



Informing Post-disaster Restoration through Modelling Interdependent Agriculture and Transportation Networks

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Transportation System-Level Resilience: Challenges and Solutions

September 12, 2025



Overview

- Many sectors depend on the transportation sector
- Arkansas agriculture depends on multiple modes of transportation
- Prior disruptions have significantly impacted agricultural systems
- **Resilience is the capacity to withstand or to recover quickly from disruptions**



Business
Hundreds of Barges Stalled as Floods Hinder Midwest Supplies
By Brian K. Sullivan, Shruti Singh, and Mario Parker
June 8, 2019, 6:00 AM CDT Updated on June 10, 2019, 6:54 AM CDT

▶ Relentless rains deter flow of farm supplies in, crops out
▶ Mississippi transport plans change daily in push to beat rains



Mississippi River barge shipping resumes after floods, but rains to return

Karl Plume, Rod Nickel 4 MIN READ

(Reuters) - The upper Mississippi River fully reopened to boat and barge traffic this week for the first time since November as shippers scrambled to move a backlog of overdue fertilizer barges to farmers racing to sow corn before the end of the month.

A photograph of a large blue barge on the Mississippi River, with a bridge in the background.

'It's Probably Over for Us': Record Flooding Pummels Midwest When Farmers Can Least Afford It



The Ruzicka family farm in Verdigre, Neb., on Monday. Farmers across Nebraska, Minnesota and South Dakota have lost livestock and livelihoods after record flooding in the region. Mitch Smith/The New York Times

Market Intel
October 30, 2019

Farm Bankruptcies Rise Again
Chapter 12 Filings Increase 24% Compared to Year-Ago Levels

A photograph of a barbed wire fence in a field. The fence is made of wooden posts and wire. The ground is dry and there are some trees in the background.

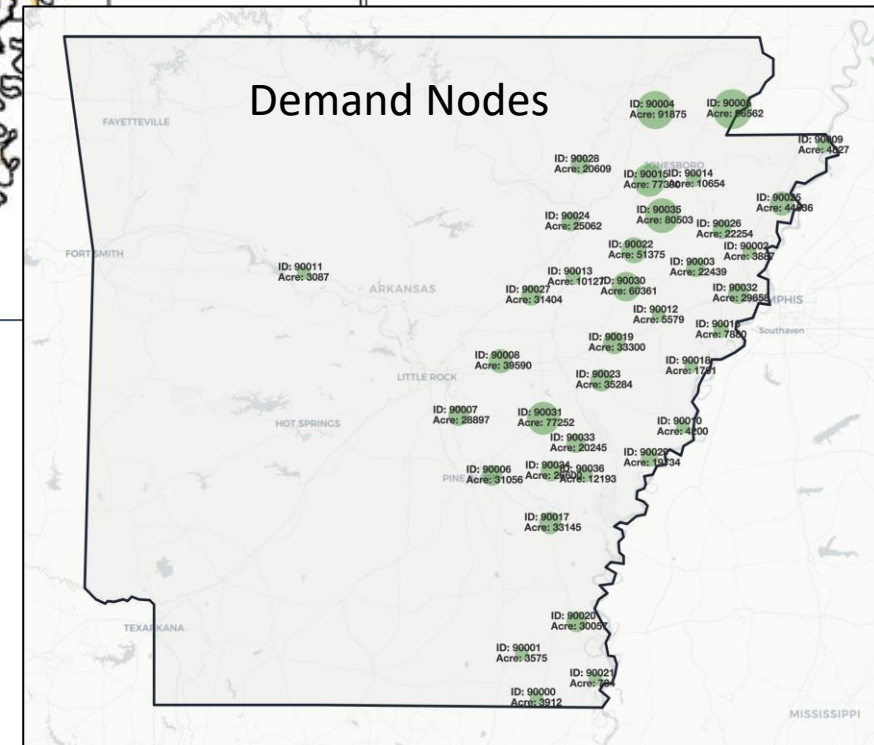
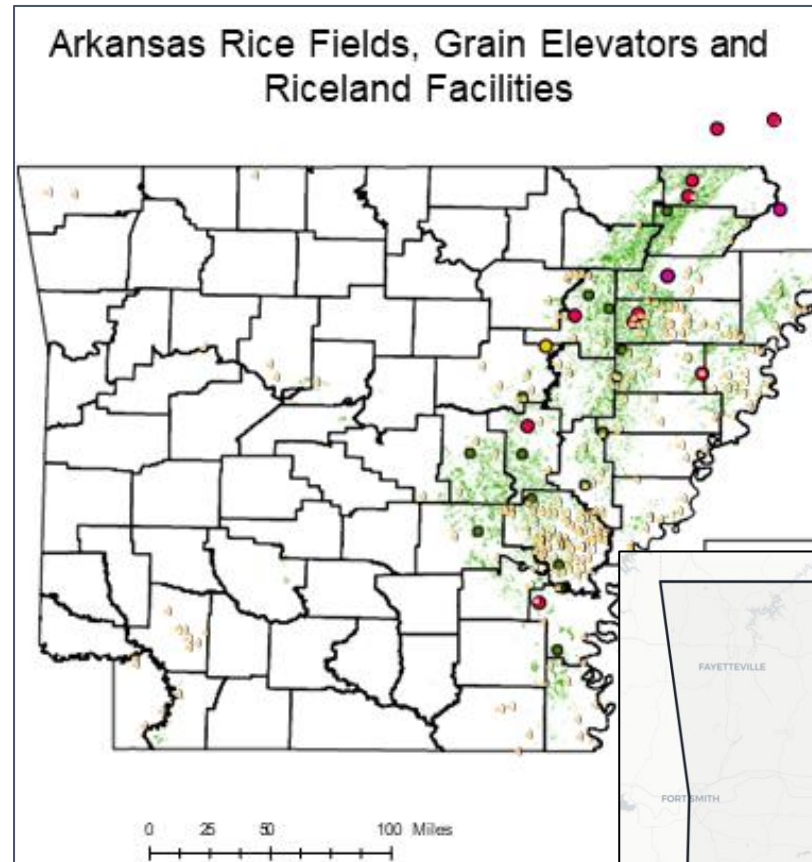


Objectives

- Mathematically characterize interdependencies arising between interdependent agriculture and transportation infrastructure.
- Build a geospatial dataset of interdependent agriculture and transportation infrastructure.
- Optimize post-disaster restoration options for interdependent agriculture and transportation infrastructures.
- Perform a case study to analyze the impact of potential disasters on multimodal transportation systems and the interdependent food and agriculture sector.

Agricultural System

- Arkansas is highest rice-producing state in US (40%)
- Rice is second highest earning agricultural product in Arkansas
- **Goal = optimize yield**
- Fertilizer key factor
- Demand nodes based upon proximity to grain elevators, acreage, etc.



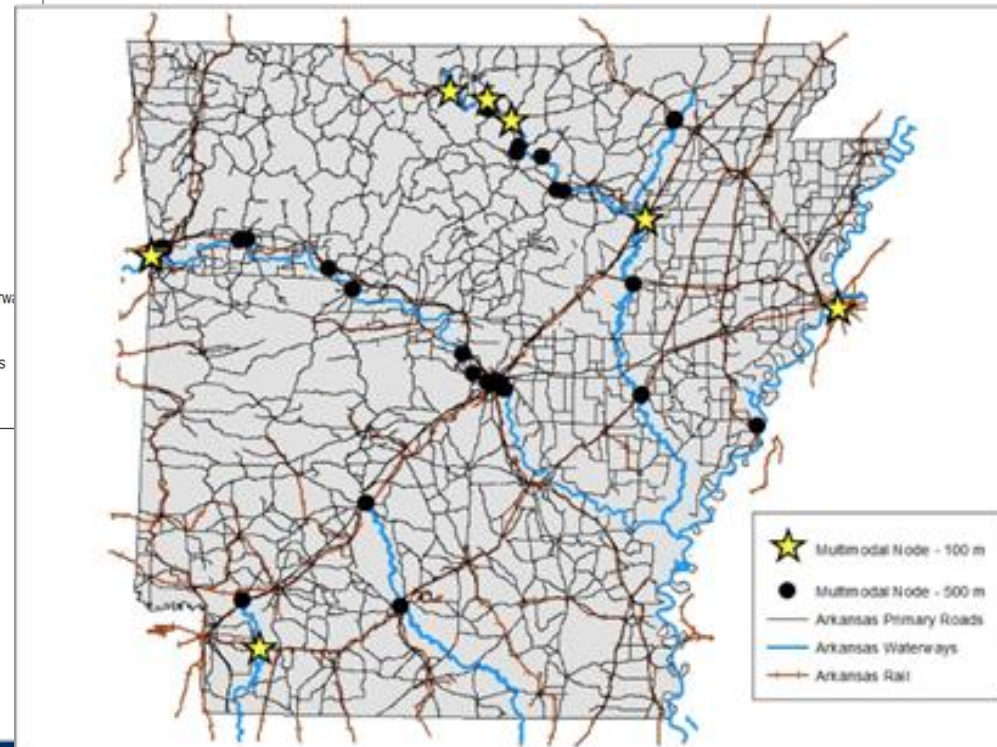
Transportation System



Arkansas Transportation Networks

Created Intermodal Terminal Points where Water, Rail, and Roads (primary only) "intersect" each other within specified distance

- ▶ 100 m – results in 7 multimodal terminal nodes
- ▶ 500 m – results in 41 multimodal terminal nodes



Transportation System Inter-Connectedness



- Created Intermodal Network Connections from individual modes to intermodal terminals for transfer of cargo



Sample of spatial transportation networks input into model

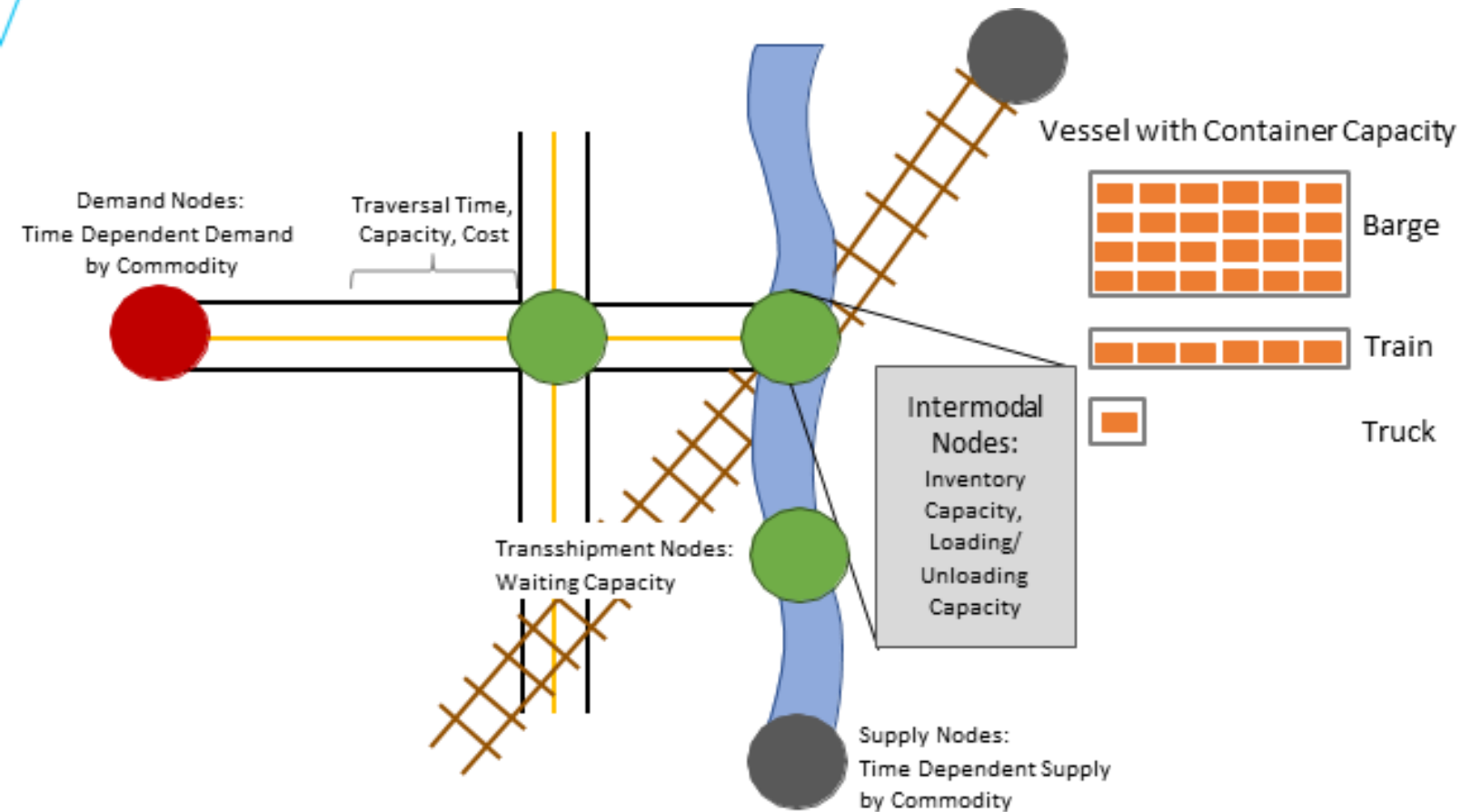
- 73 road links
- 1 waterway link
- 141 rail links
- 2 waterway nodes
- 167 road nodes
- 101 rail nodes
- 2 intermodal nodes



FIG	Shape	LINEARID	FULLNAME	RTTYP	MTFCC	X_Start	Y_Start	X_End	Y_End
1	Polyline	110400201947	State Hwy 305 E	3	S1200	-83.482729	33.502209	-83.5112	
2	Polyline	110400202144	State Hwy 4	3	S1200	-83.477736	33.642527	-83.528	
3	Polyline	1104002043013	US Hwy 58	3	S1200	-84.043087	33.582303	-84.081	
4	Polyline	1108001947264	s. 49	3	S1100	-84.027895	33.581029	-84.034	
5	Polyline	1108010908855	s. 49	3	S1100	-84.043239	33.510886	-83.961	
6	Polyline	1104701919012	State Hwy 108	3	S1200	-84.043579	33.549424	-83.934	
7	Polyline	1108011008284	US Hwy 58	3	S1200	-84.043581	33.54168	-84.047	
8	Polyline	110430060117	State Hwy 4	3	S1200	-83.477736	33.642527	-83.512	
9	Polyline	1108001929038	State Hwy 29	3	S1200	-83.628792	33.47408	-83.41	
10	Polyline	1108001920002	State Hwy 305	3	S1200	-83.618218	33.584983	-83.68	

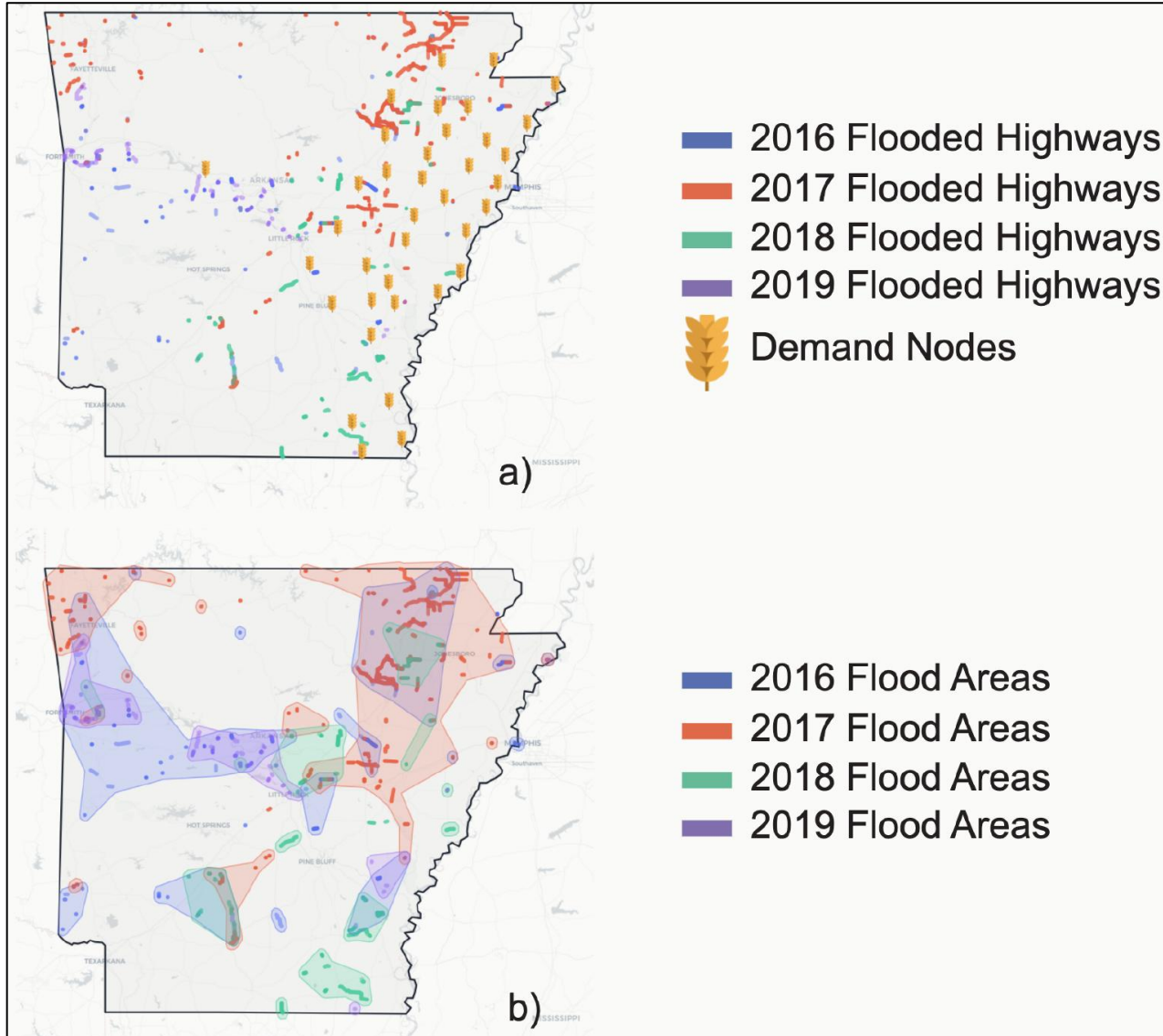
FIG	Shape	LINEARID	FULLNAME	MTFCC	X_Start	Y_Start
5	Polyline	110400202740	Amtrak RR	R1011	-83.794687	33.616321
8	Polyline	110400202749	Amtrak RR	R1011	-83.793188	33.616449
7	Polyline	110400202750	Amtrak RR	R1011	-83.793188	33.616449
6	Polyline	110400202753	Amtrak RR	R1011	-83.817942	33.627796
9	Polyline	110400203817	Kansas RR	R1011	-83.788324	33.689929
10	Polyline	110400203788	Union Pacific RR	R1011	-83.814514	33.611688
11	Polyline	110400203767	Union Pacific RR	R1011	-83.794687	33.616321
17	Polyline	1104001917448	Union Pacific RR	R1011	-81.748871	41.847111

Optimization Model



- Integrated network for commodity flow
- Container equivalents represent cargo across modes
- At each time step, determine number of vessels and containers
 - Traversing each arc/segment
 - Loaded/unloaded at nodes
 - Waiting in inventory
 - Demand and supply met or used

Disruption Scenarios



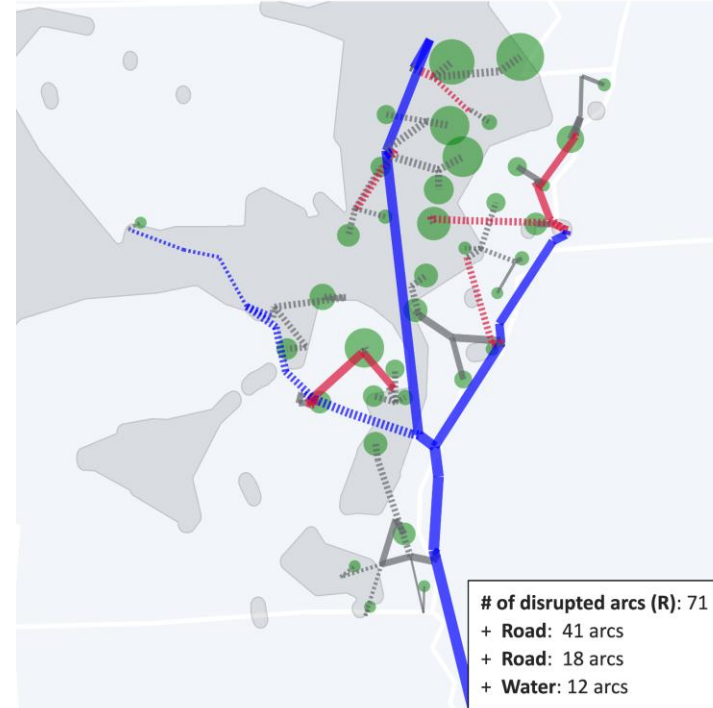
- Historic flood data from 2016-2019
- Road closures used to develop polygons of impacted areas
- Three levels of risk identified based upon overlapping polygons and extent of flooding

- Note: Future projections should be considered also.

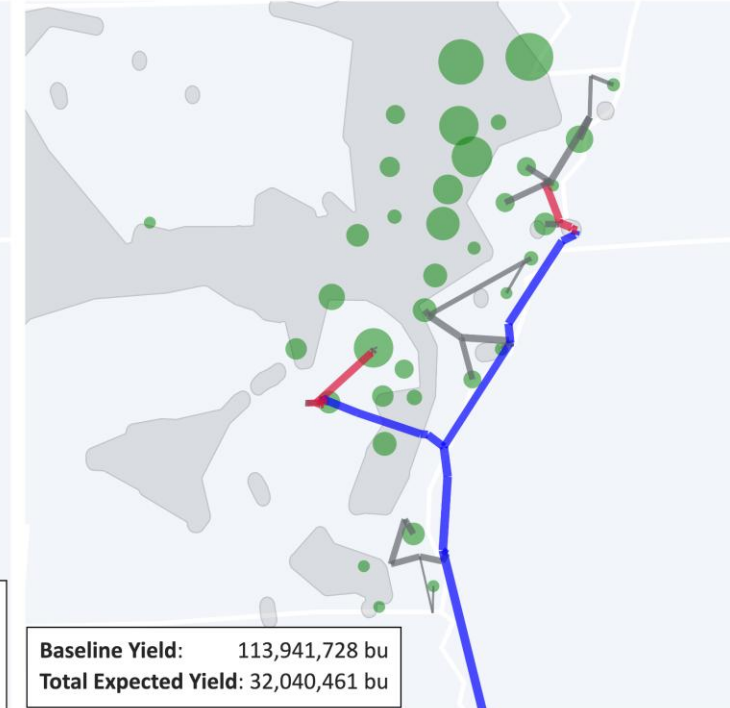
Results

- Disruptions made significant impact to fertilizer delivery and crop yield
 - Worst-case scenario = 15 demand nodes meeting yield (27.5%)
 - Rail was least preferred mode for transport

a) Baseline with potential disrupted arcs



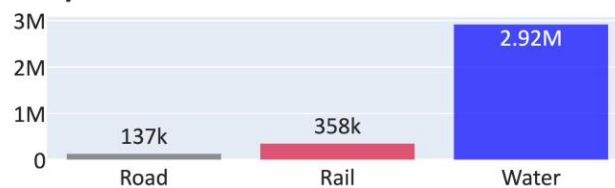
b) Worst-case scenario



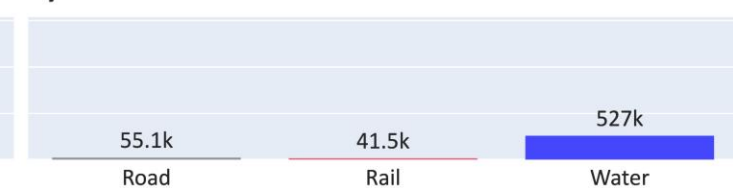
||||| Disrupted Road Arcs ||||| Disrupted Rail Arcs ||||| Disrupted Water Arcs Level 3 Land Disruption Areas Demand Nodes

Total Container Miles

c)

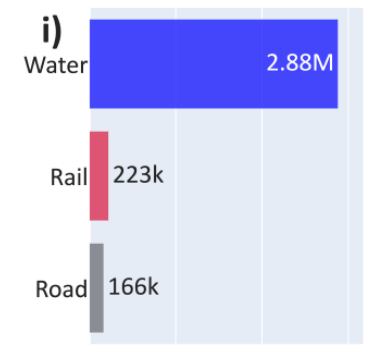
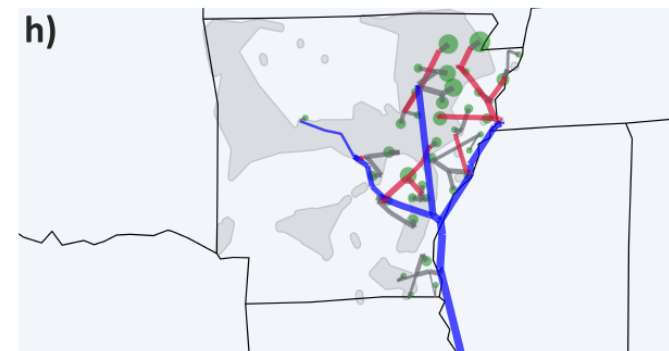
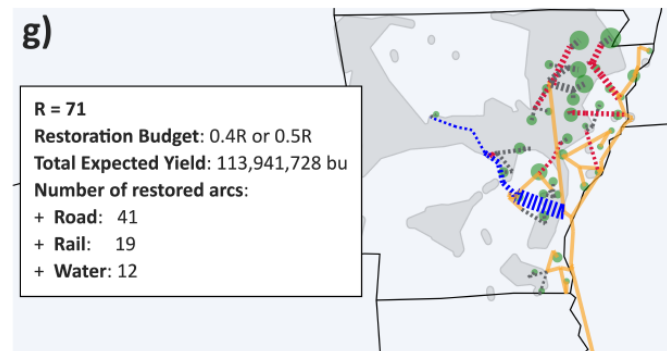
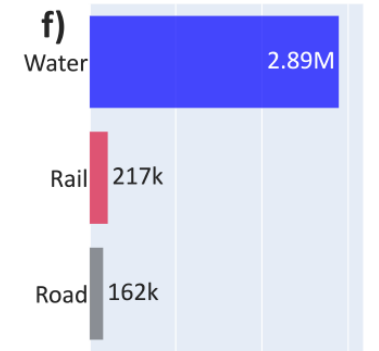
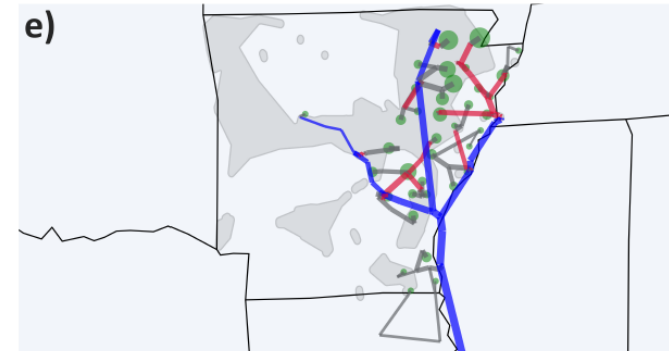
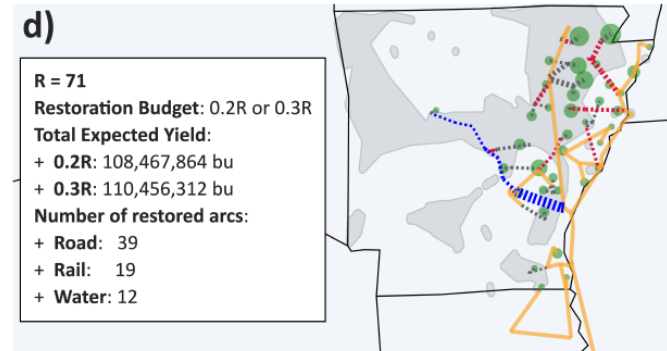
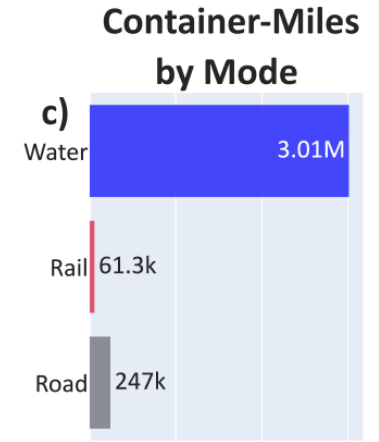
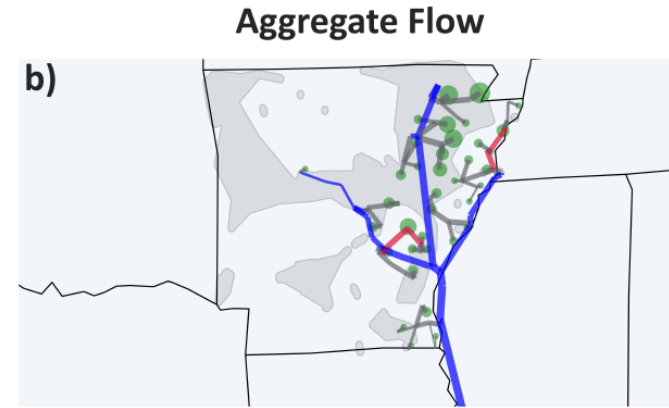
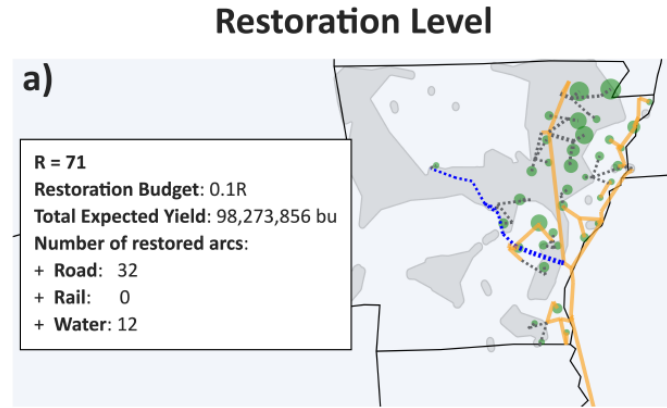


d)



Results

- Water remained favored mode due to volume/capacity
- Model tended to restore roads connecting to waterways over other roads
- Under no restoration option was full yield achieved



Restored Road Arcs Restored Rail Arcs Restored Water Arcs Undisrupted Arcs Level 3 Land Disruption Areas

0 1M 2M 3M
Total Container Miles

Thank you!

- Janey Camp (jvcamp@memphis.edu)
- Sarah Nurre Pickney (no longer in academia)
 - Kelley Sullivan (ksulliv@uark.edu)
 - Ben Runkle (brrunkle@uark.edu)

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Full project reports available at :

<https://rosap.ntl.bts.gov/view/dot/61007>

<https://rosap.ntl.bts.gov/view/dot/73426#tabs-5>