Spatiotemporal Analysis of Social Vulnerability and Natural Disasters in the Southeastern United States

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Research objectives

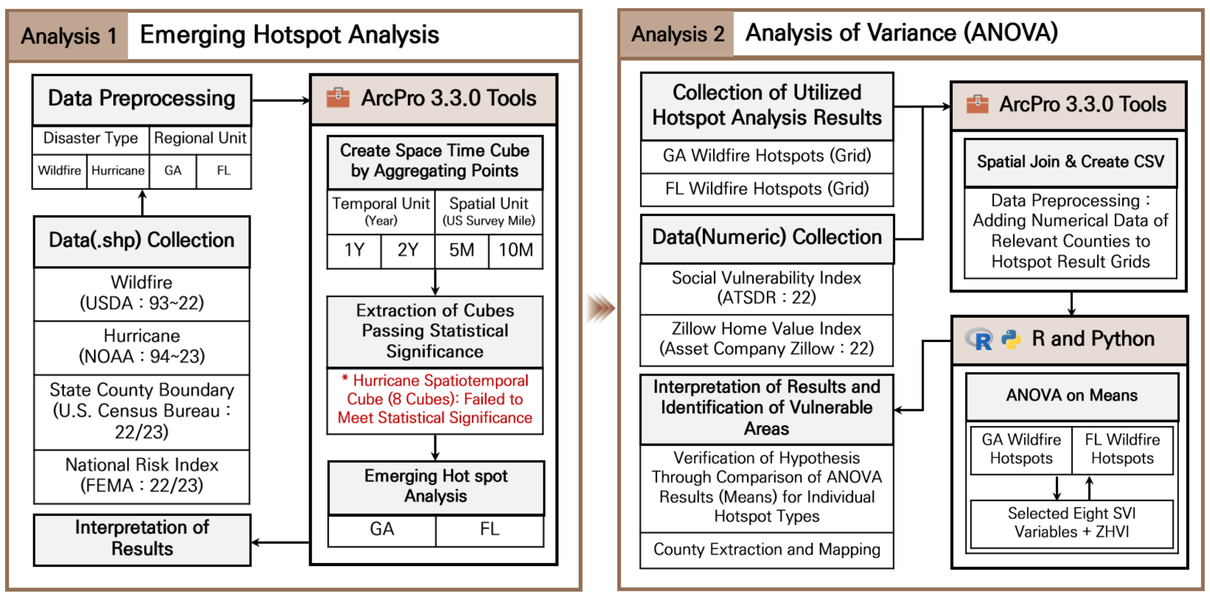
- The Southeastern United States, particularly Georgia and Florida, faces significant risks from climate crises, disproportionately affecting socially vulnerable groups during natural disasters.
- This study examines the spatiotemporal patterns of natural disasters in the region, focusing on the relationships between disaster hotspots, social vulnerability indices, and housing prices.
- This research seeks to identify high-risk areas characterized by social vulnerability and recommend priority regions for disaster mitigation and support.

Study Area GA, FL (spatially continuous but heterogeneous)

Study Period January 1, 1993 – December 31, 2022 (climate averages)

Research methods

- **Analysis1**: Emerging Hotspot Analysis - Identification of Spatiotemporal Patterns of Natural Disasters Through Analysis of Hotspot Grids with Increased Natural Disasters Over the Past 30 Years
- **Analysis2** : Analysis of Variance - Investigation of the Relationship Between Natural Disasters and Social Vulnerability Through Analysis of Hotspot Grids and SVI, and Extraction of Vulnerable Counties

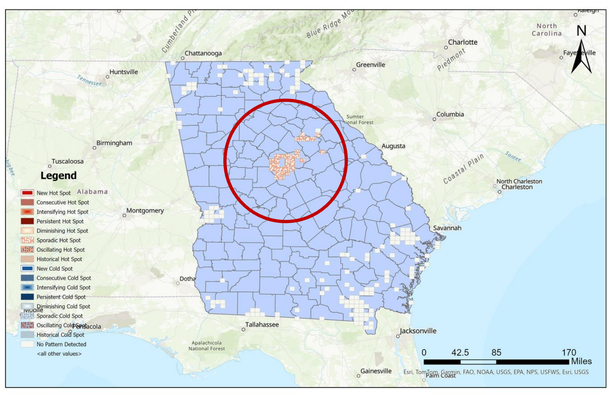


Research results

1) Emerging Hotspot Analysis Results

- Changes in Hotspot Types Were Observed Based on the Spatiotemporal Unit Configuration, with the Combination of 1 Year and 5 U.S. Survey Miles Identified as Statistically Optimal.

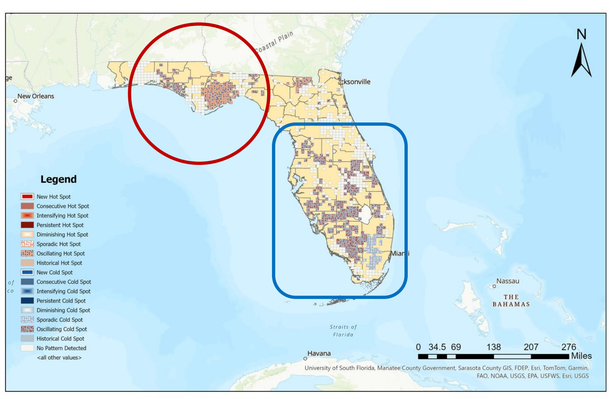
GA Fire 1993~2022 Emerging Hotspot (1Y/5M)



<fig 1> GA Fire Emerging Hotspot Map

- In GA, the central region exhibits sporadic hotspots, characterized by statistically significant hotspots that emerge intermittently over several years.

FL Fire 1993~2022 Emerging Hotspot (1Y/5M)



<fig 2> FL Fire Emerging Hotspot Map

- In FL, the northern region displays oscillating hotspots, characterized by alternating patterns of hotspots and cold spots over the years.
- In the southern region, a variety of cold spots are distributed around a central oscillating cold spot.

2) Analysis of Variance (ANOVA) Results

- From the Social Vulnerability Index (SVI), indices that could be redundantly represented by other indices were excluded. Eight representative indices were selected for use in the study (fig 3).

Mid-Level Categories of SVI	Detailed Categories of SVI	
Socioeconomic Status	Poverty	Unemployed
	No High School Diploma	No Health Insurance
Household Characteristics	Aged 65 & Older	Civilian with a Disability
Racial & Ethnic Minority Status	Minority Proportion (Race)	
Housing Type & Transportation	Mobile Homes	

<fig 3> Key Social Vulnerability Indices Selected as Study Variables

- The fire hotspot analysis results for GA and FL (1 year / 5 U.S. Survey Miles) were spatially joined with SVI and ZHVI. Subsequently, ANOVA analysis was conducted in R.
- Compared to GA, FL shows a clearer relationship between increasing natural disasters, social vulnerability, and housing indices. (fig 4)
- This indicates that in FL, areas with increasing natural disasters have a higher concentration of socially vulnerable populations and lower housing prices. (fig 4)

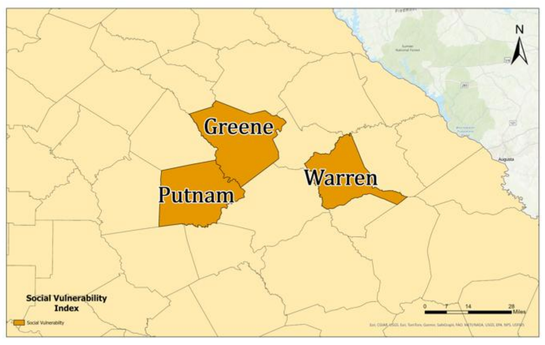
Categorical Data	Numerical Data		Statistical Significance	Aligned with Expected Outcomes
GA Fire Hotspots (1year / 5 U.S. Survey Miles)	Poverty	EP_POV150	3.67e-06 ***	X
	Unemployed	EP_UNEP	0.102	X
	No High School Diploma	EP_NOHSDP	0.000127 ***	X
	No Health Insurance	EP_UNINSUR	0.000115 ***	X
	Aged 65 & Older	EP_AGE_65	3.65e-06 ***	O
	Civilian with a Disability	EP_DISABLE	0.845	X
	Minority Proportion (Race)	EP_MINRTY	0.472	X
	Mobile Homes	EP_MOBILE	0.84	O
	Zillow Home Value Index (ZHVI)	ZHVI	1.83e-13 ***	X

Categorical Data	Numerical Data		Statistical Significance	Aligned with Expected Outcomes
FL Fire Hotspots (1year / 5 U.S. Survey Miles)	Poverty	EP_POV150	4.51e-06 ***	O
	Unemployed	EP_UNEP	7.39e-15 ***	O
	No High School Diploma	EP_NOHSDP	6.1e-14 ***	O
	No Health Insurance	EP_UNINSUR	8.61e-11 ***	X
	Aged 65 & Older	EP_AGE_65	<2e-16 ***	X
	Civilian with a Disability	EP_DISABLE	<2e-16 ***	O
	Minority Proportion (Race)	EP_MINRTY	<2e-16 ***	X
	Mobile Homes	EP_MOBILE	<2e-16 ***	O
	Zillow Home Value Index (ZHVI)	ZHVI	5.07e-15 ***	O

<fig 4> GA / FL ANOVA Analysis: Statistical Significance and Alignment with Expected Outcomes (***: Significant at p < 0.001)

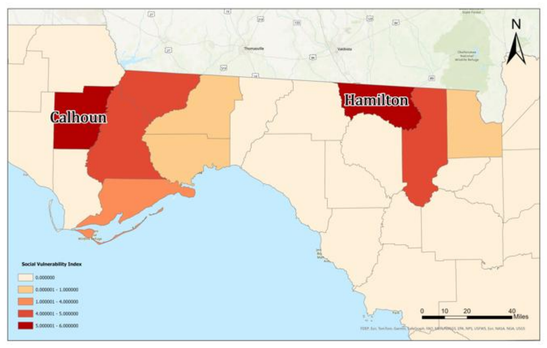
- Among hotspot counties, the greater the number of SVI variables supporting the expected outcomes, the fewer vulnerable populations are overlooked due to the exclusion of specific detailed SVI variables.
- Hotspot counties with the highest total of SVI variables meeting expected outcomes are prioritized as support-vulnerable areas
  - GA : Greene, Putnam, and Warren Counties (fig 5)
  - FL : Calhoun and Hamilton Counties (fig 6)

GA 2022 Fire-Social Vulnerability By County



<fig 5> Priority Support Vulnerable Areas in GA

FL 2022 Fire-Social Vulnerability By County



<fig 6> Priority Support Vulnerable Areas in FL

Conclusions

- This study visually presents the spatial distribution of natural disasters, such as fires, over time through the analysis of occurrence-based hotspots.
- The study quantitatively presents the relationships between social vulnerability indices using ANOVA on time-sensitive hotspot data.
- This research emphasizes supporting vulnerable groups in areas experiencing an increase in natural disasters, contributing to climate justice-oriented disaster response and informed policy recommendations.