



Academic year in review, 2025-2026

Research

The Center for Geospatial Sciences promotes cross-disciplinary work and aims to leverage geocomputational and geoinformatics methodologies to solve problems, enhance decision-making, and improve public policy. We work with various stakeholders and research groups within the UC system, across the United States, and internationally, as well as numerous government agencies and private companies. The following short report highlights a handful of successes and active collaborations for CGS for the 2025-2026 academic year.

1. Unequal Paths to Care: How Region, Rurality, and Deprivation Determine Transport to Verified Trauma Centers among the Critically Injured (Wei and Helderop)

CGS collaborated with colleagues from Rutgers Health New Jersey Medical School, NYU, Columbia, and the University of Utah on an NIH-funded study (supported by the National Institute on Minority Health and Health Disparities) that examines regional, rural-urban, and socioeconomic inequities in the prehospital transport of critically injured patients. This research, published in the journal *Surgery*, uses a large retrospective national review of the National Emergency Medical Services Information System (NEMSIS) database from 2018 to 2022, capturing a cohort of 36,897,269 critically injured adult patients. By mapping incident ZIP codes containing verified Level I–V trauma centers and overlaying neighborhood-level Area Deprivation

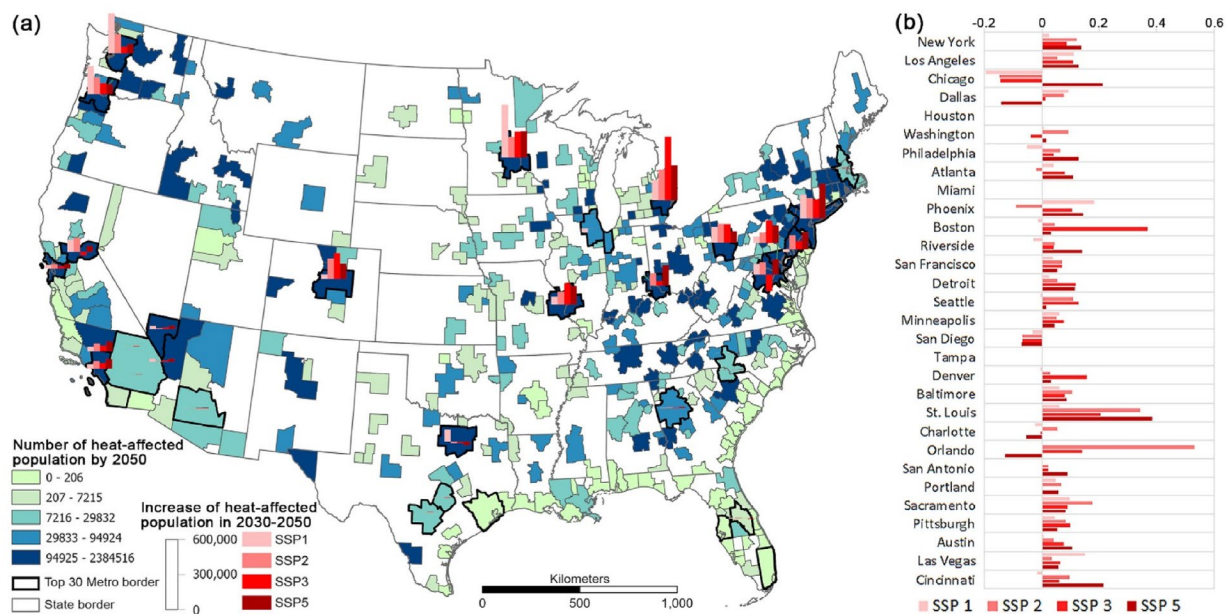
Table II
Critically injured patients transported to an urban ZIP code with a TC stratified by region and area deprivation index tertiles across the United States

Region	Deprivation	Total population	Number (%) transported to a TC	OR (reference advantaged)	95% CI	P value
United States	Advantaged	5,347,521	2,494,014 (46.6)	—		
	Neutral	12,240,582	6,665,459 (54.5)	1.368	1.365–1.371	
	Disadvantaged	5,220,994	3,105,831 (59.5)	1.680	1.676–1.684	<.001
Northeast	Advantaged	1,658,971	796,478 (48.0)	—		
	Neutral	1,855,305	823,316 (44.4)	0.864	0.860–0.868	
	Disadvantaged	525,800	275,900 (52.5)	1.196	1.188–1.203	<.001
Midwest	Advantaged	350,205	272,792 (77.9)	—		
	Neutral	2,783,620	2,012,536 (72.3)	0.741	0.734–0.747	
	Disadvantaged	1,962,462	1,209,233 (61.6)	0.456	0.452–0.459	<.001
South	Advantaged	948,088	321,236 (33.9)	—		
	Neutral	5,367,451	2,439,755 (45.5)	1.626	1.619–1.634	
	Disadvantaged	2,516,887	1,470,266 (58.4)	2.741	2.728–2.755	<.001
West	Advantaged	2,390,257	1,103,508 (46.2)	—		
	Neutral	2,234,206	1,389,852 (62.2)	1.919	1.912–1.927	
	Disadvantaged	215,845	150,432 (69.7)	2.682	2.656–2.707	P< .001

CI, confidence interval; OR, odds ratio; TC, trauma center; ZIP, Zone Improvement Plan.

Index (ADI) data, the team developed multivariable binary logistic regression models to evaluate prehospital transport decisions. Our analysis revealed that nationwide, nearly half (46.14%) of critically injured patients were not transported to verified trauma centers, with substantial regional disparities. Specifically, the Northeast had the lowest transport rate (44.0%), while the Midwest showed the highest (67.4%). Furthermore, we found that while disadvantaged urban areas often have high transport rates due to trauma center concentration, critically injured patients in highly disadvantaged rural communities face the lowest transport rates. These results underscore the severe spatial injustice and the presence of "ambulance deserts" in these regions.

2. Rising Temperatures, Rising Disparities: Projections of Socially Unequal Heat Exposure in the U.S. by 2050 (Kang)



In a collaborative study with researchers from the Spatial Sciences Institute at the University of Southern California, RMIT University, the University of Queensland, and Emory University, appearing in the *Journal of Cleaner Production*, CGS helped generate fine-grained, spatially explicit predictions of summer heat exposure and socioeconomic disparities in the continental United States by 2050. This project, funded by the Southern California Environmental Health Sciences Center and the National Institute of Environmental Health Sciences (NIEHS), integrated projected summer temperature imagery from the NEX-DCP30 dataset under the Coupled Model Intercomparison Project Phase 6 (CMIP6) with population projections under the Shared Socioeconomic Pathways (SSPs). Using historical U.S. Census and American Community Survey (ACS) data from 1980 to 2019, we then employed a neighborhood-aware second-order polynomial regression model to predict local demographic compositions and measured spatial inequalities using Gini coefficients and Getis-Ord G_i^* hotspot analysis. Our results indicate that global warming will dramatically exacerbate social inequality in heat exposure by 2050, with populations living in poverty across 52% of continental states experiencing the greatest exposure increases, followed closely by Black and Asian populations. These rising exposure inequalities are heavily concentrated in densely populated metropolitan areas, with Detroit and Minneapolis

projected to experience the highest volume of heat-affected residents among major urban regions.

3. Geoforensic Palynology Search Models and Human-Mediated Secondary Pollen Deposition (Helderop and Grubestic)

Our work on forensic geography and geoforensic palynology, published in *The Professional Geographer*,

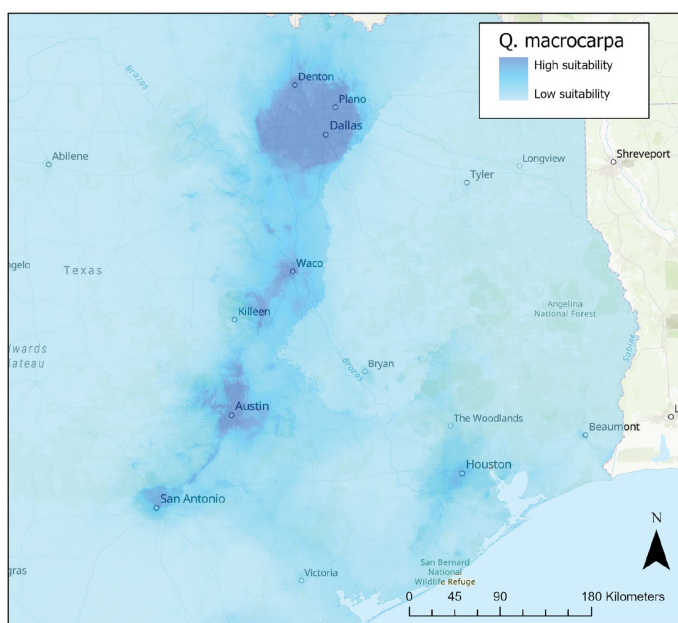


Figure 1 *Quercus macrocarpa* species distribution model (SDM) across the Texas Triangle. This is a probabilistic SDM, where each cell contains a suitability value between 0 and 1, indicating more or less suitable areas for *Q. macrocarpa*.

introduces a novel method for modeling human-mediated pollen transport and improving geolocation accuracy in criminal investigations. While traditional palynological dispersion models assume a direct spatial correspondence between plant suitability and pollen deposition, these assumptions fall short in developed urban environments where human activity causes secondary pollen redeposition far from native habitats. To address this, we constructed a social-spatial weights matrix that quantifies landscape "nearness" as a function of human flow. This includes accounting

for road network density and population-weighted distances between census tracts – all integrated into a network flow model. Demonstrating this approach with the wind-pollinated bur oak (*Quercus macrocarpa*) across the high-traffic corridors of the Texas Triangle (Dallas, Houston, Austin, and San Antonio), we showed that commuting and traffic serve as major vectors, transporting and depositing pollen miles from native habitats. In our case study of San Antonio, high-suitability suburbs in the north act as pollen sources that "spill over" into urban southern "sink" tracts where oak species do not grow. By converting traditional Species Distribution Models (SDMs) into pollen-likelihood maps, our approach can be directly integrated with advanced forensic search tools such as GOFIND+ to reduce geolocation search errors in metropolitan areas substantially.

4. Understanding the Role of the Built and Social Environments in Outcomes of Stops by Police in San Diego, California (Grubestic, Wei, and Li)

CGS researchers are also examining public policy and urban policing. In a study appearing in the *Journal of Urban Affairs*, we investigated how neighborhood-level ecological structures (physical and social environments) affect policing activities and search outcomes during

Table 2. Heckman-Probit models for the probabilities of being searched and finding no contraband.

	Step 1: Searched		Step 2: Contraband not found	
	Coefficient	Standard error	Coefficient	Standard error
Neighborhood built environment				
Density of alcohol outlets (counts per intersection)	-0.135	0.085	-1.936***	0.137
Density of transit stops (counts per intersection)	0.052	0.110	1.668***	0.119
Proportion of vacant housing units	-0.314***	0.070	-5.096***	0.307
Social environment and crime				
Proportion of African Americans	0.340***	0.074	4.290***	0.333
Proportion of Hispanics	0.353***	0.028	4.596***	0.338
Proportion of Asians	0.088	0.055	1.915***	0.099
Proportion of people living under the 100% poverty line	0.808***	0.197	12.376***	0.794
Unemployment rate	0.487	0.335	6.710***	0.547
Crime counts per thousands of people	0.014***	0.003	0.148***	0.014
Stop and driver characteristics				
Stopped at night = 1	0.066***	0.012	0.982***	0.065
Stopped before the pandemic = 1	-0.124***	0.012	-1.332***	0.119
Years of experience for the police officer	-0.024***	0.001	-0.312***	0.023
Gender of the suspect person stopped = Male	0.375***	0.017	4.830***	0.362
Perceived age of the suspect stopped (10 years)	-0.005***	0.001	0.069***	0.005
Asian	-0.091**	-0.032	-1.100***	-0.092
Black/African American	0.057***	0.017	0.674***	0.057
Hispanic/Latino/a	0.078***	0.015	1.001***	0.076
Middle Eastern or South Asian	-0.302***	0.049	-3.842***	0.296
Native American	0.182	0.116	2.242***	0.197
Pacific Islander	0.079	0.064	1.093***	0.095
Unknown	0.259***	0.018	3.215***	0.248
Traffic stops	-0.175***	0.017	-1.637***	0.170
Inverse Mills ratio			14.845***	1.083
Observations	264,379		264,379	
Log Likelihood	-23,629.430		-37,898.010	
Akaike Inf. Crit.	47,304.870		75,844.010	

*** $p < .001$, ** $p < .01$, * $p < .05$.

pedestrian and traffic stops in San Diego, California. Analyzing stop-level spatial data collected under the California Racial Identity and Profiling Act (RIPA) between 2018 and 2022, we developed a two-stage Heckman-Probit model using a final sample of 264,379 stops and 5,195 discretionary searches to correct for selection bias. While physical built-environment indicators associated with crime (such as alcohol outlets or housing vacancies) do not

predict officer decisions to conduct consent searches, social characteristics are powerful predictors. Individuals stopped in neighborhoods with higher proportions of Black and Hispanic residents, poverty, and crime are significantly more likely to be searched. Yet, these searches are substantially less likely to find contraband. This high rate of "unsuccessful" searches points to systematic overpolicing. Interestingly, our results show that high-density transit stop areas are positively associated with the absence of contraband, indicating a localized bias around transit hubs. This work provides empirical evidence of place-based biases and offers critical insights for urban planners and police departments seeking to design more equitable community policing strategies.

5. Additional Funded CGS Research Projects

a) NSF 2024-2026: POSE: Phase II: An Open-Source Ecosystem for Spatial Data Science (Kang).

This NSF-funded project (\$1.48 million), supported by the Pathways to Enable Open-Source Ecosystems (POSE) program, aims to advance spatial data science by developing the open-source Python Spatial Analysis Library (PySAL). UCR leads the education and workforce development component, focusing on training the next generation of spatial data scientists. This effort includes conducting an international survey, creating curriculum materials, supporting instructors, and promoting inclusive, participatory learning. UCR's work is central to building a

sustainable and accessible ecosystem that empowers users to apply spatial analysis tools to real-world societal challenges.

Kang organized, and Grubestic participated in a special session at the 2026 Meeting of the Association of American Geographers in San Francisco, titled "Open Source Spatial Data Science: Education," which is related to this award.

b) Short-term Environmental Exposures and Emergency Medical Service Activation in the U.S. NIH National Institute of Environmental Health Sciences (Wei and Helderop).

This NIH-funded (\$1.6 million) project explores the nationwide associations between environmental exposures and emergency medical services (EMS) events. The multidisciplinary team will analyze data on annual 20+ million 911 transport calls with detailed information on demographics and symptoms, providing sufficient statistical power to detect small differences in associated estimates across subpopulations. We will produce crucial evidence to guide future research in elucidating the underlying pathophysiological pathways by which the environment affects health and to inform policy. The unique characteristics of EMS data will be integrated with recent advancements in low-cost sensor technologies and newly available smartphone-based mobility data to improve exposure estimates and examine exposure misclassification. The methodologies and frameworks developed in this work will serve as a key resource for other investigations. We seek to advance paradigms in exposure assessment methods while addressing critical knowledge gaps regarding the potential impacts of environmental exposures on EMS services in the U.S.

c) Heat Waves, Pediatric Readiness, and Child Outcomes: Evaluating Climate Risk, Mitigation, and Resilience in Emergency Care (Wei)

This NIH-funded (\$2.05 million) award explores resilience in emergency care. While children under the age of five bear nearly 90% of the global disease burden from extreme weather, we know surprisingly little about how real-world heatwaves affect their health because pediatric data is often lumped in with adult data. This critical gap in knowledge is compounding a silent crisis in our healthcare system, where only 17% of U.S. emergency departments possess high "pediatric readiness," leaving the vast majority underprepared and leading to over 2,000 preventable child deaths each year. To confront this vulnerability, a groundbreaking, NIH-aligned research project is leveraging a decade of emergency care records matched with high-resolution climate data to finally map out the areas where extreme heat and poor emergency care intersect. Ultimately, the study seeks to prove that investing in pediatric-ready emergency departments not only saves lives during climate disasters but also provides a vital roadmap for how our entire healthcare infrastructure can adapt to protect its youngest patients.

6. Research, Development, and Outreach

Helderop finished up work as a member of the Abundance Accelerator Research Consortium (\$40k), with his report getting published by the UCB Possibility Lab:

<https://possibilitylab.berkeley.edu/reimagining-economic-opportunity-as-a-public-good/>

<https://news.ucr.edu/articles/2026/02/12/ucr-report-urges-broadband-be-state-utility>

Grubestic discussed his work on Essential Air Service in a feature for National Public Radio:

<https://www.npr.org/2026/05/12/nx-s1-5796244/aviation-rural-flights>

Grubestic also discussed his work on ZIP Codes and their implications for developing effective spatial analyses and public policy for National Public Radio's *Planet Money*:

<https://www.npr.org/2026/05/12/nx-s1-5796244/aviation-rural-flights>

7. Events and Teaching

Over the past year, the core CGS team (Grubestic, Wei, Kang, and Helderop) continued their efforts to lead the schoolwide (SPP) effort to develop a new major/minor for SPP in Geospatial Analysis and Public Policy. This proposal and the development of related course syllabi required substantial time and pedagogical effort. We hope to launch the minor in 2026. Portions of this effort were supported with an award from UOnline (\$140,000).

CGS faculty teach a range of geospatial and public policy classes, along with some additional SPP courses, and this year was no exception:

- PBPL 010 – Introduction to Geographic Information Systems
- PBPL 177 – Housing Policy
- PBPL 150 – Urban Informatics for Public Policy
- PBPL 236 – U.S. Census Data and Policy Studies
- PBPL 255 – Mapping for the Common Good
- PBPL 273 – GIS and Public Policy

CGS engages in several outreach activities each year as well, including the following:

- An annual presentation of ongoing CGS research at UCR's Geospatial Meetup.
- Drone demonstration for graduate students in Mapping for the Common Good (PBPL 255).
- Research presentations at the North American Regional Science Association Annual Meeting, the Association of American Geographers Annual Meeting, and the Institute for Operations Research and the Management Sciences Annual Meeting.
- Organized and assisted in hosting Esri Day on campus (Dangermond visit + faculty speed talks)

8. Forecasted activities for the 2025-2026 academic year

Many CGS research projects will likely continue through Autumn 2026 and Spring 2027. In addition, Grubestic, Wei, and Helderop are under contract with Springer to produce the ~250-page book: *Mapping for the Common Good: Spatial Analytics for Improving Communities – A Practitioner's Guide to Using Spatial Analysis for Social Impact and Public Policy*. We will also help host several GIS-related colloquia in SPP throughout the year and participate in GIS Day in Nov.