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Impact of lock and dam closures on rail system

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DISCLAIMER

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TECHNICAL SUMMARY

Title

Impact of lock and dam closures on rail system

Introduction

In this paper, a model simulates the changing patterns of coal distribution resulting from disruptions on the waterway network at specified Ohio River locks. The paper portrays the extensive geographic and intermodal connectivity of coal shipments in the U.S., and demonstrates how disruptions at even a single node on the network can manifest in dramatic changes throughout the nationwide network.

Approach and Methodology

The network model is built using ESRI ArcMap 10.1, and utilizes the program's Network Analyst toolset. The Network Analyst toolset enables users to model data flows, in this case coal, across a network. The network is comprised of a set of lines, representing the highway, railway, and waterway segments, as well as a collection of points, representing intermodal access points, such as river ports and intermodal facilities.

Findings

Results presented in the paper are specific to changes in volumes of coal by rail, as this mode would experience the largest increase in demand for coal shipments in case of a waterway disruption.

Conclusions

The resulting routes, or diversions, and the associated volumes of coal, represent the changes that occur on the network according to the model. For each set of scenarios, maps are included to demonstrate the volume level and geographic extent of the changes on the railways.

Recommendations

This model, available upon request, can be used to estimate the impact of any combination of lock closures on water, rail and highway freight traffic in the Ohio River basin.

Publications

Appendix A: *Intermodal Freight Network Model of Coal Diversions from Lock Closures,* A white paper by Ben Blandford

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Intermodal Freight Network Model of Coal Diversions from Lock Closures

A white paper by Ben Blandford

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This paper presents the results from a set of analyses of modeled coal shipments across an integrated freight network model. In this paper, the model simulates the changing patterns of coal distribution resulting from disruptions on the waterway network at specified Ohio River locks. The paper portrays the extensive geographic and intermodal connectivity of coal shipments in the U.S., and demonstrates how disruptions at even a single node on the network can manifest in dramatic changes throughout the nationwide network. Results presented in the paper are specific to changes in volumes of coal by rail, as this mode would experience the largest increase in demand for coal shipments in case of a waterway disruption.

The network model is built using ESRI ArcMap 10.1, and utilizes the program's Network Analyst toolset. The Network Analyst toolset enables users to model data flows, in this case coal, across a network. The network is comprised of a set of lines, representing the highway, railway, and waterway segments, as well as a collection of points, representing intermodal access points, such as river ports and intermodal facilities. This network data, which represents the transportation systems available for the shipment of coal, is described below:

- Highways: the Oak Ridge National Highway Network was used (available at http://cta.ornl.gov/transnet/Highways.html). This data set includes over 500,000 miles of roadway and includes most rural and urban arterials.
- Railways: the Center for Transportation Analysis (CTA) Rail Network was used (available at http://cta.ornl.gov/transnet/RailRoads.html). For this network, rail networks for each of the seven Class I carriers of the U.S. were created separately. These include BNSF, Union Pacific, CSXT, Norfolk Southern, Kansas City Southern, Canadian National, and Canadian Pacific. The remaining class II and short line railways were combined into a separate and single railway network.
- Waterways: the National Waterway Network (NWN) was obtained from the Navigation Data Center of the U.S. Army Corps of Engineers (available at http://www.navigationdatacenter.us/data/datanwn.htm). For this project, only waterway segments capable of handling coal shipments by barge were included for modeling purposes.
- Inland River Ports: River port data was obtained through several measures. For the last two years, the Kentucky Transportation Center has collaborated with the University of Louisville College of Engineering in conducting a survey of river ports along Kentucky's navigable waterways. Data obtained from this surveying effort helped provide information for ports along Kentucky's portion of several rivers, including the Ohio River, the Green River, the Mississippi River, the Cumberland River, the Tennessee River, and the Big Sandy River. Detailed river port information for West Virginia was obtained from the WV Department of Transportation.

Additional inland river port data was obtained from Crounse Corporation, a barge operator throughout much of the inland waterway network.

- Intermodal Facilities: Data for intermodal facilities was obtained from the 2012 National Transportation Atlas Databases, available from the U.S. Department of Transportation.

Coal movement data used to populate the network was obtained from the U.S. Energy Information Administration (EIA). EIA releases monthly and annual reports on the movement of energy related fuels, including coal, natural gas and oil. For this model, data from the 2010 coal annual report was used, as the 2010 data was the most recent full data set available at the outset of this project. The coal movement data obtained from EIA contains, among other things, the full origin, destination, and mode(s) of transportation used for the coal shipment. For the origins, this includes the mine name, operator, county, state, and MSHA identification number. For the destinations, this includes the power plant name, ORISPL identification number, operator, and state identification number. For the mode(s) of transportation, two columns are included. The first indicates the primary mode (or longest duration of the shipment), while the second, if necessary, indicates the secondary mode for the shipment. The modes may include rail, water (river, great lakes, tidal pool), road, or conveyor. For this model, coal shipments that traveled solely by conveyor (generally directly from mine to a neighboring power plant) were not included, as those shipments are not captured on this multimodal network. Additionally, only coal involving the contiguous 48 U.S. states was included.

For this model, coal origins were produced at the county centroid level. In other words, all coal produced from mines within a given county were created with a shared origin at the county's centroid. County centroids were connected to the highway network and to any appropriate rail networks contained within the county. For example, for a county that contained both NS and CSXT rail lines within its borders, the centroid would be provided connectivity to both those rail networks.

Power plant destinations were obtained from EIA as a GIS shapefile. Connectivity to the network for these destinations was created based on proximity to the relevant network lines. The EIA data was used to justify these connections. For example, if the EIA data showed a particular power plant receiving coal by rail, truck, and water, then the power plant was provided connectivity to each of these modes.

A second form of destinations was created for coal that was produced in the U.S. for export. Because exported coal is not burned in U.S. power plants, these coal shipments are not included in the highly detailed EIA origin-destination data. To understand the nature of coal exports, several data sources were conferred. The MSHA annually releases the total amount of coal produced by county in the U.S. The EIA data contains only coal produced by county for use within the U.S. Subtracting the EIA data from the MSHA data yields a total amount of coal unaccounted for in the EIA origin-destination data. This total is then compared to the total amount of coal exported from the U.S. by port (available from EIA) to determine how much coal each county produced for export. This coal volume was then assigned to particular ports based on a logical proximity basis, where shipping costs are minimized.

Each set of scenarios, one set for the Greenup locks closure and one set for the Newburgh locks closure, offer two analyses based upon differing relative rate structures for shipping coal across the three modes of barge, rail, and truck. Because of the inherent properties of the three modes, shipping bulk commodities by barge is generally more efficient than by rail, and rail is generally more efficient than truck. On the ground, of course many factors play into specific rate structures for each mode and each shipment, including volume, distance, fuel prices, shipper competition, existing business relationships, availability of backhaul, and others. For these sets of analyses, however, rate structures are set based upon an order of magnitude, with varying levels of competitiveness between barge and rail. For the first, a standard order of magnitude is used, where rail cost per mile is three times that of barge, and truck cost per mile is six times that of barge. In the second, rail is priced more competitively, where rail is two times that of barge, and truck remains at six times that of barge.

In addition to the rate schemes used for the modes, a rate penalty is also assessed for intermodal and intra-rail moves. This penalty is meant to represent the costs of transloading shipments from one mode to another or from one rail carrier to another. The rate penalty for transloading between modes is 600, the rate penalty for intra-rail shifting from one Class I carrier to another is 300, and the rate penalty for shifting to and from short line rail carriers is 100.

The EIA data serves as the baseline for the analyses presented in this paper. This paper presents scenarios of how the pattern of coal distribution could change on railways if there was a significant disruption on the waterway network. Using the modeled EIA data from 2010, all coal shipment routes that pass through the specified points of disruption on the waterway network, i.e. either the Greenup locks or Newburgh locks, are remodeled on the network after the disruption is put in place within the model. Because of the disruption on the waterway network, diversion routes may consist of rerouting, partial or complete modal shifting to either rail or truck.

The resulting routes, or diversions, and the associated volumes of coal, represent the changes that occur on the network according to the model. For each set of scenarios, maps are included to demonstrate the volume level and geographic extent of the changes on the railways.

This first set of scenarios represent a closure at the Greenup locks, which are located on the Ohio River at the northeastern Kentucky and southern Ohio border. The Greenup locks have been in operation since 1959, and feature two parallel lock chambers, one 1200 feet long and the other 600 feet long. In 2010, 42 tons of coal moved through the Greenup locks. The Greenup locks are located within the Appalachian coal basin, and the locks handle coal shipments moving both upstream and downstream to power plants located on the Ohio River, as well as to more distant destinations, such as New Orleans for export and other power plants located along the Gulf of Mexico coast.

The second set of scenarios represent a closure at the Newburgh locks, which are located on the Ohio River at the western Kentucky and southwestern Indiana border. The Newburgh locks have been in operation since 1969, and feature two parallel lock chambers, one 1200 feet long and the other 600 feet long. In 2010, 48 million tons of coal moved through the Newburgh locks. The Newburgh locks are located within the Illinois coal basin, and the locks handle significant volumes of coal moving both upriver toward the upper Ohio River power plants and downriver, particularly for export through New Orleans or power plants along the Gulf of Mexico coast.

The model simulations are based on EIA coal movement data from 2010, and the model simulates the shipments of coal from the original origins and destinations even after the closure of the locks. Modeled results present the volumes of coal for the entire year of 2010. In reality, it is likely that such a prolonged disruption of the waterway network would alter the distribution patterns of coal in ways that this model cannot predict. For example, many power plants might deploy alternate sourcing for coal. In other words, they would purchase coal from different mines where shipping is more cost effective. Additionally, the rate structures for railroad might alter in response to a disruption of the waterway network due to decreased modal competition.

Greenup Locks Closure

The first scenario represented in Figure 1 shows the changes in rail volume of coal resulting from a closure of the Greenup locks (location identified as a black diamond on the map). The rate structure for this scenario is rail at three times the cost per mile of barge and truck at six times the cost per mile of barge. As to be expected, the volume of coal on the CSX rail line parallel to the Ohio River in eastern Kentucky and West Virginia increases dramatically, by as much as 19 million tons, due to the disruption in the waterway network. Demand on the rail network in northern Ohio also increases, as coal both originating from and destined for Pennsylvania and the upper Ohio River basin seeks to bypass the waterway disruption. Also of significance, as will be demonstrated in all four scenarios, is the changing distribution pattern of coal originating from the far West. Coal rail volumes across Missouri decrease, as coal routes that were formerly destined for St. Louis to be transloaded onto barge are no longer viable. Instead coal now moves by rail across the upper Midwest before fanning out to its final destinations. As a result of these changes, the volume of coal through riverports shifts significantly. In St. Louis, volume of coal through the ports decreases by over 3 million tons; in the Ashland, KY – Huntington, WV area volume through ports decreases by 8 million tons; and in the Wheeling, WV area volume decreases by 4.5 million tons. Other ports are winners in this scenario, especially those near Maysville, KY, which gain nearly 8 million tons of coal moving through.

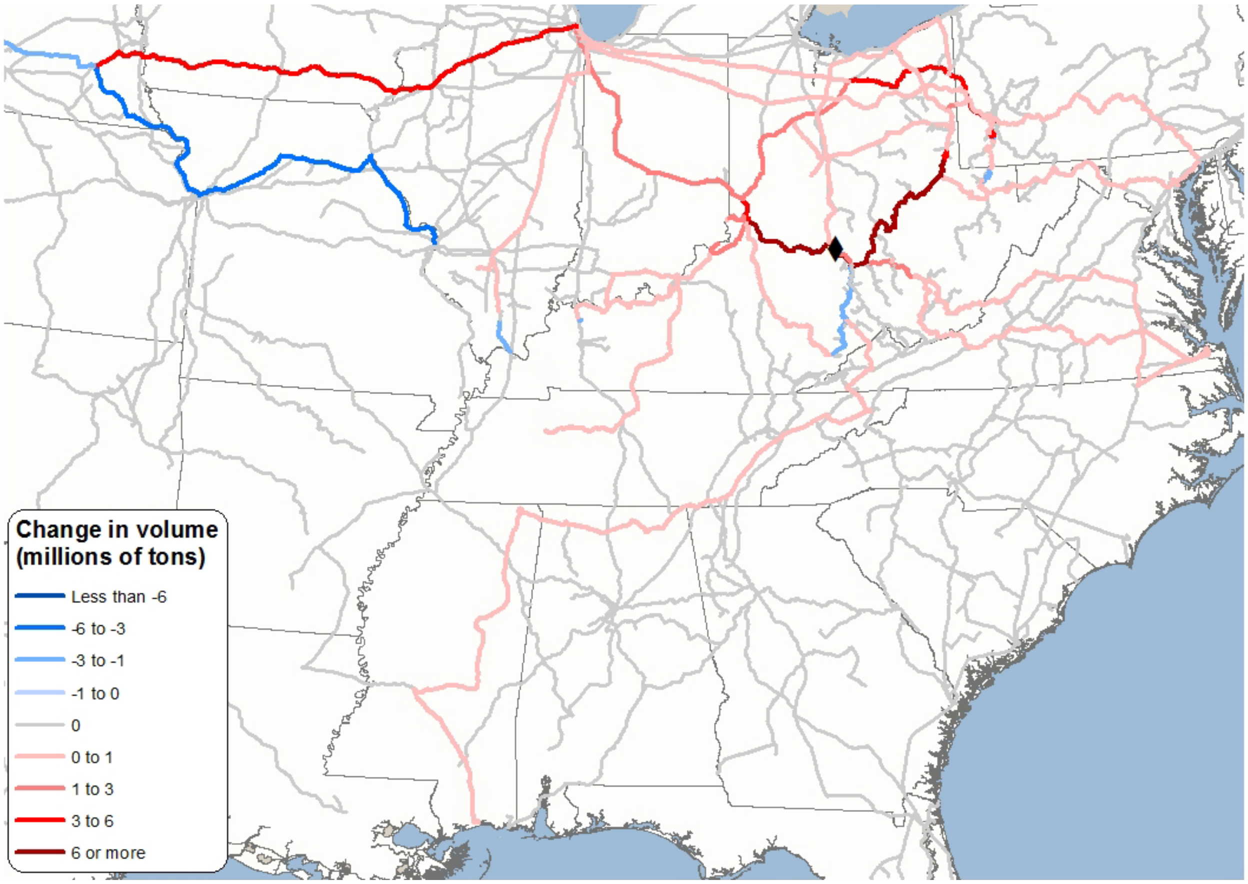

Figure 1 Modeled changes in the rail volume of coal for 2010 resulting from a disruption at the Greenup locks, where rail rates are modeled at three times that of barge and truck rates are modeled at six times that of barge.

The second scenario represented in Figure 2 also shows the changes in rail volume of coal resulting from a closure of the Greenup locks but with rail rates more competitive with barge rates. The rate structure for this scenario is rail at two times the cost per mile of barge and truck at six times the cost per mile of barge. Similar patterns emerge to the previous scenario, where the CSX rail line parallel to the Ohio River increases in volume significantly, rail lines across Ohio and the upper Midwest increase in volume significantly, and rail volumes across Missouri decrease. With rail rates more competitive in this scenario, other patterns emerge as well. Most significant is the increase in volume of coal by 4 million tons moving by rail from central Appalachia directly to New Orleans. Whereas before, this coal primarily moved by barge, in this scenario with the combined disruption of the waterway network and the increased competitiveness of rail, more coal moves by rail to the transloading and export facilities near New Orleans. This also entails a slight reduction in volume of coal by almost 4 million tons moving northward within Kentucky from the eastern coal fields to transloading facilities on the Ohio River. This scenario results in similar changes to volumes of coal moving through riverports, with a few minor changes. Volume of coal through Cincinnati ports actually decreases in this scenario by just under 1 million tons, and the volume of coal through Maysville, KY ports is lower at about 6 million tons. Other changes in volumes of coal through ports remain the same as in the previous scenario.

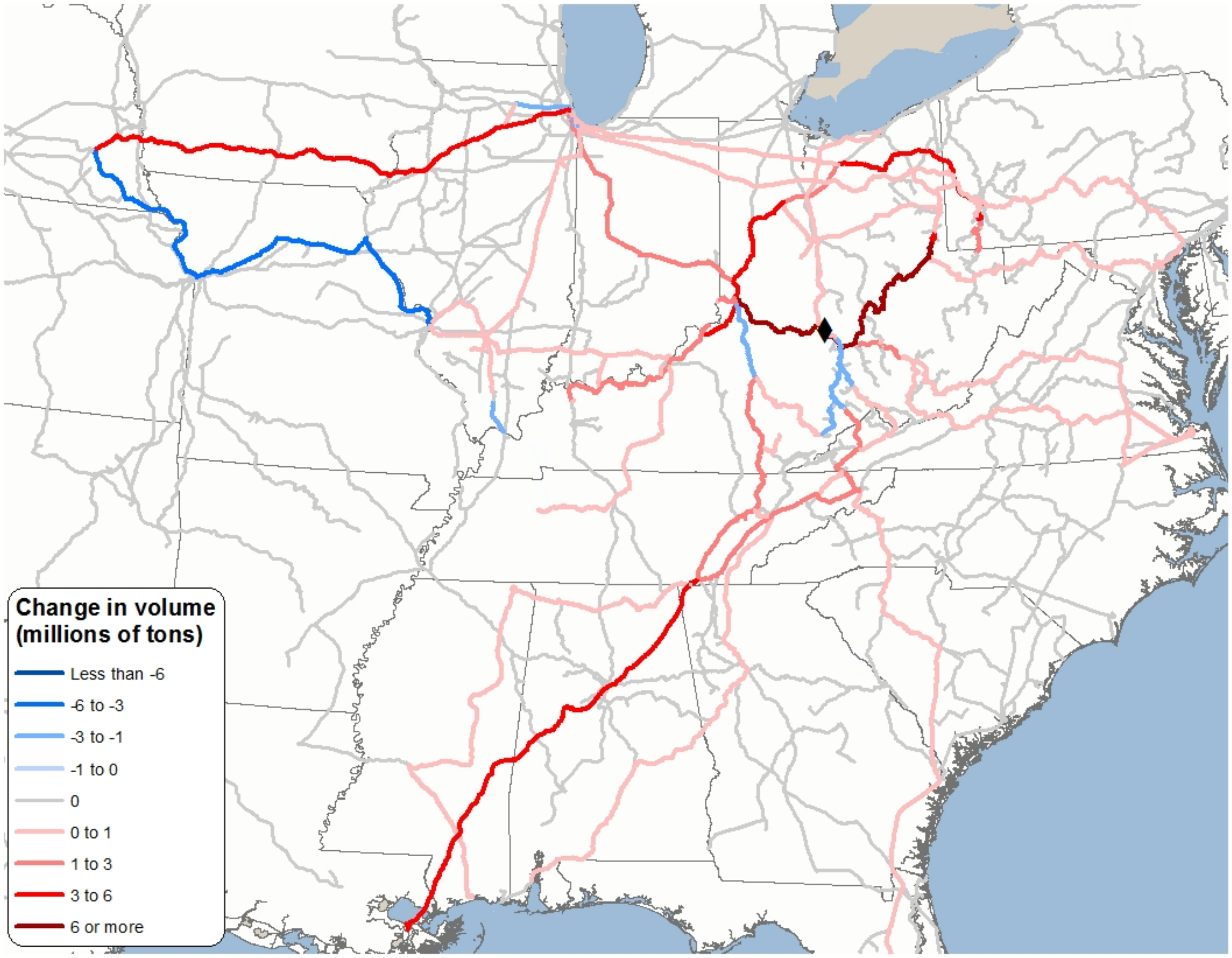

Figure 2 Modeled changes in the rail volume of coal for 2010 resulting from a disruption at the Greenup locks, where rail rates are modeled at two times that of barge and truck rates are modeled at six times that of barge.

Newburgh Locks Closure

The third scenario represented in Figure 3 shows the changes in rail volume of coal resulting from a closure of the Newburgh locks (location identified as a black diamond on the map). The rate structure for this scenario is rail at three times the cost per mile of barge and truck at six times the cost per mile of barge. In this scenario, rail volume of coal increases significantly by as much as 15 million tons on the CSX rail line upstream from the Newburgh locks and parallel to the Ohio River. Rail volumes across southern Illinois and Indiana also alter significantly. In these states, coal moving southward toward transloading facilities near Paducah, KY and Mt. Vernon, IN decreases in volume by over 6 million tons, whereas coal moving east and west increases in volume by over 8 million tons in order to bypass the lock closure. Similar to the Greenup scenarios, rail volumes of coal from the far West decrease significantly across Missouri and instead increase across the upper Midwest in order to bypass the lock closure. In this scenario, even with rail rates not reduced, more coal also moves from eastern Kentucky and West Virginia by rail directly to New Orleans because of the location of the waterway disruption so far downstream on the Ohio River. A disruption at the Newburgh locks has a significant impact on the volume of coal moving through inland waterway ports, though the pattern differs significantly from the Greenup scenarios. In this scenario, the volume of coal decreases through the ports of St. Louis by 6.4 million tons, ports of Paducah, KY by 6.3 million tons, ports on the Green River of Kentucky by 3 million tons, ports of Cincinnati by 1.2 million tons, and ports Ashland KY – Huntington WV by 6 million tons. In this scenario, the only ports that gain volume are those near Louisville, KY which increase by 3 million tons, and ports immediately upriver from the Newburgh locks, which gain 5 million tons in volume.

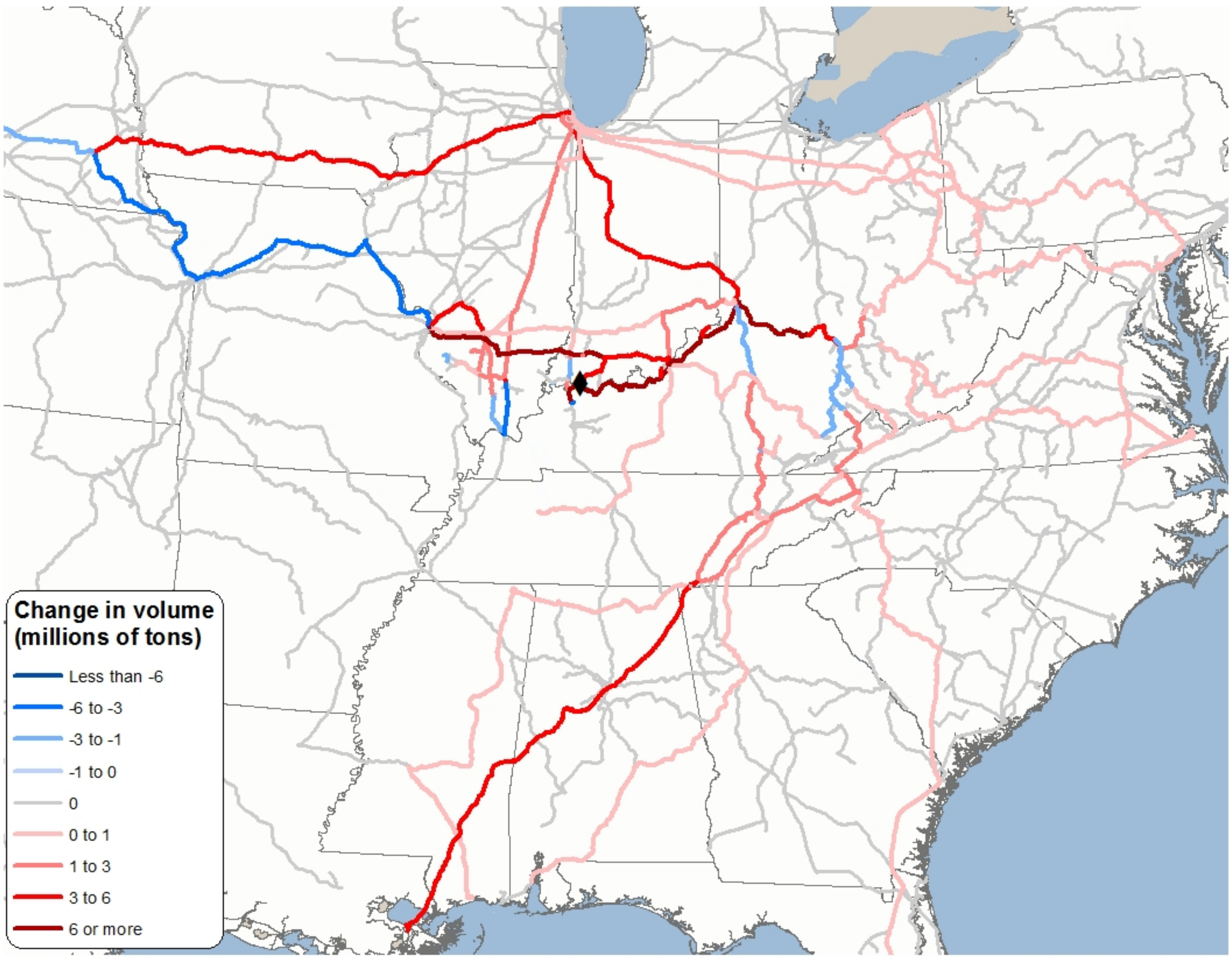

Figure 3 Modeled changes in the rail volume of coal for 2010 resulting from a disruption at the Newburgh locks, where rail rates are modeled at three times that of barge and truck rates are modeled at six times that of barge.

The fourth scenario represented in Figure 4 also shows the changes in rail volume of coal resulting from a closure of the Newburgh locks but with rail rates more competitive with barge rates. The rate structure for this scenario is rail at two times the cost per mile of barge and truck at six times the cost per mile of barge. By and large, this scenario is very similar to the previous, as decreased rail rates here do not result in many further changes associated with a Newburgh locks disruption. In this scenario, more coal does move southward toward the Gulf coast directly by rail, as just under 6 million tons of coal moves by rail to New Orleans and an additional 2.7 million tons of coal moves by rail to Mobile, AL. The changes in the volume of coal through the river ports in this scenario are nearly identical to the previous Newburgh scenario, with the largest difference being that ports on the Green River in Kentucky double their loss in volume to 6 million tons of coal.

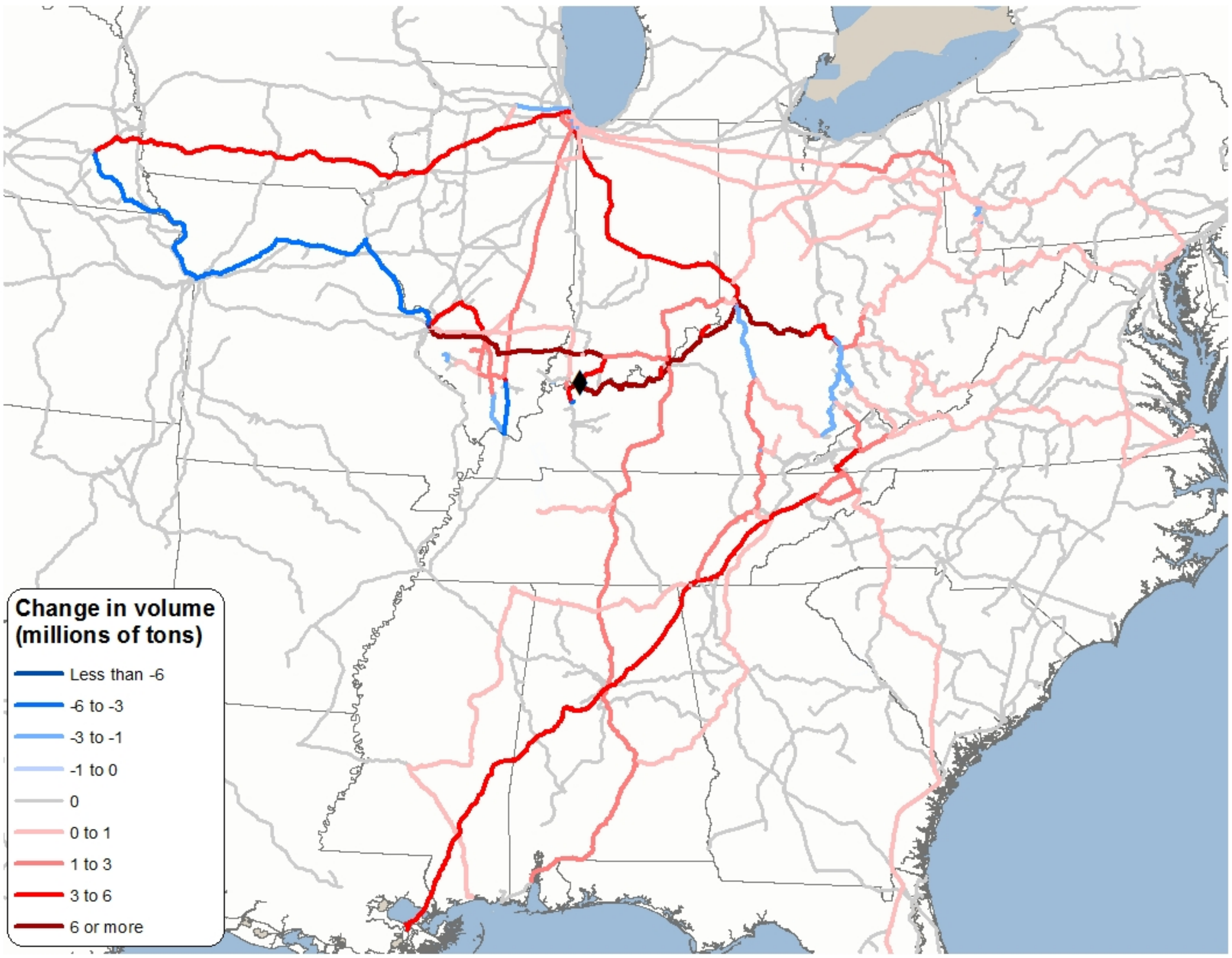

Figure 4 Modeled changes in the rail volume of coal for 2010 resulting from a disruption at the Newburgh locks, where rail rates are modeled at two times that of barge and truck rates are modeled at six times that of barge.

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