

Data Time

with J. M. Christoph, PhD

Why are we doing this?

Highlight modeling & analysis by RPA's research team

Recognizing the contributions of:

- *Members*: Dan Bilka, Mike Christensen
- *RPA Interns*: Maxwell Middleton, Maximillian Pohlenz, Rifqa Khadim
- *Student Collaborators*: Cecelia Paparella, Elizabeth Hartmetz
- USM Trent Lott Center
- *The entire RPA staff*

Focus on work done with the following groups:

- Sally Mead Hands Foundation
- Maine Rail Group & TrainRiders Northeast
- Transportation For America

How does RPA's modeling work?

1. Predicting *future ridership* based on demographic & geographic data from the US Census
2. Estimating *economic impact* of Amtrak ridership with input-output software
3. Quantifying *environmental benefits* of Amtrak ridership in economic terms

1. Predicting Ridership

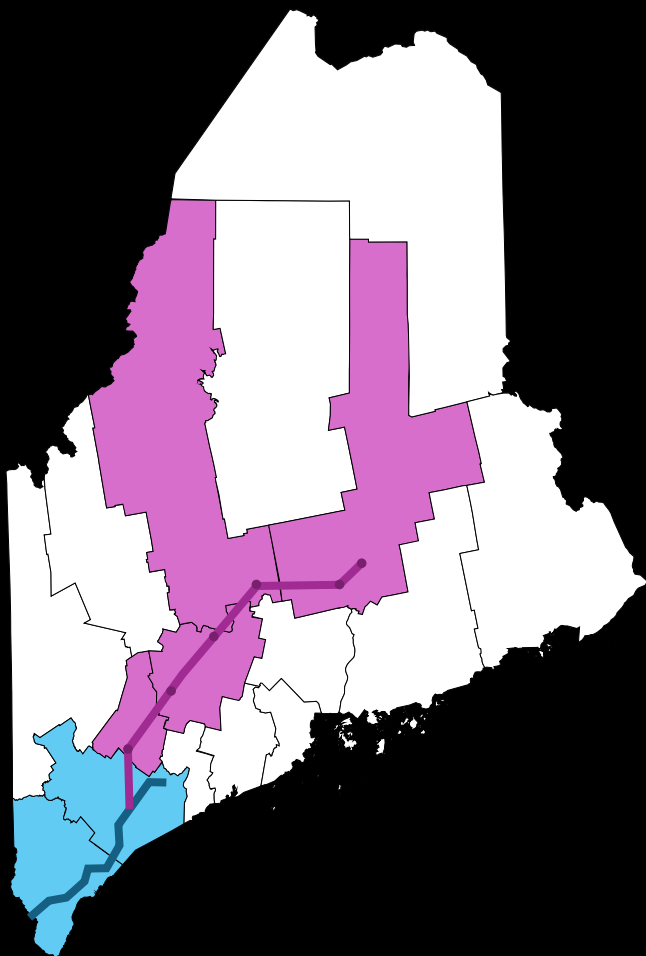
Measuring Geography & Population

Variable Category	# of Variables	Variables List
Demographic	13	Population over age 65, % Disabled, % Higher Ed Enrollees, Median Income, % Below Poverty Line, % Immigrant, % Metro Area Residents, % Renters, % Black, % Asian, % Native American, Population Density, Unemployment Rate
Industrial	10	% Employed in: Agriculture, Transportation, Finance, Professional Services, Education, Construction, Manufacturing, Wholesale, Retail
Land & Nature	5	Monthly Rent, Land Area, Ratio Urban Land / Total, Minimum Annual Temperature, Precipitation
Travel	8	% Car-Free Households, % Transit Commuters, % Walking/Biking Commuters, Roadway Density, Transit Stop Density, Number of Commercial Airports, Rail Route Density, Number of Amtrak Stations

Most Predictive Variables

Variable	Category	Scale Factor
Number of Amtrak Stations	Travel	+0.461
Unemployment Rate	Demographic	+0.185
% Employment in Wholesale	Industrial	+0.151
% Car-Free Households	Travel	+0.096
% Renters	Demographic	+0.038
Median Household Income	Demographic	+0.00003178
Yearly Minimum Temperature	Land & Nature	-0.023
% Employment in Education	Industrial	-0.037
% Employment in Manufacturing	Industrial	-0.046
% Employment in Agriculture	Industrial	-0.093
% Disabled	Demographic	-0.119
% Employment in Construction	Industrial	-0.126

Example: Downeaster Extension



Statewide Total:

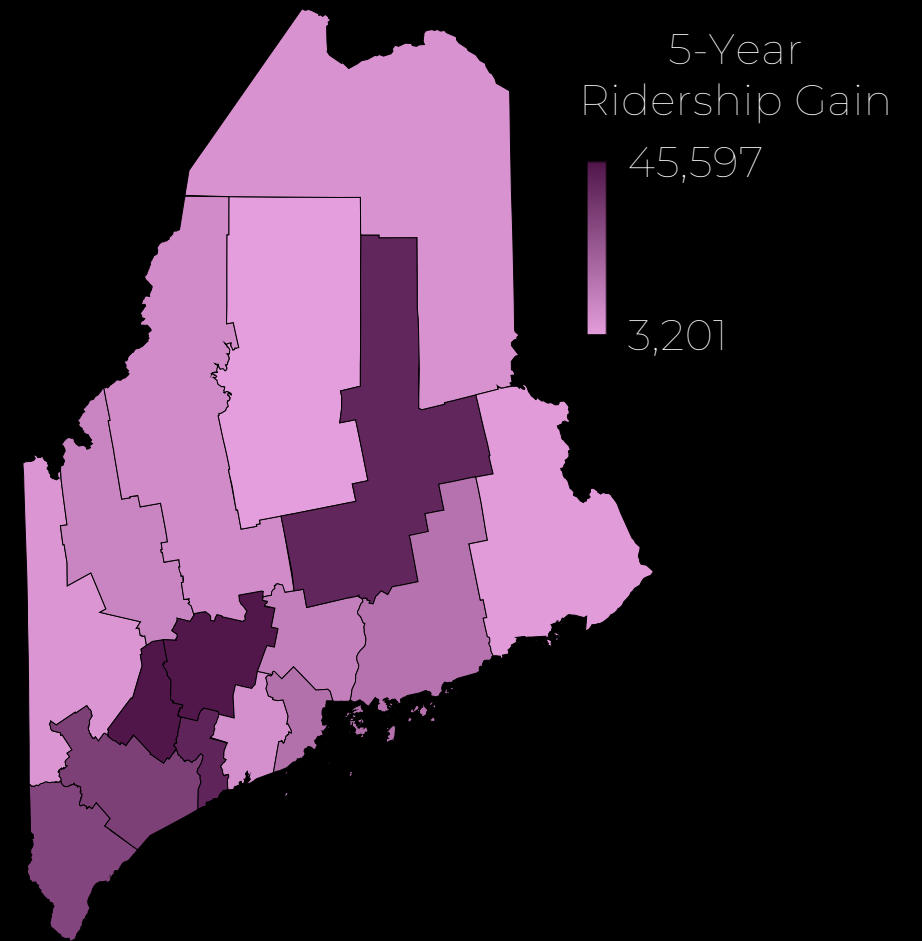
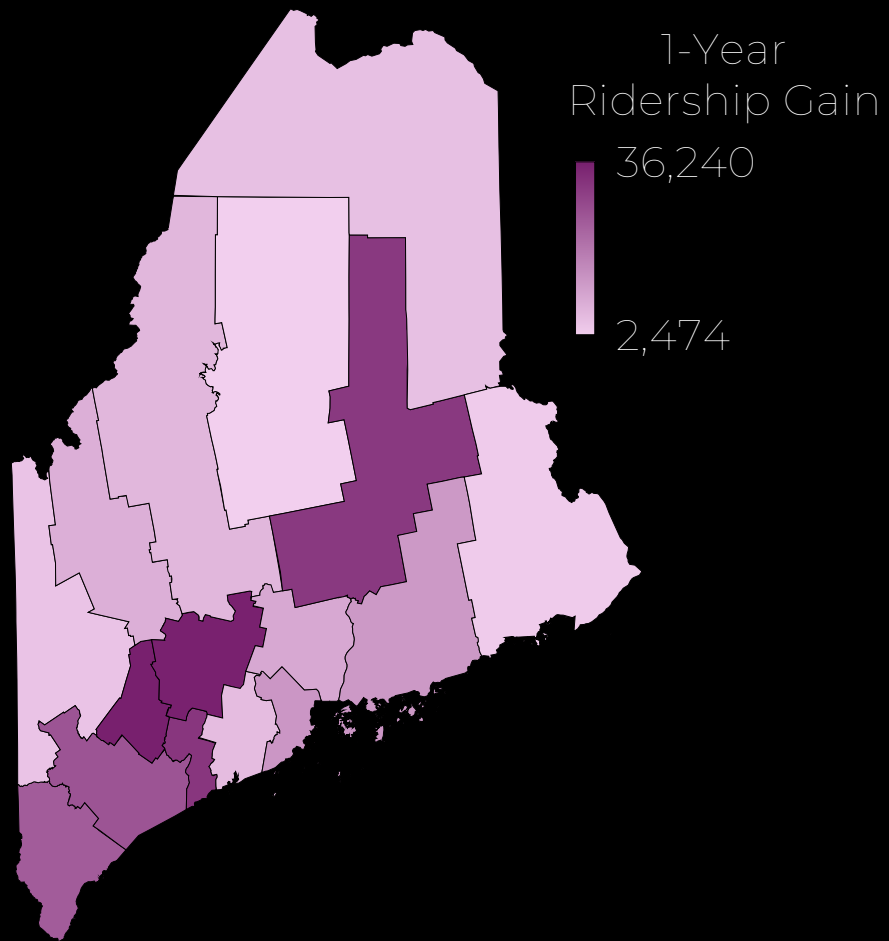
260,534 Riders
in first year

332,702 Riders
after 5 years

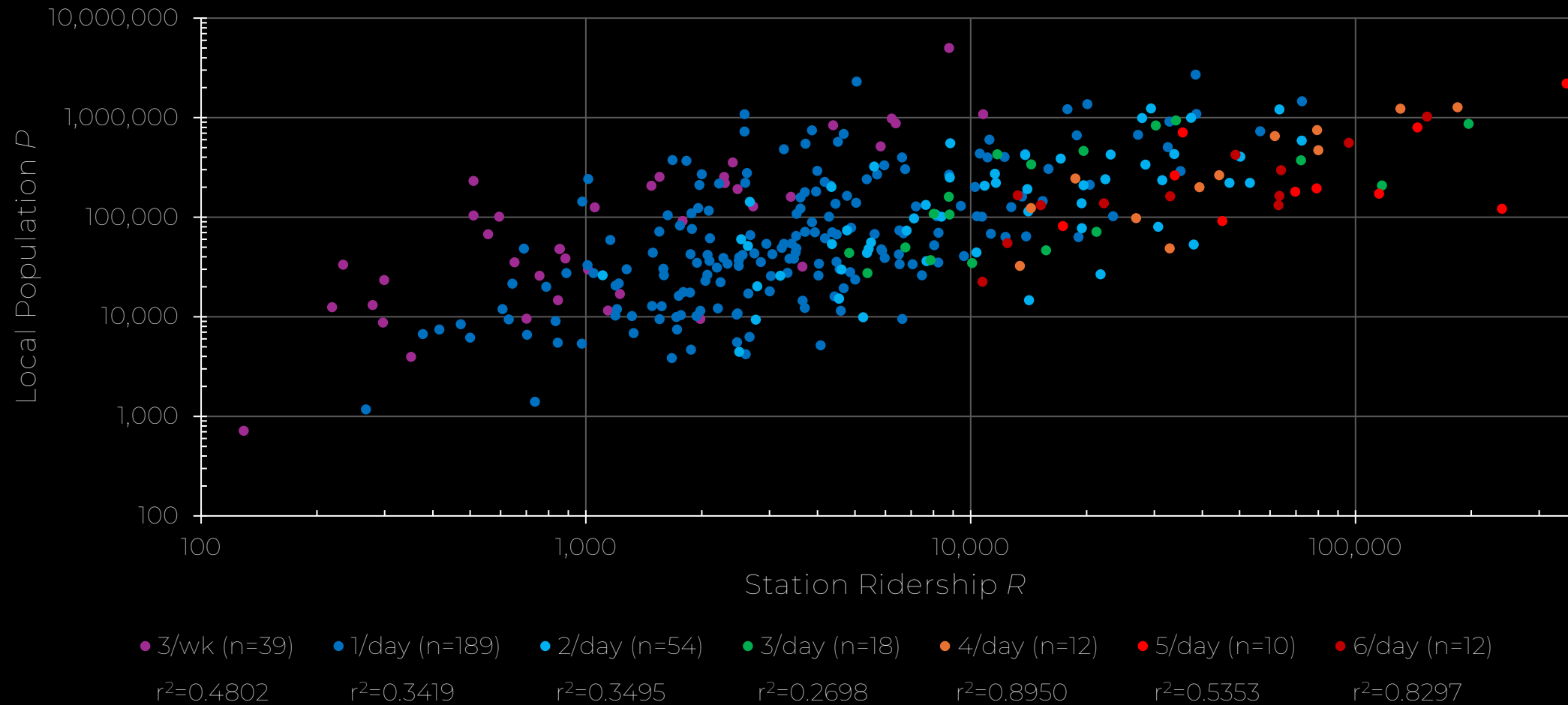
ON TOP OF
591,948 Downeaster
riders in FY2024

County	Pop	Y 1	Y 5
<i>York</i>	220,143	24,637	30,998
<i>Cumberland</i>	313,809	26,196	32,960
<i>Androscoggin</i>	115,272	36,240	45,597
<i>Kennebec</i>	128,461	36,034	45,338
<i>Somerset</i>	51,338	7,091	9,175
<i>Penobscot</i>	156,840	31,479	40,729
<i>Aroostook</i>	66,776	5,406	6,995
<i>Oxford</i>	60,039	4,703	6,085
<i>Hancock</i>	56,946	12,988	16,804
<i>Knox</i>	40,981	13,380	17,312
<i>Waldo</i>	40,617	9,990	12,926
<i>Sagadahoc</i>	37,582	31,919	41,298
<i>Lincoln</i>	36,491	6,132	7,934
<i>Washington</i>	31,383	3,281	4,245
<i>Franklin</i>	30,902	8,584	11,106
<i>Piscataquis</i>	17,432	2,474	3,201

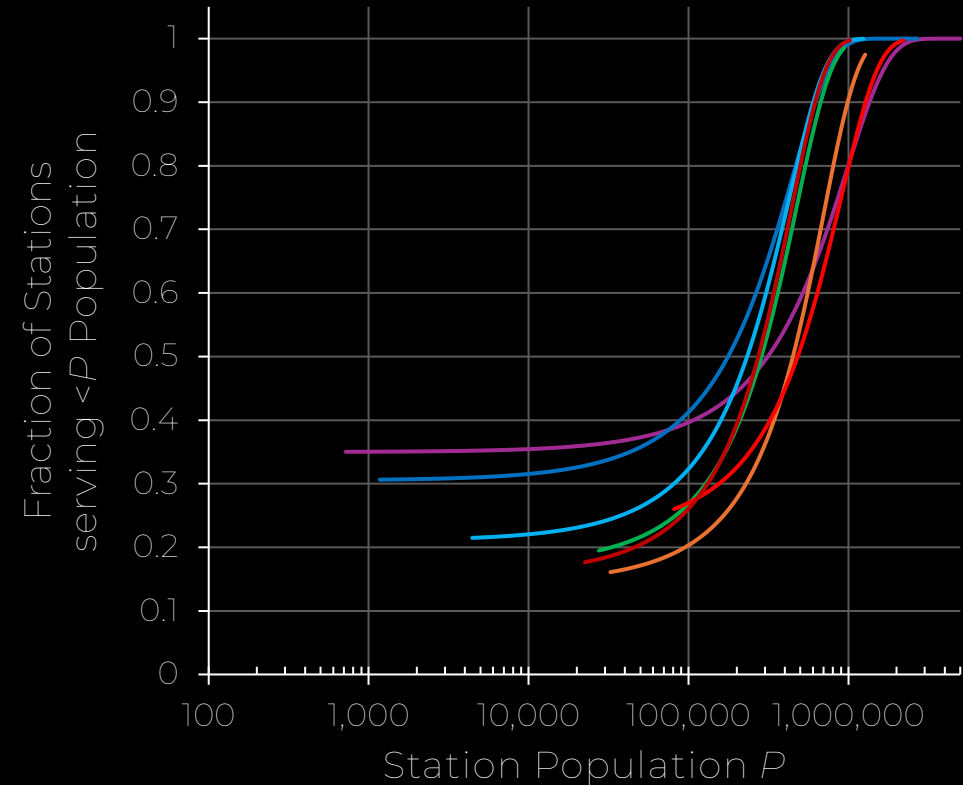
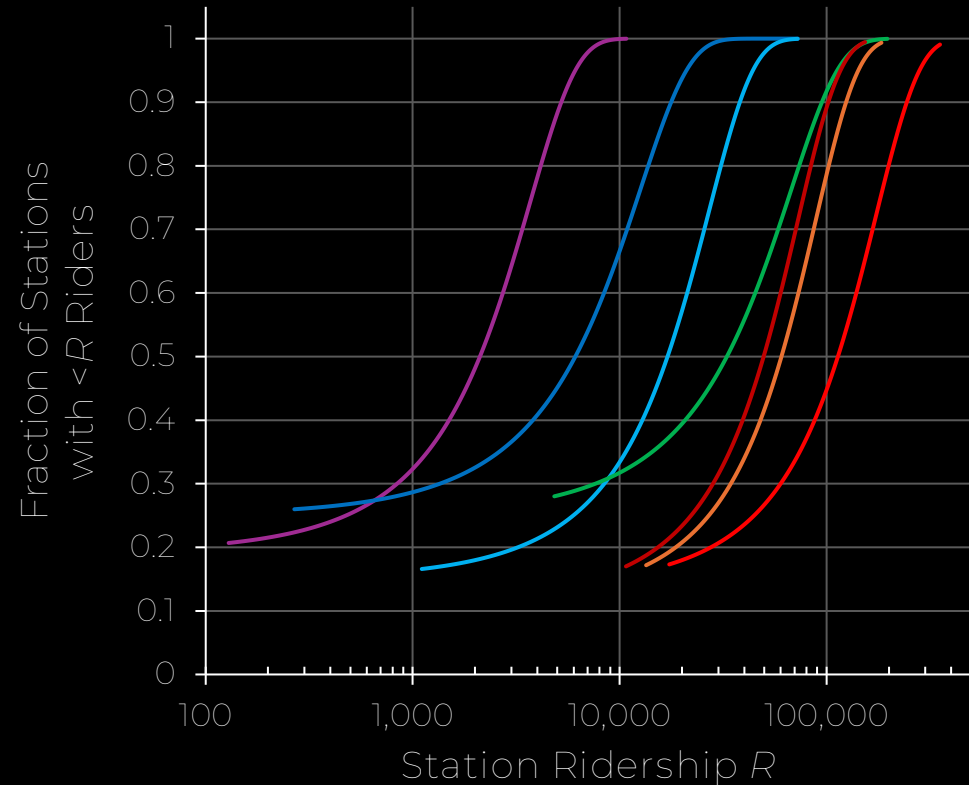
Maine Ridership Projections



... but what about *frequency*?



...yes, what *about* frequency?

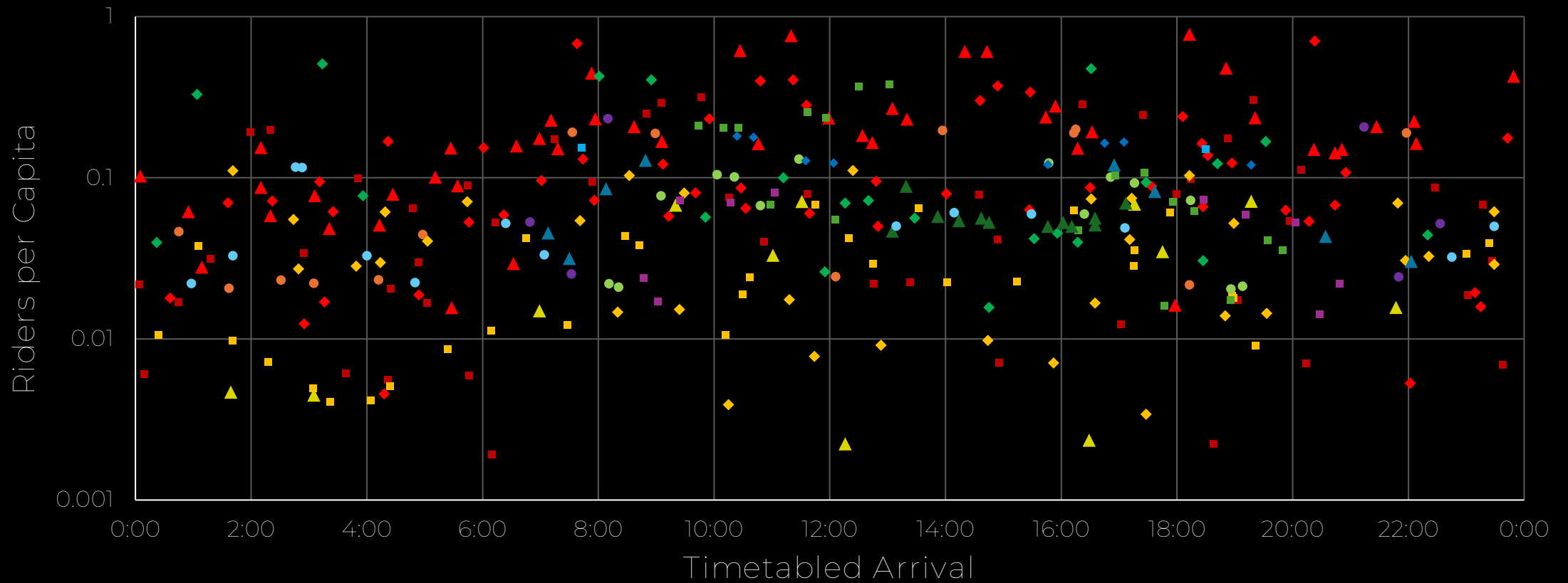


— 3/wk PaxDst — 1/day PaxDst — 2/day PaxDst — 3/day PaxDst
— 4/day PaxDst — 5/day PaxDst — 6/day PaxDst

— 3/wk PopDst — 1/day PopDst — 2/day PopDst — 3/day PopDst
— 4/day PopDst — 5/day PopDst — 6/day PopDst

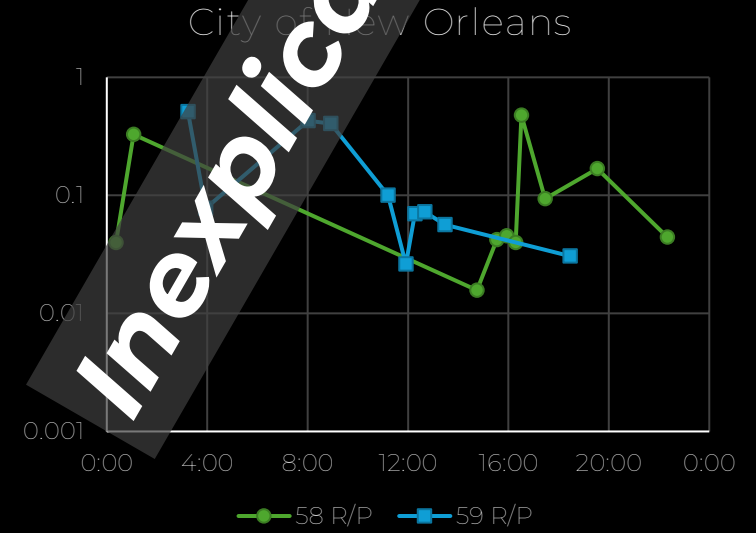
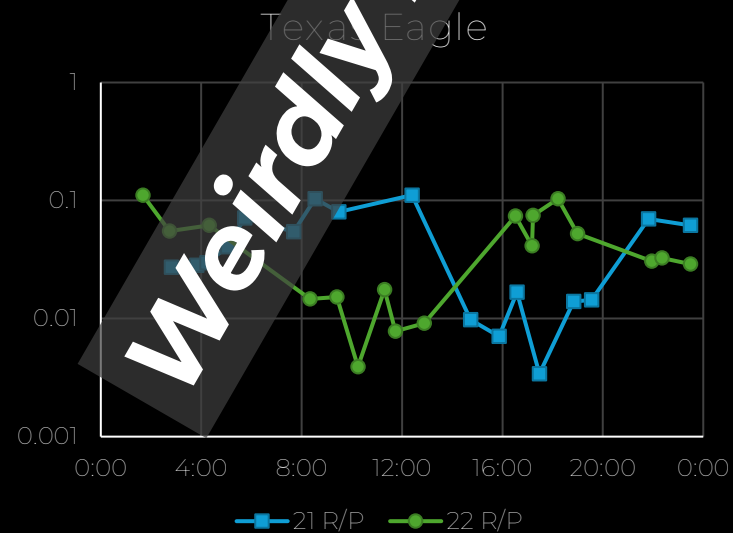
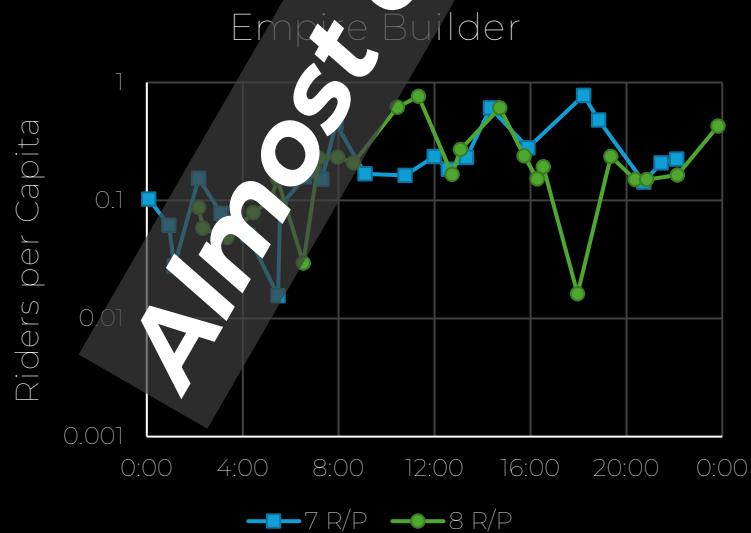
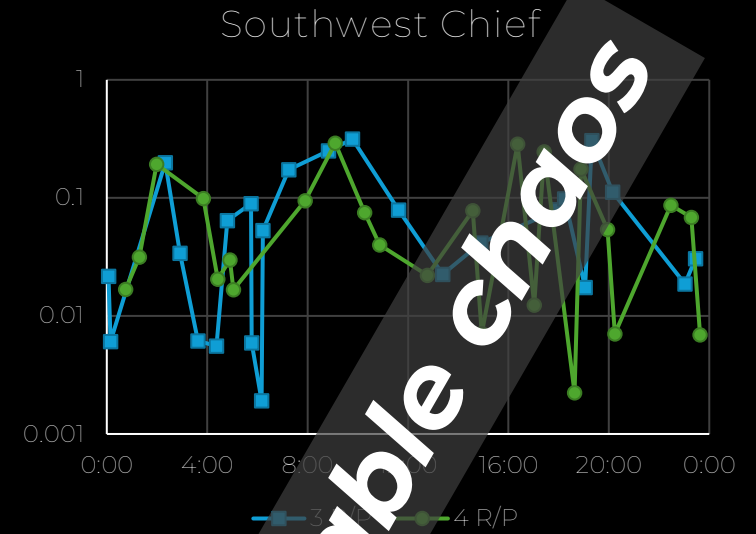
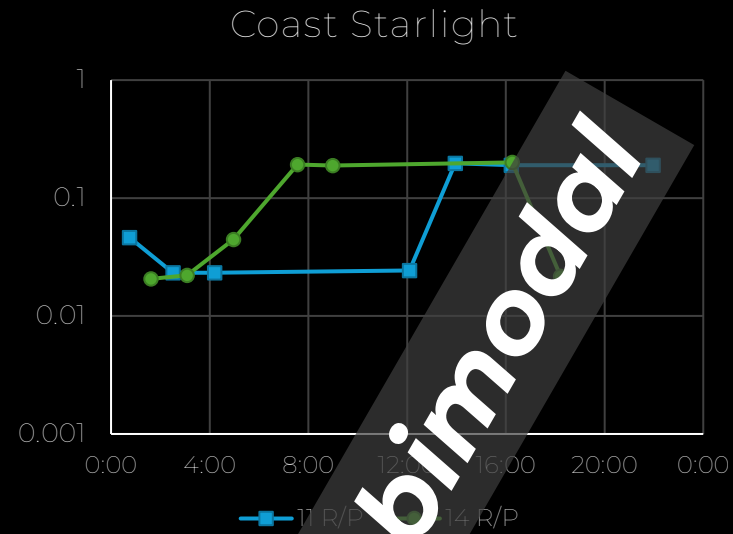
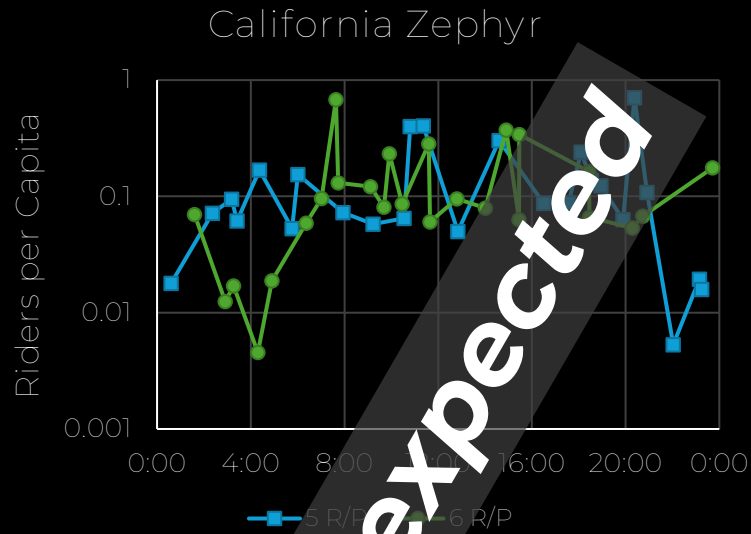
Does *timetable* affect ridership?

1 TPD Ridership vs. Timetable



■ 3/4 ♦ 5/6 ▲ 7/8 ● 11/14 ■ 19/20 ◆ 21/22 ▲ 29/30 ● 42/43 ■ 54/55 ◆ 58/59 ▲ 68/69 ● 91/92 ■ 97/98 ◆ 290/291 ▲ 364/365 ● 370/371 ■ 821/822

Route-Specific Timetable Ridership



Almost expected

Weirdly bimodal

Inexplicable chaos

Ridership Takeaways

- Frequency less than *3 trains/day* leaves riders unserved, but *when* the train comes matters less than you'd think
- Precise timetable planning requires more data than advocates can access at the early proposal stage
- For best ridership predictions: look at *who* is most likely to take the train, then look at *where* they're traveling

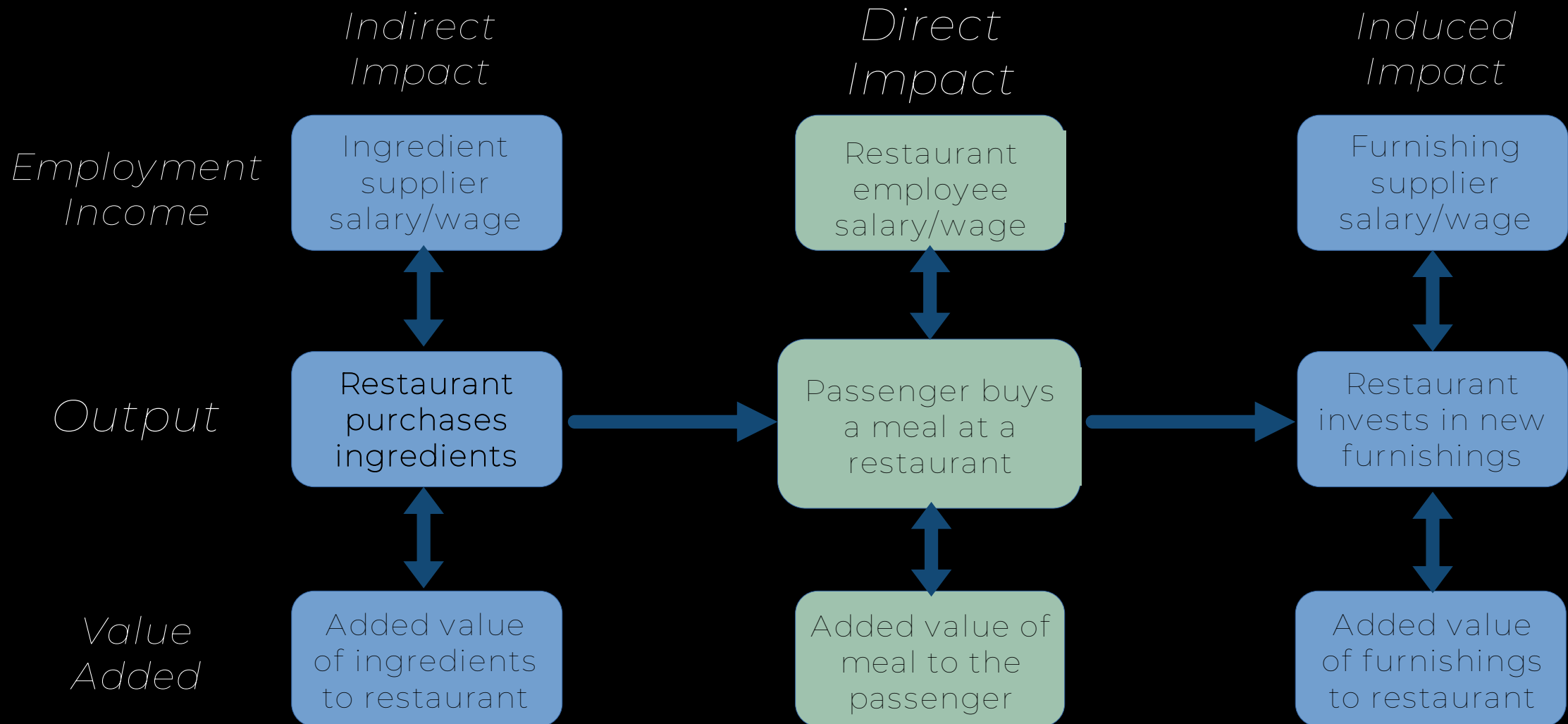
2. Economic Impacts

What passengers do on their trips

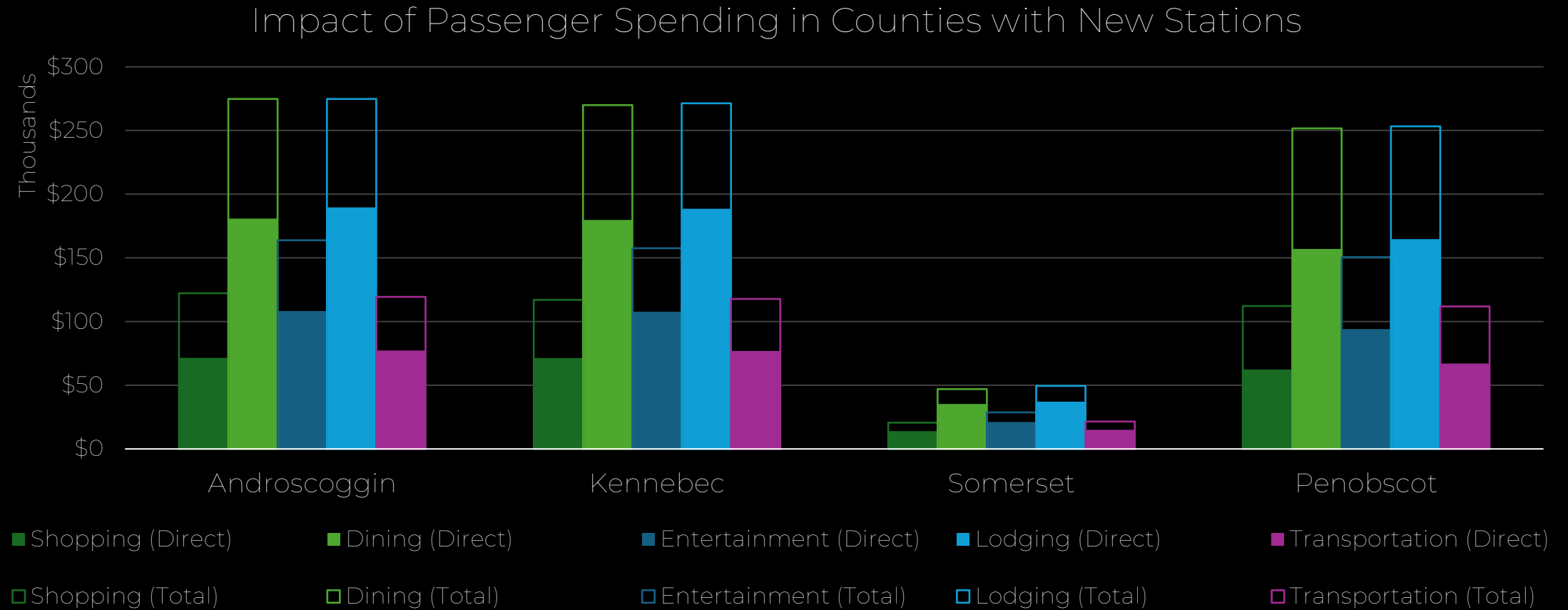
Per-Capita Tourist Spending by State

	<i>Minimum</i>	<i>Median</i>	<i>Maximum</i>
<i>Shopping</i>	\$14.41 (ID)	\$40.01 (AZ)	\$170.86 (NH)
<i>Dining</i>	\$20.66 (WV)	\$66.46 (MO)	\$227.16 (NC)
<i>Entertainment</i>	\$14.89 (KY)	\$35.93 (VA)	\$198.62 (NV)
<i>Lodging</i>	\$12.19 (WV)	\$65.39 (NE)	\$226.39 (FL)
<i>Transportation</i>	\$13.59 (WV)	\$56.18 (MI)	\$346.32 (UT)

IMPLAN Input-Output Model

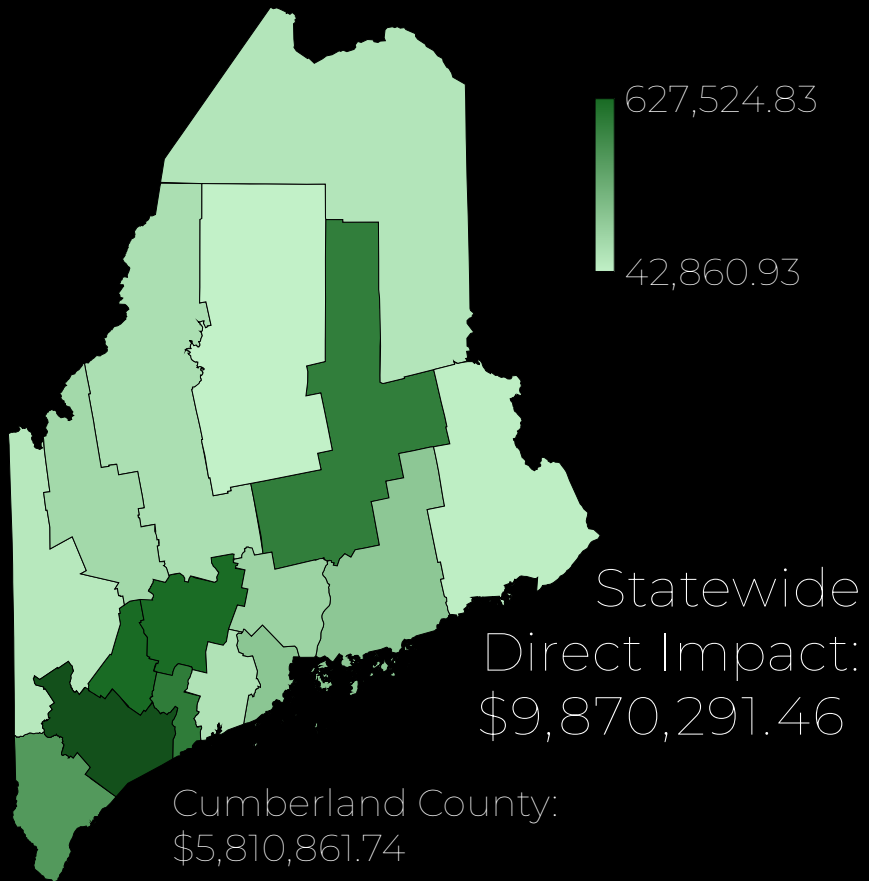


Example: Downeaster Extension

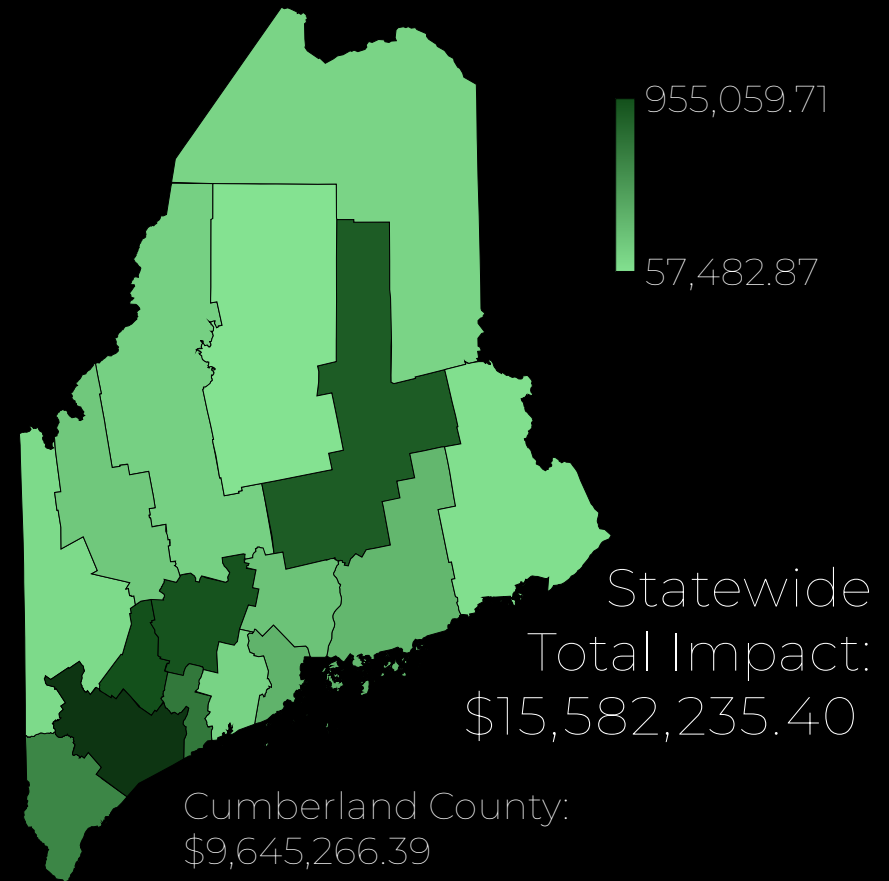


Example: Downeaster Extension

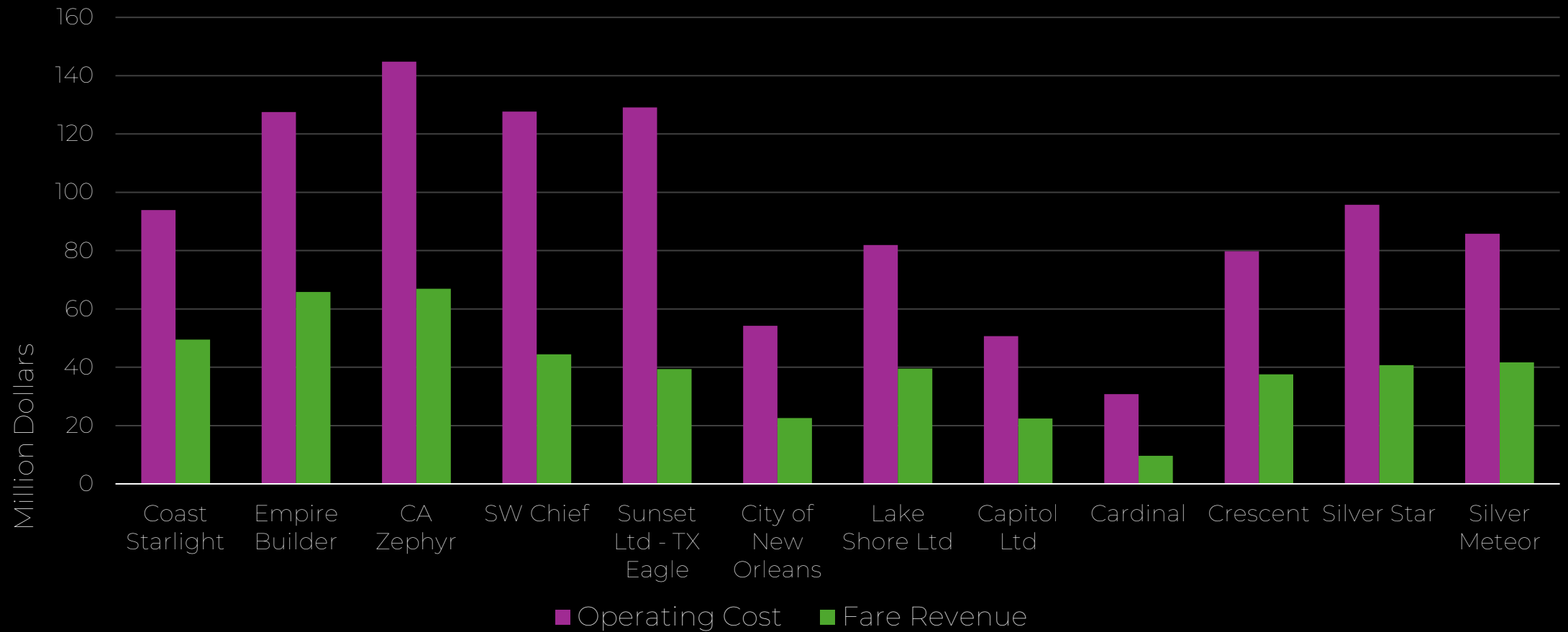
Direct Impact
of Passenger Spending



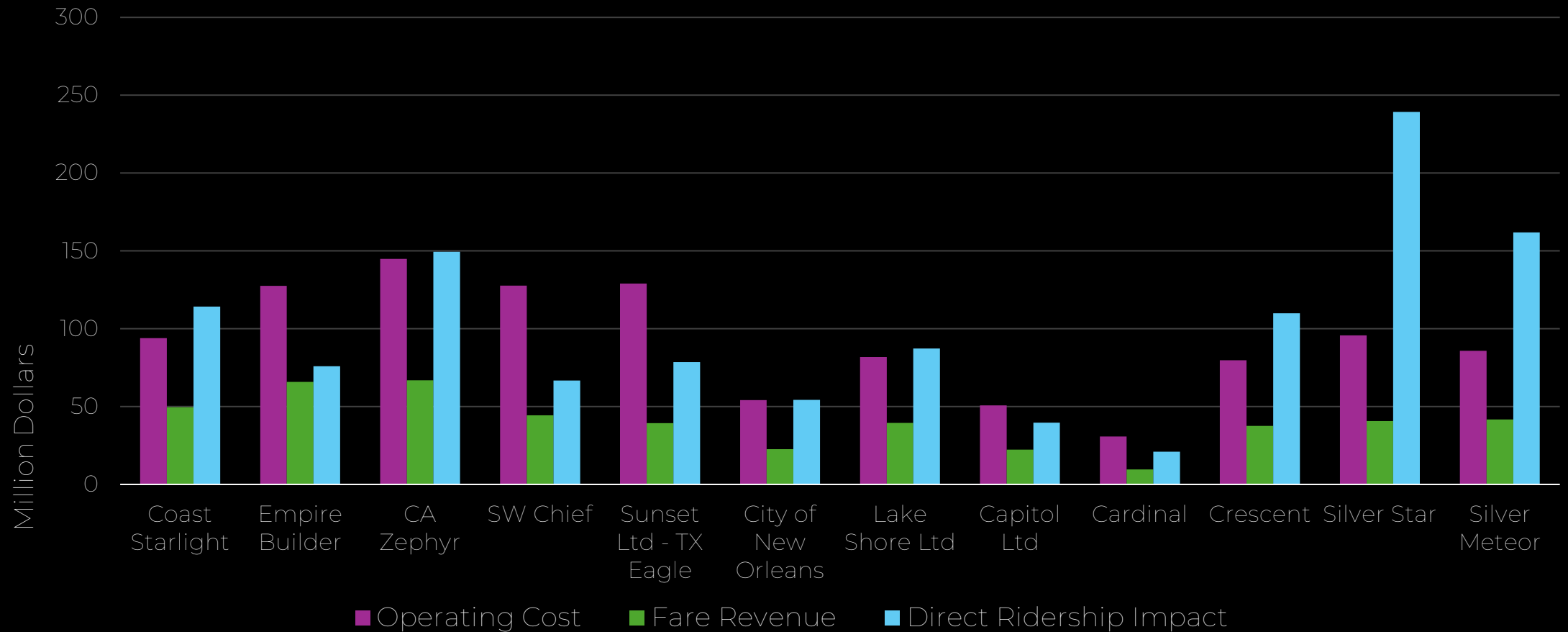
Total Impact
of Passenger Spending



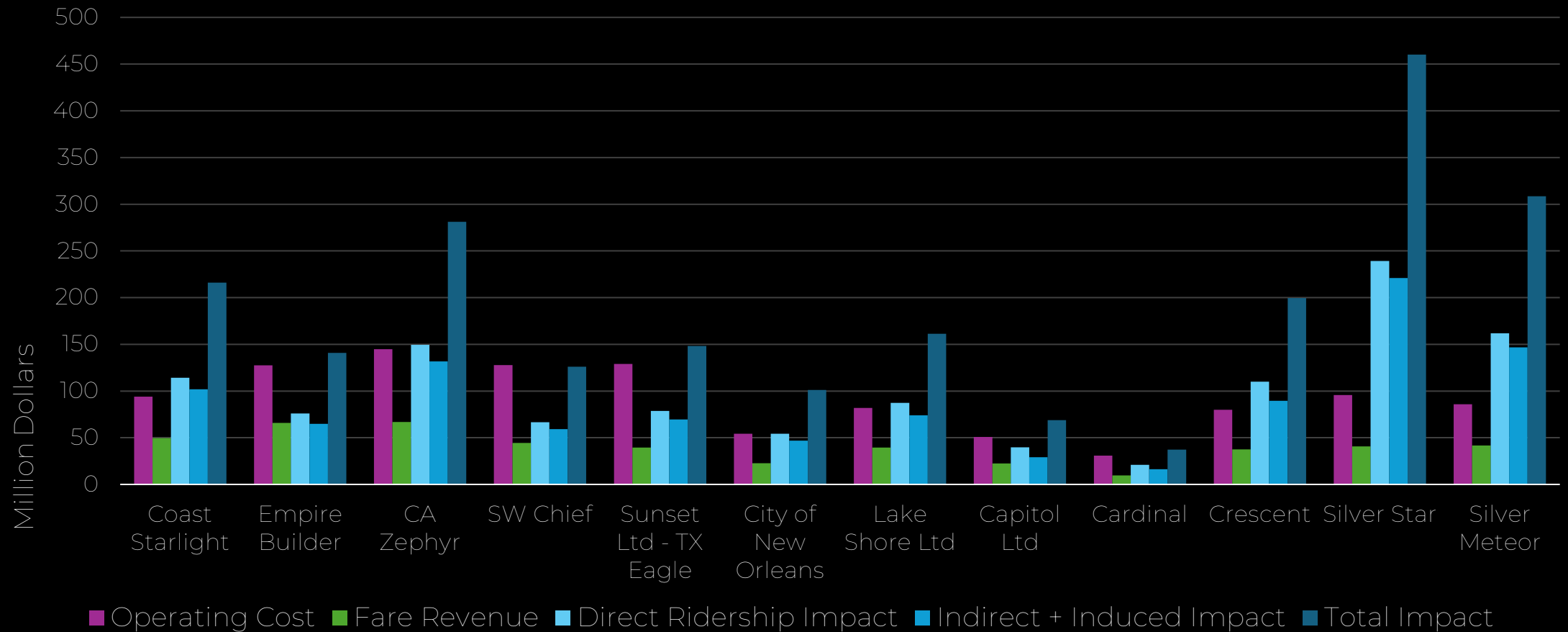
Nationwide Impact by Route (part 1)



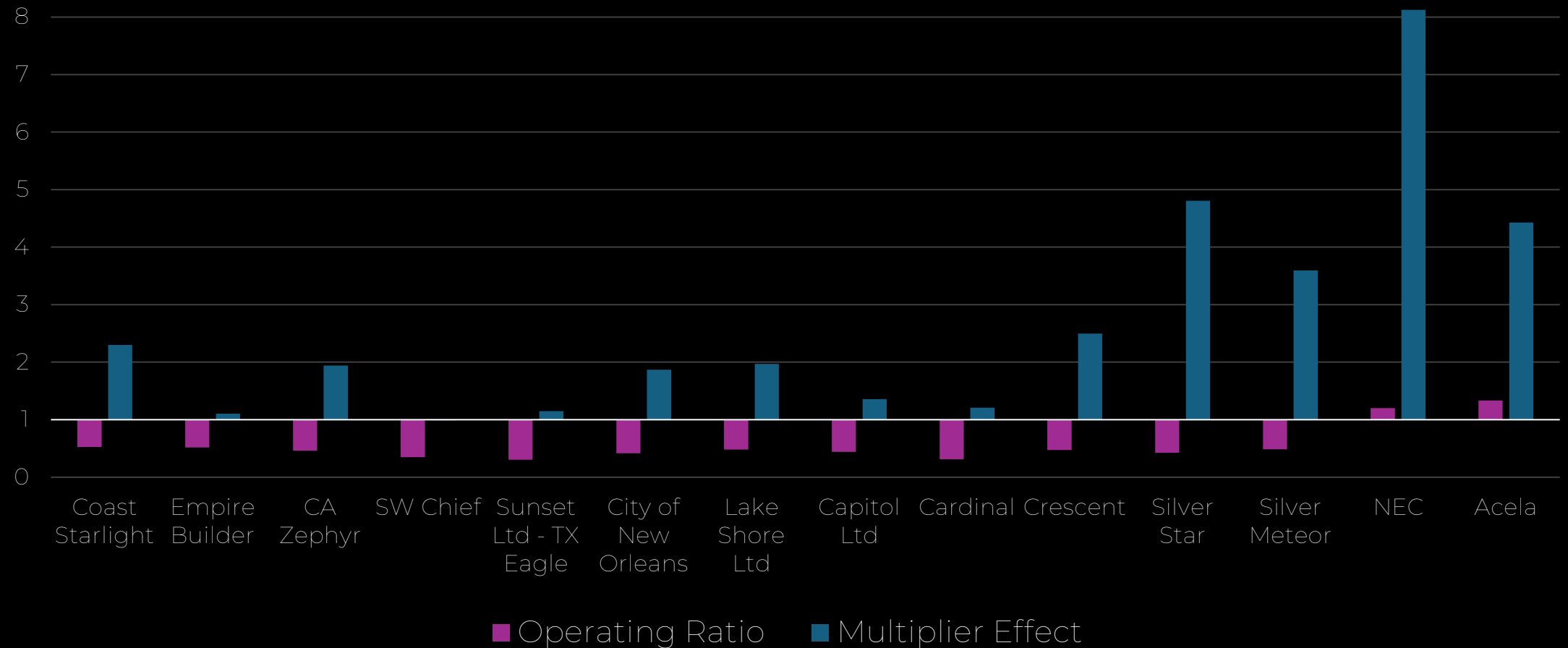
Nationwide Impact by Route (part 2)



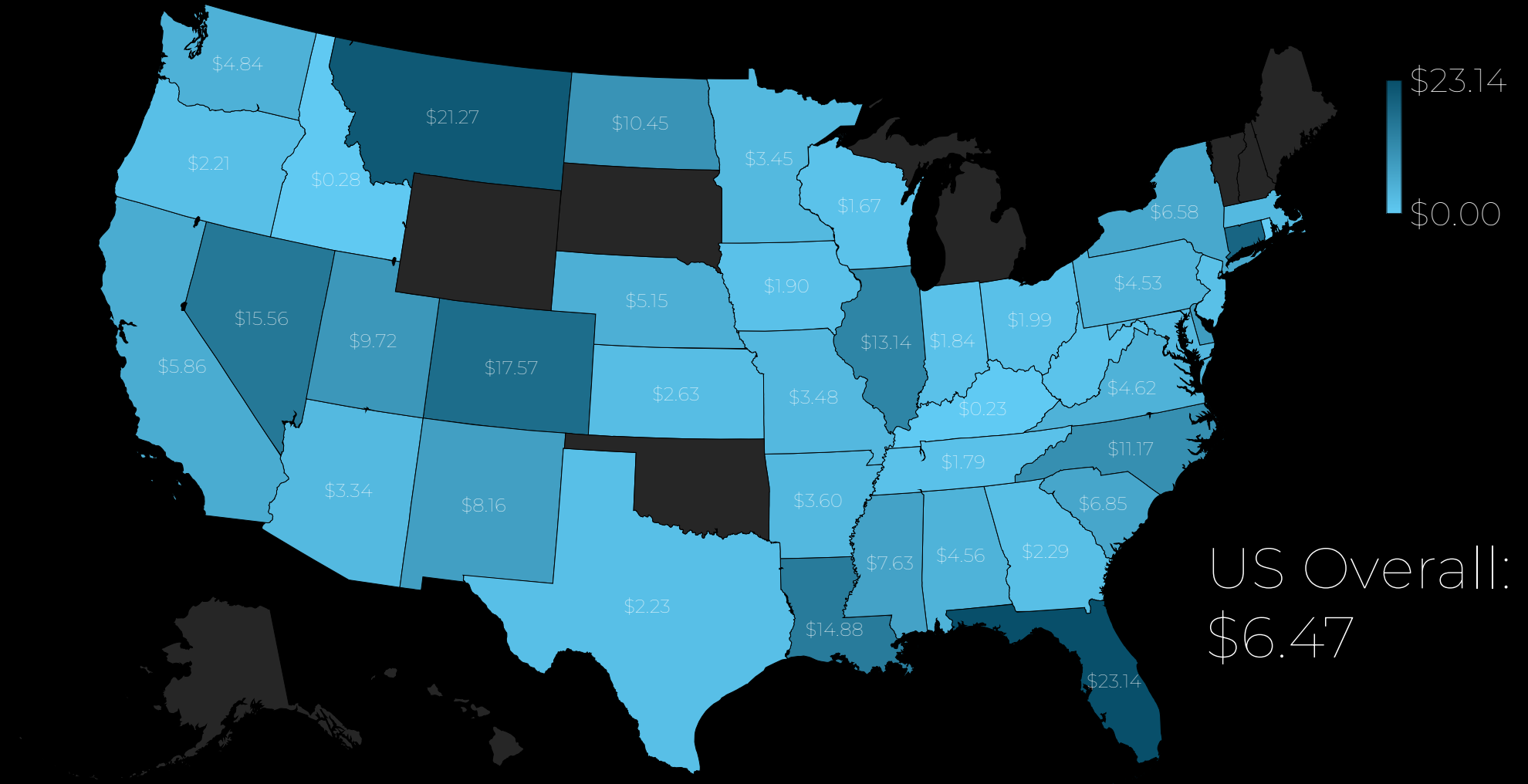
Nationwide Impact by Route (part 3)



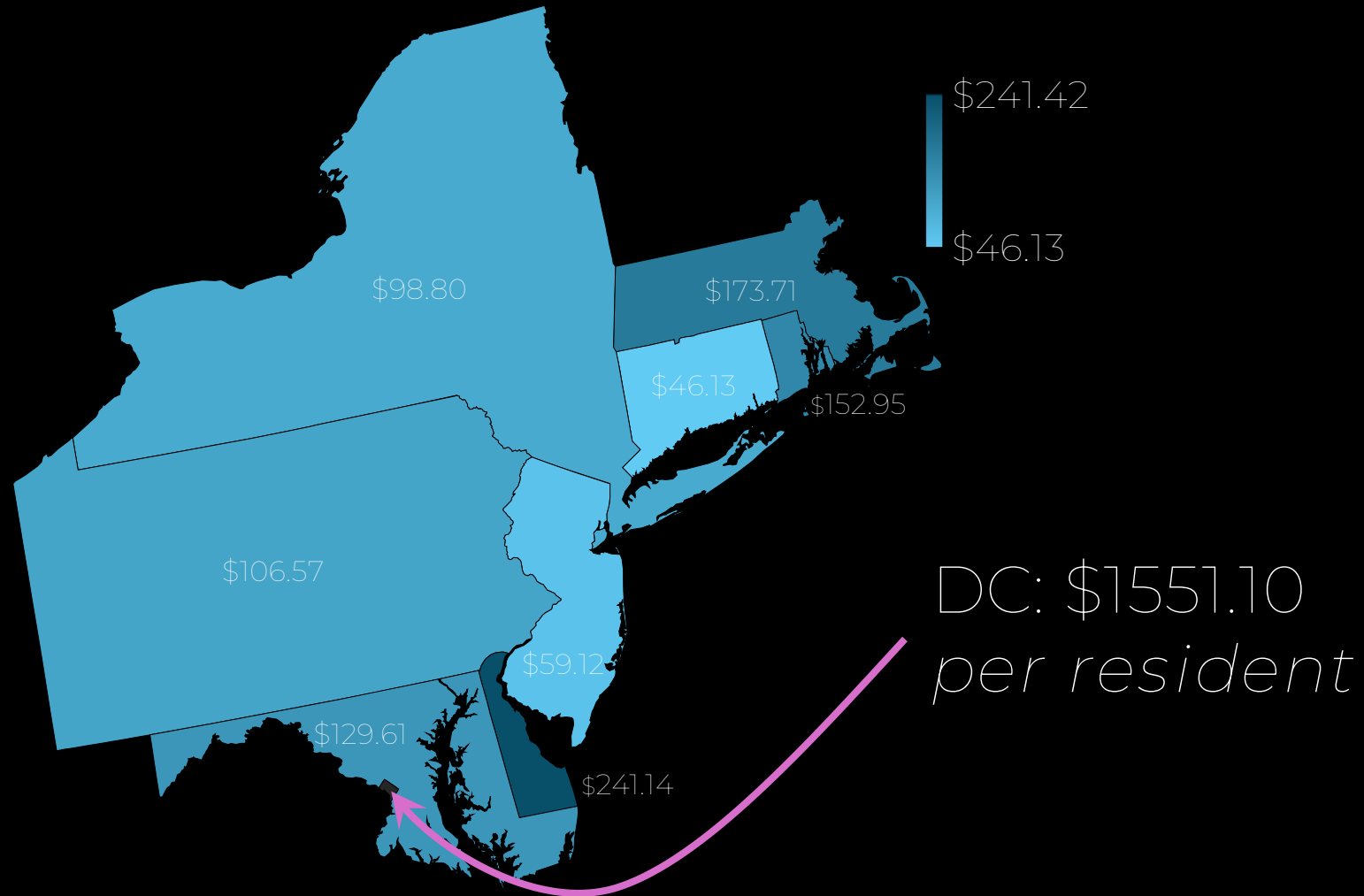
Operating Ratio vs. Multiplier Effect



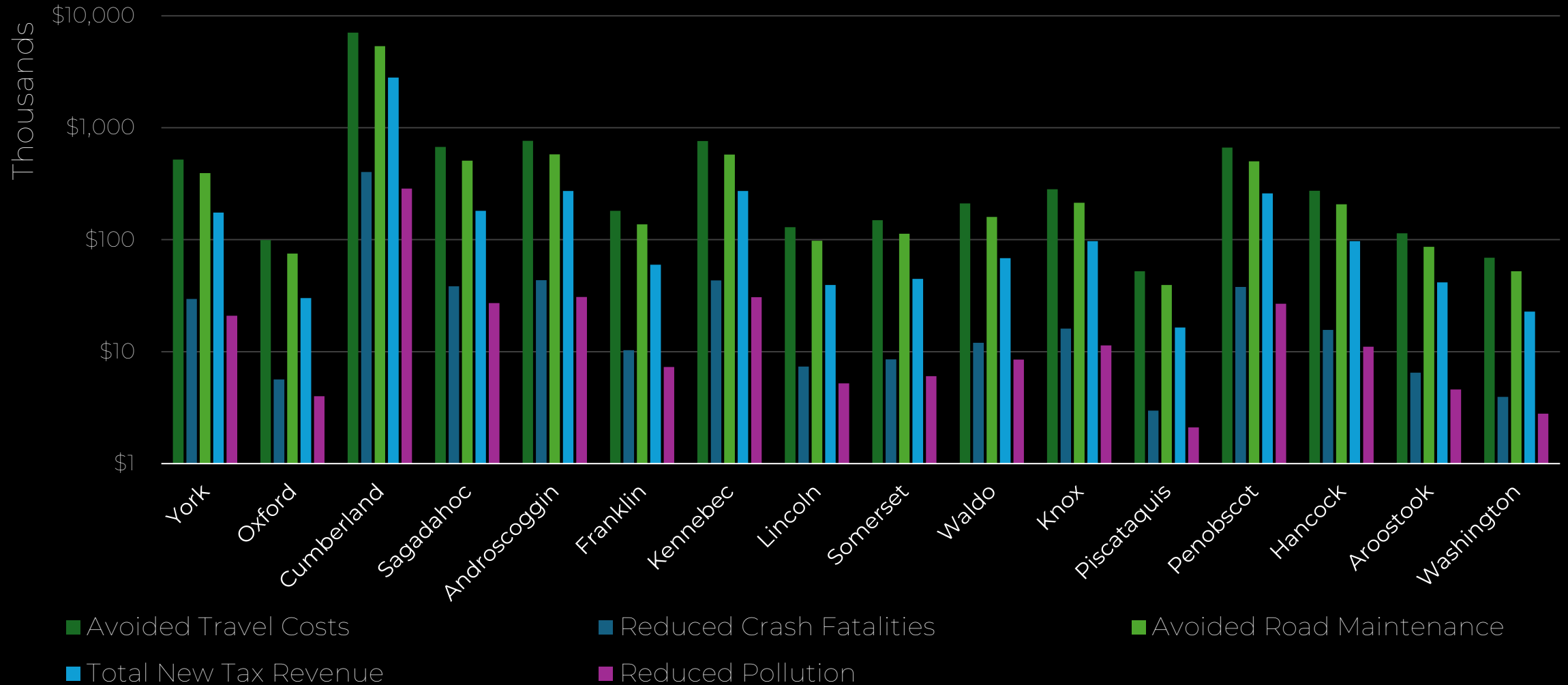
National Network Per-Capita Impact



NE Corridor Per-Capita Impact



Passengers *and* taxpayers save \$\$



Economic Impact of IIJA

Project Region	Direct Employment	Indirect & Induced Jobs	IIJA Award Value	Total Economic Impact
NEC	75,356	26,638	\$15.8 Billion	\$22.1 Billion
CAHSR	17,144	10,863	\$3.33 Billion	\$6.02 Billion
Brightline West	15,208	9,444	\$3.00 Billion	\$5.29 Billion
North Carolina	7,374	4,344	\$1.20 Billion	\$2.12 Billion
Virginia	4,093	2,025	\$736 Million	\$1.17 Billion
Gulf Coast	1,251	595	\$178 Million	\$296 Million

... all of which the administration is trying to unilaterally withhold.

Economic Impact Summary

- Main economic benefit of Amtrak comes not from revenue, but from *passenger spending* at destinations
- Train travel *saves both passengers and taxpayers* money, compared to other modes
- New services can contribute *2 to 8 times more* to the economy than they cost to operate
- The National Network and NEC are *not in competition*
- Impact of infrastructure upgrades is felt long *before service begins*

3. Environmental Impacts

(why should we care?)

We *do* care about climate!

Fig. 2: Percentage of people who believe Earth will continue to warm in the future.

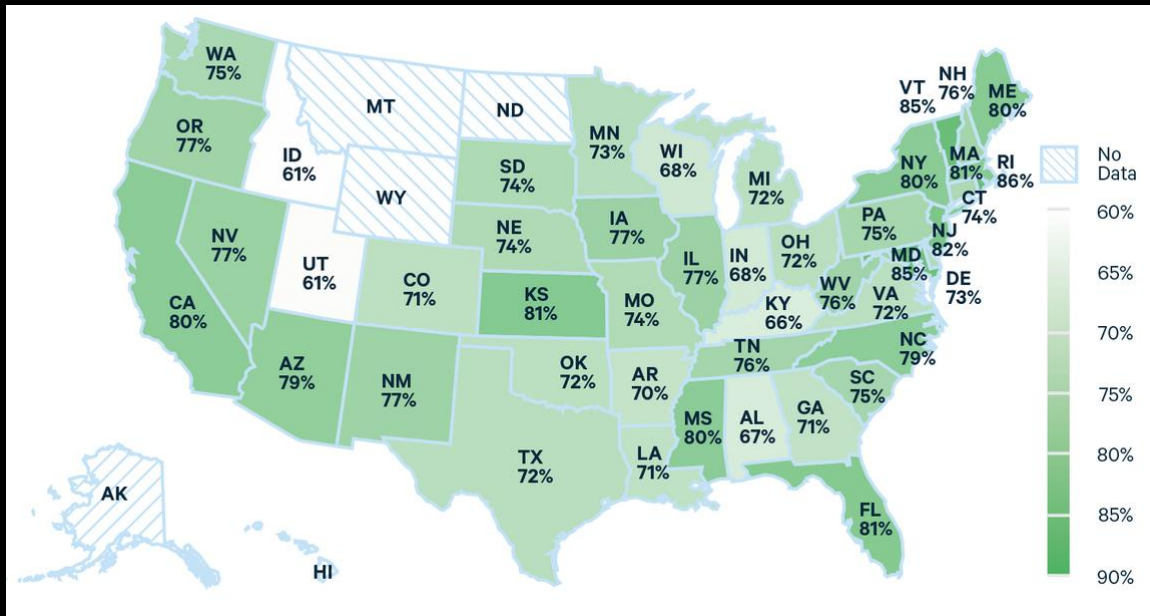
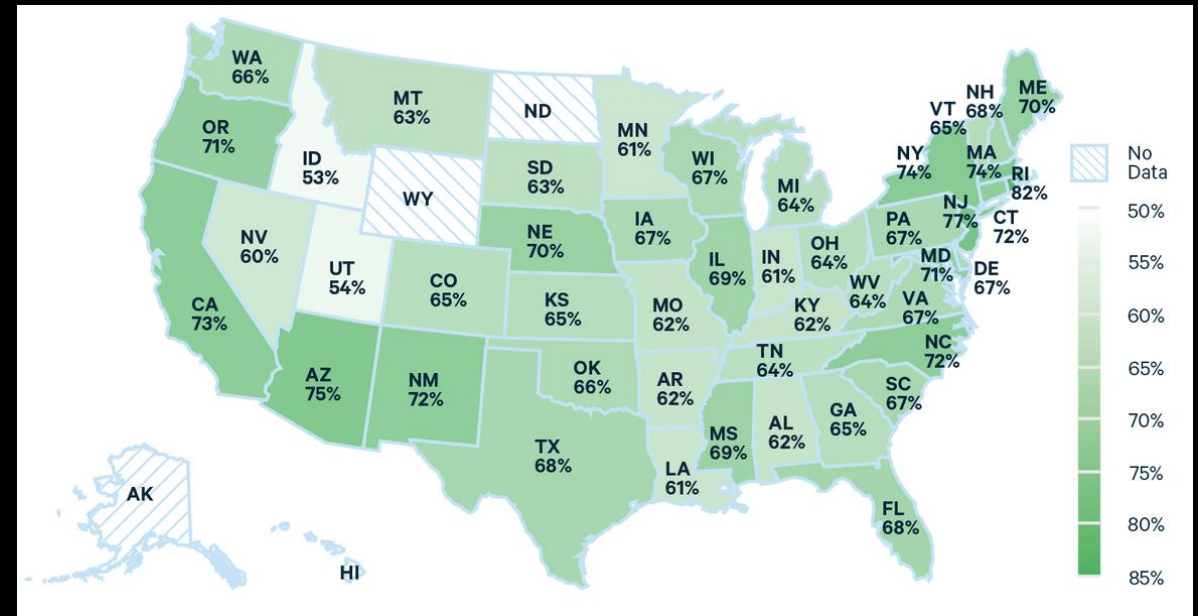
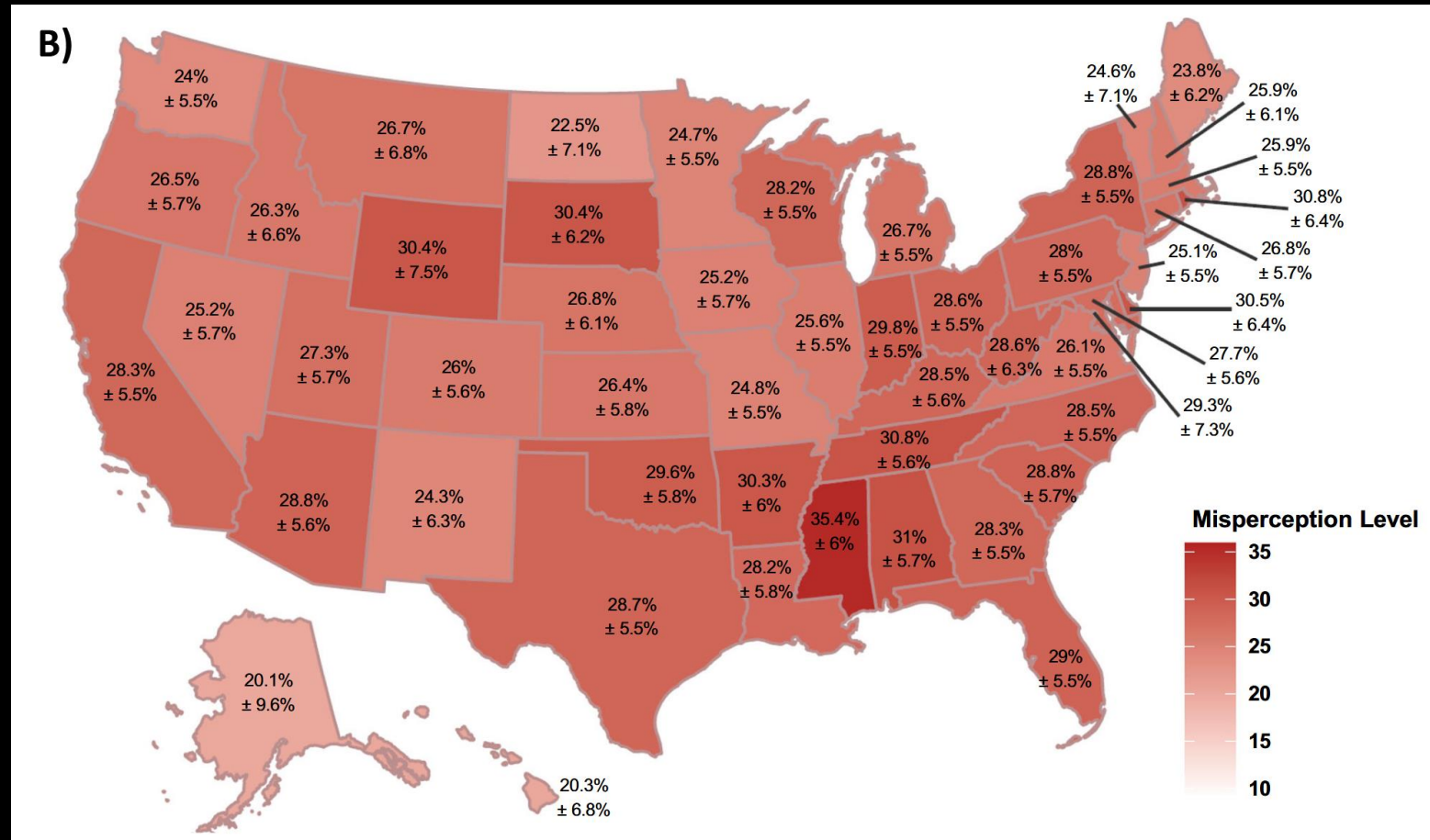


Fig. 7: Percentage of people who believe government should do more to address global warming.



Macdonald, MacInnis, and Krosnick, *Climate Insights 2020: Opinion in the States*

...we just *think* others don't care!



Sparkman, Geiger, and Weber (2022) *Nature Communications*

Geography of Emissions

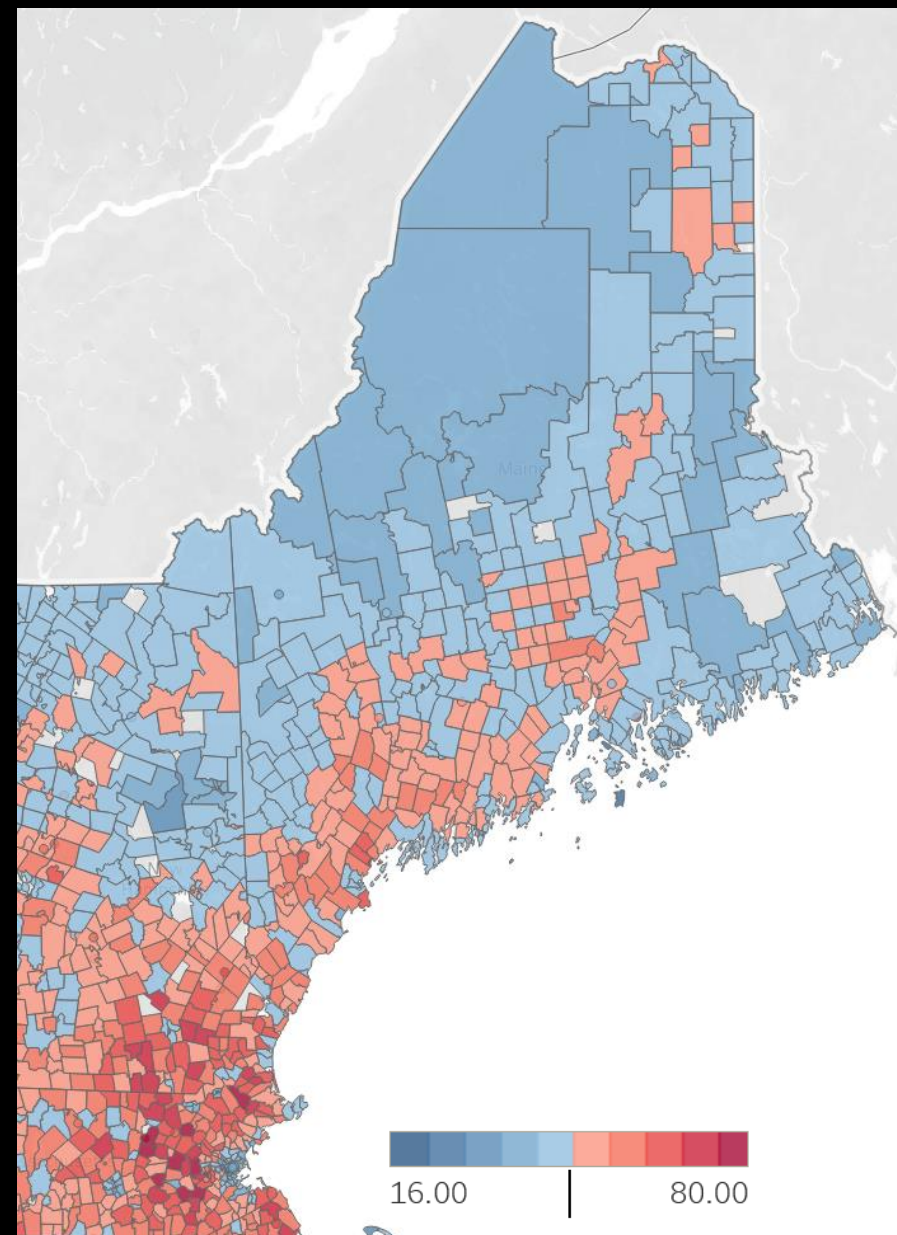
	Maine	USA
Total Emissions	14.9 M tons	4,934.4 M tons
Emissions per Capita	10.6 tons/person 26.9 tons/household	15.9 tons/person 40.5 tons/household
Electricity Generation	11.6%	31.0%
Transportation	48.4%	37.3%

Public transit in rural Maine is sparse. Improving it could help the state fight climate change

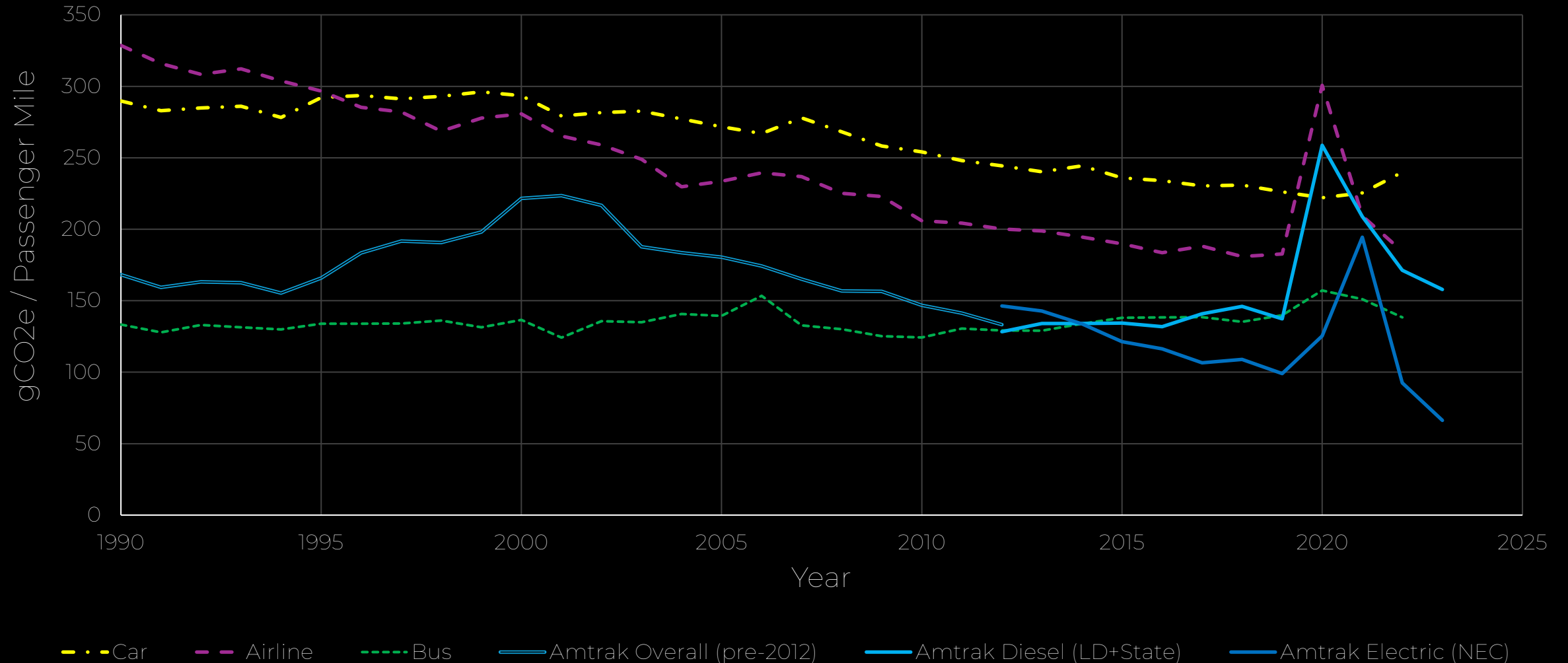
Maine Public | By [Charlie Eichacker](#)
Published December 21, 2021 at 1:49 PM EST



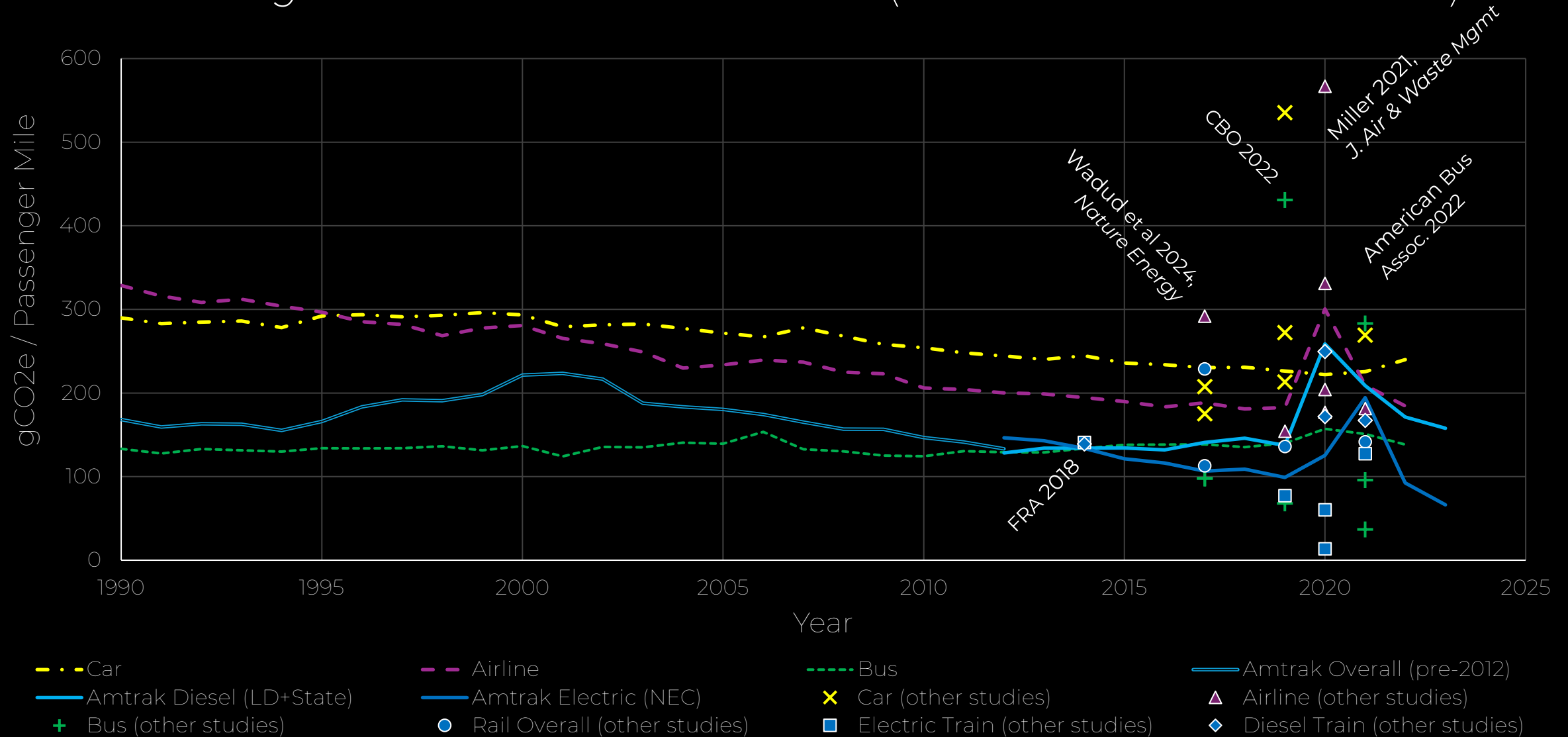
Data from Jones and Kammen 2013, *Env. Sci. & Tech.*
Map from <https://coolclimate.org/maps>



History of Emissions (USDOT data)



History of Emissions (other studies)



“Social Cost of Carbon” (SCC)

- Warming climate → Natural disasters → Economic costs
 - What is the *total cost* of damage a given amount of CO₂ would cause?
- Emissions price → Incentives change → Invest in mitigation
 - What is the *minimum price* we would need to pay to decarbonize?

How to calculate SCC?

How much do you care about...

- **when** the damage occurs: within a project lifetime or further in future?
- how **permanent** the damage is: can it be repaired or is the harm irreparable?
- how **disproportionate** the damage will be on places with less resources?

All of these make SCC go up!

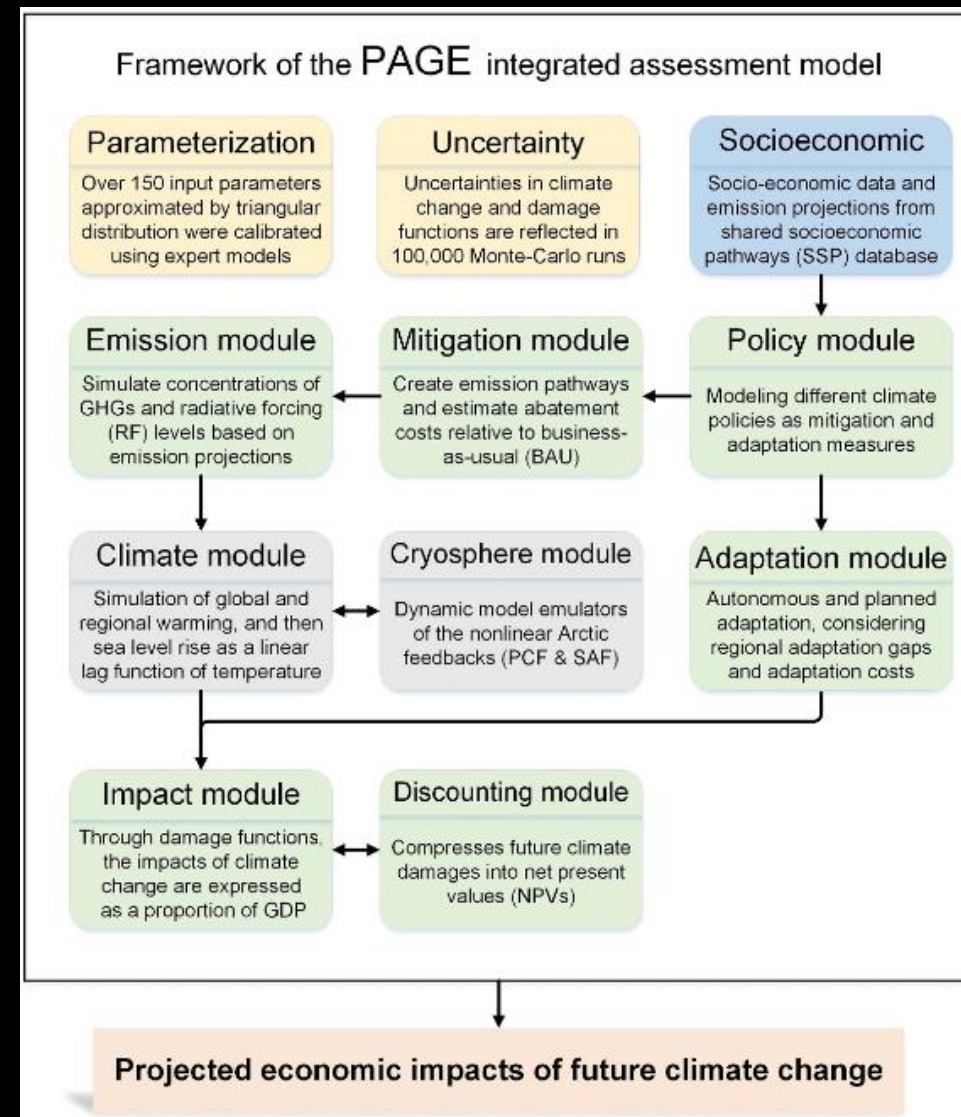


Figure 2 from Liu and colleagues 2022, *Env. Research Letters*

What value should SCC be?

“Reward of the Farsighted”

- \$100 ton: minimum to bring atmospheric $\text{CO}_2 < 400\text{ppm}$

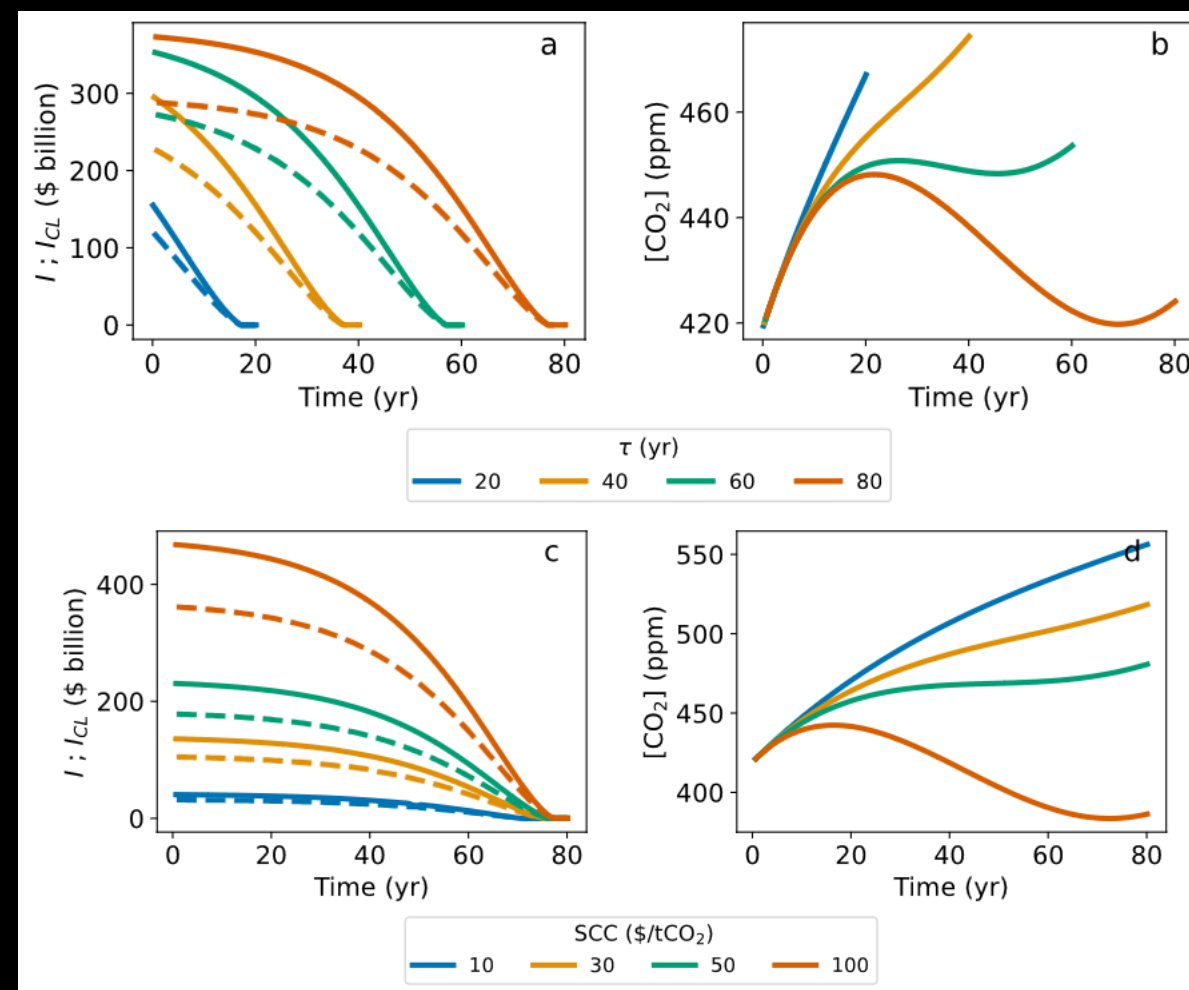
Cerasoli and Porporato 2023, *Sustainability*

- \$2000/ton: highest published estimate to date

Liu and colleagues 2021, *Env. Res. Letters*

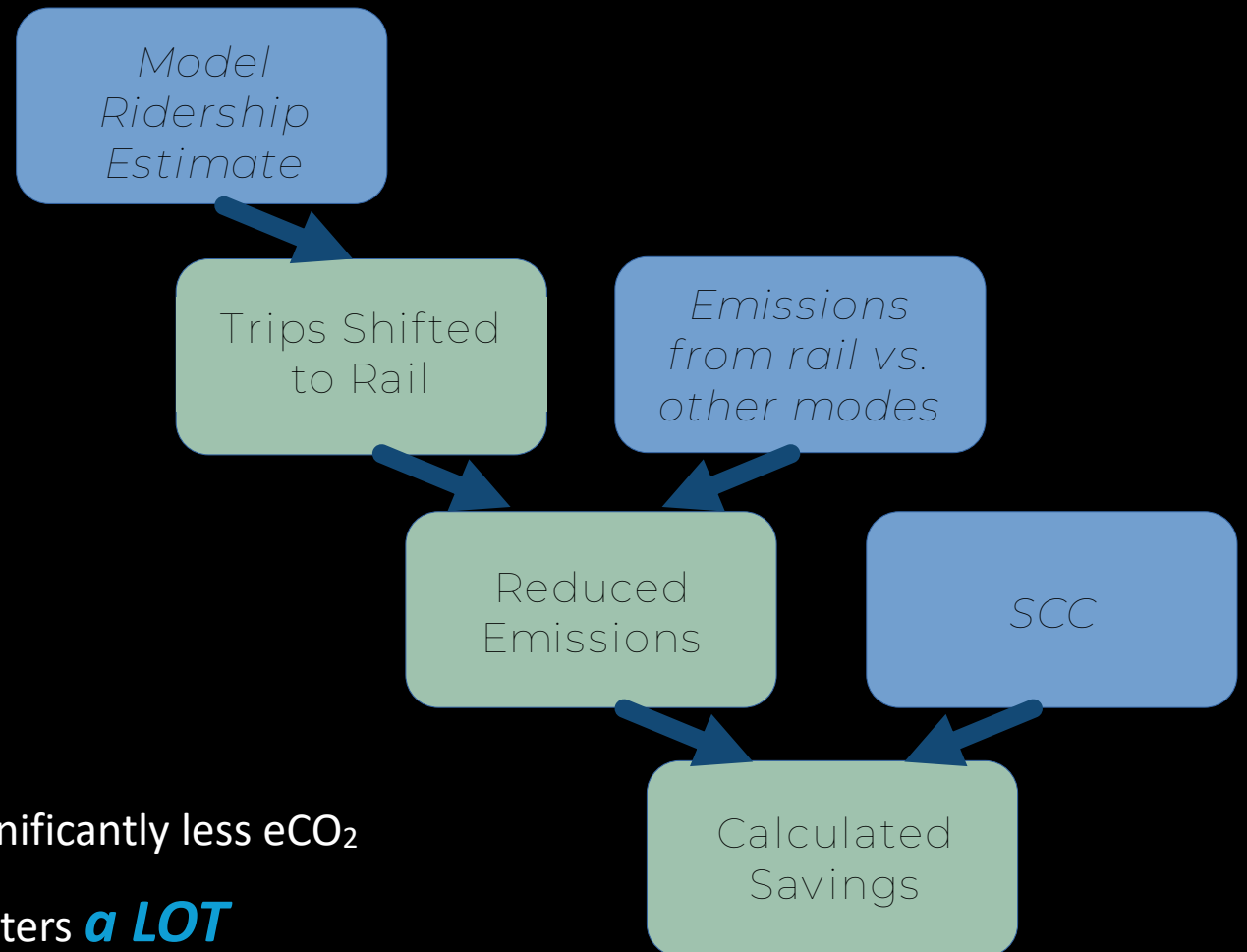
- SCC estimates *increased 10x* last decade; *policy severely lags*

Tol 2022 *Arxiv*



How RPA's model uses SCC

Mode	CO ₂ Emissions
Personal Car	184 g/pax-mile
Airline	239 g/pax-mile
Intercity Bus	138 g/pax-mile
Amtrak Diesel	171 g/pax-mile
Amtrak Electric	92.5 g/pax-mile



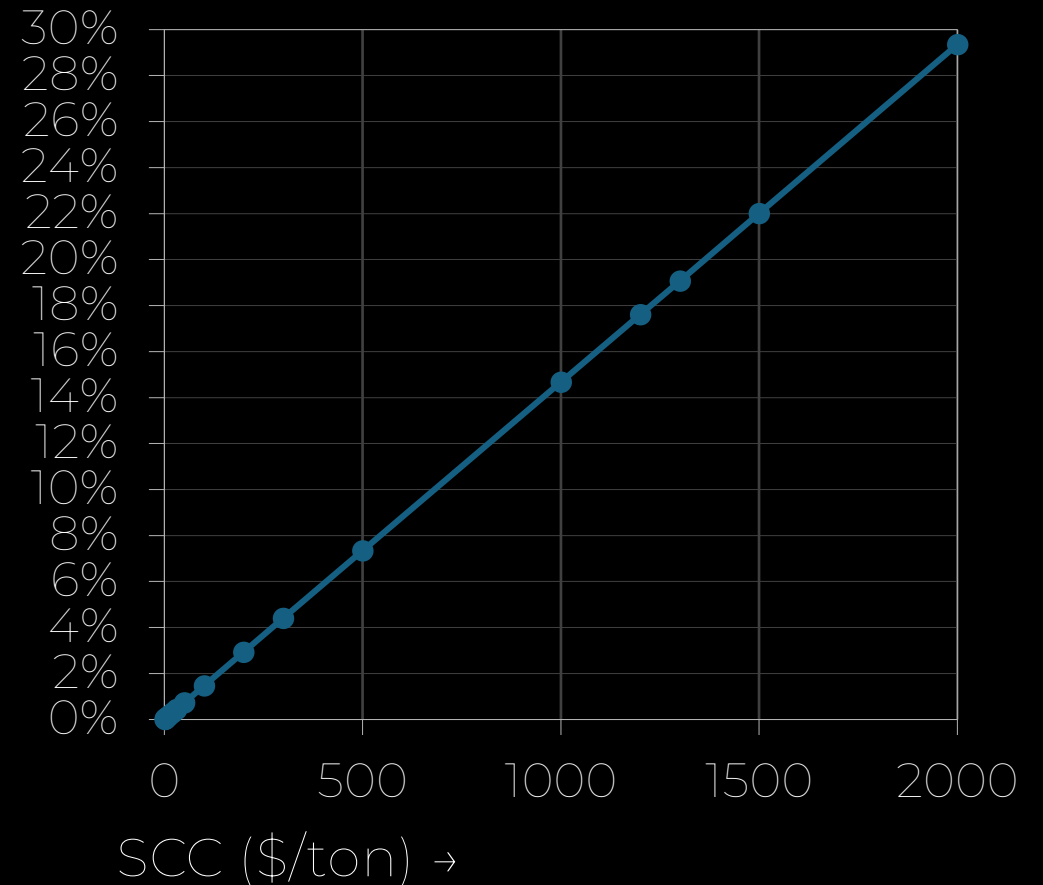
Important Caveats:

- New Amtrak diesel equipment emits significantly less eCO₂
- Regional variation in travel patterns matters **a LOT**

What RPA's model shows

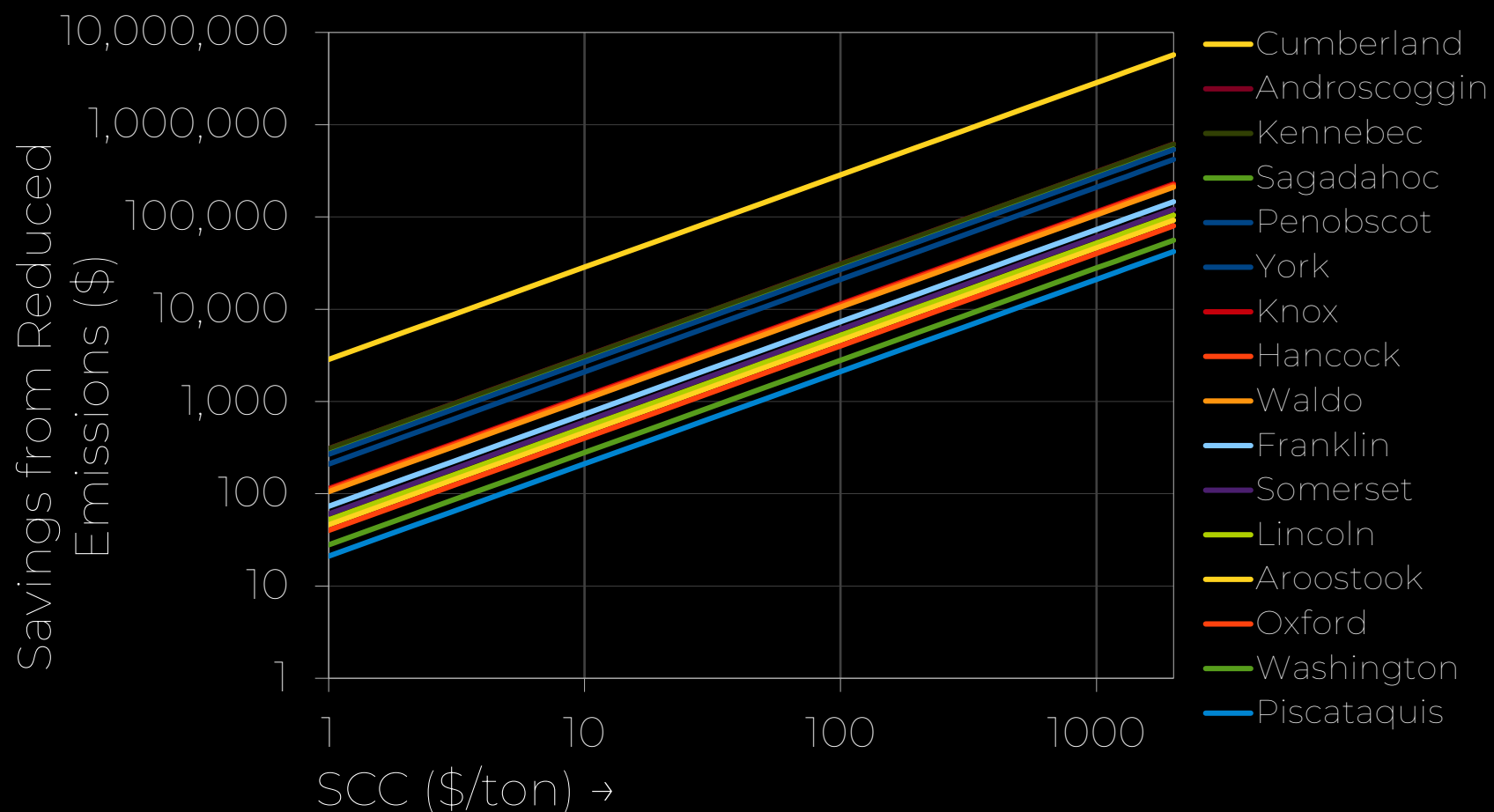
- Benefit of reduced emissions scales linearly with both ridership & SCC
- \$57/ton (2024 Interagency Working Group recommendation): < 1% of total econ. impact of ridership
- \$100/ton (minimum which achieves 400ppm in year 2100): 1.5% of total econ. impact of ridership
- \$446/ton (low-end of estimates considering future damage): 6.6% of total impact
- \$1925/ton (high-end estimate): 28.3% of total impact

Benefit of Reduced Emissions Compared to other Benefits of Rail



Emissions benefits breakdown: Maine

SCC	Statewide Savings
\$57/ton	\$277,800
\$100/ton	\$478,300
\$446/ton	\$2,173,000
\$1,925/ton	\$9,380,000



What is to be done?

- *It doesn't take much* to motivate climate solutions
- Greatest environmental impact comes from
Mode Shift : car & (short) plane trips → *Train Trips*
- Electrification has smaller comparative environmental impact than mode shift, but it *gets us to the finish line*

LEVERAGE IT!

...so what are we supposed to do with all this data?

RPA's research fills a niche

Where else could you go for data analysis supporting passenger rail expansion?

Mainstream consulting firms (expensive, not rail experts)

Transportation planning groups (expensive, produce more detailed studies suited for projects already under development)

...and then there's RPA:

- Rail experts
- Right-sized for early advocacy
- Affordable
- *TRUSTED*

What RPA research needs:

Please *DO NOT* send member donation checks for research.

Instead, help *connect us with customers outside our membership* who could use our research services.

Please *DO NOT* write or submit unsolicited grant applications on RPA's behalf.

Instead, help *connect us with funders outside our membership* whom we could partner with on projects.

Please *volunteer* with task groups organized by staff & committees.
WE CAN USE YOUR HELP!