Enhancing Non-motorized Safety by Simulating Non-motorized Exposure using a Transportation Planning Approach

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OUTLINE

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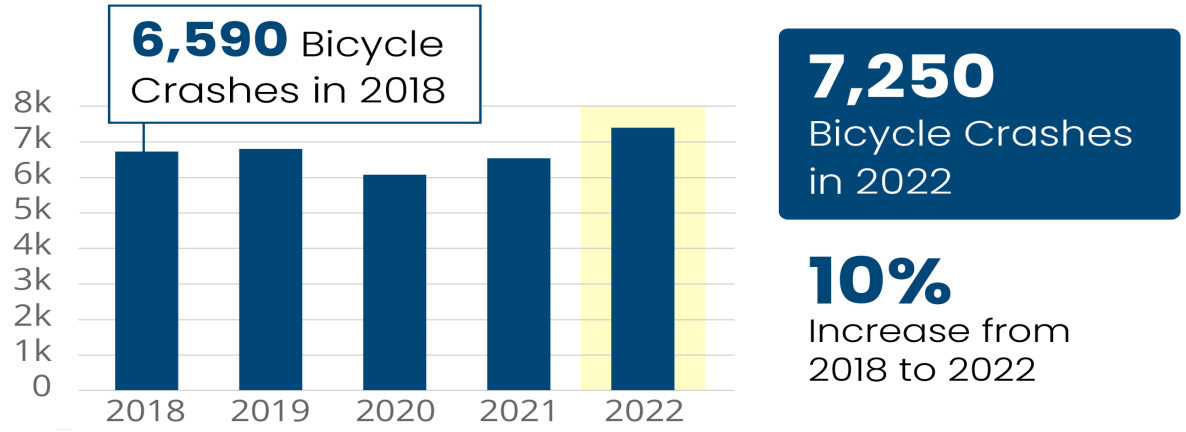
- Background
- Current Study
- Study Area
- Data Preparation
- Model Framework
- Estimation Results
- Conclusion

BACKGROUND

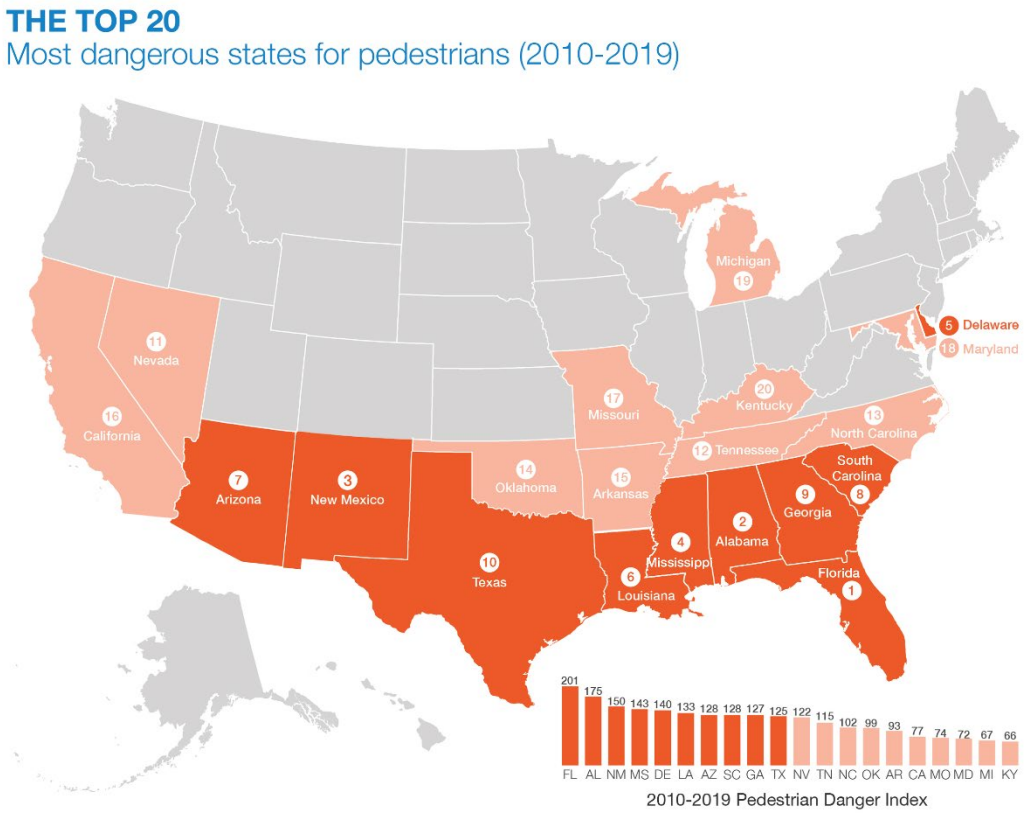
- Safety risk posed to active transportation users in Florida is rising compared to rest of the US.
- Average pedestrian (bicyclist) fatalities per 100,000 population is 3.70 (7.60) for Florida whereas in whole US it is 1.98 (2.70)

Florida Annual Bicycle Crashes



7,250 Bicycle Crashes in 2022

10% Increase from 2018 to 2022



Smart Growth America
Improving lives by improving communities

DANGEROUS BY DESIGN 2021

National Complete Streets Coalition

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BACKGROUND

Literature in Non-motorized Safety

identifying attributes for the crashes and propose countermeasure to improve the roadway design

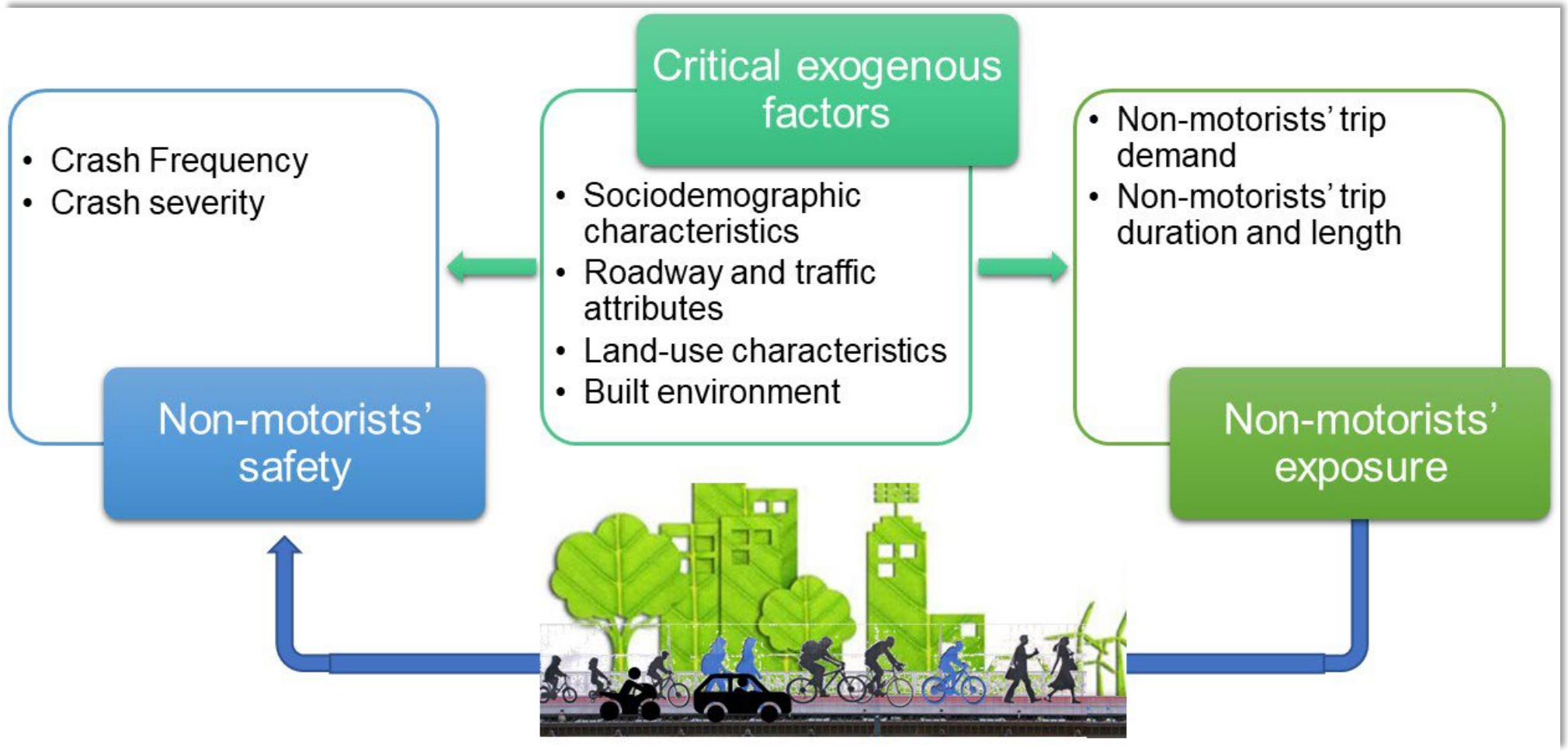
Crash Prediction Model

Crash frequency analysis → **Quality Affected** ← **Crash severity analysis**

identifying factors that impact the crash outcome and providing recommendations to reduce the consequences

Lack of true non-motorized exposure data

CURRENT STUDY



Proposed non-motorists' safety evaluation framework

CURRENT STUDY

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- Integrated framework of non-motorized demand and safety
- 3-step approach proposed

Aggregate level model for non-motorists generation and attraction at zonal level

Exposure Model

Use aggregate trip information
Four model developed-

- Pedestrian generation & attraction,
- Bicycle generation and attraction

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CURRENT STUDY

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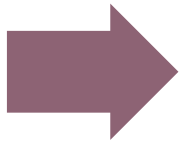
Aggregate level model for non-motorists generation and attraction at zonal level



Non-motorists exposure measure matrices for safety evaluation

Exposure Model

Exposure Matrices

Use aggregate trip information
Four model developed-

- Pedestrian generation & attraction,
- Bicycle generation and attraction

Generating different zonal level trip exposure matrices for both mode using trip counts from the exposure model.

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CURRENT STUDY

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- Integrated framework of non-motorized demand and safety
- 3-step approach proposed

Use aggregate trip information
Four model developed-
- Pedestrian generation & attraction,
- Bicycle generation and attraction

Generating different zonal level trip exposure matrices for both mode using trip counts from the exposure model.

Estimate non-motorists safety model
Four model developed-
Pedestrian and Bicycle crash frequency model
Pedestrian and Bicycle crash severity model

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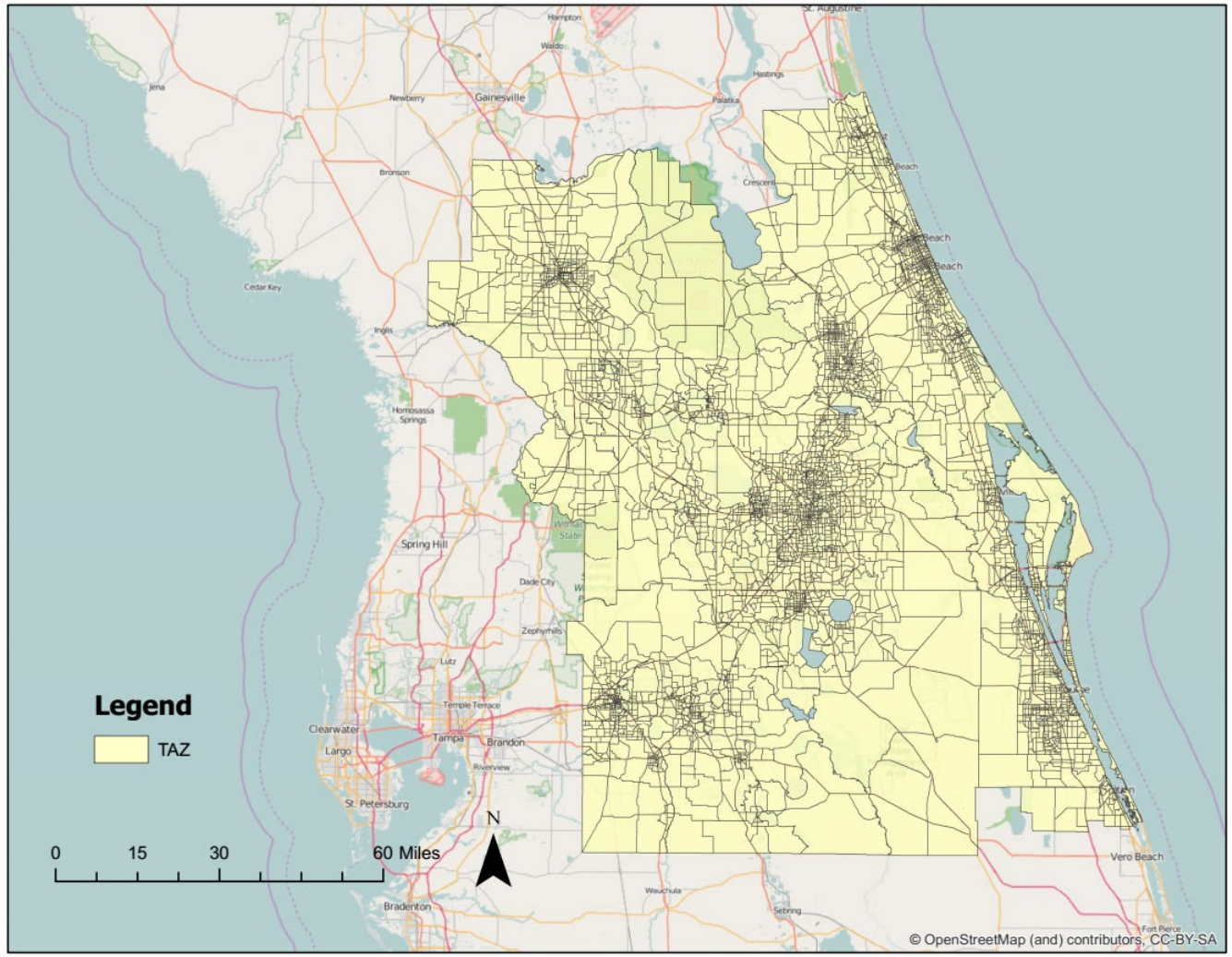
STUDY AREA



- CFRPM v6.0
- 4,747 TAZs (Traffic analysis zones)
- 9 counties
- District 5, part of District 1 and 4
- Base year
  - 2010 (Phase I)
  - **2017 (Phase II)**
  - **2022 (Phase III)**

DATA PREPARATION

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Data Source:

- **Exposure Model**- 2009 NHTS (National Household Travel Survey)
  - 2,749 Household, 5,090 individuals
  - 22,359 trips, Walk trips (8.8%), Bike trips (1.3%),
  - **Person trip-weight considered**

- **Safety Model**- FDOT Crash Analysis Reporting System (CARS) and Signal Four Analytics (S4A)
  - Base year 2010
  - 1,474 Pedestrian Crash
  - 1,012 Bicycle Crash

- **Independent Variables-**
  - sociodemographic characteristics,
  - roadway and traffic attributes,
  - built environment characteristics and
  - land use characteristics

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1st STEP
EXPOSURE MODEL

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METHODOLOGY

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- More than **84% and 96% TAZs have 0 pedestrian and bicycle trip counts**
- Hurdle Negative Binomial Regression Approach

First part is a binary logit model to identify whether there are any trips in that zone or not (0/1)

2nd part is the count model, if there are trips, what would be the corresponding number?

ESTIMATION RESULTS

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Exposure Type	Component	Likelihood of Walk Trips	
		Increases	Decreases
Pedestrian Generator	Probabilistic	**Land-use mix**, Urban area and number of household	---
	Count	Proportion of 65+ aged population, proportion of arterial road, length of sidewalk, recreational, residential, office and institutional area	Average zonal speed, **AADT**, proportion of 3 or more lane road, industrial area
Pedestrian Attractor	Probabilistic	**Land-use mix**, Urban area and number of household	---
	Count	Proportion of arterial road, length of sidewalk, number of business, entertainment, financial, shopping park and recreational center, recreational, residential, office and institutional area	**AADT**, proportion of 3 or more lane roads, number of restaurant, number of transit hub, industrial area

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ESTIMATION RESULTS

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Exposure Type	Component	Likelihood of Bicycle Trips	
		Increases	Decreases
Bicycle Generator	Probabilistic	Land-use mix, Urban area and number of household	---
	Count	Proportion of arterial roads, length of sidewalk, industrial, residential, recreational and institutional area	Proportion of 65+ aged population, AADT, proportion of 3 or more lane roads, retail/office area
Bicycle Attractor	Probabilistic	Land-use mix, Urban area and number of household	---
	Count	Proportion of arterial roads, length of sidewalk, number of educational, entertainment, restaurant, transit hub, park and recreational center, industrial, residential and institutional area	Proportion of 3 or more lane roads, number of commercial, financial and shopping center, recreational and office area

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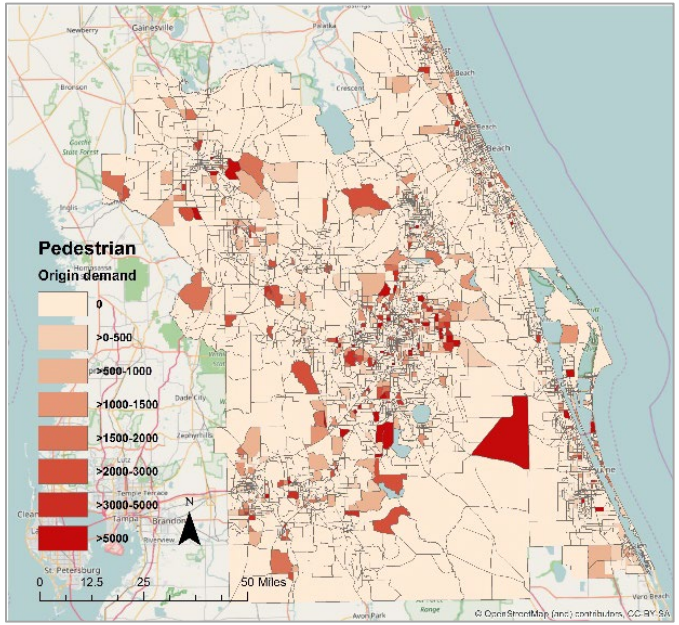
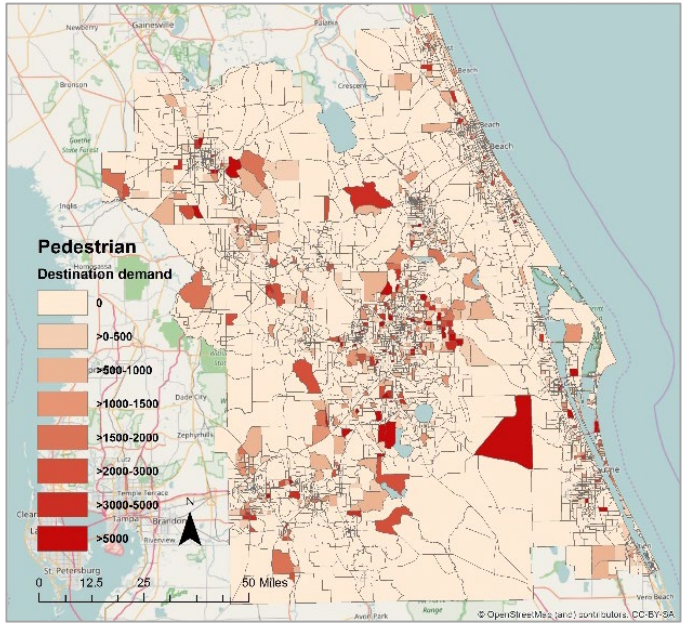
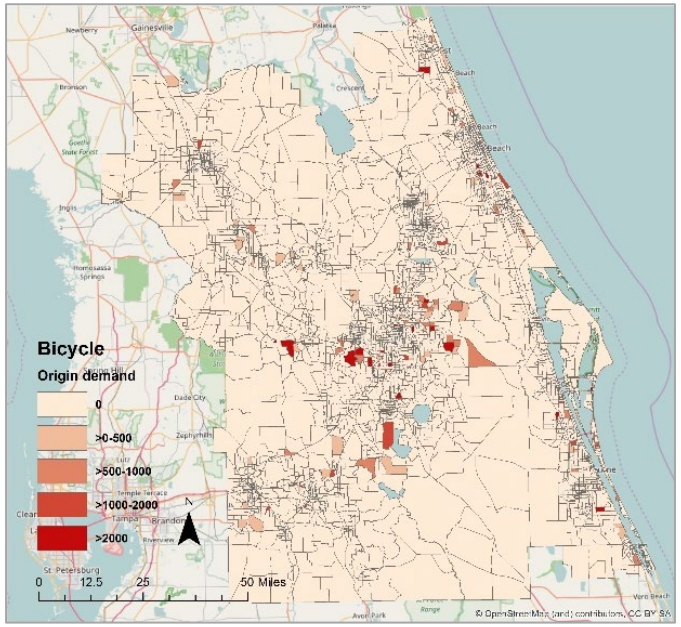
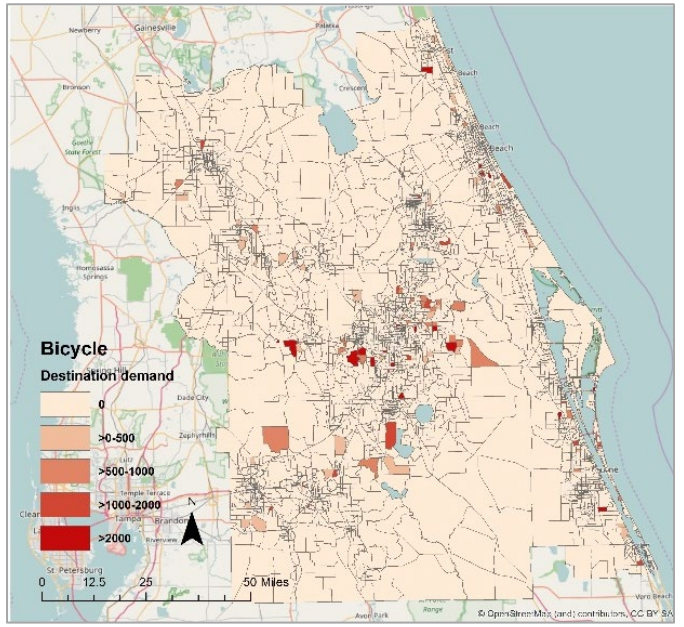
Zones with Non-motorized O-D Demand









2nd STEP
EXPOSURE MATRICES

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DESTINATION CHOICE MODEL

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- Examine the zonal attributes that influence the decision process of destination location
- Two different models: (1) Pedestrian destination choice model, and (2) Bicycle destination choice model
- A random utility maximization approach (Multinomial Logit Model)
- Generate the destination choice set by assuming that people will walk up to 2 miles and bike up to 6 miles in a trip
- **Objective:** forecast and/or evaluate policy implications for future year considering the real-world change

ESTIMATION RESULTS

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DESTINATION CHOICE	Likelihood of Destination Choice	
	Increases	Decreases
Pedestrian	**Population density**, proportion of people aged 65+, traffic signal, number of commercial, educational, financial, restaurant and transit hub, urban, residential and institutional area.	Proportion of people aged 18 to 21, average zonal speed, AADT, truck AADT, number of shopping center, industrial and recreational area
Bicycle	Proportion of 22-29 aged population, length of bike lane, average zonal speed, number of transit hubs ,commercial, educational, financial and shopping center, urban, residential, recreational, institutional and office area	**Population density**, number of restaurant, industrial area

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TRIP O-D MATRICES

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County	Number of TAZs	Pedestrian			Bicycle		
		Trip origin demand	Trip destination demand	Total trip demand	Trip origin demand	Trip destination demand	Total trip demand
Brevard	692	154936.5	149804.8	304741.3	21663.59	23172.9	44836.49
Flagler	141	26241.46	23153.66	49395.12	2940.338	2634.027	5574.365
Indian River	37	12066.78	11826.16	23892.94	1735.289	999.454	2734.743
Lake	350	67309.28	66545.88	133855.2	10784.29	9977.642	20761.94
Marion	422	95199.85	89602.94	184802.8	5238.246	4226.254	9464.501
Orange	781	348163.9	355169.8	703333.7	57661.94	64084.73	121746.7
Osceola	250	67651.62	65181.71	132833.3	4026.134	3875.623	7901.758
Polk	621	185959.9	195543.4	381503.4	10931.12	10687.68	21618.8
Seminole	230	75690.14	79212.17	154902.3	12179.38	11558.89	23738.27
Sumter	147	32272.77	26598.91	58871.68	553.048	817.907	1370.955
Volusia	1076	189987.7	174051.2	364038.8	37957.98	39924.86	77882.84

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3rd STEP SAFETY MODEL

CRASH FREQUENCY ANALYSIS

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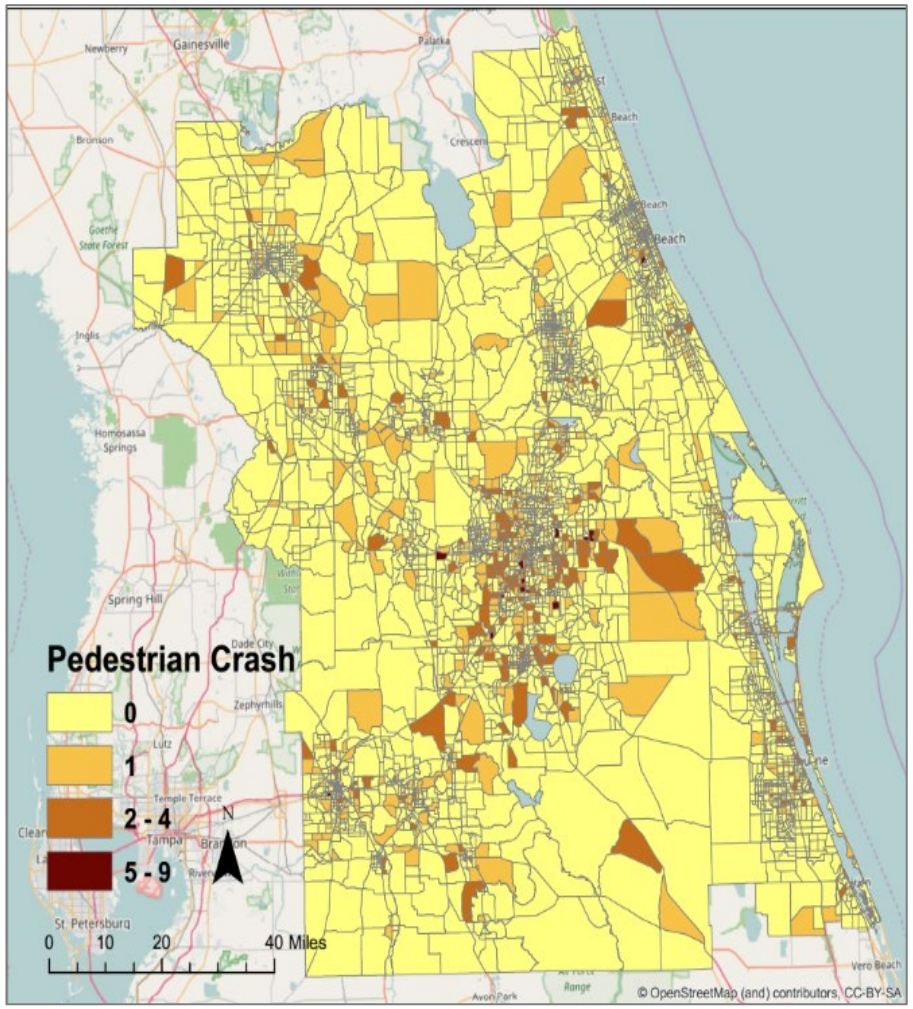
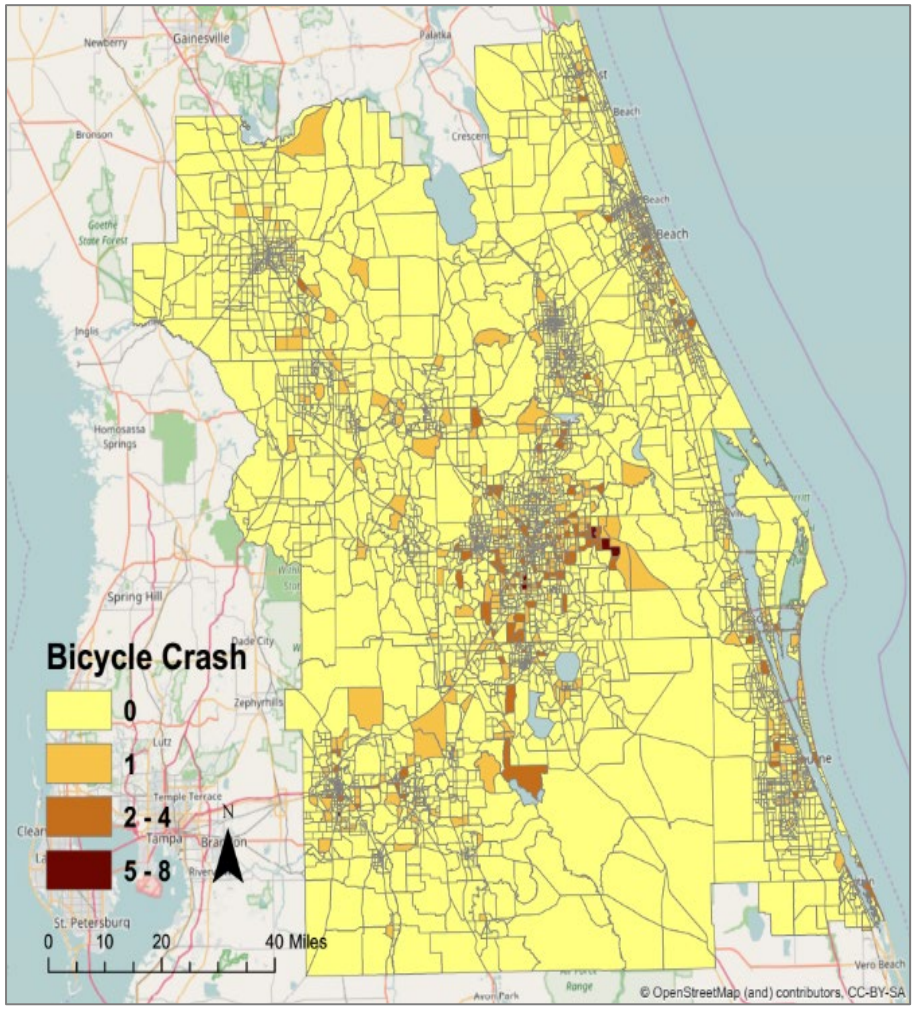
Crash Frequency Analysis





Total number of pedestrian and bicycle crashes for the year 2010

NB ESTIMATION RESULTS

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CRASH FREQUENCY	Likelihood of Crash Counts	
	Increases	Decreases
Pedestrian	Population density, traffic signal density, proportion of arterial road, length of sidewalk, **AADT**, number of educational, transit hubs, restaurant, park and recreational center, urban, residential and land use mix	Proportion of people aged 65+, **pedestrian trip demand**
Bicycle	Population density, traffic signal density, proportion of arterial road, length of bike and bus lane, **AADT**, number of commercial, financial, restaurant, hospital, urban, residential and land use mix, bicycle trip demand	Proportion of people aged 65+,proportion of local road, truck AADT, recreational area

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3rd STEP SAFETY MODEL

CRASH SEVERITY ANALYSIS

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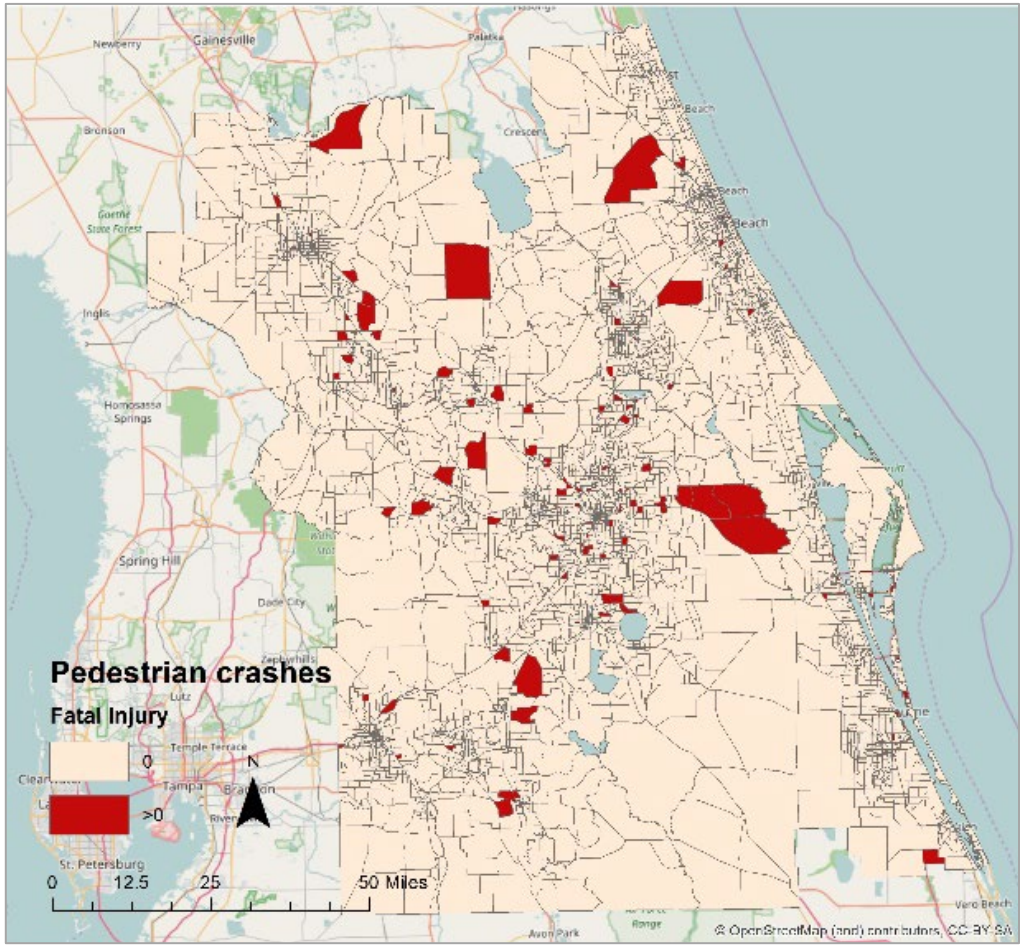
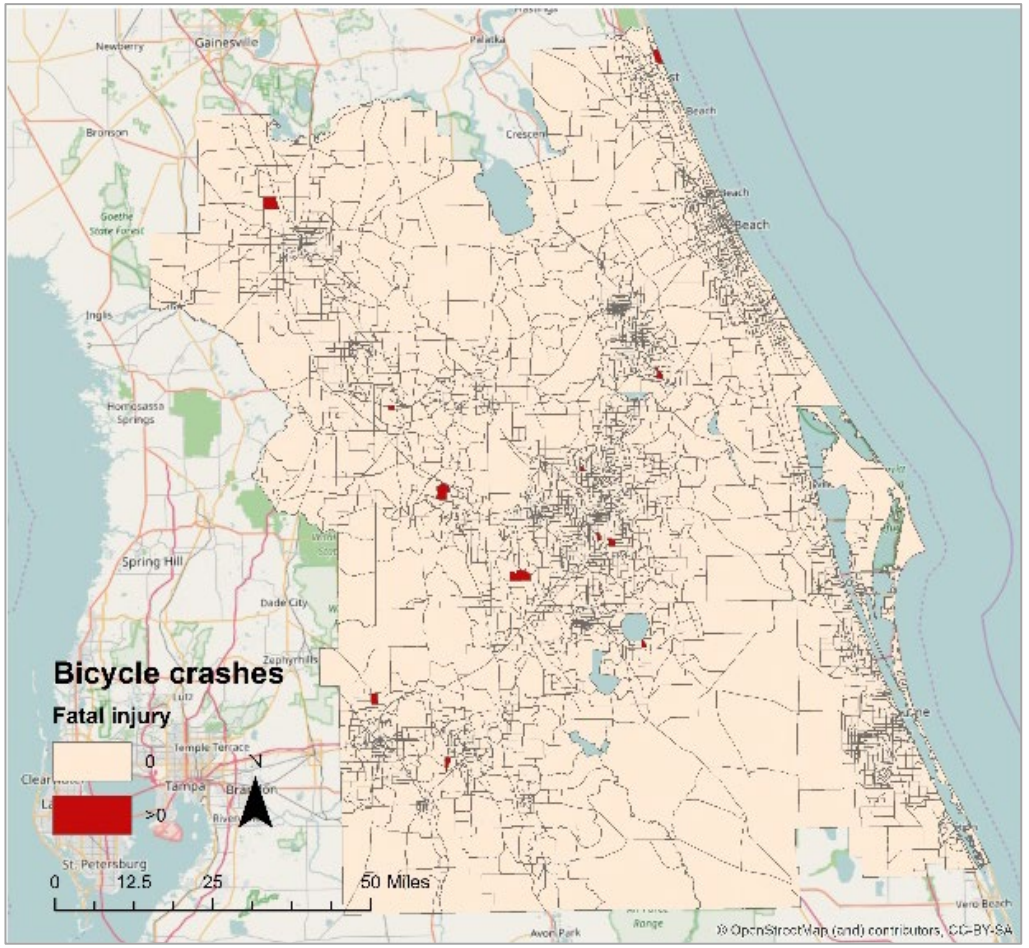
Crash Severity Analysis





Total number of pedestrian and bicycle fatal crashes for the year 2010

OPFS ESTIMATION RESULTS

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CRASH SEVERITY	Likelihood of Crash Proportions	
	Increases	**Decreases**
Pedestrian	VMT	Population density, proportion of people aged 22 to 29, number of commercial center, urban area, **pedestrian trip demand**
Bicycle	Number of flashing beacon, school signal, park and recreational center, residential area	Population density, availability of bike lane, number of hospitals, urban area, **bicycle trip demand**

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POLICY SCENARIO ANALYSIS

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POLICY SCENARIOS

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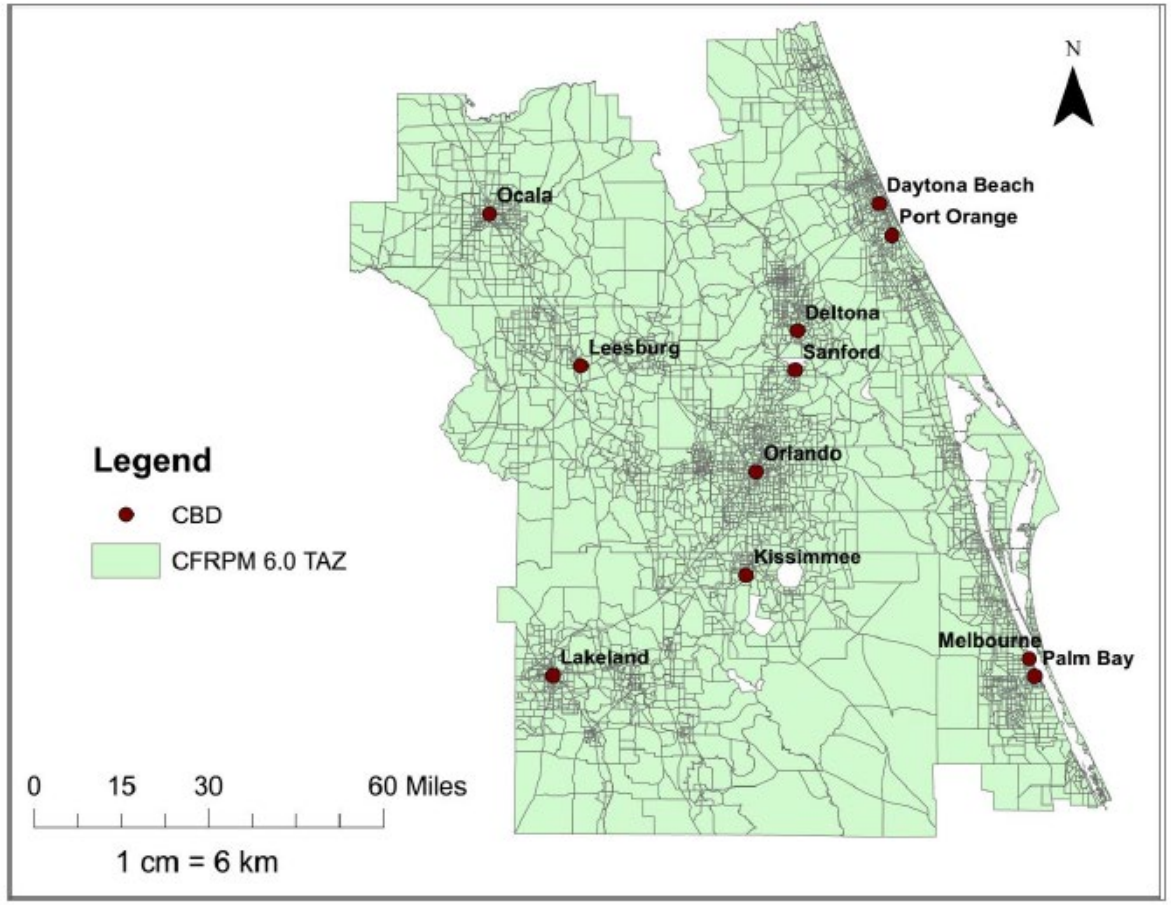
- Compute aggregate level exogenous variable impact in demand and safety models
- All zones, Pedestrian and Bicycle separately
- Multiple CBDs considered in Central Florida region
- Compute effect as percentage change



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POLICY SCENARIOS

Scenarios	Description of scenarios	Study region	Number of zones	Change in zonal demand		Change in crash count		Change in crash severity proportions	
								Fatal Crash	
				Walk	Bicycle	Walk	Bicycle	Walk	Bicycle
Scenario 1	**50% reduction in traffic volume with 2 miles buffer area of different central business district (CBD)**	All zones	4747	**0.164**	**0.043**	**-0.63**	**3.144**	**-4.967**	**-0.066**
		Zones within 2 miles buffer of CBD	703	**1.804**	**0.389**	**-3.266**	**-2.889**	**-4.687**	**-0.045**
Scenario 2	30% reduction in traffic volume with 2 miles buffer area of different central business district (CBD)	All zones	4747	0.096	0.026	-0.437	3.622	-4.963	-0.066
		Zones within 2 miles buffer of CBD	703	1.060	0.231	-2.120	-0.274	-4.664	-0.045
Scenario 3	15% reduction in traffic volume with 4 miles buffer area of different central business district (CBD)	All zones	4747	0.125	0.030	-0.482	3.554	-4.963	-0.066
		Zones within 4 miles buffer of CBD	1375	0.498	0.090	-1.280	1.680	-4.55	0.003
Scenario 4	5% reduction in traffic volume with 6 miles buffer area of different central business district (CBD)	All zones	4747	0.071	0.013	-0.34	3.935	-4.96	-0.066
		Zones within 6 miles buffer of CBD	1985	0.166	0.027	-0.589	3.281	-4.891	0.015

POLICY SCENARIOS

Scenarios	Description of scenarios	Study region	No. of zones	Change in zonal demand		Change in crash count		Change in crash severity proportions	
								Fatal Crash	
				Walk	Bicycle	Walk	Bicycle	Walk	Bicycle
Scenario 5	All zones have sidewalk and the new proposed sidewalk length = $\frac{(TAZ\ area)^{0.5}}{2}\ meter$	All zones	4747	-0.438	0.108	-1.360	4.367	-1.013	-0.063
Scenario 6	**50% increase in existing sidewalk length**	All zones	4747	**0.705**	**0.289**	**0.985**	**4.436**	**-1.111**	**-0.071**
Scenario 7	15% reduction in zonal average maximum speed	All zones	4747	1.407	0.000	-0.143	0.000	-1.107	0.000
Scenario 8	25% reduction in zonal average maximum speed	All zones	4747	2.389	0.000	-0.150	0.000	-1.135	0.000
Scenario 9	15% reduction in zonal proportion of 3+lane road	All zones	4747	0.287	0.576	-0.138	4.436	-1.077	-0.068
Scenario 10	25% reduction in zonal proportion of 3+lane road	All zones	4747	0.484	0.337	-0.143	4.415	-1.085	-0.066

FUTURE YEAR PREDICTION

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FUTURE YEAR PREDICTION (2017)

County	Error Rate (Pedestrian)				Error Rate (Bicycle)			
	Total Crash		Fatal Crash		Total Crash		Fatal Crash	
	Without Exposure	*With Exposure*	*Without Exposure*	*With Exposure*	*Without Exposure*	*With Exposure*	*Without Exposure*	*With Exposure*
Brevard	7.03%	3.95%	5.28%	3.66%	8.07%	5.98%	6.08%	5.96%
Flagler	11.16%	5.82%	9.37%	4.04%	9.86%	7.05%	9.24%	7.83%
Indian River	3.19%	3.03%	6.51%	5.45%	3.91%	2.72%	8.96%	5.86%
Lake	5.35%	2.99%	2.69%	2.38%	3.38%	2.11%	4.53%	2.39%
Marion	5.13%	4.03%	5.63%	5.33%	7.72%	5.41%	5.93%	3.72%
Orange	7.08%	3.11%	5.89%	3.16%	3.79%	2.97%	6.15%	4.67%
Osceola	9.11%	2.36%	11.84%	8.91%	11.57%	8.74%	4.75%	2.67%
Polk	1.35%	1.35%	3.27%	1.38%	3.56%	1.34%	8.69%	8.45%
Seminole	6.11%	3.13%	4.38%	2.91%	11.89%	11.25%	6.29%	6.28%
Sumter	9.82%	4.93%	10.28%	6.66%	3.07%	2.98%	6.08%	5.71%
Volusia	2.03%	1.56%	3.37%	1.04%	5.86%	4.05%	6.24%	5.83%

CONCLUSION

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- An integrated non-motorized demand and crash prediction framework is developed
- Identify and incorporate non-motorists' exposure
- 3-step framework is proposed

- Current Work
  - Working on a tool
  - Checking with 2022 data
    - Checking whether the model needs to be updated
    - Predict in future year to demonstrate the applicability of the 3-step approach

THANK YOU
Questions?

Yasmin. S., Bhowmik T., M. Rahman and N. Eluru (2021). “Enhancing Non-Motorized Safety by Simulating Trip Exposure using a Transportation Planning Approach”, Accident Analysis and Prevention, Volume 156, June 2021, 106128

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Supplementary Materials

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VALIDATION (2010)

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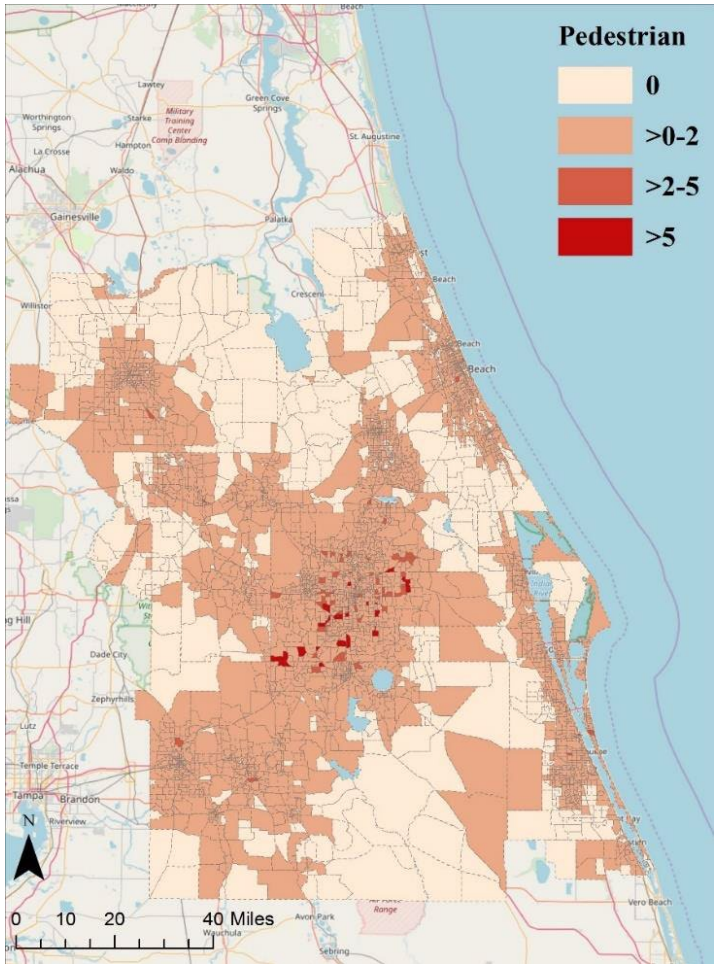
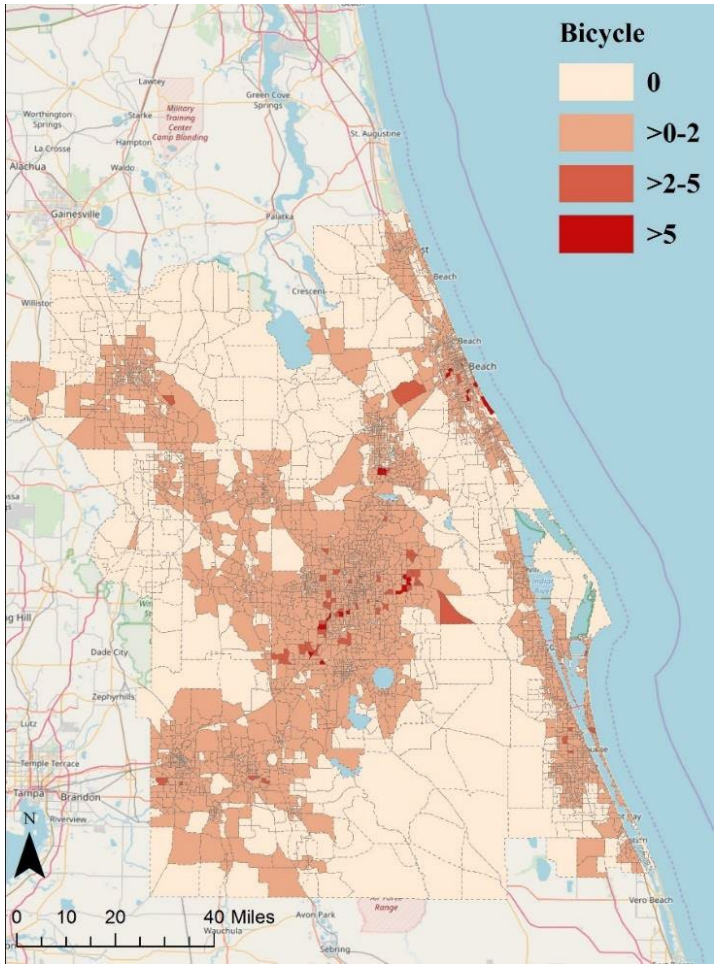
Models	Events	Observed	Predicted
Pedestrian generator model	Total Zones with zero trip count	4007.00	4006.80
	Total number of zonal trips	1260090.60	1255479.90
	Average zonal trips	265.45	264.48
Pedestrian attractor model	Total Zones with zero trip count	4010.00	4010.49
	Total number of zonal trips	1242270.50	1236690.70
	Average zonal trips	261.70	260.52
Bicycle generator model	Total Zones with zero trip count	4574.00	4573.82
	Total number of zonal trips	166248.45	165671.36
	Average zonal trips	35.02	34.90
Bicycle attractor model	Total Zones with zero trip count	4581.00	4581.18
	Total number of zonal trips	165845.77	171959.97
	Average zonal trips	34.94	36.22

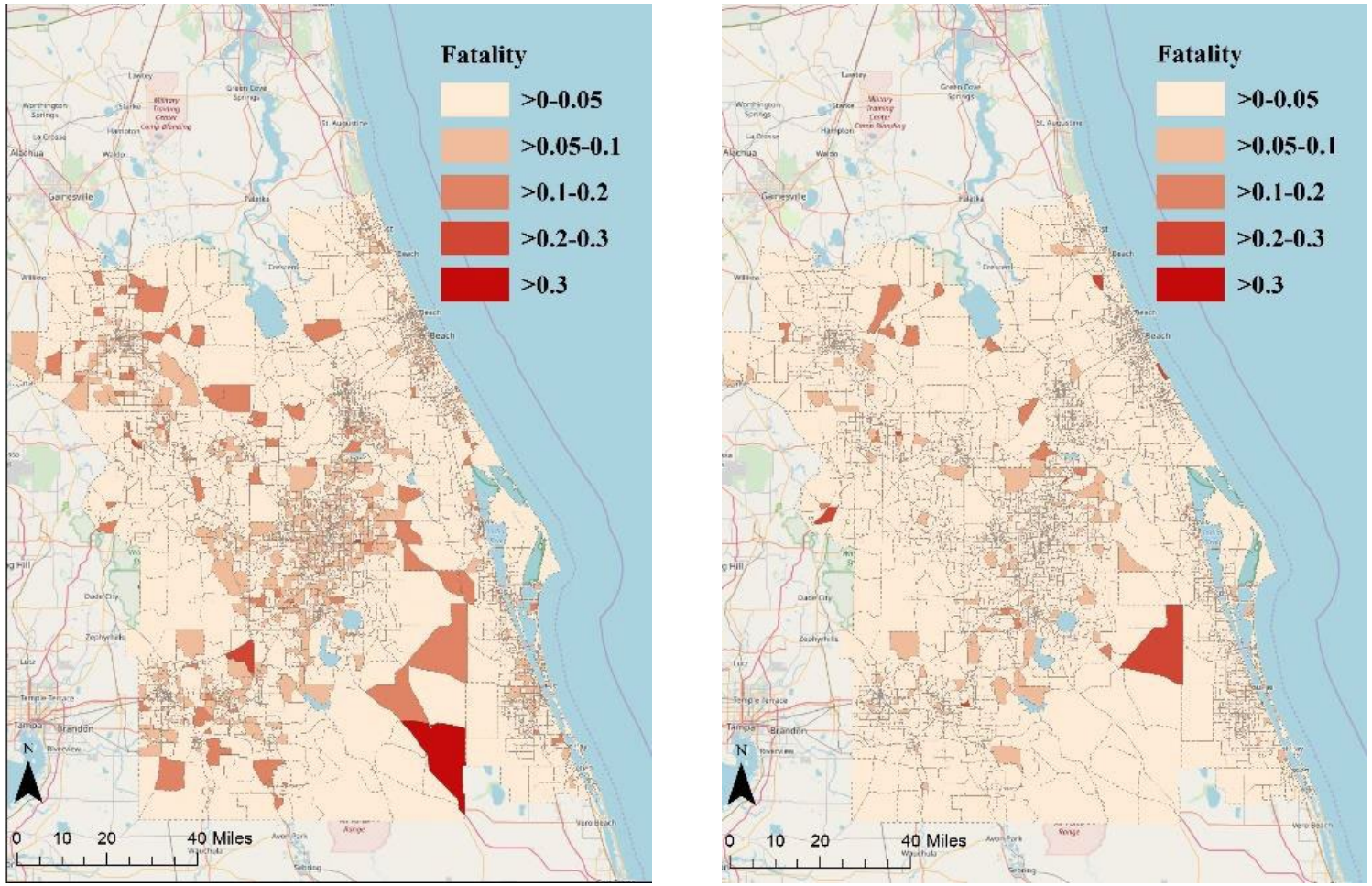
FUTURE YEAR PREDICTION (2017)





Total number of pedestrian and bicycle crashes for the year 2017

FUTURE YEAR PREDICTION (2017)



Total number of pedestrian and bicycle fatal crashes for the year 2017