FREIGHT COMMODITY FLOW IN KENTUCKY

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16. Abstract The primary objectives of this project were to further the understanding of freight flows throughout Kentucky and to make recommendations on the potential value of freight commodity flow data as an input for statewide transportation planning models. Freight flow data are difficult to accumulate and to convert to common units for use. However, the data available from Reebie Associates that were developed with the Federal Highway Administration have proved useful. The database itself was found to be consistent with other sources of aggregate freight data for Kentucky except for airports. The data assigned to the highway network was in general agreement with weigh station counts and previous research conducted by Morehead State University. However, modeled truck volumes were found to have poor correspondence with the 1996 KYTC classification counts particularly for non-freeway routes. These errors are attributed to the large zone size (3-digit zip code) used in the model as well as the representation of Tennessee as a single zone. Specific recommendations are made for KYTC's consideration for future freight transportation planning efforts.

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Table of Contents

List of Tables

List of Figures

1.0 Introduction and Background

The "Freight Movement and Intermodal Access in Kentucky" research project was undertaken by the Kentucky Transportation Center (KTC) and the Department of Civil Engineering at the University of Kentucky. This two-year undertaking was funded by the Kentucky Transportation Cabinet (KYTC). KYTC's Intermodal Advisory Panel (IAP) recommended the undertaking of the study. This report presents the findings of the statewide freight commodity flow analysis, while other reports summarize the findings related to truck access to individual intermodal and other sites throughout the state.

The broad objective of the freight commodity flow portion of this study is to contribute to the understanding of freight flows for all modes within Kentucky. The research team was to investigate the availability of data and the issues affecting the ability to document freight commodity flows. On October 22, 1997, the research team sought the guidance of the IAP on prioritizing the need and scale of a state-initiated freight commodity analysis. It was agreed at that time that the focus of the work would be statewide and multimodal. Further, commodity detail and intra-urban freight flow was deemed of secondary interest.

After decades of focus on passenger demand forecasting and flow modeling, many jurisdictions have turned attention to the freight commodity problem. Many parties have a use for information on freight commodity flows. These uses include multimodal planning, siting intermodal facilities, urban congestion management, economic development, weight and load enforcement, and provision of better freight transportation services.

In an ideal world, one would have the freight flows by exact commodity on every link of the transportation network, for every mode in the present and for the future. No state or jurisdiction has this type of complete freight flow information (or even close to it). Several issues complicate the freight flow documentation. These complications include the many measurement units for commodities (dollars, tons, vehicle units), the variety of vehicles (trucks, barges, partially filled vehicles, etc.) and the number of players or actors involved. Releasing data on freight flows becomes a potential breech of confidentiality or a competitive disadvantage. Most freight shipments are private shipments and as such they are proprietary. Over the years, many indirect factors have impacted the levels of freight flow: the economy, globalization, international trade agreements, just-in-time inventory practices, carrier-shipper alliances, centralized warehousing, material packaging, fuel prices and recycling (Cambridge Systematics Inc et al. 1997). Accounting for all these factors in a freight demand forecasting model is complex. For these reasons, both the technical advisory committee (TAC) for this project and the IAP concurred with the recommendation of the study team that this analysis would focus on documenting and / or modeling current freight commodity flows, and that future demand forecasting would remain a possible future undertaking.

The potential goals for understanding the current freight commodity flow patterns in Kentucky include understanding the following: international trade flows in Kentucky; carrier violations on minor highways; the potential for modal substitution; urban freight flows; hazardous material transport; and by-pass versus Kentucky destined / originating freight. The level of detail used for freight flow data collection affects the type of policy questions that can be answered. For example, a detailed survey of trucks along a single corridor in a region of the state could be used to estimate the amount of a particular commodity but would be of no use in broader modal substitution questions. The items listed above can not all be answered with a single data collection effort or source.

The level of data collected related directly to the question of whether a comprehensive or specialized model was to be developed. Although a specialized model might have seemed reasonable to answer a single question or issue, such as those related to hazardous material transport, it precludes being useful for overall statewide multimodal planning which was the focus recommended by the IAP. The KYTC Statewide Traffic Model already contains a module for truck traffic forecasting that was developed based on aggregate freight data. It seemed reasonable to suggest that efforts undertaken as part of this research project would build on that existing form and function. Unfortunately, this precludes the results being useful for internal urban commodity flows or targeting enforcement on particular minor highways.

The final and possibly most critical issue affecting what type of commodity flow research tasks were undertaken in the project was the relative effort or cost required to collect or buy data. Some data collection methods proposed in the initial phases of the research by either the TAC or the research team proved unfeasible upon investigation. While data collection is always a costly portion of any research, care must be exercised to ensure that if data is collected that data is sufficient and useful for the purpose of the study. Any special data collection effort undertaken here was considered to be too small scale for the statewide focus. Data collection would have been limited to the point where it lacked broad applicability or statistical validity; therefore, data collection was not be undertaken at all.

The study started with a review of the existing data. It was intended to point to the "gaps" that needed to be filled in order to have use of a comprehensive freight commodity dataset. This aggregated data would then have been used to answer the research questions posed. Some effort to collect data to fill these gaps was expected. However, as outlined below, the existing data was not easily amenable to aggregation due to many of the issues raised above. Aggregation of existing data or collection of a new comprehensive dataset was deemed unfeasible. Those existing datasets are described below and comprise a source of comparison for the model developed with purchased freight data.

The first existing datasets outlined here are available from the Bureau of Transportation Statistics (BTS) (U.S. Department of Transportation 1996). The Commodity Flow

Survey (CFS) was an extensive survey effort undertaken by the BTS in 1993 and another was undertaken in 1997 for which the results are not yet available. Unfortunately, in order to protect the shipper information and avoid disclosure of sensitive information, the BTS does not release information at a level below the NTAR zones. There are only 89 such zones within the entire U.S. representing one or more Bureau of Economic Analysis (BEA) zones. A summary report of the 1993 CFS is available for Kentucky (U.S. Department of Commerce 1996), which lists freight originating in Kentucky by 2-digit Standard Transportation Commodity Classification (STCC) commodity code. The survey data was collected in considerably more detail at the 5-digit commodity level. However, for statewide multimodal planning it is the large geographic zones which make this survey less desirable, not the detail of commodity type. The 1997 Commodity Flow Survey is not expected to be significantly different in the level of data publicly available. The state of Indiana used the 1977 CFS to produce a gravity-style freight flow model (Black 1997). The most difficult task in that case was extrapolating the large zone data down to county level. The model has been praised particularly for this comprehensive detail.

The Surface Transborder Commodity Data is available over the Internet from the BTS. It contains information on freight commodities at the 2-digit level between the entire state of Kentucky and either Mexico or Canada as well as the mode used. The data is produced on a monthly basis with an approximate three to five months of lag. While this data might be of use for economic development purposes, its use on understanding specific freight flows within Kentucky might be limited. It will not contain pass-by transborder traffic destined or originating in other states that may travel through Kentucky by highway.

The Rail Waybill Data is comprised of aggregate rail shipments by class I railroads. The information is presented with origins, destinations and interchanges making it useful from a geographic/zonal point of view. Due to the bulk nature of commodities shipped by rail, the unit measure (rail cars and tons) would be sufficient. It was also deemed possible to obtain background rail freight commodity flows directly from the railways for main Kentucky lines.

The United States Waterway Data is available for a small fee from the BTS. Where there are at least 3 operators or shippers, they can provide specific origin and destination information. Overall commodity flows at points along inland waterways can be directly obtained, although no specific origin and destination information could be attached. As with rail, the nature of the commodities shipped by water may enhance the practicality of using this data given the aggregate measures involved. However, in both cases, where shippers are few, data could not be released and further, no rail or water drayage information would be available to know where the commodity travels before or after it travels by water / rail. Requests to the BTS for waterborne data revealed many locations in Kentucky where the minimum (3) shipper policy precluded data release.

The Truck Inventory and Use Survey (TIUS) can provide detailed information about the nature of individual carriers, their main area of operations and the primary commodities hauled. However, the information does not contain origins, destinations or routes that would be needed in this case to apply the information to understanding the flow along specific highway sections within the state. It is also limited in that it is categorized by the state where trucks are registered, not necessarily where they operate.

It has been suggested that truck accident records could be used to extrapolate information regarding truck commodity flows. In this case, one would assume the sample of trucks involved in accidents (usually the party not at fault) is a random sample of the trucks traveling. Investigation of the number of truck accidents in Kentucky suggested this method could not provide sufficient information to warrant further consideration.

The aggregation of BTS publicly available data was deemed to be a large task, particularly accounting for different units of measure and filling in gaps in the information. Furthermore, the BTS data does not have origin, destination or route information associated with highway based shipments. For these reasons, the study team was referred to Reebie Associates, a firm based in Connecticut, for detailed freight commodity flow information. A representative of Reebie Associates traveled to the University of Kentucky to present information on their products and services. Reebie specializes in freight flow data. They have several sources of information: the Rail Waybill, the Waterborne Commerce Data, a National Manufacturers Association survey, and most importantly an information exchange with a large group of motor carriers. They collect the exchange information on a three-digit zip code level (there are 27 such zones in KY) and use a specialized model to fill in data gaps and combine data sources to a common unit of measure (tons per year) in an origin destination matrix format.

Reebie Associates sells data, forecasts, GIS interfaces and transportation policy analysis services. Their most disaggregate product, which was developed in cooperation with the FHWA, is a county-to-county origin-destination freight commodity flow database at the 4-digit commodity code level. Such detailed information is relatively expensive. Its accuracy for a state like Kentucky with 120 counties is also questionable. Reebie uses a model to disaggregate the data down to the more local county zones and some accuracy is lost particularly when the counties are very small. It is possible to purchase the data at any commodity classification level and at the three-digit zip code level. The data is not completely comprehensive as discussed later in this report. Coverage of some commodities, intra-city freight flows and some drayage, are missing. Several states which had purchased Reebie Associates' freight data were contacted for references and they seemed pleased with the product. Despite imperfections, the data in its comprehensive format represents a significant improvement over the previous almost complete lack of information of freight commodity flows in their respective states.

On October 22, 1997, the freight project research team attended the Intermodal Advisory Panel quarterly meeting in Louisville. The meeting was attended by approximately 30 transportation professionals who work with a wide range of intermodal transportation. After a brief introduction to the objectives of this research project and the issues affecting the freight commodity flow portion of the work, a group work session was held. The larger group was divided into two and a member of KTC team facilitated each group.

Two main questions were asked of the work groups. First, what types of problems do you face in your daily business that could be answered by better information on freight commodity flows? Second, what form should a state-based freight flow database take? Some very useful input was received.

The groups felt that the detail of commodity type was not as important as the need for detailed origins, destinations and routes. The need for route information was seen as particularly important for highway transportation where issues such as large numbers of trucks using inadequate roads are a concern. The data/model could be used in that case for infrastructure planning. Routes are also an issue for intermodal connections where capacity and operating conditions for either mode might affect the choice of an intermodal terminal.

The key policy issue raised by many individuals was the ability of the model developed or data generated to be useful for modal substitution evaluations. There was wide consensus that the study should consider all modes of freight transportation but that the lack of specific information on motor carriers and highway transport was most problematic.

In order to pursue a multimodal statewide freight commodity flow model as recommended by the IAP, the study team recommended that 3-digit zip code zone level, 3-digit STCC commodity freight flow data be purchased from Reebie Associates. This recommendation was then approved by KYTC and the TAC. A three-time purchase contract was signed between the Kentucky Transportation Center and Reebie Associates. The data purchase in the first phase of the contract is the basis for most of the analysis described in this report.

The first section of this report describes the format and extent of the Reebie data. The subsequent section describes descriptive summary statistics of the freight flows based on the Reebie dataset as well as a comparison to aggregate freight flow information collected from the other sources described above. Section 4.0 describes the development and results of a commodity flow assignment modeling effort and presents the results in terms of total flow by highway segment, external flow by highway segment and commodity flow by highway segment. The validation of these results against KYTC classification counts and other sources is also covered. Finally, the conclusion and recommendation section summarizes findings of this work, discusses other analyses possible with the current dataset, and suggests ways to change the type of future purchases made from Reebie to further benefit the state.

2.0 Reebie Associates Transearch Database Description

A complete description of the Reebie database referred to as Transearch can be found in their reference manual (Reebie Associates 1998). Figure 1 illustrates the data sources used by Reebie Associates. The first production of the database was undertaken in 1978. The advantage of using the Transearch database is that many sources of data have been aggregated and converted to common units. The missing information has been modeled. Most importantly, the exchange arrangement with groups of motor carriers gives Reebie access to truck transport information that is not available by origin and destination from federal sources.

2.1 Commodity Detail

The Transearch database contains commodity tons per year transported between zones within North America[1] by mode. Commodity interchanges are reported by seven modes: for-hire truckload, for-hire less-than-truckload, private truck, rail intermodal, rail carload, water, and air.

Figure 2 illustrates the composition or coverage of the Reebie data in terms of commodity type. Reebie reports their broadest coverage is within the manufacturing sector of the economy, but it also includes substantial portions of the agricultural, mining and mineral sectors (Reebie Associates 1998). The following commodities are not included in the database: pipeline shipments, empty trucks, mail and small package shipments (except by rail), truck shipments of non-manufactured goods (except coal and produce). In the Kentucky case, several characteristics of the database result in some lack of coverage including water, rail and air shipments that transfer in Kentucky but do not originate and/or terminate in Kentucky. These include transfers that occur at the United Parcel Service hub in Louisville. Drayage of freight to and from riverports is not included. Rail and air drayage is included. Reebie Associates can collect data on river drayage and add it to the database on a case-by-case basis; however, this service was declined due to the resources available for this project. Many shipments, particularly those by rail, are not specified by detailed commodity and are represented in the database as miscellaneous or mixed shipments.

Commodity types are recorded by Reebie using the 4-digit Standard Transportation Commodity Code (STCC). For this study, it was decided to proceed with 3-digit commodity codes. For example, the commodity codes 3220 (pressed or blown glassware) and 3221 (glass containers) would be reported as 3-digit STCC 322 (glassware). The commodity detail is not needed for transportation planning purposes. In fact, later in the analysis researchers aggregated the data to 2-digit commodity codes

[1] International shipments (exports and imports to locations other than Canada and Mexico) are reported in the Reebie Transearch database as originating or destined for their port of origin/destination in the United States.

(32 is clay, concrete, glass or stone) in order to allow a manageable number of graphics and tabulations.

2.2 Geographic Detail

Reebie Associates collects data on a 3-digit zip-code level (the mean area of a 3-digit zip code in Kentucky is 1493 square miles). This level of geographic detail is usually converted by Reebie to county level data. For Kentucky, this conversion would have involved disaggregating the data to smaller zones. For this exploratory freight commodity flow research, it was jointly decided by the research team, the TAC and KYTC to proceed with the 3-digit zip code zones in order to avoid the unknown error of disaggregation. Three-digit zip code format was also purchased for four major out-of-state areas that border Kentucky: Cincinnati, Ohio; Evansville, Indiana; Clarksville, Indiana; and Huntington, West Virginia. The adjacent states were each designated as a zone, while the remainder of the United States was divided into census Regions. Canada and Mexico comprised one external zone each. The zonal structure of the data generated for Kentucky by Reebie is shown in Figures 3 and 4. While most zip code zones are continuous some are not. A description of the zones is shown in Table 1. Note in Figure 4 that extracting West Virginia and Virginia from census zone 9 has left Maryland and Delaware as completely separate from the rest of zone 9 to the south. This is adjusted for in the modeling. Similarly in Kentucky, zones 403, 410 and 411 were disaggregated in the network model presented later in this report.

An excerpt from the Kentucky Transearch database for zip code geographic zones and 3-digit commodity zones is shown Table 2. The full database has approximately 52,000 lines. Shipments to and from Mexico and Canada do not have the same commodity detail as shipments within the United States; truck and rail modes are not subdivided.

3.0 Summary of Kentucky Freight Flows

This section discusses the freight flow estimates obtained from the following sources: 1) Reebie Associates Transearch database, 2) Rail Waybill Summary statistics from the Bureau of Transportation Statistics (BTS), 3) Waterborne Commerce Data obtained from the Kentucky Transportation Cabinet and the US Army Corp of Engineers, 4) Summary Data from the 1993 Commodity Flow Survey conducted for the Bureau of Transportation Statistics, and 5) airport freight data obtained by phone conversations with airport management.

Comparing freight data from different sources is complicated. Measurements are taken at different times, in different units and most methodologies systematically eliminate some data. The primary intent here is to document the overall type and magnitude of Kentucky freight flows. However, a secondary objective is to consider the validity of the Reebie Associates data which are used for the modeling effort described in the next section of this report.

3.1 Total Freight Tonnage

The volume of commodities originating in Kentucky based on the Reebie Transearch database is shown in Table 3. The conversion factors shown in Table 4 have been used to convert all commodities from tons per year to equivalent trucks per year. This allows for a normalization as commodities vary greatly in their volume to weight ratio. The equivalent trucks are of interest in a highway planning perspective. A 1993 conversion for tons of each commodity to dollars from the Bureau of Transportation Statistics is shown in Appendix A.

Table 3 includes the freight commodities originating in Kentucky destined for both in- and out-of-state destinations. Measured in both tons and trucks per year, coal is by far the largest type of freight originating in Kentucky. However, very little coal is shipped by truck. Recall Reebie data does not include river drayage, so some miles of truck travel of coal to riverports are not shown here. The second largest commodity shipped from Kentucky is code 51, described as warehouse distribution. All of this commodity is shipped by truck. Shipments of clay, glass, concrete or stone, chemicals, lumber / wood, and nonmetallic minerals are ranked high by tons and trucks per year. While many commodities are shipped almost exclusively by truck, the overall shipments by truck is only 34%.

Table 5 contains the summary of freight commodities destined for Kentucky zones. Again this table contains both freight originating in and outside of Kentucky. The top five products shipped by tons and by truck equivalents are the same as the commodities originating in Kentucky (Tables 3). This could suggest a significant portion of freight originating in the state is also destined for a zone within the state. Reebie data indicates that 34% (by weight) of shipments from Kentucky are destined for Kentucky, while the 1993 Commodity Flow Survey by the BTS found 49% internal-internal freight flow. Clay, concrete, glass, and stone, which comprise a significant portion of the freight terminating in the state, is shipped 96% by truck. This may also reflect short hauls; 74% of this freight is internal-internal. Overall, more freight that is destined for Kentucky is shipped by truck (57%) than the freight originating in Kentucky. While this may indicate good access in Kentucky as origin to water and rail modes, it may also reflect a high level of export of bulk raw materials compared to manufactured and higher value goods.

Table 6 illustrates the portion of freight shipped from Kentucky to each of the external zones. Zone codes on maps are found in Figure 3 (3-digit internal and external zones) and Figure 4 (1 and 2-digit external zones). The largest amount of freight is destined for zone 4 (Alabama and Mississippi). This is primarily coal, shipped by rail and water. Shipments to adjacent states are very significant (recall some adjacent urban areas are included in the 3-digit zone codes). However, zone 11 (west south central) is also high. Shipments to zone 256 in West Virginia are all truck-based, likely due to the short distance. However, shipments to zones 3, 5, 6, 7, 8 and 9 (New England, Great Lakes and the southeast) are also mostly by truck. These shipments are composed of commodities 28, 35, 33 and 20. There may be some potential for conversion to rail transport for these shipments. Overall, very little freight is shipped out of Kentucky by truck (17%).

Table 7 illustrates the commodities shipped from external origin zones into Kentucky. By far, the largest quantity of freight is being shipped into Kentucky from Ohio (zones 39, 450, 451, and 452). All of the freight reported from zone 452 (downtown Cincinnati) to Kentucky is shipped by rail. While zero percent shipped by truck seems unbelievable – recall there are some shipments missed in the database and that these zeros correspond to this and other small zones adjacent to Kentucky where a broad range of commodity shipments and industries may not exist. As with exports from Kentucky to the north and southeast a very small portion of imports from these areas are traveling by truck. This represents the potential for significant modal conversion. Table 7 also indicates a large amount of freight shipped to Kentucky from Mississippi, Alabama and Indiana (zones 4 and 18). For Mississippi and Alabama very little is shipped by truck. Overall this table again illustrates that more freight is shipped into Kentucky by truck (43%) than out (17%).

Tables 8 and 9 contain the internal freight shipments classified by destination and origin zones for Kentucky. On average, 65% of these shipments are made by truck. In general, the largest internal shipments are originating from, and destined for, the larger urban areas or zones on the rivers. While some of these amounts seem rather small (zones 417 and 418 in Table 8 for example), these totals have been double checked. It is assumed that significant freight must be shipped form out of state or that some freight is missing form the data.

The Reebie Transearch data can be compared to several other datasets available for Kentucky. Most of these datasets lack detail in order to protect individuals' proprietary shipments. Table 10 compares the 1996 Reebie Transearch data for rail shipments to the 1994 Rail Waybill data available from the BTS. For the 10 commodity shipments provided by the BTS, the two data sources agree relatively well except for primary metal shipments originating in Kentucky. In this case, Reebie estimates significantly higher than the Rail Waybill data reports.

The commodities shipped into and out of Kentucky by water are recorded by the US Army Corps of Engineers in their Waterborne Commerce Dataset. This information is shown in Table 11. Note that because the waterborne data uses a different aggregation of commodity categories, exact comparisons are not possible for all individual commodities. However, for the commodity categories that match, there is reasonable agreement between the two datasets. This is expected as Reebie uses this dataset as one of its inputs.

Table 12 contains information from the state summaries of the BTS's 1993 Commodity Flow Survey (CFS). For the total and top four commodities shipped from Kentucky based on the CFS, Reebie is lower in all cases. This may be due to the different years but also illustrates the incomplete coverage of the Reebie data. Reebie Associates estimate they capture only 60% of truck shipments. The percentage of freight shipped internally and to the two highest individual states is similarly lower as shown in the second portion of Table 12. Some of the shipments from adjacent states indicated in the bottom of Table 12 are higher than the CFS while others are lower. It is difficult to compare different sources of freight data as none can be considered complete. There is general, but not good agreement between Reebie's Transearch database and the CFS information.

Airport aggregate freight tonnage was obtained for the airports in Kentucky by calling management offices and asking for the information. This information is shown in Table 13. The Reebie dataset indicates only a total of 57,251 tons per year of air freight originating and destined for Kentucky. This is less than ten percent of one airport's uni-directional tonnage as reported in Table 13. One reason for this discrepancy is that air freight just passing through airports, but not originating or destined for that city does not show up in an origin-destination flow database such as Transearch. Based on this inconsistency, the Reebie dataset is not recommended for use for Kentucky airports, particularly given the nature of both Louisville and Northern Kentucky as air freight hubs.

3.2 Geographic Origins and Destinations of Freight

The Reebie Transearch data was provided using origin and destination zones in Kentucky that corresponded to 3-digit zip code zones. This information can be used to consider where freight originates and terminates in the state. Figure 5 illustrates the commodity that represents the maximum export commodity by weight and zone. This figure indicates that for most of the state, raw materials are the primary originating shipment by weight. This could be due to the fact that manufactured or value-added products are lighter than raw materials; however, the series of Figures 6 through 11 indicates that most Kentucky zones ship very few manufactured products.

The pattern for freight destinations shown in Figure 12 follows closely with populations. Figure 13 indicates the largest freight shipment destined for each zone. More goods are imported to populated areas. Presumably, the coal shipped to power plants is a factor that increases these totals for some zones. Figures 14 through 19 indicate the tons of each commodity grouping to each zone. Both raw materials and manufactured goods are generally traveling to manufacturing centers which are located in the population centers.

3.3 Modes Used for Freight

The mode used to ship freight is of importance to highway planning, urban traffic congestion, air quality and also economics / cost. The availability of modes to shippers is a function of natural factors such as the location of rivers, but also state-influenced factors such as intermodal terminal locations and facilities. Figure 20 illustrates the overall mode split of freight originating in Kentucky. Less than half of this freight moves by truck while most moves by rail and water. Figure 21 illustrates that when the destination is outside Kentucky, significantly more of the freight travels by water and rail. This is expected due to the bulk nature of Kentucky's exports. Figure 22 illustrates that more than half of the freight destined for Kentucky arrives by truck. Even for origins outside Kentucky, 43 % of the freight destined for Kentucky arrives by truck. (Figure 23). Given Kentucky's small area, it is surprising that only 69% of the internal-internal freight commodities move by truck (Figure 24). The high mode share of rail and water for this freight is attributed to the extensive rail and water network, but again also to the nature of the bulk commodities shipped in Kentucky. Figures 25 and 26 demonstrate that the option to use a non-highway mode is a function of both placement and commodity type. Water shipments originate adjacent to the rivers, while rail movements originate at the source of bulk commodities such as coal.

For this analysis, substitutable freight was defined as a commodity that might have potential to move by water or rail that currently moves by truck. Commodities were considered possible rail or water shipments if significant tonnage was currently transported from or to Kentucky by rail or water (codes 10, 11, 13, 14, 26, 28, 29, 32, 33, 37 and 42). A substitutable interchange was considered a trip to or from Kentucky and a state that does not touch Kentucky's borders. For example, an interchange of forest products between a Kentucky zone and West Virginia would not be considered substitutable. However, an interchange between Kentucky and California of metal products would be. Trips to non-adjacent states were deemed long enough to make the transfer to rail or water worthwhile. The total truck equivalents of substitutable freight currently traveling by truck originating and destined for Kentucky are shown in Figures 27 and 28 respectively. The tonnage pattern observed in both figures supports the possible need for additional intermodal facilitates in Louisville, western Kentucky and northeastern Kentucky. A definitive determination of substitution for a particular freight shipment requires consideration of whether the intermodal, rail or water facility exists at the non-Kentucky end of the trip. This cannot be conducted given the level of detail of information for areas outside Kentucky (in this dataset). However, it points to the need for interstate cooperation for intermodal transportation. Development of a new riverport or rail intermodal terminal in one of these areas of Kentucky could not attract new freight unless the appropriate facility exists at the other end of the trip.

4.0 Commodity Flow by Highway Section

One of the main motivations for undertaking this research was to determine the composition of truck traffic along highway corridors. In other words, at any given point of the highway system, where have trucks come from, where are they going, and what is inside them? These questions are harder to answer for highways than they are for commodity flow on the rail or water systems. Railways have exclusive control of their network and can document flows. The US Army Corps of Engineers has good commodity flow data past points including specific flow counts at locks. Neither of these datasets is completely available for public planning purposes.

Highway freight flow is considerably more complex. The number of players, their relative freedom of maneuvering, their proprietary shipments and competition with each other makes documentation difficult. These factors made the database offered by Reebie Associates of greater interest for this task due to their data exchange with a large group of motor carriers. Reebie estimates they capture approximately 60% of truck trips. Many of the missing trips are local and include trips such as local distribution and waste movements.

Although Reebie Associates develops highway assignment models with their data to estimate flows by highway segment, in this case resources dictated that a model be developed in-house at the University of Kentucky. The internal-external, internal-internal and external-internal trip interchanges by commodity described in section 3.0 were again used and assigned to a state highway network. External-external traffic on Kentucky highway segments was obtained from Reebie Associates as directional commodity tons per year by highway segment.

4.1 Model Development

The internal network used for the assignment model is shown in Figure 29. The extent of this network was dictated partially by the Reebie background external-external commodity flow data which were provided for the National Highway Planning network. An effort was also made to include known "shortcut" routes around interstates and weigh stations in particular. This resulted in US 31E, US 31W, and US 27 being included. The large zone size created problems in that many of these less minor roads did not have flow assigned to them. Unfortunately, the section of US 60 that parallels I-64 so closely between Frankfort and Louisville could not be included at all given the single path nature of the assignment intended. Flows output from the model along this and other corridors should be considered as corridor flows. The external network followed out-of-state highways when minor roads crossed Kentucky's border; however, the external network was mainly focused on interstate paths to external zones.

The zones provided by Reebie were used with four exceptions. Zone 403 surrounding Lexington (see Figure 3) was divided into 3 parts and flows were equally split. This was undertaken due to the strange shape of the zone, the large physical size and the very different road access throughout the zone. Zone 410 which originally ran from North Kentucky to Maysville was divided into two zones one centered in each area. Zone 411 was divided into 2 zones one of which was Ashland and area. The census region 9 (see Figure 4) was divided into two zones and commodity flows to and from the two centroids were split based on relative population of the two areas. Zone centroids were placed primarily at the population center of zones. Some exceptions to this logic were made for coal areas where geographic centroids were used.

The impedance along the network for assignment purposes was taken to the travel time at an assumed free-flow speed. All interstates were assigned a speed of 70 mph. All other external highways were assigned speeds of 50 mph to reflect the interrupted flow conditions and possible slowed time through towns or built up areas. Internal limited access highways such as the parkways were given a speed of 60 mph. The four-lane sections of KY 4, KY 9, KY 80, US 23, US 31W and US 25E were assigned a speed of 55 mph. All other internal highways were two-lane highways and were therefore assigned a speed of 50 mph. In larger urban areas, the interstate speed was reduced to 65 mph. Three slower urban alternative routes were assigned speeds of 45 mph: the signalized portion of New Circle Road in Lexington, a signalized route around the airport in Northern Kentucky, and urban signalized highways in Louisville. The assignment model was built in ArcInfo GIS and therefore external links could not be assigned unrealistically high impedances as is often the case. External links followed external highways and interstate corridors and had realistic speeds.

Several model runs were attempted before assigned traffic volumes and routes were considered appropriate. Routes were hand-checked while overall truck flow was compared within the network. Several impedance changes were needed to address an over-assignment of truck traffic to the Western Kentucky Parkway. The final impedance values are those reported in the previous paragraph.

All commodity interchanges and the Reebie background external-external flows were converted to trucks per year using the conversion factors in Table 4. Once the trucks had been assigned to the network, the background and assigned trucks were summed to obtain the total trucks per year shown in Figure 30. Although background traffic was only provided for approximately one link per county, these flows were transferred to adjacent links for presentation purposes on the full 771 links.

4.2 Comparison to Existing Truck Count Data

Three existing sources of truck count information were available for comparison with the modeled truck volumes: KYTC classification counts from 1996, hazardous material studies conducted in 1994 through 1996 by Morehead State University, and KYTC weight station counts.

The tabulations of modeled truck volumes and classification counts are shown in Table 14. Yearly truck volumes were converted to daily truck volumes by dividing by 312 (6 days times 52 weeks). All 1996 KYTC classification counts taken on portions of the study network where the model assigned truck traffic are included. On average, the modeled truck volumes are 311 trucks per day lower than the classification counts. However, the average absolute error is 1635 trucks per day. There large differences between the model output and the classification counts. Even on the interstate the average absolute percent error in the model results versus the classification counts is 48%. The magnitude of the error is attributed to the zone size which was too large for the highway network of interest. In the future county level zones are recommended. The low internal flow rates on southern I-75 is attributed to the representation of Tennessee as one zone (the centroid is placed at approximately Nashville). In the future Tennessee should be divided into three parts by Reebie.

The large differences between the modeled data and the classification counts is strange given the relatively good match between the model results and the other two sources of total truck count data. The hazardous material counts taken between 1994 and 1996 at several places along interstate corridors are shown with the modeled truck flow for the same approximate locations in Table 15. The study collected both total truck flows and hazardous material truck flows and both are shown in Table 15. Counts in the corridor studies were undertaken 24 hours per day for many days depending on the location. The study found hazardous material trucks by reading placards while in the model potential hazardous materials were considered commodity codes 28 and 29. There was on average only 21% difference between the model output and the Morehead total truck counts. The model overestimated the Hazmat truck volumes by an order of magnitude. However, this difference is assumed to be due to the assumption that all of the commodity code 28 and 29 are hazardous materials and they may not be.

The total truck traffic that passes the state's weigh stations for 1996 was obtained from KYTC and is shown in Table 16. There is also good agreement between these counts and the model output (average 5% too low). Together with the Hazmat total truck result, this suggests that the model does a good job of predicting truck traffic on the major corridors in the state but with the current large zone size the model cannot predict the lesser route truck flows with good accuracy.

4.3 Total Truck Flows

Due to the limitations described in the previous section, the total truck flows presented in this section should be considered for corridor level information only. Figures 31 and 32 can be compared to Figure 30 to consider the relative magnitude of external versus internal truck traffic along highway corridors. Note in this case an internal flow is considered to be composed of trucks with either a Kentucky origin or destination or both. Figure 33 illustrates the range of the percentage of total trucks which are external-related. On interstate highways, this percentage is relatively high. The high percentage of external truck traffic in western Kentucky is expected due the narrowness of the state at that point. The sections of highway with external trucks greater than or equal to 75% of the total truck traffic are shown in Figure 34. This figure is included to further demonstrate that with current internal zone structure the internal traffic on non-major routes cannot be modeled accurately. These segments with the appearance of very high external traffic percentage are actually a reflection of the inaccuracy of the internal traffic assignment on the non-major routes.

Figures 35 through 38 illustrate that the highway sections used for internal versus external freight is different for raw materials and coal. Raw materials are defined as commodity codes 1-14, 24, 32, 33 and 40. Coal is included in this subset but is also presented individually. External raw materials travel primarily on the I-71 and I-65 corridor in a north-south direction, while external coal trucks are using the Daniel Boone Parkway and I-64 corridor to travel east-west. Internal raw materials travel throughout the state. Internal coal travels more in western Kentucky where external coal traffic does not appear.

Manufactured goods (codes 19-23, 25-31, 34-39, 41-46) travel through the state on all interstate corridors but primarily north-south on I-71 / I-64 and I-75 (Figure 39). Recall that the relatively lower volume of trucks on I-75 may be due to the configuration of Tennessee as a single zone. Internal manufactured truck travel (Figure 40) is concentrated on I-71 and also makes use of the parkways to a larger degree than the external traffic.

The external-related probable hazardous materials (codes 28 and 29) are concentrated on the interstate corridors and also the parkways into Western Kentucky (Figure 41). The internal hazardous material truck flows are found on a number of two lane highways, particularly those in the Bluegrass and south central Kentucky (Figure 42).

The final commodity category is aggregated by Reebie and represents the warehouse and distribution truck flows. As might be expected, the external traffic is primarily on the interstates while internal traffic is heaviest in the triangle made up of Louisville, Lexington and Northern Kentucky (Figure 43 and 44).

External agricultural truck traffic is concentrated in western Kentucky as might be expected (Figure 45). However, internal agriculture traffic is found along the interstate corridors leading to larger population areas. This may be indicative of deliveries to a state with a relatively small agricultural base. It also indicates the central and eastern portions of the state are more likely to farm produce that are transported by truck where western Kentucky may be using water transportation. Recall river drayage is not accounted for in the dataset.

The series of maps in Figures 47 through 52 indicate the percentage of each commodity class along highway segments. Note the commodity categories overlap as indicated above, so percentages will not sum to 100. The percentages are taken in trucks per year not tons. Figures 47 and 48 illustrate that a large portion of the truck traffic in Kentucky, but particularly eastern Kentucky, is carrying raw materials, especially coal. Manufactured goods (Figure 49) are concentrated on the I-71 / I-65 corridor and the western routes. In the latter case, these goods are likely external-external traffic. The warehouse distribution commodity code represents a significant portion of the truck flow on some Kentucky highways (Figure 50). It is unlikely there is much modal substitution potential within this category. Agricultural products shown in Figure 51 represent very little of the truck commodities on Kentucky's highways. Potentially hazardous materials comprise up to a quarter of the truck flows on some segments including urban areas within Kentucky (Figure 52).

5.0 Conclusions and Recommendations

The primary objectives of this project were to further the understanding of freight flows throughout Kentucky and to make recommendations on the potential value of freight commodity flow data as an input for statewide transportation planning models. Freight flow data are difficult to accumulate and to convert to common units for use. However, the data available from Reebie Associates that were developed with the Federal Highway Administration have proved useful. The database itself was found to be consistent with other sources of aggregate freight data for Kentucky except for airports. The data assigned to the highway network was in general agreement with weigh station counts and previous research conducted by Morehead State University. However, modeled truck volumes were found to have poor correspondence with the 1996 KYTC classification counts particularly for non-freeway routes. These errors are attributed to the large zone size (3-digit zip code) used in the model as well as the representation of Tennessee as a single zone.

The Reebie data contained useful mode information. A large percentage of Kentucky's exports and less of its imports travel by water and rail. Specific zones in the central and northeastern portion of the state are the termini for significant truck shipments of commodities that could be transferred to rail or water. A future application that considers the commodity and distance of shipments by different modes might provide further insight on the potential quantity of freight that could be transferred from trucks to rail or water. Given the importance of water transportation to the state, a future data acquisition might include a specialized data collection effort to obtain river drayage. The benefits of this information would have to be weighed against the cost. The Reebie data were not suitable for air transportation planning in Kentucky.

The analysis of commodities by zone provided an indication of which commodities are imported and exported from different parts of the state. Raw materials comprise a significant portion of the state's shipments throughout the state, especially out-going. Many origin / destination patterns of flow correlate to population, suggesting a potential future modeling approach. A future analysis with economic development objectives could convert the commodities to dollar values and consider relative ratios of raw materials to manufactured goods. The potential also exists to model the quantity of commodity generated by zone based on employment by sector data currently held by the KYTC.

Planning models based on these data are feasible. The assignment model developed in this project, despite inconsistencies and an under-representation versus classification counts, provided useful general information. Different commodities make up varying portions of the truck traffic on different routes throughout the state. Raw materials comprise the largest portion of truck flow in Kentucky. External-external traffic comprises a significant portion of traffic on several interstate corridors but commodity composition varies by corridor. There may be significant Hazmat flows on non-interstate highways.

Currently, KTC has a contract with Reebie Associates for two subsequent data purchases. If the KYTC authorizes continuing this effort and carrying forward with those purchases, Reebie has indicated the flexibility to change what is purchased. Therefore, the following specific recommendations are made for KYTC's consideration for future freight transportation planning efforts.

- Overall, the disaggregate freight commodity flow data obtained from Reebie Associates would be a very useful resource for transportation planning in Kentucky. This research has found that a freight commodity dataset could be used to complement the KYTC Statewide Traffic Model.

- The 3-digit zip code origin and destination zones within Kentucky were not appropriate for assignment model development for the highway network of interest. Therefore, any future data purchases should be made based on the county zone level. It may be possible to aggregate some counties into groups of two or three if this would lower the purchase cost of the data.

- Tennessee should be represented as at least 3 zones because of its unique shape along Kentucky's entire southern border. Representation as a single zone creates an inability to properly assign truck flows to the three Interstates that cross the border with Tennessee.

- Census region 9 (see Figure 4) should be divided into two or three zones representing the states around Washington D.C. and up to 2 areas of the southeastern United States.

- This first commodity database did not contain river drayage. Inclusion of these data would increase the purchase price. However, given the importance of water transportation to the state and the potential to build or upgrade public riverports, such a purchase might be warranted.

- In this study, results of the commodity analysis were presented in aggregate commodity categories (2-digit STCC code for analysis and a total of 6 categories for mapping and tabulation). Therefore, the 3-digit commodity detail is not necessary and potential future work should proceed with 2-digit datasets from Reebie or a similar source.

- Finally, the research has demonstrated that freight commodity flow is feasible. While documenting current flow patterns is beneficial it is the modeling of future freight flow projections that will be most useful to the KYTC Division of Planning. Therefore, one of the future two purchases of data (if made) could be a re-structured base year dataset, however, the third purchase could be a 10 or 20 year forecast to match the base data. This information would be useful for several existing state efforts: planning highway corridor improvements; the KYTC Statewide Traffic Model; the analysis of traffic growth rate factors; and siting new commercial vehicle monitoring stations.

6.0 References

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Table 1: Zone Codes

Code	Zone
1	Canada
2	Mexico
3	East North Central
4	East South Central
5	Middle Atlantic
6	Mountain
7	New England
8	Pacific
9	South Atlantic
10	West North Central
11	West South Central
17	Illinois
18	Indiana
21	Kentucky
29	Missouri
39	Ohio
47	Tennessee
51	Virginia
54	West Virginia
255-257	West Virginia Zones
400-427	Internal Kentucky
450-452	Ohio Zones
471-477	Indiana Zones

Table 2: Excerpt from Reebie Transearch Database for Kentucky

Origin Zone	Destination Zone	Commodity	Carload Rail	Intermodal Rail	Truck	Less than Truck	Private Truck	Air	Water
400	3	112	0	0	0	0	0	0	13242
400	3	201	0	0	2146	2	0	0	0
400	3	202	0	0	1427	0	57	0	0
400	3	203	0	0	161	2	42	0	0
400	3	204	0	0	6096	156	3598	0	0
400	3	205	0	0	90	0	157	0	0
400	3	208	0	0	5867	356	451	0	0
400	3	209	0	0	595	0	90	0	0
400	3	213	0	0	11	0	0	0	0
400	3	231	0	0	0	8	0	0	0
400	3	241	0	0	1151	0	111	0	0
400	3	242	0	0	195	0	93	0	0
400	3	243	0	0	392	0	0	0	0
400	3	244	0	0	0	1	0	0	0
400	3	251	0	0	80	0	0	0	0
400	3	262	0	0	20	0	6	0	0

*Volume is in tons per year

Table 3: Commodity Totals Originating In Kentucky per Year

STCC2	Commodity	Commodity Totals (tons)	Commodity Totals (truck equivalents)	Commodity Totals Shipped By Truck (tons)	Percent Shipped By Truck
1	FARM PRODUCTS	3,371,732	140,491	14,106	0
8	FOREST PRODUCTS	110	9	110	100
9	FRESH FISH OR MARINE PRODUCTS	84,164	14,028	4	0
10	METALLIC ORES	526,297	21,930	935	0
11	COAL	153,037,590	6,376,577	10,533,772	7
13	CRUDE PETROL. OR NATURAL GAS	3,800	271	0	0
14	NONMETALLIC MINERALS	21,534,494	1,133,396	61,447	0
19	ORDNANCE OR ACCESSORIES	3,637	151	7	0
20	FOOD OR KINDRED PRODUCTS	7,484,955	415,851	6,453,373	86
21	TOBACCO PRODUCTS	149,895	24,991	147,386	98
22	TEXTILE MILL PRODUCTS	302,081	60,406	177,278	59
23	APPAREL OR RELATED PRODUCTS	123,135	41,048	122,054	99
24	LUMBER OR WOOD PRODUCTS	7,261,320	484,091	6,892,141	95
25	FURNITURE OR FIXTURES	108,431	36,145	107,280	99
26	PULP, PAPER OR ALLIED PRODUCTS	2,332,951	64,800	1,579,553	68
27	PRINTED MATTER	644,328	71,566	641,059	99
28	CHEMICALS OR ALLIED PRODUCTS	9,099,066	413,605	6,312,151	69
29	PETROLEUM OR COAL PRODUCTS	7,657,099	403,005	4,893,598	64
30	RUBBER OR MISC. PLASTICS	835,874	209,051	815,901	98
31	LEATHER OR LEATHER PRODUCTS	12,131	4,040	11,228	93
32	CLAY, CONCRETE, GLASS OR STONE	20,260,898	880,910	18,868,159	93
33	PRIMARY METAL PRODUCTS	7,117,611	374,597	2,008,557	28
34	FABRICATED METAL PRODUCTS	1,961,740	81,741	1,885,026	96
35	MACHINERY	1,205,950	133,982	1,193,952	99
36	ELECTRICAL EQUIPMENT	733,521	91,709	531,047	72
37	TRANSPORTATION EQUIPMENT	4,225,519	352,145	2,596,327	61
38	INSTRUM., PHOTO EQ., OPTICAL EQ.	13,256	2,646	12,886	97
39	MISC. MANUFACTURING PRODUCTS	103,513	51,911	100,868	97
40	WASTE OR SCRAP MATERIALS	2,810,425	175,657	11,587	0
41	MISC. FREIGHT SHIPMENTS	47,813	2,078	5	0
42	SHIPPING CONTAINERS	28,070	7,019	0	0
43	MAIL OR CONTRACT TRAFFIC	9,050	3,017	0	0
44	FREIGHT FORWARDER TRAFFIC	810	203	0	0
46	MISC. MIXED SHIPMENTS	513,242	73,320	0	0
51	WAREHOUSE DISTRIBUTION	28,356,351	3,544,594	28,356,351	100
52	RAILROAD DRAYAGE	1,379,649	81,159	1,379,649	100
53	AIRPORT TERMINAL DRAYAGE	64,211	12,841	64,211	100
	Totals	283,404,719	15,784,981	95,772,008	34

Table 4: Truck Load Conversions per Year

STCC2	COMMODITY	TONS/TL
1	FARM PRODUCTS	24.0
8	FOREST PRODUCTS	13.0
9	FRESH FISH OR MARINE PRODUCTS	6.0
10	METALLIC ORES	24.0
11	COAL	24.0
13	CRUDE PETROL. OR NATURAL GAS	14.0
14	NONMETALLIC MINERALS	19.0
19	ORDNANCE OR ACCESSORIES	24.0
20	FOOD OR KINDRED PRODUCTS	18.0
21	TOBACCO PRODUCTS	6.0
22	TEXTILE MILL PRODUCTS	5.0
23	APPAREL OR RELATED PRODUCTS	3.0
24	LUMBER OR WOOD PRODUCTS	15.0
25	FURNITURE OR FIXTURES	3.0
26	PULP, PAPER OR ALLIED PRODUCTS	36.4
27	PRINTED MATTER	9.0
28	CHEMICALS OR ALLIED PRODUCTS	22.0
29	PETROLEUM OR COAL PRODUCTS	19.0
30	RUBBER OR MISC. PLASTICS	4.0
31	LEATHER OR LEATHER PRODUCTS	3.0
32	CLAY, CONCRETE, GLASS OR STONE	23.0
33	PRIMARY METAL PRODUCTS	19.0
34	FABRICATED METAL PRODUCTS	24.0
35	MACHINERY	9.0
36	ELECTRICAL EQUIPMENT	8.0
37	TRANSPORTATION EQUIPMENT	12.0
38	INSTRUM., PHOTO EQ., OPTICAL EQ.	5.0
39	MISC. MANUFACTURING PRODUCTS	2.0
40	WASTE OR SCRAP MATERIALS	16.0
41	MISC. FREIGHT SHIPMENTS	23.0
42	SHIPPING CONTAINERS	4.0
43	MAIL OR CONTRACT TRAFFIC	3.0
44	FREIGHT FORWARDER TRAFFIC	4.0
45	SHIPPER ASSOCIATION TRAFFIC	3.0
46	MISC. MIXED SHIPMENTS	7.0
47	SMALL PACKAGED FREIGHT SHIPMENTS	4.0
51	DISTRIBUTION OR WAREHOUSE SHIPMENTS	7.5
52	RAILROAD DRAYAGE	17
53	AIRPORT TERMINAL DRAYAGE	4.5

Table 5: Commodity Totals Destined For Kentucky per Year

STCC2	Commodity	Commodity Totals (tons)	Commodity Totals (truck equivalents)	Commodity Totals Shipped By Truck (tons)	Percent Shipped By Truck
1	FARM PRODUCTS	1,509,132	62,884	564,389	37
8	FOREST PRODUCTS	15,008	1,155	0	0
9	FRESH FISH OR MARINE PRODUCTS	34,693	5,784	62	0
10	METALLIC ORES	3,808,788	158,699	735	0
11	COAL	47,801,066	1,991,723	9,150,899	19
13	CRUDE PETROL. OR NATURAL GAS	50,066	3,578	520	1
14	NONMETALLIC MINERALS	8,156,470	429,287	7,543	0
19	ORDNANCE OR ACCESSORIES	5,058	211	70	1
20	FOOD OR KINDRED PRODUCTS	6,030,946	335,067	5,211,888	86
21	TOBACCO PRODUCTS	58,438	9,738	58,438	100
22	TEXTILE MILL PRODUCTS	87,344	17,448	85,420	98
23	APPAREL OR RELATED PRODUCTS	151,950	50,658	151,297	100
24	LUMBER OR WOOD PRODUCTS	7,696,020	513,060	6,522,192	85
25	FURNITURE OR FIXTURES	150,060	50,023	148,933	99
26	PULP, PAPER OR ALLIED PRODUCTS	3,229,607	89,704	2,145,408	66
27	PRINTED MATTER	313,788	34,837	311,103	99
28	CHEMICALS OR ALLIED PRODUCTS	10,817,962	491,739	6,124,890	57
29	PETROLEUM OR COAL PRODUCTS	8,155,853	429,256	4,099,164	50
30	RUBBER OR MISC. PLASTICS	540,069	135,094	534,354	99
31	LEATHER OR LEATHER PRODUCTS	4,344	1,441	4,206	97
32	CLAY, CONCRETE, GLASS OR STONE	21,031,143	914,391	20,144,219	96
33	PRIMARY METAL PRODUCTS	4,416,569	232,433	2,498,224	57
34	FABRICATED METAL PRODUCTS	2,909,571	121,234	2,686,496	92
35	MACHINERY	560,038	62,195	545,267	97
36	ELECTRICAL EQUIPMENT	617,354	77,203	550,129	89
37	TRANSPORTATION EQUIPMENT	4,801,241	400,119	4,175,198	87
38	INSTRUM., PHOTO EQ., OPTICAL EQ.	37,575	7,501	36,889	98
39	MISC. MANUFACTURING PRODUCTS	198,753	99,556	198,235	100
40	WASTE OR SCRAP MATERIALS	5,543,756	346,492	10,548	0
41	MISC. FREIGHT SHIPMENTS	56,431	2,453	0	0
42	SHIPPING CONTAINERS	55,472	13,868	0	0
43	MAIL OR CONTRACT TRAFFIC	13,612	4,537	0	0
44	FREIGHT FORWARDER TRAFFIC	994	249	0	0
45	SHIPPER ASSOCIATION TRAFFIC	41,892	13,964	0	0
46	MISC. MIXED SHIPMENTS	334,088	47,727	0	0
51	DISTRIBUTION OR WAREHOUSE SHIPMENTS	28,440,979	3,555,187	28,440,979	100
52	RAILROAD DRAYAGE	1,159,219	68,186	1,159,219	100
53	AIRPORT TERMINAL DRAYAGE	95,464	19,089	95,464	100
	Totals	168,930,813	10,797,770	95,662,378	57

Table 6: Commodity Totals Destined For External Zones per Year

Destination Zone	Destination Zone Name	Commodity Totals (tons)	Commodity Totals (truck equivalents)	Commodity Totals Shipped By Truck (tons)	Percent Shipped By Truck
1	Canada	1,357,918	84,342	544,183	40
2	Mexico	527,789	30,258	105,101	20
3	East North Central	2,087,537	234,425	2,068,289	99
4	East South Central	71,331,953	3,122,045	446,170	1
5	Middle Atlantic	4,527,949	287,642	2,966,087	66
6	Mountain	240,308	22,984	239,835	100
7	New England	3,584,405	251,882	3,584,243	100
8	Pacific	467,484	38,934	465,863	100
9	South Atlantic	2,987,537	222,654	2,558,997	86
10	West North Central	1,995,168	113,046	1,075,757	54
11	West South Central	12,653,980	656,795	736,945	6
17	Illinois	3,421,231	221,284	1,714,114	50
18	Indiana	9,427,772	598,035	5,213,803	55
29	Missouri	1,067,507	81,197	578,233	54
39	Ohio	16,728,558	957,792	5,700,482	34
47	Tennessee	27,136,430	1,306,997	2,648,618	10
51	Virginia	15,179,915	658,253	422,592	3
54	West Virginia	6,013,155	302,728	1,104,884	18
255	North West West Virginia	2,058,838	88,954	76,309	4
256	South West West Virginia	652	65	652	100
257	Huntington	1,015,793	42,585	2,609	0
450	North Cincinnati	4,729,533	260,376	1,016,161	21
451	East Cincinnati	1,315,150	61,845	70,328	5
452	Cincinnati	51,612	3,702	4,382	8
471	Central South Indiana	233,708	16,092	96,804	41
476	Greater Evansville	2,118,695	99,743	80,466	4
477	Evansville	472,057	28,782	111,030	24
Totals		192,732,634	9,793,437	33,632,937	17

Table 7: Commodity Totals Originating In External Zones and Destined For Kentucky per Year

Origin Zone	Origin Zone Name	Commodity Totals (tons)	Commodity Totals (truck equivalents)	Commodity Totals Shipped By Truck (tons)	Percent Shipped By Truck
1	Canada	1,512,216	101,477	664,998	44
2	Mexico	198,551	15,588	150,515	76
3	East North Central	1,222,204	82,832	1,221,225	100
4	East South Central	10,476,615	590,048	1,849,350	18
5	Middle Atlantic	2,496,931	163,442	1,808,703	72
6	Mountain	1,792,183	108,295	1,791,938	100
7	New England	400,370	20,288	399,972	100
8	Pacific	439,853	50,998	438,602	100
9	South Atlantic	1,948,600	166,890	1,944,769	100
10	West North Central	632,684	36,563	301,013	48
11	West South Central	7,167,977	372,953	1,135,692	16
17	Illinois	5,378,319	312,772	1,210,860	23
18	Indiana	7,406,233	482,445	5,483,929	74
29	Missouri	1,313,541	103,913	682,444	52
39	Ohio	11,262,411	770,188	7,020,509	62
47	Tennessee	5,071,503	418,818	3,737,023	74
51	Virginia	598,268	41,092	248,433	42
54	West Virginia	5,427,714	301,255	1,349,106	25
255	North West West Virginia	6,161,105	267,776	123,726	2
256	South West West Virginia	103,614	4,318	81	0
257	Huntington	8,579	743	1,649	19
450	North Cincinnati	1,596,710	114,663	1,132,483	71
451	East Cincinnati	227,729	17,550	178,815	79
452	Cincinnati	141,298	9,429	0	0
471	Central South Indiana	834,635	47,980	191,257	23
476	Greater Evansville	3,863,575	174,283	287,487	7
477	Evansville	575,310	34,282	168,728	29
Totals		78,258,728	4,810,881	33,523,307	43

Table 8: Commodity Totals Destined for Kentucky Zones From Other Kentucky Zones per Year

Destination Zone	Commodity Totals (tons)	Commodity Totals (truck equivalents)	Commodity Totals Shipped By Truck (tons)	Percent Shipped By Truck
400	1,517,190	127,498	1,517,190	100
401	1,601,463	119,733	1,587,942	99
402	28,869,133	1,697,189	20,282,852	70
403	5,175,737	345,109	3,629,370	70
404	1,440,325	118,490	1,417,381	98
405	2,894,560	206,809	2,889,013	100
406	993,717	80,978	987,629	99
407	1,341,003	124,917	1,334,067	99
408	650,634	68,509	650,634	100
409	1,430,364	108,708	1,430,364	100
410	11,785,467	679,148	5,097,956	43
411	2,345,714	186,433	1,871,141	80
412	826,008	42,854	218,834	26
413	980,484	41,546	29,978	3
414	106,583	8,154	106,583	100
415	2,483,539	262,890	2,483,539	100
416	4,863	405	3	0
417	6	0	6	100
418	2	0	2	100
420	7,433,946	480,924	3,253,344	44
421	1,916,404	152,168	1,899,844	99
422	2,626,060	157,062	1,298,938	49
423	4,870,635	322,325	3,270,680	67
424	6,173,109	412,561	3,686,633	60
425	1,756,170	126,810	1,753,622	100
426	410,883	31,652	410,883	100
427	1,038,086	84,017	1,030,643	99
Totals	90,672,085	5,986,889	62,139,071	69

Table 9: Commodity Totals Originating In Kentucky Zones Destined For Other Kentucky Zones per Year

Origin Zone	Commodity Totals (tons)	Commodity Totals (truck equivalents)	Commodity Totals Shipped By Truck (tons)	Percent Shipped By Truck
400	3,306,138	267,927	3,148,370	95
401	4,275,674	252,023	2,360,550	55
402	16,484,530	1,351,198	13,868,323	84
403	4,869,925	293,688	4,844,859	99
404	2,431,903	172,121	2,429,389	100
405	5,986,686	638,859	5,969,578	100
406	1,327,899	93,073	1,252,299	94
407	1,615,405	78,545	1,410,370	87
408	1,000,776	42,353	649,832	65
409	790,641	38,701	752,831	95
410	6,195,966	480,543	5,522,980	89
411	1,906,983	103,340	1,286,654	67
412	733,256	30,679	733,256	100
413	1,059,142	44,859	30,321	3
414	93,027	4,391	93,027	100
415	3,978,572	168,806	3,114,094	78
416	362,362	15,163	19	0
417	2,869,159	119,553	47	0
418	2,849,159	118,715	0	0
420	3,410,586	202,412	2,512,430	74
421	1,993,514	196,581	1,947,718	98
422	2,432,548	187,572	1,552,305	64
423	5,890,544	330,467	2,520,437	43
424	11,021,572	487,800	2,359,799	21
425	2,452,697	152,323	2,452,697	100
426	240,789	16,186	240,789	100
427	1,092,632	99,011	1,086,097	99
Totals	90,672,085	5,986,889	62,139,071	69

Table 10: Comparison to Rail Waybill Data 1994

	Waybill (tons)	**Reebie (tons)**
Originating in Kentucky		
Coal	104,701,181	113,456,733
Primary metals	2,331,287	4,854,112
Chemicals	1,976,220	2,422,672
Farm Products	1,197,972	1,023,663
Transportation Equipment	1,088,800	1,626,088
Destined for Kentucky		
Coal	25,360,488	25,886,128
Chemicals	2,628,628	3,006,953
Metallic Ores	1,974,633	2,668,540
Lumber / Wood Products	1,265,600	1,154,247
Primary Metal Products	1,197,176	1,471,783

Table 11: Waterborne Commodities to and from Kentucky

COMMODITY	2-DIGIT	REEBIE TONS	CORP 1994 TONS*
FARM PRODUCTS	1	2686845	
FOREST PRODUCTS	8	0	
FRESH FISH OR MARINE PRODUCTS	9	101325	
METALLIC ORES	10	1602039	
COAL	11	39200466	44139356
CRUDE PETROL. OR NATURAL GAS	13	46040	
NONMETALLIC MINERALS	14	23831658	
ORDNANCE OR ACCESSORIES	19	0	
FOOD OR KINDRED PRODUCTS	20	699510	
TOBACCO PRODUCTS	21	726	
TEXTILE MILL PRODUCTS	22	124858	
APPAREL OR RELATED PRODUCTS	23	415	
LUMBER OR WOOD PRODUCTS	24	19581	
FURNITURE OR FIXTURES	25	251	
PULP, PAPER OR ALLIED PRODUCTS	26	75242	
PRINTED MATTER	27	147	
CHEMICALS OR ALLIED PRODUCTS	28	2009207	2725056
PETROLEUM OR COAL PRODUCTS	29	4809470	
RUBBER OR MISC. PLASTICS	30	0	
LEATHER OR LEATHER PRODUCTS	31	55	
CLAY, CONCRETE, GLASS OR STONE	32	867122	
PRIMARY METAL PRODUCTS	33	698391	
FABRICATED METAL PRODUCTS	34	265854	
MACHINERY	35	682	
ELECTRICAL EQUIPMENT	36	116	
TRANSPORTATION EQUIPMENT	37	676	
INSTRUM., PHOTO EQ., OPTICAL EQ.	38	76	
MISC. MANUFACTURING PRODUCTS	39	0	
WASTE OR SCRAP MATERIALS	40	5552076	
MISC. FREIGHT SHIPMENTS	41	53097	
SHIPPING CONTAINERS	42	0	
MAIL OR CONTRACT TRAFFIC	43	0	
FREIGHT FORWARDER TRAFFIC	44	0	
SHIPPER ASSOCIATION TRAFFIC	45	0	
MISC. MIXED SHIPMENTS	46	0	
SMALL PACKAGED FREIGHT SHIPMENTS	48	0	
BULK COMMODITY SHIPMENTS IN BOXCARS	50	0	
OTHER		41436252	34530029
TOTAL		82645925	81394441

Table 12: Comparison to 1993 Commodity Flow Survey

	CFS Tons	Reebie Tons
Total Tons Shipped	353,200,000	283,404,719
Coal Shipped	197,085,600	153,037,590
Nonmetallic Minerals Shipped	44,150,000	21,534,494
Clay, Concrete, glass, or stone	22,604,800	20,260,898
Food or kindred products shipped	9,889,600	7,484,955
Total Shipments destined ...	**Percent by Weight**	
Kentucky	49	33.9
Ohio	8.5	7.7
Indiana	5.8	4.4
Shipments from...	**Tons**	
Ohio	10,442,000	13,228,148
Tennessee	6,285,000	5,571,503
West Virginia	6,533,000	11,701,012
Indiana	11,186,000	12,679,753
Illinois	7,176,000	5,378,319

Table 13: Airport Freight Tonnage

Airport Name	City	Status	Year	Tons/year
Blue Grass Airport	Lexington	on	97	246,536
Blue Grass Airport	Lexington	off	97	1037598
Blue Grass Airport	Lexington	on	98	79453
Blue Grass Airport	Lexington	off	98	255641
Northern Kentucky Airport	Hebron	off	97	399813
Louisville Airport	Louisville	on	97	2187428
Louisville Airport	Louisville	off	97	4229404
Louisville Airport	Louisville	on	98	762514
Louisville Airport	Louisville	on	98	1351371

Table 14: Model Truck ADT Versus Classification Count Data

County	Station	Route	Milepoint	AADT	Count Trucks / day	Model Trucks / day	Difference Trucks / day
3	A38	US 127	6	14500	42	873	831
5	P71	KY9008	9	6320	942	883	-59
7	507	US 25E	0	17300	1556	207	-1349
7	A06	US 25E	3	23900	1351	257	-1094
7	D53	US 25E	13	11600	1412	560	-852
9	P26	US 68	4	7430	448	390	-58
10	17	I 64	191	20700	4652	307	-4345
11	37	US 127	8	11700	896	562	-334
15	P72	I 65	109	42700	9843	13531	3688
16	813	KY9007	30	4610	1232	650	-582
17	301	KY9001	16	8950	1027	1973	946
17	565	KY9010	6	7695	1599	1973	374
19	301	KY 9	16	5970	1143	730	-413
19	L84	US 27	14	21600	417	730	313
24	105	KY9004	28	5930	2236	1328	-908
24	286	US 41A	5	14300	2322	463	-1859
27	253	US 127	4	5660	257	34	-223
27	286	US 127	10	1600	230	34	-196
30	822	KY9005	19	7260	752	237	-515
30	P17	US 60B	6	24900	1405	237	-1168
30	C15	US 60B	7	19300	1420	1914	494
34	784	I 75	116	64000	16634	7441	-9193
34	E32	US 27	9	24700	628	3073	2445
34	G51	US 60	4	38900	2754	2230	-524
34	G16	US 60	3	36600	2385	2230	-155
36	779	US 23	11	22100	4594	1837	-2757
36	5	US 23	9	17500	2312	1846	-466
37	507	I 64	50	27900	6032	6290	258
38	A16	KY9003	2	5690	1127	311	-816
42	112	KY9003	25	6990	1494	237	-1257
42	P10	US 45	6	1670	57	311	254
45	2	US 23	18	6900	860	275	-585
47	174	I 65	96	38700	7244	13531	6287
48	P18	US 119	10	9730	857	403	-454
51	B75	KY9004	78	20100	3313	2138	-1175
51	C58	US 41	19	38800	3827	2313	-1514
52	P48	I 71	36	22300	9798	19929	10131
54	A61	KY9004	41	26100	3673	916	-2757
56	P92	I 64	1	54400	4905	5458	553
56	N09	I 64	8	77600	5348	6727	1379
56	M86	I 64	6	78300	5469	10488	5019
56	P99	I 65	133	121000	9466	6493	-2973
56	G23	I 65	129	136000	14317	12897	-1420
56	590	I 65	124	74600	15000	13531	-1469
56	A07	I 71	7	38700	7624	11236	3612
56	N13	I 264	3	53300	3107	125	-2982

56	N17	I 264	0	36400	3886	5583	1697
56	P94	I 264	15	137700	6482	7188	706
56	A13	I 265	34	49500	3398	145	-3253
56	P98	I 265	16	48600	4075	634	-3441
56	D01	I 265	24	44500	3844	634	-3210
56	G74	I 265	11	63900	3394	634	-2760
56	460	US 31E	12	37000	499	7188	6689
56	439	US 31E	12	39800	95	7188	7093
56	675	US 31W	10	35300	205	909	704
56	L54	US 31W	0	4920	77	909	832
58	3	US 23	11	10800	2670	438	-2232
59	805	I 275	83	80600	3014	4937	1923
64	60	US 23	17	6480	4766	307	-4459
67	258	US 119	9	1490	67	13	-54
68	P52	KY 9	16	4130	874	718	-156
68	38	KY 9	20	3050	722	718	-4
68	5	KY 9	0	263	516	1004	488
69	315	US 27	5	5850	530	963	433
70	788	US 60	19	3050	148	174	26
71	P38	US 68	3	2140	412	107	-305
77	17	US 460	20	6120	912	159	-753
84	P25	US 127	2	14230	916	562	-354
87	504	I 64	108	17900	2805	3204	399
90	287	KY9002	23	8350	1696	2049	353
92	285	KY9001	76	9833	1913	2803	890
92	782	KY9007	56	6626	1528	539	-989
97	28	KY 80	5	2810	125	342	217
97	750	KY 80	4	5830	770	355	-415
98	515	US 23	1	3900	1580	110	-1470
98	A73	US 23	25	21800	4232	174	-4058
98	A67	US 23	28	23000	3253	174	-3079
98	P70	US 119	2	10100	1305	27	-1278
98	763	US 119	9	9010	2594	27	-2567
100	821	KY9008	84	6690	788	883	95
100	1	KY 80	35	5340	1209	902	-307
100	P32	US 27	6	6050	420	36	-384
100	A05	US 27	16	39400	629	268	-361
102	P46	I 75	51	31500	10070	6515	-3555
105	539	I 64	68	19700	6147	6176	29
105	7	I 75	130	34000	9072	7208	-1864
105	291	I 75	124	39400	9922	7676	-2246
106	P22	I 64	38	31700	5242	7091	1849
111	7	US 68	28	4657	510	108	-402
113	P15	US 60	4	3104	893	174	-719
114	572	KY9007	2	13480	1878	488	-1390
120	800	KY9002	66	15900	2167	2230	63
120	P53	KY9002	70	14200	1749	2230	481

Table 15: Comparison Between Morehead State University Hazmat Corridor Studies and Freight Commodity Assignment Model

				Hazardous Materials Data		Model Data	
County Number	**Year**	**Route**	**Mile Point**	**Trucks Per Year**	**Hazmat Trucks Per Year**	**Trucks Per Year**	**Hazmat Trucks Per Year**
corridor	1996	I-71	corridor	2185992	58593.6		
8	1996	I-71	Walton	2358768	69110.4	3667237	424085
93	1996	I-71	Crestwood	2454921.6	70612.8	5318951	625778
56	1996	I-71	Zorn Valley	1600056	30048	3505787	419118
corridor	1994	I-75	corridor	2376796.8	74669.28		
59	1994	I-75	North Region	2253600	57692.16	2918358	303445
34	1994	I-75	South Region	2493984	91646.4	2189971	128419
corridor	1996	I-24	corridor	1840440	72115.2		
24	1996	I-24	Hopkinsville	1987675.2	82632	1186726	63157
73	1996	I-24	Paducah	1691702.4	61598.4	1748090	124678
corridor	1994	I-64	corridor	1736774.4	99759.36		
10	1994	I-64	East Region	994889.28	63852	970216	148446
56	1994	I-64	West Region	2479410.72	135516.48	3671184	333703
corridor	1995	I-65	corridor	3185088	84134.4		
Indiana	1995	I-65	Clarksville	2690798.4	54086.4	1046959	163353
56	1995	I-65	Arthur Street	2857564.8	63100.8	2025836	163831
47	1995	I-65	Elizabethtown	3683884.8	103665.6	4860943	480369
107	1995	I-65	Franklin	3305280	103665.6	3798808	392717

Table 16: Truck Counts at Weight Stations Compared to Model Output

Direction	Year	Location	Route	Truck Traffic*	Truck Total from Model
Eastbound	96	Lyon Co.	I-24	1,617,000	1,836,045
Northbound	96	Fulton Co.	Purchase Pky	416,000	97,027
Northbound	96	Simpson Co.	I-65	4,074,000	3,798,808
Southbound	96	Hardin Co.	I-65	4,739,000	4,185,551
Westbound	96	Shelby Co.	I-64	1,693,000	2,212,507
Northbound	96	Scott Co.	I-75	2,630,000	2,248,997
Westbound	96	Rowan Co.	I-64	646,000	999,598
Southbound	96	Laurel Co.	I-75	3,003,000	1,638,479
Southbound	96	Henderson Co.	US 41	1,198,000	721,508
Southbound	96	Boone Co.	I-71	2,824,000	3,667,237
Northbound	96	Henry Co.	I-71	2,954,000	3,551,007
Southbound	96	Kenton Co.	I-75	2,584,000	2,248,997

*Source: Division of Transportation Planning

*when both directions not available, truck traffic = single direction * 2

Figure 1: Reebie Associates Principle Transearch Database Sources

PRIMARY DOMESTIC TRAFFIC FLOW SOURCES

- Annual Motor Carrier Data Exchange (Proprietary Shipment Data)
- Annual ICC Railroad Waybill Sample
- Annual Corps of Engineers Waterborne Commerce Statistics
- Annual Federal Aviation Administration Airport Activity Statistics
- Import/Export Trade Statistics & Inland Traffic Survey
- Annual Department of Energy Coal Movement Statistics
- Annual Department of Agriculture Produce Movement Data
- Census of Transportation - Commodity Movement Survey

PRIMARY PRODUCTION AND SHIPMENTS SOURCES

- Census/Annual Survey of Manufacturers
- Annual Bureau of Mines Commodity Reports
- Annual Motor Carrier Industry Financial & Operating Statistics
- Annual Railroad Freight Commodity Statistics
- Federal Reserve Board Industrial Production Indices
- Survey of Current business
- Trade Association Production and Shipment Reports
- Annual County Employment and Population Data
- State Economic Output By Industry
- Inter-Industry Trade Patterns (Input/Output Table)

Figure 2: Reebie Associates Transearch Data Commodity Coverage

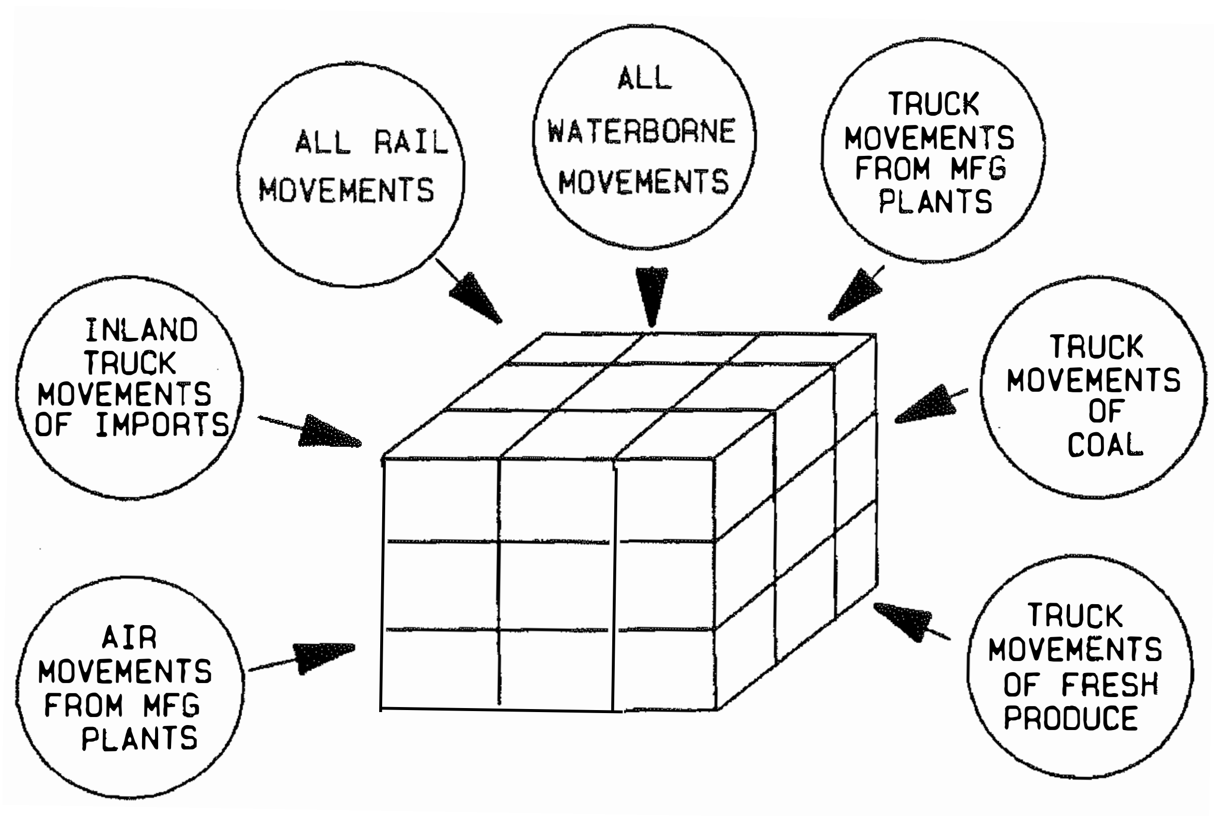
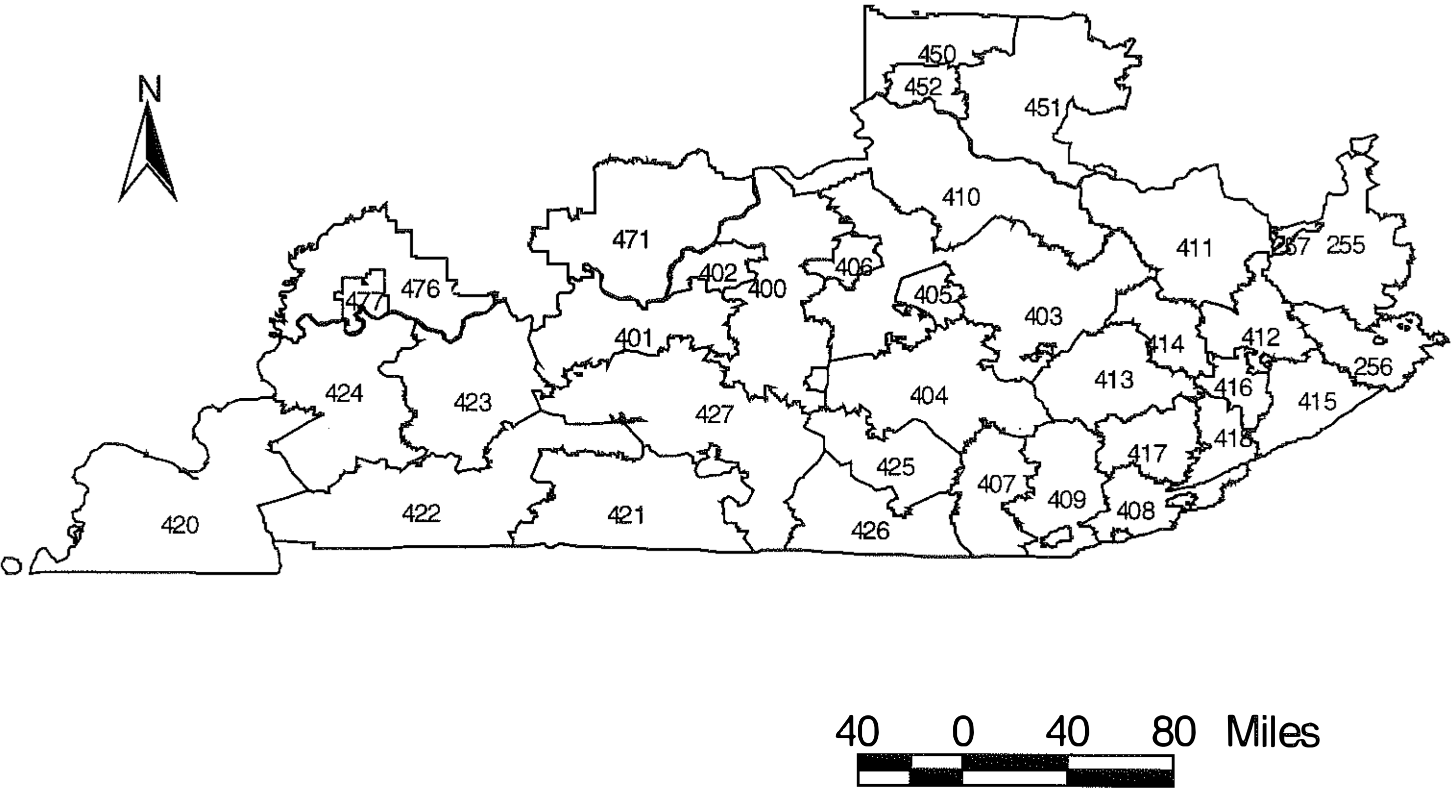
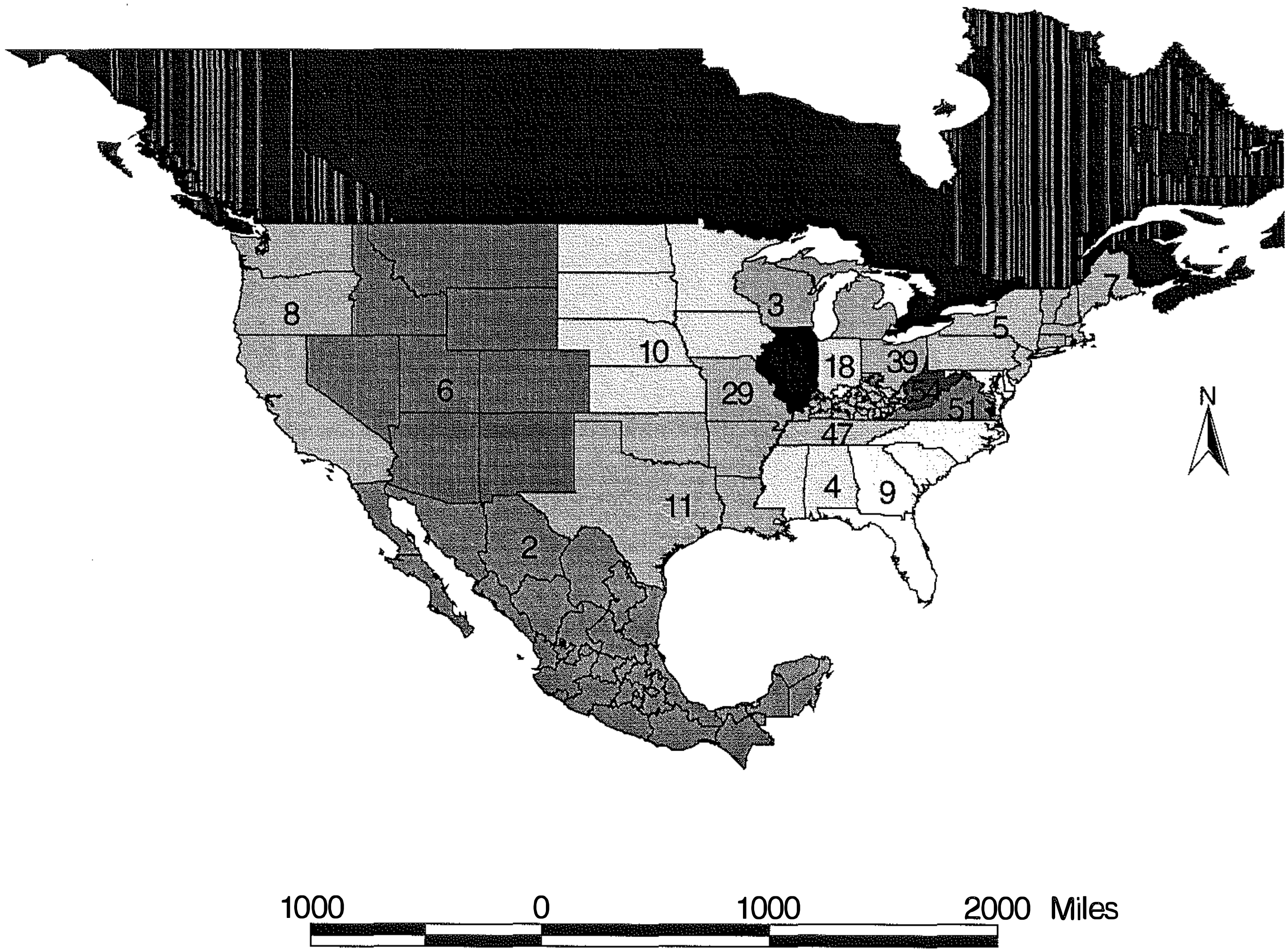


Figure 3: Zonal Structure for Kentucky and Adjacent Areas



***Note that some out of state areas adjacent to Kentucky are also represented as three digit zip code zones. Zone number descriptions are in Table 1.**

Figure 4: Zonal Structure for Areas Outside Kentucky



* **Zone number descriptions are in Table 1.**

Figure 5: Largest Commodity by Weight Category Shipped from Each Zone

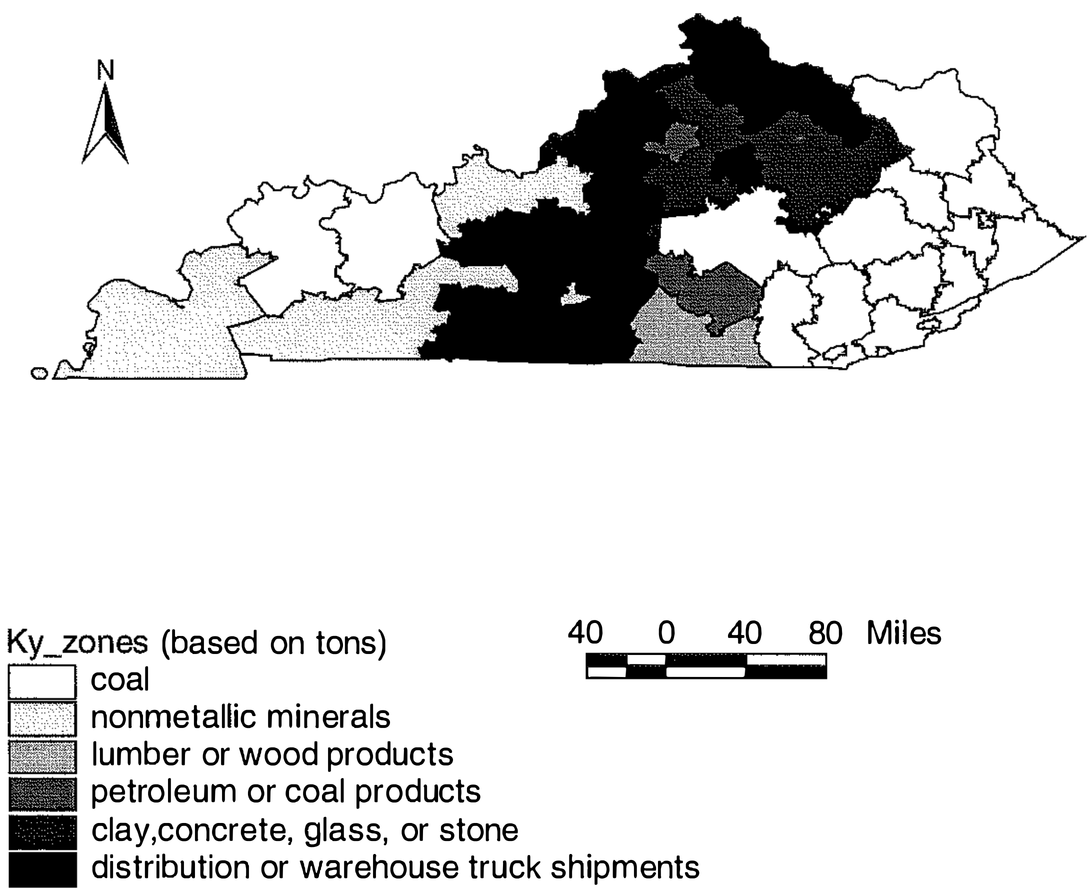


Figure 6: Total Tons per Year of Farm, Forest and Fish Products (codes 1, 8, 9) Originating by Internal Zone

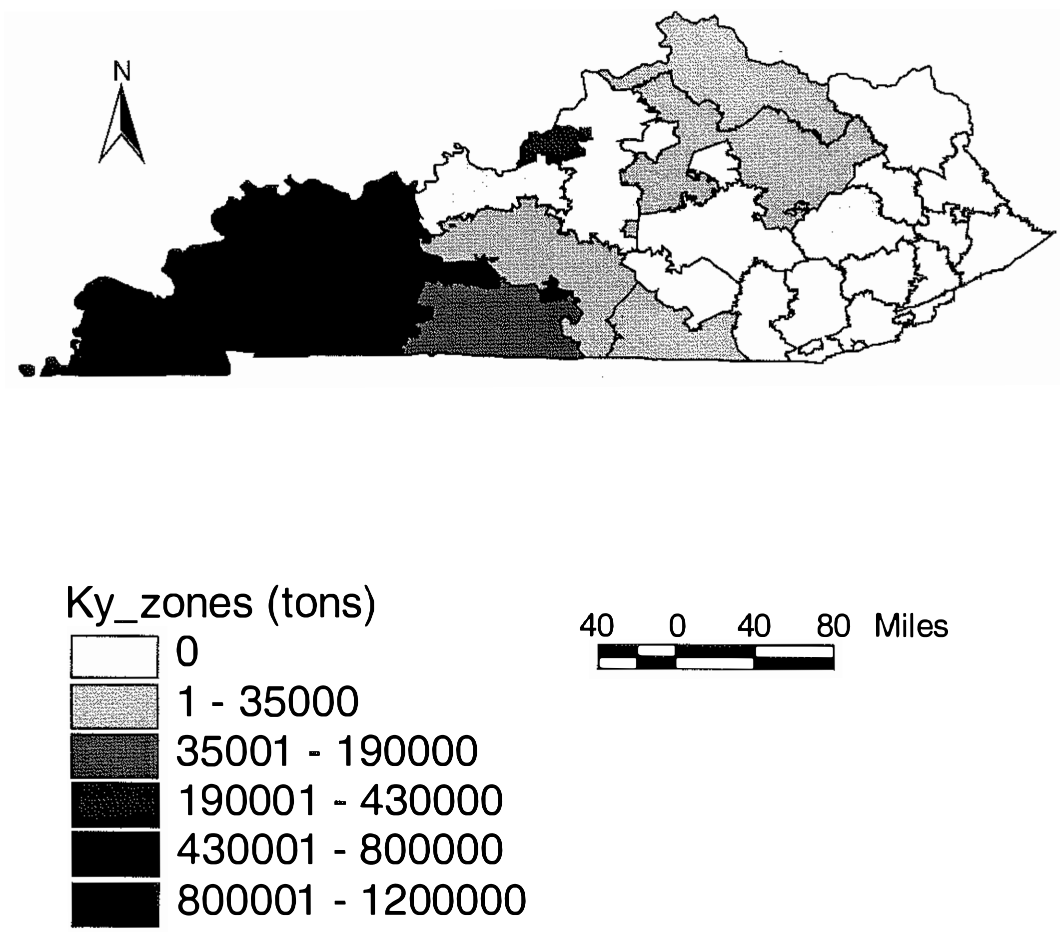


Figure 7 : Total Tons per Year of Coal, Petroleum, Metallic Ores, Nonmetallic Minerals, Ordnance (codes 10, 11, 13, 14, 19) Originating by Internal Zone

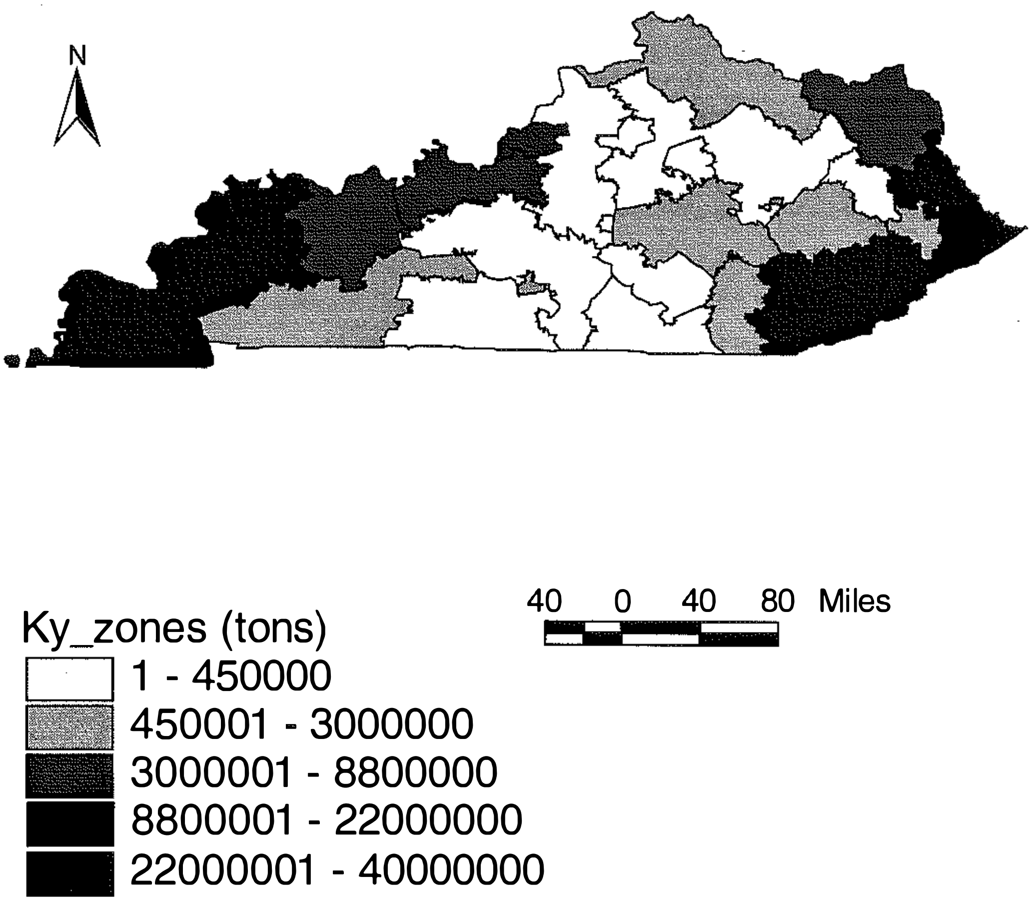


Figure 8: Total Tons per Year of Manufactured Goods, Lumber, Paper Products, and Chemicals (codes 20 - 29) Originating by Internal Zone

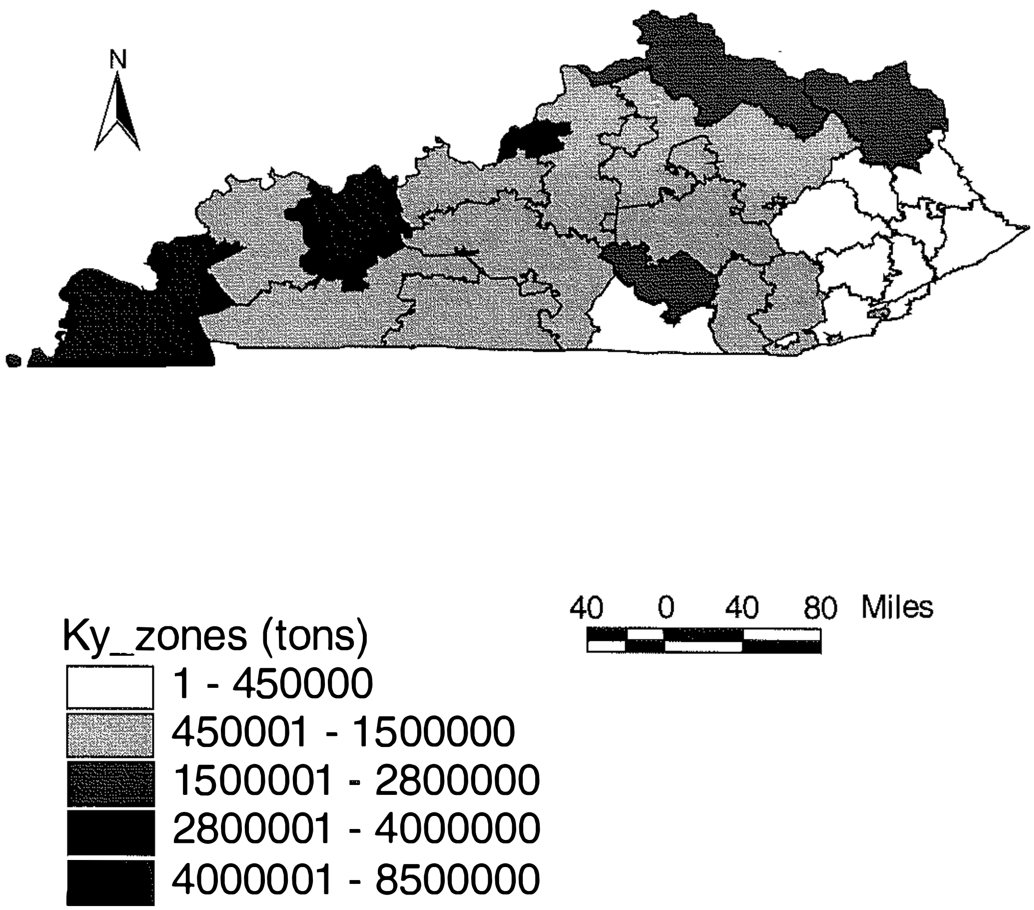


Figure 9: Total Tons of per Year Clay, Concrete, Glass, Stone, Metal Products, Machinery (codes 30-39) Originating by Internal Zone

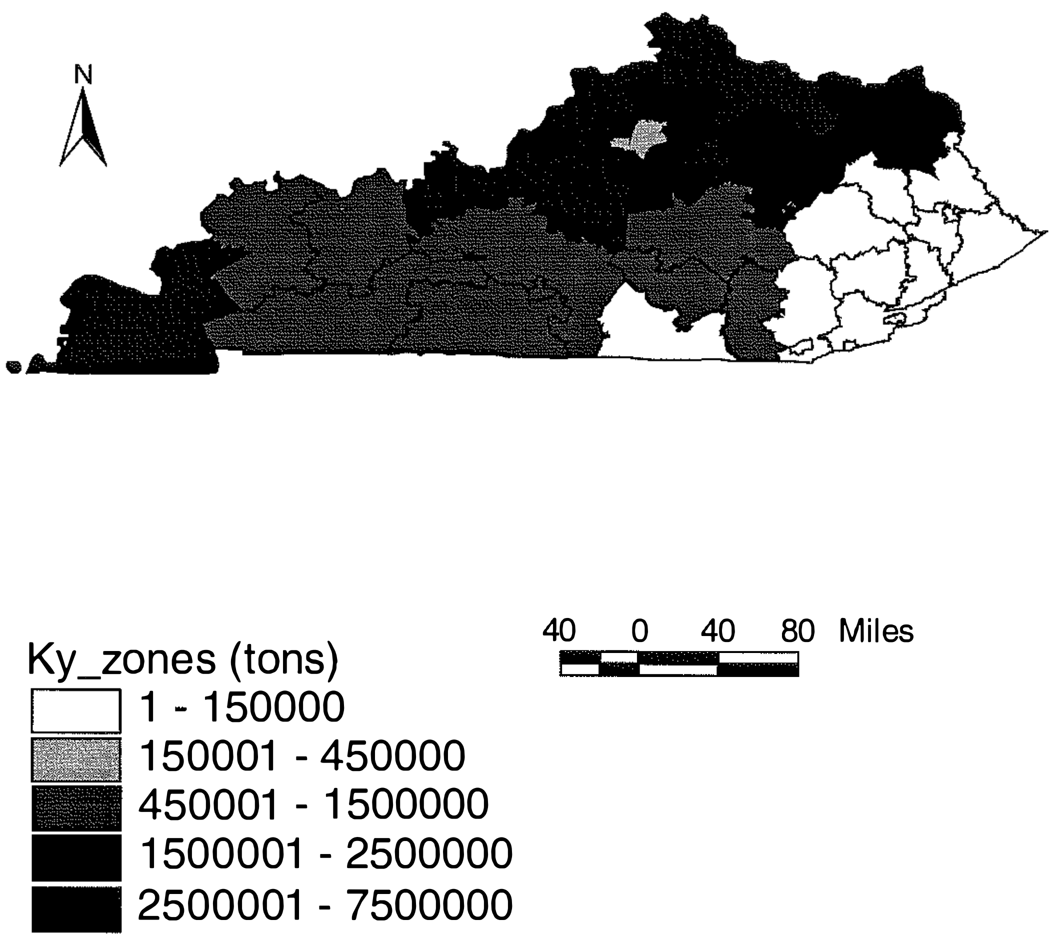


Figure 10: Total Tons per Year of Miscellaneous Shipments including Mixed Shipments, Mail, and Waste (codes 40-49) Originating by Internal Zone

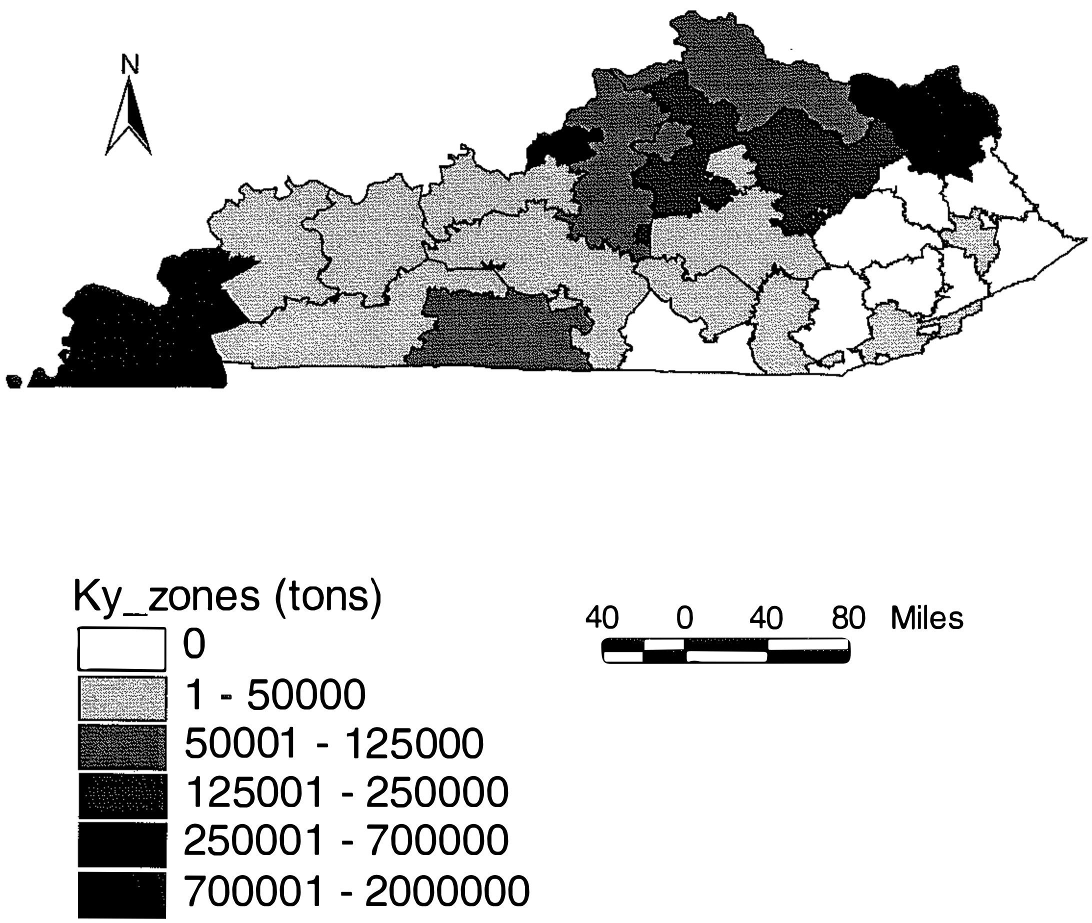


Figure 11: Total Tons per Year of Warehouse Distributions (code 53) Originating by Internal Zone

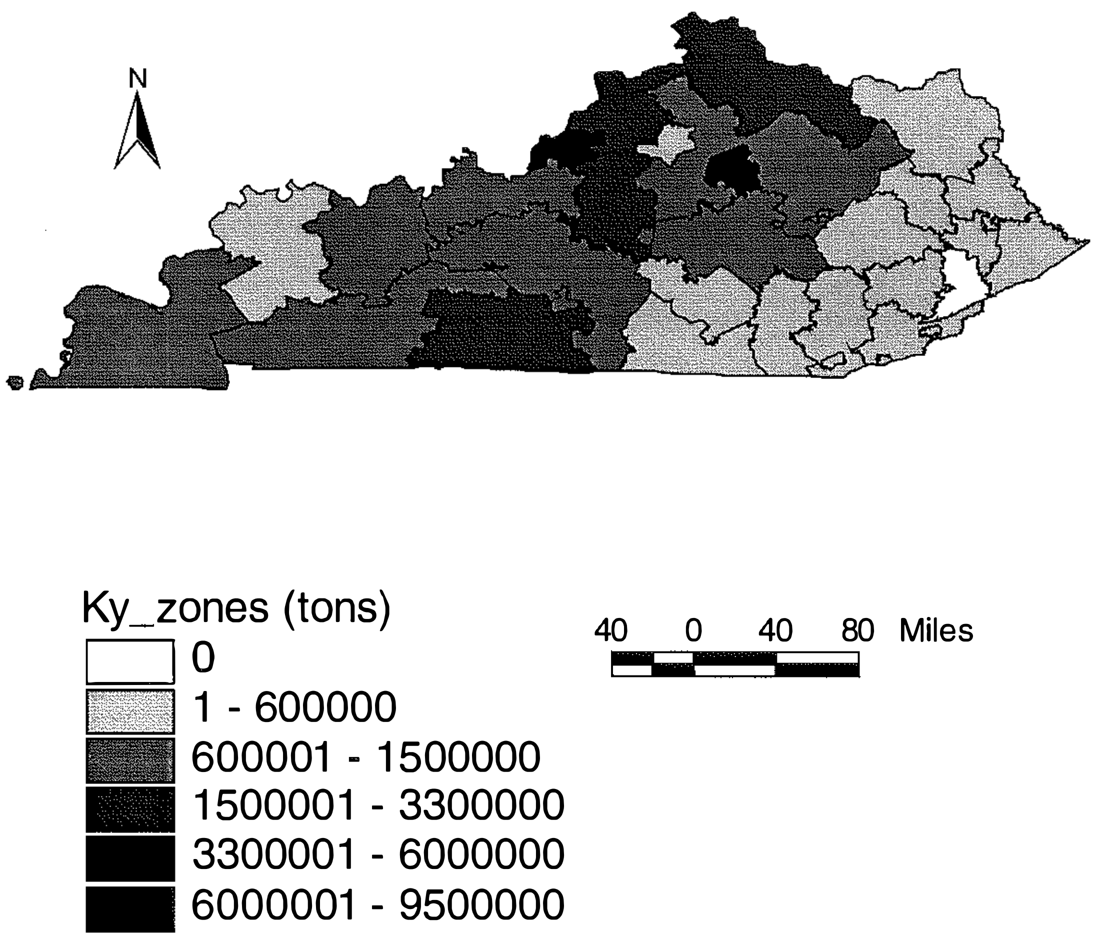


Figure 12: Total Tons of Freight Per Year Destined for Each Internal Zone

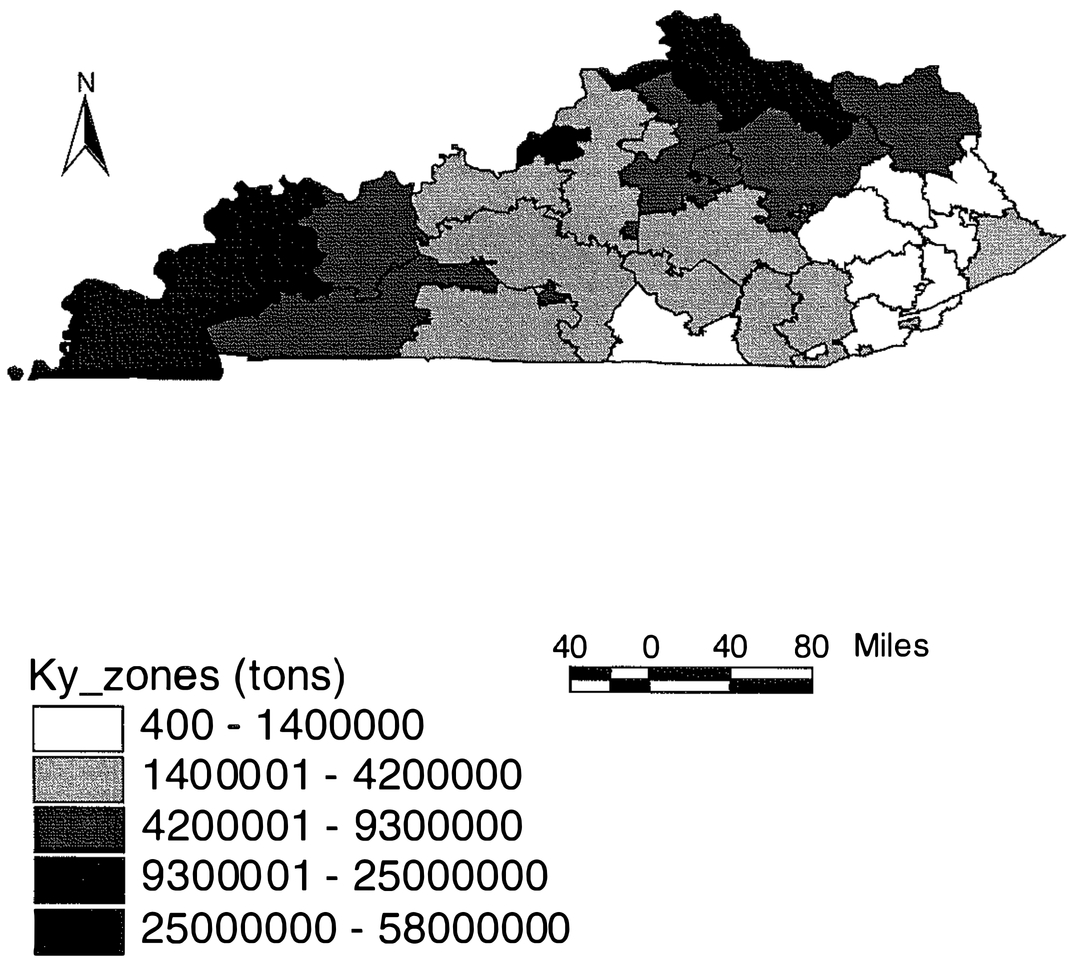


Figure 13: Largest Commodity by Weight Category Shipped to Each Zone

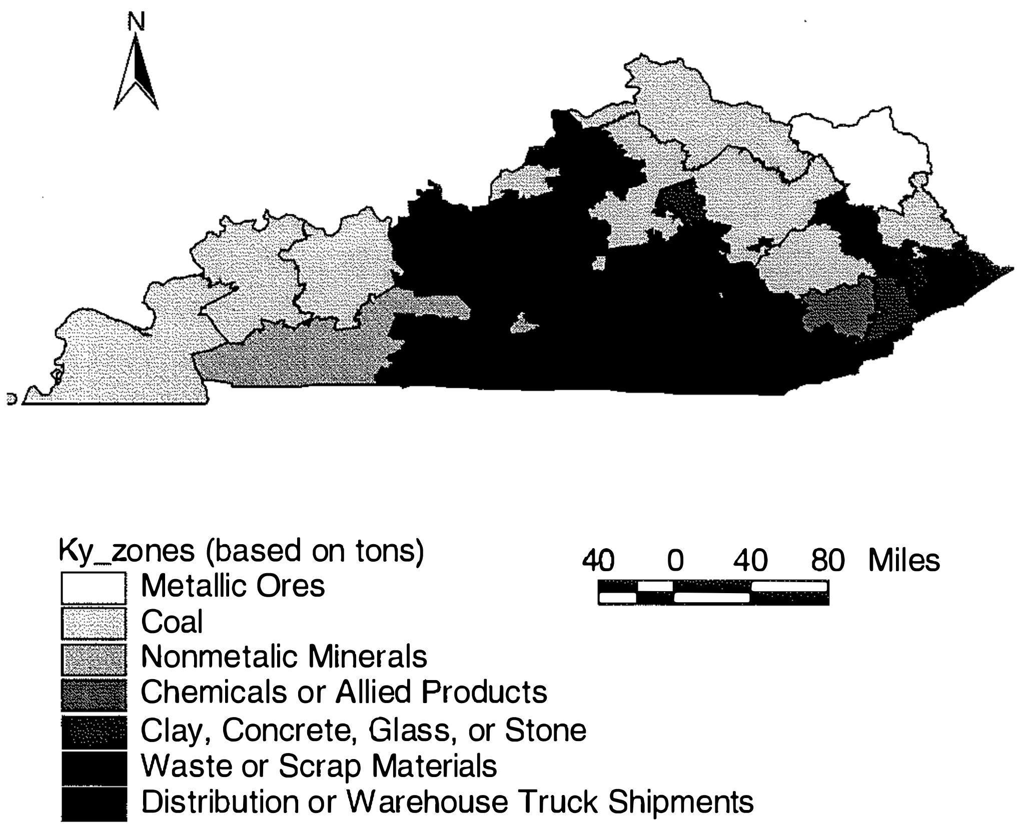


Figure 14: Total Tons of Farm, Forest and Fish Products (codes 1, 8, 9) Terminating by Internal Zone

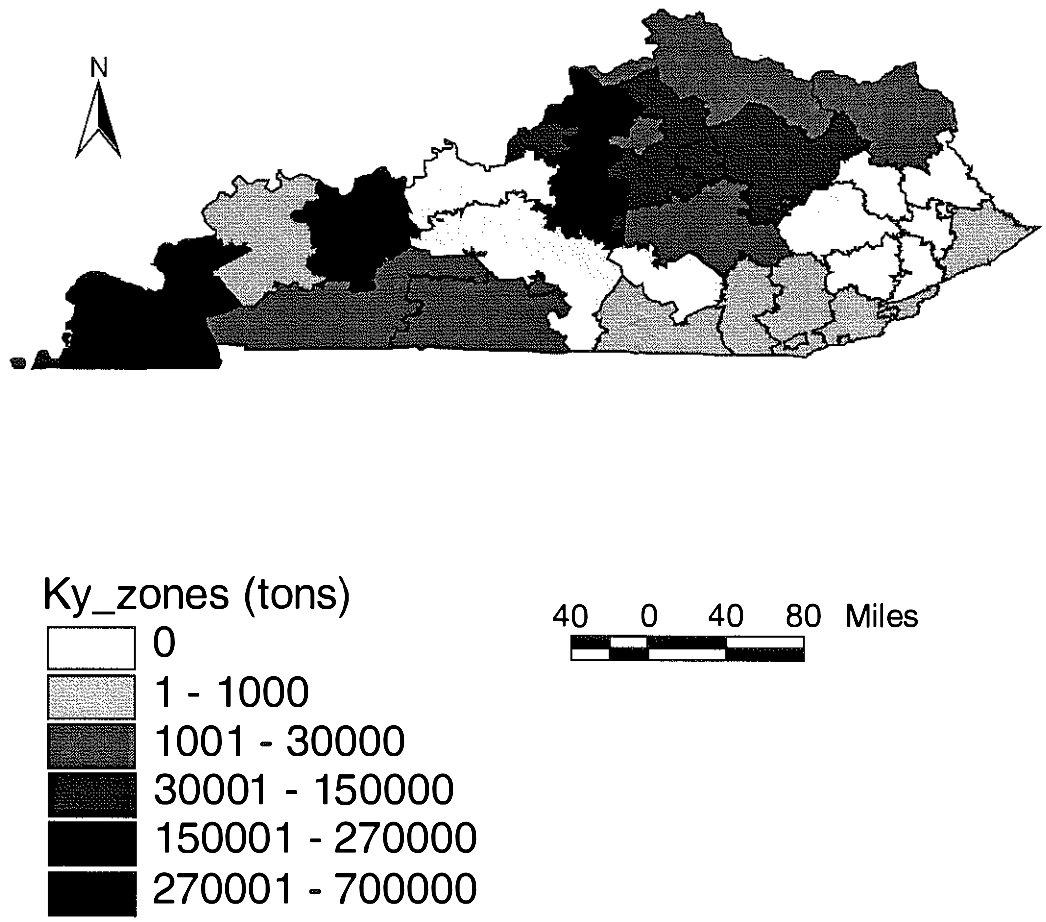


Figure 15 : Total Tons per Year of Coal, Petroleum, Metallic Ores, Nonmetallic Minerals, Ordnance (codes 10, 11, 13, 14, 19) Terminating by Internal Zone

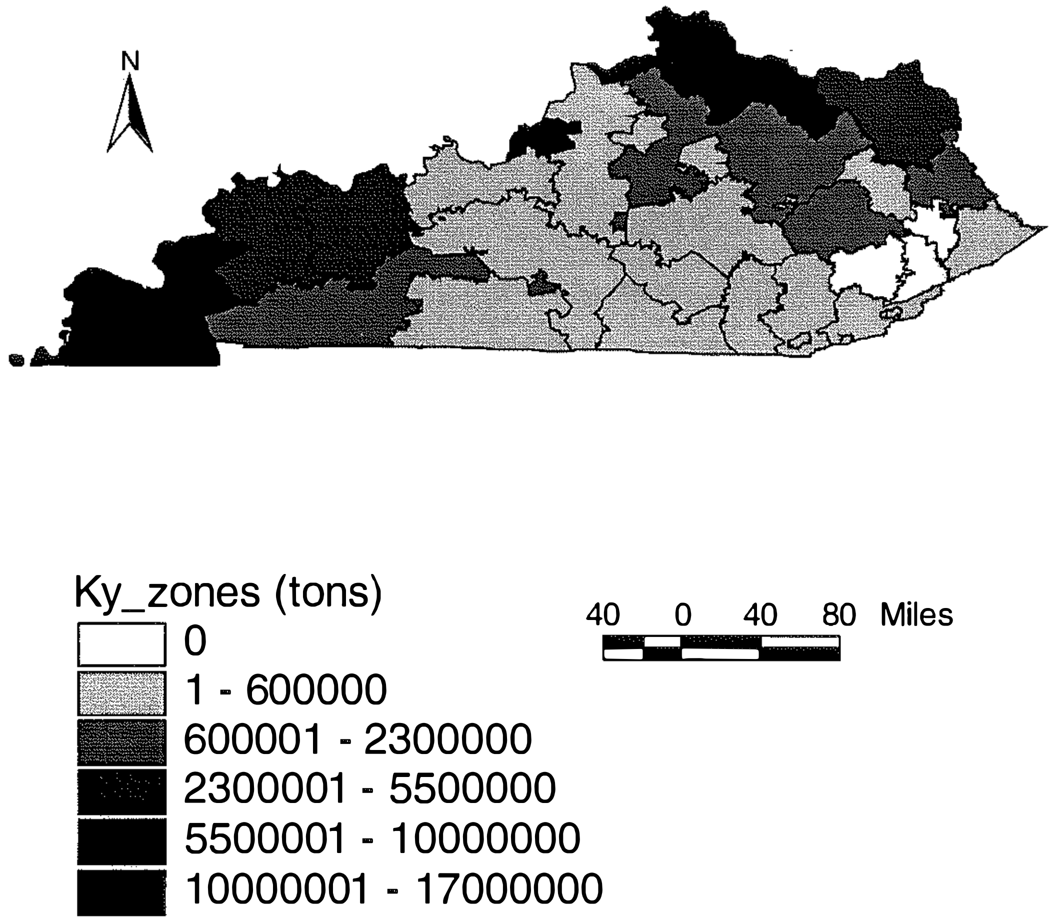


Figure 16: Total Tons per Year of Manufactured Goods, Lumber, Paper Products, and Chemicals (codes 20 - 29) Terminating by Internal Zone

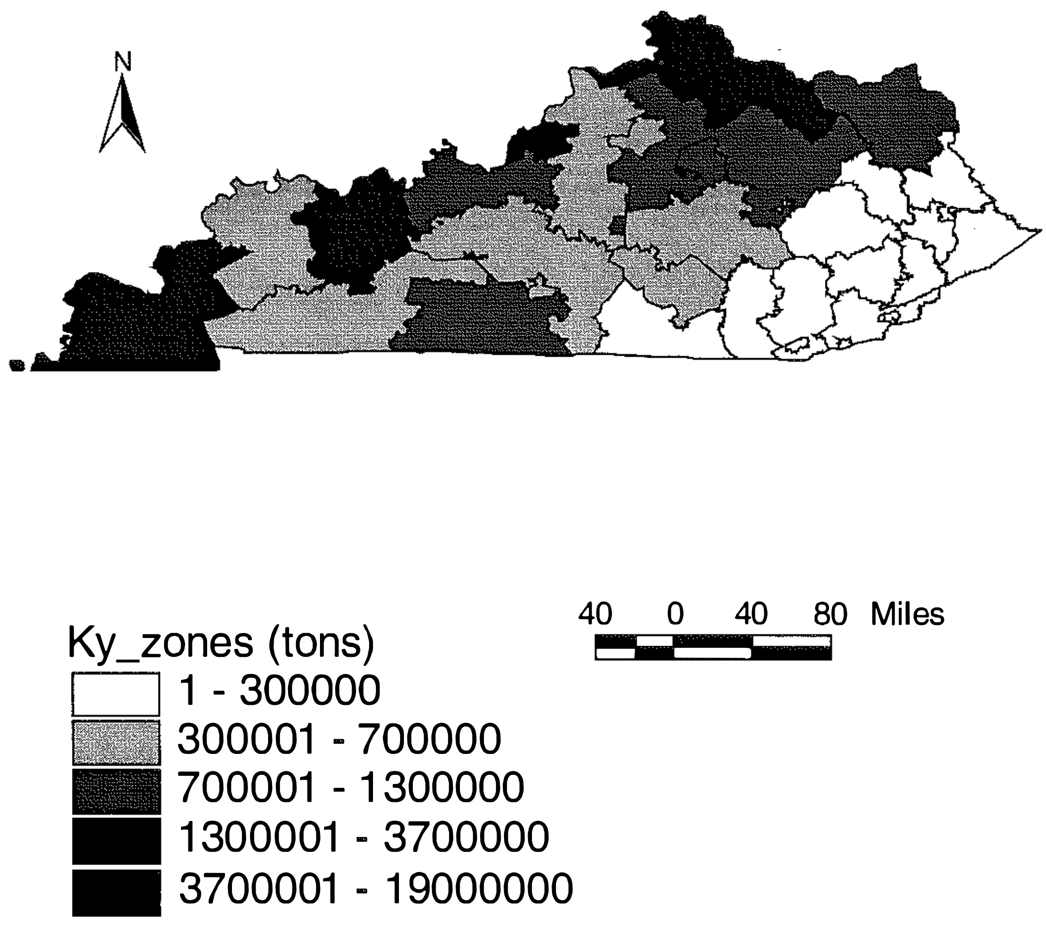


Figure 17: Total Tons per Year of Clay, Concrete, Glass, Stone, Metal products, Machinery (codes 30-39) Terminating by Internal Zone

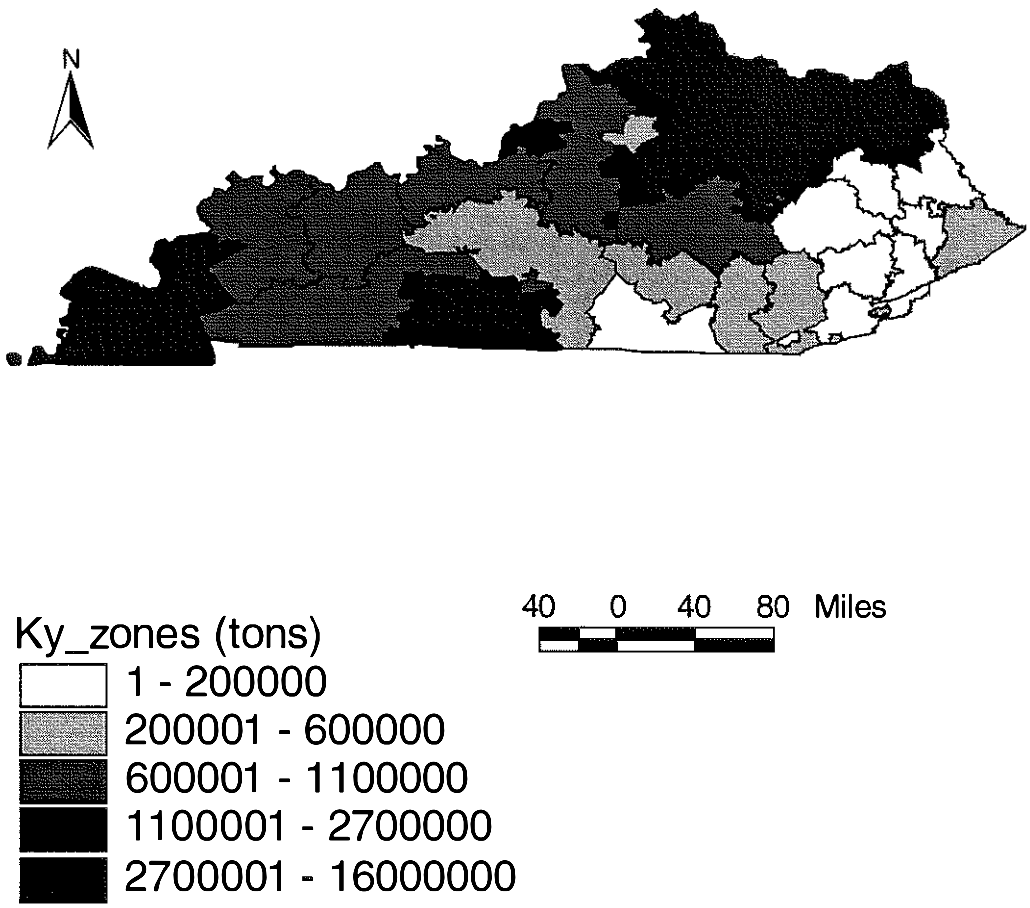


Figure 18: Total Tons per Year of Miscellaneous Shipments including Mixed Shipments, Mail, and Waste (codes 40-49) Terminating by Internal Zone

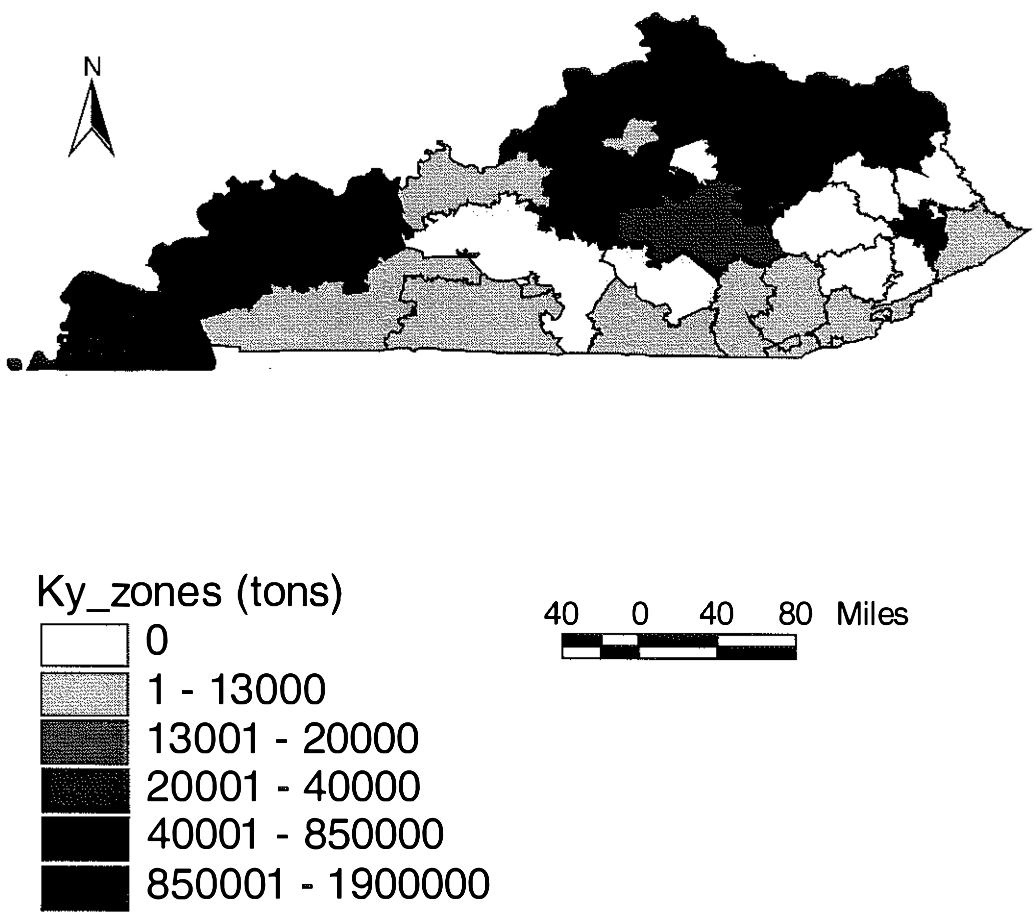


Figure 19: Total Tons per Year of Air / Rail Drayage and Warehouse Distributions (code 50) Terminating by Internal Zone

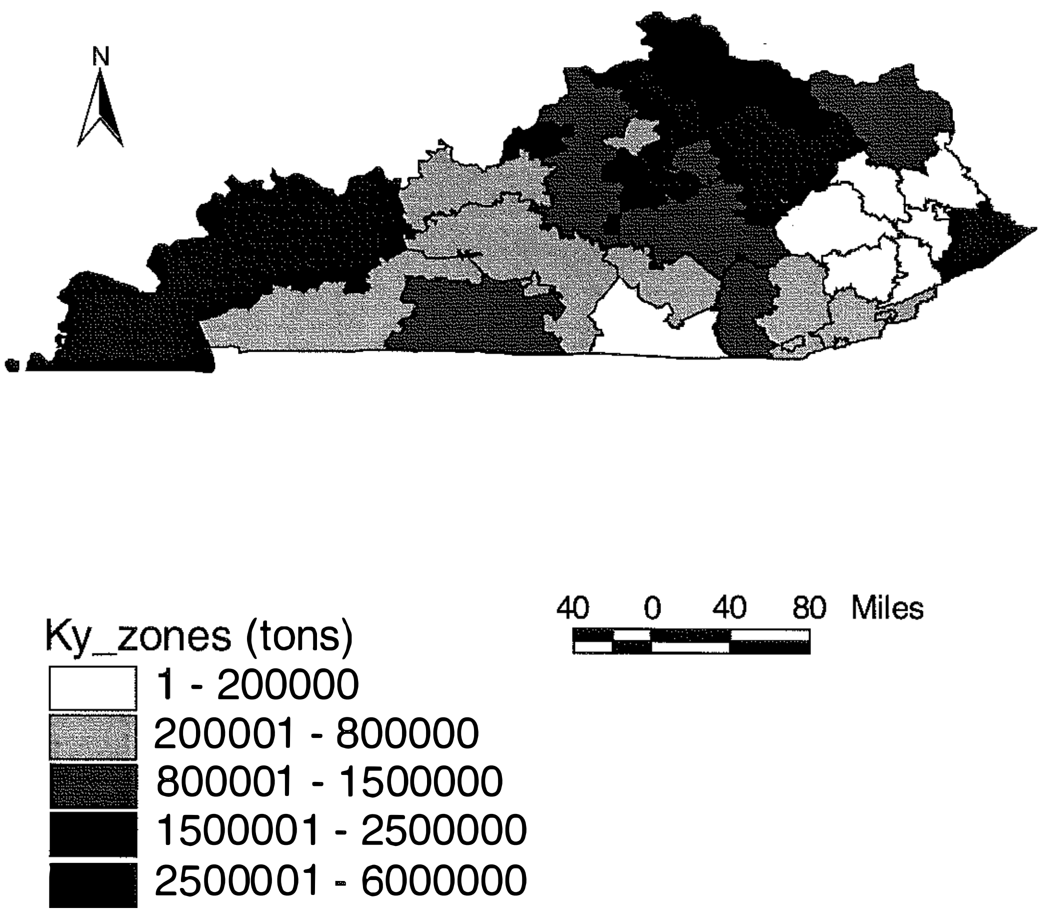


Figure 20: Mode Split for Shipments Originating in Kentucky

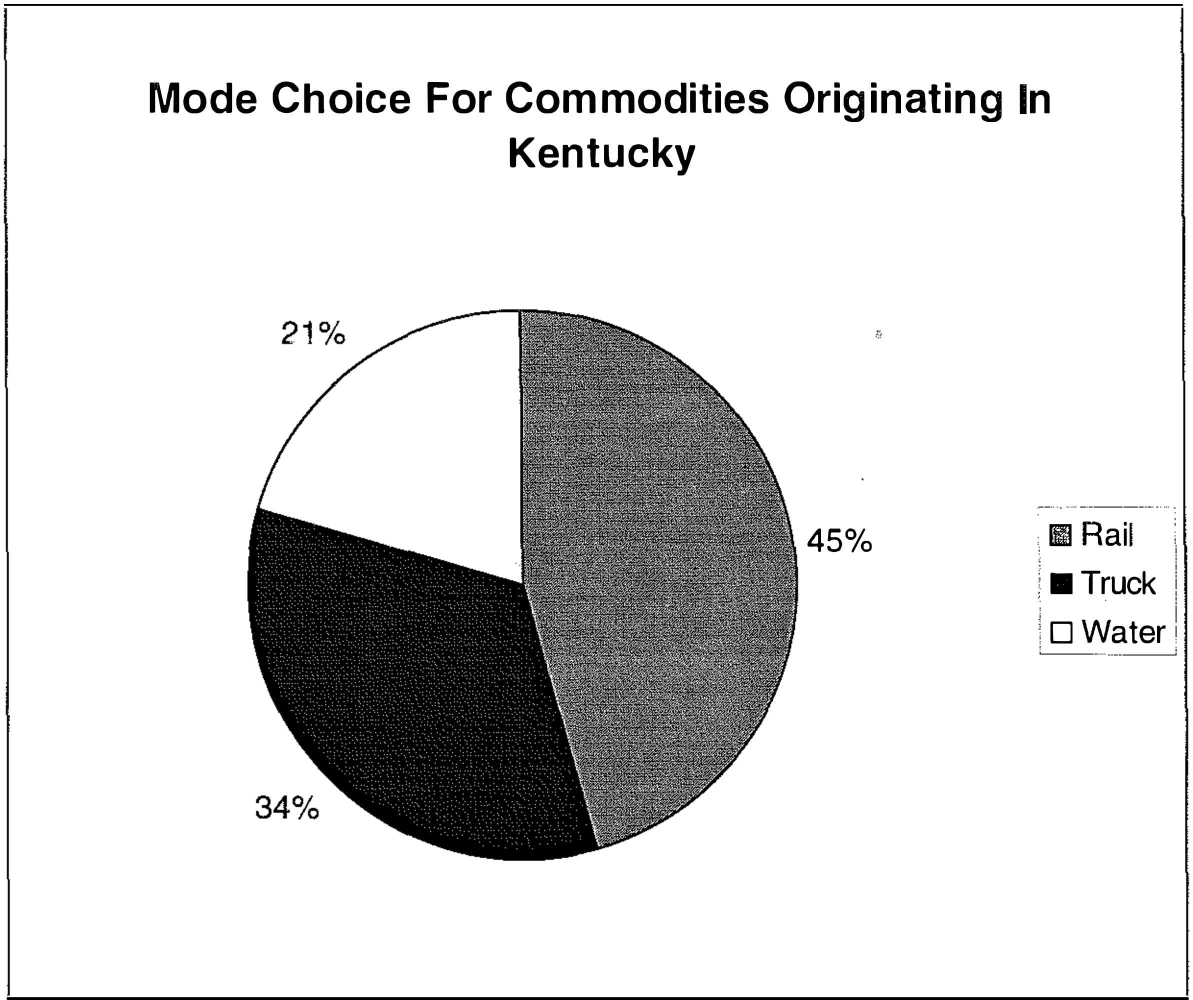


Figure 21: Mode Split for Shipments Originating in Kentucky for External Zones

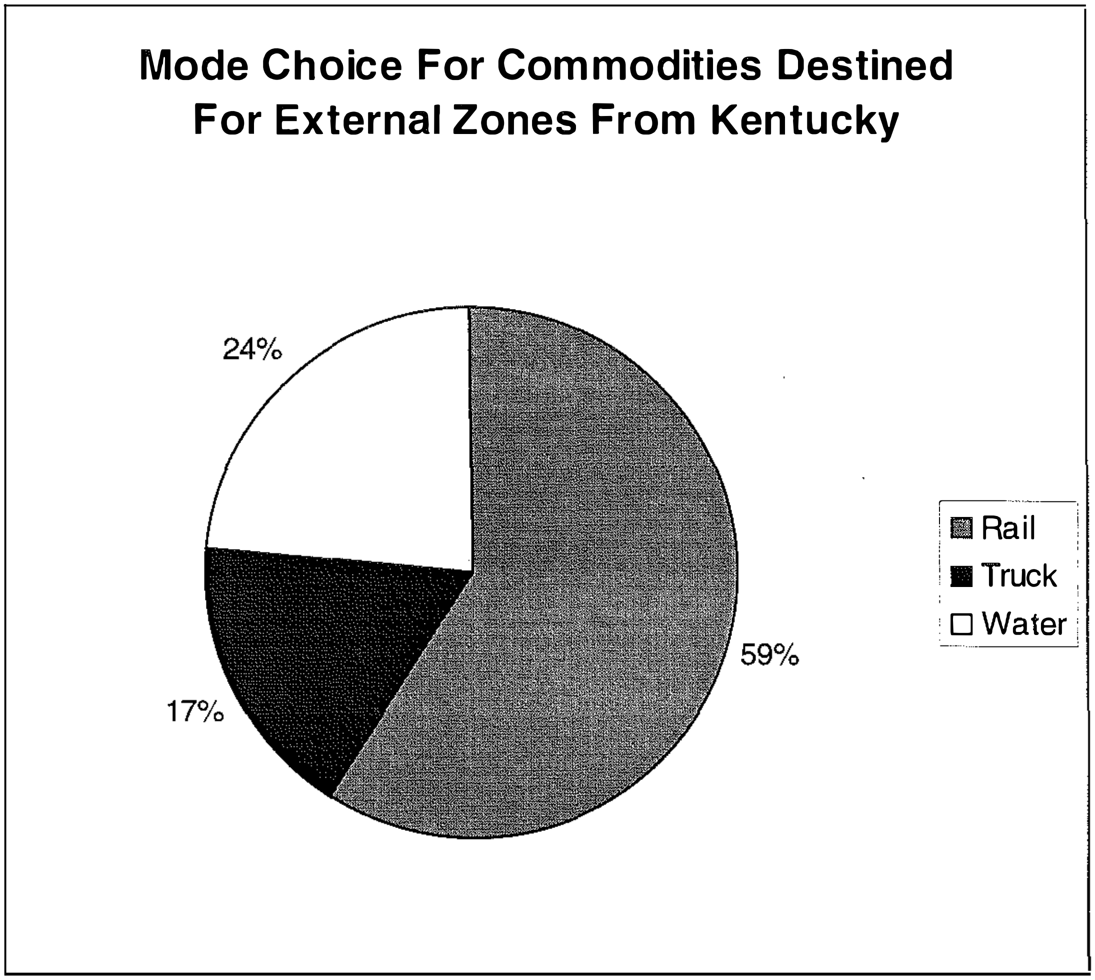


Figure 22: Mode Split for Shipments Destined for Kentucky

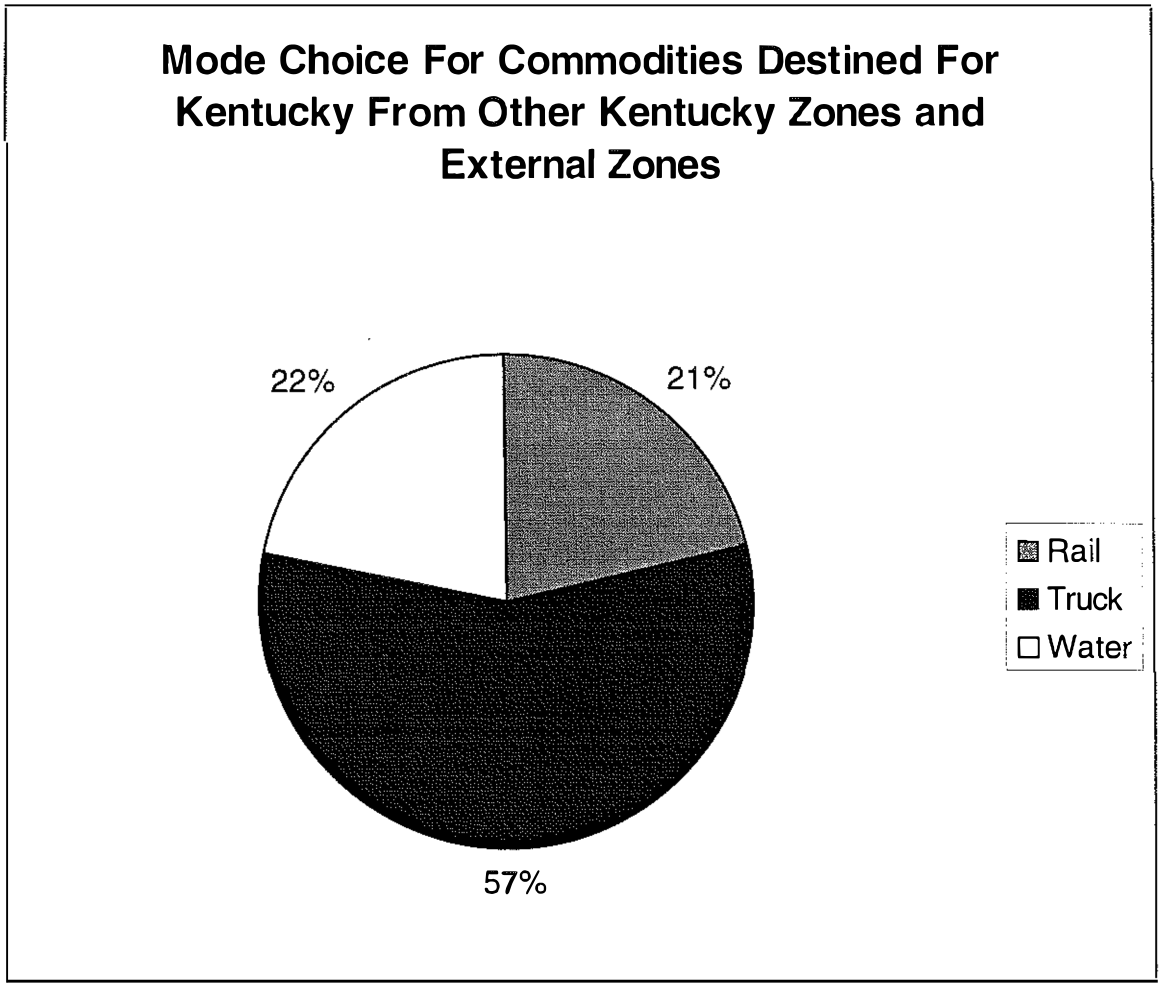


Figure 23: Mode Split for Shipments Originating Outside Kentucky

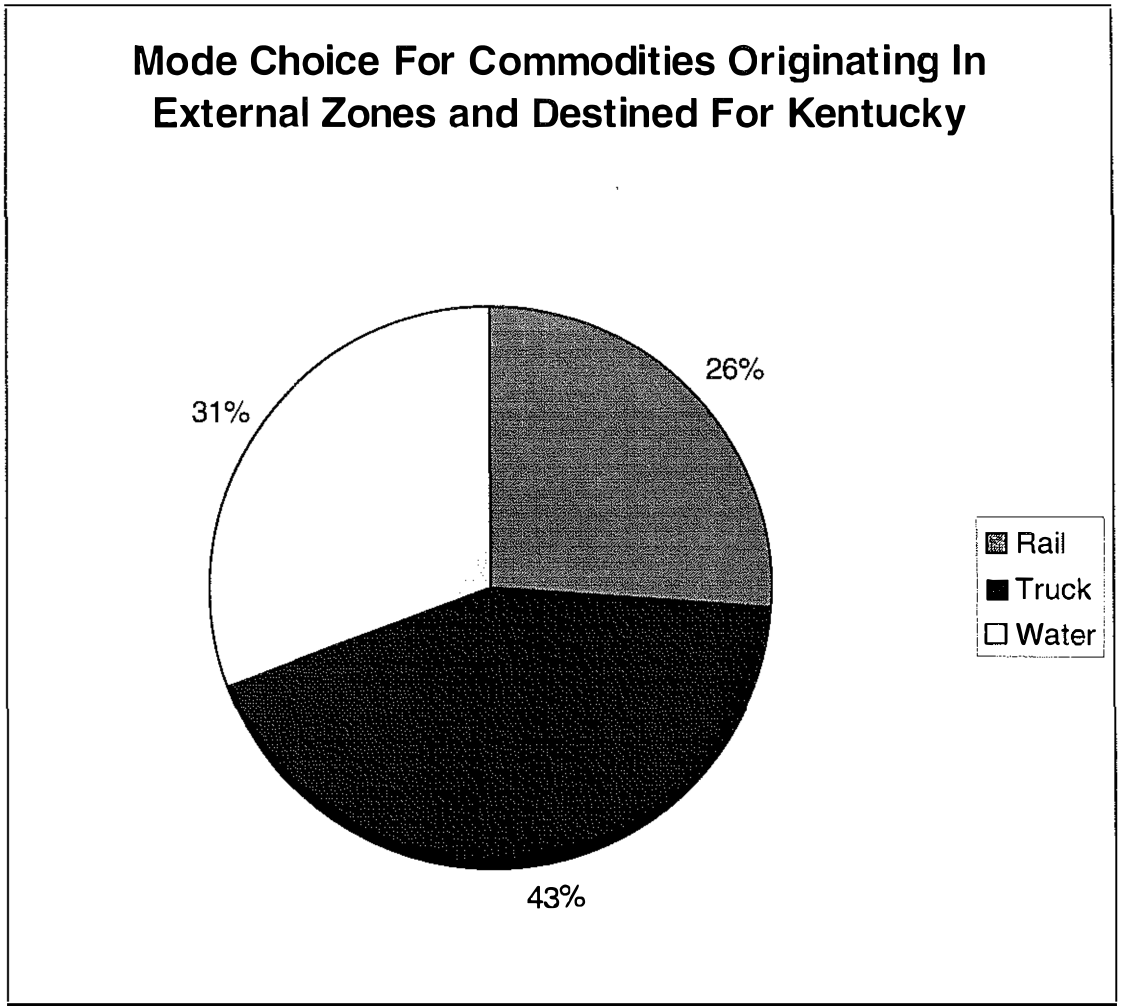


Figure 24: Mode Split of Internal Internal Freight Shipments

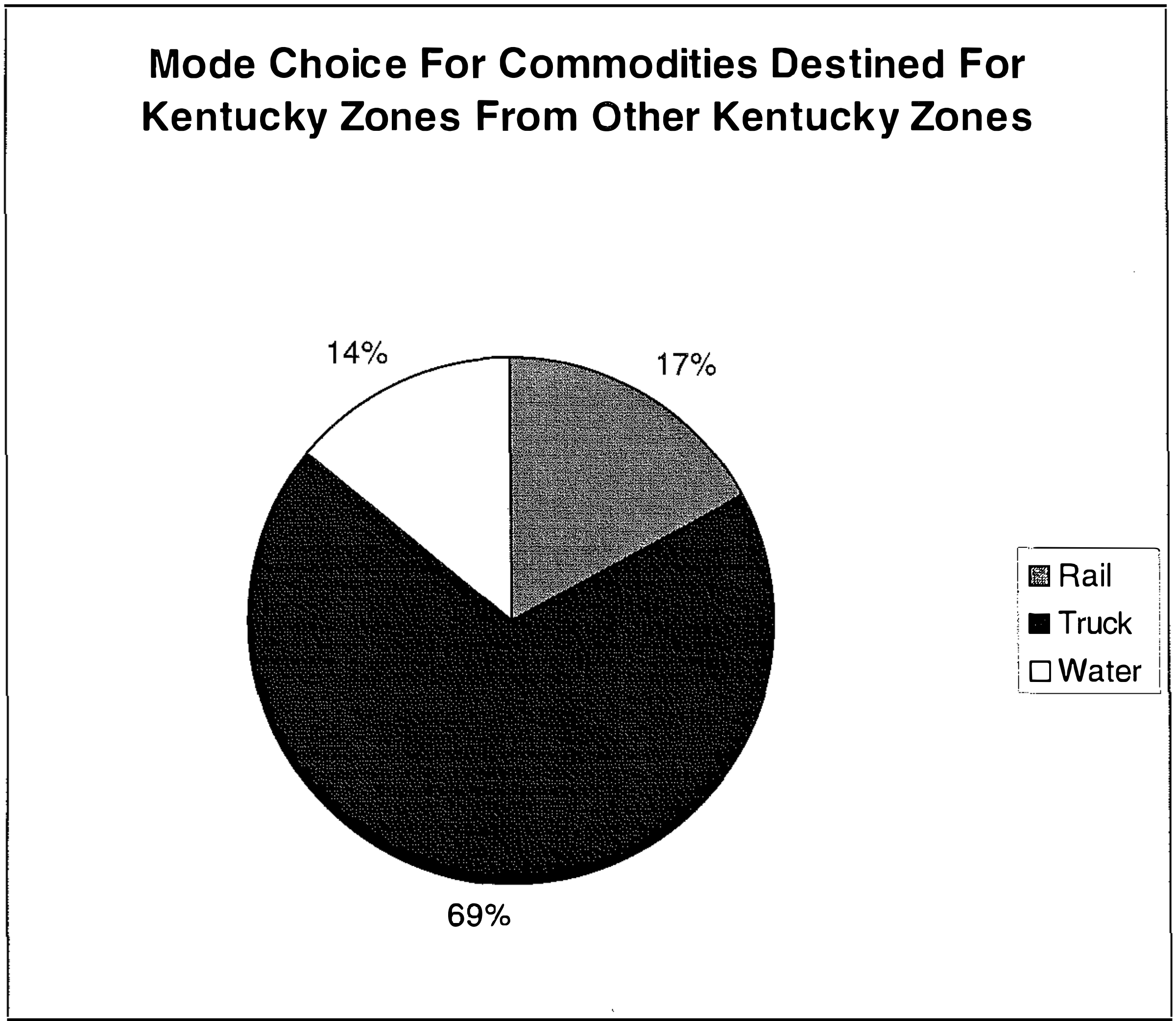


Figure 25: Commodity Tons Shipped from Kentucky Zones by Water

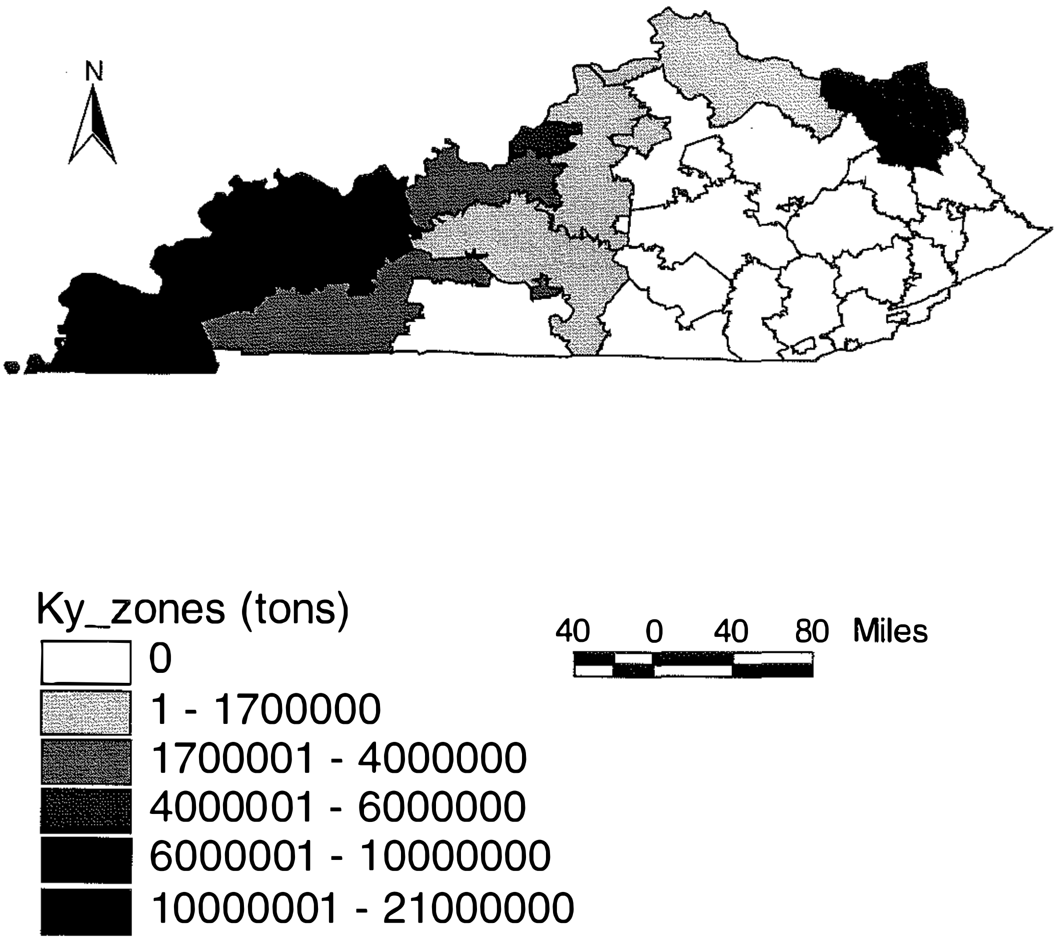


Figure 26: Commodity Tons Shipped from Kentucky Zones by Rail

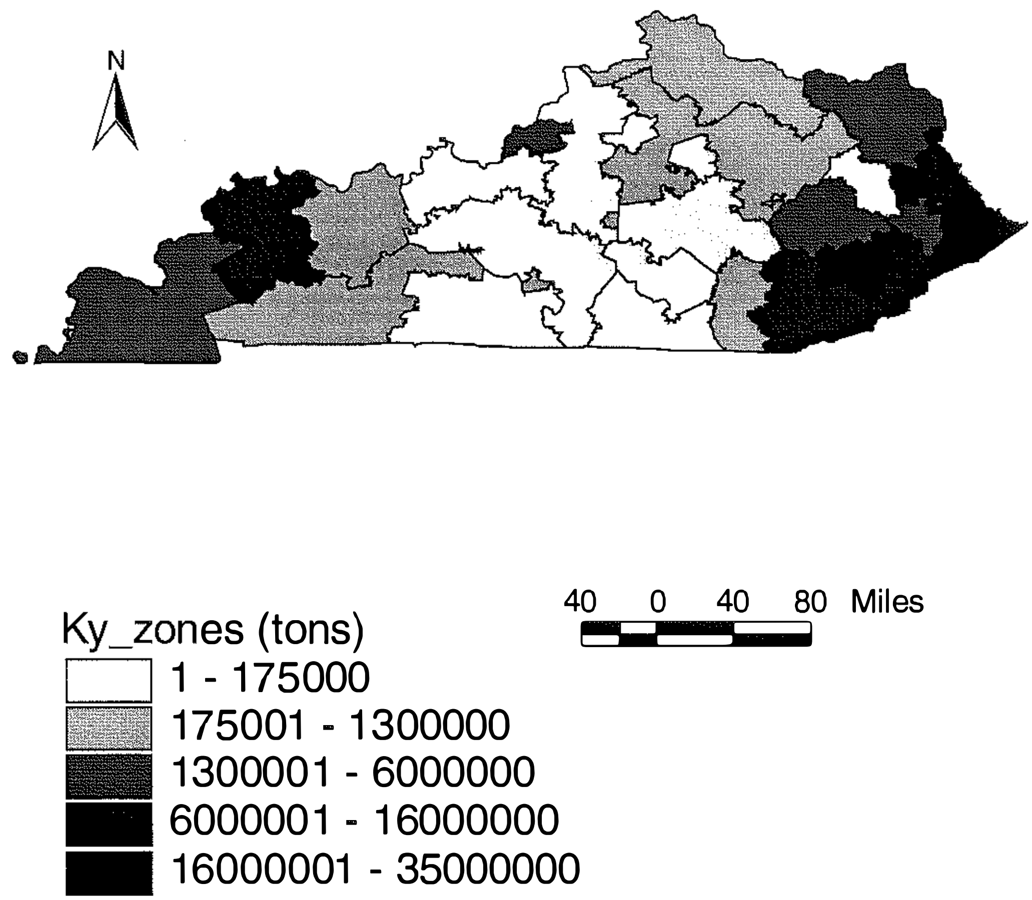


Figure 27: Truck Equivalents per Year of Substitutable Freight Destined for Kentucky Zones

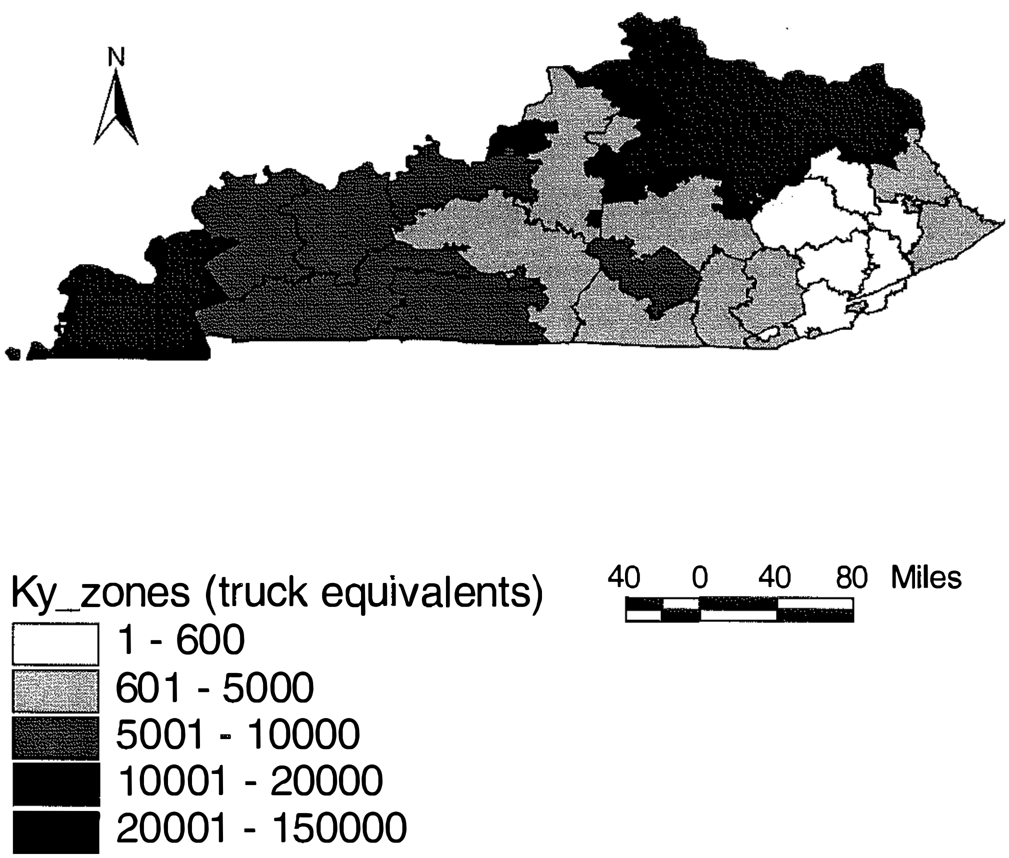


Figure 28: Truck Equivalents per Year of Substitutable Freight Originating in Kentucky

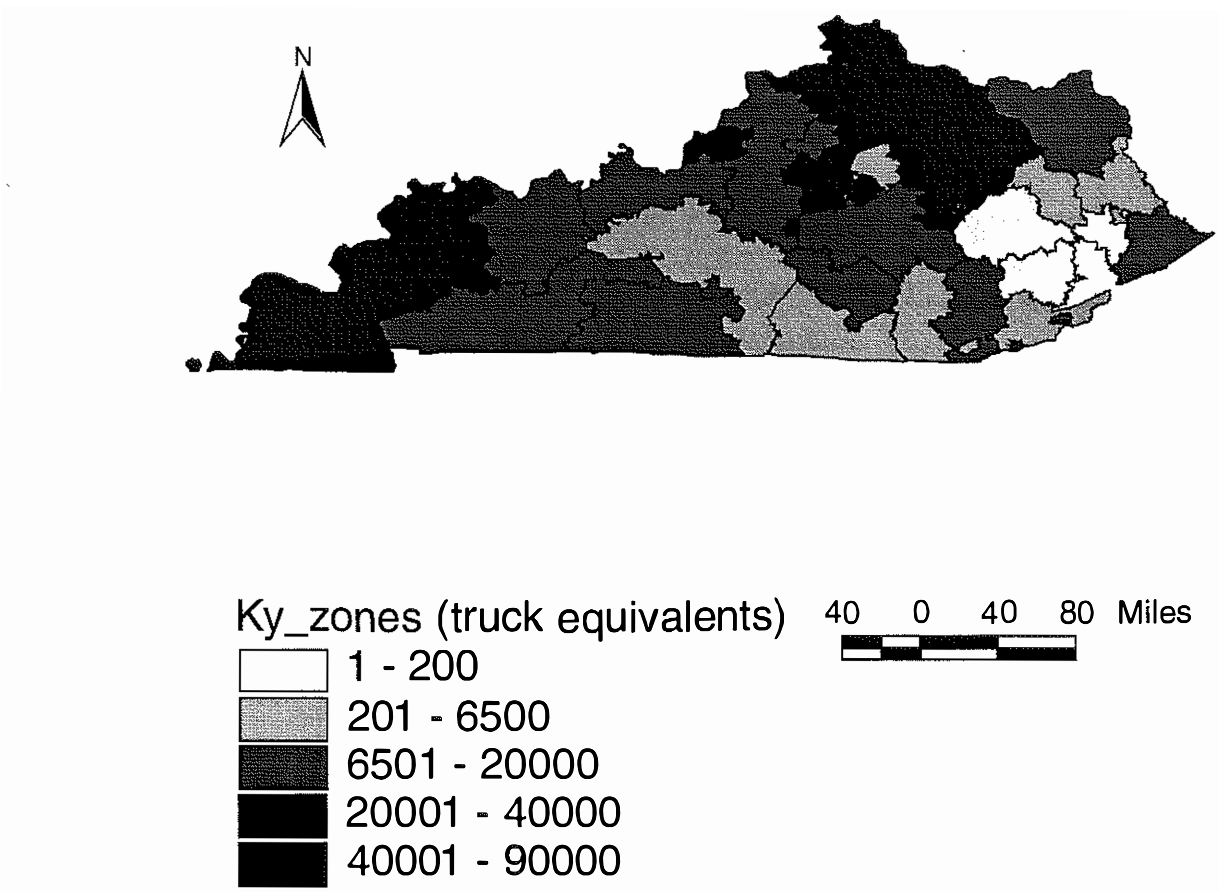
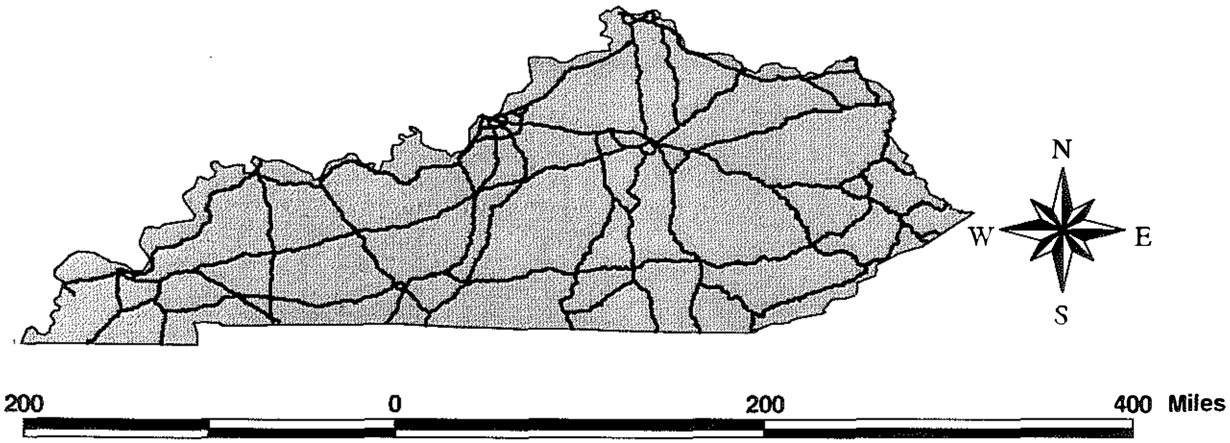


Figure 29: Internal Links for Network Model



Highways in network: all Interstates, all parkways, US45, US68, US60, KY80, US41A, US31W, US31E, US27, US127, KY9, US23, US119, US25E, US460, KY114, KY90

Figure 30: Total Trucks per Year from Commodity Assignment Model

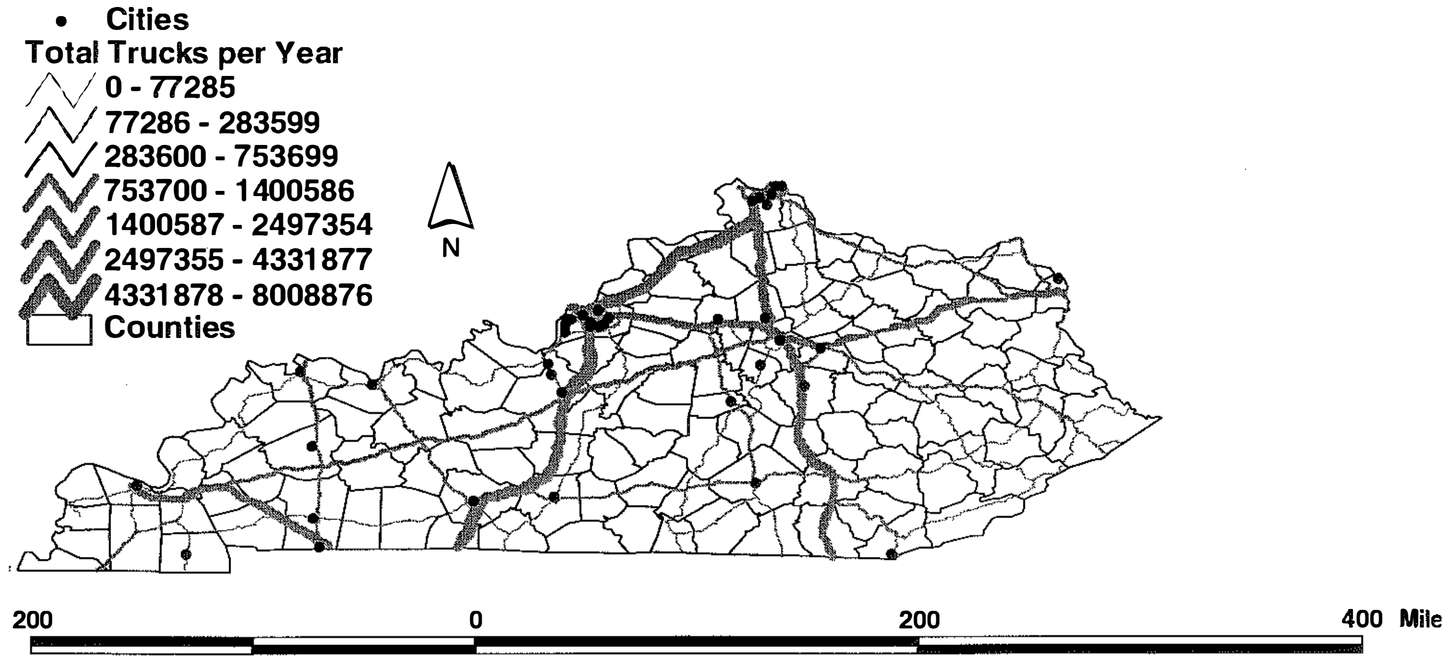


Figure 31: Total Internal-Internal, Internal-External and External-Internal Truck Flows per Year from Commodity Assignment Model

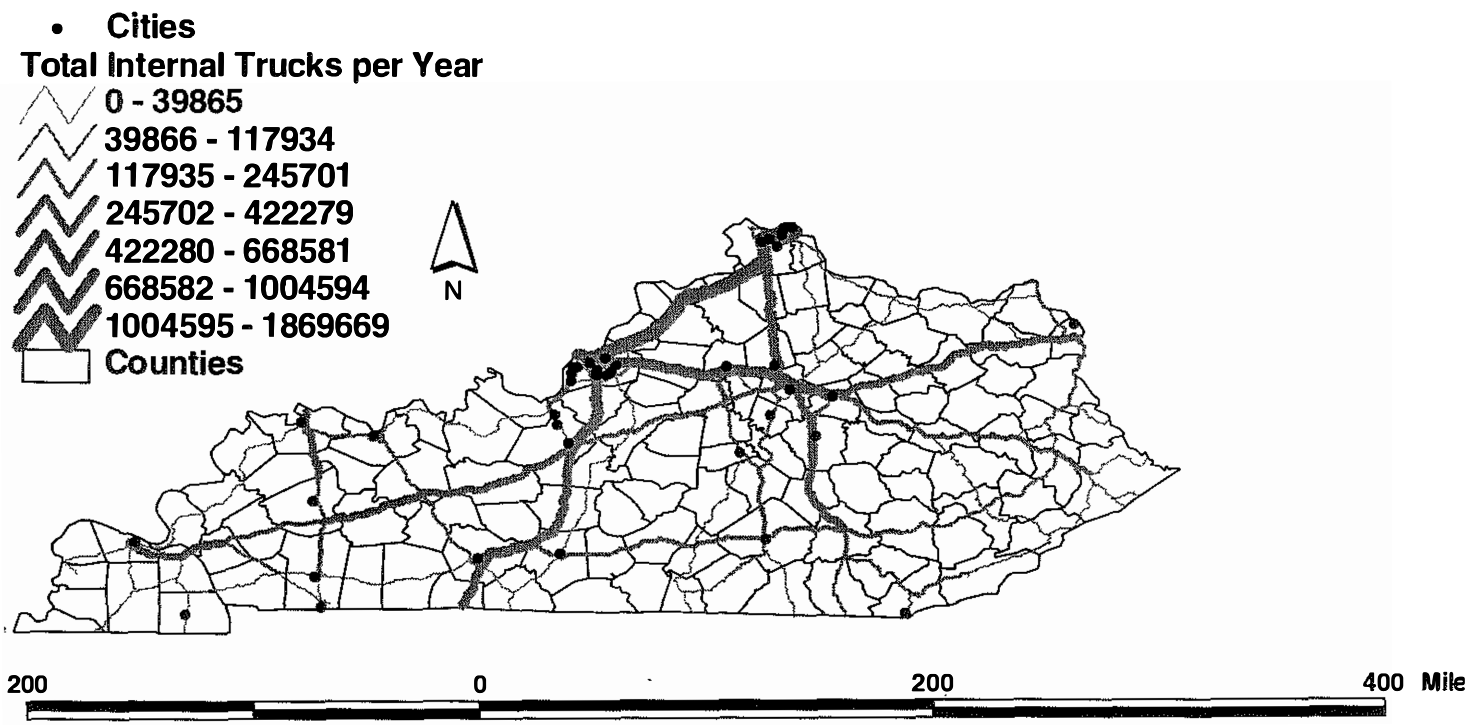


Figure 32: Total External-External Truck Flows per Year from Commodity Assignment Model

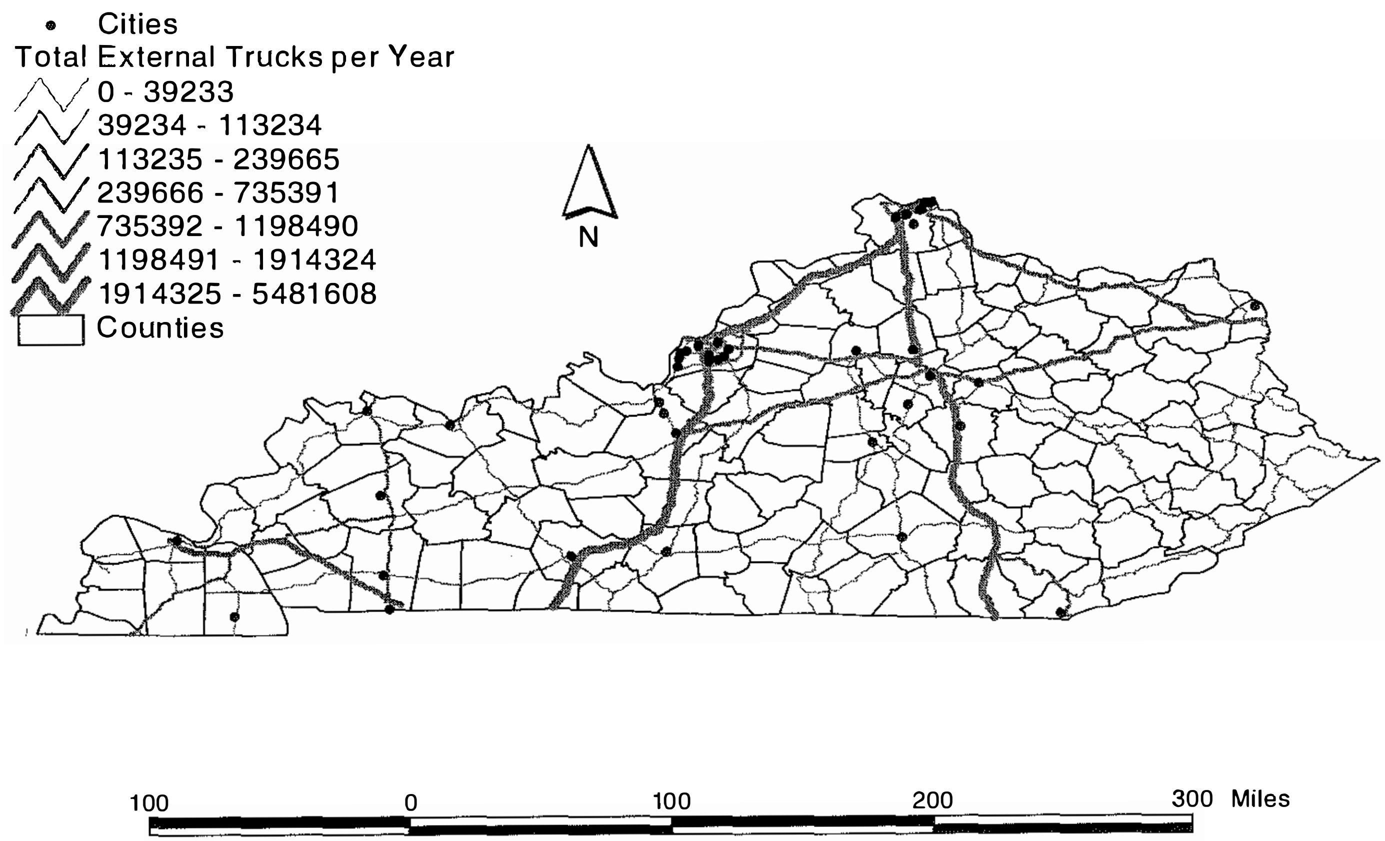


Figure 33: Percent External-External Trucks from Commodity Assignment Model

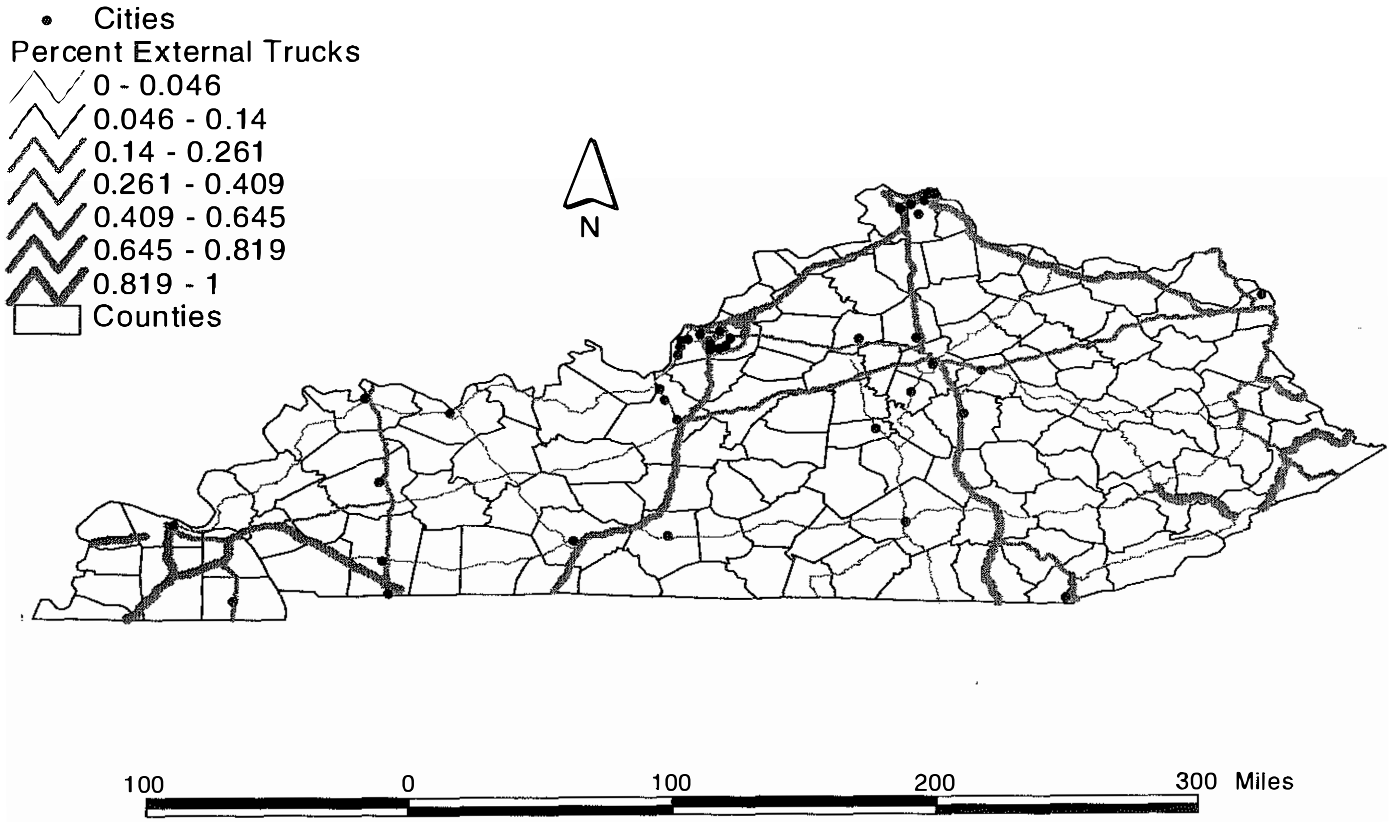


Figure 34: Roads with Over 75% External-External Trucks per Year from Commodity Assignment Model

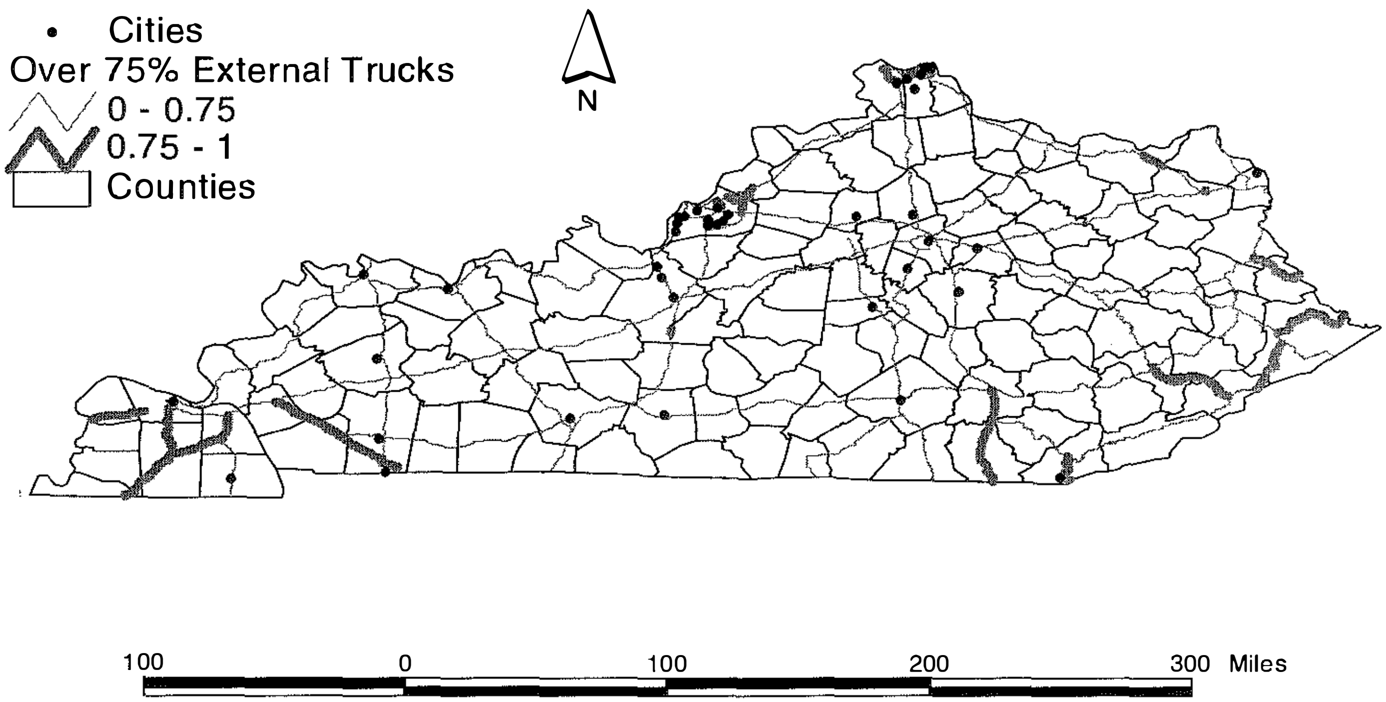


Figure 35: Total Raw Material Truck Flows per Year from Commodity Assignment Model

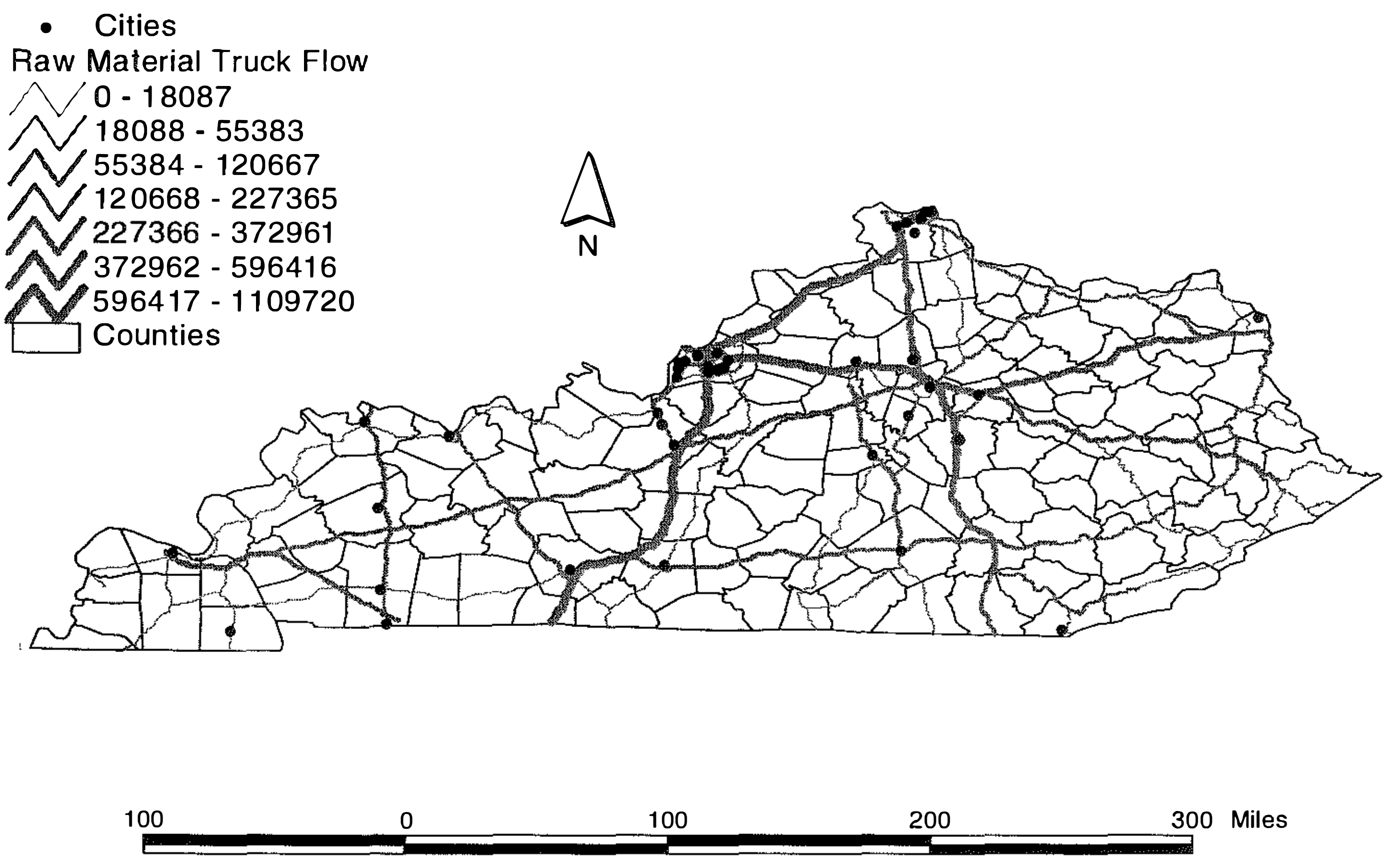


Figure 36: Total Coal Truck Flows per Year from Commodity Assignment Model

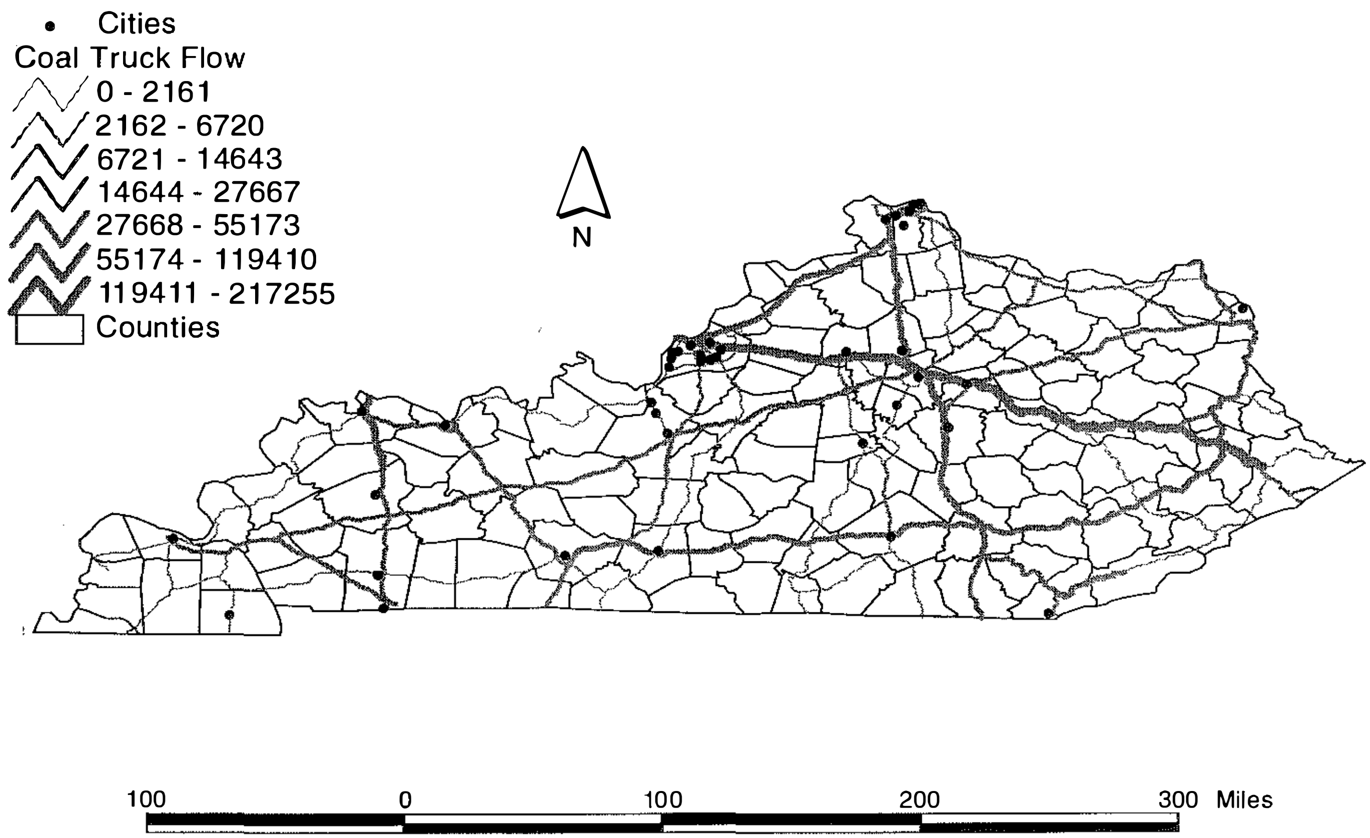


Figure 37: Raw Material Internal-Internal, Internal-External and External-Internal Truck Flows per Year from Commodity Assignment Model

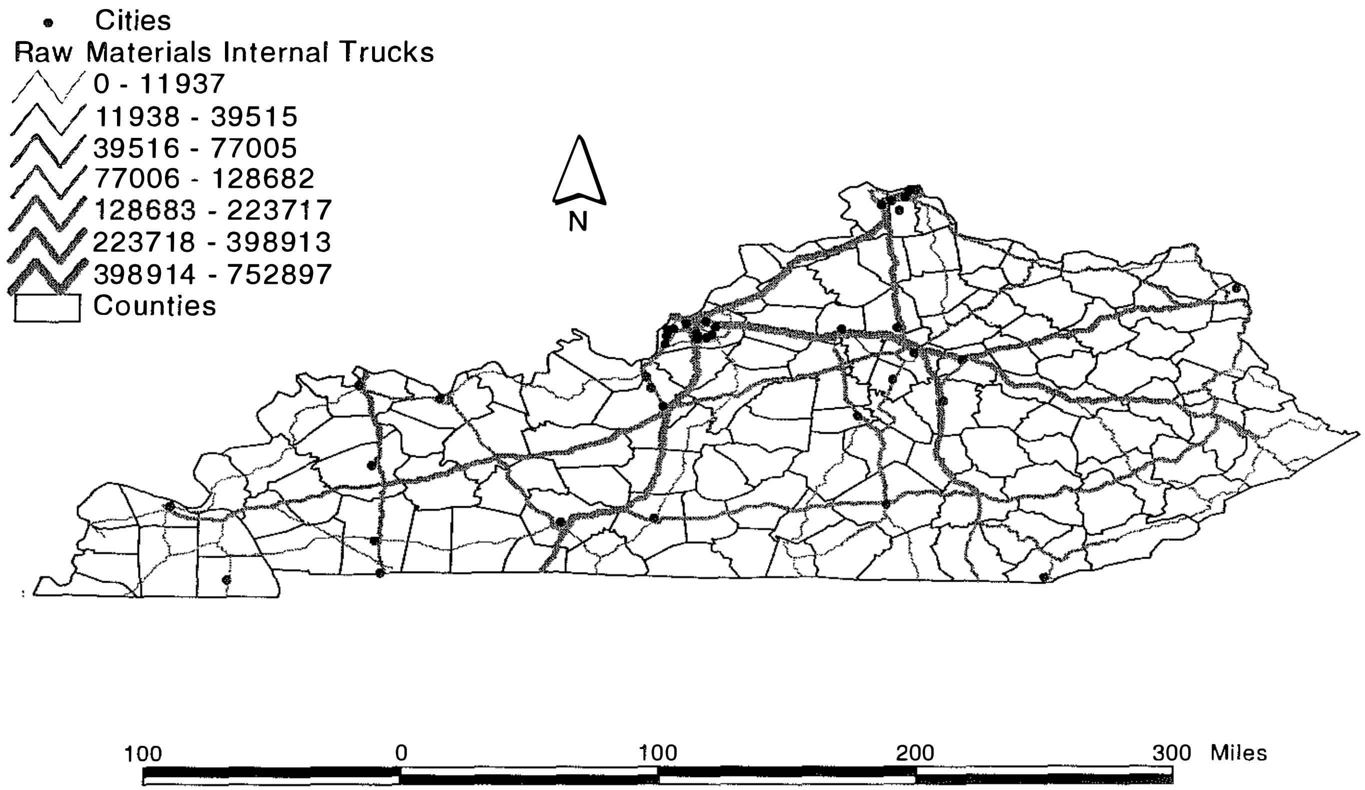


Figure 38: Coal Internal-Internal, Internal-External and External-Internal Truck Flows per Year from Commodity Assignment Model

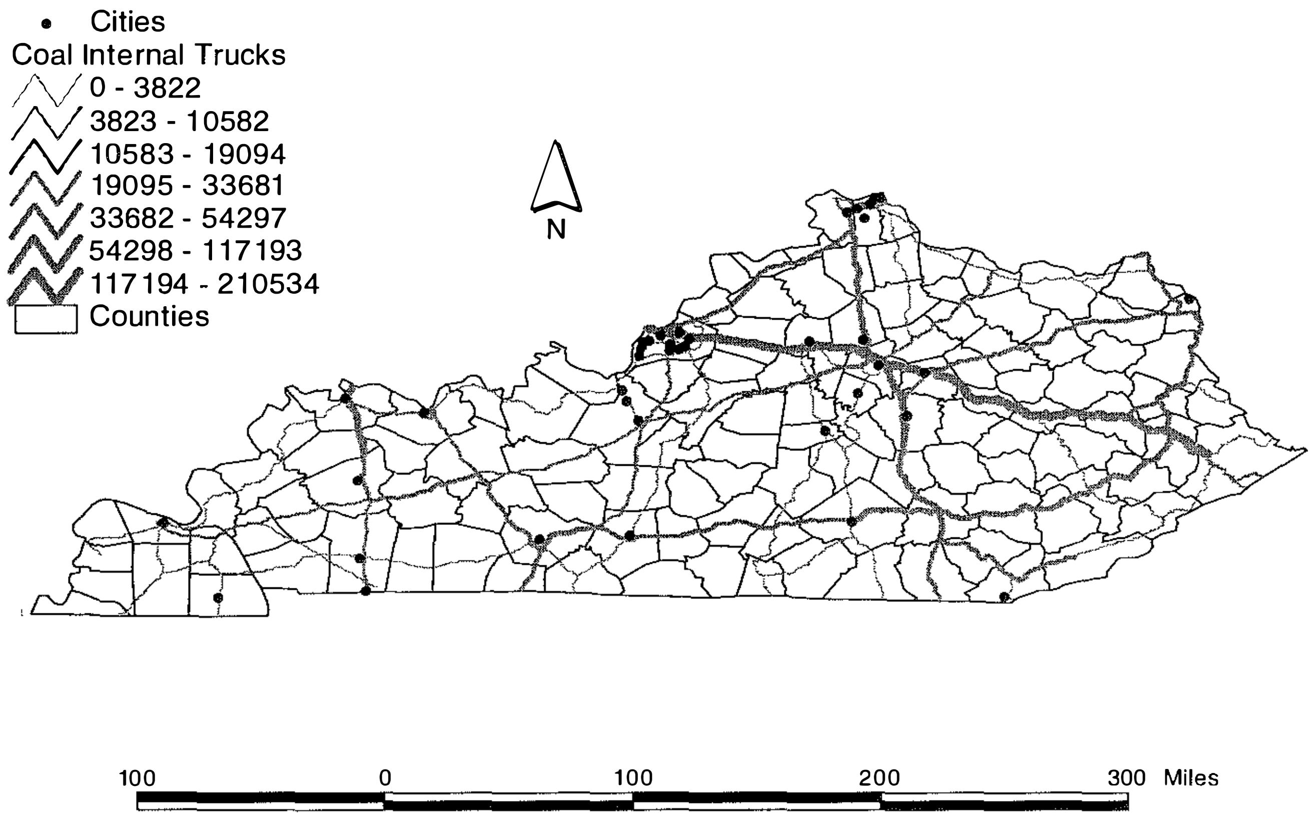


Figure 39: Total Manufactured Goods Truck Flows per Year from Commodity Assignment Model

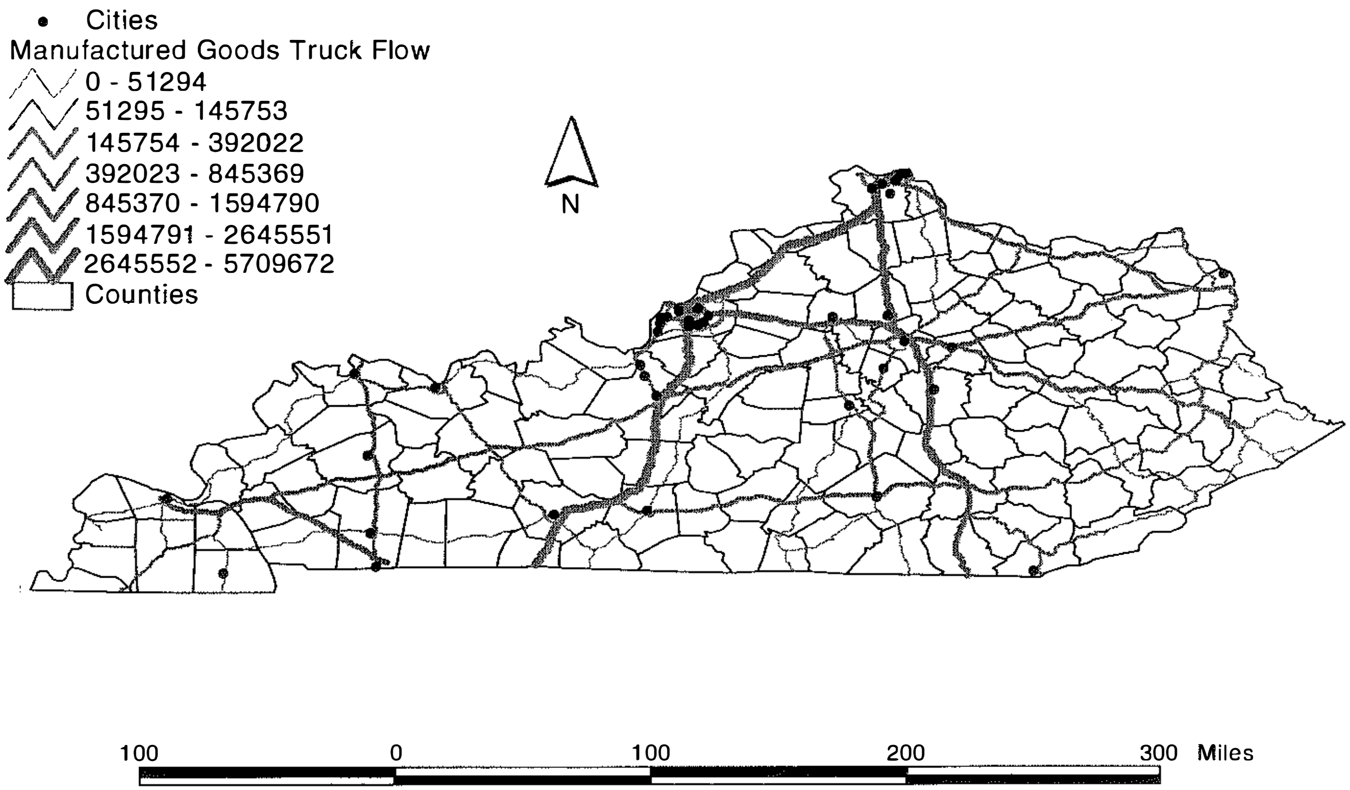


Figure 40: Manufactured Goods Internal-Internal, Internal-External and External-Internal Truck Flows per Year from Commodity Assignment Model

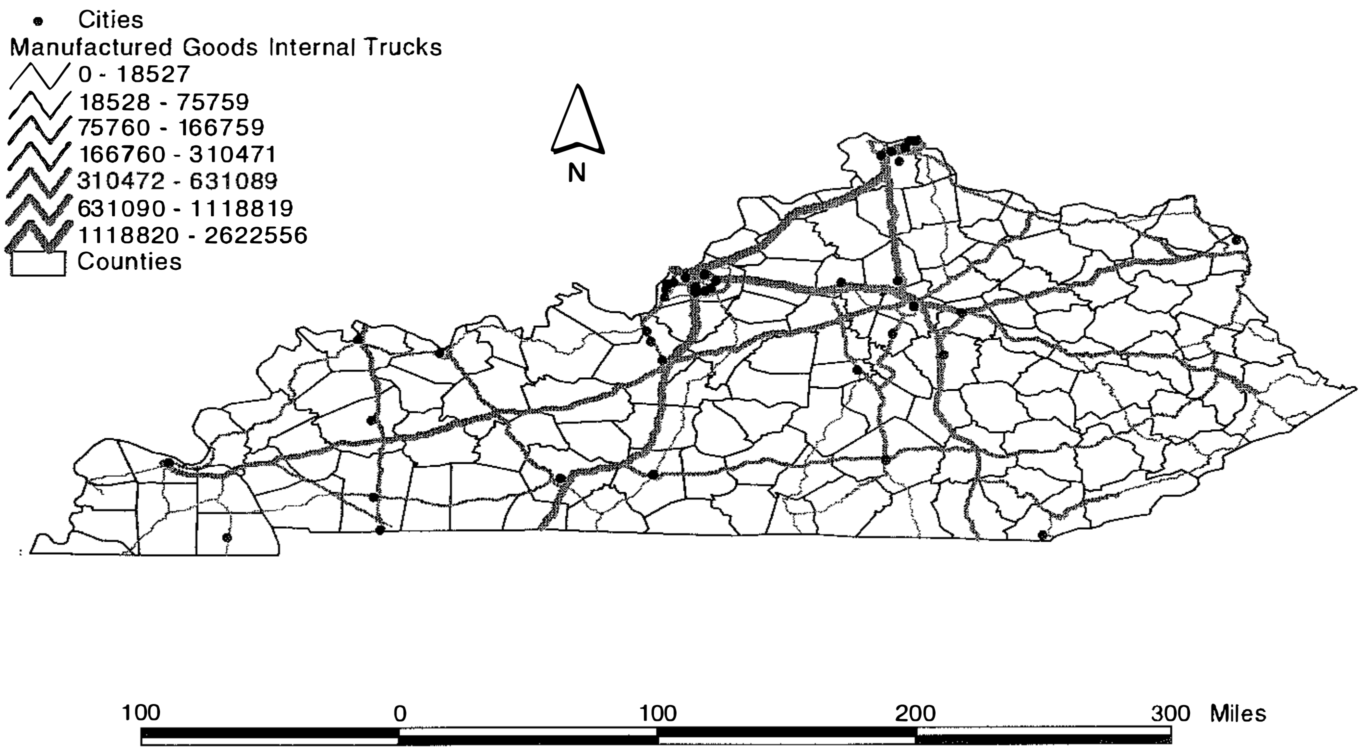


Figure 41: Total Probable Hazmat Truck Flows per Year from Commodity Assignment Model

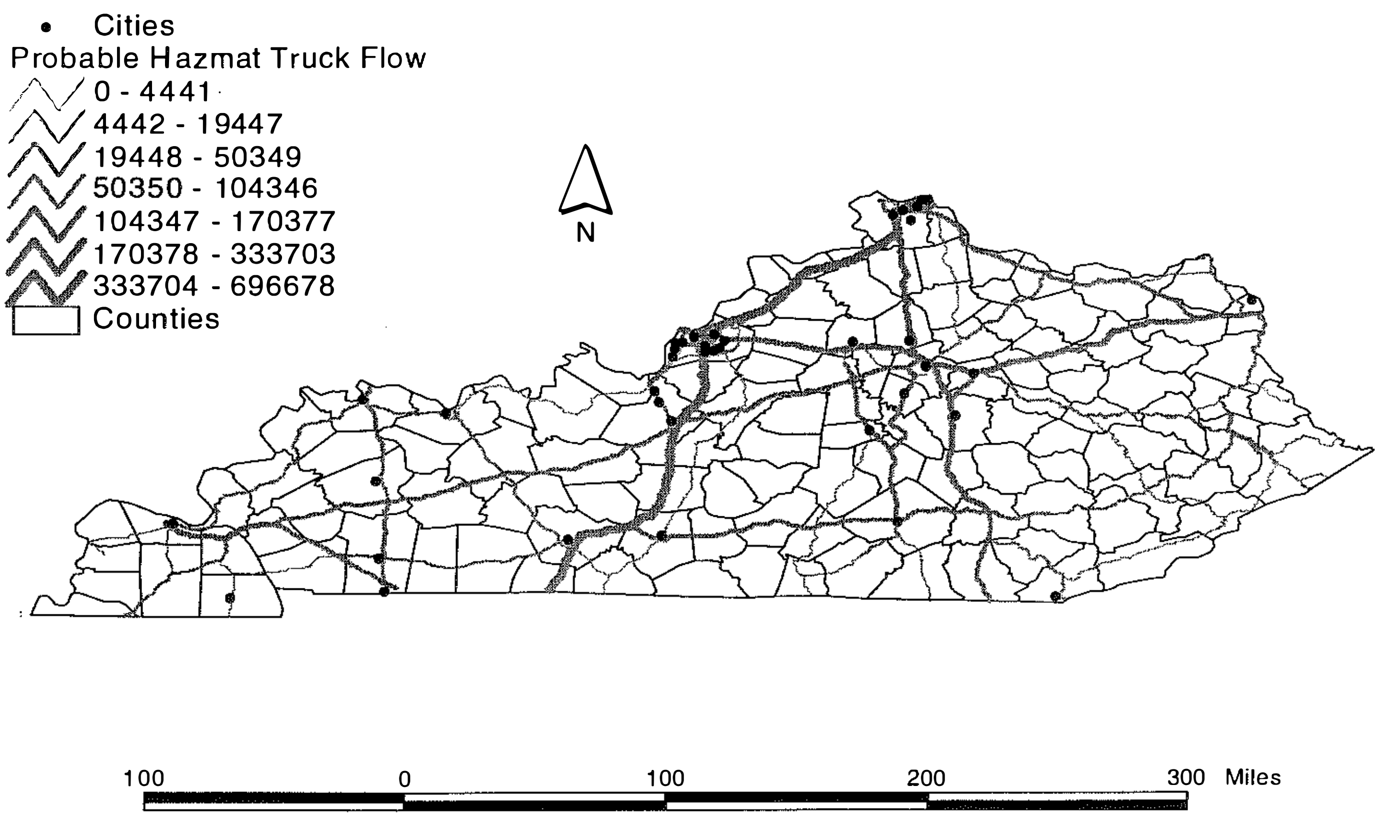


Figure 42: Probable Hazmat Internal-Internal, Internal-External and External-Internal Truck Flows per Year from Commodity Assignment Model

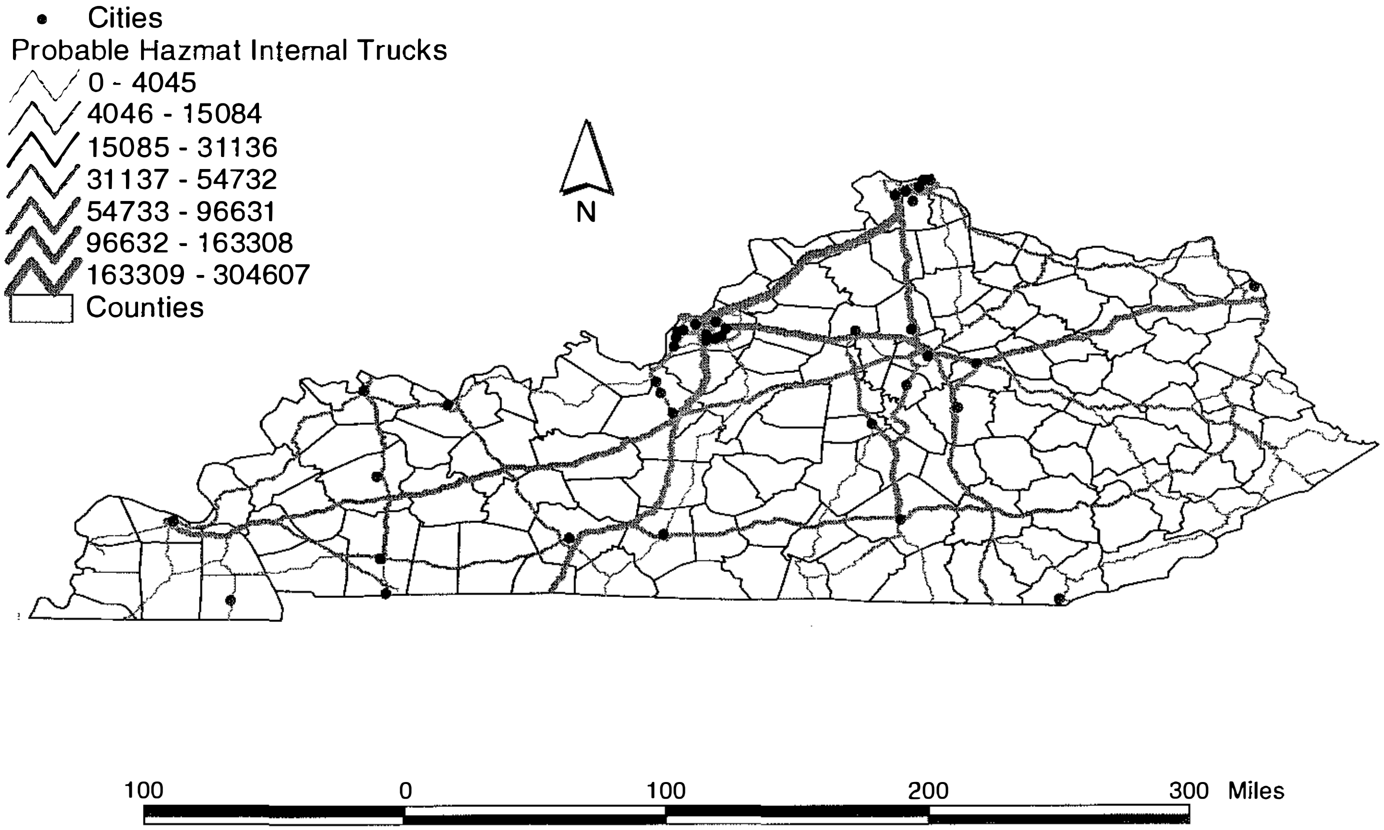


Figure 43: Total Warehouse and Distribution Truck Flows per Year from Commodity Assignment Model

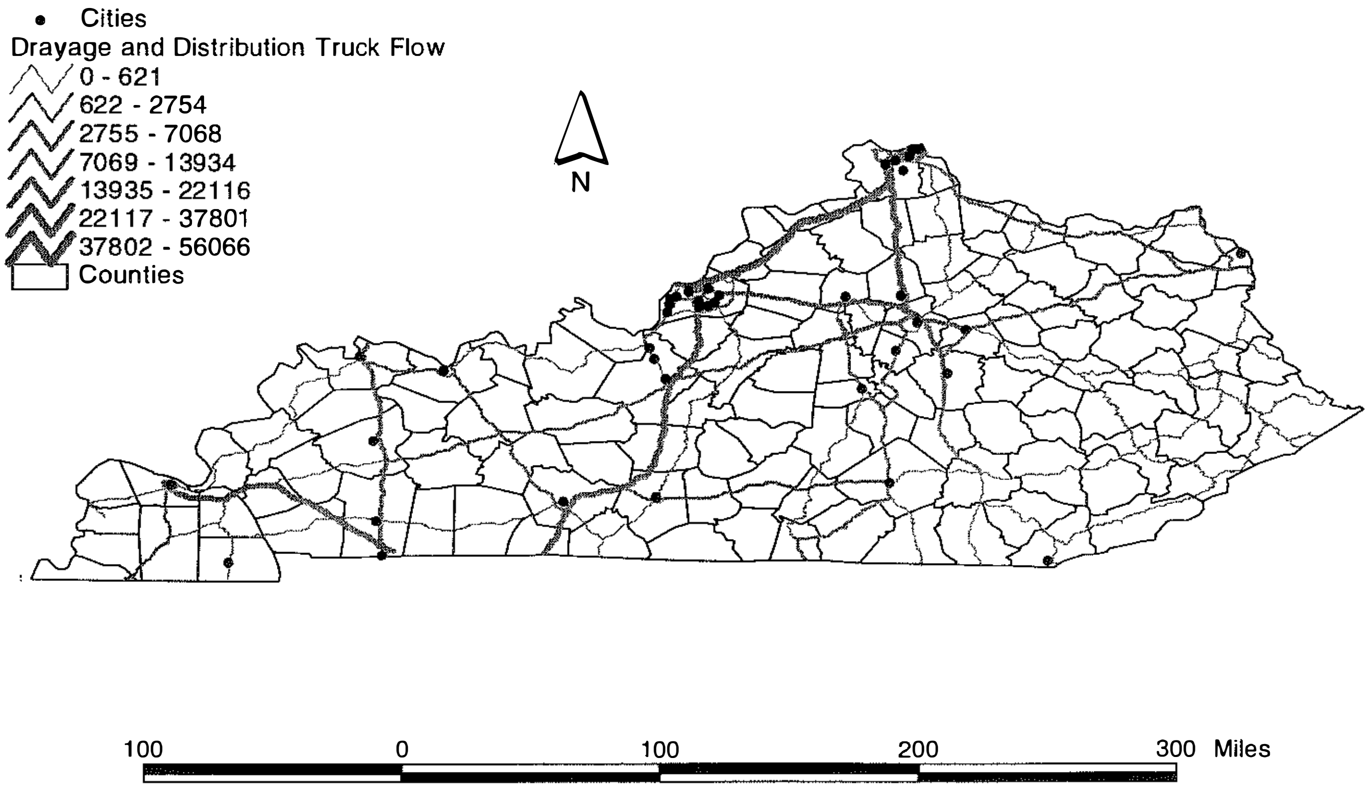


Figure 44: Warehouse and Distribution Internal-Internal, Internal-External and External-Internal Truck Flows per Year from Commodity Assignment Model

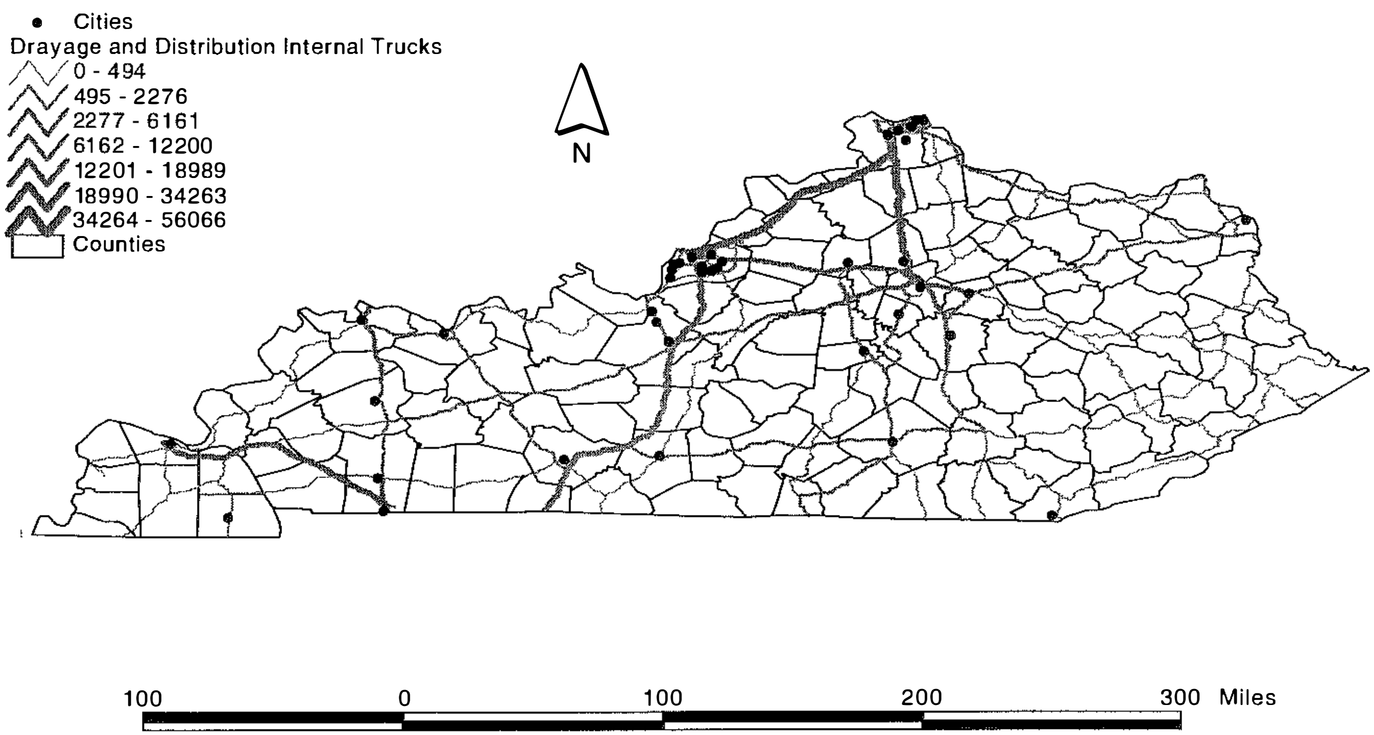


Figure 45: Total Agricultural Truck Flows per Year from Commodity Assignment Model

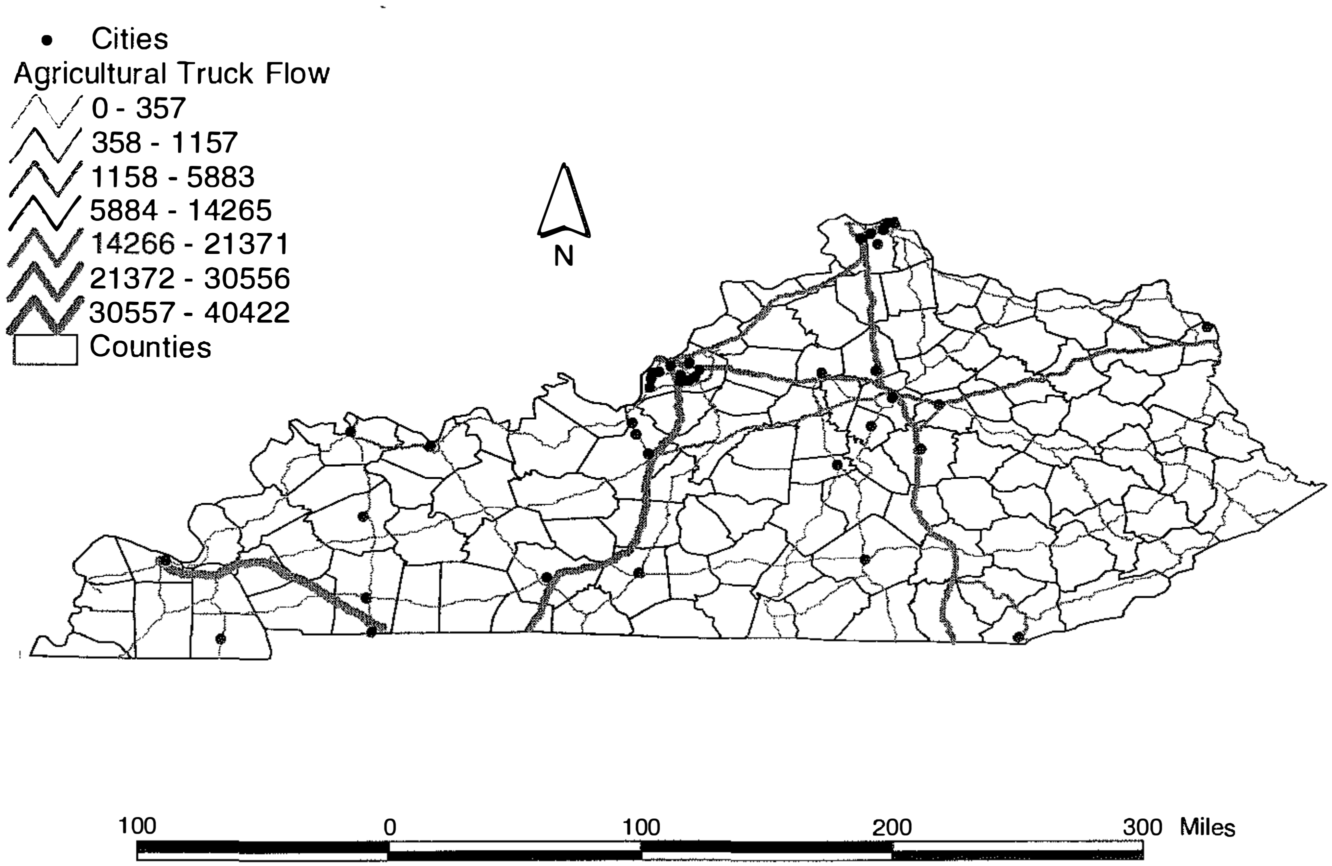


Figure 46: Agricultural Internal-Internal, Internal-External and External-Internal Truck Flows per Year from Commodity Assignment Model

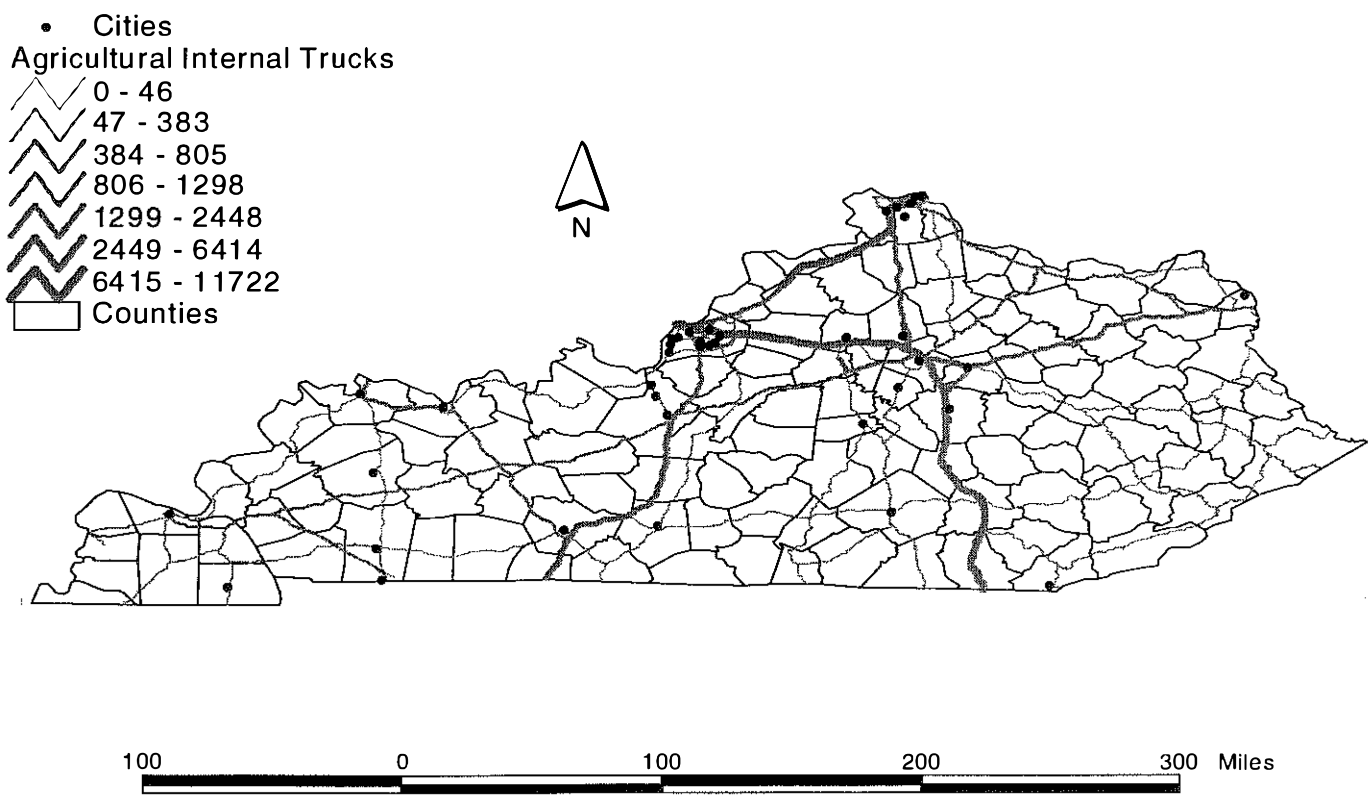


Figure 47: Percent Trucks Hauling Raw Materials from Commodity Assignment Model

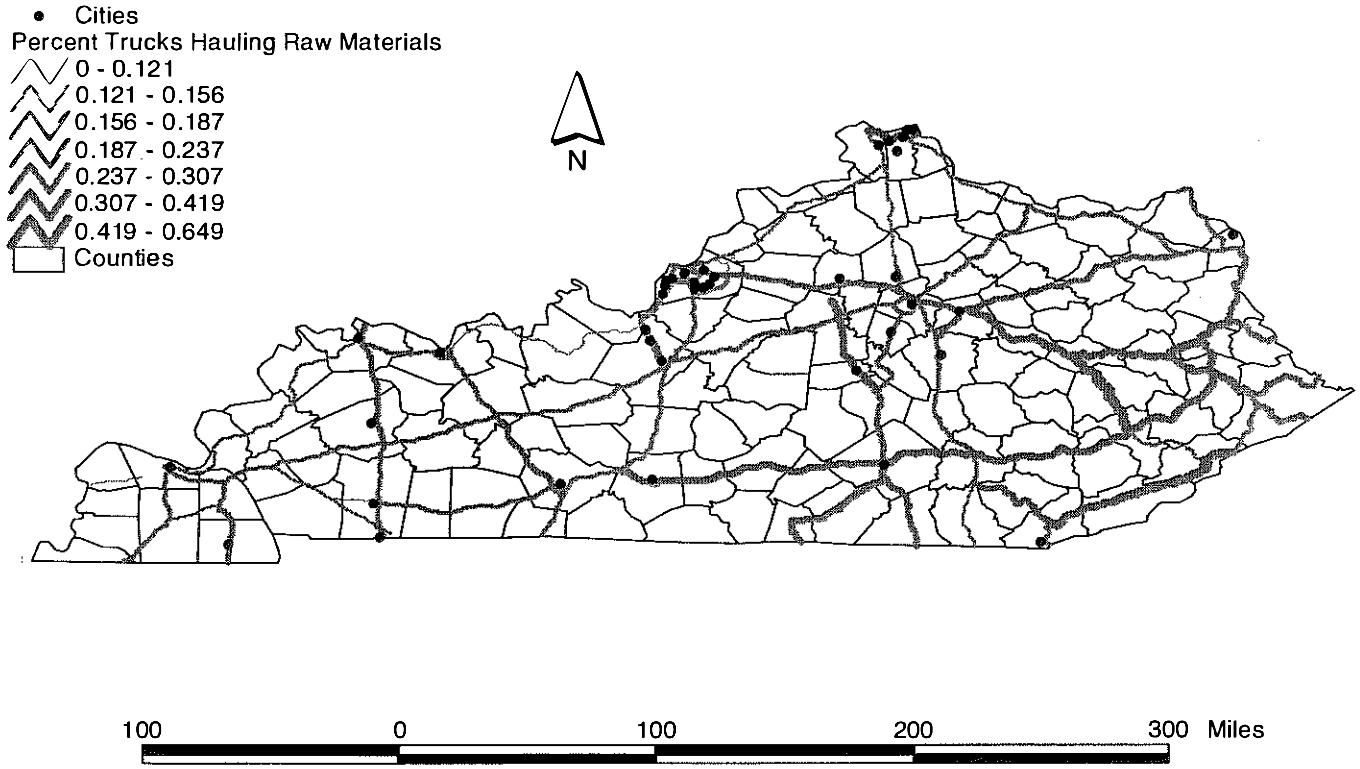


Figure 48: Percent Trucks Hauling Coal from Commodity Assignment Model

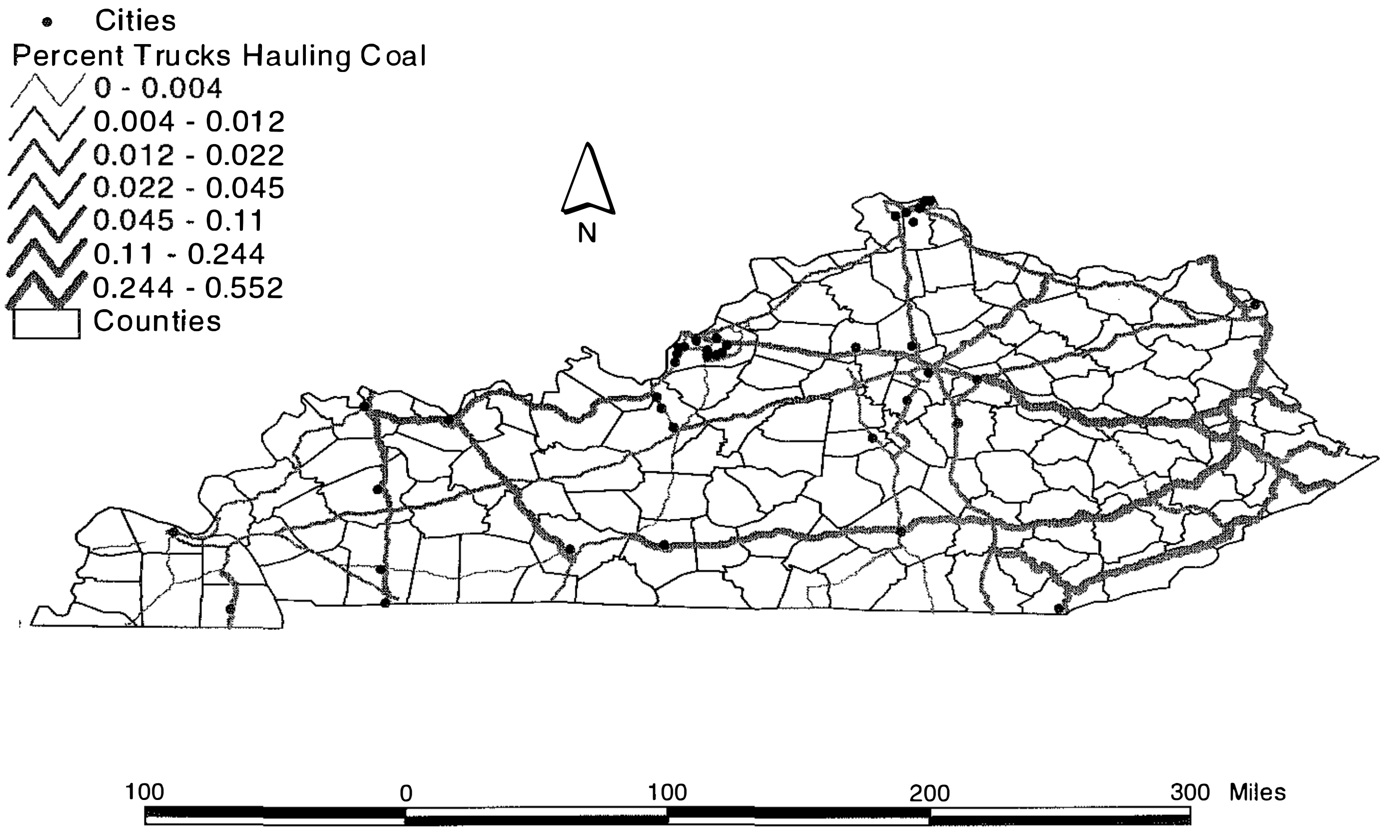


Figure 49: Percent Trucks Hauling Manufactured Goods from Commodity Assignment Model

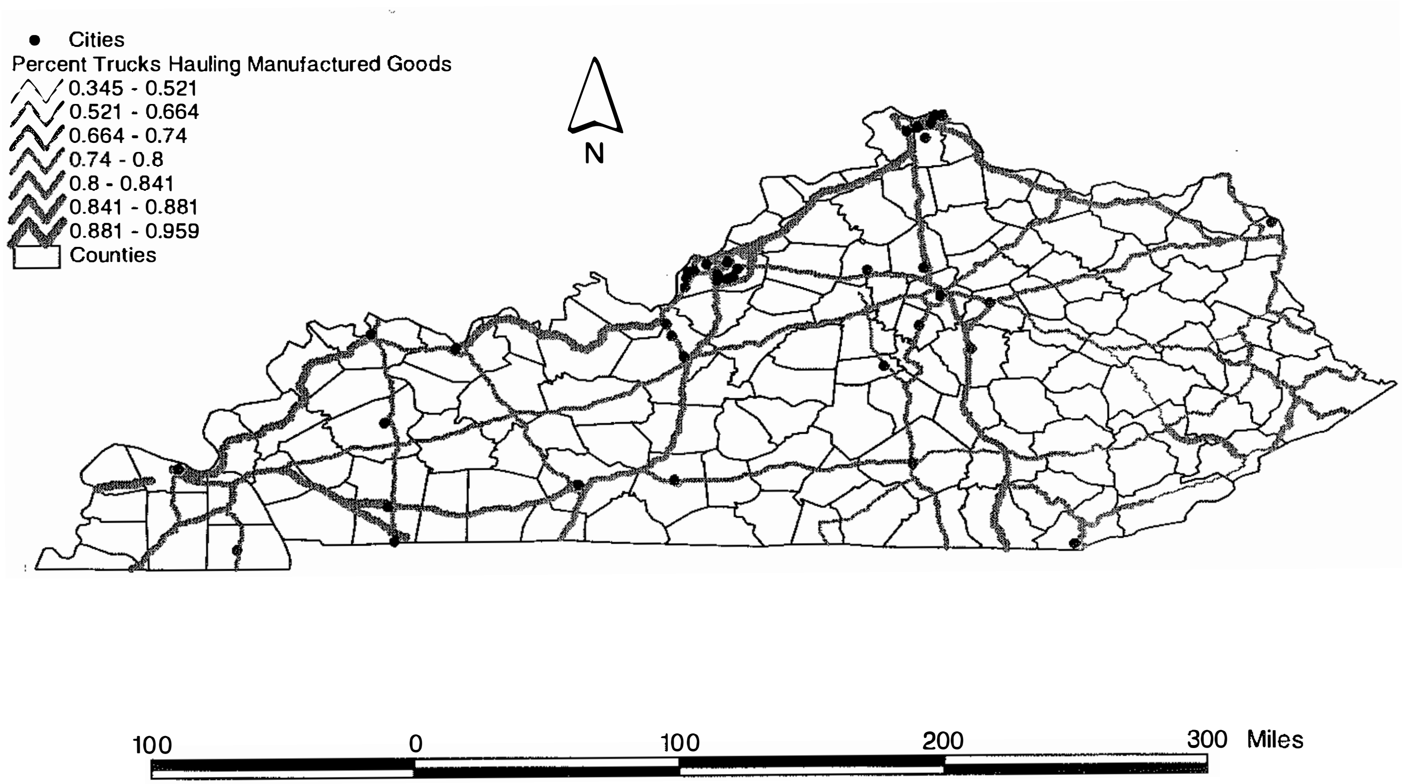


Figure 50: Percent Trucks Hauling Drayage or Distribution from Commodity Assignment Model

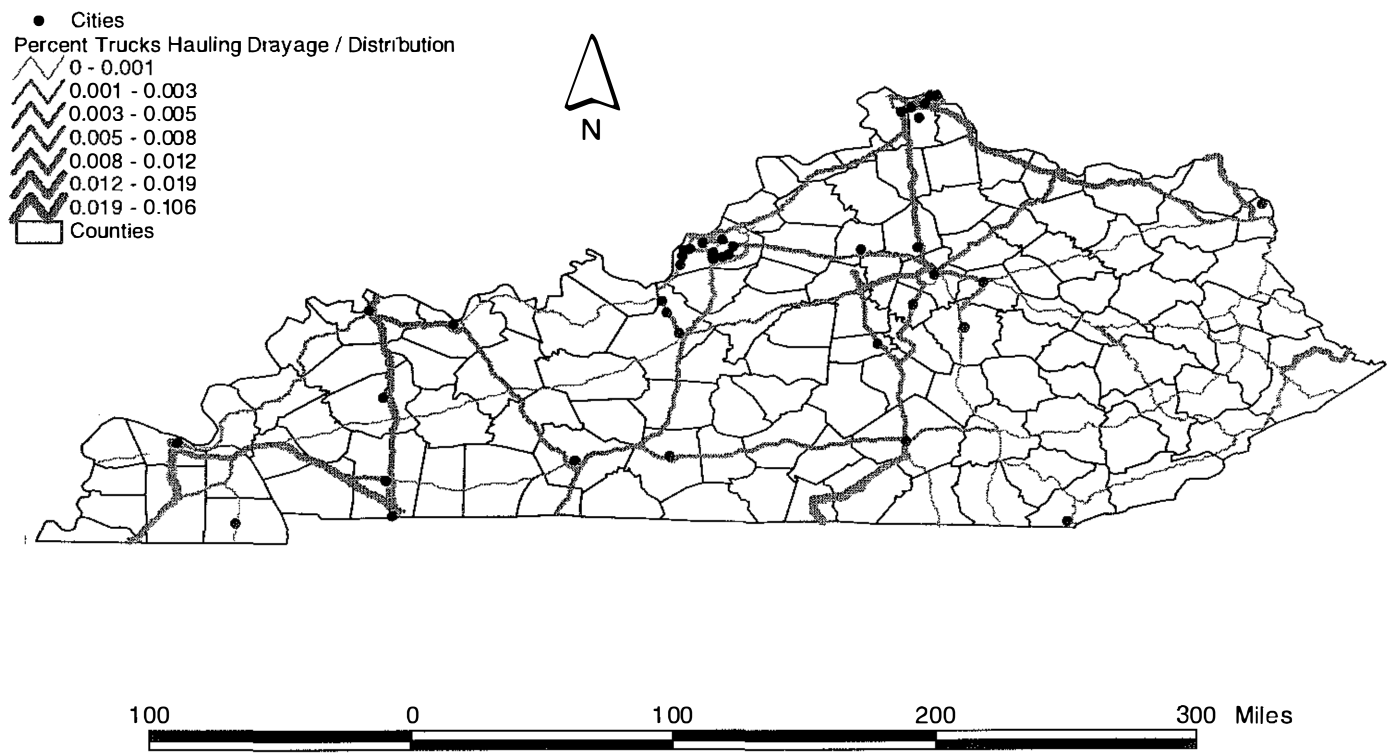


Figure 51: Percent Trucks Hauling Agricultural Products from Commodity Assignment Model

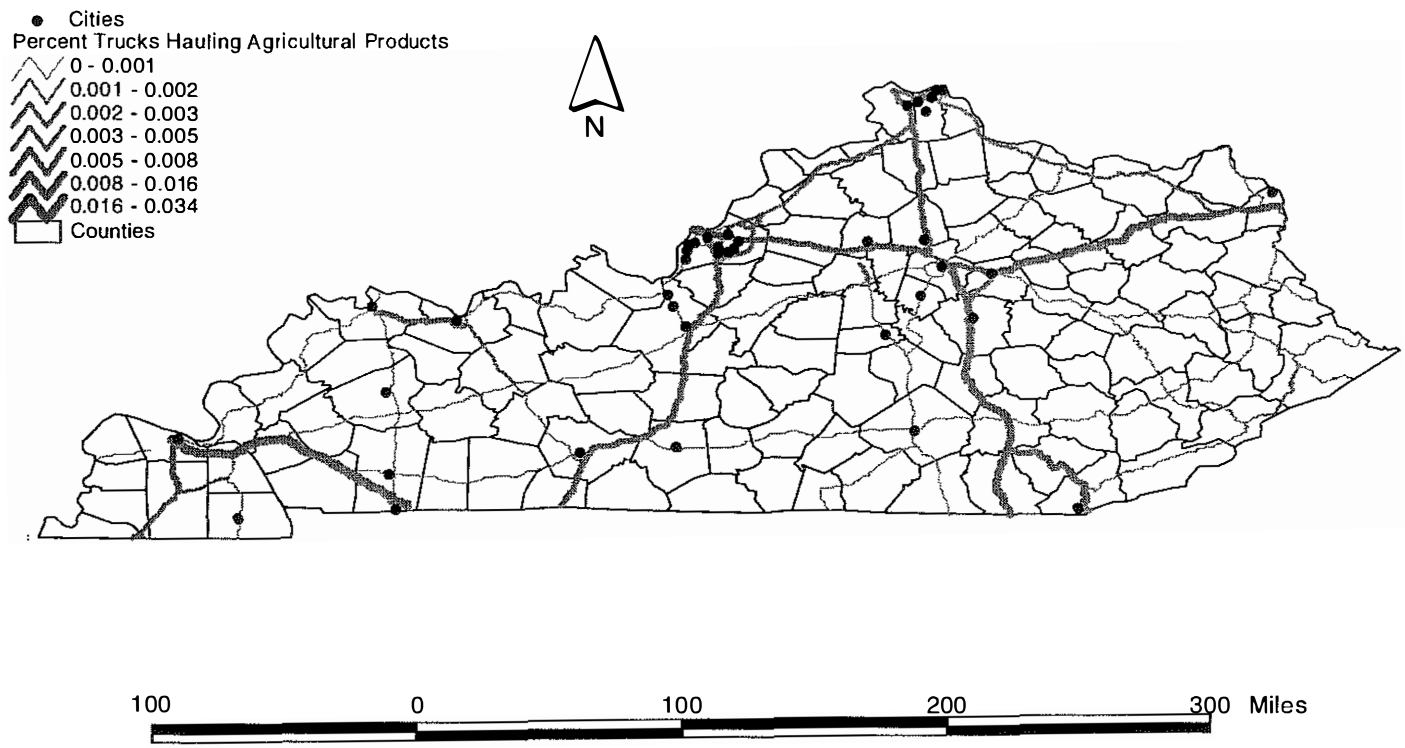
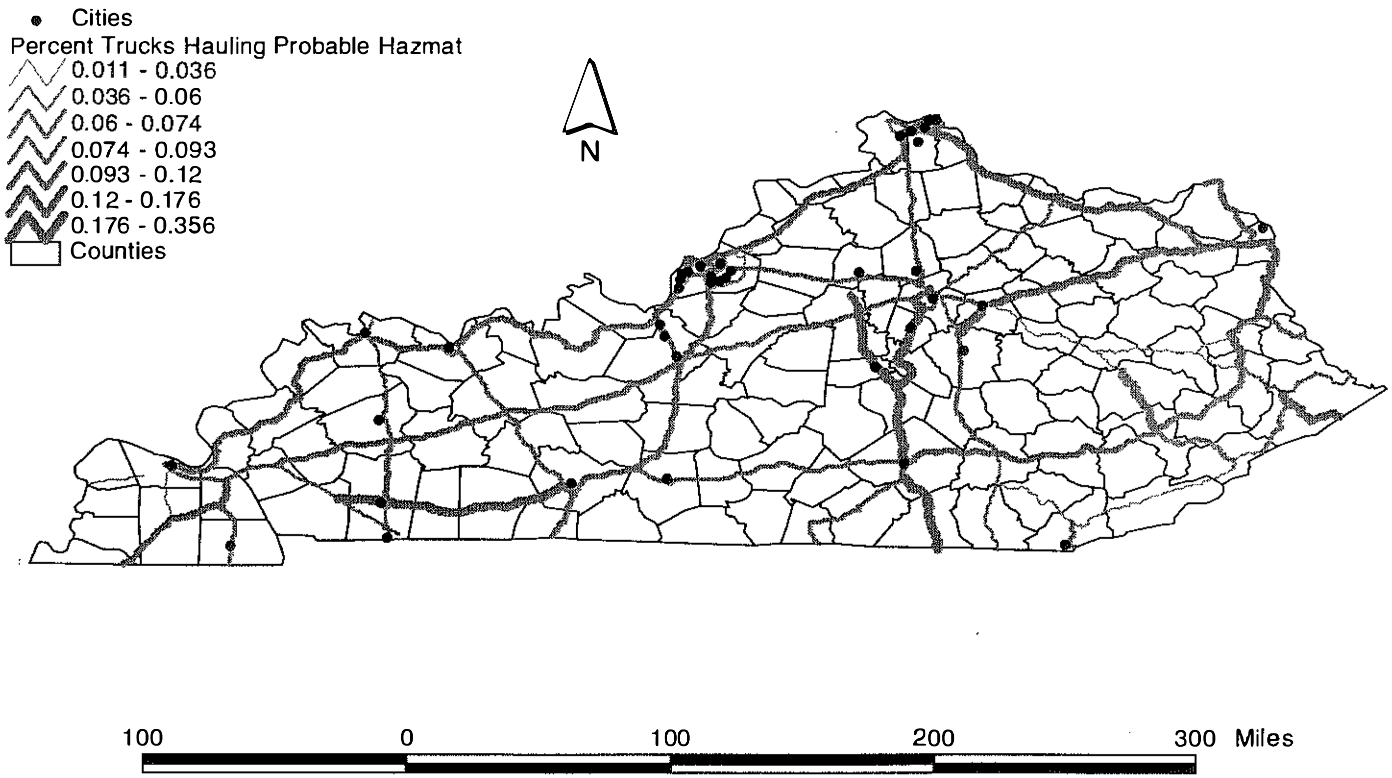


Figure 52: Percent Trucks Hauling Probable Hazmat Products from Commodity Assignment Model



Appendix A: Commodity Values Per Ton[1]

STCC2	Value Per Ton ($/ton)
1	224
8	56
9	3,693
10	136
11	21
14	12
19	25,903
20	997
21	18,803
22	4,128
23	19,249
24	191
25	4,193
26	898
28	977
29	191
30	3,348
31	21,093
32	114
33	858
34	2,795
35	12,954
36	13,630
37	7,447
38	23,080
39	9,686
40	139
41	3,903
42	1,630
48	686
Unknown	2,812

[1] From the 1993 Commodity Flow Survey – Bureau of transportation Statistics