Appendix C: Rural Grocery Distribution Prefeasibility Study, August 2018

Rural Grocery Distribution Prefeasibility Study – Geographic Information System, Routing Analysis, and Data Visualization

Prepared for: North Dakota Association of Rural Electric Cooperatives

By Alan Dybing, PhD., Associate Research Fellow
Upper Great Plains Transportation Institute
North Dakota State University

NDSU UPPER GREAT PLAINS TRANSPORTATION INSTITUTE

North Dakota State University
Upper Great Plains Transportation Institute
NDSU Dept 2880 | P.O. Box 6050
Fargo, North Dakota 58108-6050

AUGUST 15 2018

Contents

1. Overview

UGPTI was contracted to provide spatial modeling and data visualization for a pre-feasibility study of the distribution system for rural grocery stores serving small communities in North Dakota. As part of this process, publicly available data was used in conjunction with survey data collected by the North Dakota Association of Rural Electric Cooperatives and Neil Doty & Associates.

2. Geographic Information System Data

2.1. Routable Roadway Network

Within the initial project scope, a primary task would be to develop a geospatial model to represent supply chain movements between grocery wholesalers and rural grocery stores. In order to complete this analysis, a routable network was constructed using line shapefiles sourced from the United States Census Bureau Topologically Integrated Geographic Encoding and Referencing (TIGER) data system. TIGER road shapefiles include numerous attributes that describe the ownership, surface type, travel speed and accessibility of all roads and trails within a specified geographic extent. Although the geographic scope of the study is the state of North Dakota, some supplier locations were located in Minnesota and selected counties linking these locations were included in the network. As not all rural grocery stores are located on primary or secondary roads, the full road system was downloaded for each of the counties within the study area. These county shapefiles were merged into one shapefile consisting of 53 counties in North Dakota and 16 in Minnesota.

A GIS network is initially a representation of a road system that is primarily used for mapping or analytical purposes. Network analysis requires a roadway network that is routable, that is – connected at logical intersections with minimal error in connectivity. Often, connecting individual road segments at end points will provide a sufficient level of connectivity, but network quality checks must be implemented to ensure that the road network is not underconnected (end points exceed a specified distance and are not connected) or overconnected (a road segment is connected to another segment that does not physically touch, such as a county road crossing an interstate road via a ramp-less overpass).

Once connectivity has been established, impedance measures are established. Impedance is essentially a cost of utilizing segments of road, and the network routing process will seek to minimize the cost of traveling between origin and destination points. Often, distance is used as an impedance factor. In North Dakota's road network, this is often problematic, particularly on the county road systems. In cases where section line roads have curves rather than 90 degree intersections, the GIS routing algorithm interprets this as a shorter distance option and the resulting routes exhibit a tell-tale "zig-zag" pattern which is not reflective of common traveler behavior. Time is also a commonly used impedance factor and is a closer representation of traveler behavior, so long as the travel speeds have large enough discrepancies between road classes.

This study utilized time as an impedance factor with arbitrarily lower speed limits on lower classes of roads to reflect traveler behavior of choosing a higher class of road (i.e. state highway vs. township road) whenever possible.

2.2. Store and Supplier Address Geocoding

Once the GIS road network was established the process of geocoding origins and destinations was undertaken. A list of mailing addresses for rural grocery stores was provided by NDAREC with street addresses where available. In cases where the store mailing address was a PO Box, the physical location of the store was determined, using Google Earth and the latitude and longitude coordinates were collected. For stores with a physical location as a mailing address, the World Geocode Service was utilized to reconcile the coordinates of individual stores. The resulting store locations are shown in Figure 1 below. A similar process was used to locate the wholesaler locations and are shown in Figure 2.

Figure 1. Locations of Rural Grocery Stores Surveyed

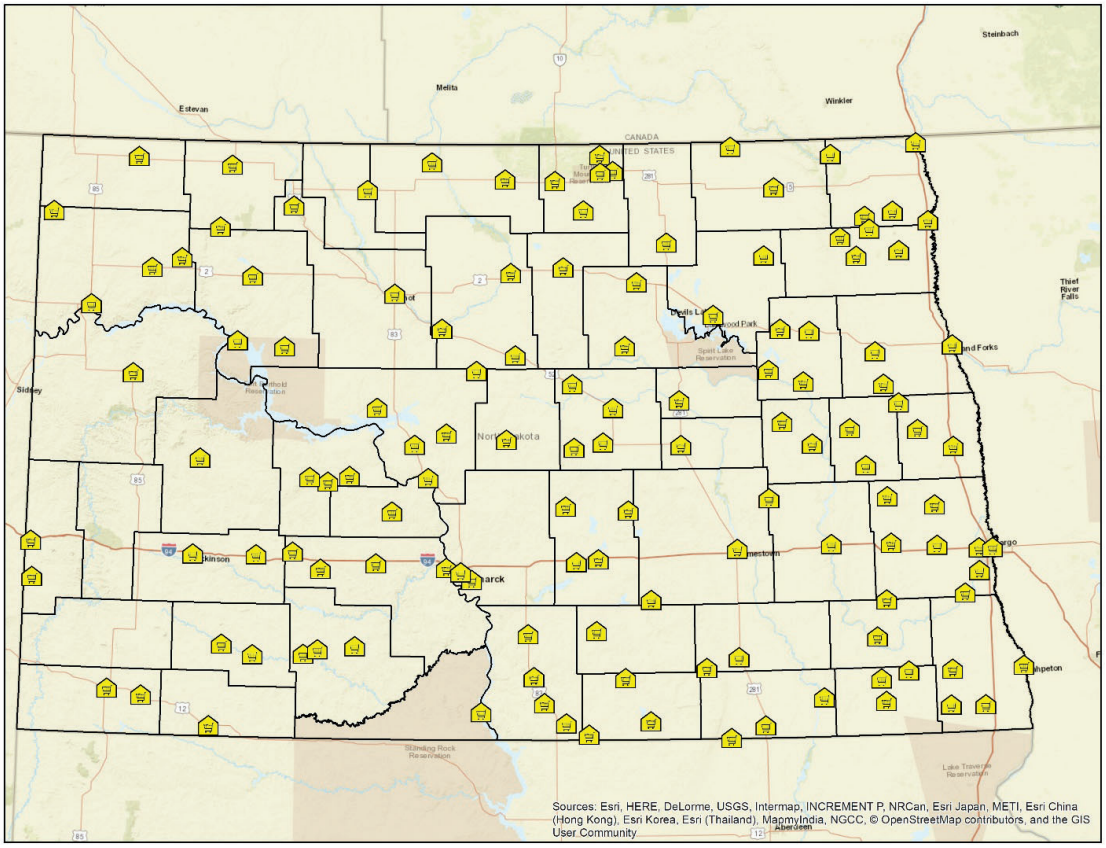
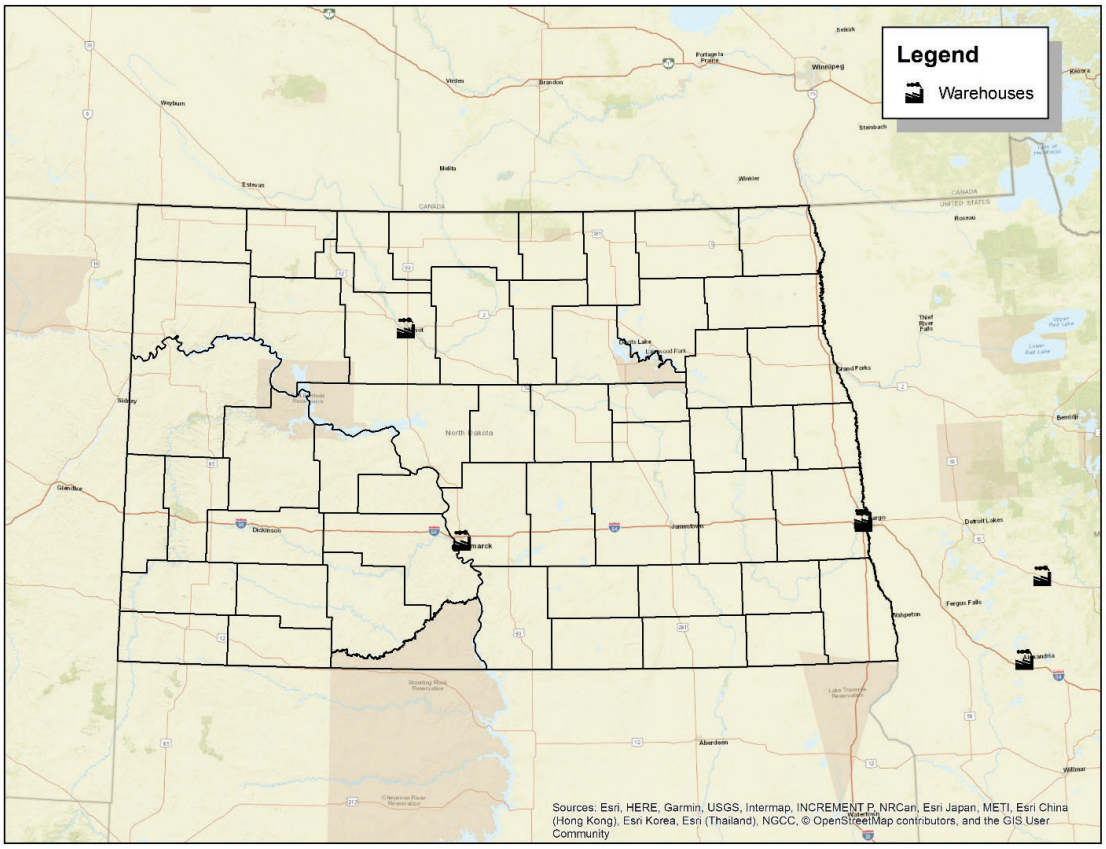


Figure 2. Wholesale Distributor Locations



3. Visual Representation of Survey Results

Neil Doty & Associates developed the survey instrument. A separate report will be complied by Neil Doty & Associates that addresses the descriptive statistics as well as the survey process. Once the initial survey results were completed, the responses were merged with the individual store locations, where possible. A unique identifier for each store was not implemented during the survey process, but survey respondents did provide zip code information that was used to match responses with the mailing list addresses. Non-matches were identified by NDAREC staff. Visual representation of the survey responses are shown in Figures 3-11.

Figure 3. Survey Respondents and Non-Responses

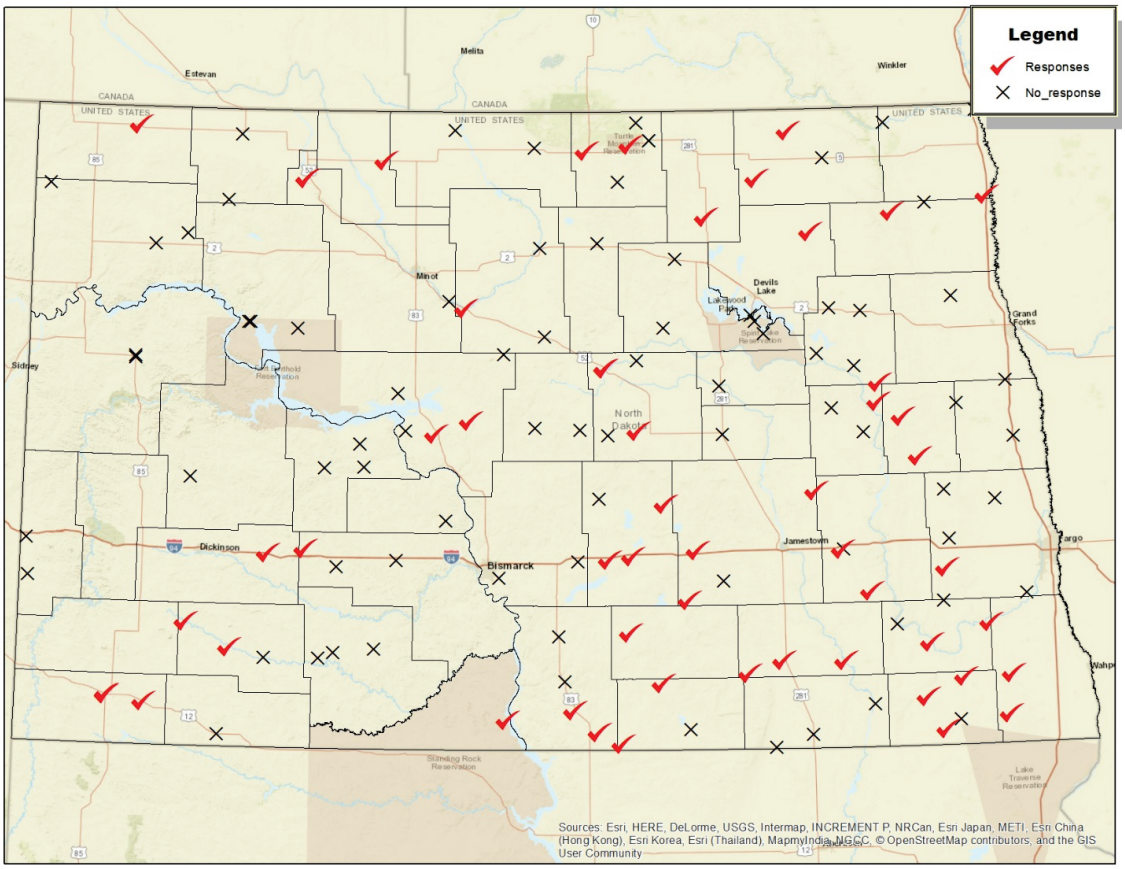


Figure 4. Stores whom Indicated Wholesale Distributor Service.

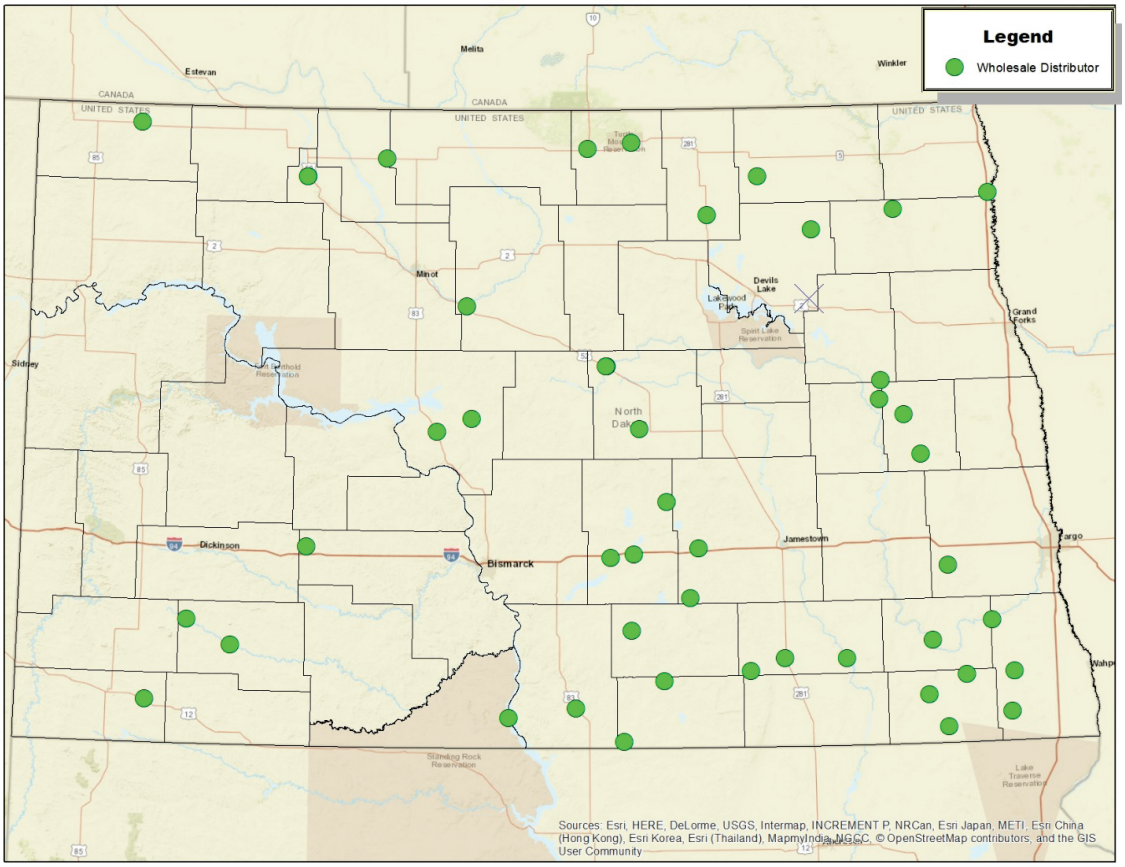


Figure 5. Rural Grocery Stores by Primary Wholesale Distributor

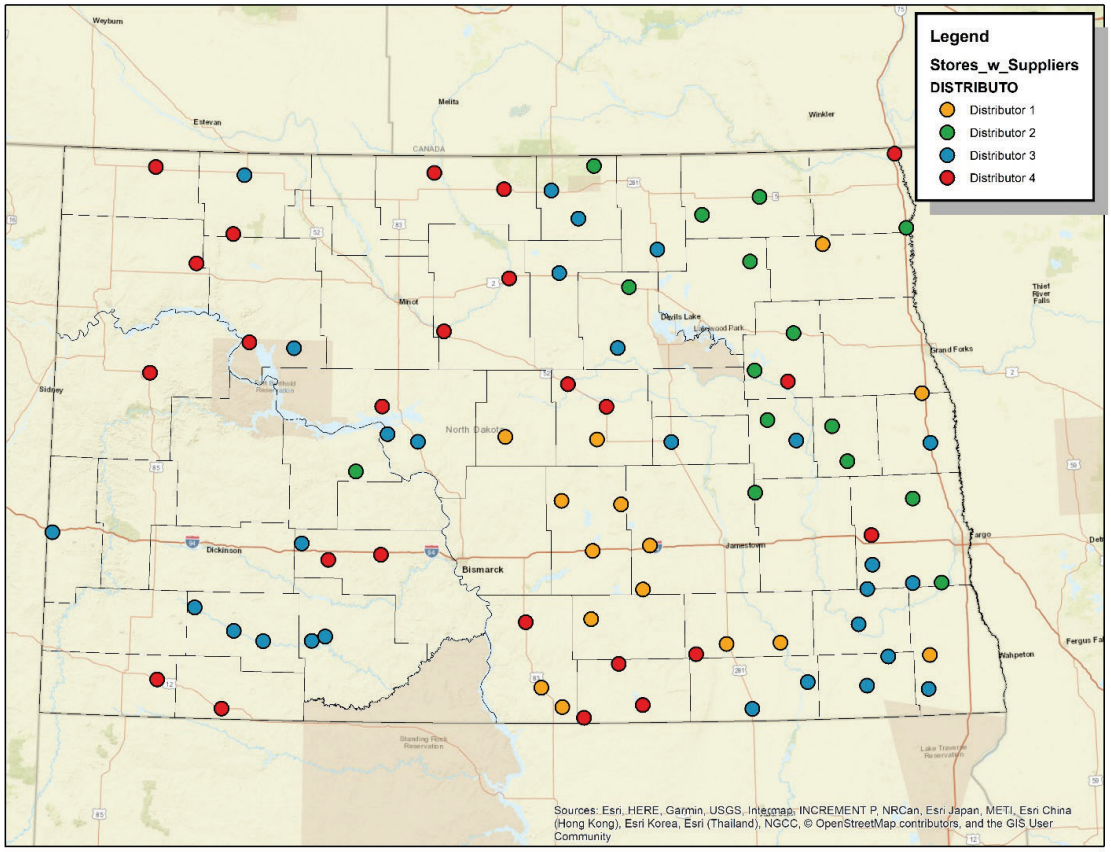


Figure 6. Stores that Reported Direct Sales Distributor Service

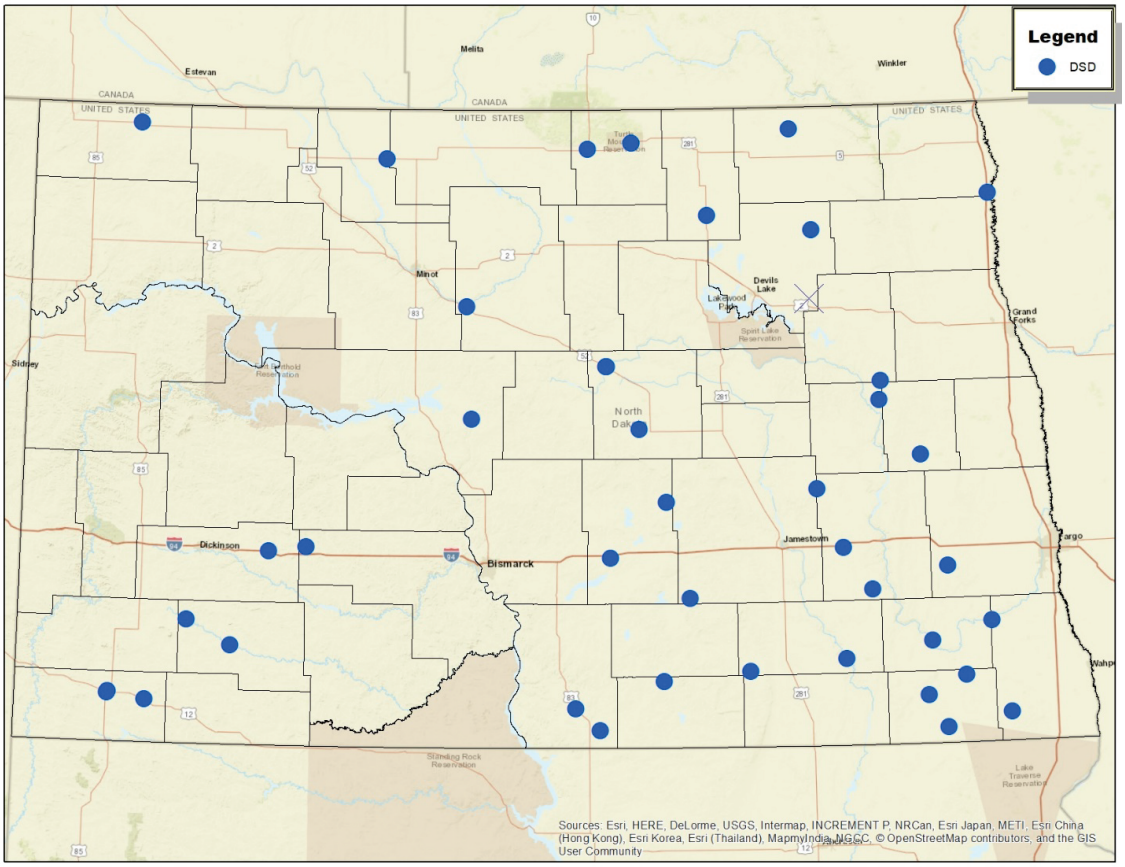


Figure 7. Stores that Reported Sourcing from Big Box Store Locations

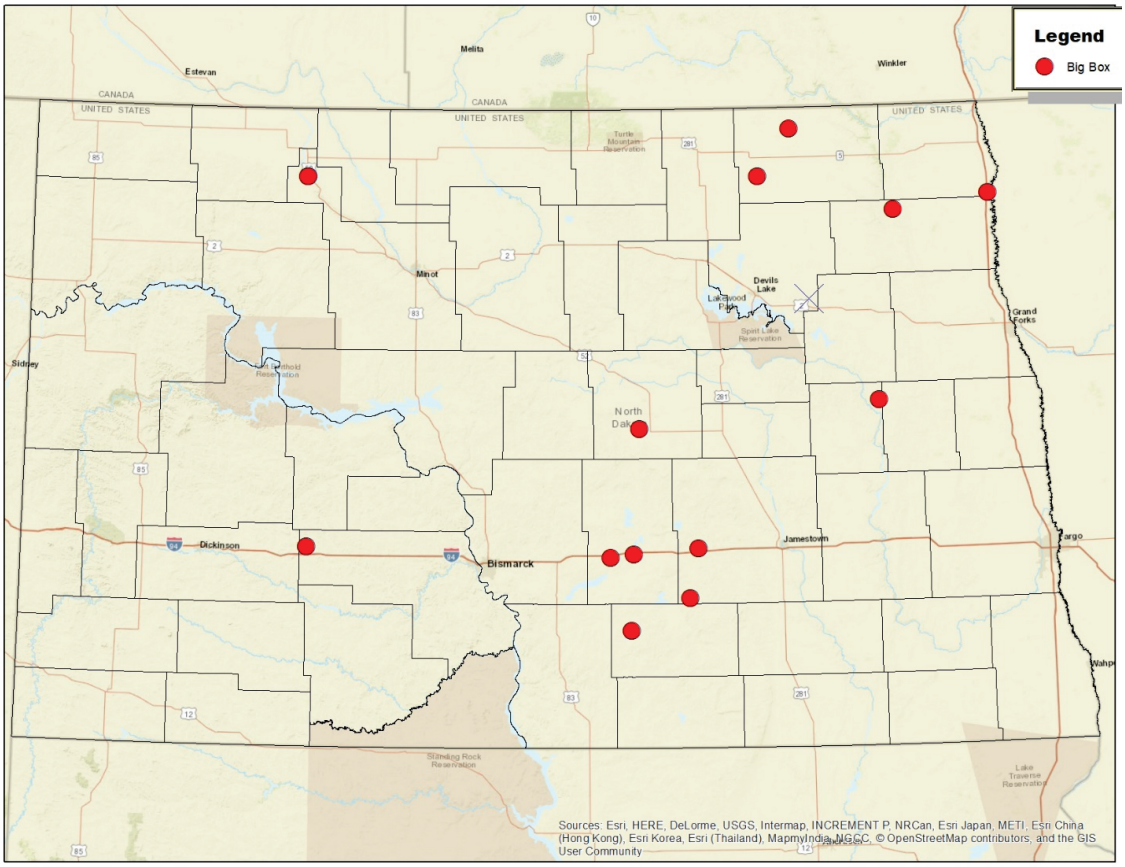


Figure 8. Stores that Reported Direct from Farm Sourcing

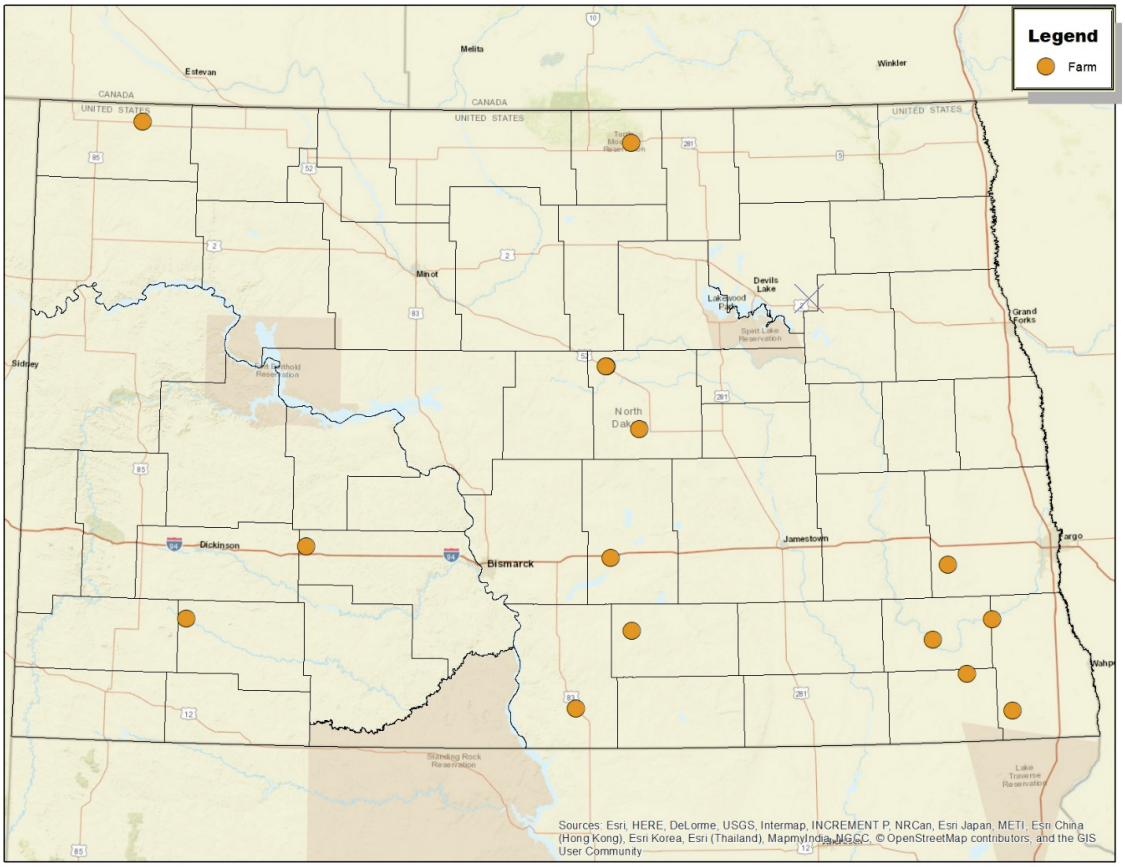


Figure 9. Stores that Currently Collaborate or are Intersted in Collaboration

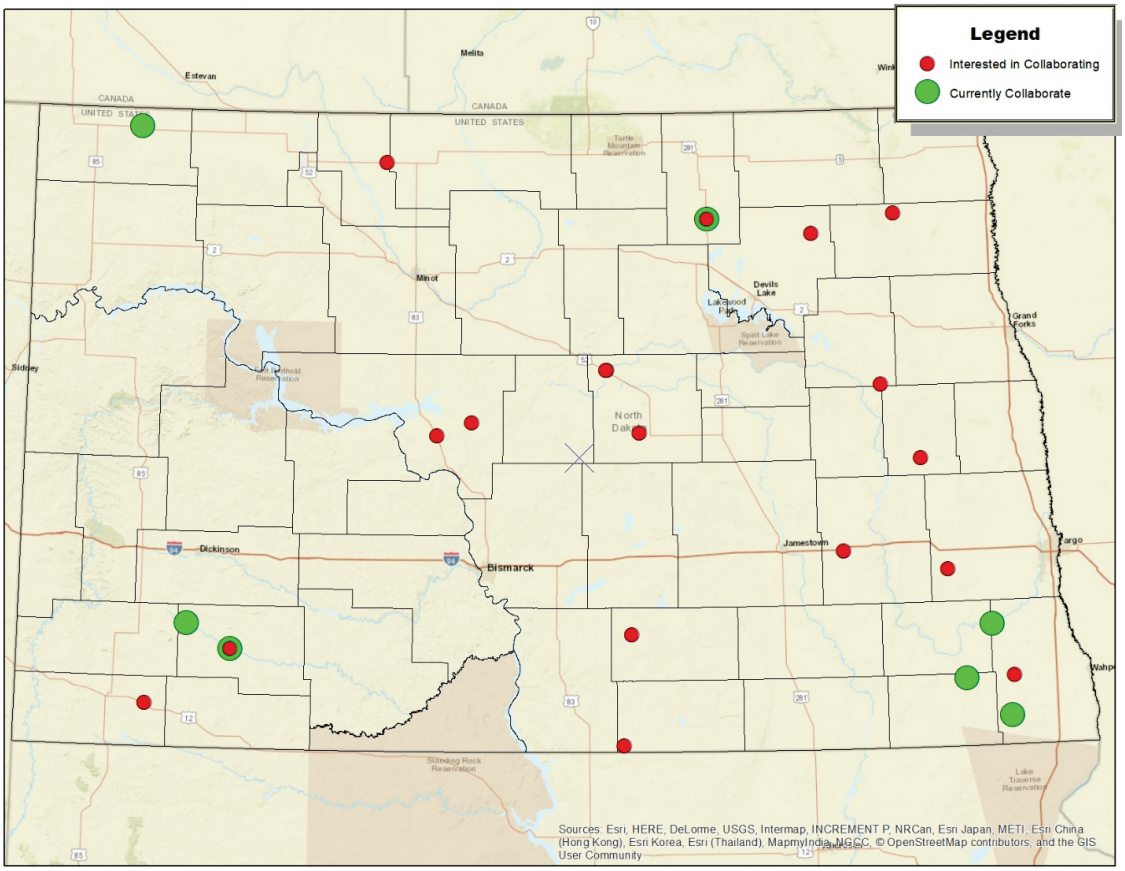


Figure 10. Stores that have Excess Storage Capacity

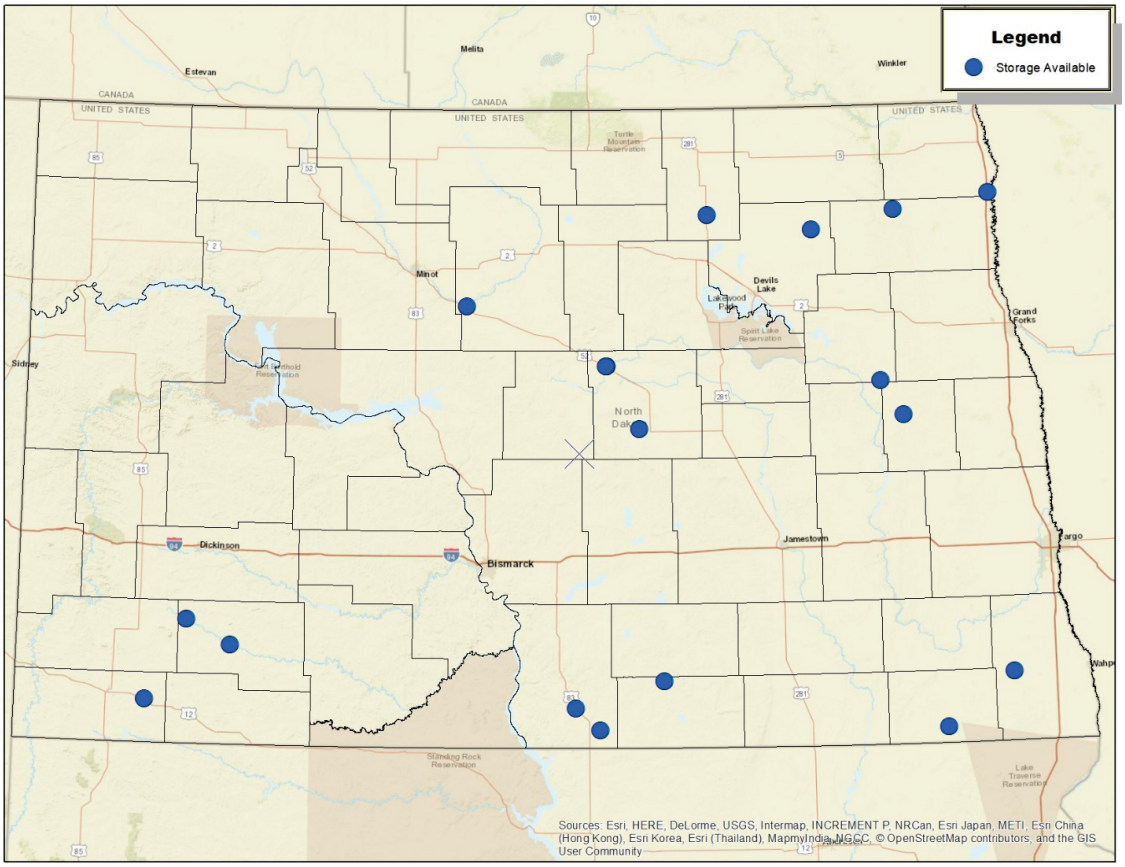
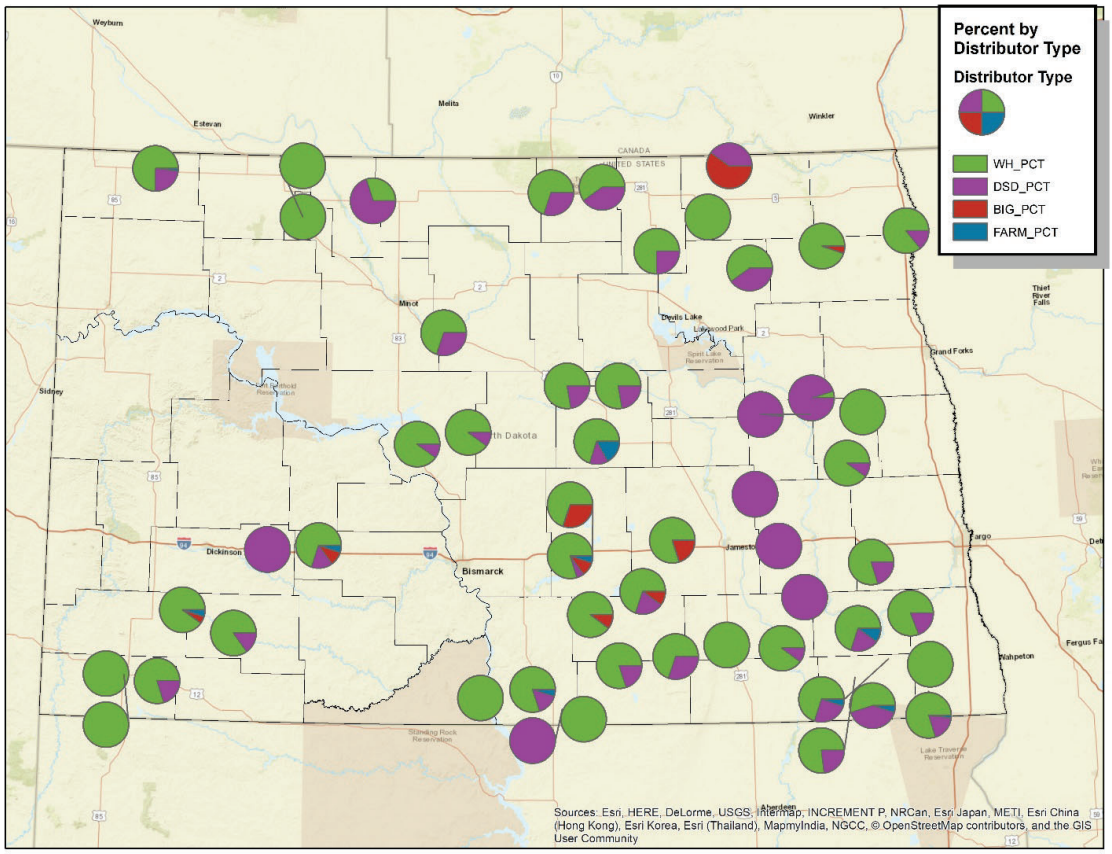


Figure 11. Percent of Goods Procured by Source



4. Routing Comparisons

The reported wholesale distributors shown in Figure 5 identify the service areas of the four largest wholeale distributors by store numbers. To estimate potential distribution cost savings due to consolidation or route optimization, the initial routes for each wholesale distributor were estimated to develop a baseline cost estimate. If the actual routes numbers and highway segments traveled were known, the true distribution cost could be used for the baseline estimate. At the time of the writing of this report, the actual routes traveled are not known, and therefore were estimated. Each of the modeled baseline and optimized routes reach each store once, representing a weekly service from wholesale distributors.

Routing Assumptions

A variety of assumptions was made to achieve route estimates for each of the four largest distributors. First, the routes estimated only include rural grocery stores. The survey instrument was not administered to grocery stores in urban areas, which undoubtedly comprise a portion of the routes that also serve rural grocery stores. The resulting routes connect only the distributor warehouses to rural grocery stores. Truck capacities were not known as well, but it is assumed that the volume purchased at rural stores in each route would not exceed the truck capacity, either by weight or by volume. The primary restriction on selected routes is based upon time. The routing analysis utilized a ten hour per day time limit representing the hours of service regulations for drivers serving the routes. The delivery time at each store was estimated to be 30 minutes. In reality, the time spent during deliveries would vary from store to store based upon loading facilities and volume delivered. Since this information was not available, the 30-minute delivery time was assumed for all stores. Finally, the routes estimated only include rural grocery stores located within the state of North Dakota. It is likely that many of the distributors also serve stores in Minnesota and South Dakota and that the routes used to serve stores in North Dakota would include stores outside of the state. For this reason, the baseline and estimated routes should only be used for the purpose of comparison and the costs estimated should not be used as potential cost savings under the current distribution system.

Baseline Routes

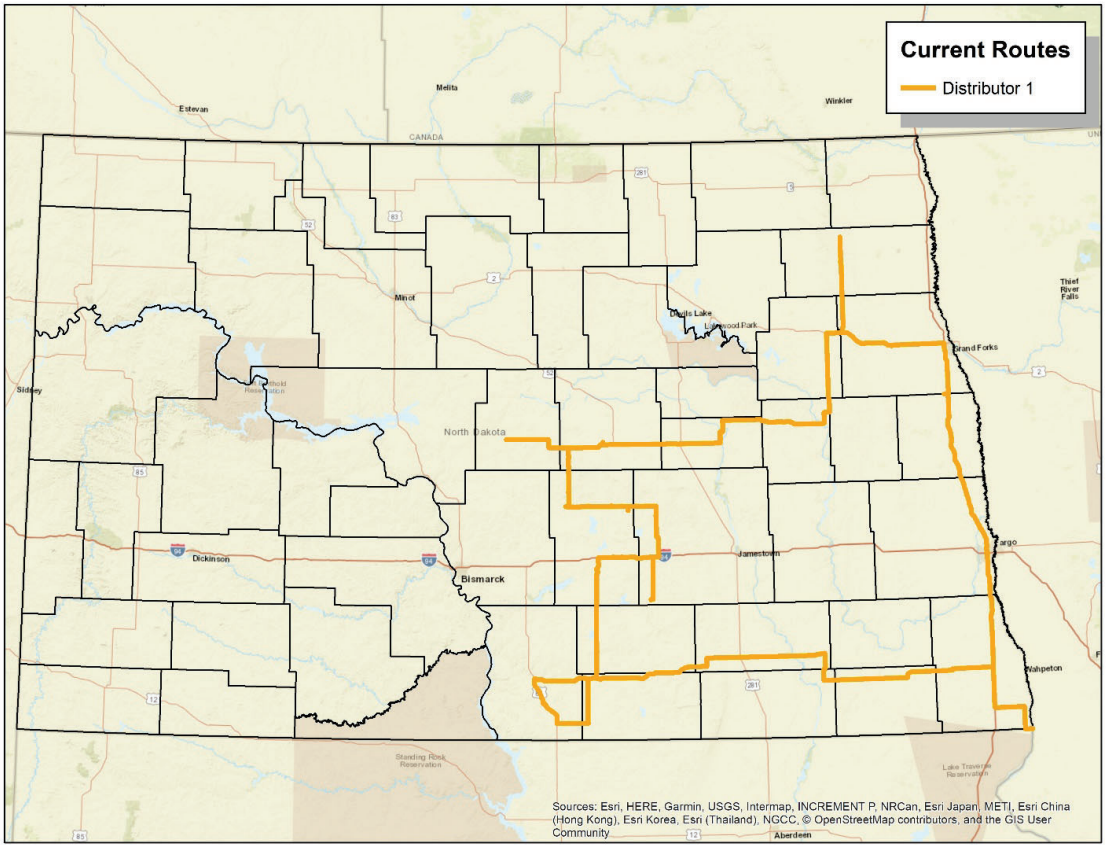
For each of the four major distributors' baseline routes were estimated using the Network Analyst add-in to ESRI ArcMap. For each of the distributors, six routes were modeled, though only the number of routes required serving a distributor's stores were used, constrained by the hours of service per route. In all cases, the software selected no more than four routes. Network Analyst uses the highway road network to calculate distance, time and cost for use in route selection. Given all possible routes, the software selects the route, which serves locations at the lowest cost given the time constraints. The cost parameters used in developing the delivery cost were the labor rate for drivers ($25/hour) and a $2/mile truck operating cost. These costs are consistent with average truck driver wages in North Dakota and estimates of trucking cost using the UGPTI Truck Cost Calculator. Individual baseline routes for each distributor are discussed below.

Distributor 1 Baseline Route

The distribution warehouse for Distributor 1 is located in Alexandria, MN. As discussed above, it is likely that routes originating in Minnesota would include rural stores in Minnesota as part of the routes that serve rural grocery stores in North Dakota. Because the survey did not include stores outside of North Dakota, the routes estimated are only to serve stores located within North Dakota.

The baseline routes for Distributor 1 are shown in Figure 2. The combined cost of the Distributor 1 routes to serve rural grocery stores in North Dakota was estimated to be $2,122 per week.

Figure 12. Baseline Routes for Distributor 1

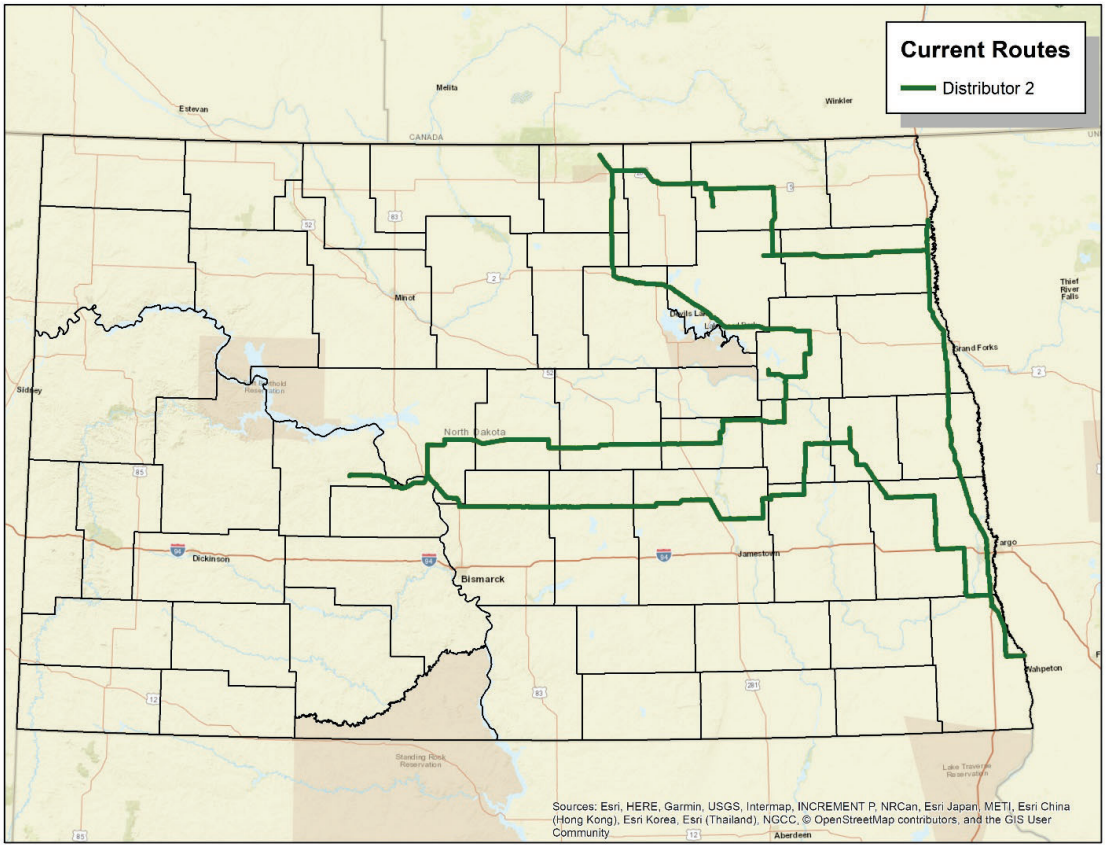


Distributor 2 Baseline Route

The distribution warehouse for Distributor 2 is located in Ada, MN. As discussed above, it is likely that routes originating in Minnesota would include rural stores in Minnesota as part of the routes that serve rural grocery stores in North Dakota. Because the survey did not include stores outside of North Dakota, the routes estimated are only to serve stores located within North Dakota.

The baseline routes for Distributor 2 are shown in Figure 3. The combined cost of the Distributor 2 routes to serve rural grocery stores in North Dakota was estimated to be $2,559.92 per week.

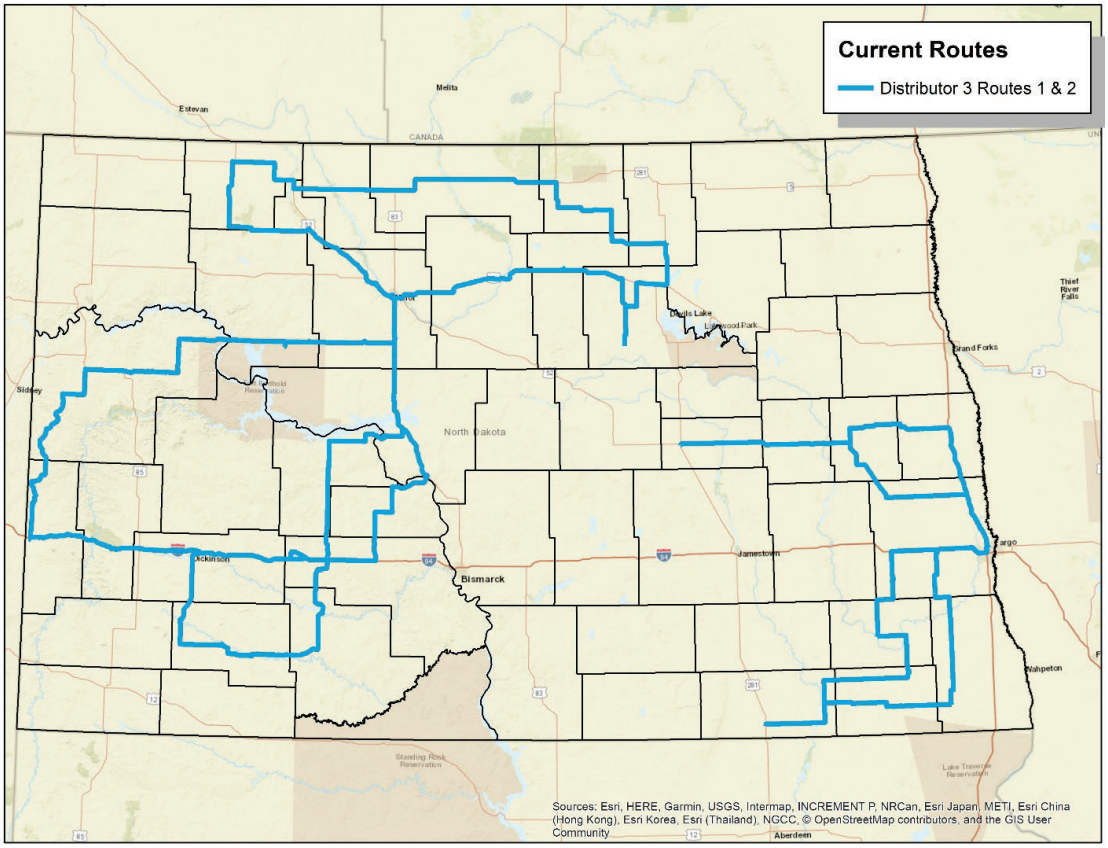
Figure 13. Baseline Routes for Distributor 2



Distributor 3 Baseline Route

The distribution warehouses for Distributor 3 are located in Fargo and Minot. The baseline routes for Distributor 3 are shown in Figure 4. The combined cost of the Distributor 3 routes to serve rural grocery stores in North Dakota was estimated to be $5,009.05 per week.

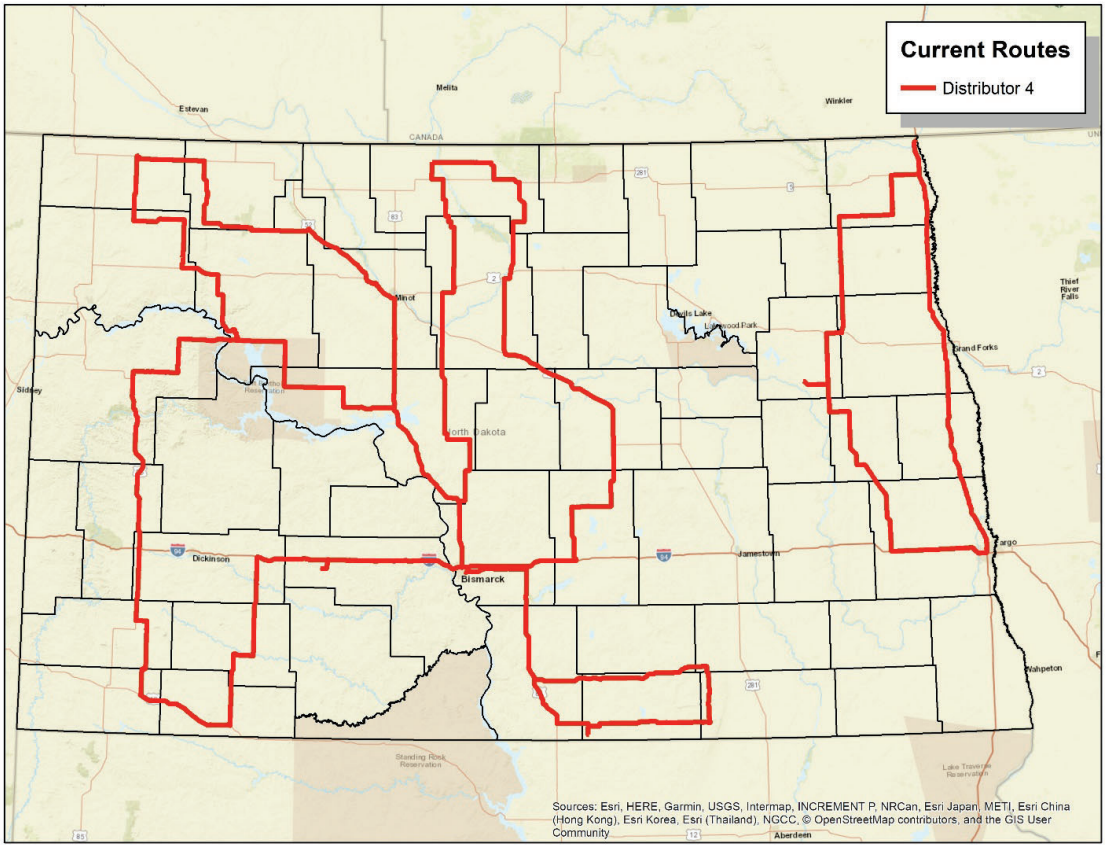
Figure 14. Baseline Routes for Distributor 3



Distributor 4 Baseline Route

The distribution warehouses for Distributor 3 are located in Fargo and Minot. The baseline routes for SuperValu are shown in Figure 5. The combined cost of the SuperValu routes to serve rural grocery stores in North Dakota was estimated to be $5,620.29 per week.

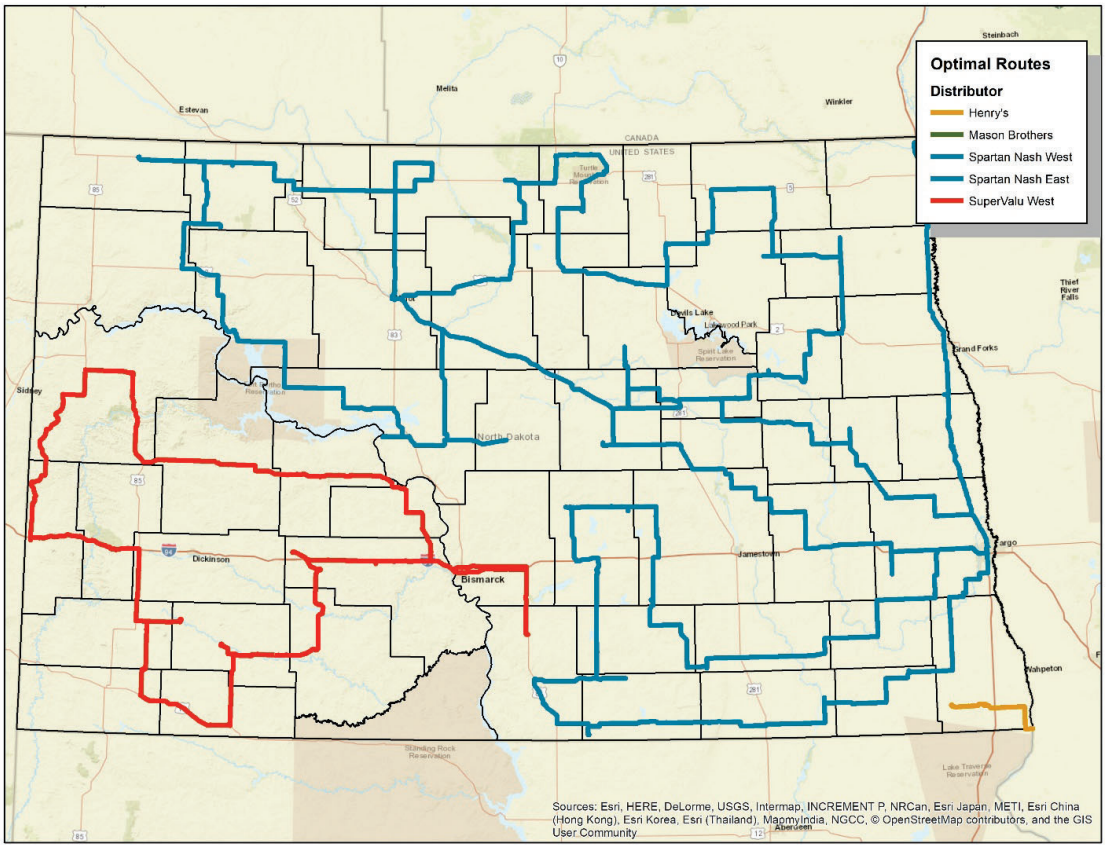
Figure 15. Baseline Routes for Distributor 4



Optimized Routes

The baseline routes discussed above are a representation of potential service routes for the four largest wholesale distributors in North Dakota. These routes assume that the current warehouse supplier remains constant for rural stores in North Dakota. The total cost for all of the combined routes for these four suppliers is $15,311.26. To examine whether there are potential efficiencies in route selection, an optimal supplier routing analysis was conducted. This analysis assumes that stores can switch suppliers and that wholesale distributors would not have any volume restrictions in place. The optimized routes are found in Figure 6. The selection of these routes are primarily based upon location of warehouses relative to the location of rural grocery stores. The total cost of the combined optimized routes is $7,937.00, which is roughly half of the combined baseline routes. This demonstrates that there are potential cost savings from route consolidation. Whether these cost savings can be realized is dependent on many decisions which are made by independent private organizations.

Figure 16. Optimized Routes without Predetermined Suppliers



5. Service Areas

Using ArcMap's Network Analyst utilities, service areas for each rural grocery store were mapped. Within the service area utility, the user can specify the search distances. For the purposes of this study, 10, 20 and 30-mile distances were specified. Figure 17 below shows the distances represented by three colors and incorporated cities in North Dakota using points.

Figure 17. Ten, Twenty and Thirty-Mile Service Boundaries from Rural Grocery Stores in North Dakota