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Leveraging Earth science data to heighten awareness of environmental injustices within the U.S. prison system

Annual Report

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# Executive Summary

Incarceration rates in the United States have increased 700% since 1970 and are the highest in the world, such that the U.S. constitutes 4% of the global human population but 25% of the world’s prisoners. This U.S. prison population is also made up of disproportionately poor people and people of color (3/5 of prisoners), and hence expands the current system of racial capitalism by exploiting unpaid or vastly underpaid (and oftentimes dangerous) labor to fund prison operations and generate revenue, while justifying it through claims of rehabilitation.

Within this system of inequitable incarceration and racial capitalism also lies many environmental injustices, as inmates have been forced to endure various environmental abuses. Documented burdens related to climate, air quality and toxic exposure have led to long-term and/or life-threatening illnesses and mortality, such as non-air-conditioned cells that reach 150 degrees Fahrenheit and nearby hazardous waste sites causing toxic air quality. While numerous cases of these environmental injustices towards prisoners have been exposed by journalists and activists, the examination of prisons as sites of environmental injustice is still understudied. Most prison facilities have not been scrutinized or evaluated for adverse environmental conditions and risks, likely given that prisoners are not often considered as environmental justice (EJ) communities, and these injustices are therefore commonly ignored by authorities. However, prisons are by definition EJ communities, as they are highly overrepresented by people of color, indigenous persons, and poor people, and recent work has highlighted that prisons are often subject to adverse environmental health threats, of which prisoners have no choice to endure.

We addressed these vital equity and environmental justice issues by leveraging Earth science data - including satellite, land cover, climate, and air quality datasets - in a novel way to characterize the environmental harms faced by prisoners across the U.S. The main outcomes of our project are 1) an assessment of environmental conditions at all state- and federally-operated prisons in the U.S. (*n = 1,865*), which includes producing an overall standardized vulnerability index and 11 individual environmental indicators for each prison, and 2) integration of this information with our extensive dataset and mapping platform on prison agriculture, which includes specific agricultural activities and their drivers (i.e., benefits to the prison system) for over 600 state-run prisons.

The variables and methodology used to calculate these environmental indicators and final vulnerability index were modeled after multiple established methods for measuring environmental risk. Our method consisted of averaging three component scores, namely climate risk (heat exposure, canopy cover, wildfire risk and flood hazard), environmental exposures (Ozone, PM 2.5, pesticide use, and traffic density) and environmental effects (proximity to superfund sites, risk management plan facilities, and hazardous waste facilities). The final product of this project is a GIS-enabled dataset with raw values and percentiles for each indicator, averaged component scores, and a final environmental vulnerability index tied to all state and federal prisons in the U.S. As a geospatial dataset, it can be easily added to EJ mapping platforms and will highlight the spatially differentiated types and levels of risk faced by prisoners across the country. We also developed an entirely reproducible code base to allow others to replicate our methods to carry out further analyses of other facilities such as jails and detention centers or to assess comparisons to non-prison communities. This novel, open-source dataset will allow for activists, researchers, policy makers, government agencies and beyond to become even more aware of prison environmental injustices and aid in informed decision-making to mitigate any unjust burdens faced by prisoners across the U.S.

# Project Summary

## Project Goals & Objectives

The United States has the highest incarceration rate in the world (Walmsley 2018), along with a highly inequitable incarceration system with disproportionate numbers of minorities and low-income individuals (Hayes and Barnhortst 2020). These inmates have also been forced to endure unjust environmental conditions, with documented abuses of climate extremes, unhealthy air quality, and toxic exposure incidents (McDaniel et al. 2014; Holt 2015; Pellow et al. 2018; Veit 2018). While the exposure of these cases by journalists, activists and researchers has been vital in heightening awareness of environmental injustices prisoners face, the examination of prisons as sites of environmental injustice is still relatively understudied (Opsal and Malin 2019). Most prison facilities across the U.S. have not been scrutinized or evaluated for adverse environmental conditions and risks, likely given that prisoners are not often considered as EJ communities (Pellow et al. 2017; 2018), and these injustices are therefore commonly ignored by authorities. This project defines to a fuller extent the environmental burdens faced by prisoners across the U.S. by leveraging Earth science data in combination with modern geospatial technologies to fill a vital gap in our knowledge of EEJ injustices forced upon prison communities. The extensive satellite and ancillary data products available today uniquely provide gridded datasets at high temporal and spatial resolutions that allow us to measure these environmental variables at the level of prison boundaries. The overarching objective of this project is to heighten awareness of these widespread EEJ issues and inform actionable steps to tackle injustices that deserve more attention and legal action than they have received thus far.

Specifically, our project objectives were to:

1. Quantify the environmental conditions at all state and federally run prisons in the U.S. (n = 1,865) using various Earth science datasets, toxic facility and potential pollution information, and geospatial analysis.
2. Calculate a standardized vulnerability index for each prison, creating a comparable metric of environmental risk faced by prisoners across the country that will result in geospatial data products.
3. Integrate this information with our extensive dataset and mapping platform on prison agriculture, which includes specific agriculture activities and their drivers (i.e., benefits to the prison system) for over 600 state-run prisons, to link racial capitalism of prison agriculture to environmental injustices.

Our goal by the end of this project was to produce an open-access geospatial dataset with calculated environmental indicators for all state and federal U.S. prisons, with reproducible open-access methods to promote application of these assessments to other institutions such as jails, juvenile detention centers, or any other spatial location to make comparisons with non-prison sites and communities.

## Executive Summary of Project Progression

We accomplished all our originally proposed goals, producing an open-access geospatial dataset with a total of 11 environmental indicators calculated for 1865 U.S. prisons. This consists of all active state- and federally-operated prisons according to the Homeland Infrastructure Foundation-Level Data (HIFLD), last updated June 2022. The final dataset includes both raw values and percentiles for each indicator. Percentiles denote a way to rank prisons among each other, where the number represents the percentage of prisons that are equal to or have a lower ranking than that prison. Higher percentile values indicate higher vulnerability to that specific environmental burden compared to all the other prisons. Full descriptions of how each indicator was calculated and the datasets used can be seen in Table 1.

From these raw indicator values and percentiles, we developed three individual component scores to summarize similar indicators, and to then create a single vulnerability index (methods based on other EJ screening tools such as Colorado Enviroscreen, CalEnviroScreen and EPA’s EJ Screen). The three component scores include climate vulnerability, environmental exposures and environmental effects. Climate vulnerability factors reflect climate change risks that have been associated with health impacts and includes flood risk, wildfire risk, heat exposure and canopy cover indicators. Environmental exposures reflect variables of different types of pollution people may come into contact with (but not a real-time exposure to pollution) and includes ozone, particulate matter (PM 2.5), traffic proximity and pesticide use. Environmental effects indicators are based on the proximity of toxic chemical facilities and includes proximity to risk management plan (RMP) facilities, National Priority List (NPL)/Superfund facilities, and hazardous waste facilities. Component scores were calculated by taking the geometric mean of the indicator percentiles. Using the geometric mean was most appropriate for our dataset since many values may be related (e.g., canopy cover and temperature are known to be correlated).

To calculate a final, standardized vulnerability score to compare overall environmental burdens at prisons across the U.S., we took the average of each component score and then converted those values to a percentile rank. While this index only compares environmental burdens among prisons and is not comparable to non-prison sites/communities, it will be able to heighten awareness of prisons most vulnerable to negative environmental impacts at county, state and national scales. As an open-access dataset it also provides new opportunities for other researchers, journalists, activists, government officials and others to further analyze the data for their needs and make comparisons between prisons and other communities. This is made even easier as we produced the methodology for this project as an open-source code base so that others can apply the code to calculate individual indicators for any spatial boundaries of interest. Links to the full dataset (hosted on Zenodo) and code base are included in the Appendix of this report.

While the main objective of this project was to produce this novel open-access dataset and code base to further efforts related to prison environmental injustice, we can report some summary findings of the data set. Figure 1 shows the spatial distribution of environmental burdens characterized within each component (climate risk, environmental exposures, and environmental effects) and the overall environmental vulnerability score. In the maps you can see the spatial distribution of environmental burdens at U.S. prisons varies by components and the vulnerability score. Overall, of the top 100 prisons according to the vulnerability score, 37% of them are in California (which only constitutes 6% of the nation’s state and federal prisons), and of the top 50, 30 of them are in California. When looking at the individual components, in terms of climate risk, 58% of the top 100 are in California, Florida and Arizona. For environmental exposure variables, California (36%), Michigan (12%) and Wisconsin (12%) make up 60% of the top 100 highest exposure scores. Finally, for environmental effects, of the top 100 highest risk scores, 16% are in Maryland and 10% in Florida. These overarching summaries and the differences in spatial distribution based on components show the importance of not only looking at a summarized metric of environmental burden, but also investigating the individual burdens driving those high scores, which our dataset easily allows for.

**Figure 1.** Maps showing the spatial distribution of the three components and the overall vulnerability score at all 1865 prisons assessed in this study, where larger points (located at the prison boundary centroid) represent higher environmental risk, displayed transparently such that darker colors signify overlapping prisons in that area.

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**Table 1.** Summary of each indicator calculated, the component it is grouped with, the linked data source, indicator description, time frame of the dataset or the last date it was updated, and the spatial resolution (if raster) or type of spatial layer (if vector).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Indicator | Component | Data Source | Indicator Description | Time frame / last updated | Spatial Resolution / type |
| Heat Exposure | Climate Risk | [MODIS daily land surface temperature](https://developers.google.com/earth-engine/datasets/catalog/MODIS_061_MYD11A1#description) | Mean daily LST for summer months (June-August) from the last 10 years (2013-2023) averaged within prison boundaries. | 2013 - 2023 | 1 km |
| Canopy Cover | [USGS National Land Cover Database](https://developers.google.com/earth-engine/datasets/catalog/USGS_NLCD_RELEASES_2016_REL) | Average percent canopy cover within prison boundaries + 1km buffer. | 2016 | 30 m |
| Wildfire Risk | [Wildfire Hazard Potential for the United States](https://www.fs.usda.gov/rds/archive/catalog/RDS-2015-0047-3) | Mean wildfire hazard potential within prison boundary + 1km buffer. | 2020 | 270 m |
| Flood Risk | [FEMA National Flood Hazard Layer](https://www.fema.gov/flood-maps/national-flood-hazard-layer) | Percentage of each prison boundary + 1km buffer that is covered by a high risk flood zone (Zones A and Z; at least a one percent chance of flooding annually). | August 2021 | Polygon features |
| Ozone | Environmental Exposures | [SEDAC Annual O3 Concentrations for CONUS](https://sedac.ciesin.columbia.edu/data/set/aqdh-o3-concentrations-contiguous-us-1-km-2000-2016) | Average annual ozone levels for 2015 and 2016 within prison boundaries + 1km buffer. | 2015 - 2016 | 1 km |
| PM 2.5 | [SEDAC Annual PM2.5 Concentrations for CONUS](https://sedac.ciesin.columbia.edu/data/set/aqdh-pm2-5-concentrations-contiguous-us-1-km-2000-2016) | Average annual PM2.5 levels for 2015 and 2016 within prison boundaries + 1km buffer. | 2015 - 2016 | 1 km |
| Traffic Volume and Proximity | [FHA’s Annual Average Daily Traffic](https://www.fhwa.dot.gov/policyinformation/hpms/shapefiles.cfm) | Count of vehicles (AADT, avg. annual daily traffic) at major roads within 500 meters, divided by distance in meters. | 2018 | Line features |
| Pesticide Use | [SEDAC Global Pesticide Grids](https://sedac.ciesin.columbia.edu/data/set/ferman-v1-pest-chemgrids-v1-01) | The total pesticide application from 2015 in kg/ha\*yr averaged over prison boundaries + 1km buffer. | 2015 | ~ 10 km (5 arc-minute) |
| Risk Management Plan (RMP) Facility Proximity | Environmental Effects | [EPA](https://cumulis.epa.gov/supercpad/CurSites/srchsites.cfm)  | Count of Risk Management Plan (potential chemical accident management plan) facilities within 5km (or nearest one beyond 5km) each divided by the distance in km. | May 2023 | Point features |
| Superfund/National Priorities List (NPL) Site Proximity | [HIFLD EPA ER Risk Management Plan Facilities](https://hifld-geoplatform.opendata.arcgis.com/datasets/geoplatform%3A%3Aepa-emergency-response-er-risk-management-plan-rmp-facilities/explore?location=29.842034%2C-113.806709%2C3.92) | Count of proposed and listed NPL facilities within 5km (or nearest one beyond 5km) each divided by the distance in km. | October 2022 | Point features |
| Hazardous Waste Facility Proximity | [EPA FRS geospatial download](https://www.epa.gov/frs/geospatial-data-download-service) | Count of hazardous waste facilities within 5km of prison boundary (or nearest beyond 5km) each divided by distance in km. | March 2023 | Point features |

# Activities & Outcomes

## Project Advancements

This project involved three main milestones: 1) dataset selection, retrieval, and processing, 2) indicator and index calculation and 3) code and data sharing.

We included all indicators originally proposed, but after thorough dataset search, we selected various new data sources that were the best fit based on the scale of our study (e.g., temporal and spatial resolution). We also focused on selecting the most up-to-date datasets. With a reproducible workflow in mind, when possible we used datasets that could be retrieved programmatically such as those with an ArcGIS REST URL, those hosted on Google Earth Engine, and other datasets accessible via an API. Due to the national extent of our project (including Alaska and Hawaii), many of the required datasets were very large in size (e.g., multiple GBs), and therefore users wanting to replicate our workflow will need to have sufficient infrastructure for data storage. Exploration and selection of datasets was an iterative process throughout this project. We chose final datasets that maximize temporal resolution, spatial resolution, and spatial coverage (to be inclusive of AK and HI), while also having to consider data size and complexity of processing and analysis due to the scope and time frame of this project. All data sources are U.S. government agencies, including NASA, USGS, USFS, EPA, FEMA, and FHA. Full data metadata and links to data sources can be found in Table 1.

While developing the code base to retrieve, clean and process all datasets, we used a mix of programming languages based on data source. Most of the code is written in R, however for datasets retrieved from Google Earth Engine (MODIS land surface temperature and NLCD canopy cover) we used Python due to easier use with its GEE API over R. Each indicator has its own R function (apart from heat exposure and canopy cover, which are standalone Python scripts). A vital aspect of our work is that the codebase can perform all calculations on any spatial boundary, not just prison boundaries. This greatly expands the impact of our work and increases the accessibility of the workflow to others wishing to carry out similar calculations and/or build off our investigation of prison environmental injustice. The code base is published via GitHub/Zenodo with an open-access MIT license and a citable DOI.

In addition to publishing a reproducible workflow for our methods, we also published our final dataset freely available to download via Zenodo (link here) in both table (.csv) and spatial (.shp) formats. As an open-access dataset others can analyze, visualize, and incorporate this data into their own research and mapping platforms. We also integrated this dataset into the CSU Prison Agriculture Lab’s mapping platform for prison agriculture data, to provide an environmental context to prison agriculture labor statistics and other demographics. The final mapping platform is still under construction but soon it will be available to the public at this link: <https://prisonagriculture.com/arcgis-map/>. Due to the time frame of this project, we were not able to submit any publications before project closeout, however we have one publication in preparation that will be submitted to an open-source journal in the next few months.

## Community Engagement Activities

Community engagement activities related to this project mostly include presenting the work at scientific conferences and events. In March 2023 Co-I Chennault presented this work at the American Association for Geographers (AAG) meeting in a session titled “Incarceration and Climate Change”. In October 2022 PI Mothes presented a lightning talk on this work at Google’s Geo for Good Summit. This dataset will also be used in an educational context, as Co-I Chennault plans to use it in her Human-Environment Geographies course taught at Colorado State University.

## Calendar of Milestones Achieved

|  |  |
| --- | --- |
| **Milestone** | **Date Achieved** |
| Indicator and data source search and selection\* | 12 / 2022 |
| Develop codebase to retrieve and process datasets | 02 / 2023 |
| Calculate environmental vulnerability index for all prisons | 05 / 2023 |
| Final code review, data set and code base publication | 08 / 2023 |

\*While the initial search efforts finished in December 2022, data source search was an iterative process as we became aware of better data sources in some cases.

## ARL Reporting (for data integration projects only)

N/A

# Inclusion Plan Narrative

## Metrics Tracked

Our inclusion plan activities and metrics tracked include:

1. The proportion of staff and students within the Geospatial Centroid that identify with an underrepresented group (goal of 25-50%, never below 25%).
2. Implement regular reflective activities to maintain an inclusive environment. This includes soliciting an anonymous survey to student interns every semester regarding workplace environment and inclusivity, along with implementing quarterly DEI meetings with staff to discuss student surveys and other DEI-related topics to create a list of DEI actionable steps.
3. Designate a DEI coordinator, preferably a student intern that will be paid for their efforts and gain valuable leadership experience. This coordinator will ensure that our group keeps up with DEI goals and initiatives and will attend DEI staff meetings.

## Progress Narrative

Regarding the first metric, currently within the Geospatial Centroid ~40% of our team consists of staff and students from underrepresented groups, and we strive to increase that number and the involvement of minority groups in the geospatial sciences. The hiring process for the student research assistant for this project led our group to deeply reflect on our strategy for advertising open positions, given the limited number of applications, and have compiled a list of more resources and listservs we should share open positions with. We have focused this list on resources that will reach a wider audience of people from underrepresented groups. Regarding this, PI Mothes is in the process of establishing an R Ladies chapter in Fort Collins to build a local community of women+ in tech. Within these meetups Mothes plans to focus some sessions on the job application process, educating others on relevant job boards, give resume advice, and help spread confidence of participant’s applicability to jobs of interest.

In relation to the second metric, our group has implemented anonymous student surveys every semester since 2015, which ask questions regarding their satisfaction working with the Geospatial Centroid and specific aspects they enjoyed and recommendations for ways to improve the student experience. As a part of this inclusion plan, we reflected on all previous responses, particularly those related to the workplace environment. We were happy to find all positive responses when workplace environment was mentioned, however realized we do not specifically ask questions regarding inclusivity and accessibility aspects of their experience. We have implemented more DEI-specific questions for future student surveys. Additionally, within the Geospatial Centroid specifically we were unsuccessful in setting up regular DEI staff meetings and recognize that as a priority. However, the Geospatial Centroid is a unit with the CSU Libraries, which has recently implemented an Equity and Social Justice Advisory Group (ESJAG) charged with advocating DEI within Libraries employees and identifying, recommending and carrying out DEI-related initiatives. For example, this past semester they have implemented “ESJAG tool of the month”, where all staff meet to discuss some “tool” to help us improve inclusivity within the workplace and beyond.

Finally, we were unable to hire a student or pay a current student intern to take on DEI coordinator duties. We are limited to project-specific funds, such that there are only enough funds to pay students on specific project tasks from clients, and we do not want to request supplemental work from a student without being paid for their efforts. However, in an effort to hire students to take on non-project specific tasks, starting this semester we have received funding for two interns per semester that are not tied to client/partner-specific tasks. We are very excited about this opportunity which will allow us to pay interns to carry out DEI activities and gain valuable leadership experience. As a final reflection, we plan to take funding for DEI work into account when putting together proposal budgets.

# Budget Narrative

## Year’s Costing

Caitlin Mothes – PI (6 months). Led project implementation and was responsible for overall management of team members, including the mentorship and training for the hired student research assistant. Specific to the proposed work, Dr. Mothes performed the majority of the tasks related to data processing, environmental vulnerability index calculation, metadata and code documentation, and publication of open-access code base and dataset.

Carrie Chennault – Co-I (0.5 months). Dr. Chennault is an expert in social and environmental justice, having particular experience with prison injustices as the co-director of the CSU Prison Agriculture lab. Dr. Chennault provided vital conceptual advice throughout project development and implementation, guided the usage and integration of the data products to the existing prison agriculture dataset, and is leading manuscript preparation and publication.

Dan Carver – Co-I (1.72 months). Provided consultation on the data inputs and indicator selection and assisted with methodology, having relevant experience from leading the Colorado Enviroscreen risk calculation and tool development. Also aided in mentorship of student research assistant.

OTHER PERSONNEL

Devin Hunt, Student Research Assistant (200 hours). Assisted with data input search, compiling metadata and source information for each dataset, file management, data processing and code documentation.

Josh Reyling, Research Assistant (40 hours). Led the task of publishing the final data set on an ArcGIS Online mapping platform to provide environmental context to prison agriculture data for 600 prisons across the U.S. This will allow users to interact with our data while also viewing it in the context of prison agriculture labor across the U.S. and other prison demographic information.

## Adjustments Made (if applicable)

One adjustment made was related to the original other direct cost of $2,000 for publication charges. Due to the short time frame of this project, we were not able to submit and get a manuscript published in time. We also plan to publish in an open-access journal without publication fees, so these funds will not be needed. Therefore, we thought these funds would be best spent instead on staff hours to publish the data on the CSU Prison Agriculture Lab’s online mapping platform. This way the data will have direct impacts on related research and prison injustice efforts and will allow users to explore it interactively. We still have a manuscript in preparation regarding this work that we plan to submit within the coming months. Also to note, since this adjustment involved less than 10% of the total budget it was approved internally.

We also hired a single student research assistant that continued to work on this project for the entirety of the 9 months, as opposed to hiring two student research assistants. This was beneficial due to the short time frame of this project to keep on the same student that was familiar with the project and the workflow.

# Appendix

## Communications: Publications

Code base for our entire workflow is published with GitHub/Zenodo with an MIT open-access license and a citable DOI. The Zenodo link is here: <https://zenodo.org/record/8306856> and the GitHub repository is here: <https://github.com/GeospatialCentroid/NASA-prison-EJ>.

The final dataset is published for open-access use on Zenodo and can be downloaded here: <https://zenodo.org/record/8306892> .

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