

Human Well-Being, Equity, and Nature-Based Solutions: Assessing Opportunities for Engineering with Nature® Project Planning and Implementation

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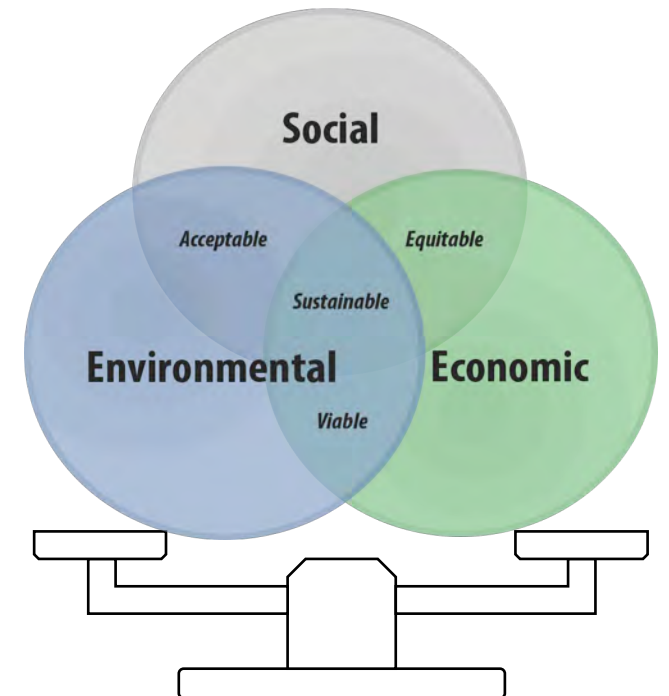
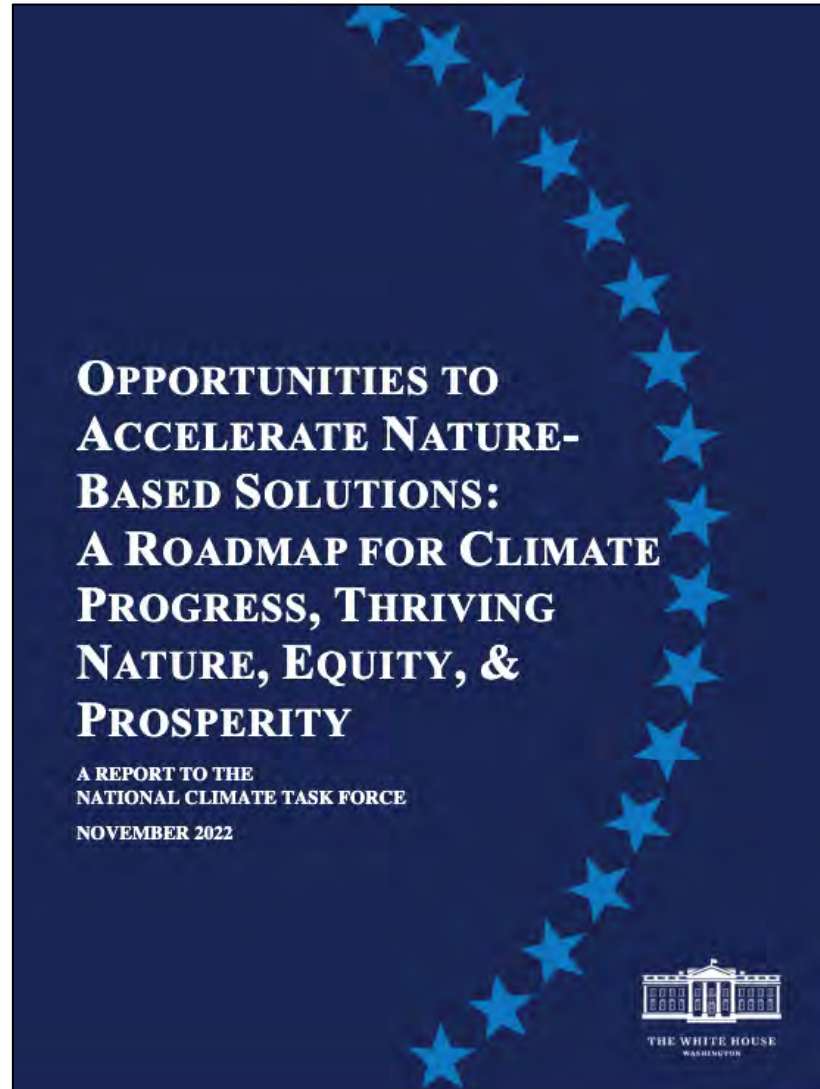
³ US Army Engineer Research & Development Center (ERDC) | Coastal and Hydraulics Lab

Stone Living Lab 2023 Conference
April 27th, 2023



Project Exigency

- Large demand for nature-based solutions (NBS) BUT lack of methods to account for NBS co-benefits thwarts efforts to scale up



Project Exigency

- Federal directives to comprehensively account for project benefits in decision-making

“Social effects...refers to how the constituents of life that influence personal and group definitions of satisfaction, well-being, and happiness are affected by some condition or proposed intervention.”

Other Social Effects

- Health & Safety
- Economic Vitality
- Social Connectedness
 - Identity
- Social Vulnerability & Resilience
 - Participation
- Leisure & Recreation

Institute for
Water Resources

April 2013

Applying Other Social Effects
In Alternatives Analysis

2013-R-03



IWR

www.iwr.usace.army.mil

“...equally across a full array of benefit categories...even if non-monetary measures are used, these benefits and impacts must be accounted for in the most substantive way possible.”

USACE Policy Directive (Comprehensive Documentation of Benefits)



DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

SACW

5 January 2021

MEMORANDUM FOR COMMANDING GENERAL, U.S. ARMY CORPS OF ENGINEERS

SUBJECT: POLICY DIRECTIVE – Comprehensive Documentation of Benefits in Decision Document

1. **Purpose.** This memorandum issues policy direction on the comprehensive assessment and documentation of benefits in the conduct of U.S. Army Corps of Engineers (USACE) water resources development project planning. This policy updates current procedures, and emphasizes and expands upon policies and guidance to ensure the USACE decision framework considers, in a comprehensive manner, the total benefits of project alternatives, including equal consideration of economic, environmental and social categories. This directive pertains to pre- and post-authorization decision documents (reports), as well as other decision documents approved under delegated authorities. In addition, the directive may be applied to benefit-cost analyses required to support budgetary decision-making processes. As stated in my 15 July 2020 memorandum to the Deputy Commanding General for Civil and Emergency Operations, one of my highest priorities is to ensure this policy directive is implemented as soon as practicable.

Objectives

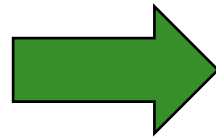
- Investigate the relationship between human well-being & nature
 - What evidence exists?*
 - What does it mean for NBS?*
- Use understanding of that relationship to develop decision-support products for well-being benefits accounting & equitable distribution of NBS projects

Approach



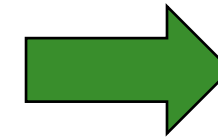
Literature Review

- Well-being benefits of having access to nature
- Methods for accounting for well-being benefits



Geospatial Investigation

- Socioeconomic/demographic characteristics of communities surrounding EWN projects
- Impacts of adding/removing EWN projects to health/well-being of communities



**Benefits
Accounting
Method**

Literature Review

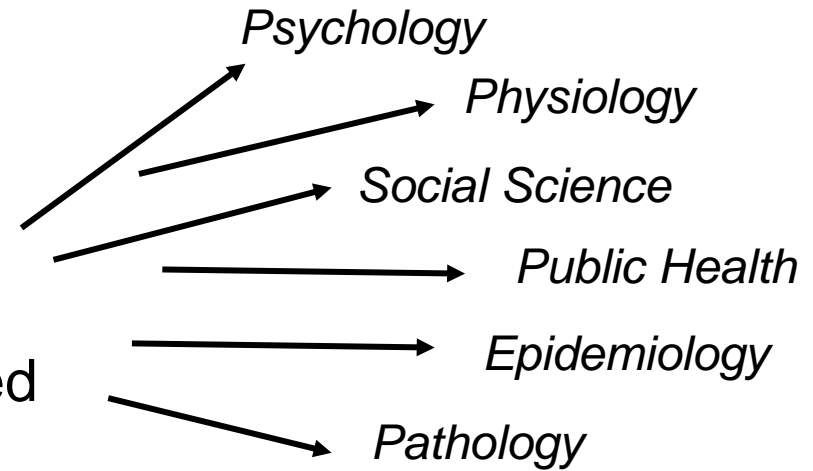


- 1) What well-being benefits of having access and being exposed to nature have been documented?
- 2) What methods and approaches currently exist to measure/account for well-being benefits and the contribution from nature?
- 3) How can those benefits inform the planning and design of NBS projects?

The image shows the cover of a report. On the left, a red vertical bar contains the text 'ERDC/EL TR-YY-DRAFT' in white. The main cover area is white with a faint background image of a city skyline. At the top left is the US Army Corps of Engineers logo (a red shield with a white castle). To its right is the ERDC logo, which consists of a colorful circular graphic and the text 'ERDC ENGINEER RESEARCH & DEVELOPMENT CENTER'. Below the logos, the text reads 'US Army Corps of Engineers® Engineer Research and Development Center'. Further down, it says 'Engineering with Nature® Program'. The main title is 'Reviewing the Well-being Benefits of Nature: Opportunities for Engineering with Nature® Project Planning and Implementation'. Below the title, the authors are listed: 'Ellis H. Kalaidjian, Margaret H. Kurth, Stephanie E. Galaitsi, and Elissa M. Yeates'. The date 'March 2023' is in the bottom right corner. At the very bottom of the cover is a blue horizontal bar with a white cloud pattern.

Literature Review

- ~170 papers – academic articles & grey literature
- Selection of papers & scope of review largely based on other meta-analyses



Not all studies reviewed target well-being directly

- Many focused on components of well-being (e.g., aspects of health, cognitive functioning, physiological and psychological responses, and others)

Many types of nature in which human well-being is studied

- Indoor spaces (e.g., homes or public buildings with indoor plants or window views of nature)
- Urbanized public green spaces
- Remote wilderness settings removed from human influence (e.g., national parks)
- More

Literature Review

- 18 total benefits identified
- Many nuances

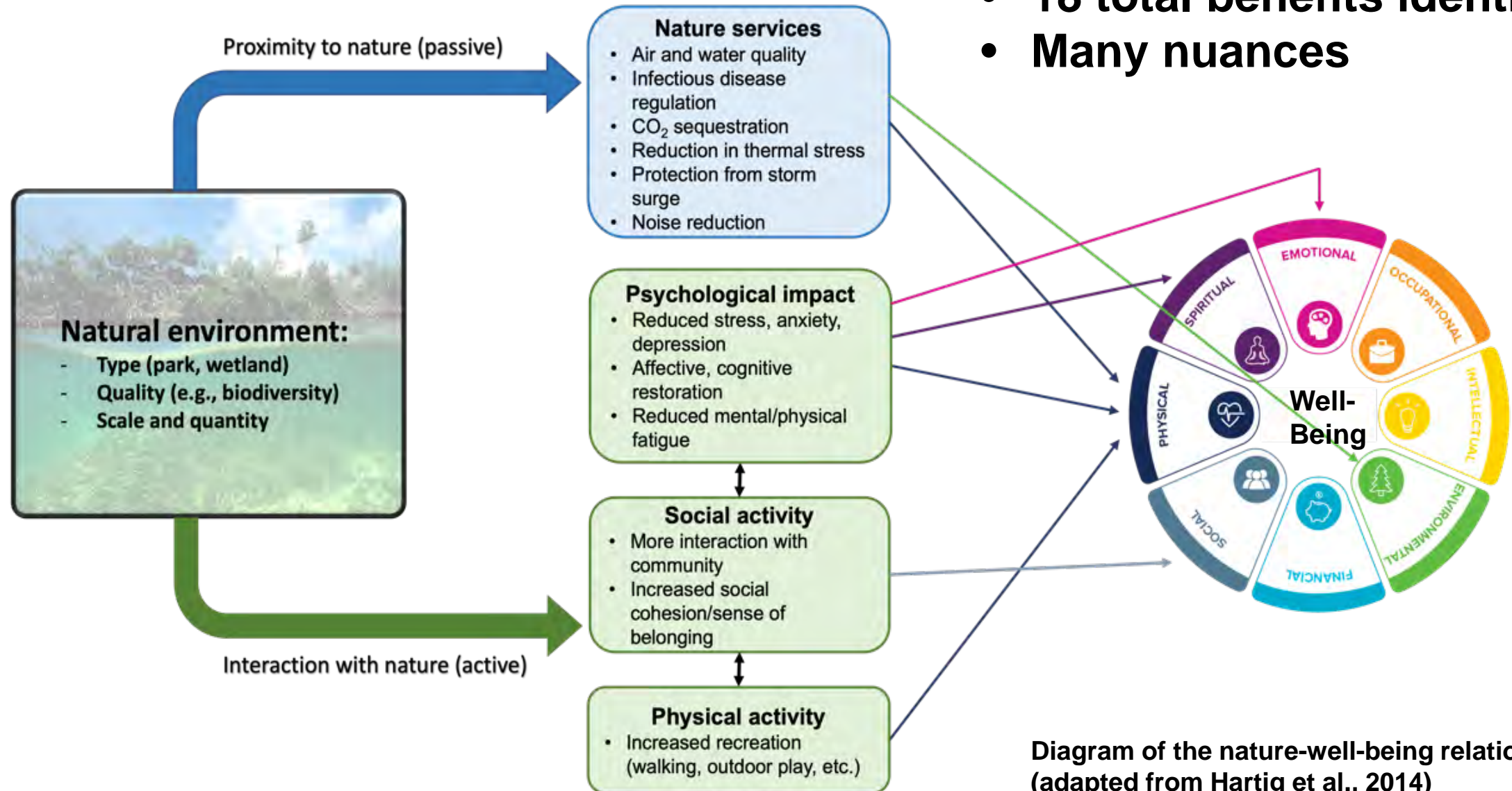


Diagram of the nature-well-being relationship (adapted from Hartig et al., 2014)

Literature Review

Well-being Focused Design Considerations

Proximity – passive regulating benefits are local; ease of getting nature “dose” and recommended physical activity

Publicly accessible – routes to; mobility constraints; mentors

Type and size – different people benefits from different nature

Amenities – trails, benches, sports fields, gardening

Safety – elements that build confidence that space is safe

Quality and maintenance – important for perception and safety

Distribution – site selection can improve equity/ nature-deficit

Designs that maximize well-being are those that people say are good for their well-being.

Geospatial Investigation

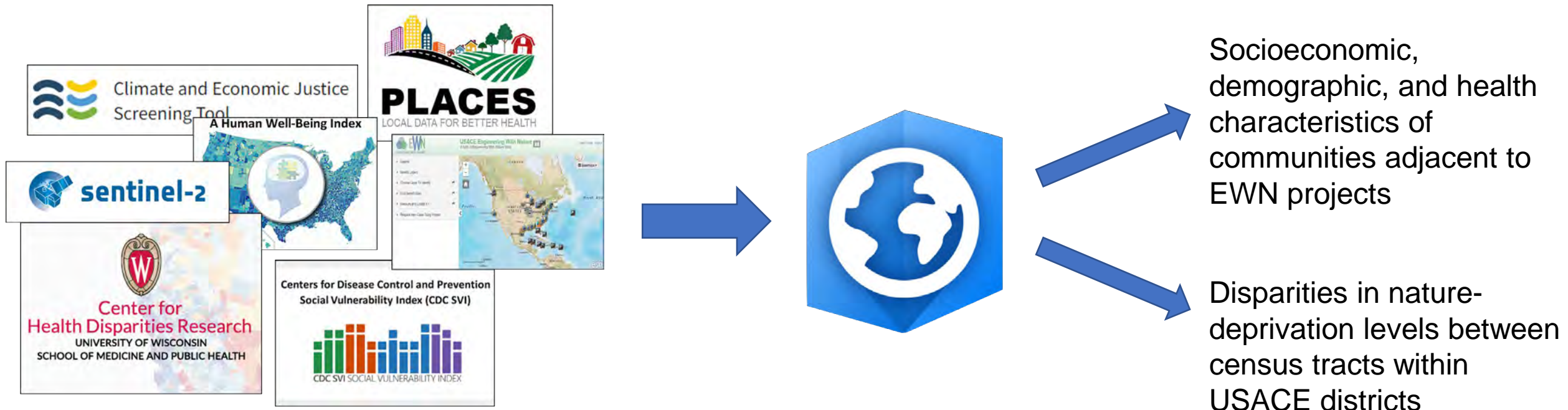
Objective: Use social factors, such as human well-being and health, to prioritize locations for EWN projects and promote equitable distribution of nature benefits

Research Questions:

- 1) How are EWN projects distributed across the country / within USACE districts? Which communities benefit? Which are left out?
- 2) What variables (e.g., socioeconomic status) are controlling any observed spatial relationships?

Geospatial Investigation

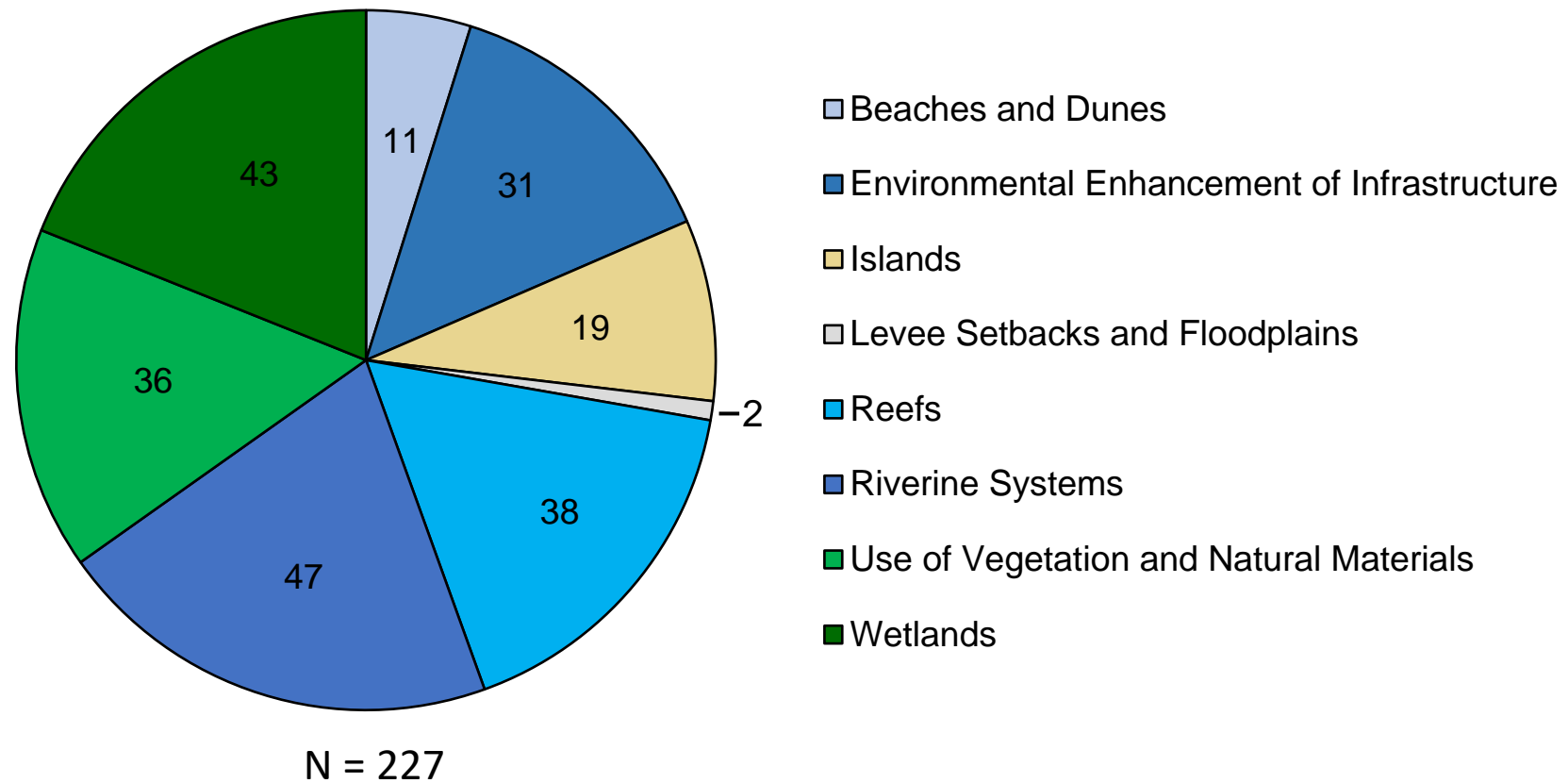
Task 1: Explore characteristics of communities living adjacent to EWN projects



Geospatial Investigation



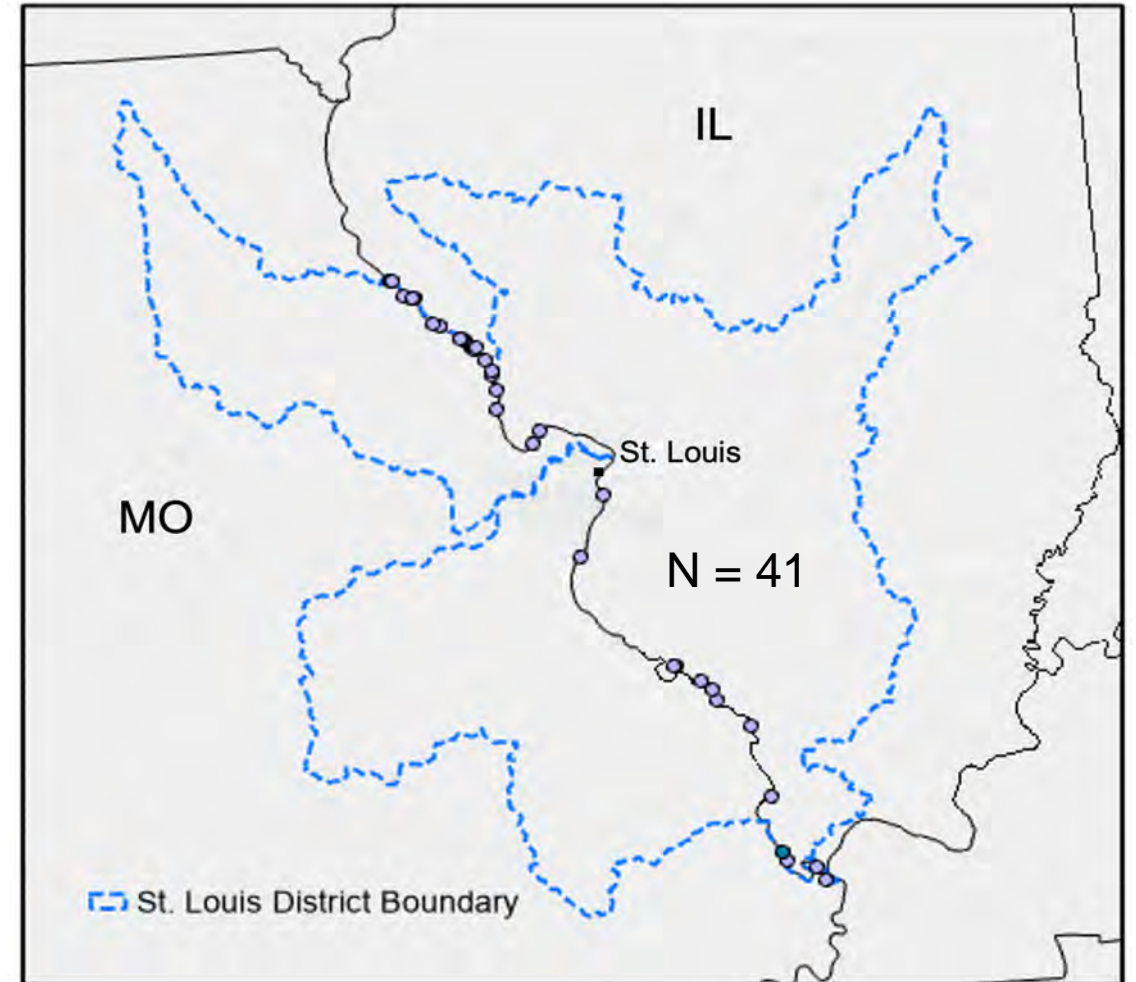
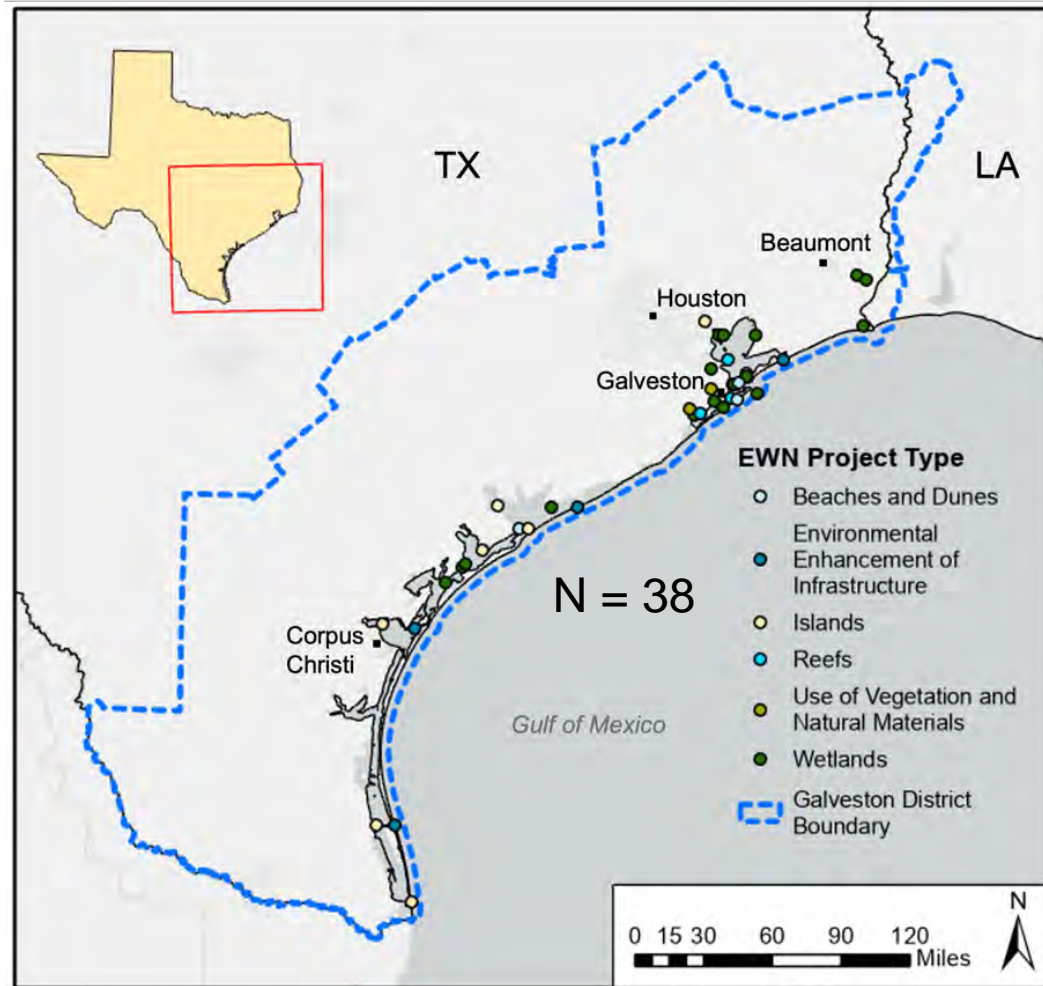
EWN Project Types in CONUS



N = 227

Geospatial Investigation

Clustering in Galveston and St. Louis Districts



Geospatial Investigation

Demographic, Socioeconomic, and Health Characteristics
of all US Census Tracts Containing EWN Projects

Geospatial Investigation



Demographic composition & socioeconomic status

Metric*	N	Minimum	Maximum	Mean	Std. Deviation	Median	Mode
Percent of tract population below 150% poverty	127	0	56.1	19.2	12.3	16.0	0
Percent of tract population (≥16yrs) that is unemployed	127	0	29.1	4.7	4.2	3.9	0
Percent of tract population belonging to housing cost-burdened occupied housing units with annual income less than \$75,000	127	0	59.1	22.2	10.9	20.9	0
Percent of tract population (≥25yrs) with no high school diploma	127	0	51.8	10.5	8.5	8.8	0
Percent of tract population that is uninsured within the total civilian noninstitutionalized population estimate	127	0	34.3	8.1	6.0	7.4	0
Percent of tract population aged 65 years and older	127	0	48.5	21.2	10.4	19.7	0
Percent of tract population aged 17 years and younger	127	0	35.8	17.9	8.6	19.3	0
Percent of tract population with a disability	127	0	30.3	14.4	6.6	14.5	0
Percent of tract population belonging to a single-parent household with children under 18	127	0	20.6	5.1	4.4	4.3	0
Percent of tract population (≥5yrs) who speak English "less than well"	127	0	26.5	1.7	3.8	0.0	0
Percent of tract population belonging to a minority group**	127	0	90.3	23.8	22.5	16.0	0
Percent of tract population inhabiting housing in structures with 10 or more units	127	0	96.9	8.2	18.5	0.5	0
Percent of tract population inhabiting mobile homes estimate	127	0	66.8	10.1	12.2	7.0	0
Percent of tract population occupying housing units with more people than rooms	127	0	19.8	1.9	3.2	1.0	0
Percent of tract population belonging to households with no vehicle available	127	0	38.1	5.6	7.0	3.1	0
Percent of tract population inhabiting group quarters	127	0	83.3	3.0	8.8	0.1	0
Overall SVI Score (0 - 1)	127	0	0.99	0.4	0.3	0.4	0

*All metrics are 2016-2020 ACS estimates
 **(Hispanic or Latino (of any race); Black and African American, Not Hispanic or Latino; American Indian and Alaska Native, Not Hispanic or Latino; Asian, Not Hispanic or Latino; Native Hawaiian and Other Pacific Islander, Not Hispanic or Latino; Two or More Races, Not Hispanic or Latino; Other Races, Not Hispanic or Latino)

Source: CDC/ATSDR SVI20

- On average, small proportions of communities adjacent to EWN projects are of lower socioeconomic status or belong to more at risk demographic groups (e.g., minority group, elderly, etc.)
- Medium-low social vulnerability

Geospatial Investigation



Health status

Health Metric	N	Minimum	Maximum	Mean	Std. Deviation	Median	Mode
Percent of tract population (≥18yrs) with arthritis	122	14.8	38	26.8	5.1	26.9	24.2
Percent of tract population (≥18yrs) with high blood pressure	122	0	48.3	34.7	7.6	35	32
Percent of tract population (≥18yrs) with cancer (excluding skin cancer)	122	3.7	11.9	7.0	1.5	7	7.4
Percent of tract population (≥18yrs) with asthma	122	7.6	13.1	9.5	1.1	9.3	9.3
Percent of tract population (≥18yrs) with coronary heart disease	122	3.4	10.4	7.0	1.6	6.9	8.1
Percent of tract population (≥18yrs) with chronic obstructive pulmonary disease	122	3.5	12.1	7.4	2.0	7.3	5.9
Percent of tract population (≥18yrs) diagnosed with depression	122	12.1	30.8	21.0	3.3	20.7	23.8
Percent of tract population (≥18yrs) diagnosed with diabetes	122	5.3	19.2	11.2	2.8	10.7	11.8
Percent of tract population (≥18yrs) of fair or poor health	122	6.8	28.2	15.5	4.7	14.8	18.1
Percent of tract population (≥18yrs) with chronic kidney disease	122	1.9	5	3.1	0.6	2.9	2.6
Percent of tract population (≥18yrs) that experienced poor mental health for ≥14 days	122	9.4	19.7	14.4	2.1	14	13.9
Percent of tract population (≥18yrs) that is obese	122	17.4	48.6	33.8	5.8	33.6	35.3
Percent of tract population (≥18yrs) that experienced poor physical health for ≥14 days	122	6.5	16.7	10.9	2.3	10.7	11.9
Percent of tract population (≥18yrs) that have had a stroke	122	1.7	6.2	3.4	0.9	3.2	2.6

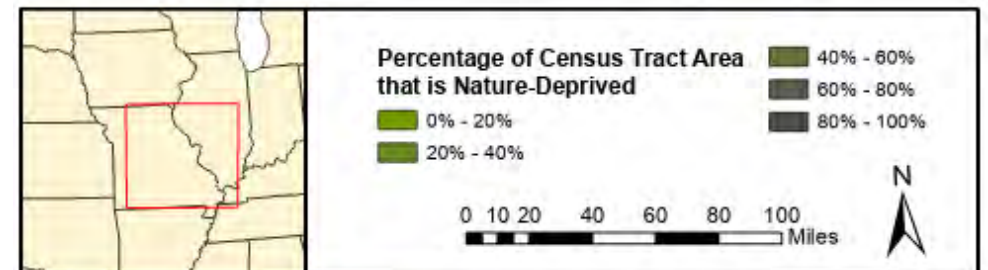
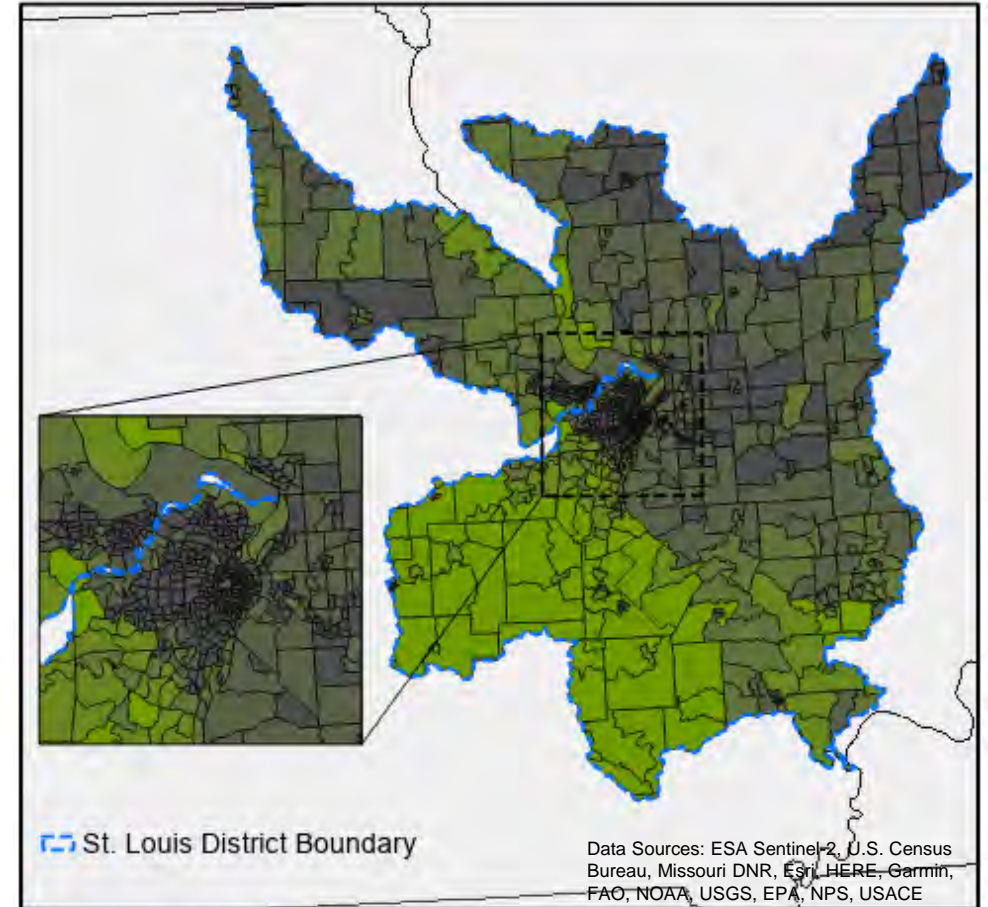
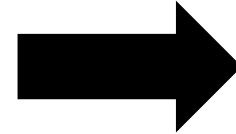
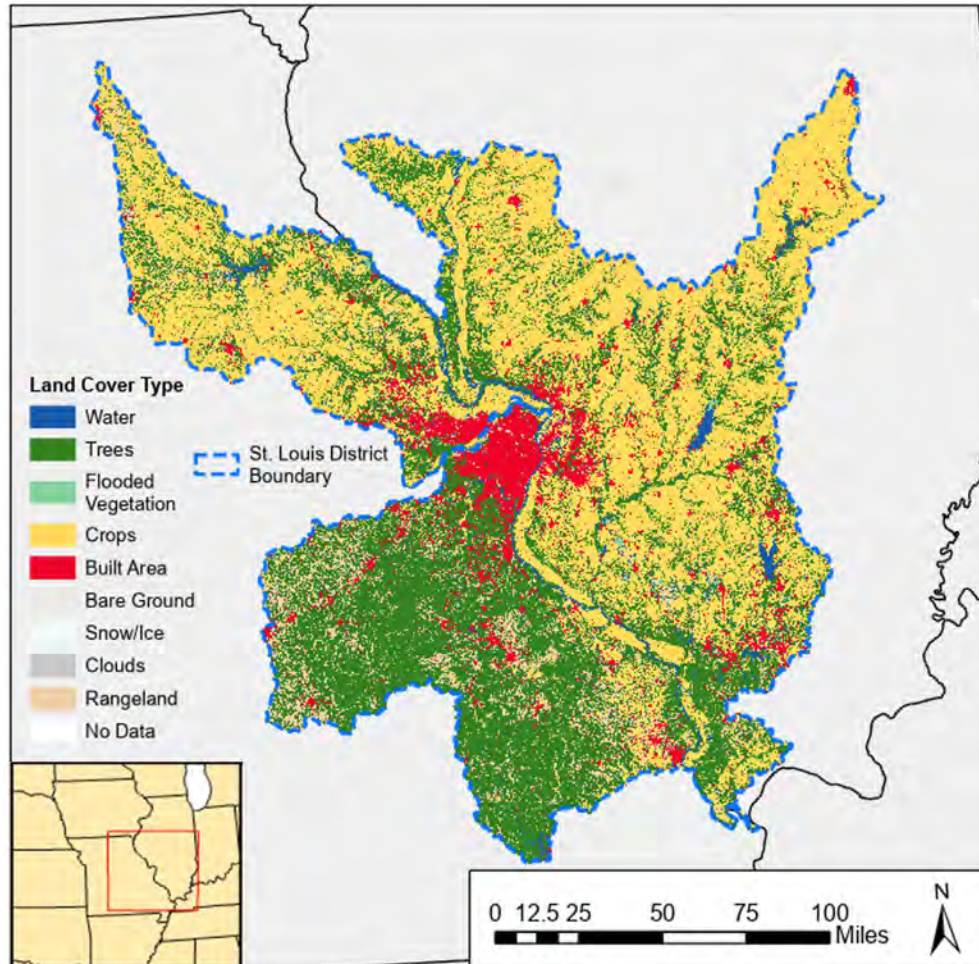
Source: CDC PLACES (2022)

- Overall, lower proportions of communities adjacent to EWN projects experience health complications, though high blood pressure & obesity are present in about a third of tract populations on average

Geospatial Investigation



Nature deprivation = (Sum of cells in census tract classified as crops and built area) / Total number of cells



Next Steps

1. Determine best proxies for well-being by establishing statistical relationships
2. Means comparison tests

Preliminary insights:

- Social vulnerability (SVI) of US census tracts containing EWN (avg 0.4; med-low) significantly lower than national SVI (avg 0.5; medium)

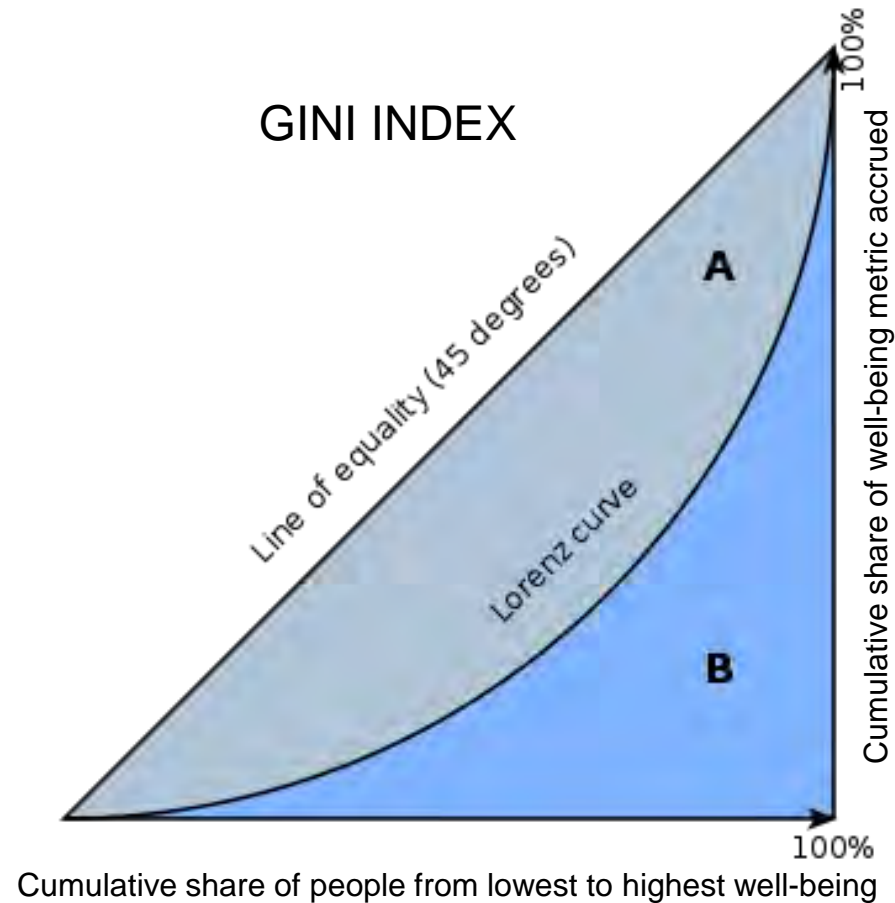
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	8.84	3	2.95	34.72	2.04027E-22	2.61
Within Groups	7449.29	87736	0.08			
Total	7458.14	87739				

POST-HOC		
Groups	P-value (T-test)	Significant?
SVI_allEwn vs. SVI_CONUS	0.001064633	Yes
SVI_GalvDist vs. SVI_CONUS	1.34608E-18	Yes
SVI_SLDist vs. SVI_CONUS	0.000153895	Yes
SVI_allEWN vs. SVI_GalvDist	4.34289E-07	Yes
SVI_allEWN vs. SVI_SLDIST	0.053518237	No
SVI_SLDist vs. SVI_GalvDist	1.28591E-15	Yes

- No significant differences between SVI of tracts within districts that contain EWN and entire district tract populations

Next Steps

3. Evaluate impacts of adding/removing an EWN project to the health and well-being of surrounding communities



Acknowledgements

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Geospatial Investigation

Health, Demographic, and Socioeconomic Characteristics of Galveston District Census Tracts



Geospatial Investigation



Demographic composition & socioeconomic status

Metric*	N	Minimum	Maximum	Mean	Std. Deviation	Median	Mode
Percent of tract population below 150% poverty	2443	0	93.9	27.6	17.8	25.1	0
Percent of tract population (≥16yrs) that is unemployed	2443	0	53.4	6.2	5.0	5.2	0
Percent of tract population belonging to housing cost-burdened occupied housing units with annual income less than \$75,000	2443	0	75.4	27.8	13.1	26.3	0
Percent of tract population (≥25yrs) with no high school diploma	2443	0	86.9	19.2	15.5	15.5	0
Percent of tract population that is uninsured within the total civilian noninstitutionalized population estimate	2443	0	70.1	20.0	12.3	18.5	0
Percent of tract population aged 65 years and older	2443	0	100.0	12.9	7.6	12.0	12.1
Percent of tract population aged 17 years and younger	2443	0	57.7	25.6	8.2	25.9	0
Percent of tract population with a disability	2443	0	56.3	11.6	6.2	10.6	9.4
Percent of tract population belonging to a single-parent household with children under 18	2443	0	48.5	8.5	6.8	7.2	0
Percent of tract population (≥5yrs) who speak English "less than well"	2443	0	59.0	9.3	10.4	5.1	0
Percent of tract population belonging to a minority group**	2443	0	100.0	65.7	28.3	71.6	100
Percent of tract population inhabiting housing in structures with 10 or more units	2443	0	100.0	15.6	22.1	4.6	0
Percent of tract population inhabiting mobile homes estimate	2443	0	95.5	7.6	12.6	0.9	0
Percent of tract population occupying housing units with more people than rooms	2443	0	49.4	6.1	6.7	4.1	0
Percent of tract population belonging to households with no vehicle available	2443	0	50.3	6.0	6.7	3.8	0
Percent of tract population inhabiting group quarters	2443	0	100.0	1.7	8.6	0.0	0
Overall SVI Score (0 - 1)	2443	0	1.0	0.5	0.3	0.6	0

*All metrics are 2016-2020 ACS estimates

** (Hispanic or Latino (of any race); Black and African American, Not Hispanic or Latino; American Indian and Alaska Native, Not Hispanic or Latino; Asian, Not Hispanic or Latino; Native Hawaiian and Other Pacific Islander, Not Hispanic or Latino; Two or More Races, Not Hispanic or Latino; Other Races, Not Hispanic or Latino)

Source: CDC/ATSDR SVI20

- High percentage of Galveston District CT populations that belongs to a minority group on average
- To a lesser extent, Galv District communities are of lesser financial means
- Medium Social Vulnerability

Geospatial Investigation



Health status

Health Metric	N	Minimum	Maximum	Mean	Std. Deviation	Median	Mode
Percent of tract population (≥18yrs) with arthritis	1694	2.70	37.60	20.50	4.89	20.00	18.60
Percent of tract population (≥18yrs) with high blood pressure	1694	9.40	63.50	34.09	6.38	33.40	32.30
Percent of tract population (≥18yrs) with cancer (excluding skin cancer)	1694	0.50	12.20	5.01	1.52	4.90	4.90
Percent of tract population (≥18yrs) with asthma	1694	5.80	14.90	9.14	1.16	9.10	9.30
Percent of tract population (≥18yrs) with coronary heart disease	1694	0.70	13.60	6.08	1.87	6.00	6.00
Percent of tract population (≥18yrs) with chronic obstructive pulmonary disease	1694	1.30	15.80	6.38	2.12	6.20	6.90
Percent of tract population (≥18yrs) diagnosed with depression	1694	12.20	28.40	20.64	2.22	20.60	21.20
Percent of tract population (≥18yrs) diagnosed with diabetes	1694	1.50	30.80	13.23	4.30	12.80	9.90
Percent of tract population (≥18yrs) of fair or poor health	1694	5.30	50.20	20.63	8.33	19.80	17.30
Percent of tract population (≥18yrs) with chronic kidney disease	1694	0.60	7.50	3.10	0.93	3.00	2.50
Percent of tract population (≥18yrs) that experienced poor mental health for ≥14 days	1694	9.50	23.30	15.85	2.33	16.00	15.80
Percent of tract population (≥18yrs) that is obese	1694	19.70	55.30	38.43	5.90	38.60	40.20
Percent of tract population (≥18yrs) that experienced poor physical health for ≥14 days	1694	4.10	26.10	12.30	3.61	12.20	11.60
Percent of tract population (≥18yrs) that have had a stroke	1694	0.40	10.50	3.15	1.18	3.00	2.80

Source: CDC PLACES (2022)

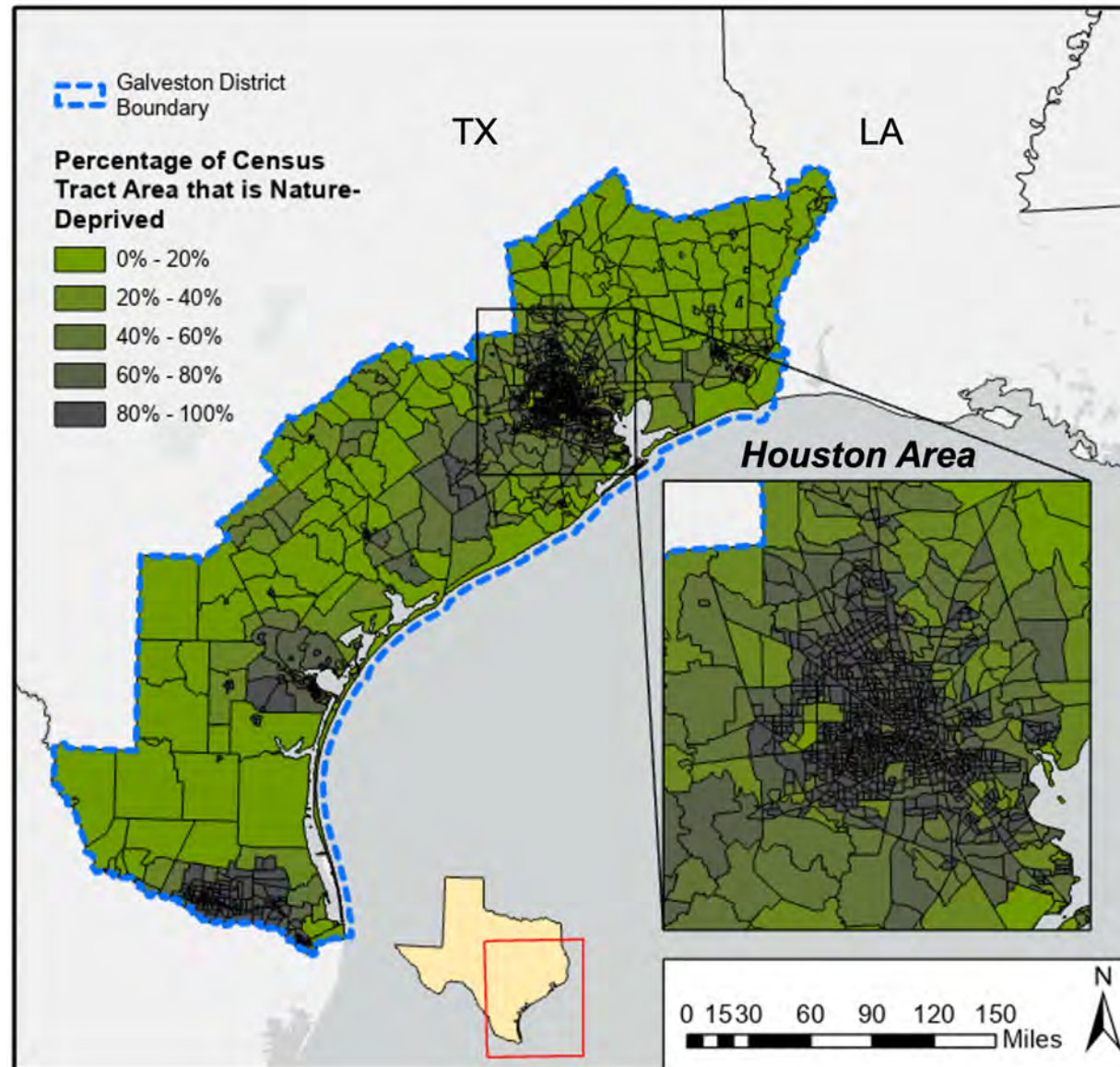
- Overall, Galv Distric communities are of fair health, though certain health complications (high blood pressure & obesity) are present amongst ~a third of tract populations

Geospatial Investigation



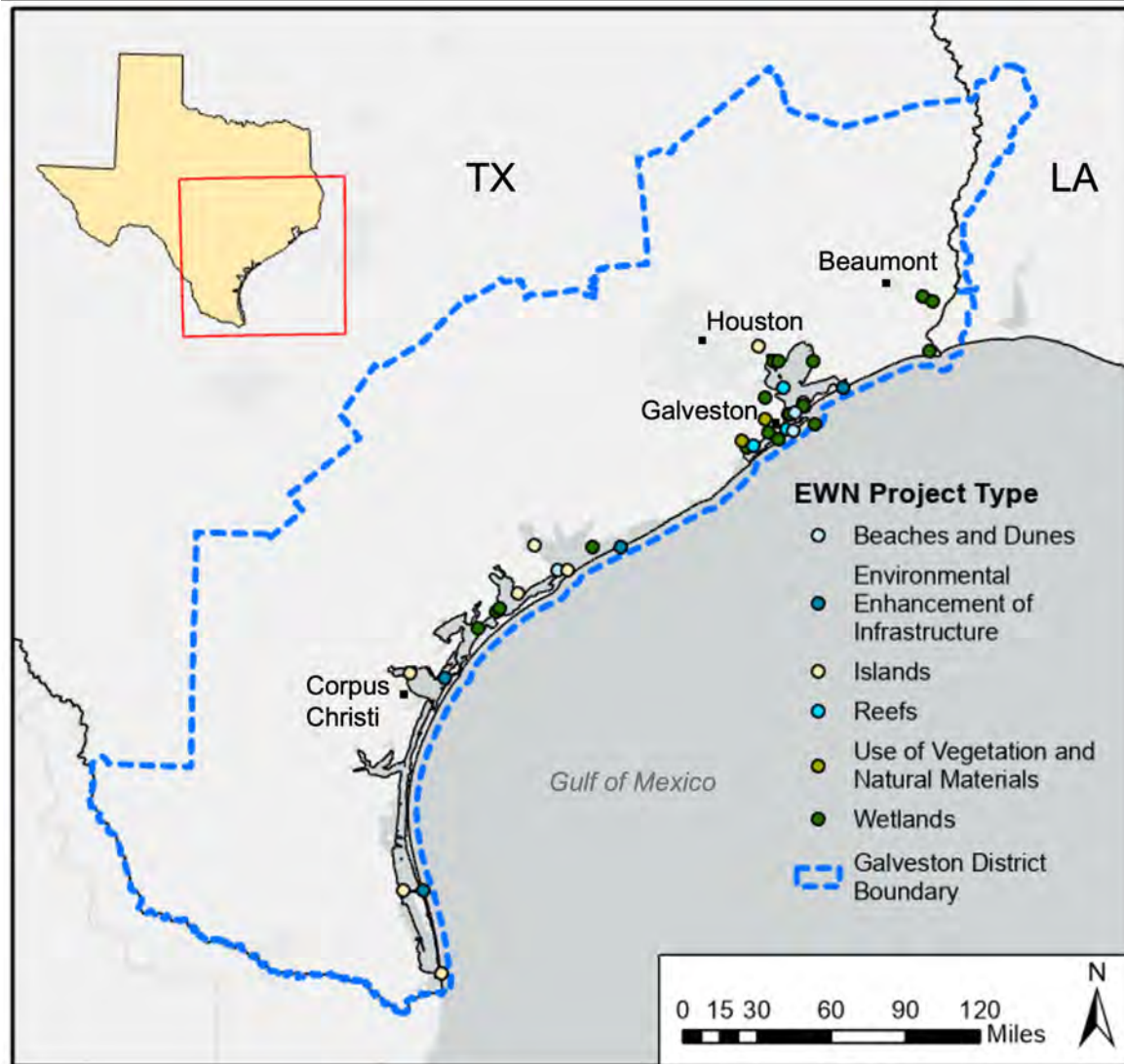
Sentinel-2 LULC
9 classes –
Water; trees; flooded
vegetation; crops; built area;
bare ground; snow/ice;
clouds; rangeland

Nature deprivation = (sum
of cells in census tract
classified as crops and built
area) / total number of cells
in census tract

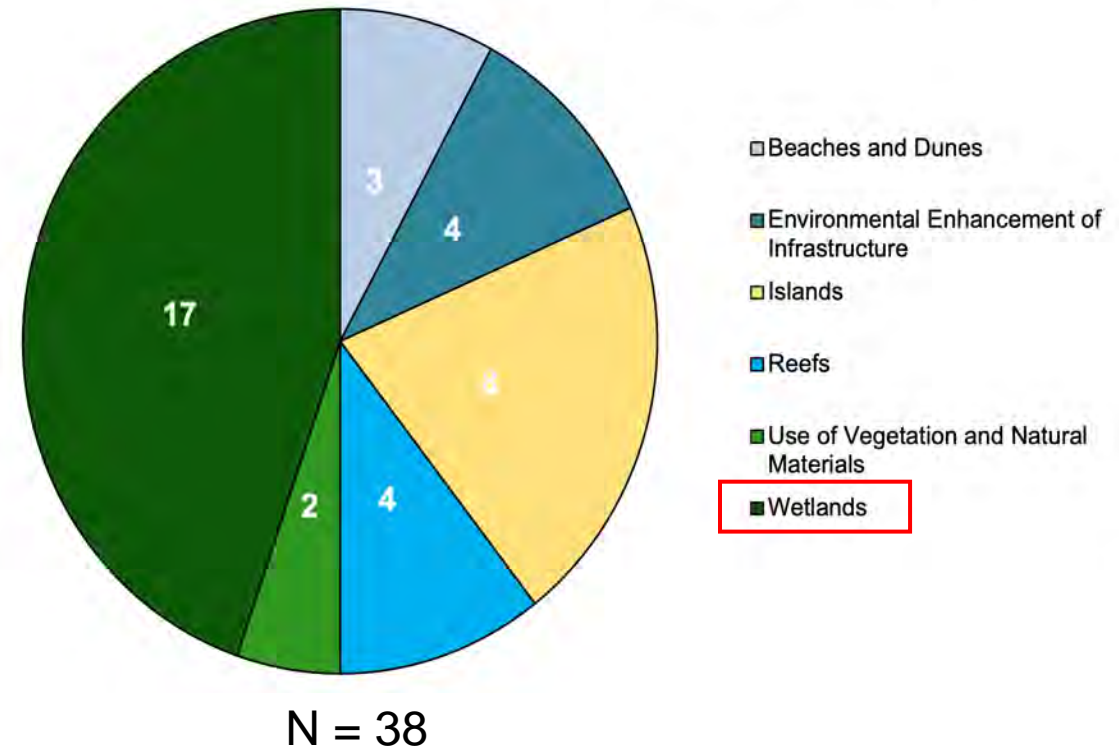


Data Sources: ESA Sentinel-2, U.S. Census Bureau, Texas Parks & Wildlife, CONANP, Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, Baylor University, City of Houston, USACE

Geospatial Investigation



EWN Project Types in USACE Galveston District



Geospatial Investigation

Health, Demographic, and Socioeconomic Characteristics of St. Louis District Census Tracts



Geospatial Investigation



Demographic composition & socioeconomic status

Metric*	N	Minimum	Maximum	Mean	Std. Deviation	Median	Mode
Percent of tract population below 150% poverty	1048	0	100.0	21.8	14.5	18.7	16.2
Percent of tract population (≥16yrs) that is unemployed	1048	0	50.0	5.3	4.3	4.1	2.7
Percent of tract population belonging to housing cost-burdened occupied housing units with annual income less than \$75,000	1048	0	100.0	24.0	11.0	21.4	20.7
Percent of tract population (≥25yrs) with no high school diploma	1048	0	51.8	9.2	6.4	8.1	3.7
Percent of tract population that is uninsured within the total civilian noninstitutionalized population estimate	1048	0	39.0	7.0	4.9	6.0	2.2
Percent of tract population aged 65 years and older	1048	0	51.3	17.4	6.2	17.1	16.2
Percent of tract population aged 17 years and younger	1048	0	47.7	21.8	5.7	22.0	24.7
Percent of tract population with a disability	1048	0	37.7	14.8	5.9	14.2	16.2
Percent of tract population belonging to a single-parent household with children under 18	1048	0	32.7	6.8	5.2	5.6	0.0
Percent of tract population (≥5yrs) who speak English "less than well"	1048	0	16.8	0.7	1.5	0.2	0.0
Percent of tract population belonging to a minority group**	1048	0	100.0	23.9	27.4	11.8	4.3
Percent of tract population inhabiting housing in structures with 10 or more units	1048	0	98.1	6.9	11.7	2.4	0.0
Percent of tract population inhabiting mobile homes estimate	1048	0	69.8	6.1	8.6	1.6	0.0
Percent of tract population occupying housing units with more people than rooms	1048	0	23.4	1.5	2.1	0.8	0.0
Percent of tract population belonging to households with no vehicle available	1048	0	51.4	7.4	8.6	4.7	0.0
Percent of tract population inhabiting group quarters	1048	0	99.6	2.7	7.8	0.2	0.0
Overall SVI Score (0 - 1)	1048	0	1.0	0.5	0.3	0.6	0.0

*All metrics are 2016-2020 ACS estimates

** (Hispanic or Latino (of any race); Black and African American, Not Hispanic or Latino; American Indian and Alaska Native, Not Hispanic or Latino; Asian, Not Hispanic or Latino; Native Hawaiian and Other Pacific Islander, Not Hispanic or Latino; Two or More Races, Not Hispanic or Latino; Other Races, Not Hispanic or Latino)

Source: CDC/ATSDR SVI20

- On average, majority of SL District communities are of higher socioeconomic status
- Medium Social Vulnerability

Geospatial Investigation



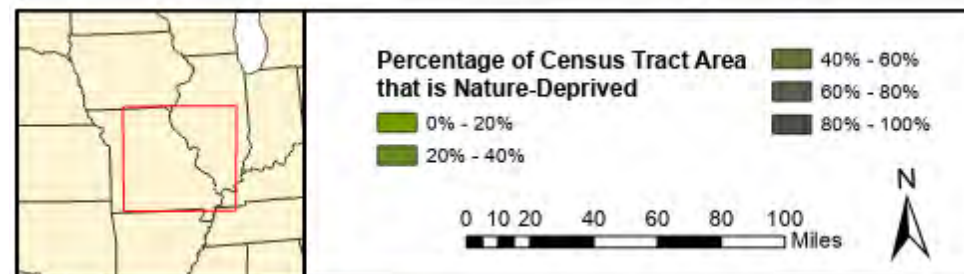
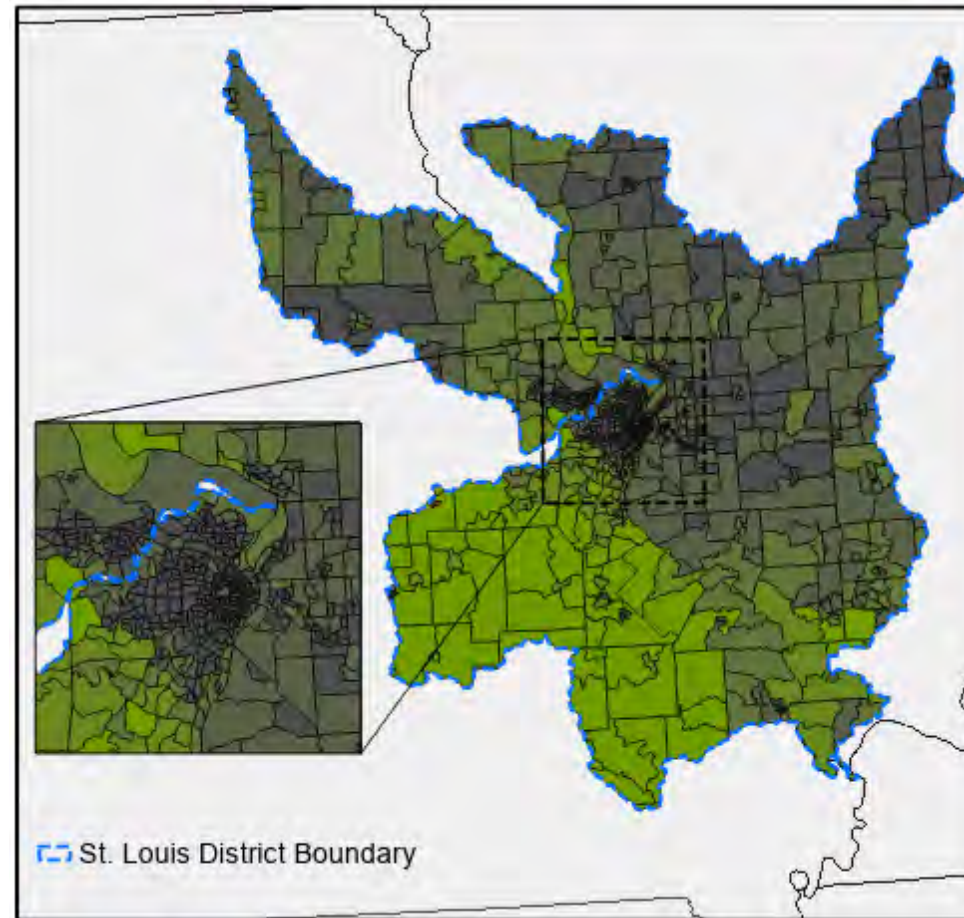
Health status

Health Metric	N	Minimum	Maximum	Mean	Std. Deviation	Median	Mode
Percent of tract population (≥18yrs) with arthritis	939	8.20	36.80	26.70	4.29	27.20	28.40
Percent of tract population (≥18yrs) with high blood pressure	939	12.80	55.20	33.01	6.37	33.00	32.50
Percent of tract population (≥18yrs) with cancer (excluding skin cancer)	939	0.80	11.20	6.55	1.30	6.70	7.30
Percent of tract population (≥18yrs) with asthma	939	7.80	16.50	10.01	1.44	9.70	10.00
Percent of tract population (≥18yrs) with coronary heart disease	939	1.80	11.20	6.59	1.53	6.70	6.90
Percent of tract population (≥18yrs) with chronic obstructive pulmonary disease	939	2.70	14.70	7.56	2.19	7.50	7.50
Percent of tract population (≥18yrs) diagnosed with depression	939	13.60	36.60	20.90	3.35	20.50	18.20
Percent of tract population (≥18yrs) diagnosed with diabetes	939	2.90	23.60	10.57	3.36	10.10	10.00
Percent of tract population (≥18yrs) of fair or poor health	939	7.00	39.10	16.19	5.96	15.00	10.00
Percent of tract population (≥18yrs) with chronic kidney disease	939	1.10	6.20	3.00	0.77	2.90	3.00
Percent of tract population (≥18yrs) that experienced poor mental health for ≥14 days	939	8.70	31.10	14.74	2.43	14.50	13.00
Percent of tract population (≥18yrs) that is obese	939	18.30	57.70	35.68	6.80	35.80	38.50
Percent of tract population (≥18yrs) that experienced poor physical health for ≥14 days	939	5.40	20.60	11.03	2.80	10.70	12.70
Percent of tract population (≥18yrs) that have had a stroke	939	0.90	8.50	3.36	1.20	3.20	3.20

Source: CDC PLACES (2022)

- On average, roughly a third of SL District census tracts have high blood pressure and are obese

Geospatial Investigation

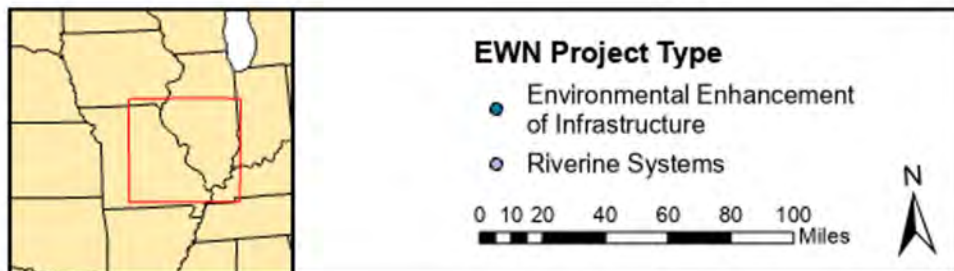
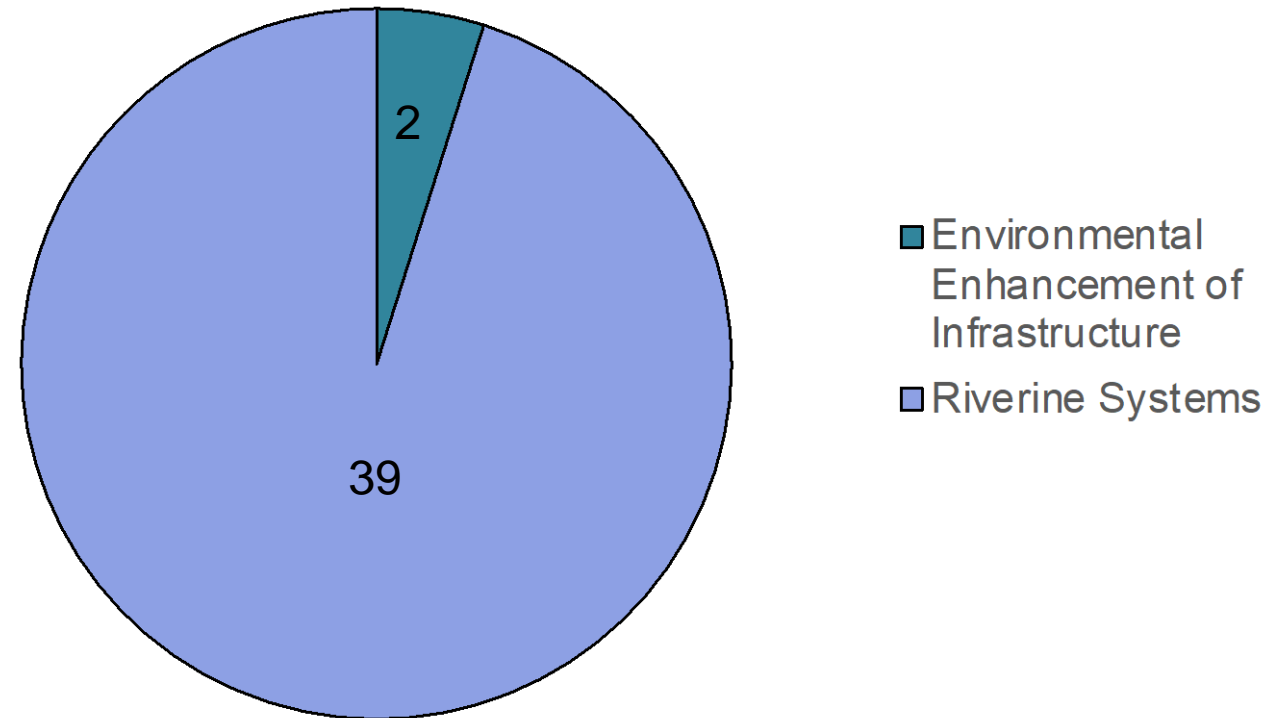


Data Sources: ESA Sentinel-2, U.S. Census Bureau, Missouri DNR, Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, NPS, USACE

Geospatial Investigation



EWN Project Types in USACE St. Louis District



Data Source: USACE EWN ProMAP