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Corresponding Author

Katherine Auerswald, CSS/NOAA NCCOS
katherine.auerswald@noaa.gov

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Methods Report for Prescribed Fire in the Gulf: A Spatial Analysis in Coastal Alabama and Mississippi

Authors

Katie C. Auerswald,[1] Aleia C. Fobia,[2] and Sarah Ball Gonyo[2]

[1] *CSS, Inc., under contract to NOAA, National Ocean Service, National Centers for Coastal Ocean Science*
[2] *NOAA, National Ocean Service, National Centers for Coastal Ocean Science*

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1. Data Overview and Accessibility

All derived data described within this report are listed below and can be found archived at Harvard dataverse (https://doi.org/10.7910/DVN/S5GWRH) and at www.data.gov.

Thematic Category	Datasets	Data Type
Population	Density	1-km Raster
Smoke	Aggregated by Block Group	Polygon
Prescribed Fire	Aggregated by Hexagonal Grid	Polygon
	Unaggregated	Polygon
	Density	30-m Raster

All source data are publicly hosted by other organizations or federal agencies and can be accessed through their respective data source references.

2. Project Background

Prescribed fire—also referred to as prescribed burns, controlled fire, or controlled burns—is the intentional, planned use of fire for land management purposes. Prescribed fire is primarily used to reduce excess vegetation and accumulated fuels in a timely and cost-effective manner. The benefits of prescribed fire vary depending on specific objectives but may include reducing the risk of wildfires, controlling invasive species, improving forest access, enhancing opportunities for recreation, and promoting fire-adapted plant and wildlife communities (Virginia Department of Forestry, n.d.). Although fire was largely abandoned as a land management tool after European colonization of the Americas, recent practices have re-established its role as a valuable management technique (Ryan et al., 2013).

In contemporary land management practices, prescribed fire is conducted under specific environmental conditions so as to disperse smoke and control fire behavior. Key factors such as wind speed, wind direction, debris buildup, temperature, precipitation, and humidity are assessed prior to fire ignition (Waldrop and Goodrick, 2018). If conditions are deemed unsuitable, prescribed fires are either postponed or canceled. Land managers and individual practitioners must receive training facilitated by local or state agencies and are required to obtain burn permits from local authorities before conducting a burn. Permits are not always granted, particularly during periods of heightened fire risk, such as regional droughts, when statewide burn bans may be enacted. However, these bans often apply only to individual practitioners, not land managers. Other barriers to prescribed fire include environmental laws and policy, such as air quality regulations, culturally entrenched fire suppression practices, increased wildland urban interface, and excessive debris buildup, which can increase the risk of fire outbreak in some areas.

For this National Centers for Coastal Ocean Science assessment, the Social Science Team collaborated with land managers from the Grand Bay and Weeks Bay National Estuarine Research Reserves (NERRs) to improve understanding and visualization of prescribed fire and smoke across Jackson County in Mississippi, and Baldwin and Mobile Counties in Alabama. This spatial analysis is designed to support a subsequent public survey aimed at understanding perceptions of prescribed fire. Insights from this analysis will inform educational efforts to enhance public awareness and understanding of prescribed fire practices within the study area.

3. Methods

3.1 Study Area

The study area encompassed three coastal counties bordering the Gulf of America (hereafter, the "Gulf"): Jackson County in Mississippi, and Baldwin and Mobile Counties in Alabama. These counties were selected for this assessment due to their proximity to Grand Bay NERR and Weeks Bay NERR. Together, these reserves protect over 27,000 acres of highly biologically diverse tidal and forested wetland habitats in the northern Gulf. The NERRs are home to a variety of endangered and rare species, including carnivorous pitcher plants, swallow-tailed kites, eastern indigo snakes, and the Alabama red-bellied turtle (NOAA Office for Coastal Management, n.d.-a, n.d.-b). The reserves and the surrounding landscape serve a total of 820,949 people across the three coastal counties (U.S. Census Bureau, n.d.-a, n.d.-b, n.d.-c), including the larger urban area of the City of Mobile, Alabama.

The study site and associated maps were projected in NAD 1983 UTM Zone 16N using ArcGIS Pro version 3.4.0. Study site boundaries were collected from TIGER/Line files from the U.S. Census Bureau 2022 outputs (U.S. Census Bureau, 2022).

3.2 Population Density

For this study, population density data were included between 2000–2020 from WorldPop at the 1-km resolution (WorldPop, n.d.). Population density maps enable a comparative analysis between fire density heat maps, smoke maps, and population distribution across the study area. These help to understand where fire and smoke are in relation to population and provide insights into how public perceptions of fire may be influenced by proximity to fire events and smoke. The WorldPop data were imported and clipped to the study area (Figure 1).

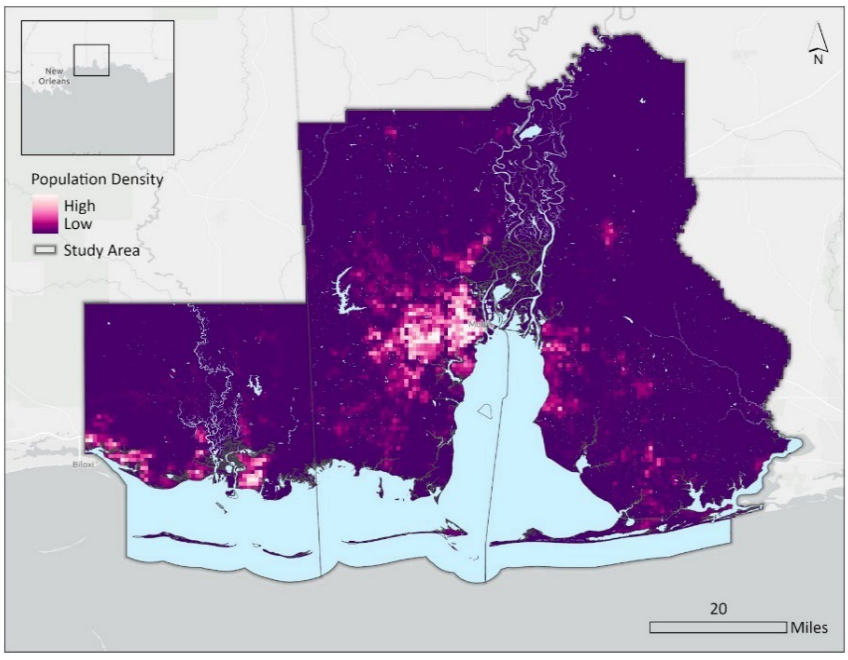

Figure 1. WorldPop population density at 1-km resolution clipped to the study area.

3.3 Smoke

Smoke is a hazardous outcome of fire that can impact human health and wellness. Smoke from unplanned fires can be widespread and concerning. However, prescribed fires typically produce minimal and short-lived smoke that does not adversely affect health or air quality. Because prescribed fire is conducted under prime conditions, it typically creates smoke that disperses quickly, has lower emissions of PM2.5 than wildfire, and has reduced potential impacts to respiratory health and air quality (Jaffe et al., 2020). Distinguishing between smoke from prescribed fire and that from unplanned fire may prove difficult to the general public, and further research is needed to determine whether communities in the area are aware that smoke, although sometimes visually present in prescribed fire, is not necessarily harmful as it is with wildfire.

In order to understand potential associations between prescribed fire and smoke, secondary smoke data from NOAA's Hazard Mapping System (HMS) were used to visualize smoke distribution across the study site (NOAA Hazard Mapping System, n.d.). The HMS shapefiles are polygon representations of visible smoke, derived from satellite imagery. Data from January 1, 2017 to December 31, 2022 were downloaded from NOAA's HMS online data portal. Shapefiles of daily smoke data were imported into ArcGIS Pro, grouped by month and year, and filtered based on smoke presence. Files containing no visual smoke originating within the study area were removed. Out of a total of 2,189 days, 614 days showed smoke presence, and 309 days had visible smoke originating from within the study area. Filtered smoke data were merged into a single shapefile, clipped to the study area, and summarized within U.S. Census Bureau block groups (U.S. Census Bureau, 2022) by the count of smoke polygons. Block groups were selected for this study to facilitate future research on the demographic impacts of uneven smoke distribution on heterogeneous populations. To control for block group area, counts of smoke were summarized within a 10-mi grid. Figure 2 illustrates that the block groups and hexagons in the north of the study area show higher counts of smoke.

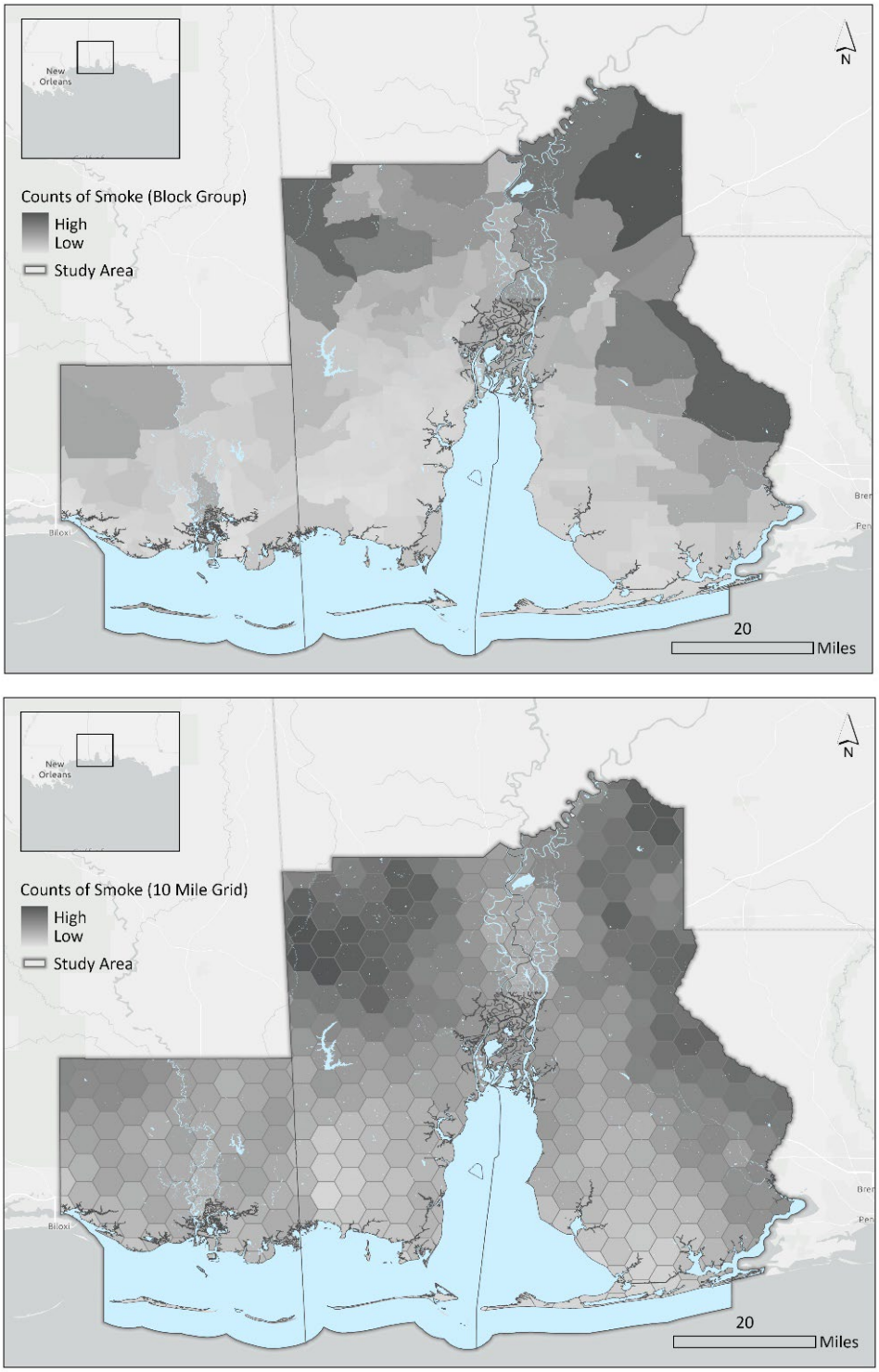

Figure 2. Counts of smoke polygons summarized by block group (top) and a 10-mi grid (bottom).

3.4 Prescribed Fire Density

Prescribed fire is implemented unevenly across the landscape. Variables such as population density, debris buildup, knowledge of fire need, and local environmental conditions influence locations of prescribed fire. In order to better understand prescribed fire distribution across the study area, secondary data sourced from the Fire Program Analysis Fire-Occurrence Database from the U.S. Forest Service (Short, 2022) were used. These point data from 1992–2020 are a database of all recorded wildfires, natural and human-caused, across the U.S. (Short, 2022). For the purpose of this study, data were downloaded and filtered to include only human-caused fires for debris and open burning. Point data were clipped to the study area and converted to a raster format using the kernel density estimation (KDE) in ArcGIS Pro. Fires were weighted by size based on partner requests, with larger fires having more weight and smaller fires having less weight in the KDE.

KDE is commonly used in studies of wildfire risk and spatial distribution (Kuter et al., 2011; Koutsias et al., 2014; Monjarás-Vega et al., 2020) because it allows users to rasterize fire distribution with associated severity data while minimizing and smoothing locational inaccuracy typical of fire point data (Monjarás-Vega et al., 2020). Despite more accurate knowledge of prescribed fire ignition points due to permit records, fire behavior cannot be captured by point longitudinal and latitudinal data, as fire expands from ignition points and affects surrounding landscapes, requiring a smoothed density output that minimizes assumptions of fire behavior and includes fire size in analysis. The final output after running the KDE was a single 30×30-m raster displaying fire ignition distribution weighted by fire size. Figure 3 illustrates the areas with more numerous and larger prescribed fires between 1992–2020 in dark orange.

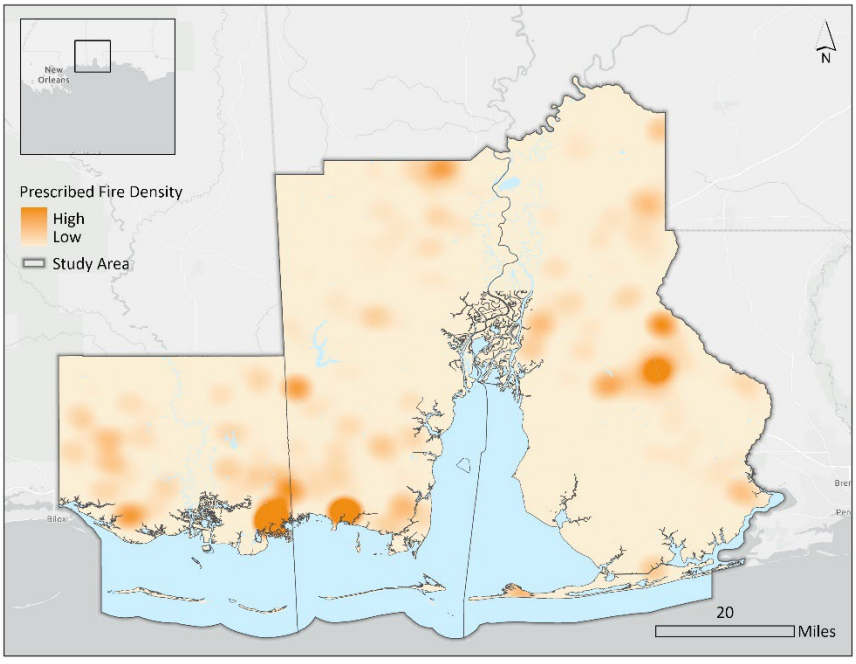

Figure 3. Prescribed fire density weighted by fire size using kernel density estimation.

3.5 Combination Mapping

In order to assess the ways in which population density, smoke, and prescribed fire intersect, combination maps were created in ArcGIS Pro. Figure 4 illustrates that smoke is less frequent in densely populated areas. Figure 5 demonstrates that smoke and prescribed fire are not necessarily aligned, as hotspots of prescribed fire fall outside of high smoke count polygons, especially in the southern region of the study area. Finally, Figure 6 illustrates that prescribed fire occurs more frequently and at larger scales outside of densely populated areas.

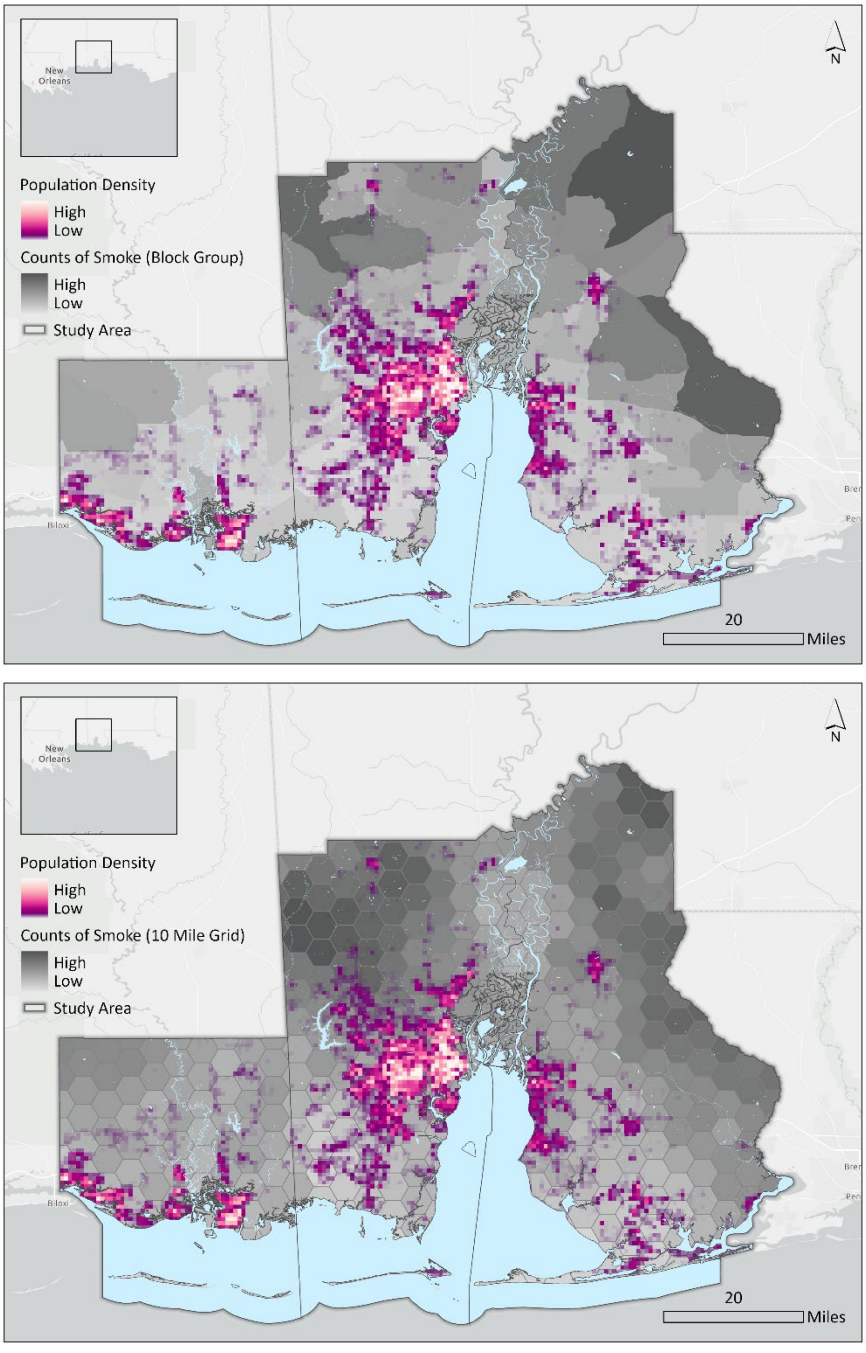

Figure 4. Counts of smoke polygons summarized by block group with population density included as an overlay (top) and counts of smoke polygons summarized by a 10-mi grid of hexagons with population density included as an overlay (bottom).

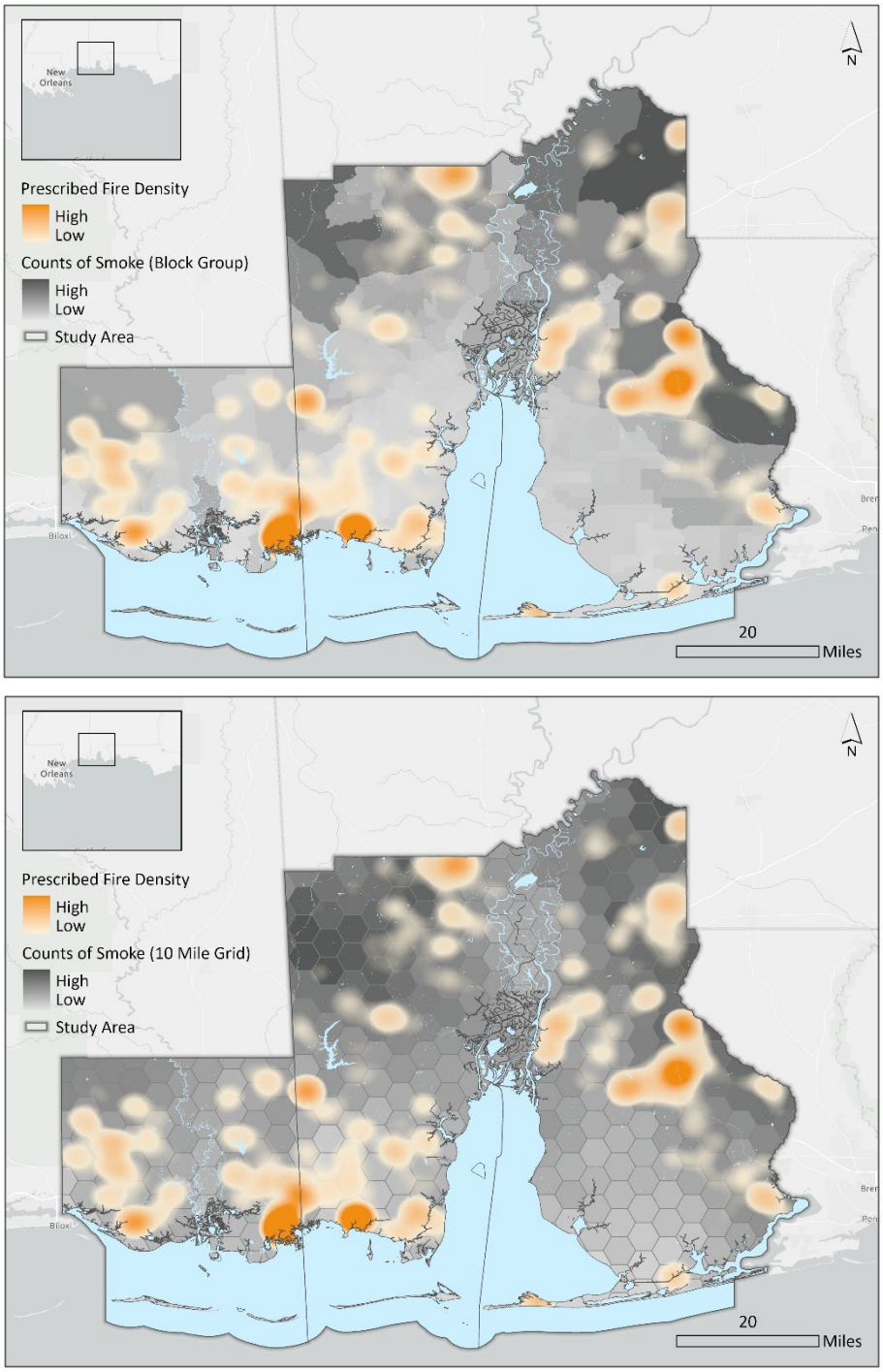

Figure 5. Smoke density compared to prescribed fire density in both block groups (top) and a 10-mi grid (bottom).

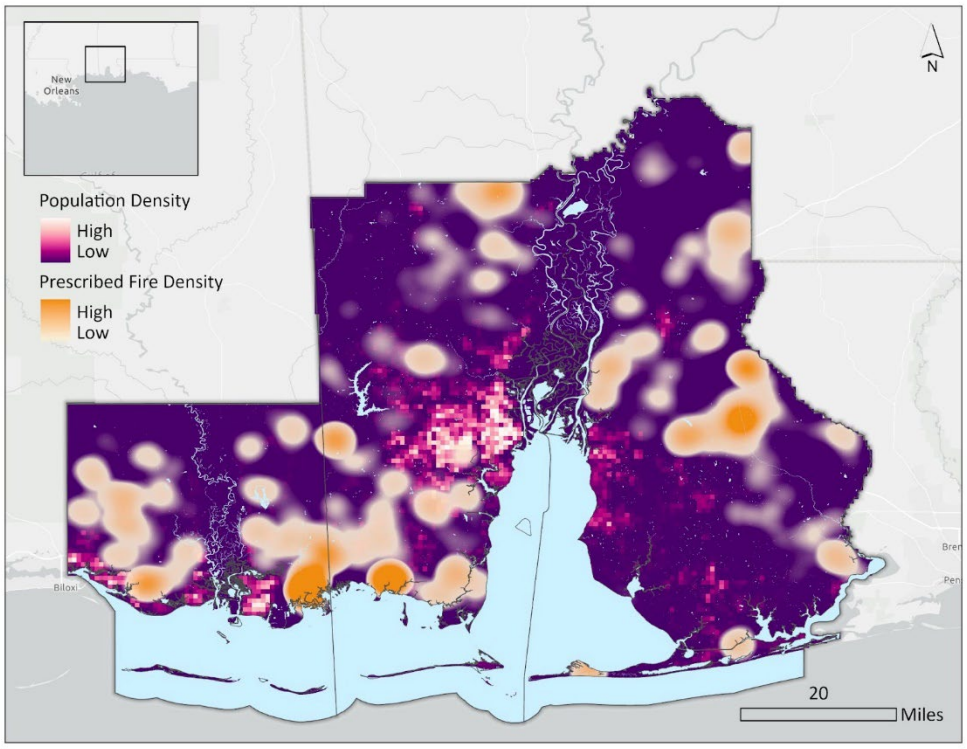

Figure 6. Population density compared to prescribed fire density.

4. References

Jaffe, D. A., O'Neill, S. M., Larkin, N. K., Holder, A. L., Peterson, D. L., Halofsky, J. E., and Rappold, A. G. (2020). Wildfire and prescribed burning impacts on air quality in the United States. *Journal of the Air & Waste Management Association*, *70*(6), 583–615. https://doi.org/10.1080/10962247.2020.1749731

Koutsias, N., Balatsos, P., and Kalabokidis, K. (2014). Fire occurrence zones: Kernel density estimation of historical wildfire ignitions at the national level, Greece. J*ournal of Maps*, *10*(4), 630–639. https://doi.org/10.1080/17445647.2014.908750

Kuter, N., Yenilmez, F., and Kuter, S. (2011). Forest fire risk mapping by kernel density estimation. *Croatian Journal of Forest Engineering*, *32*(2), 599–610. https://hrcak.srce.hr/72661

Monjarás-Vega, N. A., Briones-Herrera, C. I., Vega-Nieva, D. J., Calleros-Flores, E., Corral-Rivas, J. J., López-Serrano, P. M., Pompa-García, M., Rodríguez-Trejo, D. A., Carrillo-Parra, A., González-Cabán, A., Alvarado-Celestino, E., and Jolly, W. M. (2020). Predicting forest fire kernel density at multiple scales with geographically weighted regression in Mexico. *Science of The Total Environment*, *718*, 137313. https://doi.org/10.1016/j.scitotenv.2020.137313

NOAA Hazard Mapping System. (n.d.). Fire and smoke product. Retrieved July 2024 from https://origin-east-01-www-ospo.woc.noaa.gov/products/land/hms.html#data

NOAA Office for Coastal Management. (n.d.-a) Grand Bay National Estuarine Research Reserve. NOAA Office for Coastal Management. Retrieved April 21, 2025, from https://coast.noaa.gov/data/docs/nerrs/Handout-Grand-Bay.pdf

NOAA Office for Coastal Management. (n.d.-b). Weeks Bay National Estuarine Research Reserve. National Estuarine Research Reserve System. Retrieved April 21, 2025, from https://coast.noaa.gov/nerrs/reserves/weeks-bay.html

Virginia Department of Forestry. (n.d.). Prescribed burning. https://dof.virginia.gov/wildland-prescribed-fire/prescribed-burning/

Ryan, K. C., Knapp, E. E., and Varner, J. M. (2013). Prescribed fire in North American forests and woodlands: History, current practice, and challenges. *Frontiers in Ecology and the Environment*, *11*(s1), e15–e24. https://doi.org/10.1890/120329

Short, K. C. (2022). Spatial wildfire occurrence data for the United States, 1992–2020 [FPA_FOD_20221014]. 6th Edition. U.S. Forest Service. https://doi.org/10.2737/RDS-2013-0009.6

U.S. Census Bureau. (n.d.-a). U.S. Census Bureau QuickFacts: Baldwin County, Alabama. https://www.census.gov/quickfacts/fact/table/baldwincountyalabama/PST045223

U.S. Census Bureau. (n.d.-b). U.S. Census Bureau QuickFacts: Mobile County, Alabama. https://www.census.gov/quickfacts/fact/table/mobilecountyalabama/PST045224

U.S. Census Bureau. (n.d.-c). U.S. Census Bureau QuickFacts: Jackson County, Mississippi. https://www.census.gov/quickfacts/fact/table/jacksoncountymississippi/PST045224

U.S. Census Bureau. (2022). TIGER/Line with selected demographic and economic data. https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-data.html

Waldrop, T. A., and Goodrick, S. L. (2018). Introduction to prescribed fires in Southern ecosystems. U.S. Forest Service, Southern Research Station. https://research.fs.usda.gov/treesearch/41316

WorldPop. (n.d.). WorldPop_Population_Density_1km [data set]. Accessed from https://worldpop.arcgis.com/arcgis/rest/services/WorldPop_Population_Density_1km/ImageServer, which was formatted from data acquired from https://www.worldpop.org/doi/10.5258/SOTON/WP00674 on September 15, 2021.

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