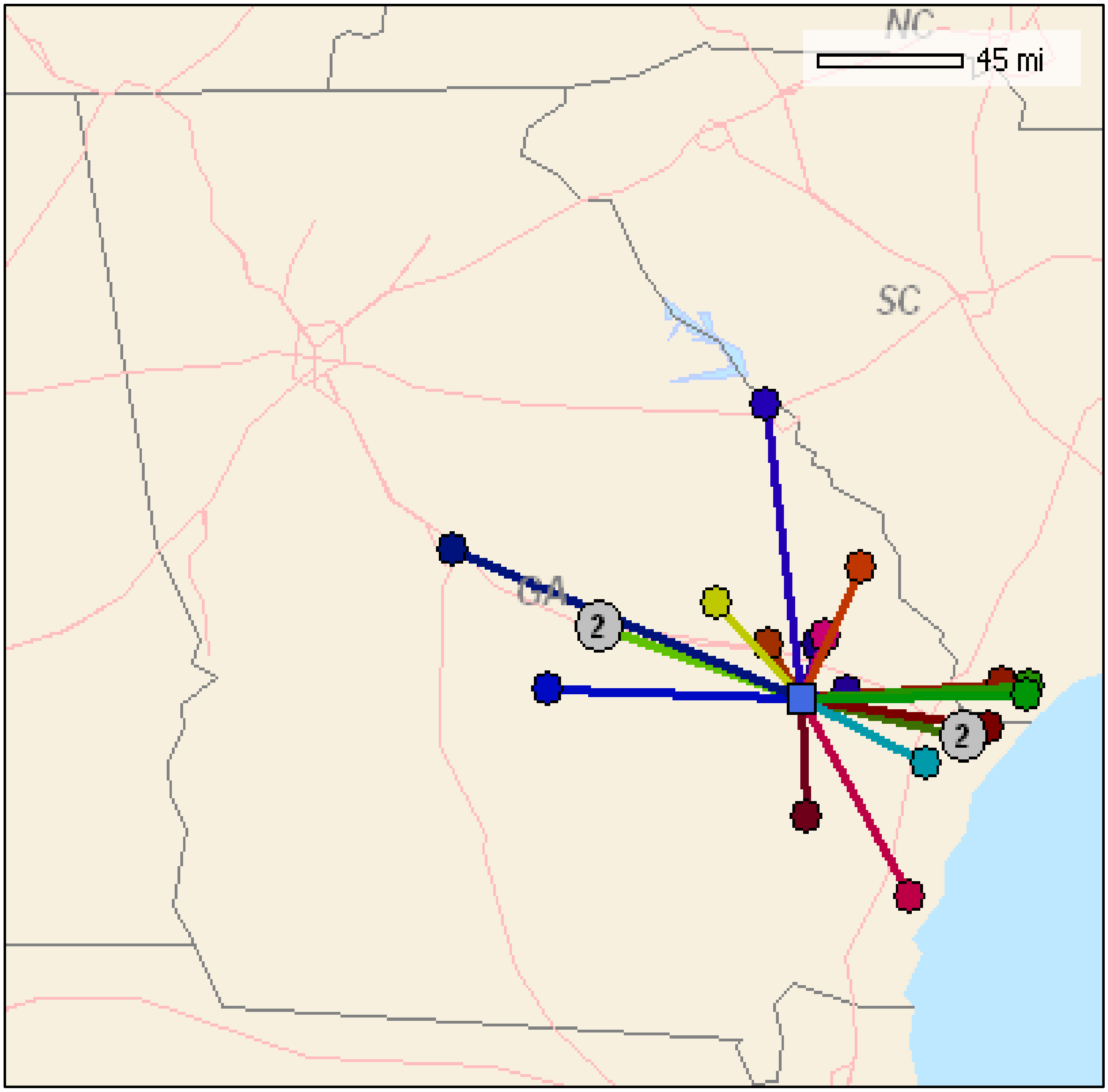

Figure C.3 Routing Plan C

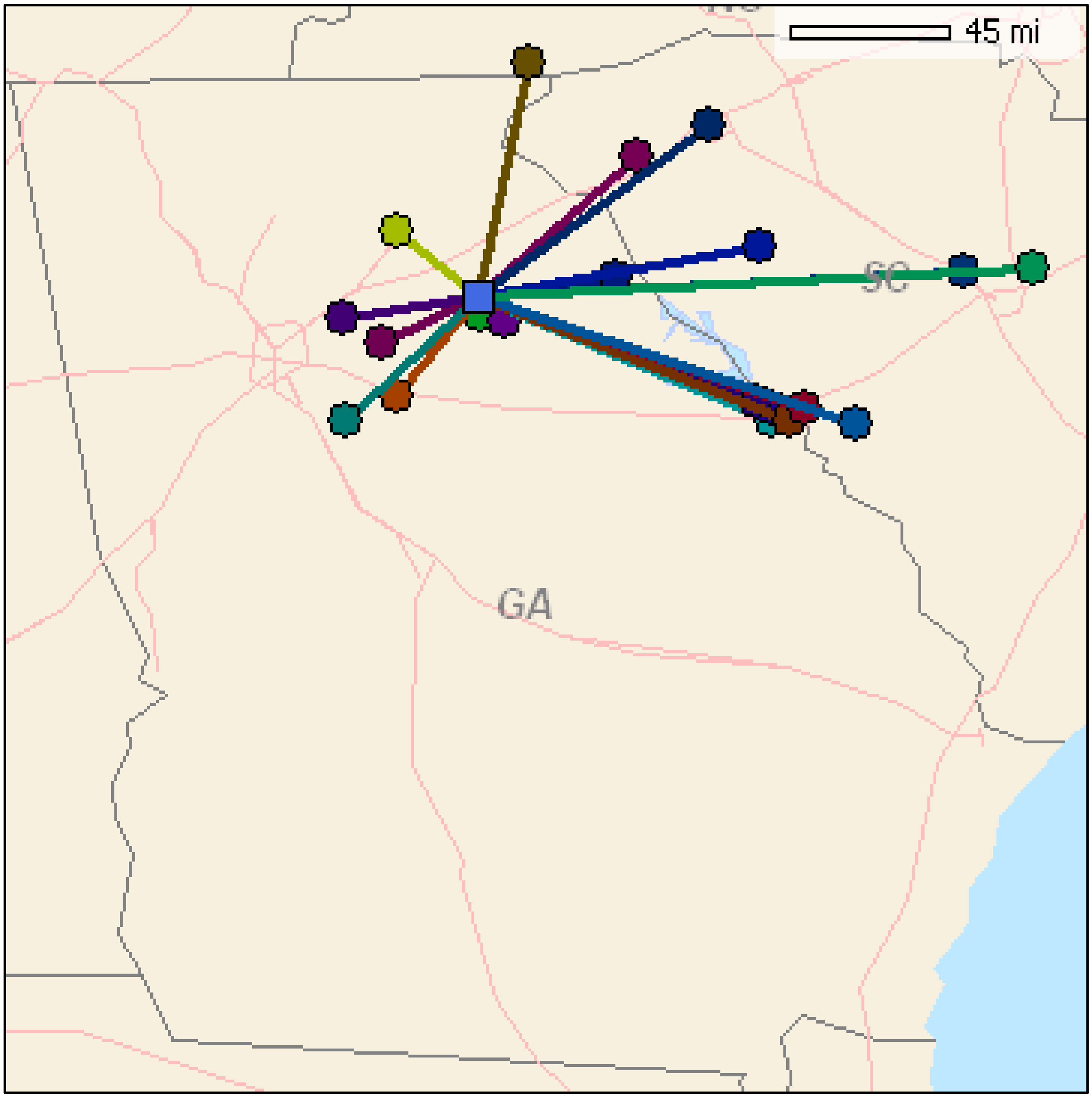

Figure C.4 Routing Plan D

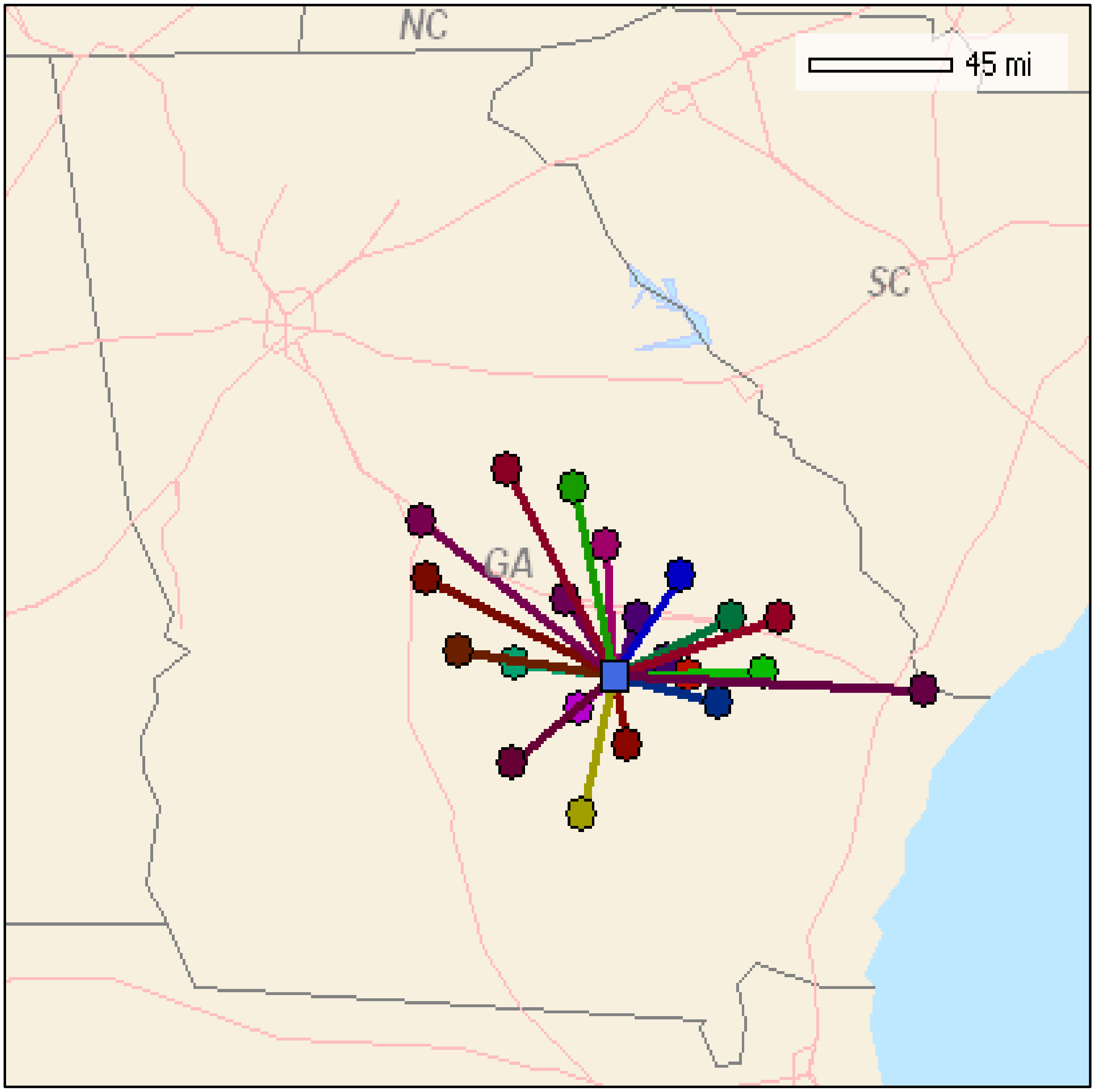

Figure C.5 Routing Plan E

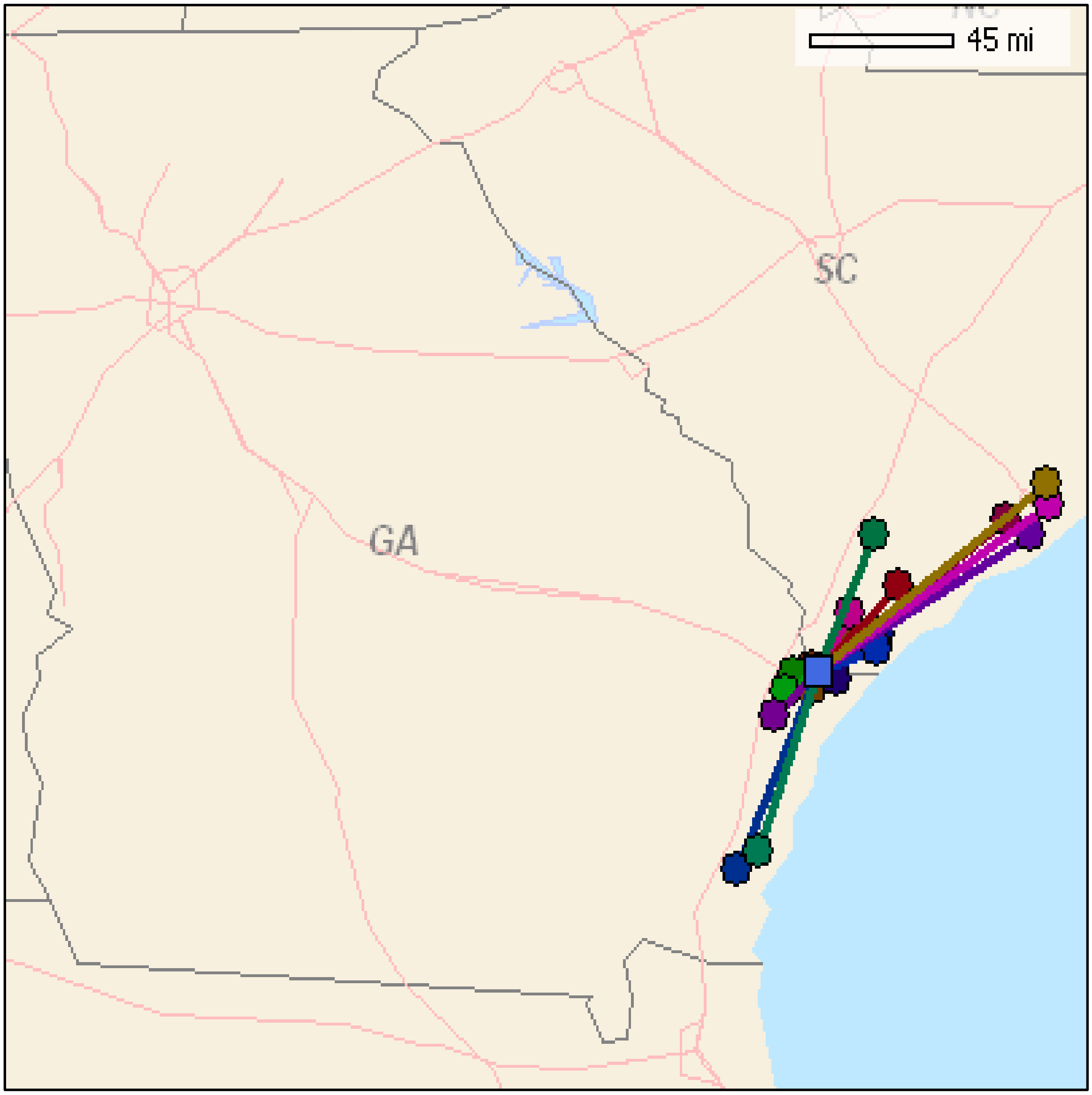

Figure C.6 Routing Plan F

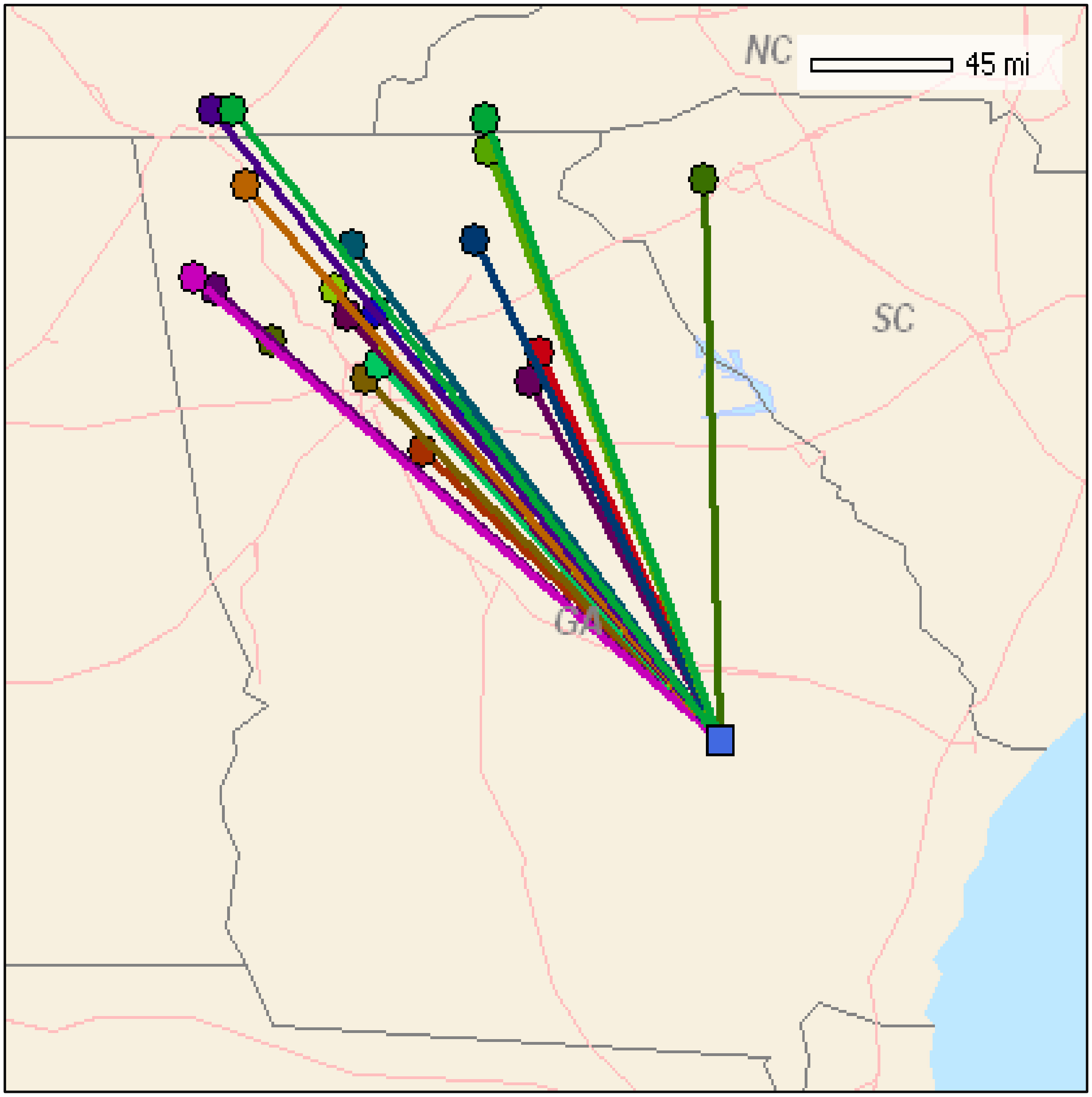

Figure C.7 Routing Plan G

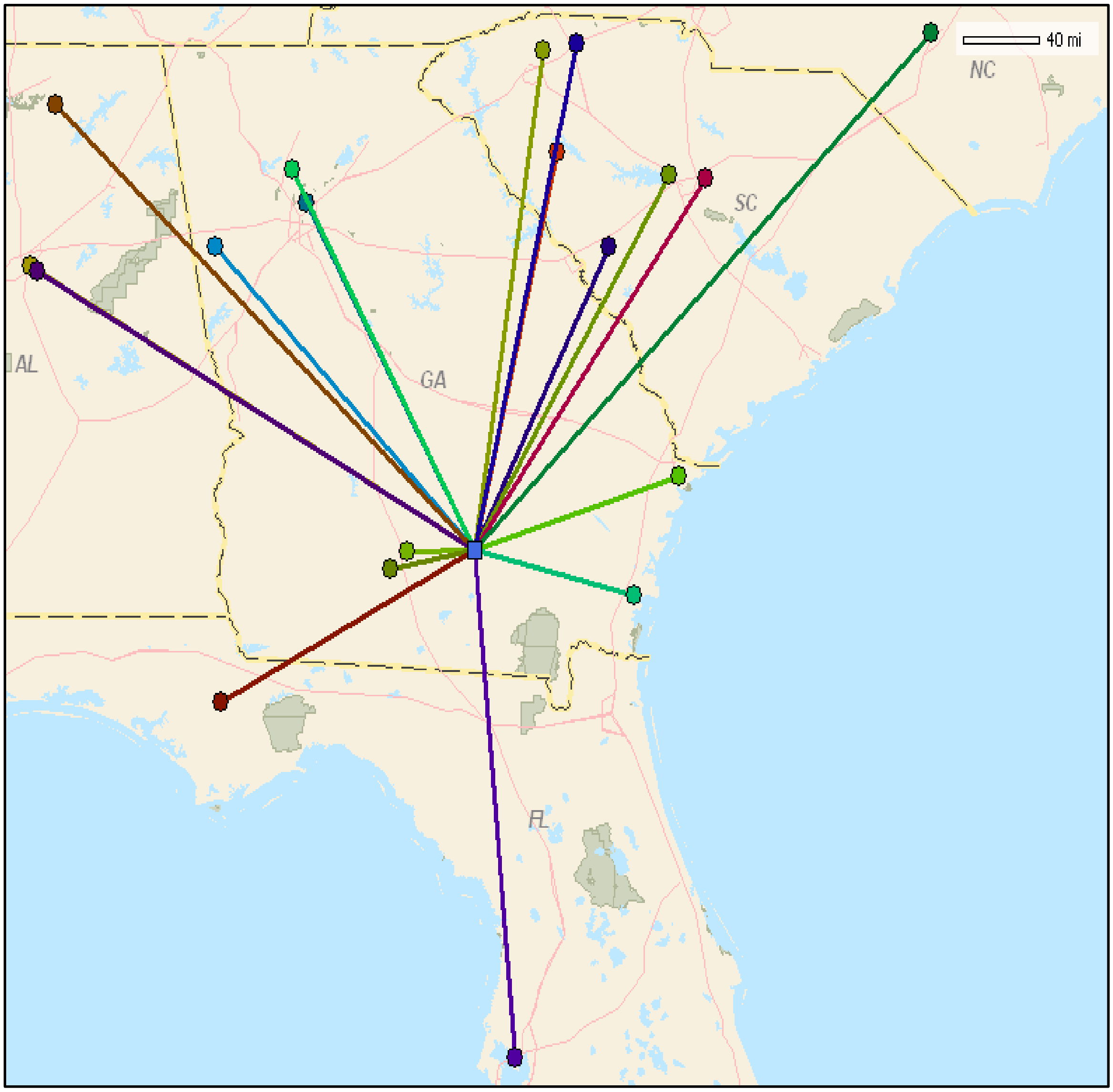

Figure C.8 Routing Plan H