

TRC2303

Evaluation of Impacts Due to a Bridge Closure: A Case Study of the Mississippi River Bridges in Arkansas

Sarah Hernandez, PhD, PE
Associate Professor
Department of Civil Engineering
University of Arkansas

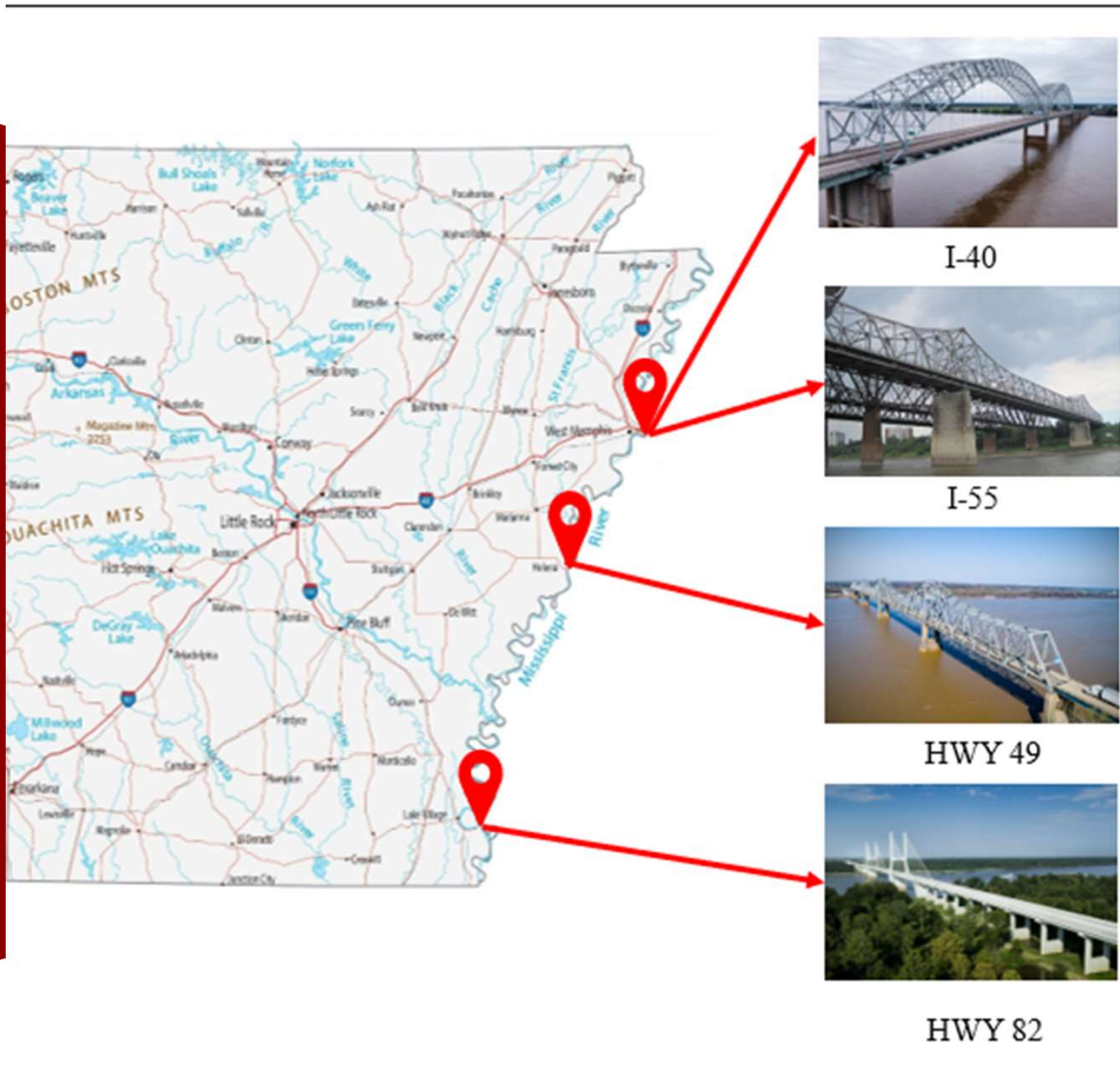


I-40

BRIDGE CLOSURE

- Closure due to fracture
- Closed May 11 to Aug 2, 2021 (83 days)
- Traffic rerouted to I-55
- AADT of 41,000 vehicles per day
- 29% trucks
- 3 lanes each direction
- Delays reported 30 min to 2 hours





I-40



I-55



HWY 49



HWY 82

MISSISSIPPI RIVER BRIDGES

- Hernando de Soto (I-40)
- Memphis-Arkansas (I-55)
- Helena (HWY 49)
- Greeneville (HWY 82)

Research Objectives

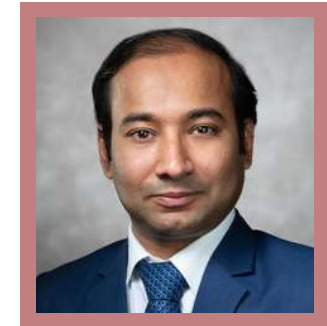
- Quantify the Road User Costs (RUC) for each of the four Mississippi River Bridges
- Quantify the system impacts in terms of congestion effects of individual and combinations of bridge closures
- Develop a tool for analyzing the impacts of bridge closures

Our TEAM

University of Arkansas, Department
of Civil Engineering



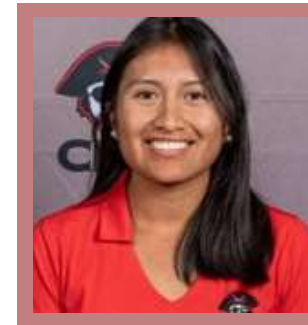
SARAH HERNANDEZ
PI



SUMAN MITRA
Co-PI



GEOFFERY AGORKU
PhD Student



LEIRE ASQUI
MS Student



MEHDI ZOLALI
PhD Student

METHODS



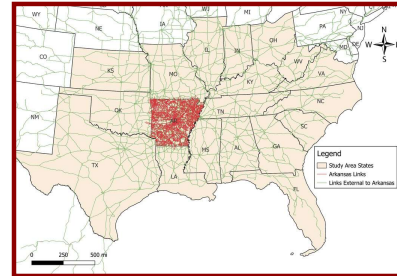
Origin Destination

Probe Vehicle Data

Traffic Data	
AADT Construction Year (total for both directions)	54,000
Cars as Percentage of AADT (%)	61.8
Single Unit Trucks as Percentage of AADT (%)	3.2
Combination Trucks as Percentage of AADT (%)	35.0
Speed Limit Under Normal Operating Conditions (mph)	55
No. of Lanes in Each Direction During No Lane Closure	3
Free Flow Capacity (vphpl)	2350
Maximum Queue Length (miles)	10.0
Will There Be Lane Closures All Day?	Yes
Will Lane Closures Ever Be Present During the Period Analyzed?	Yes
M Eastbound Closure Time Restrictions (Traffic Above Capacity)	End Lane Closure Begin Lane Closure
M Westbound Closure Time Restrictions (Traffic Above Capacity)	End Lane Closure Begin Lane Closure
M Eastbound Closure Time Restrictions (Traffic Above Capacity)	End Lane Closure Begin Lane Closure
M Westbound Closure Time Restrictions (Traffic Above Capacity)	End Lane Closure Begin Lane Closure

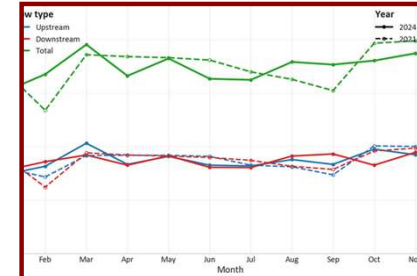
Segment Level

ARDOTs Road User
Cost Tool



System Level

ARDOTs Statewide
Travel Demand Model

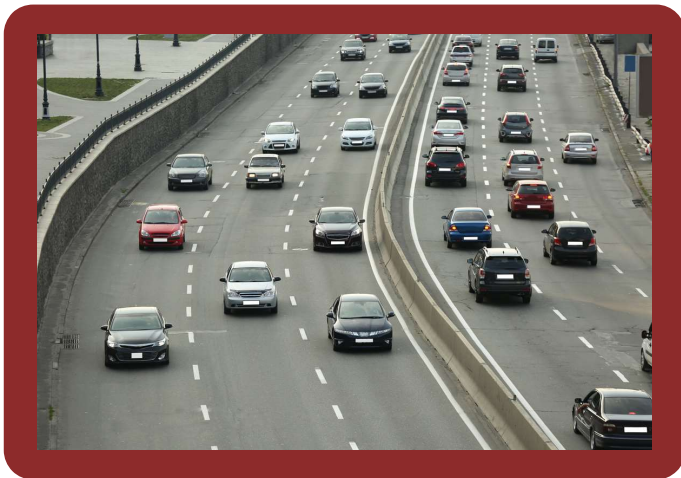


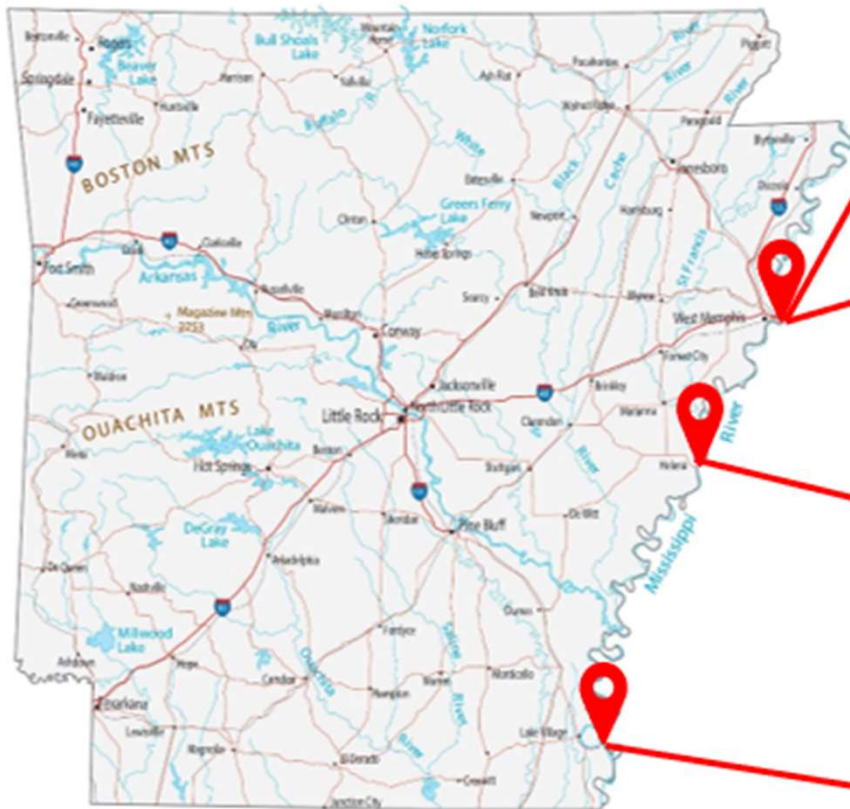
Waterways

Vessel Movement

PROBE DATA SOURCES

Passenger and commercial vehicle origin destination patterns assessed with probe vehicle data from two data vendors.





I-40

48,000 (29%)

6 lanes



I-55

41,000 (35%)

4 lanes



HWY 49

3,900 (20%)

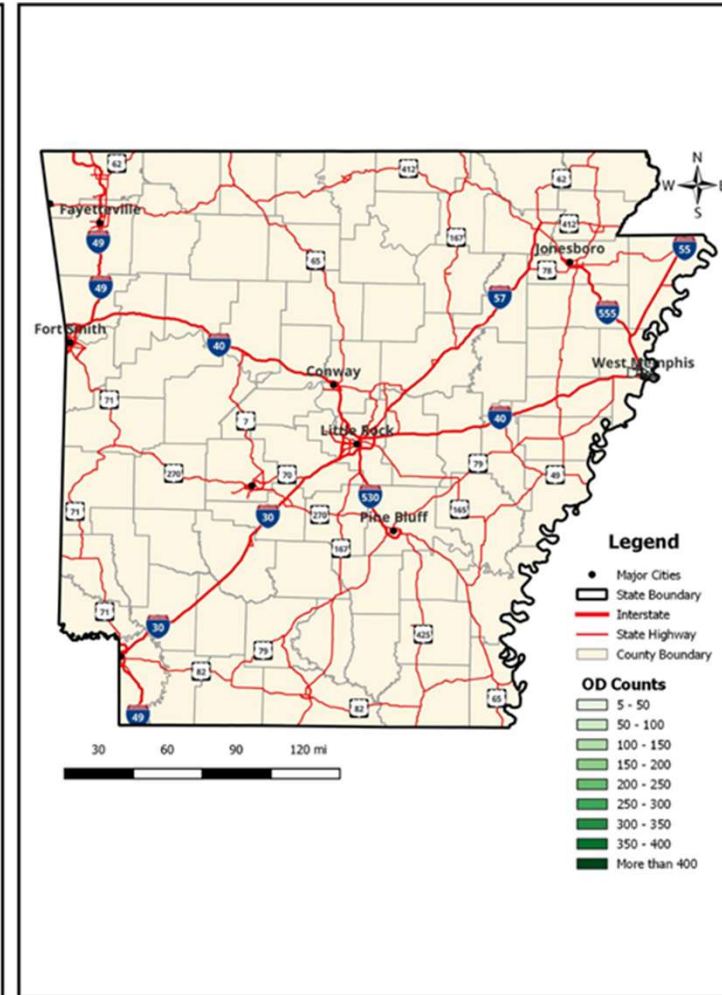
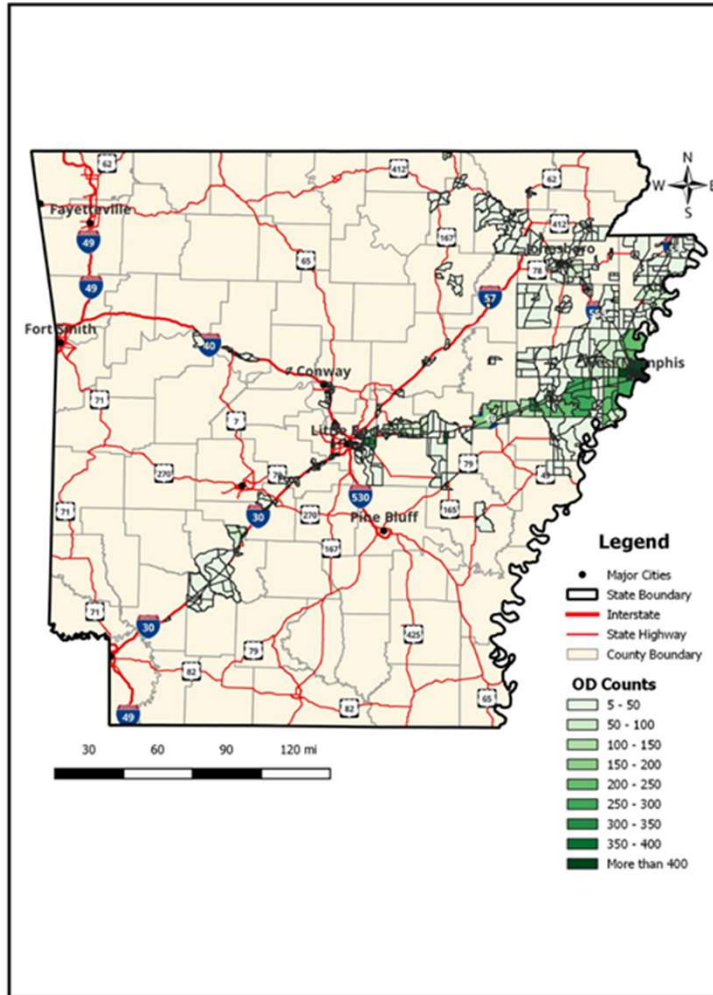
2 lanes



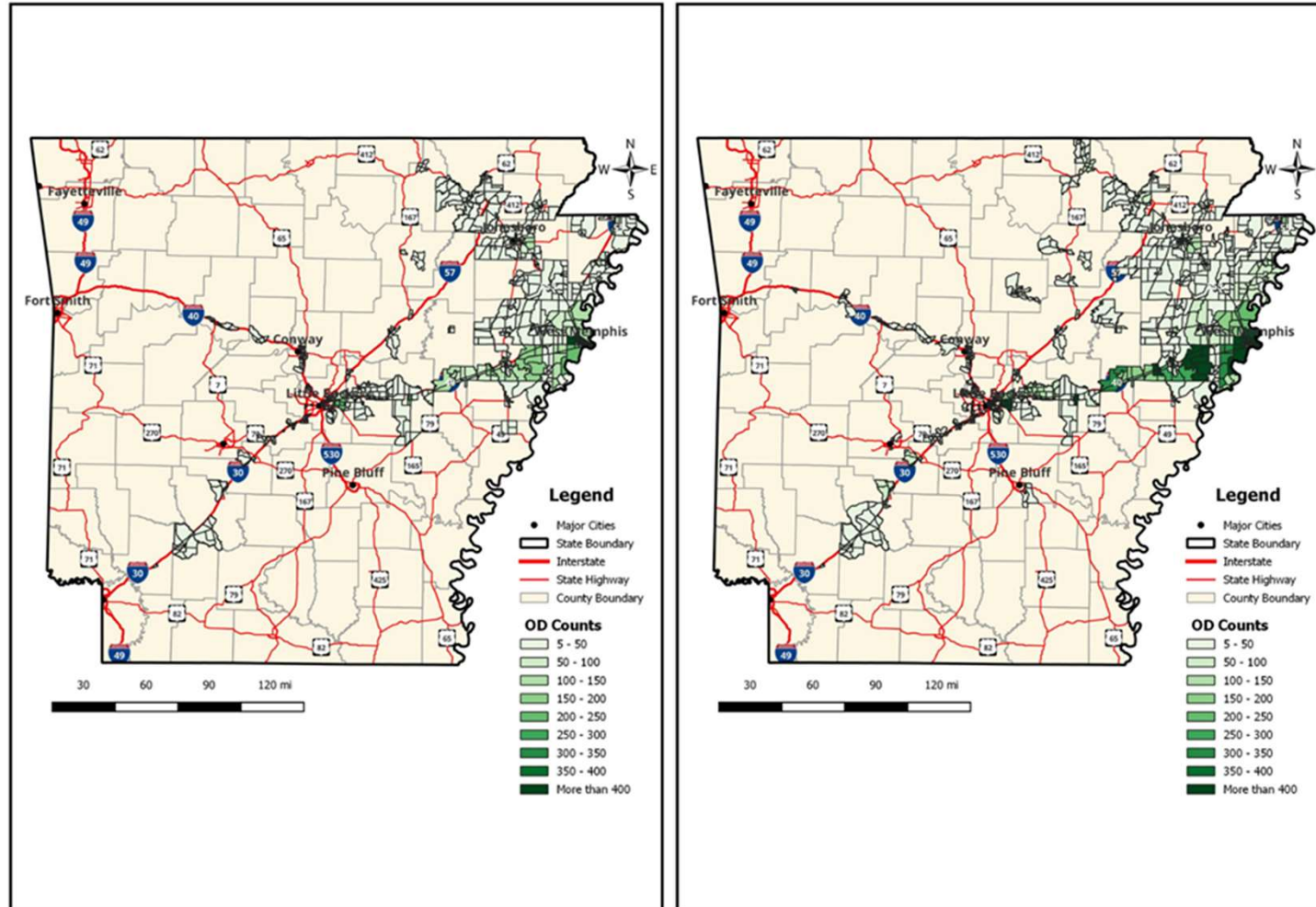
HWY 82

7,100 (24%)

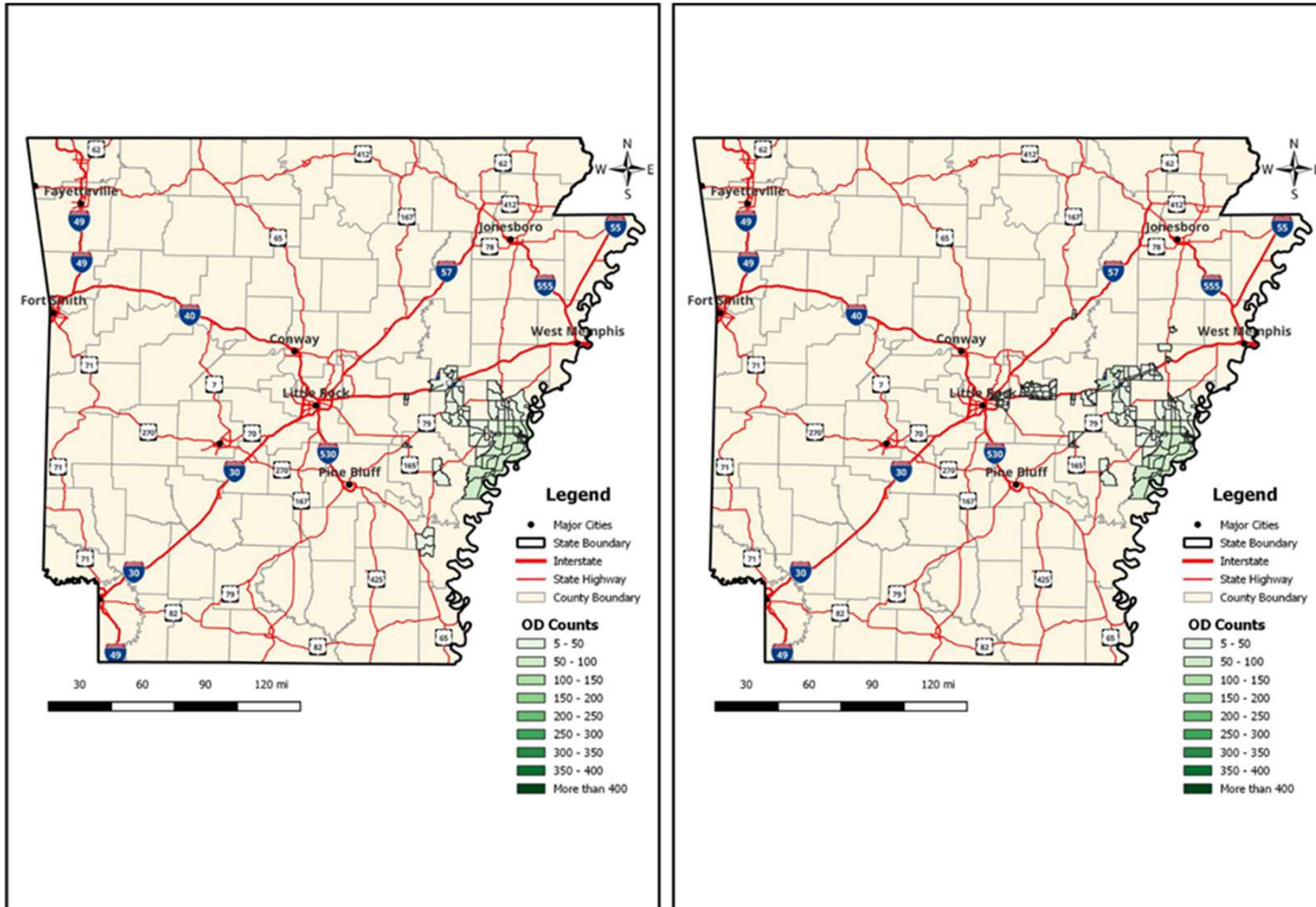
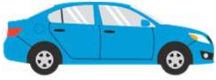
2 lanes



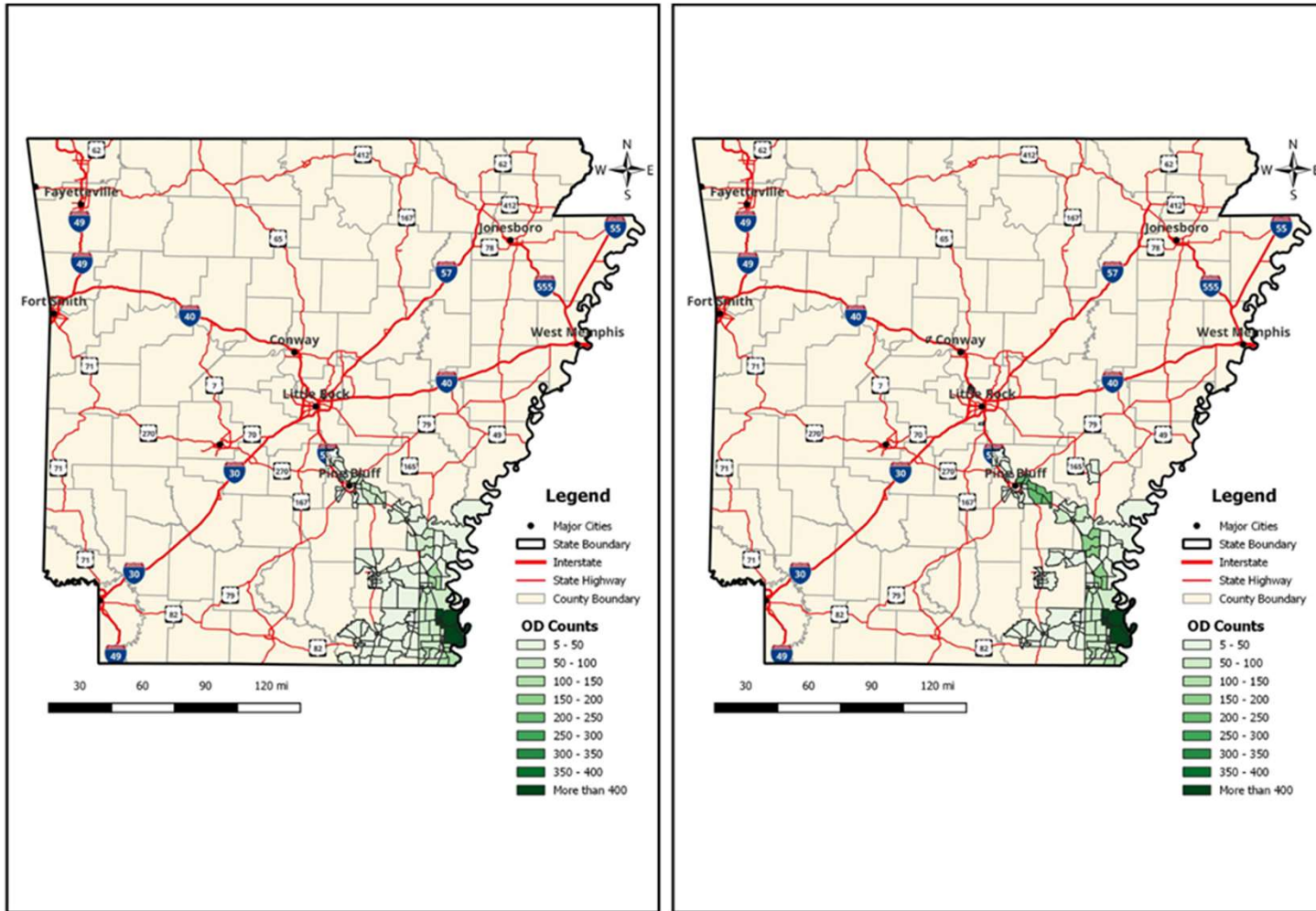
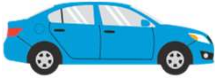
Comparison of Passenger Vehicle Flows from TAZs to the I-40 bridge (A) before (April 15-30, 2021) and (B) during (May 11 through July 31, 2021) the I-40 Bridge Closure



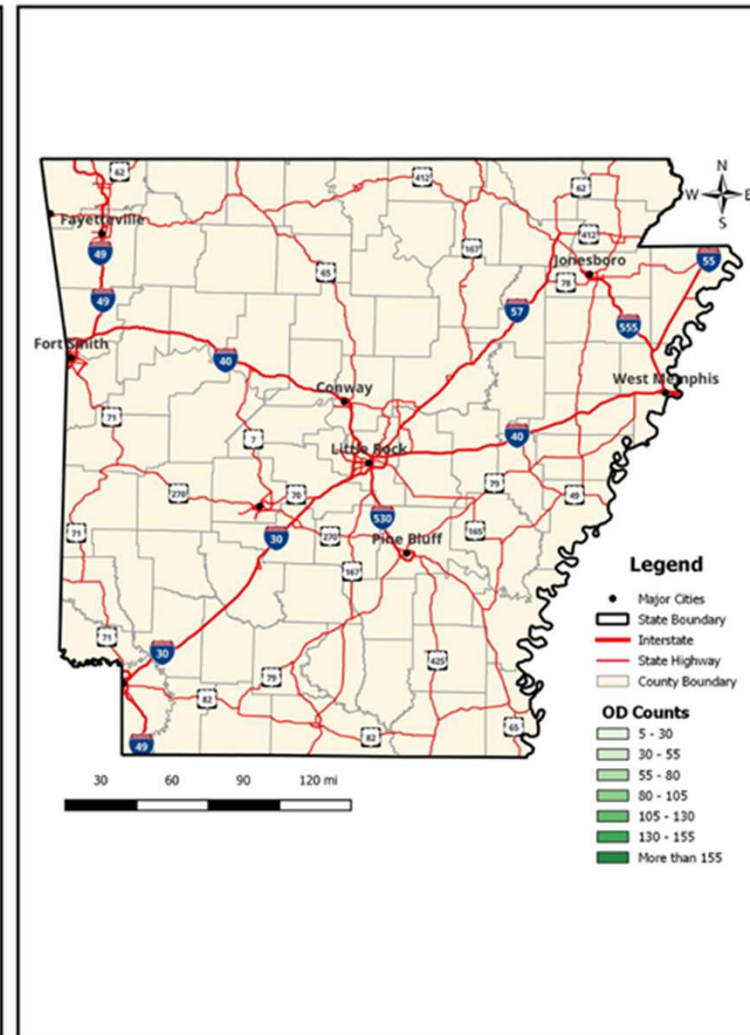
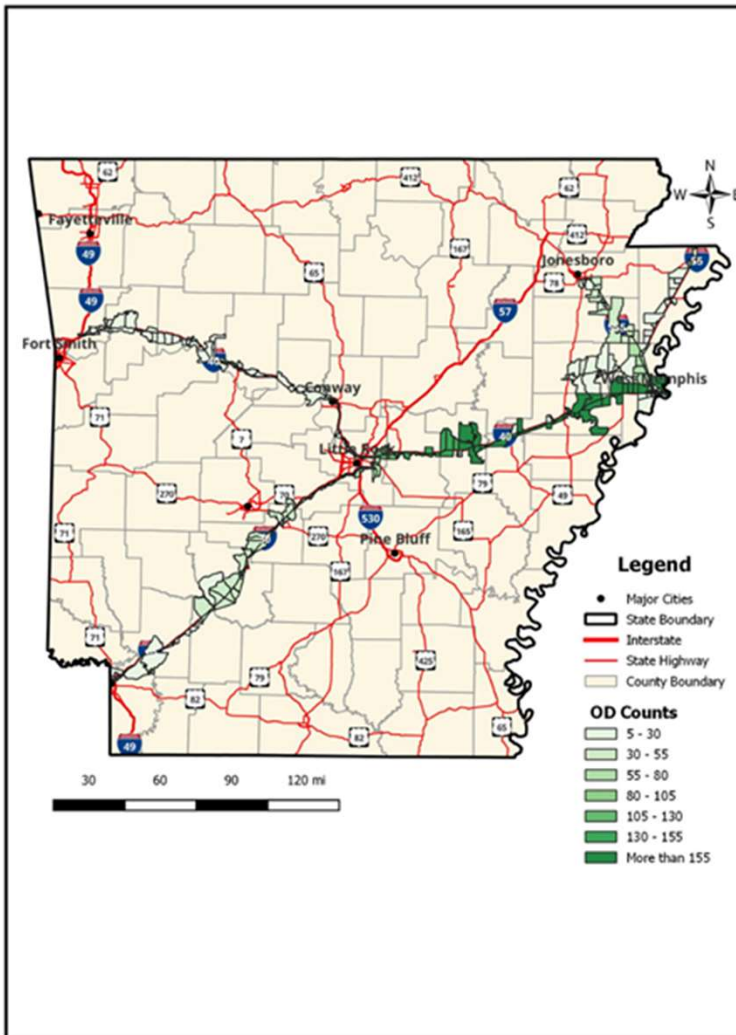
Comparison of Passenger Vehicle Flows from TAZs to the I-55 bridge (A) before (April 15-30, 2021) and (B) during (May 11 through July 31, 2021) the I-40 Bridge Closure



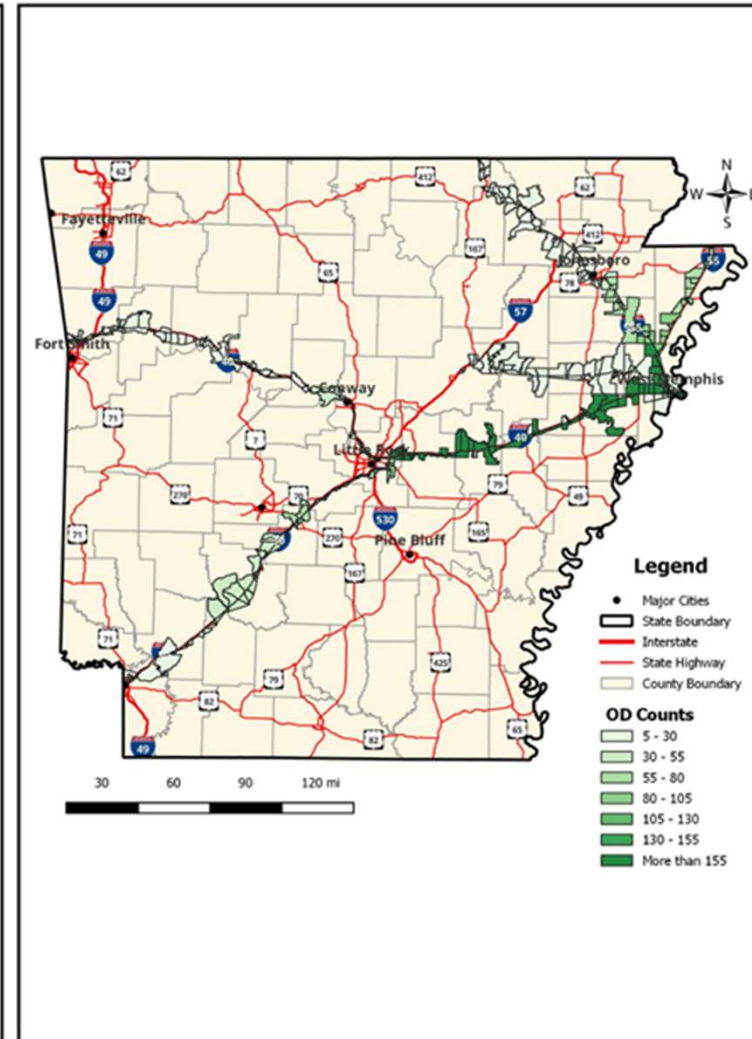
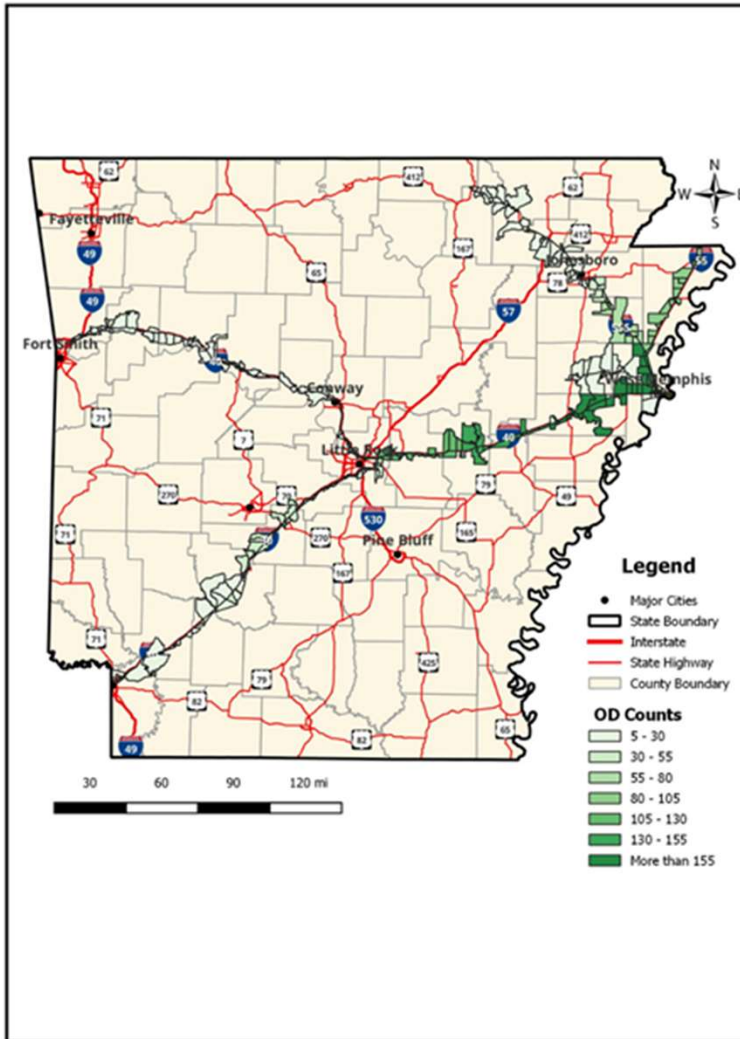
Comparison of Passenger Vehicle Flows from TAZs to the HWY 49 bridge (A) before (April 15-30, 2021) and (B) during (May 11 through July 31, 2021) the I-40 Bridge Closure



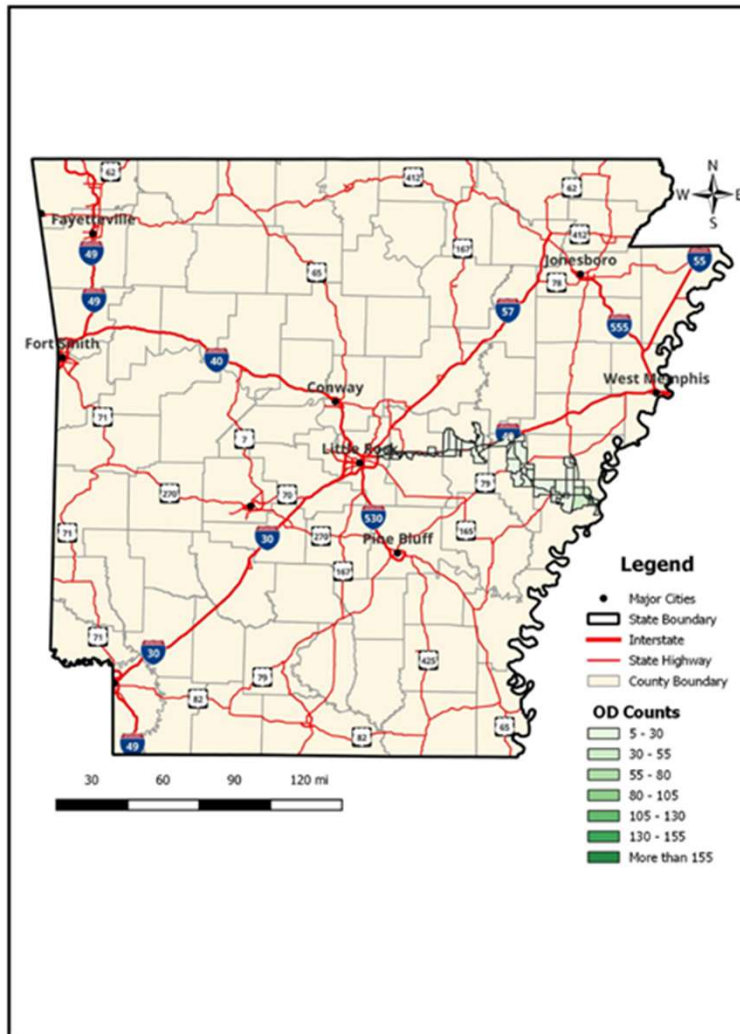
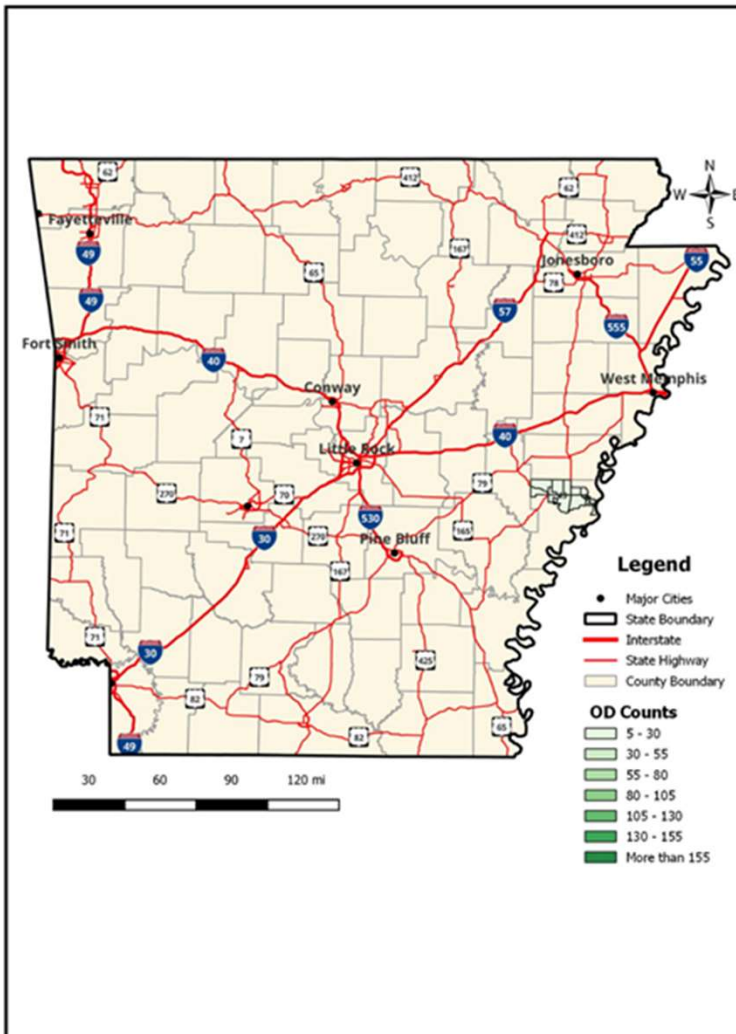
Comparison of Passenger Vehicle Flows from TAZs to the HWY 82 bridge (A) before (April 15-30, 2021) and (B) during (May 11 through July 31, 2021) the I-40 Bridge Closure ¹²



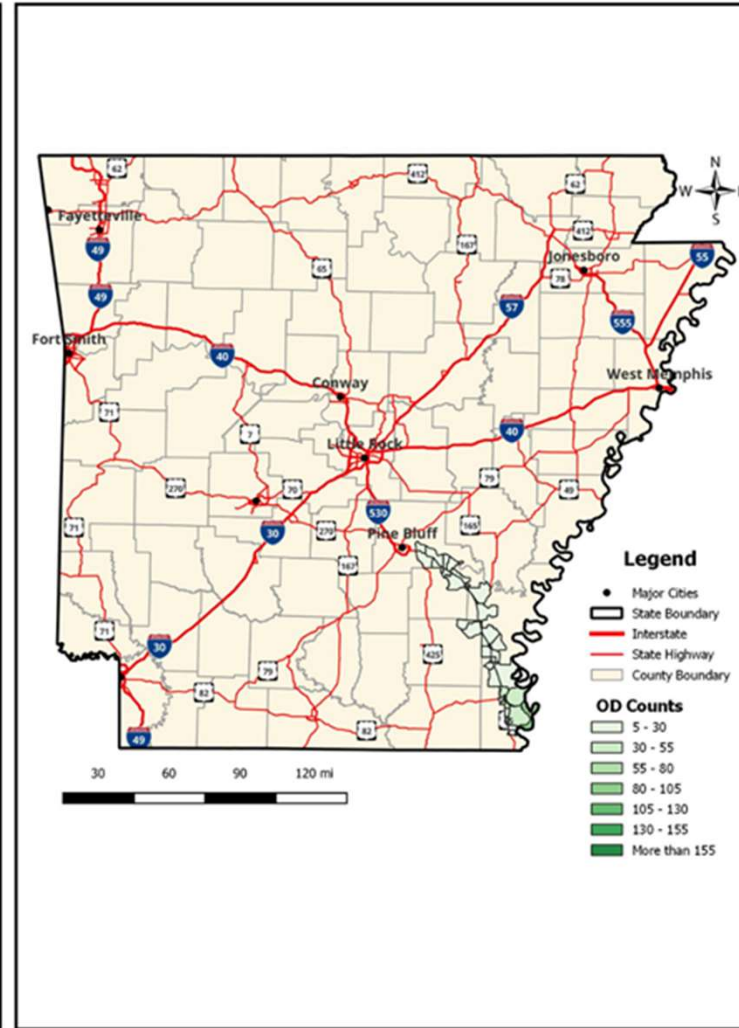
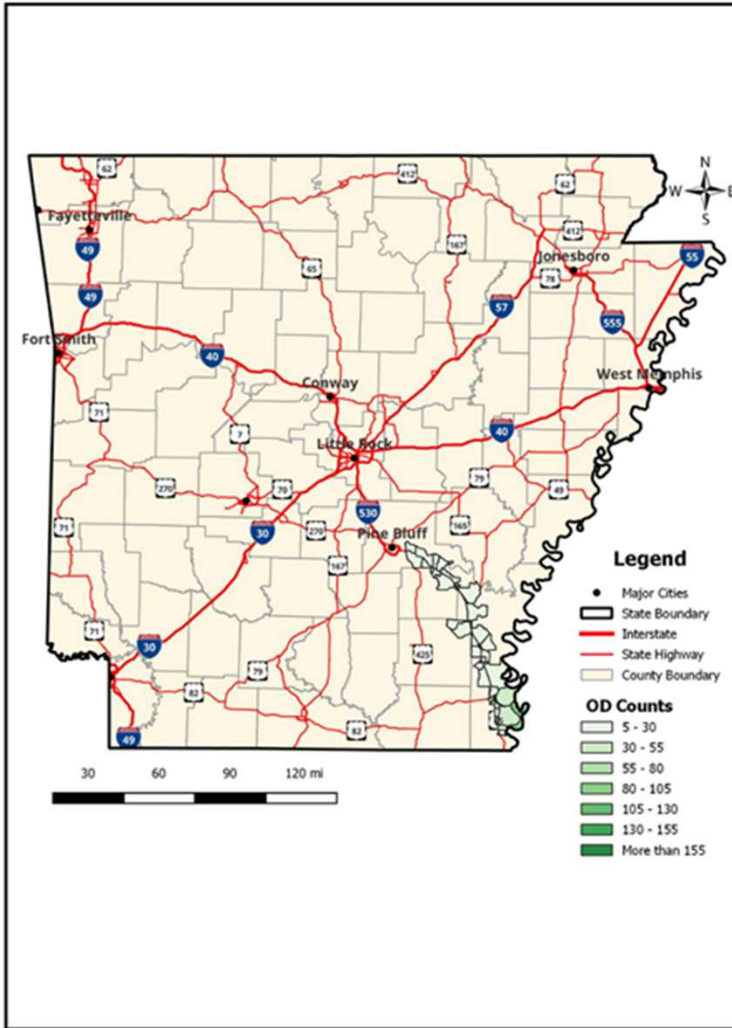
Comparison of Average Daily Commercial Vehicle Flows from TAZs to the I-40 bridge (A) before (April 15-30, 2021) and (B) during (May 11 through July 31, 2021) the I-40 bridge closure



Comparison of Average Daily Commercial Vehicle Flows from TAZs to the I-55 bridge (A) before (April 15-30, 2021) and (B) during (May 11 through July 31, 2021) the I-40 bridge closure



Comparison of Average Daily Commercial Vehicle Flows from TAZs to the HWY 49 bridge (A) before (April 15-30, 2021) and (B) during (May 11 through July 31, 2021) the I-40 bridge closure



Comparison of Average Daily Commercial Vehicle Flows from TAZs to the HWY 82 bridge (A) before (April 15-30, 2021) and (B) during (May 11 through July 31, 2021) the I-40 bridge closure

USER IMPACTS

- Federal Highway Administration (FHWA) manual titled Work Zone Road User Costs – Concepts and Applications
- Estimates based on:
 - Traffic (AADT)
 - Economic unit costs
 - Delay and Operations
 - Detours

Traffic Data	
ADT Construction Year (total for both directions)	54,000
Cars as Percentage of AADT (%)	61.8
Single Unit Trucks as Percentage of AADT (%)	3.2
Combination Trucks as Percentage of AADT (%)	35.0
Speed Limit Under Normal Operating Conditions (mph)	55
Number of Lanes in Each Direction During No Lane Closure	3
Free Flow Capacity (vphpl)	2350
Maximum Queue Length (miles)	10.0
Will There Be Lane Closures All Day?	Yes
Will Lane Closures Ever Be Present During the Period Analyzed?	Yes
Eastbound Closure Time Restrictions (Traffic Above Capacity)	End Lane Cl Begin Lane Cl
Westbound Closure Time Restrictions (Traffic Above Capacity)	End Lane Cl Begin Lane Cl
Eastbound Closure Time Restrictions (Traffic Above Capacity)	End Lane Cl Begin Lane Cl
Westbound Closure Time Restrictions (Traffic Above Capacity)	End Lane Cl Begin Lane Cl



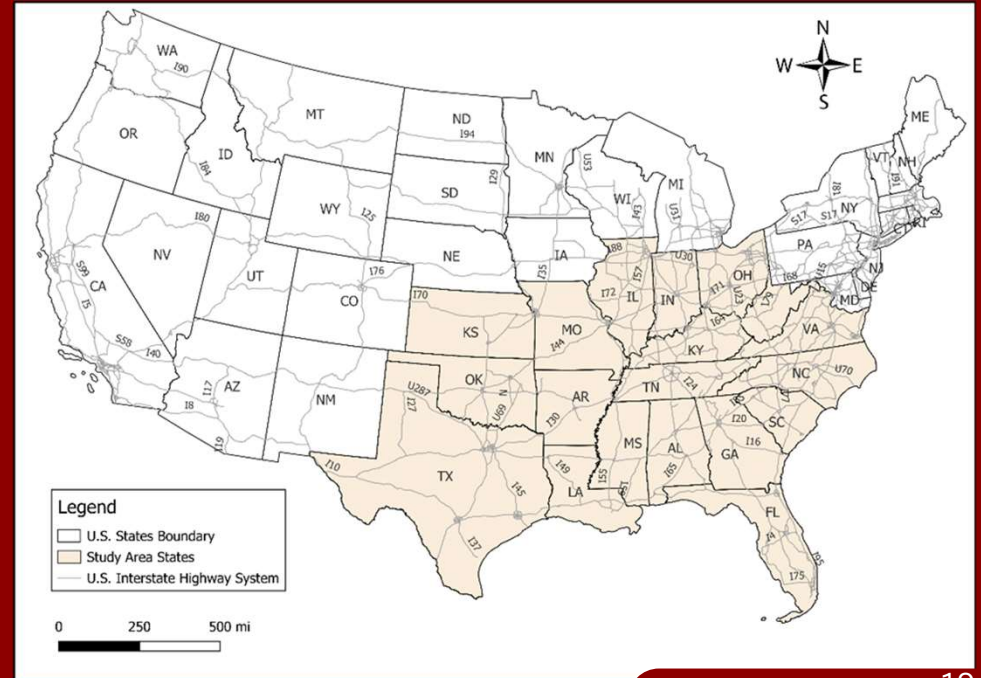
Job 0		Full Closure for Maintenance			
I-40					
No Work Time Limitations =		\$23,439,029 per day (both directions)			
Lane Closures All Day)		EB	\$12,207,546 per day		
		WB	\$11,191,483 per day		
User Cost for Delay					
	Cars	SU	TT	Total	
EB	\$4,495,171	\$259,212	\$7,240,424	\$11,994,806	
WB	\$3,765,945	\$241,664	\$6,881,065	\$10,888,673	
User Operating Cost					
	Cars	SU	TT	Total	
EB	\$151,016	\$7,705	\$151,897	\$310,617	
WB	\$127,117	\$7,207	\$146,363	\$280,687	
Crash Cost					
Both Directions		(\$36,756)			
Per Direction		(\$17,877)			

System Impacts

- 1 Arkansas Statewide Travel Demand Model
- 2 Peak Periods (AM, PM, Midday, and Nighttime)
- 3 Passenger Vehicles, Single Unit Trucks, Tractor Trailer Trucks
- 4 90,000+ miles of modeled network
- 5 2,303 modeled scenarios

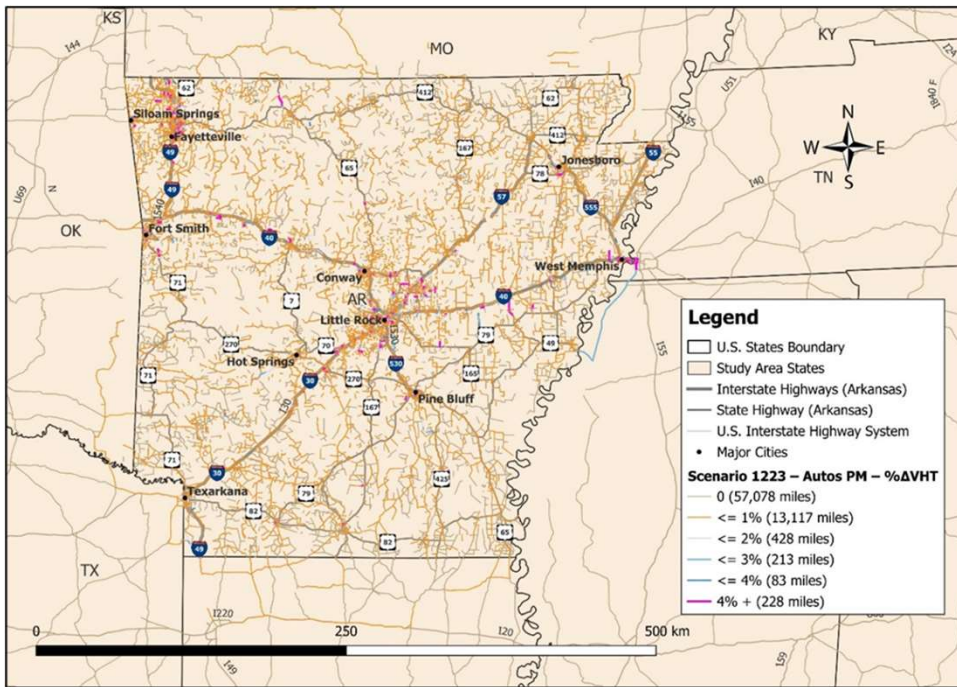
TRAVEL DEMAND MODEL

$$\% \Delta VHT = \left(\frac{VHT_{closed} - VHT_{open}}{VHT_{open}} \right) \times 100$$

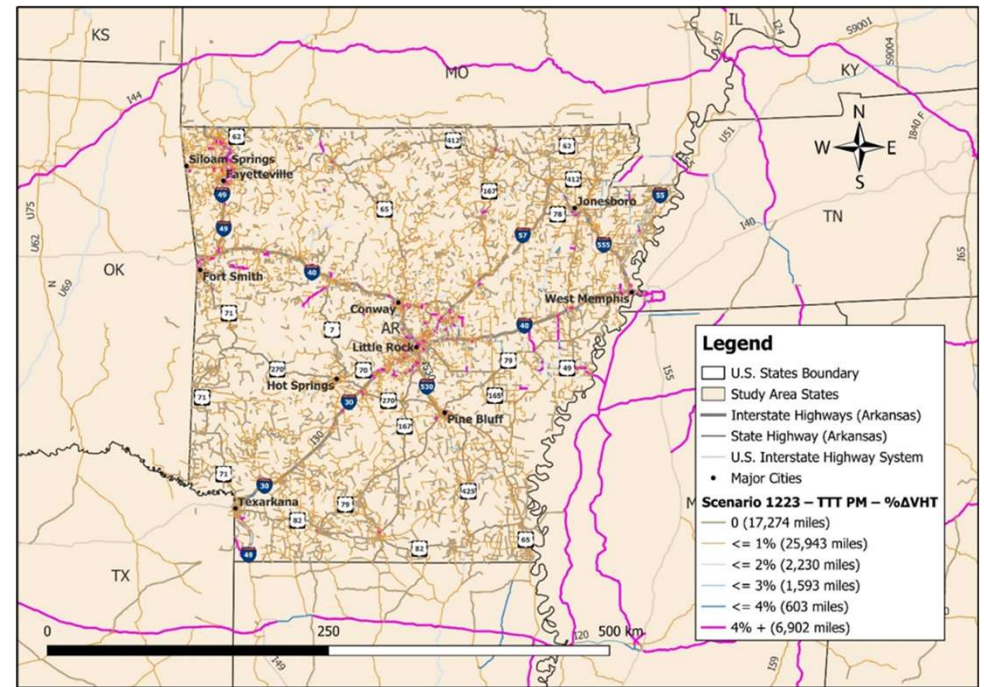


STATEWIDE IMPACTS

I-40 Bridge Closed



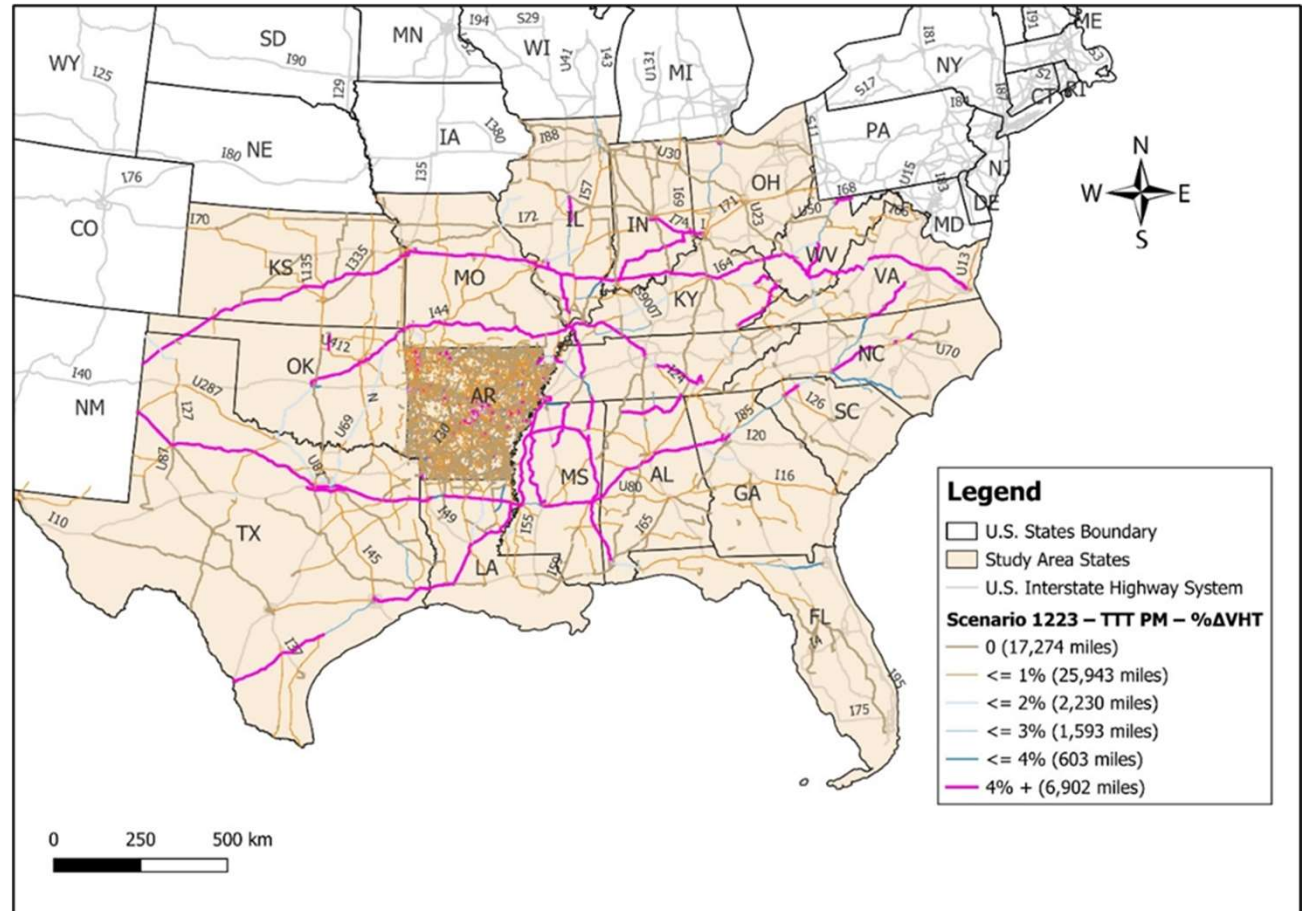
Passenger
Vehicles



Tractor Trailer
Trucks

REGIONAL IMPACTS

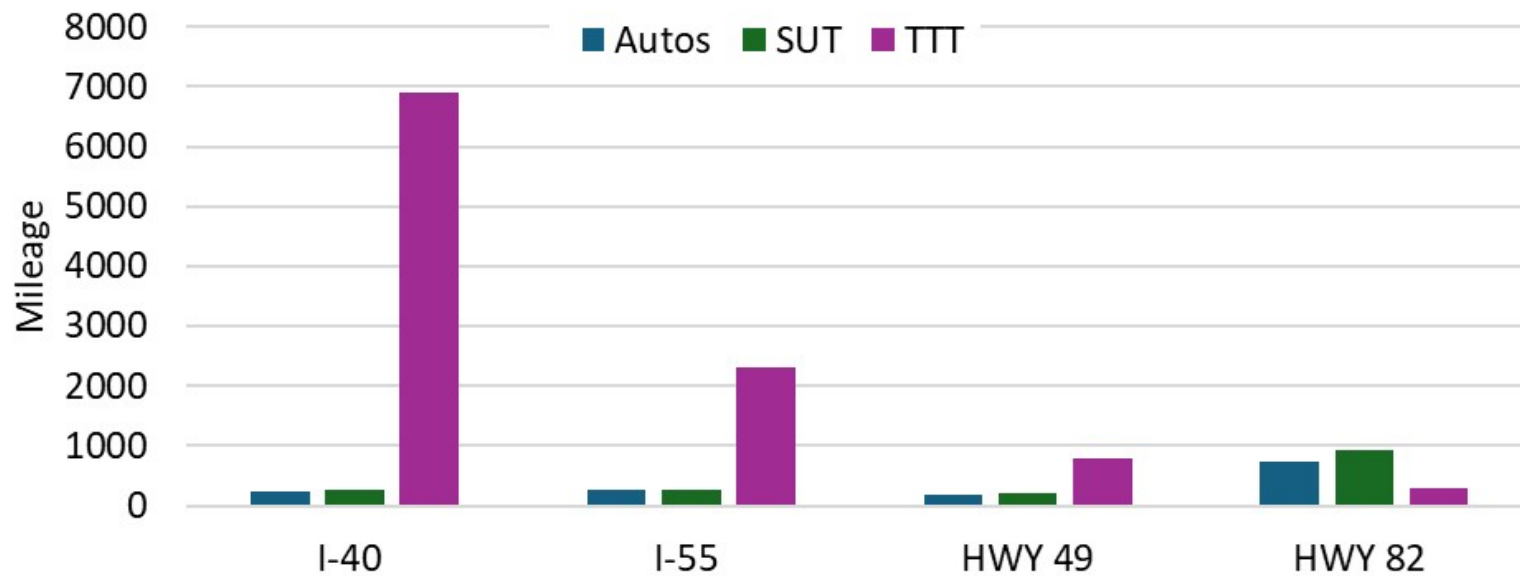
I-40 Bridge Closed



Tractor Trailer Trucks

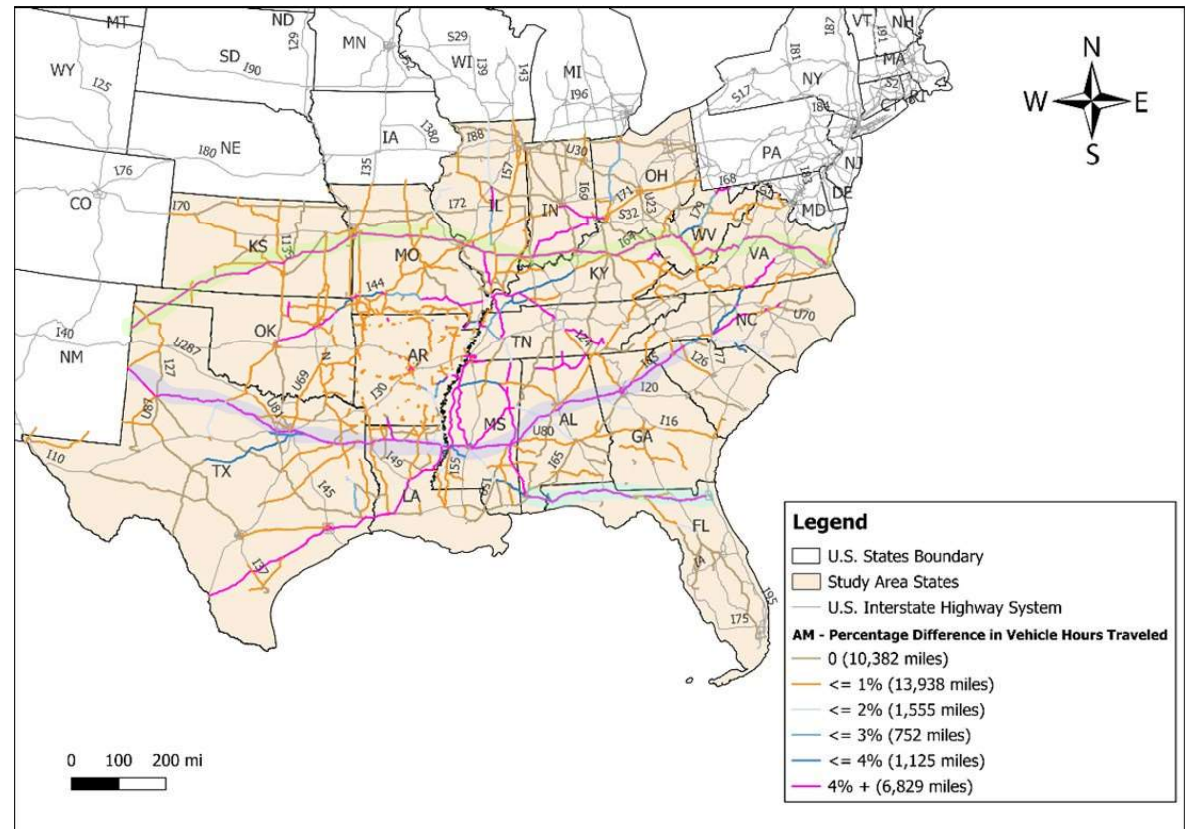
SYSTEM IMPACTS

Mileage with more than 4% change in VHT



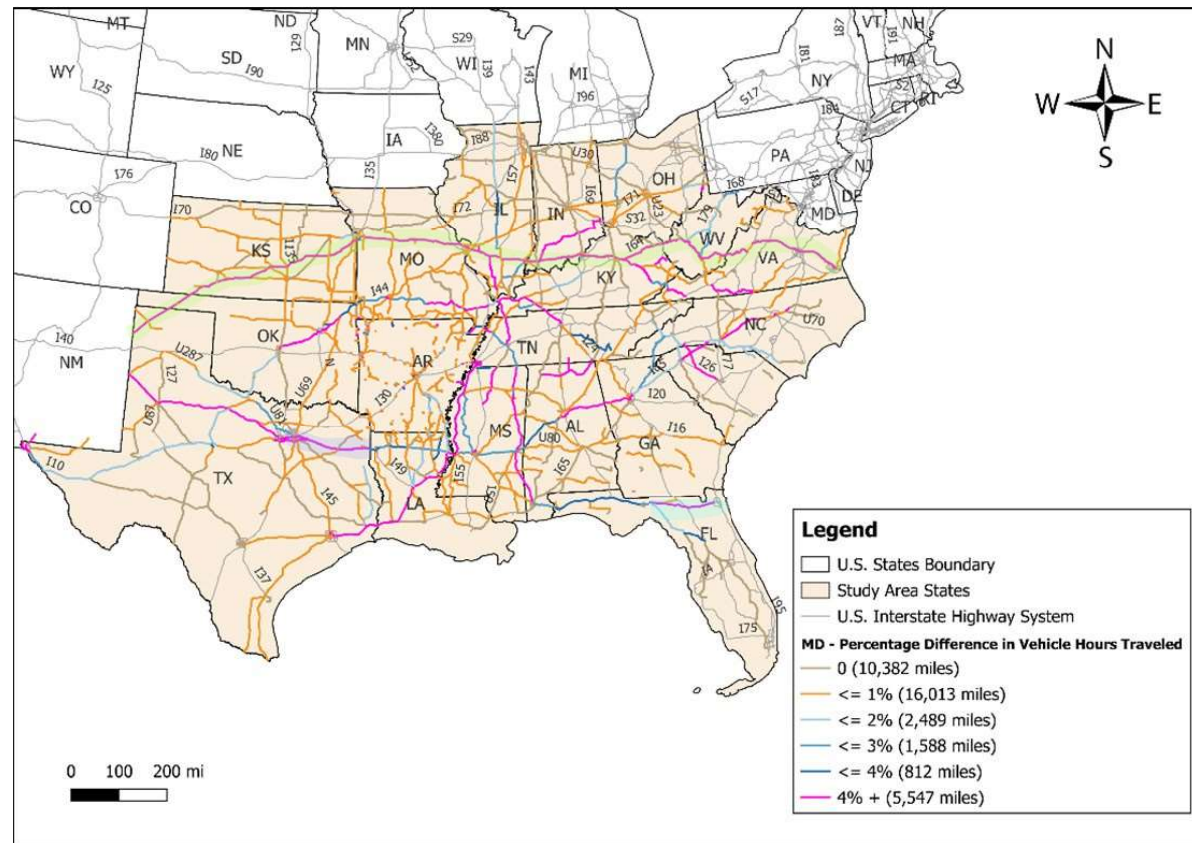
PERCENTAGE DIFFERENCE IN VHT AM PERIOD

- 20% of all network miles (3,538 links) experienced increases above the 4% threshold
- Consistently elevated impacts
 - I-64/I-70 (Virginia to Kansas)
 - I-80/I-20 (South Carolina to Texas)
 - I-20 (North Florida)



PERCENTAGE DIFFERENCE IN VHT MD PERIOD

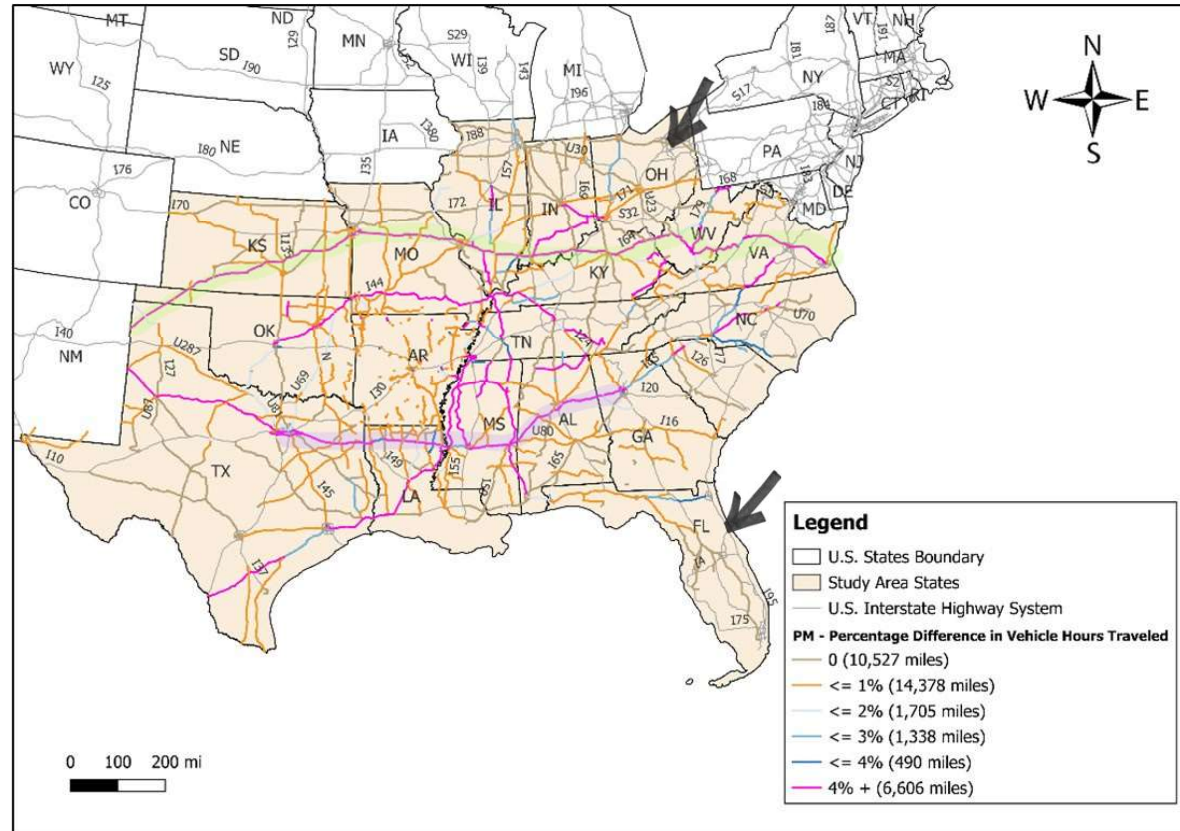
- 15% of all network miles (3,043 links) experienced increases above the 4% threshold
- I-64/I-70 (Virginia to Kansas)
- I-20 (Texas)
- I-10 (North Florida)



PERCENTAGE DIFFERENCE IN VHT

PM Period

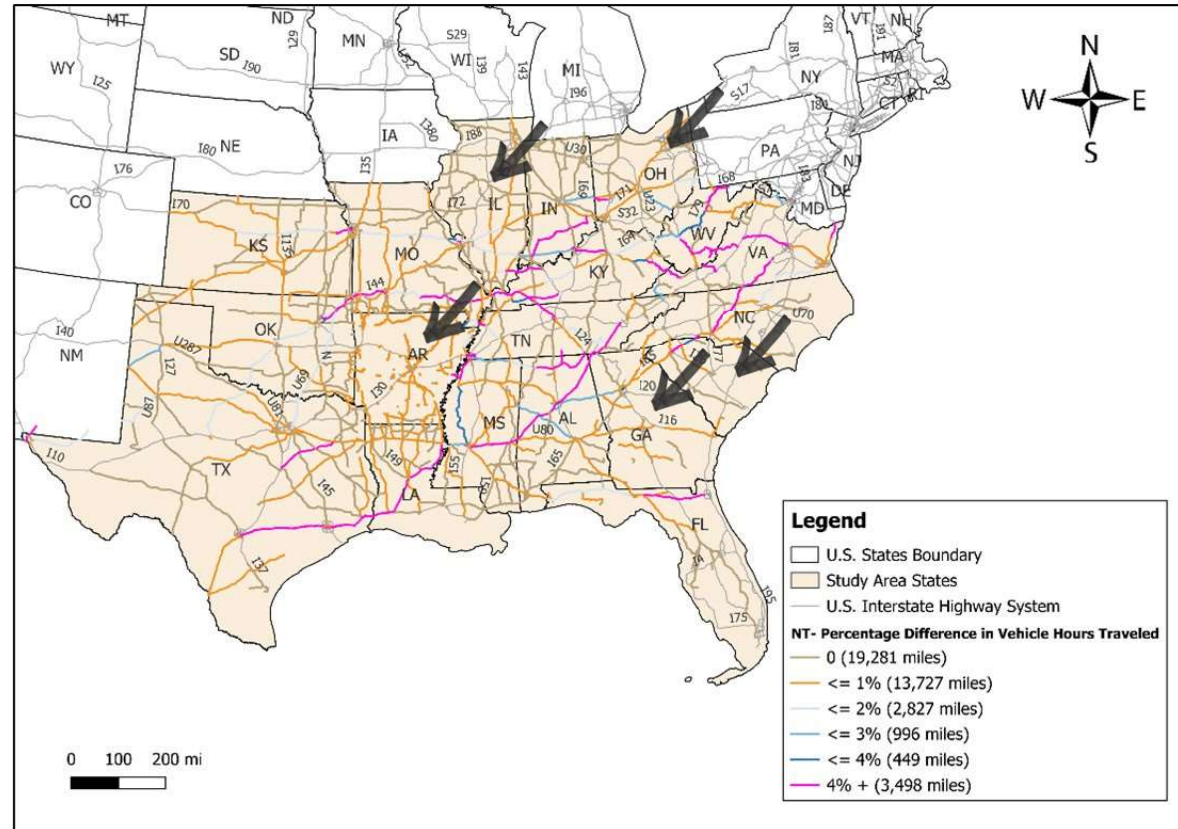
- 20% of all network miles (3,263 links) experienced increases above the 4% threshold
- I-64/I-70 (Virginia to Kansas) and I-80/I-20 (Georgia to Texas)



PERCENTAGE DIFFERENCE IN VHT

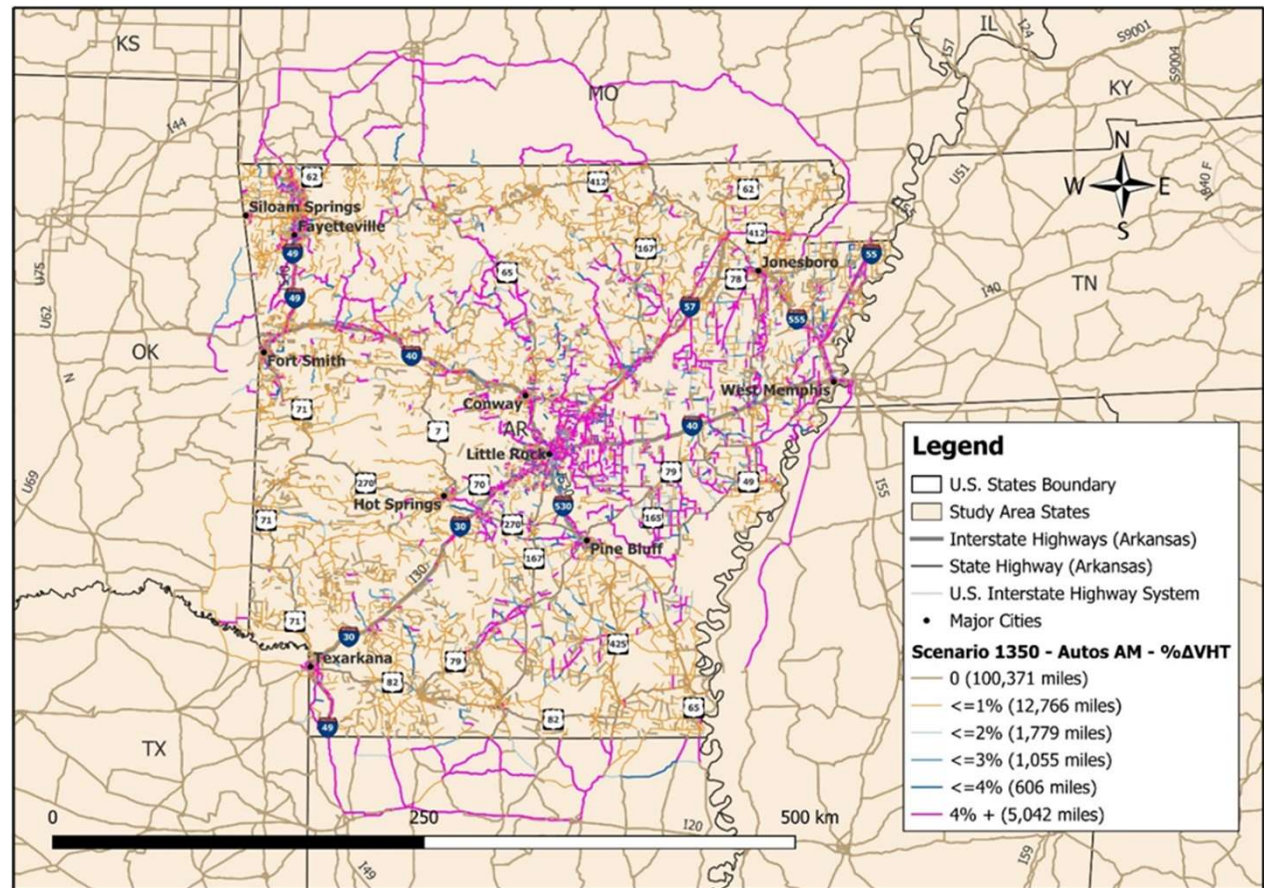
Nighttime

- 8% of all network miles (1,864 links) experienced increases above the 4% threshold
- Illinois, Ohio, South Carolina, Georgia, and Arkansas had no segments exceeding the 4% threshold



WORST CASE

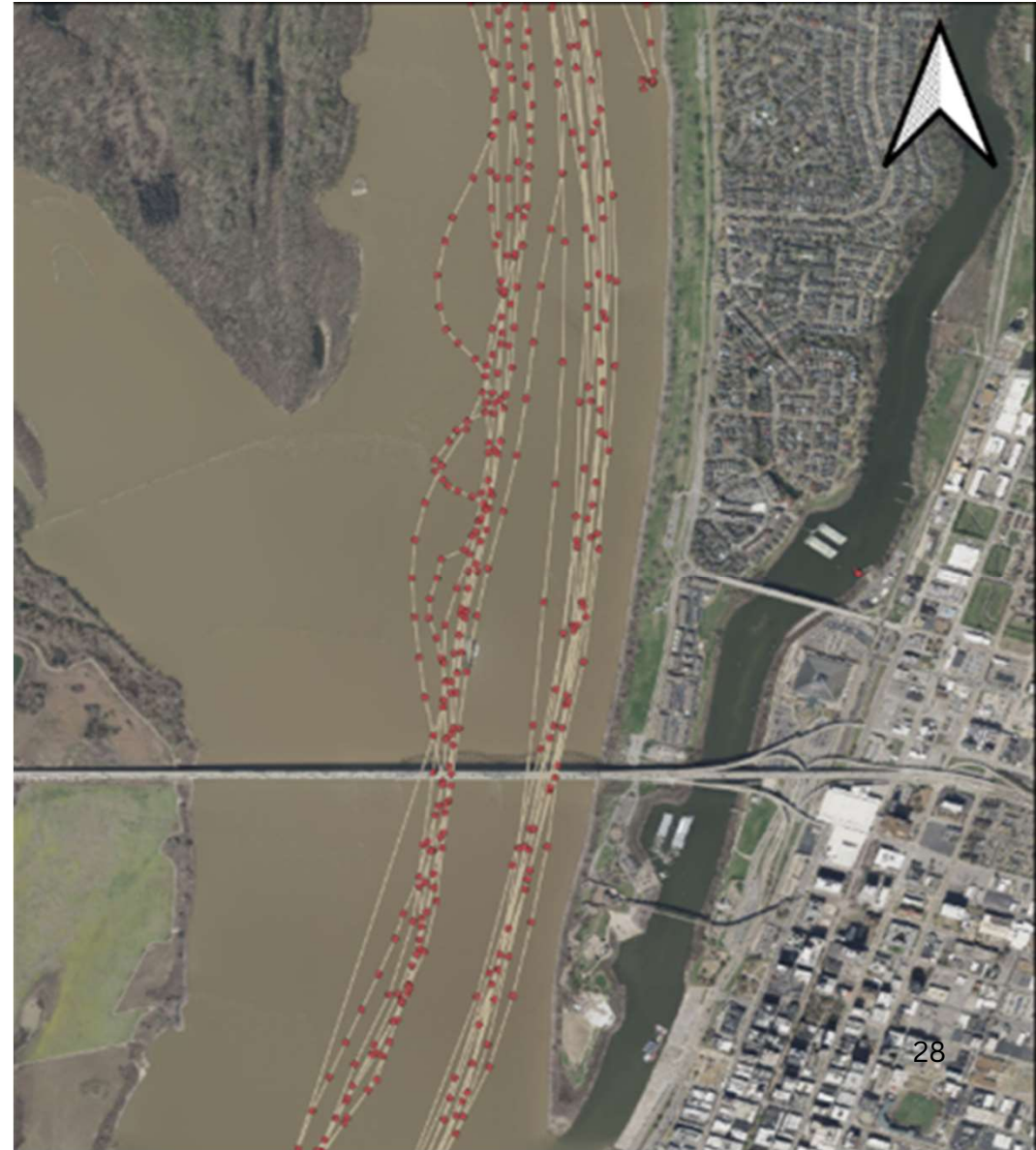
- I-40 Bridge WB Closed
- I-55 Bridge Closed
- HWY 49 WB Closed
- HWY 82 Open



Passenger Vehicles

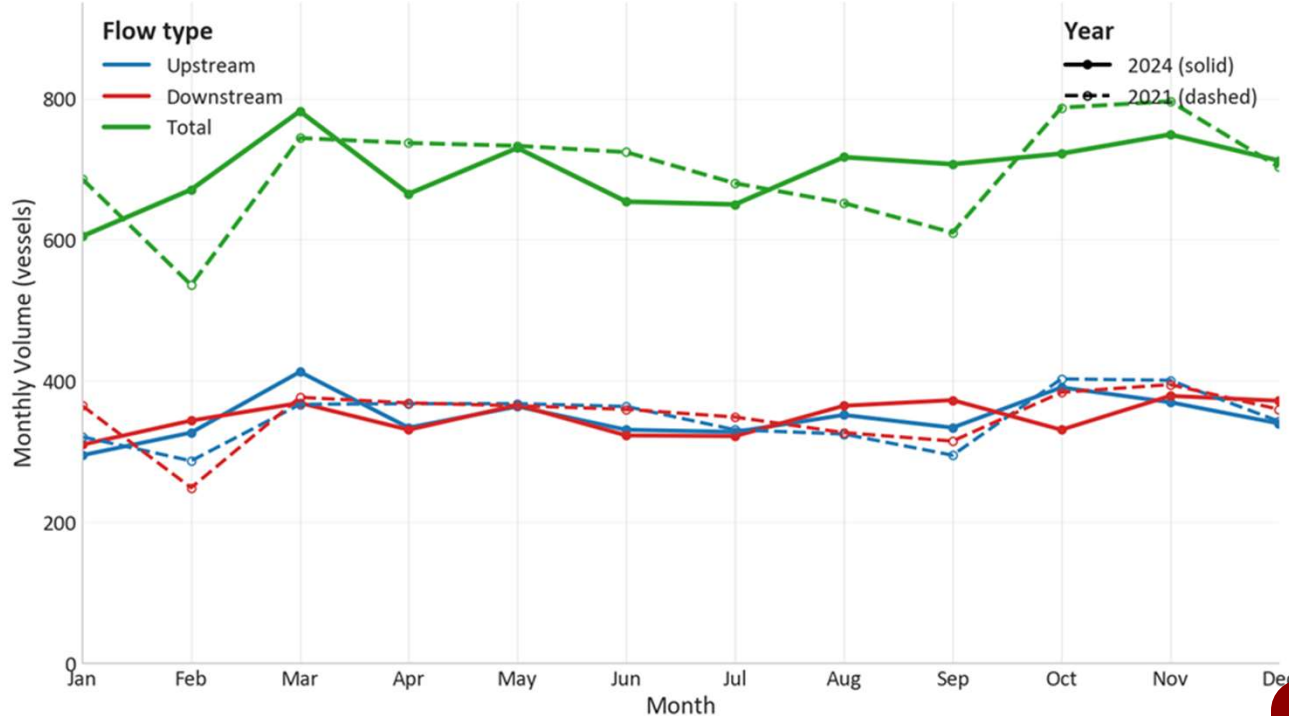
WATERWAY IMPACTS

- Vessel trajectories from Automatic Identification System (AIS)
- Count vessels passing under each bridge
- 2021 (during I-40 closure) and 2024 (future volume)



WATERWAY IMPACTS

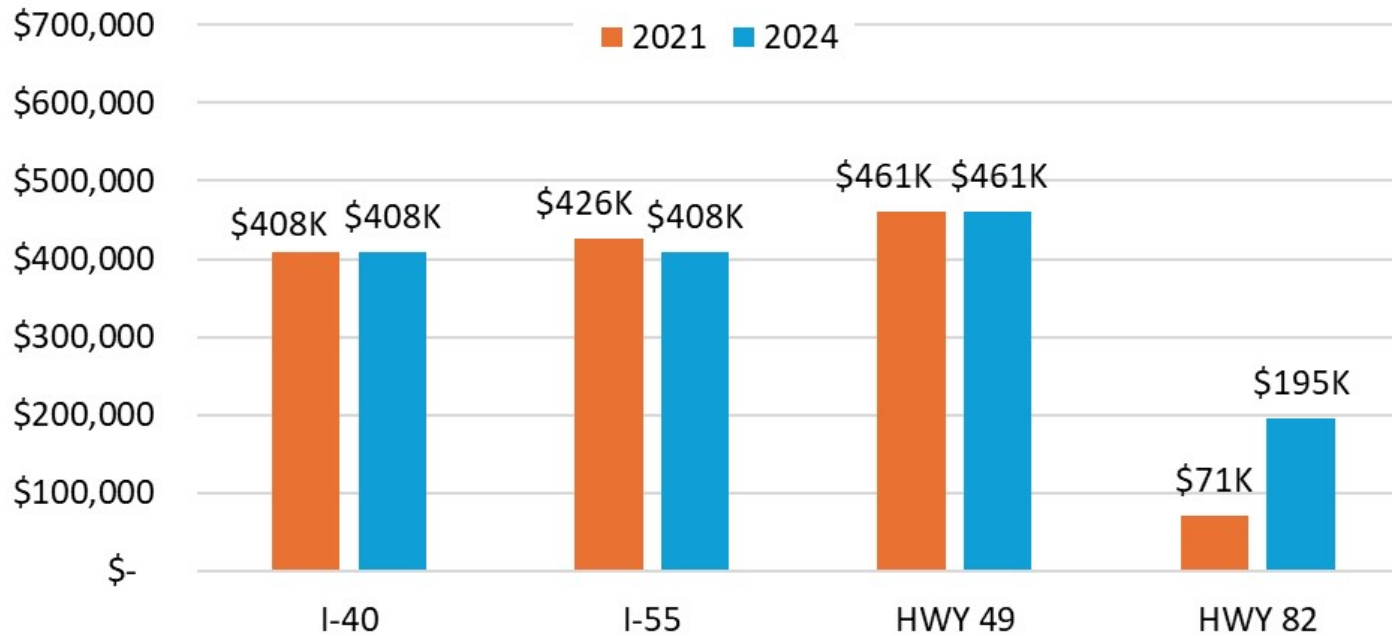
Vessel Volumes under I-40 Bridge



I-40 Vessel Traffic by Month for 2021 and 2024

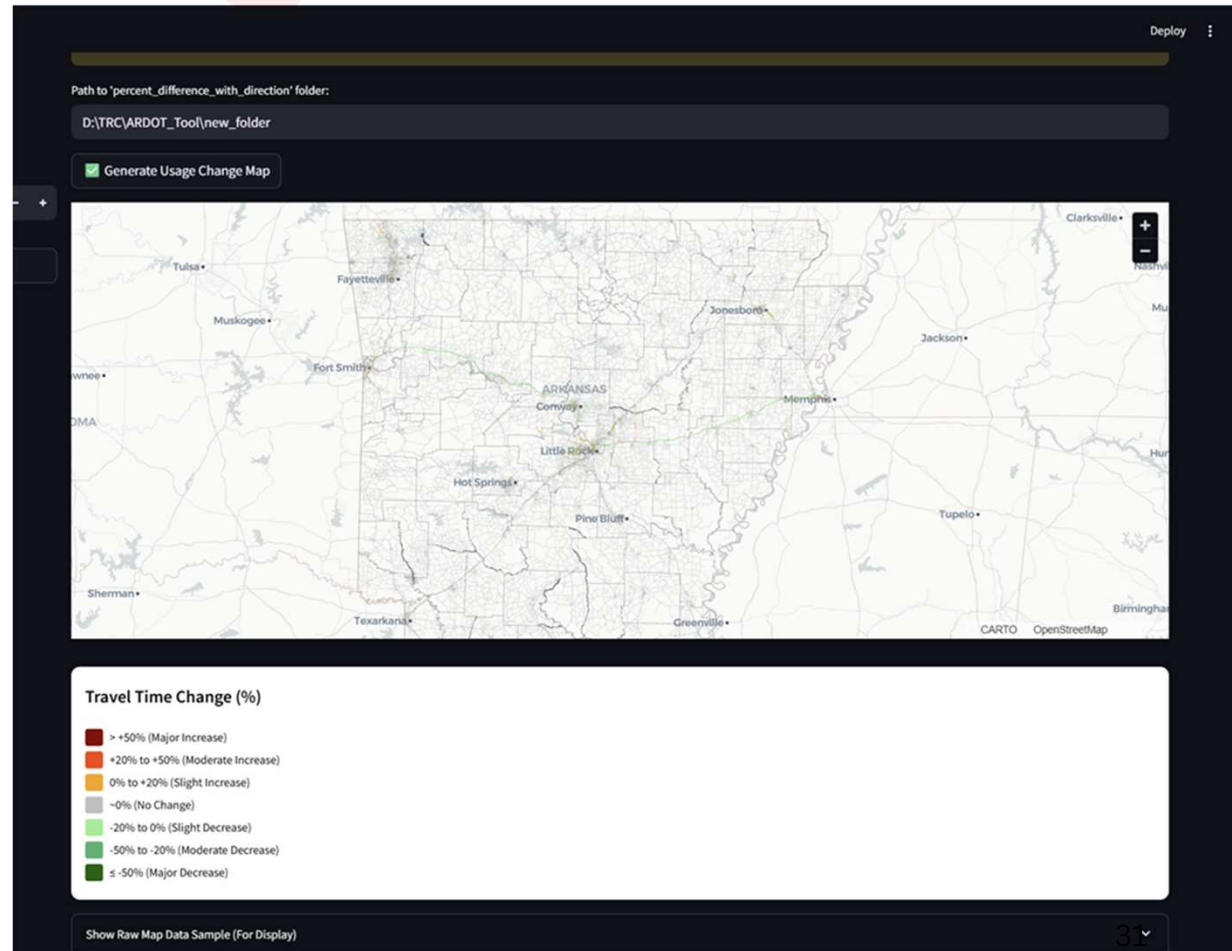
ROAD USER COSTS

Cost by Closure Duration



User Tool

- Bridge Closure Impact Analysis Tool
- Web-based
- Backend calculations for RUC and pre-run ARSTDm scenarios

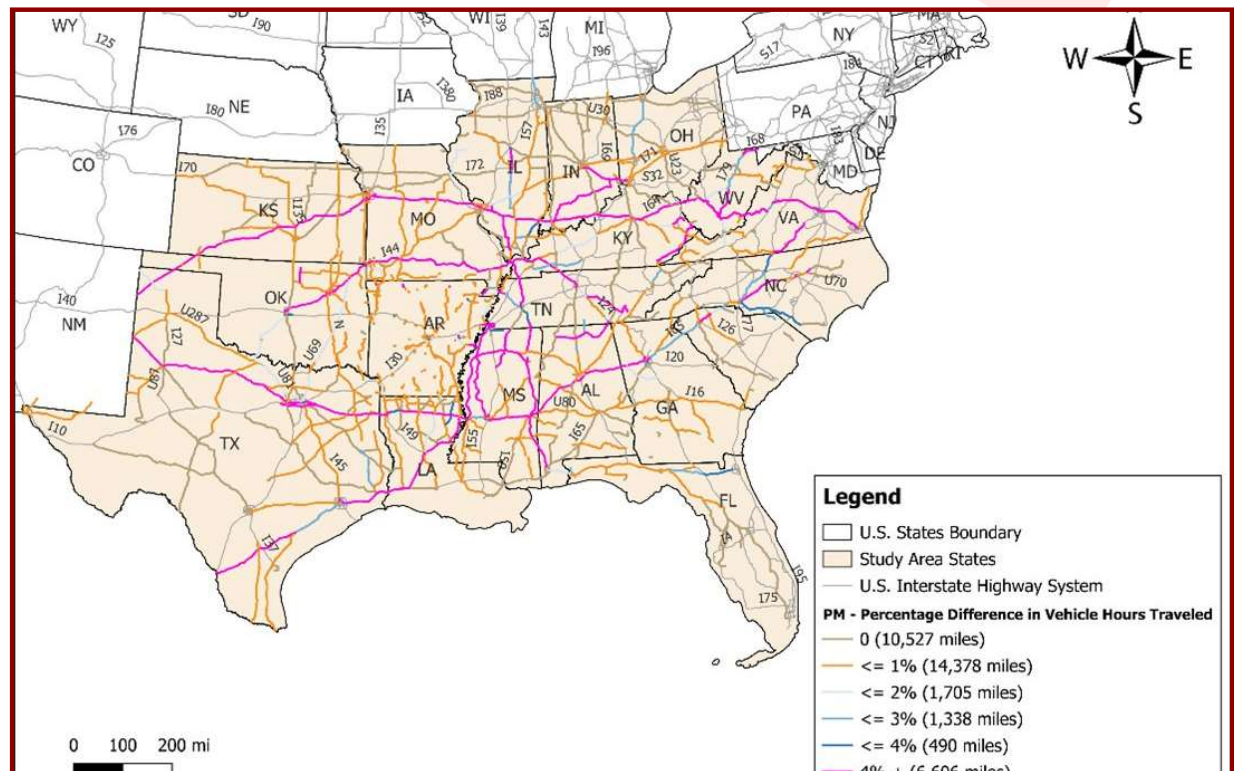


KEY FINDINGS

- 1 Tractor Trailer Trucks experience greatest disruptions, **7.7% of network with more than 4% change in VHT** with I-40 closed
- 2 **Nearby states** (TN, MS, MO, LA, AL) experienced higher impacts of Tractor Trailer Truck traffic
- 3 Waterway closure costs as high as **\$461k/day** with traffic volumes as high as **500 vessels per day** per direction

Implementation

- Dynamic Lane Management
- Traveler Information
- Structural Health Monitoring
- Scenario modelling
- Coordinated scheduling
- Pre-planned long-haul detours



Questions?

✉ Sarahvh@uark.edu

🌐 www.freightdatalab.uark.edu



FREIGHT DATA LAB



THANK YOU